Application of Objective Degree Evaluation System of Main Scenarios in Earthquake Disaster Assessment Deduction Training in Web Simulation Exercise System

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ABSTRACT

After the occurrence of a destructive earthquake, it is of great guiding significance for the country to quickly, accurately and comprehensively grasp the casualties and economic losses in the disaster area and timely release the earthquake intensity map for the effective implementation of emergency rescue, post-disaster reconstruction, earthquake prevention and disaster reduction investment planning. The simulation exercise of earthquake disaster loss investigation and assessment is a method to effectively improve the on-site loss investigation and assessment ability of earthquake emergency response team members. Based on the analytic hierarchy process, combined with a questionnaire survey and expert scoring, this paper constructs a set of objective evaluation systems for the main scenarios of earthquake disaster loss investigation, evaluation and deduction training, and applies the evaluation system to the web-based simulation exercise system for earthquake intensity evaluation and disaster loss evaluation to realize the objective evaluation of the simulated earthquake disaster scenarios generated by the exercise system, so as to further improve the effectiveness of the drill.

Keywords: *earthquake; loss assessment; objectivity; drill; system*

1. INTRODUCTION

High frequency, high intensity and wide distribution of earthquake disasters are the basic national conditions of our country. Frequent earthquake disasters seriously threaten the safety of people's lives and property. In the face of sudden earthquake disasters, earthquake emergency commanders are required to have the ability of rapid response, organization and coordination and decisive decision-making. In recent years, earthquake emergency deduction training, which aims to test the government's emergency response procedures and response capabilities, has gradually attracted the attention of governments and researchers at all levels. The investigation and evaluation of earthquake disaster losses is an important part of earthquake emergency deduction training, in which the objectivity and reliability of building damage scenarios and human death scenarios are directly related to the success of earthquake emergency deduction training. Therefore, on the basis of establishing the scenario objective degree deduction model of earthquake direct economic loss and the scenario prediction and analysis objective degree model of earthquake personnel death, the author designed and developed a web-based earthquake disaster loss investigation and evaluation simulation drill system. In order to improve the objectivity of the system in the process of setting earthquake disaster drill scenarios, a set of objective evaluation systems for the main scenarios of earthquake disaster assessment deduction training was constructed and integrated into the system. It is of important research significance for effectively carrying out earthquake emergency deduction training, improving the quality and emergency handling level of relevant emergency management personnel, and scientifically and reasonably providing emergency relief measures and post-disaster reconstruction suggestions for government departments. [15-19]

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2. OBJECTIVITY EVALUATION SYSTEM OF MAIN SCENARIOS OF EARTHQUAKE DISASTER ASSESSMENT AND DEDUCTION TRAINING

The objectivity and reliability of the setting of building damage scenarios and personnel death scenarios are important components of earthquake emergency deduction training. Whether the setting is reasonable will also directly affect the objectivity of earthquake disaster scenarios. In order to determine whether the selected economic losses and the set number of deaths meet the objective degree requirements of the main scenarios, this paper uses the analytic hierarchy process to realize the objective degree evaluation of the main scenarios of earthquake disaster assessment deduction training, and the specific contents are as follows:

2.1 Establishment of a hierarchical structure of the objectivity degree evaluation model for the main scenarios of earthquake disaster assessment deduction training

As shown in Figure 1, the objective degree evaluation system of the main scenarios of earthquake disaster assessment deduction training is constructed, which is divided into three levels. Among them, the loss probability range of buildings and engineering structures and facilities is divided according to Table 1. The number of deaths is compared with the number of deaths caused by similar earthquakes according to the estimated value, which is distinguished between within an order of magnitude or not within an order of magnitude. [1-5] [8-14]

Table 1: The Bayesian network node variable value range of direct economic loss of earthquake disasters

Number	Network Node Variables	Value Range	Network Node Assignment
A	Epicenter intensity	degree VI and below/ degree Ⅶ/ degree Ⅷ/ degree IX and above	1/2/3/4
B	Scope of influence	below 2000 km^2/ 2000-4000 km^2/ above 4000 km^2	1/2/3
C	Building damage	damaged/ undamaged	1/2
D	Water supply system damage	damaged/ undamaged	1/2
E	Power supply system damage	damaged/ undamaged	1/2
F	Communication system damage	damaged/ undamaged	1/2
G	Traffic system damage	damaged/ undamaged	1/2
H	Water conservancy system damage	damaged/ undamaged	1/2
I	Economic losses of buildings	0/ less than 50 million yuan/ 50-100 million yuan (excluding 100 million yuan)/ 100-500 million yuan (excluding 500 million yuan)/ 500-100 million yuan (excluding 100 million yuan)/ more than 100000 yuan	0/1/2/3/4/5
J	Loss of water supply system	0/ less than 1 million yuan/ 1-2 million yuan (excluding 2 million yuan)/ 2-4 million yuan (excluding 4 million yuan)/ more than 4 million yuan	0/1/2/3/4
K	Loss of power supply system	0/ less than 1 million yuan/ 1-2 million yuan (excluding 2 million yuan)/ 2-10 million yuan (excluding 10 million yuan)/ 10-40 million yuan (excluding 40 million yuan)/ more than 40 million yuan	0/1/2/3/4/5

L	Loss of communication system	0/ less than 1 million yuan/ 1-2 million yuan (excluding 2 million yuan) / 2-10 million yuan (excluding 10 million yuan)/ more than 10 mission yuan	0/1/2/3/4
M	Traffic system loss	0/ less than 5 million yuan/ 5-10 million yuan (excluding 10 million yuan)/ 10-50 million yuan (excluding 50 million yuan)/ more than 50 million yuan	0/1/2/3/4
N	Loss of water conservancy system	0/ less than 5 million yuan/ 5-10 million yuan (excluding 10 million yuan)/ 10-20 million yuan (excluding 20 million yuan)/ 20-50 million yuan (excluding 50 million yuan)/ more than 50 million yuan	0/1/2/3/4/5

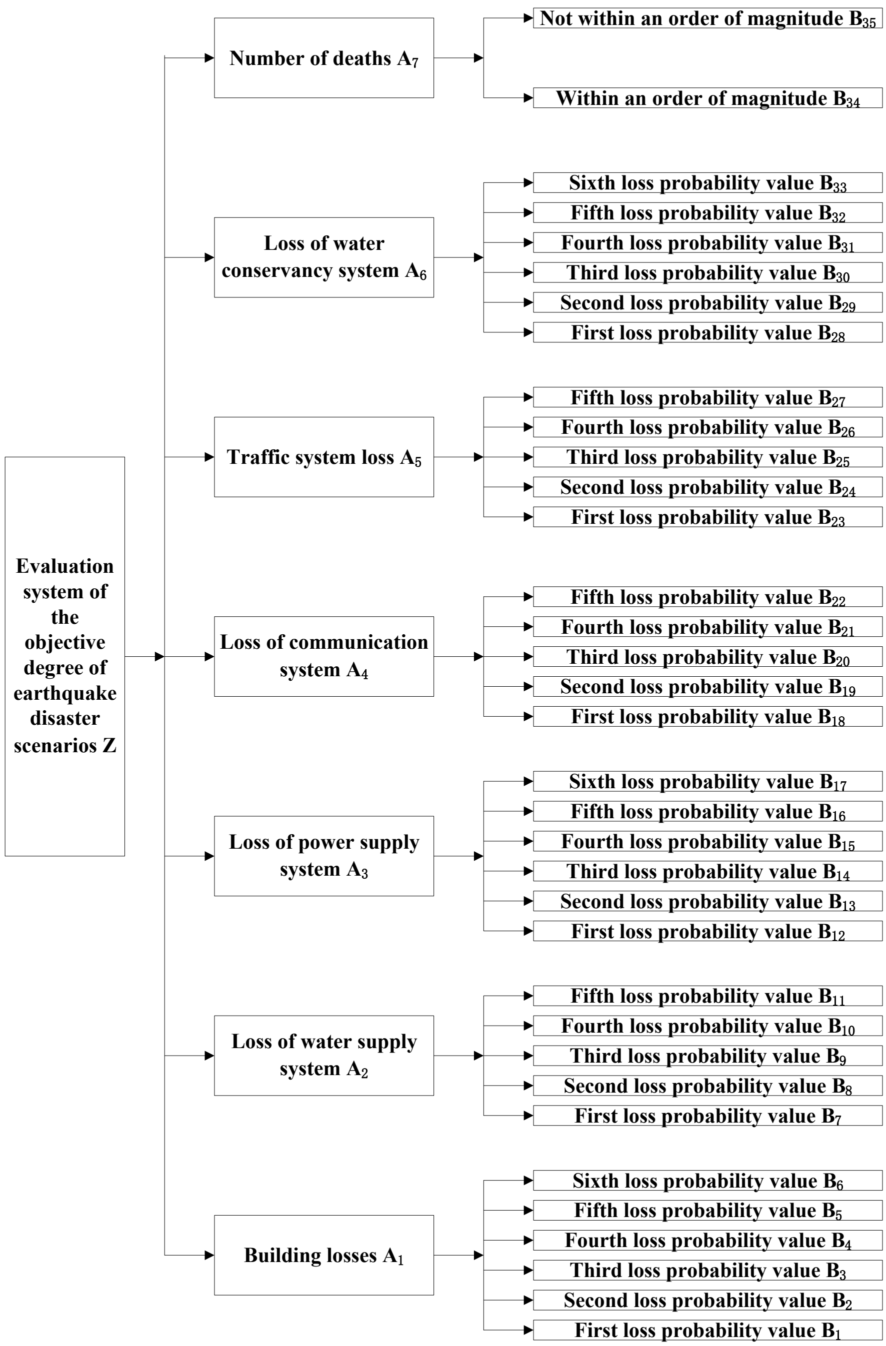

Figure 1: Evaluation system of the objective degree of earthquake disaster scenarios（photo credit:original）

2.2 Construction of pairwise comparison discrimination matrix

After constructing the hierarchical structure of the objective degree evaluation model of the main scenarios of the earthquake disaster assessment deduction training, combined with questionnaires, consulting industry experts and other ways, the pair-pair scales for level 1 and Level 2 indicators are realized. Table 2 shows the meaning of each scale.

Table 2: Meaning of Scale

Scale	Meaning
1	Compare two elements with equal importance
3	Compare two elements, one of which is slightly more important than the other
5	When comparing two elements, one element is obviously more important than the other
7	When comparing two elements, one element is more important than the other
9	When comparing two elements, one element is extremely important than the other
2, 4, 6, 8	This scale represents the intermediate value between each of the above two adjacent judgments

In the form of a questionnaire survey, senior experts engaged in disaster assessment work in the earthquake industry voted, counted the voting results, obtained a discriminant matrix, and then realized the analysis and calculation of the weight of each indicator according to the discriminant matrix, as shown in Table 3 to 10.

Table 3: Comparison and judgment among first-level indicators (A-A_i)

A-A_i	A_1	A_2	A_3	A_4	A_5	A_6	A_7
A_1	1	5	4	3	3	5	2
A_2	1/5	1	1/2	1/3	1/3	1	1/4
A_3	1/4	2	1	1/2	1/2	2	1/3
A_4	1/3	3	2	1	1	3	1/2
A_5	1/3	3	2	1	1	3	1/2
A_6	1/5	1	1/2	1/3	1/3	1	1/4
A_7	1/2	4	3	2	2	4	1

Table 4: Comparison and judgment among first-level indicators (A_1-B_i)

A_1-B_i	A_1	A_2	A_3	A_4	A_5	A_6
B_1	1	2	3	4	5	6
B_2	1/2	1	2	3	4	5
B_3	1/3	1/2	1	2	3	4
B_4	1/4	1/3	1/2	1	2	3
B_5	1/5	1/4	1/3	1/2	1	2
B_6	1/6	1/5	1/4	1/3	1/2	1

Table 5: Comparison and judgment among first-level indicators (A_2-B_i)

A_2-B_i	B_7	B_8	B_9	B_{10}	B_{11}
B_7	1	2	3	4	5
B_8	1/2	1	2	3	4
B_9	1/3	1/2	1	2	3

B_{10}	1/4	1/3	1/2	1	2
B_{11}	1/5	1/4	1/3	1/2	1

Table 6: Comparison and judgment among first-level indicators (A_3-B_i)

A_3-B_i	B_{12}	B_{13}	B_{14}	B_{15}	B_{16}	B_{17}
B_{12}	1	2	3	4	5	6
B_{13}	1/2	1	2	3	4	5
B_{14}	1/3	1/2	1	2	3	4
B_{15}	1/4	1/3	1/2	1	2	3
B_{16}	1/5	1/4	1/3	1/2	1	2
B_{17}	1/6	1/5	1/4	1/3	1/2	1

Table 7: Comparison and judgment among first-level indicators (A_4-B_i)

A_4-B_i	B_{18}	B_{19}	B_{20}	B_{21}	B_{22}
B_{18}	1	2	3	4	5
B_{19}	1/2	1	2	3	4
B_{20}	1/3	1/2	1	2	3
B_{21}	1/4	1/3	1/2	1	2
B_{22}	1/5	1/4	1/3	1/2	1

Table 8: Comparison and judgment among first-level indicators (A_5-B_i)

A_5-B_i	B_{23}	B_{24}	B_{25}	B_{26}	B_{27}
B_{23}	1	2	3	4	5
B_{24}	1/2	1	2	3	4
B_{25}	1/3	1/2	1	2	3
B_{26}	1/4	1/3	1/2	1	2
B_{27}	1/5	1/4	1/3	1/2	1

Table 9: Comparison and judgment among first-level indicators (A_6-B_i)

A_6-B_i	B_{28}	B_{29}	B_{30}	B_{31}	B_{32}	B_{33}
B_{28}	1	2	3	4	5	6
B_{29}	1/2	1	2	3	4	5
B_{30}	1/3	1/2	1	2	3	4
B_{31}	1/4	1/3	1/2	1	2	3
B_{32}	1/5	1/4	1/3	1/2	1	2
B_{33}	1/6	1/5	1/4	1/3	1/2	1

Table 10: Comparison and judgment among first-level indicators (A_7-B_i)

A_7-B_i	B_{34}	B_{35}
B_{34}	1	4
B_{35}	1/4	1

2.3 Calculation of the relative importance of elements under a single criterion and consistency verification

(1) Construct a judgment matrix according to the expert scores:

$$A_1=\begin{bmatrix} 1 & 5 & 4 & 3 & 3 & 5 & 2 \\ 1/5 & 1 & 1/2 & 1/3 & 1/3 & 1 & 1/4 \\ 1/4 & 2 & 1 & 1/2 & 1/2 & 2 & 1/3 \\ 1/3 & 3 & 2 & 1 & 1 & 3 & 1/2 \\ 1/3 & 3 & 2 & 1 & 1 & 3 & 1/2 \\ 1/5 & 1 & 1/2 & 1/3 & 1/3 & 1 & 1/4 \\ 1/2 & 4 & 3 & 2 & 2 & 4 & 1 \end{bmatrix}$$

(2) Determine the product of the elements in each row of the matrix A_1:

$$m_i=\prod_{i=1}^{n} a_{ij} (i=1,2...,n) \tag{1}$$

$$m_1=1\times5\times4\times3\times3\times5\times2=1800$$

$$m_2=\frac{1}{5}\times1\times\frac{1}{2}\times\frac{1}{3}\times\frac{1}{3}\times1\times\frac{1}{4}=\frac{1}{360}$$

$$m_3=\frac{1}{4}\times2\times1\times\frac{1}{2}\times\frac{1}{2}\times2\times\frac{1}{3}=\frac{1}{12}$$

$$m_4=\frac{1}{3}\times3\times2\times1\times1\times3\times\frac{1}{2}=3$$

$$m_5=\frac{1}{3}\times3\times2\times1\times1\times3\times\frac{1}{2}=3$$

$$m_6=\frac{1}{5}\times1\times\frac{1}{2}\times\frac{1}{3}\times\frac{1}{3}\times1\times\frac{1}{4}=\frac{1}{360}$$

$$m_7=\frac{1}{2}\times4\times3\times2\times2\times4\times1=96$$

(3) Determine the indicator weight:

$$\omega_i=\varpi_i / \sum_{j=1}^{n}\varpi_j \tag{2}$$

$$W_A=\sum_{j=1}^{n}\varpi_j \tag{3}$$

where

$$\varpi_i=\sqrt[n]{m_i} \tag{4}$$

$$\varpi_1=\sqrt[7]{1800}=2.917689$$

$$\varpi_2=\sqrt[7]{\frac{1}{360}}=0.431334$$

$$\varpi_3=\sqrt[7]{\frac{1}{12}}=0.701183$$

$$\varpi_4=\sqrt[7]{3}=1.169931$$

$$\varpi_5=\sqrt[7]{3}=1.169931$$

$$\varpi_6=\sqrt[7]{\frac{1}{360}}=0.431334$$

$$\varpi_7=\sqrt[7]{96}=1.919471$$

To sum up, we can obtain

$$W_A=\sum_{j=1}^{7}(2.917689+0.431334+0.701183+1.169931+1.169931+0.431334+1.919471)=8.740873$$

(4) Normalization:

$$\omega_1=\frac{\varpi_1}{W_A}=0.333798 \quad \omega_2=\frac{\varpi_2}{W_A}=0.049347$$

$$\omega_3=\frac{\varpi_3}{W_A}=0.080219 \quad \omega_4=\frac{\varpi_4}{W_A}=0.133846$$

$$\omega_5=\frac{\varpi_5}{W_A}=0.133846 \quad \omega_6=\frac{\varpi_6}{W_A}=0.049347$$

$$\omega_7=\frac{\varpi_7}{W_A}=0.219597$$

The normalized weight vector can be obtained as follows

$$W=\begin{bmatrix}\omega_1\\ \omega_2\\ \omega_3\\ \omega_4\\ \omega_5\\ \omega_6\\ \omega_7\end{bmatrix}=\begin{bmatrix}0.333798\\ 0.049347\\ 0.080219\\ 0.133846\\ 0.133846\\ 0.049347\\ 0.219597\end{bmatrix}$$

(5) Consistency verification:

$$AW=\begin{bmatrix}2.390\\ 0.350\\ 0.568\\ 0.945\\ 0.945\\ 0.350\\ 1.557\end{bmatrix}=\lambda_{max}W$$

Maximum characteristic value

$$\lambda_{\max}=\frac{1}{n}\sum_{i=1}^{n}(AW)/\omega_i \tag{5}$$

$$\lambda_{\max}=\frac{1}{7}\left(\frac{2.390}{0.334}+\frac{0.350}{0.049}+\frac{0.568}{0.080}+\frac{0.945}{0.134}+\frac{0.945}{0.134}+\frac{0.350}{0.049}+\frac{1.557}{0.220}\right)=7.090$$

$$CI=\frac{\lambda_{\max}\text{-n}}{\text{n-1}}=\frac{7.090\text{-}7}{7\text{-}1}=0.01506$$

n=7, RI=1.32, $CR=\frac{CI}{RI}=0.01141<0.1$, so the judgment matrix is reasonable.

2.4 Weight and ranking of each indicator of the objective evaluation of the main scenarios in earthquake disaster assessment deduction training

Using the method described above, the weights and rankings of each indicator of the objective degree evaluation of the main scenarios of earthquake disaster assessment deduction training are calculated, respectively, as shown in Tables 11 and 12.

Table 11: The weight and ranking of the objective evaluation indicators of main scenarios in earthquake disaster assessment deduction training in their respective levels

Primary Indicator	Secondary Indicator	Weight of Secondary Indicators in Primary Indicators	Ranking of Secondary Indicators in Primary Indicators	Weight of Primary Indicators in the Overall System	Ranking of Primary Indicators
Building Losses A_1	First loss probability value B_1	0.381	1	0.334	1
	Second loss probability value B_2	0.252	2		
	Third loss probability value B_3	0.160	3		
	Fourth loss probability value B_4	0.101	4		
	Fifth loss probability value B_5	0.064	5		
	Sixth loss probability value B_6	0.042	6		
Loss of water supply system A_2	First loss probability value B_7	0.417	1	0.049	5
	Second loss probability value B_8	0.263	2		
	Third loss probability value B_9	0.160	3		
	Fourth loss probability value B_{10}	0.097	4		
	Fifth loss probability value B_{11}	0.0621	5		
Loss of power supply system A_3	First loss probability value B_{12}	0.381	1	0.080	4
	Second loss probability value B_{13}	0.252	2		
	Third loss probability value B_{14}	0.160	3		
	Fourth loss probability value B_{15}	0.101	4		
	Fifth loss probability value B_{16}	0.064	5		
	Sixth loss probability value B_{17}	0.042	6		
Loss of communication system A_4	First loss probability value B_{18}	0.417	1	0.134	3
	Second loss probability value B_{19}	0.263	2		
	Third loss probability value B_{20}	0.160	3		

	Fourth loss probability value B_{21}	0.097	4		
	Fifth loss probability value B_{22}	0.0621	5		
Traffic system loss A_5	First loss probability value B_{23}	0.417	1	0.134	3
	Second loss probability value B_{24}	0.263	2		
	Third loss probability value B_{25}	0.160	3		
	Fourth loss probability value B_{26}	0.097	4		
	Fifth loss probability value B_{27}	0.0621	5		
Loss of water conservancy system A_6	First loss probability value B_{28}	0.381	1	0.049	5
	Second loss probability value B_{29}	0.252	2		
	Third loss probability value B_{30}	0.160	3		
	Fourth loss probability value B_{31}	0.101	4		
	Fifth loss probability value B_{32}	0.064	5		
	Sixth loss probability value B_{33}	0.042	6		
Number of deaths A_7	within an order of magnitude B_{34}	0.7	1	0.220	2
	not within an order of magnitude B_{35}	0.3	2		

Table 12: The weights and rankings of each indicator in the objective evaluation of the main scenarios of the earthquake disaster assessment deduction training

Primary Indicator	Secondary Indicator	Weight of Secondary Indicators in Primary Indicators	Ranking of Secondary Indicators in Primary Indicators	Weight of Primary Indicators in the Overall System
Building Losses A_1	First loss probability value B_1	0.127	0.334	1
	Second loss probability value B_2	0.084		
	Third loss probability value B_3	0.053		
	Fourth loss probability value B_4	0.034		
	Fifth loss probability value B_5	0.021		
	Sixth loss probability value B_6	0.014		
Loss of water supply system A_2	First loss probability value B_7	0.020	0.049	5
	Second loss probability value B_8	0.013		
	Third loss probability value B_9	0.008		
	Fourth loss probability value B_{10}	0.005		
	Fifth loss probability value B_{11}	0.003		
Loss of power supply system A_3	First loss probability value B_{12}	0.030	0.080	4
	Second loss probability value B_{13}	0.020		
	Third loss probability value B_{14}	0.013		

	Fourth loss probability value B_{15}	0.008		
	Fifth loss probability value B_{16}	0.005		
	Sixth loss probability value B_{17}	0.003		
Loss of communication system A_4	First loss probability value B_{18}	0.056	0.134	3
	Second loss probability value B_{19}	0.035		
	Third loss probability value B_{20}	0.021		
	Fourth loss probability value B_{21}	0.013		
	Fifth loss probability value B_{22}	0.008		
Traffic system loss A_5	First loss probability value B_{23}	0.056	0.134	3
	Second loss probability value B_{24}	0.035		
	Third loss probability value B_{25}	0.021		
	Fourth loss probability value B_{26}	0.013		
	Fifth loss probability value B_{27}	0.008		
Loss of water conservancy system A_6	First loss probability value B_{28}	0.019	0.049	5
	Second loss probability value B_{29}	0.012		
	Third loss probability value B_{30}	0.008		
	Fourth loss probability value B_{31}	0.005		
	Fifth loss probability value B_{32}	0.003		
	Sixth loss probability value B_{33}	0.002		
Number of deaths A_7	within an order of magnitude B_{34}	0.154	0.220	2
	not within an order of magnitude B_{35}	0.066		

To sum up, when constructing earthquake disaster scenarios, the maximum value of the objective degree weight of the estimated and selected scenario is 0.463, and the minimum value is 0.102. It is determined that when the value exceeds 0.25, the objective degree requirements are met.

3. WEB SIMULATION DRILL SYSTEM FOR EARTHQUAKE INTENSITY ASSESSMENT AND DISASTER LOSS ASSESSMENT

The web-based simulation drill system for earthquake intensity assessment and disaster loss assessment takes full account of the functional process requirements of simulation drill in the design process, and completely includes five links: drill preparation, drill setting, disaster investigation, loss assessment and result reporting. Through the system, the assignment of different drill groups, the designation of team leaders and the division of tasks can be realized, and group confrontation drills can be carried out, which can increase the intensity of the drill and improve the authenticity of the drill, and promote the division of work and cooperation among the disaster assessment personnel in the group. The system can quickly obtain two-dimensional earthquake disaster site simulation results through parameter settings. Combined with the disaster loss investigation and evaluation data given by the system, the earthquake disasters can be set up unlimited times, and the disaster field simulation results and emergency simulation drill environment of the preset disasters can be obtained. In the simulated drill, the disaster assessment team can simulate the disaster investigation, intensity assessment and loss assessment and other earthquake site disposal work, and report the results according to the drill results. Through the simulation exercise, the response-ability of the on-site disaster assessment work of the earthquake site team can be improved, the rationality of the emergency work content and operation procedures can be tested, and the disposal details of the actual earthquake fieldwork can be completed. In the process of setting the simulated earthquake, the objectivity evaluation system of the main scenarios is trained through the earthquake disaster assessment and deduction to ensure the objectivity and scientificity of the drill scenarios.

The simulation and drill module of earthquake disaster loss investigation and evaluation aims at details and professionalism. After many simulation drills and actual combat, more high-quality and high-tech personnel are trained to play an important role in the actual earthquake disaster emergency response work and serve as a solid backing for earthquake disaster emergency rescue in China. [6] [7]

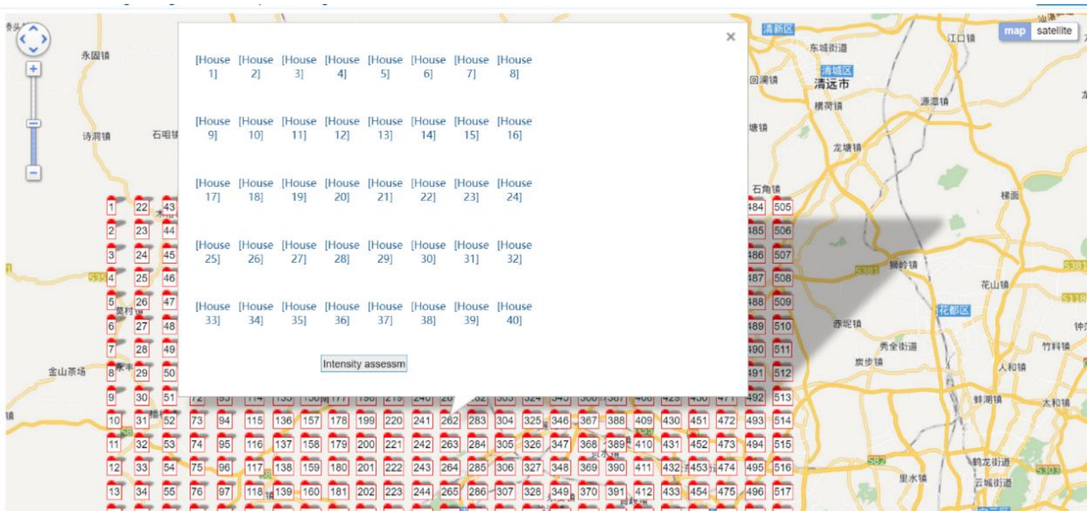

Figure 2: Distribution and selection of investigation sites（photo credit:original）

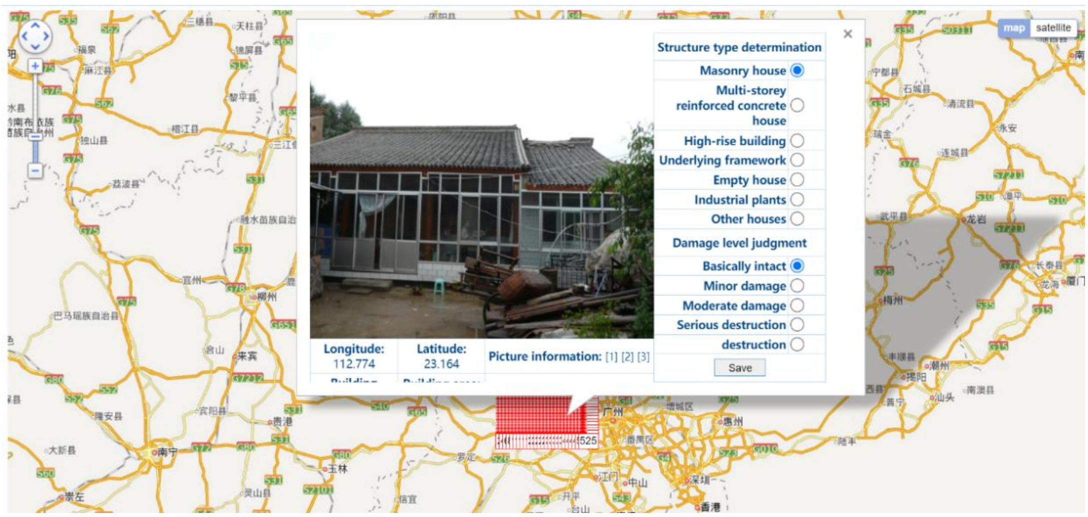

Figure 3: On-site simualtion investigation（photo credit:original）

4. CONCLUSION

Based on the analytic hierarchy process, combined with a questionnaire survey and expert scoring, this paper constructed a set of objective degree evaluation systems of main scenarios of earthquake disaster loss investigation and evaluation, deduction and training. It was applied to the Web-based simulation drill system for earthquake intensity evaluation and disaster loss evaluation, so as to realize the objective evaluation of the simulated earthquake disaster scenarios generated by the exercise system. It can effectively complete the earthquake disaster loss investigation, evaluation, and deduction training work and provide a set of drills and training models that are close to the actual situation for the disaster assessment team. The system effectively strengthens the training level, improves the overall quality of the disaster assessment team, and makes the disaster assessment team more competent for the disaster assessment work at the earthquake site. It is of great help to cultivate an efficient and capable professional team for earthquake disaster assessment and has strong practicality.

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REFERENCES

[1] CHEN Tong, ZHENG Tongyan (2016). Review of earthquake damage losses in mainland China in 2015 [J]. Journal of catastrophology,31(3):133-137.

[2] LIN Xiangyang, ZHENG Tongyan, WEN Xintao (2018). Review of earthquake damage losses in mainland China in 2017 [J], Journal of Institute of Disaster Prevention, 20(3):52-58.

[3] LIN Xiangyang, ZHENG Tongyan, WEN Xintao (2020). Review of earthquake damage losses in mainland China in 2018[J], Journal of Institute of Disaster Prevention,22(2):10-17.

[4] LIN Xiangyang, WEN Xintao, LI Huayue, ZHENG Tongyan, DUAN Yihao (2020). Review of earthquake damage losses in mainland China in 2019 [J], Technology for Earthquake Disaster Prevention,15(3):473-483.

[5] WEN Xintao, ZHENG Tongyan (2018). Review of earthquake damage losses in mainland China in 2016[J]. Journal of catastrophology, 33(3):141-144.

[6] WANG Dongming, ZHU Damiao, LI Yongjia (2015). Design and Implementation of Online Examination Subsystem for China Earthquake Disaster Loss Investigation Assessment Training System [J]. Journal of Seismological Research, 38(3):508-516. (in Chinese)

[7] WANG Dongming, ZHU Damiao (2016). Management Platform of Earthquake Ruins Rescue Database Based on Web [J]. Journal of Seismological Research, 39(3): 507-512. (in Chinese)

[8] ZHENG Tongyan, LI Yang, HOU Jiansheng, et al (2010). Review on Earthquake Disaster Loss in Chinese Mainland in 2008 [J]. Journal of Catastrophology, 25(2):113-118.(in Chinese)

[9] ZHENG Tongyan, LI Yang, HOU Jiansheng, et al (2010), A Review of Earthquake Disasters Loss in Mainland China in 2009.Journal of Catastrophology, 25(4):96-101. (in Chinese)

[10] ZHENG Tongyan, ZHAO Ping, LIU Zaitao (2011). A review of earthquake disaster loss in Chinese mainland in 2010 [J]. Journal of Natural Disasters, 20(4):107-113.

[11] ZHENG Tongyan, ZHENG Yi (2012). Review of earthquake damage losses in mainland China in 2011 [J]. Journal of Natural Disasters,21(5):88-97.

[12] ZHENG Tongyan, ZHENG Yi (2014). Review of earthquake disasters in Chinese mainland in 2012[J]. Journal of Natural Disasters, 23(3):166-170.

[13] ZHENG Tongyan, ZHENG Yi (2015). Review of earthquake damage losses in mainland China in 2013 [J]. Journal of Natural Disasters, 24(1):239-246.

[14] ZHENG Tongyan, FENG Wei, ZHENG Yi (2015). Review of earthquake damage losses in mainland China in 2014 [J]. World Earthquake Engineering, 31(2):202-208.

[15] ZHU Damiao, WANG Dongming (2021). A Web Simulation Training System for Earthquake Intensity Assessment and Disaster Damage Evaluation [J]. 2021 International Conference on Management Science and Software Engineering, 153-164.

[16] ZHU Damiao, WANG Dongming (2021).China Earthquake Disaster Loss Investigation and Evaluation: Design and Development of Online Examination Application[J].2021 International Conference Data Mining and Statistical Applications, 496-505.

[17] ZHU Damiao, WANG Dongming (2021). Application of earthquake direct economic loss prediction model based on Bayesian network in disaster assessment deduction training[J]. Journal of Natural Disasters, 10,30(5): 51-63.

[18] ZHU Damiao, WANG Dongming (2021). The study of earthquake deaths forecasting model based on the earthquake resistance index of the whole country [J]. Journal of Natural Disasters,30(6):51-60.

[19] ZHU Damiao, WANG Dongming (2021). Application of Building Spatial Distribution Method Based on Remote Sensing Image in Earthquake Disaster Loss Pre-assessment [J]. Technology for Earthquake Disaster Prevention,9,16(3):506-514.