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EVALUATION OF THE CITY'S ABILITY FOR SEISMIC DISASTER PREVENTION

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SUMMARY

In 1994 the Chinese Government made an important decision that through the ten year's consensus effort by each level of government and whole society, all the large and middle-sized cities in China, with the location along the coast, or with dense population, or with well developing of economy should be enhanced their abilities for mitigating earthquake disaster with the goal to resist earthquake of Magnitude of six.

This paper presents the definition of a city's ability for earthquake disaster mitigation, the components, which affect significantly the city's ability, the criteria, by which, the city's ability for mitigating seismic disaster can be evaluated, and a framework that can quantitatively evaluate the city's ability for seismic disaster prevention. As a result, a simple index is used to describe the comprehensive city's ability for earthquake disaster mitigation.

For evaluation of the city's ability for seismic disaster mitigation, the designed framework includes the six major factors: they are the ability of earthquake monitoring and prediction, the ability of seismic hazard assessment, the ability of civil engineering for earthquake resistance, the ability of non-structural elements for earthquake resistance, the ability of communities for earthquake disaster prevention and the ability of seismic emergency responding and recovering after the earthquake. And for each major factor, it also includes several levels sub-components. For example, the ability of civil engineering covers the abilities of buildings, lifelines, infrastructures and so on.

Finally as examples, ten cities over the world have been evaluated for their abilities in seismic disaster mitigation. Some important and interesting issues are concluded.

INTRODUCTION

At the end of last century, the Committee of International Decade for Natural Disaster Reduction had called on evaluating the ability reducing earthquake disasters of cities. However, since efficient method to assess earthquake loss of cities does not exist, the proposition did not come true. In 1994, China government put forward that the cities with dense population or developed economy and the areas off the seashore should have the ability to resist earthquake (M=6). Undoubtedly the requirement to evaluate cities' ability reducing earthquake disaster was again proposed. It is really a challenge for researchers to

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evaluate the cities' seismic ability. But setting up the model evaluating cities' seismic ability not only can make it possible to evaluate disaster losses quantitatively but also can provide object criterion to evaluate cities' ability reducing earthquake disasters and give advices to decision on reducing earthquake disasters. Based on the current research achievements on reducing earthquake disasters and the methods in economical domain, the model to evaluate cities' ability reducing earthquake disasters is proposed. This paper carries out researches from the following several aspects: the conception of cities' ability reducing earthquake disasters; foundation of index system; defining seismic casualty, economic loss and recovery time according to index system; defining the comprehensive index of cities' ability reducing earthquake disasters.

THE CONCEPTION OF CITIES' ABILITY REDUCING EARTHQUAKE DISASTERS

The ability reducing earthquake disaster refers the ability that cities guarantee their safety under earthquake. According to the characteristics of disaster losses caused by earthquake, the following three basic elements are defined to evaluate the safety of cities under earthquake: the possible seismic casualty and economic loss during the future earthquakes that are likely to occur in the city and the time required for recovery after earthquake.

Generally earthquake is a kind of disaster which can cause huge damage, but it occurs infrequently, therefore it is incorrect to devote too much money in order to achieve strong cities' ability reducing earthquake disasters. There should be a balance between the two aspects. On the other hand, even though a city has strong seismic ability, it can't assure no seismic casualty, economic loss and recovery time under earthquake. Strong ability reducing earthquake disasters refers the three elements are controlled in a certain extent that is social acceptable level. Therefore cities' ability reducing earthquake disasters is relative to social acceptable level, in addition, it is also relative to the future earthquakes that are likely to occur in the cities.

THE CONTENT OF INDEX SYSTEM

Based upon these three basic elements, six factors affecting cities' ability reducing earthquake disasters are proposed--ability on seismic hazard analysis; ability on earthquake monitor and prediction; seismic ability on engineering factors; seismic ability on cities' politics, economy and population; seismic ability on non-engineering factors and ability on earthquake hazard mitigation and rescue. The sub-factors representing the six factors are also found out, and the frame (Figure 1) evaluating cities' ability reducing earthquake disaster is developed. Then some simple and measurable indicators are utilized to represent the factors and sub-factors, consequently the content of index system is set up.

During the process of setting up the index system, because the contribution that every index gives to cities' seismic ability is different, the methods on how to define indicators' contributions are also different. For example, utilizing the Analytic Hierarchy Process (AHP) [1], the contributions of the three basic elements versus city's ability reducing earthquake disasters and the six factors versus every element of three basic elements are defined [2]. And according to earthquake examples and experience, the standards evaluating every indicator are given. Based on the above analysis, the index system on cities' ability reducing earthquake disasters is established. The content of index system is not listed hereon.

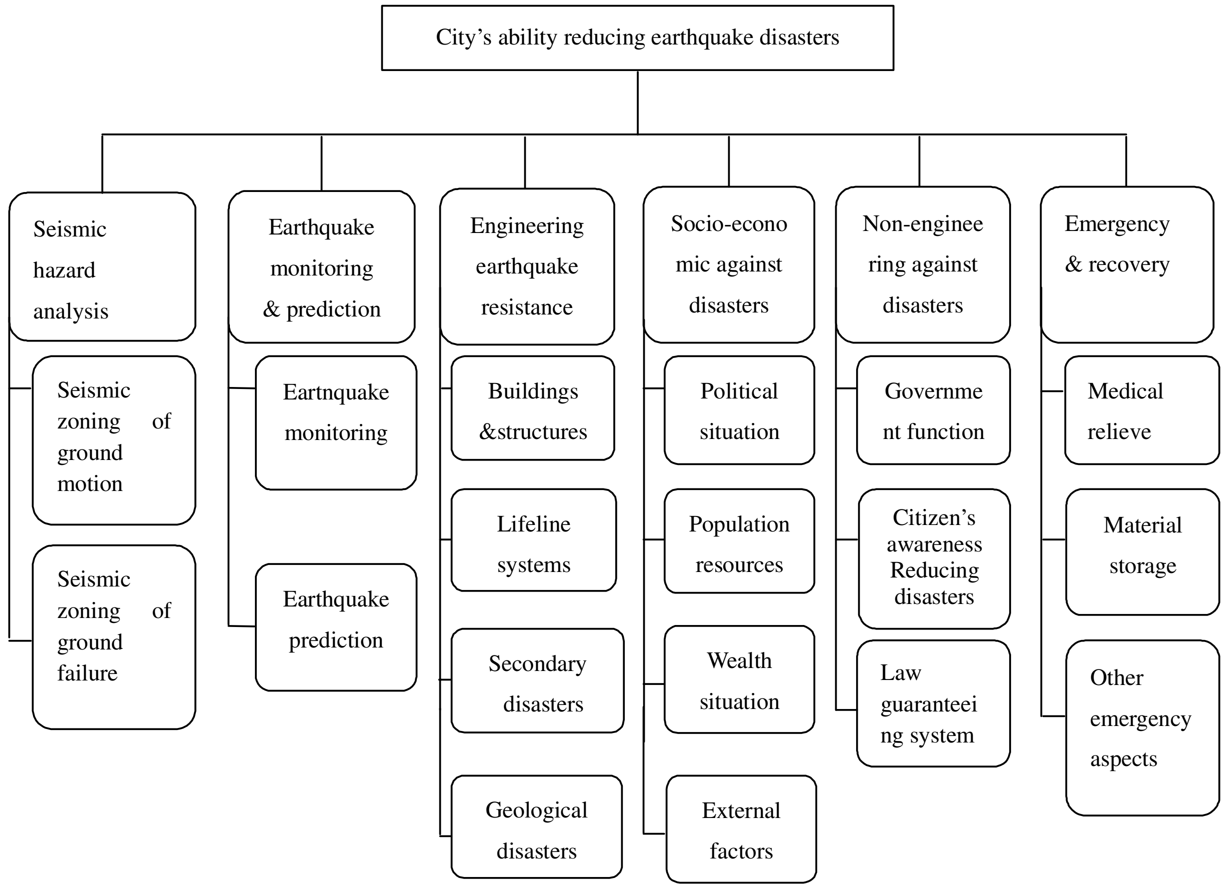

Figure1: The frame of index system on cities' ability reducing earthquake loss

DEFINING CASUALTY, ECONOMIC LOSS AND RECOVERY TIME BASED ON INDEX SYSTEM

The process of defining earthquake loss based on index system can be summarized as Figure2.

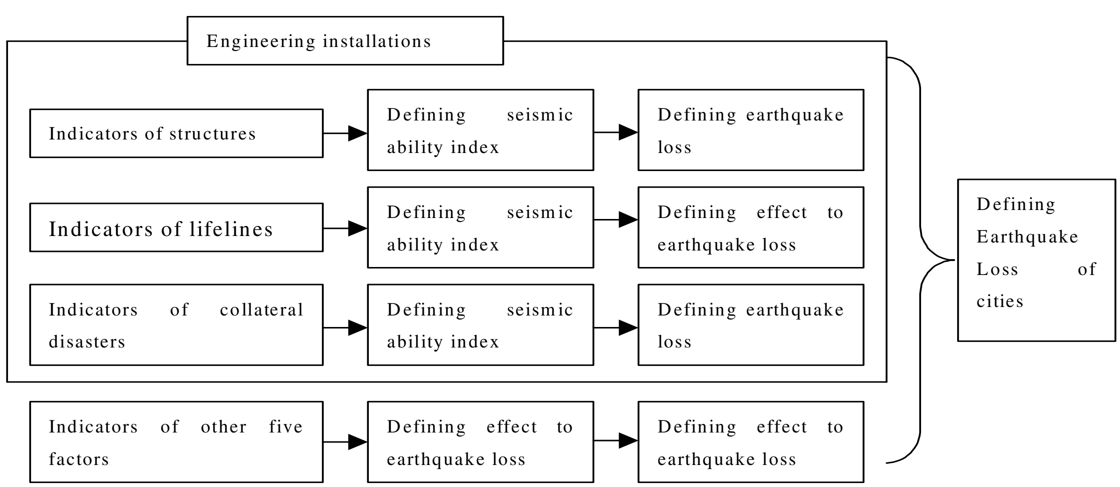

Figure 2: The frame defining earthquake loss

Defining seismic loss caused by engineering installations

1. Defining seismic loss caused by structures

1.1 Defining the seismic ability index of structures

The seismic ability of structures is mainly related to the three sub-factors--earthquake resistance condition, construction time and structure type. The method on how to synthesized the three sub-factors to a seismic ability index of structures will be discussed as follows:

Based on the vulnerability matrixes of earthquake resistance structures that Li-li Xie, etc [3] suggest in literature and the seismic ability indicator defined in this paper---when structures can keep good, slight damage, moderate damage, severe damage and collapse under earthquake, the seismic ability indexes of structures are defined as 1, 0.8, 0.6, 0.4 and 0.2, the seismic ability indexes of structures fortified various ranks under various earthquake intensities can be gained. The computation formula as follows:

$$IL1(J,I) = K * P(D_i / J, I) \quad (1)$$

In formula, $IL1(J,I)$ denotes the seismic ability indexes of structures fortified J(J=Ⅵ,Ⅶ,Ⅷ,Ⅸ)under various earthquake intensity I(I=Ⅵ,Ⅶ,Ⅷ,Ⅸ,Ⅹ); K denotes the matrix of seismic ability rank---{1,0.8,0.6,0.4,0.2}; $P(D_i / J, I)$ denotes the damage probability matrix of structures fortified J(J=Ⅵ,Ⅶ,Ⅷ,Ⅸ) under various earthquake intensity I(I=Ⅵ,Ⅶ,Ⅷ,Ⅸ,Ⅹ).The results are shown in Table 1.

Table 1: The seismic ability indexes of structures fortified various rank under various intensities

Fortified intensity	Earthquake intensity				
	Ⅵ	Ⅶ	Ⅷ	Ⅸ	Ⅹ
Ⅵ	0.884	0.724	0.534	0.424	0.392
Ⅶ	0.97	0.884	0.724	0.534	0.424
Ⅷ	1	0.97	0.884	0.724	0.534
Ⅸ	1	1	0.97	0.884	0.724

Then seismic ability indexes are modified by construction time and structure type.

The seismic ability indexes of structures which aren't fortified can be defined according to the seismic ability indexes of structures fortified Ⅵ. As shown as Table 2.

Table 2: The seismic ability indexes of structures which aren't fortified

Earthquake intensity	Ⅵ	Ⅶ	Ⅷ	Ⅸ	Ⅹ
Seismic ability index	0.85	0.7	0.5	0.4	0.35

And the seismic ability indexes of Table 2 are also modified by construction time and structure type.

Based on the analysis mentioned above, the formula defining the seismic ability index of structures can be gained as follows:

$$\begin{aligned} IL = {} & IL1 \times a\% \times (1 \times b1\% + 0.9 \times b2\% + 0.8 \times b3\%) \times (1 \times c1\% + 0.95 \times (1 - c1\%) \\ & + IL2 \times (1 - a\%)(0.8 \times d1\% + 0.75 \times d2\%) \times (1 \times f1\% + 0.95 \times (1 - f1\%)) \end{aligned} \quad (2)$$

In formula:

IL--- the seismic ability indexes of city's structures

IL1---- the seismic ability index of earthquake resistance structures

a%----the percent of fortified structures relative to all structures;

b1%----the percent of fortified structures constructed in the nineties;

b2%---- the percent of fortified structures constructed between in the seventy-five and in the eighty-nine;
b3%---- the percent of fortified structures constructed before in the seventy-five;
c1%-----the percent of steel and reinforcement structures relative to fortified structures;
IL2------ the seismic ability index of structures which aren't fortified;
d1%----- the percent of unfortified structures constructed between in the fifties and in the seventies;
d2%------ the percent of unfortified structures constructed before in the fifties;
f1%------- the percent of steel and reinforcement structures relative to unfortified structures.

1.2 Defining earthquake loss caused by structures

1) Defining casualty

The seismic ability indexes of structures and their corresponding casualty ratios which are made during the period of "95" are stated in this paper. Because casualty ratios span greatly in number and the results of casualty ratios of earthquake prediction are only exact in dimension but not absolutely precise, the negative logarithms of casualty ratios are looked upon as Y-coordinate and the seismic ability indices are looked upon as abscissa to stating their relationship. The results are shown in Figure 3.

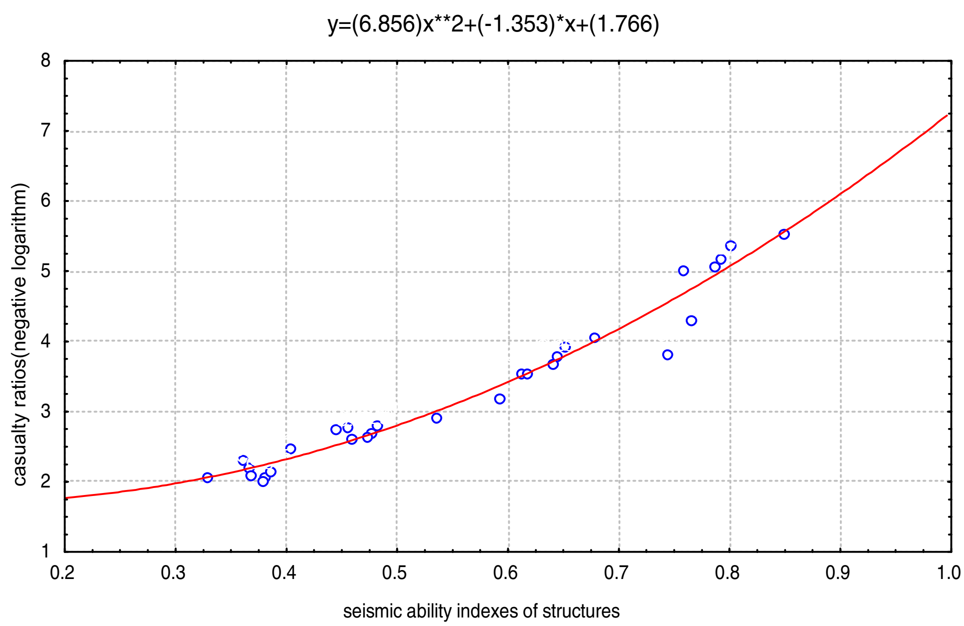

Figure 3: The relationship between the ratios of casualty and the seismic ability indexes of structures

The relationship is gained as formula 3.

$$Y = 6.856X^2 - 1.353X + 1.766 \quad (3)$$

In formula: X---the seismic ability indexes of structures; Y---the ratios of casualty.

2) Defining economical loss

The economical loss in earthquake can be classified two types: one is structural loss; the other is belongings loss.

(1) Defining structural loss

Similar to defining casualty, the seismic ability indexes of structures and their corresponding structural losses which are made during the period of "95" are stated in this paper. The logarithm of structural losses is looked upon as Y-coordinate and the seismic ability indexes are looked upon as abscissa to stating their relationship. The results are shown in Figure 4.

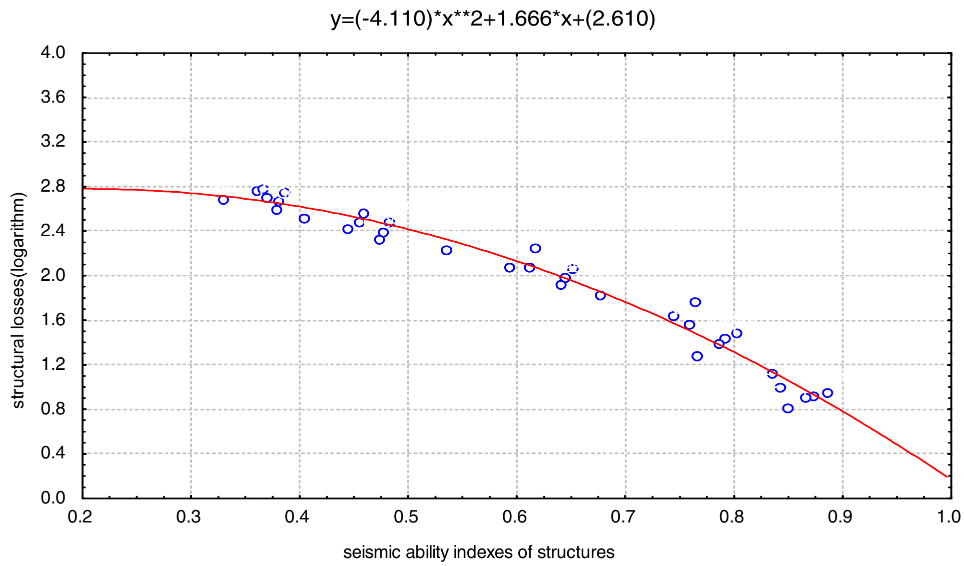

Figure 4: The relationship between structural losses and the seismic ability indices of structures

The relationship is gained as formula 4

$$Y = -4.110X^2 + 1.666X + 2.610 \tag{4}$$

In formula: X---the seismic ability indexes of structures; Y---the structural loss. (Ten thousand Yuan/ten thousand square meters)

(2) Defining belongings losses

Belongings loss is related to the seismic ability of structures and wealth accumulation condition. Similar to defining casualty, the seismic ability indexes of structures, their corresponding belongings losses and the average per "GDP" of the cities in recent ten years which are made during the period of "95" are stated in this paper. The seismic ability indexes and the logarithms of the average per "GDP" are looked upon as X, Y coordinates, and the logarithms of belongs losses are looked upon as Z-coordinate to stating their relationship. The results are shown in Figure 5.

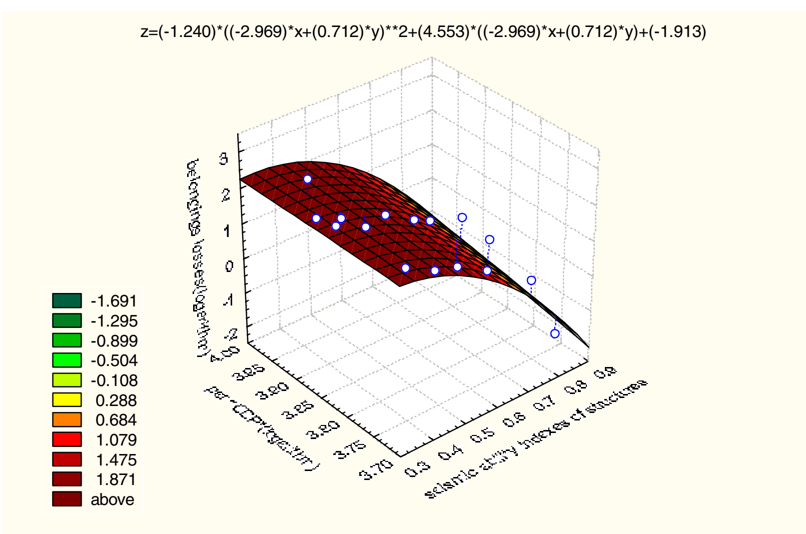

Figure 5: The relationship among belongs losses, the seismic ability indexes of structures and per "GDP"

The relationship is gained as formula 5.

$$Z = (-1.24)\times(-2.97X + 0.71Y)^2 + 4.55\times(-2.97X + 0.71Y) - 1.91 \qquad (5)$$

In formula: X---the seismic ability indexes of structures; Y--- average per "GDP" (Ten thousand Yuan) in recent ten years; Z---the belongings loss (Ten thousand Yuan/ten thousand square meters).

3) Defining the recovery time

According to average recovery time of 35 purpose structures under various damage condition based on ATC-13 [4] report and the classification standard of damage condition in china, the required recovery time of various damage conditions (china) are gained as Table 3.

Table 3:The average recovery time of structures under various damage conditions (day)(China)

Resuming function(%) / Damage condition	30%	60%	100%
Moderate damage	28	52	88
Severe damage	98	159	239
Collapse			437

The recovery time in this paper is referenced as resuming fundamental installations; resuming lifelines; cleaning out rubbish; providing people with semi-permanent houses; consequently the life of people can be normalized. Based on the earthquake experiences, when structures are in moderate damage and severe damage after earthquake, the function of houses can be utilized partly in the process of repairing, so the recovery time is assumed as 50% of time defined in ATC-13 report. In collapse damage, the houses must be rebuilt in order to resume function. But the replaces can accomplish the portion of function. The converted recovery time is considered as 2/3 of time defined in ATC-13 report. Thereby the recovery time of structures of various damage conditions defined in this paper can be gained as shown in Table 4.

Table 4: The recovery time defined in this paper

Damage rank	Slight damage	Moderate damage	Severe damage	Collapse
Recovery time	A week	Half and a month	Five month	Ten month

Based on Table 4 and the definitions of the seismic ability index and seismic ability rank in this paper, we can gain the recovery time corresponding to various seismic ability indexes of structures as shown in Table 5.

Table 5: The recovery time corresponding to seismic ability index of structures

Seismic ability index	0.8	0.6	0.4	0.2
Recovery time	A week	Half and a month	Five month	Ten month

So recovery time can be defined through seismic ability indices of structures of cities.

2. Defining earthquake loss effect caused by lifelines

The linear addition is adopted to define the seismic ability index evaluating the ability lifelines resist earthquake of intensity Ⅷ. The function that lifelines affect cities' ability reducing earthquake disaster is embodied that lifelines are a factor of the index subsystems of collateral disasters and mitigation and rescue. And the value is defined according to lifelines' seismic ability index rank-"strong, medium, poor" [6].

3. Defining earthquake loss effect caused by collateral disasters

The linear addition is adopted to define the seismic ability index evaluating the ability collateral disasters resist earthquake of intensity VIII. Based on literature [5] which stated 1100 earthquakes occurring in this century, from statistical results, the casualty caused by collateral disasters probably accounts for 15% of casualties caused by earthquake. Consequently, in this paper, the casualties caused by collateral disasters are considered 0%~30% of casualties under earthquake, the same to economical losses and recovery time. The seismic ability ranks of collateral disasters are classified three ranks---strong, medium and poor according to the seismic ability index. Relative to various intensities, the seismic ability of collateral disasters is also different which is embodied in the difference that collateral disasters affect the losses caused by structures as shown in Table 6.

Table 6: The modification coefficients of collateral disasters to the losses caused by structures

Earthquake intensity	Seismic ability rank		
	Strong	Moderate	Poor
VI	1	1	1
VII	1	1	1.05
VIII	1	1.05	1.1
IX	1.05	1.1	1.2
X	1.1	1.15	1.3

Defining the earthquake loss effect caused by other five factors

In this paper, the methods defining the losses----casualty, economical loss and recovery time caused by damaged engineering installations are gained by stating and analyzing previous earthquake disaster prediction data. The data mostly come from the cities' prediction results of earthquake disasters which are made during the period of "95". The methods applied in the cities' prediction are summarized according to previous earthquake disaster examples. Undoubtedly, they are produced in societal and economical conditions (namely other five factors). In the earthquake disaster areas, the societal and economical conditions of some areas can reduce the losses caused by engineering installations, but others are contrary. Generally, the societal and economical conditions that the method predicting losses caused by engineering installations depends on are average. That is, the methods in this paper predicting losses caused by engineering installations are proposed when other five factors are average.

Based on the analysis mentioned above, if the seismic ability of other five factors is higher than average, which can reduce the losses caused by engineering installations, otherwise increasing. The effect can be regarded as a modification coefficient to the losses caused by engineering installations. The formula computing a modification coefficient are shown as follows:

$$\lambda_{casualty} = 1 - \sum_{i=1}^{5}(a_i - \bar{a}_i)\varphi_i \quad (6)$$

$$\lambda_{economical\ loss} = 1 - \sum_{i=1}^{5}(a_i - \bar{a}_i)\eta_i \quad (7)$$

$$\lambda_{recovery\ time} = 1 - \sum_{i=1}^{5}(a - \bar{a}_i)\pi_i \quad (8)$$

in formula:

$\lambda_{casualty}$: the modification coefficient to casualty caused by engineering installations;

$\lambda_{economical\ loss}$: the modification coefficient to economical losses caused by engineering installations;

$\lambda_{recovery\ time}$: the modification coefficient to recovery time caused by engineering installations;

a_i : the seismic ability index of every factor in other five factors;

$\bar{a}_i$: the average seismic ability index of every factor in other five factors; (0.5 is assumed in this paper);

φ_i : the relative contributions of every factor in other five factors versus casualty [6];

η_i the relative contributions of every factor in other five factors versus economic loss [6];

π_i the relative contributions of every factor in other five factors versus recovery time [6]

Defining indirect economical loss

Based on the researches on how to define indirect economical loss, the indirect economical loss is referenced as "0.4---2" of direct economical loss. And indirect economical loss is the function of direct economical loss, social-economical makeup and time required to repair the damaged installations [7]. That is, indirect economical loss is related to seismic ability of structures and social economical makeup of cities.

Thus, direct economic loss and indirect economic loss constitute all economic loss of cities after earthquake.

Through above analysis, casualty, economic loss and recovery time of cities under various earthquake intensities can be gained through index system.

DEFINING THE COMPREHENSIVE INDEX OF CITIES' ABILITY REDUCING EARTHQUAKE DISASTERS

The evaluation of cities ability reducing earthquake disaster is the process of multiple objects: the ratio of casualty, the ratio of economical loss and recovery time constitute the evaluation criteria. In this paper, the method of grey correlation is applied to combine the three objects to a comprehensive index to evaluate the seismic ability of cities. The acceptable earthquake loss level is looked upon as comparative data series, which was compared with reference data series. The methods are discussed as follows.

Defining the acceptable earthquake loss levels

Based on past research achievements and some statistical data of other natural disasters [8], the acceptable earthquake loss levels are proposed. Considering two factors: 1) distinguishing economy development levels of various cities and areas; 2) distinguishing the effect of various earthquake intensities. The acceptable e earthquake loss levels are suggested as shown in Table 7.

Table 7: The suggested acceptable earthquake loss levels

General cities (economy of moderate development)					
Earthquake intensity	Ⅵ	Ⅶ	Ⅷ	Ⅸ	Ⅹ
The acceptable ratio of casualty	8×10^{-6}	2×10^{-5}	5×10^{-5}	2×10^{-4}	1×10^{-3}
The acceptable ratio of economical loss	2%	4%	5%	8%	10%
The acceptable recovery time	A week	Two week	A month	Half and a month	Two month
Important cities (developed economy)					
Earthquake intensity	Ⅵ	Ⅶ	Ⅷ	Ⅸ	Ⅹ
The acceptable ratio of casualty	8×10^{-7}	6×10^{-6}	1×10^{-5}	2×10^{-5}	4×10^{-4}
The acceptable ratio of economical loss	1%	2%	3%	4%	5%
The acceptable recovery time	A week	Two week	Three week	A month	Six week

In evaluating cities' ability reducing earthquake disasters, various evaluation criteria can be chosen from Table 7 according to actual condition. Of course, decision-maker can also set up other acceptable earthquake loss criterion.

Defining the comprehensive index of cities' ability reducing earthquake disasters [9]

1 Defining the conversion function of three evaluation criteria

In order to achieve uniform of these three evaluation criteria, conversion functions are set up.

Conversion function of the ratio of casualty

$$U(x)=\begin{cases}1 & x<8\times10^{-6}\\ \dfrac{\lg x}{\lg(8\times10^{-6})} & x\geq 8\times10^{-6}\end{cases} \tag{9}$$

Conversion function of the ratio of economy loss

$$U(x)=\begin{cases}1 & x<2\%\\ \dfrac{\lg x}{\lg(2\%)} & x\geq 2\%\end{cases} \tag{10}$$

Conversion function of the recovery time

$$U(x)=\begin{cases}1 & x<7\\ \dfrac{\lg 7}{\lg x} & x\geq 7\end{cases} \tag{11}$$

In formula: 8×10^{-6} representing the acceptable ratio of casualty;
2% representing the acceptable ratio of economy loss;
7 representing the acceptable recovery time.

2 The quantitative model of defining the comprehensive index of cities' ability reducing earthquake disasters

According to the method of grey correlation, the acceptable earthquake losses are defined as reference serials ---$U_0(u_{0j}),(u_{0j}=1, j=1,2,\cdots,m)$; which are converted "1", the actual earthquake losses of cities are comparative serials----$U_i(u_{ij}),(i=1,2,3,\cdots,n, j=1,2,\cdots,m)$, which are converted corresponding number through conversion functions.

Imitating the method of computing grey correlation coefficient, the correlation coefficients of indexes of reference serials and comparative serials can be defined as the following formula:

$$\zeta_{0i}(j)=\frac{1}{1+\Delta_{oj}(j)} \tag{12}$$

In formula: $\Delta_{0j}(j)=\left|U_0(u_{0j})-U_i(u_{ij})\right|,(i=1,2,\cdots,n, j=1,2,\cdots,m)$ representing the absolute difference of reference serial U_i and comparative serial U_0 of No. j evaluation criterion. Because the range of $\Delta_{0j}(j)$ is $[0,1]$, the range of correlation coefficient ---$\xi_{0i}(j)$ is $[0.5,1]$.

The correlation coefficient of every evaluation criteria can be gained from formula (12). Then these correlation coefficients are synthesized to a value (correlation degree) making use of linear addition. As shown in formula 13:

$$r_{0i}=\sum_{j=1}^{m}a_i\zeta_{0i}(j) \tag{13}$$

In formula: a_i ---the contributions of various evaluation criteria;

r_{0i} represents the addition of correlation coefficients of three evaluation criteria and reflects the correlation degree of reference serial and comparative serial. Apparently the range of r_{0i} is from 0.5 to 1.0. The bigger the correlation degrees are, the stronger the cities' ability reducing earthquake disasters are. Because the correlation degree can reflect cities' ability reducing earthquake disasters, it is looked upon as the comprehensive index evaluating cities' ability reducing earthquake disaster. In addition, the correlation degree defined making use of the method of grey correlation can quantitatively reflect difference with the acceptable level of actual cities. The seismic ability rank- "strong, moderate and poor" of cities are classified according to the correlation degree and the suggested criterion classifying cities' seismic ability rank is proposed in Table 8.

Table 8: The suggested criteria to classify cities' ability reducing earthquake disasters

The seismic ability rank	Strong	Moderate	Poor
VI ~ X	0.94~1	0.82~0.94	<0.82

EXAMPLES

Now the evaluation model is applied to the following ten cities in the world to evaluate their ability reducing earthquake losses. The basic data about the cities are shown in Table 9.

Table 9: The basic data of ten cities

city	Shortened form	country	state	population (ten thousand)	Per "GDP" ($)	Areas	Basic intensity or fortified intensity
Tashkent	TSGN	Uzbekistan	Asia	208	6100	326	VII–VIII
Addis Ababa	ASNY	Ethiopia	Africa	263	530	540	VII–VIII
Guayaquil.	GYJR	Ecuador	South America	210	5000	340	VIII
Bandung	WLON	Indonesia	Asia	240	1000	19	VIII
Skopie	SKPL	TFYR Macedonia	Europe	44.5	2200	338	VII
Tijuana	THAN	Mexico	North America	115	21000	230	VII
Antofagasta	ATFJ	Chile	South America	228	49000	90	VIII
Izmir	YZMR	Turkey	Europe	217	7000	650	VI-VIII
Xiamen	XMEN	China	Asia	152	2500	450	VII
Quanzhou(part)	QNZH	China	Asia	25	2150	52	VII

The analysis results of ten cities are listed as follows.

Defining seismic ability indexes of engineering installations

Seismic ability indexes of structures in these ten cities

The results of seismic ability indexes of structures in these ten cities are shown in Figure 6.

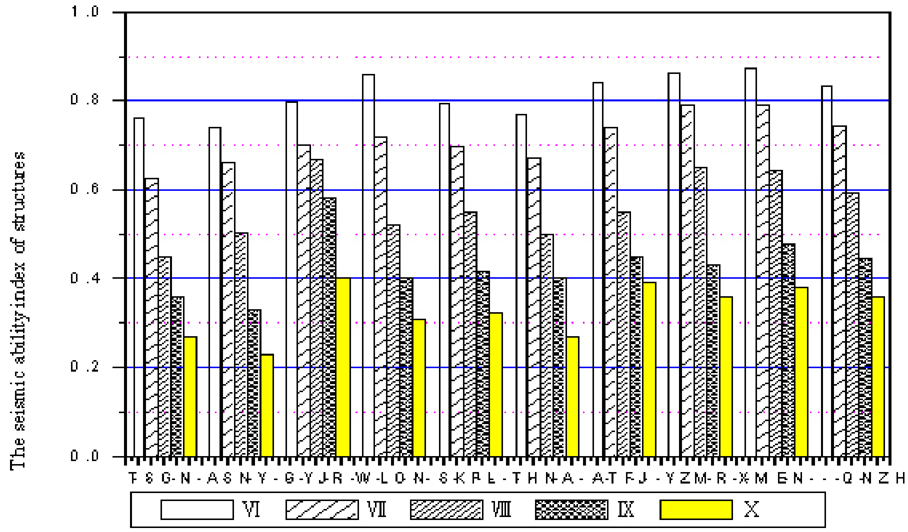

Figure 6: The seismic ability indexes of structures resisting Ⅵ- Ⅹ intensity earthquake

The seismic abilities of lifeline system and collateral disasters are shown in Table 10 and Table 11 respectively.

Table 10: The seismic ability of lifelines in the ten cities

City	TSGN	ASNY	GYJR	WLON	SKPL	THAN	ATFJ	YZMR	XMEN	QNZH
Seismic rank	Moderate	Moderate	Poor	Moderate	Strong	Moderate	Strong	Strong	Moderate	Moderate

Table11: The seismic ability of collateral disasters in the ten cities

City	TSGN	ASNY	GYJR	WLON	SKPL	THAN	ATFJ	YZMR	XMEN	QNZH
Seismic rank	Moderate	Moderate	Poor	Poor	Moderate	Poor	Moderate	Moderate	Moderate	Moderate

The seismic ability evaluation results of other five factors

The modification coefficients of other five factors to casualty, economic loss and recovery time caused by engineering installations are shown in Figure 7.

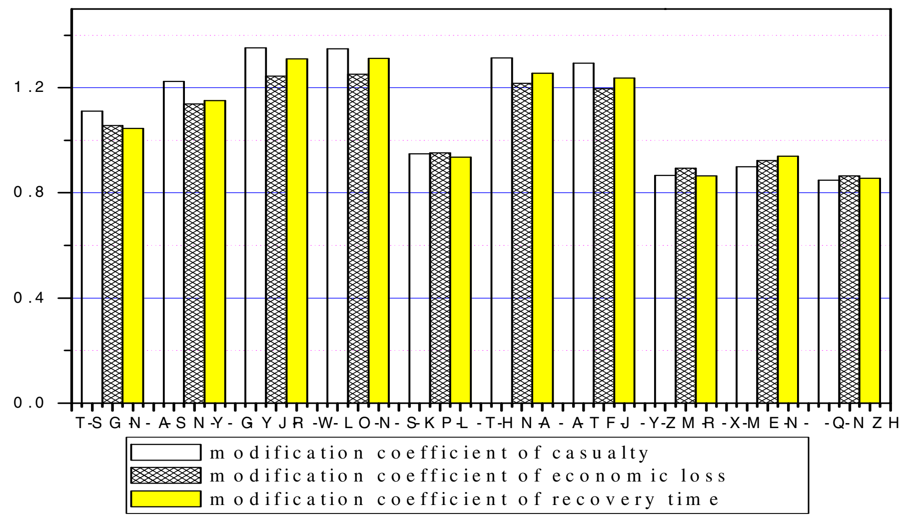

Figure 7: The modification coefficient of other five factors to casualty, economic loss and recovery time

Defining the comprehensive indexes of cities' ability reducing earthquake disasters

We have gained the ratios of casualty, economic loss and recovery time based on method mentioned above, then the comprehensive indexes evaluating cities' ability reducing earthquake disasters are computed. (The acceptable social level is the criterion, which is defined relative to common cities and developed areas (Table 7)). The results are shown in Figure 8.

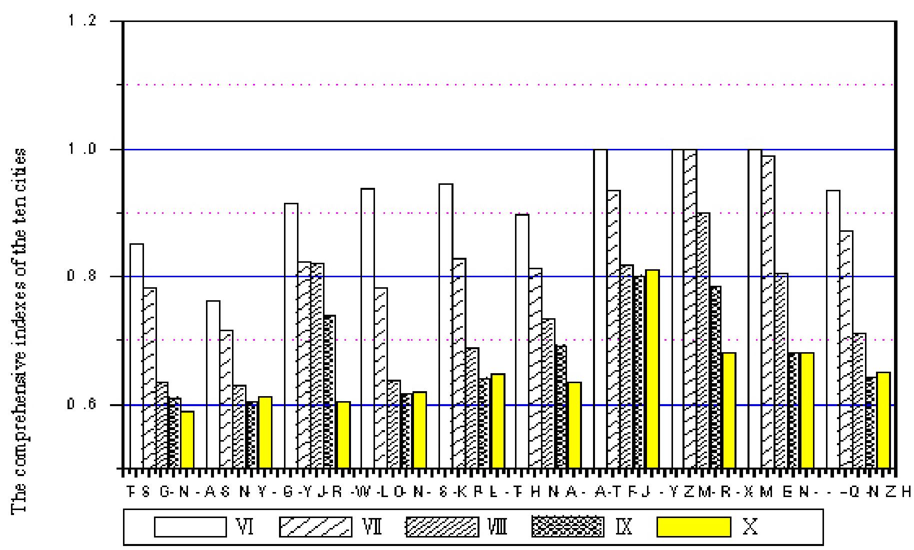

Figure 8: The comprehensive indexes evaluating cities' seismic ability of the ten cities

The seismic ability ranks of the ten cities are classified according to Figure 8, and the results are shown in Table 12.

Table 12: The seismic ability rank of the ten cities

City	Earthquake intensity				
	VI	VII	VIII	IX	X
TSGN	Moderate	Poor	Poor	Poor	Poor
ASNY	Poor	Poor	Poor	Poor	Poor
GYJR	Moderate	Moderate	Moderate	Poor	Poor
WLON	Moderate	Poor	Poor	Poor	Poor
SKPL	Strong	Moderate	Poor	Poor	Poor
THAN	Moderate	Poor	Poor	Poor	Poor
ATFJ	Strong	Moderate	Poor	Poor	Poor
YZMR	Strong	Strong	Moderate	Poor	Poor
XMEN	Strong	Strong	Poor	Poor	Poor
QNZH	Moderate	Moderate	Poor	Poor	Poor

CONCLUSIONS AND DISCUSSIONS

(1) It can be concluded from above discussion that the model evaluating cities' ability reducing earthquake disasters can evaluate cities' seismic ability absolutely, consequently can know cities' ability resisting various intensity earthquake, and also can evaluate cities' seismic ability quantitatively. On the other hand it is relative to various earthquake intensities and various social acceptable levels. Comparing to the current methods evaluating cities' earthquake losses, this method is of many merits, such as considering factors completely, gathering basic data simply and computing easily so on. In addition, it is more significant that the comprehensive index can denote the difference of current cities' ability reducing earthquake disasters and acceptable cities' seismic ability quantitatively, consequently provide the work reducing earthquake losses with beneficial advice.
(2) On the precision of model, we also should realize that the model is set up based on the development of current earthquake engineering, for example, some data and formulas are derived from earthquake losses prediction results of "95", therefore the precision and reliability of the model is consistent with development of current earthquake engineering. At the same time, the evaluation model is open, because with the development of earthquake engineering and accumulation of experience resisting earthquake disasters, the data and formulas of the model can be more precise, consequently the reliability of model can be enhanced.
(3) The frame system of model evaluating cities' ability reducing earthquake loss is discussed in this paper, but because of the limited length, some data aren't enumerated. When doing the work, you can refer to the dissertation---< The Study on Evaluation of Cities' Ability Reducing Earthquake Disasters> if meeting with problems.

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