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INTRODUCTION OF URBAN EARTHQUAKE RESISTANCE AND DAMAGE PREVENTION PROJECT OF YANTAI CITY IN CHINA

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SUMMARY

Urban earthquake resistance and damage prevention project of Yantai city is compiled on the basis of earthquake risk analysis, the study of microzonation, and damage prediction of structures. On the basis of this result assessments of economic loss, number of injured persons, size of secondary hazards, and number of evacuation persons are made. On the basis of this result, the urban earthquake resistance and damage prevention project has been compiled. It mainly includes strengthening of aseismic capabilities of fundamental facilities of city, raise of level of acceptable capability of city to resist earthquake damage, and post-earthquake restoration and rebuilding planning.

INTRODUCTION

Yantai city is a small city at the north margin of Shandong paninsula. According to "the Map of Distribution of Earthquake Intencities in China", this city will meet with earthquake of intencity 7, so that earthquake resistance and damage prevention project is compiled to mitigate the earthquake hazards. Short term planning is in five years to fully complete the strengthening of buildings, to fundamentally eliminate the sources of secondary damages which are harmful, and to promote the transformation of old city; while long term planning is to realize reasonable overall arrangement of city and land use, to finish the transformation of old city, to eliminate the hidden danger of secondary earthquake damages, and to fundamentally renew the old life line engineering.

EARTHQUAKE RISK ANALYSIS

Authors proceed to earthquake risk analysis by Anderson's method, considering that the earthquake happens according to the Poison's distribution (Ref. 1). Trifunac's attenuation rule of acceleration response spectrum is used. Response spectrum of basic rock can be obtained by this relation, and them the artificial earthquake wave relating to the spectrum also can be calculated.

THE EARTHQUAKE MICROZONATION

The prospect holes distribute at each square kilometer area in Yantai, and tests of soil dynamic characteristics are carried out. Iwan's parallel model is used as nonlinear stress strain relation. Earthquake response analysis of soil

layers is direct dynamical method with one dimension multilumped mass system. For saturated sand, it is considered that change of void water pressure influences the stiffness of soil layers. Then the earthquake response of ground in each region and the distribution map of peak accelerations are got.

DAMAGE PREDICTION OF STRUCTURES

Many authors predict the earthquake damages of structures with various methods.

1. The damage of multistory masonry buildings are predicted by multivariate statistical method (Ref. 5), and the criterion function is obtained:

$$y_g(x) = C_{og} + C_{1g}x_1 + \ldots + C_{mg}x_m \tag{1}$$

where C_{ig} — criterion coefficients. Authors choose seven factors influencing the damages, such as: pattern of roof structure, total height of building, pattern of floor system, construction quality, motar mark of load bearing walls, area ratio of walls in a building, and kind of soil at site. The criterion coefficients are determined by information of multistory masonry buildings during Tangshan earthquake. The sort corresponding to maximum $y_g(x)$ is the predicted sort.

2. Industrial buildings are predicted by successive regression analysis (Ref. 2). The following regression equations are obtained:

for reinforced concrete column industrial building

$$N = 0.2674H^{1.4319}\beta_a^{0.1446}(L/90)^{0.0194}d^{-1.4497} + 10 \tag{2}$$

for masonry industrial building

$$N = 4777H^{1.5309}(L/90)^{0.5347}d^{-1.2825}(7R)^{-1.6412} + 10 \tag{3}$$

where N — index of damage degree;
d — depth of cross section of column;
H, L — height and length of building, respectively;
β_a — ratio of heights of cross sections of upper and lower part of column.

Comparing with information of historical earthquake damages, one can judge the degree of damage from N.

3. Damage of old residential buildings are predicted by fuzzy comprehensive evaluation of fuzzy mathematics (Ref. 3). From statistical data of damages of old residential buildings in Tianjin during Tangshan earthquake, the main factors influencing damages are determined, such as length, age and quality, and number of story of the building. Giving membership functions, one can calculate predicted value by following fuzzy equation:

$$\underset{\sim}{B} = \underset{\sim}{A} \times \underset{\sim}{R} \tag{4}$$

where $\underset{\sim}{B}$ — fuzzy set of predicted value of damage;
$\underset{\sim}{A}$ — weighting factor;
$\underset{\sim}{R}$ — matrix of fuzzy relation.

4. Analysis of damage potential. Authors use the method of fuzzy approximate judgement with following calculating model (Ref. 4):

$$\text{If}((x \text{ is } \underset{\sim}{G}^{VI}),\ (y \text{ is } \underset{\sim}{S}^{1})),\ \text{then } (z \text{ is } \underset{\sim}{D}^{VI,1})$$

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$$\text{also If } ((x \text{ is } \underset{\sim}{G}^{X}),\ (y \text{ is } \underset{\sim}{S}^{3})),\ \text{then } (z \text{ is } \underset{\sim}{D}^{X,\,3})$$

where x,y — parameter of ground motion or it of condition of soil at site, respectively;
$\underset{\sim}{G}$ — fuzzy subset of variables based on the kind of soil;
$\underset{\sim}{D}$ — fuzzy subset of variables based on damage index.
The former part can be comprehensed by

$$\mu_{\underset{\sim}{M}}(u,v) = \wedge\ (\mu_G(u),\ \mu_s(v)) \tag{5}$$

where u,v — peak ground acceleration or kind of soil, respectively.
and the relation is

$$\mu_{\underset{\sim}{R}}(u,v,ind) = ((1-\mu_{\underset{\sim}{M}}(u,v) + \mu_{\underset{\sim}{D}}(ind) \wedge 1) \tag{6}$$

where ind — damage index.

For prediction we have former part M', and then we can obtain conclusion of earthquake damage by equation:

$$\underset{\sim}{C}' \triangleq \underset{\sim}{M}' \cdot R \tag{7}$$

URBAN EARTHQUAKE RESISTANCE AND DAMAGE PREVENTION PROJECT

On the basis of earthquake risk analysis, the study of earthquake microzonation, and damage prediction of structures, considering the analysis of aseismic capabilities of important engineerings, such as the buildings of sources of secondary damages, life line engineerings, elementary industry, leader's offices, and conculting losses during historical earthquakes, we calculate the possible earthquake losses of Yantai city. Urban earthquake resistance and damage prevention project consisting of three parts is compiled with these informations.

Middle or Long Term Planning to Strengthen the Aseismic Capability of Fundamental Facilities of City

1. Land use

In project it is indicated that earthquake microzonation, distribution of peak ground accelerations, predominant period of site soil, fail and liquefaction of foundation, former stream channels, and bad site soil, must be considered in land use.

2. Aseismic requirements in general project of city and transformation of old city

Considering influence factors of earthquake and comparing the possible hazard losses, economic efficiency, and possibility of various projects, etc., one can find the optimum decision.

3. Earthquake resistance of life line engineerings in city

After one-by-one evaluation and analysis of real life line engineerings in Yantai city, transformation, strengthening, temporary remedy measures, and realizing planning are pointed out.

4. To prevent and to reduce secondary damages

The sources of secondary damages in city, and type, size, and degree of damages are analyzed, and possible countermeasures, such as overall arrangement project, choose of locations of factories, aseismic design of new buildings, aseismic strengthening, rebuilding or isolation, eractment of emergency measures etc. are employed.

5. Earthquake resistance engineering

Aseismic strengthening of old buildings and aseismic design of new buildings play the important role in safety of people life and asset, in reduction of discontinuity of industrial production, in avoidance of secondary damages, and in employment of emergency measures.

To Raise the Level of Acceptable Capability of City to Resist Earthquake Damages in City To raise the aseismic capability of city, following measures are employed:

1. To establish the leading system of earthquake resistance and damage prevention

Headquarter of earthquake resistance and damage prevention in Yanti city, consisting of office, engineering department, propagation department, and service department, is established. There are five systems led by this headquarter, which are the systems of hazard mitigation and exclusion, medical treatment and anti-epedemic, public security and fire fighting, transportation and communication, and water and power supply. These five systems are led by the departments of government.

2. Pre-earthquake emergency preparation and post-earthquake exclution of damages and rescue

The planning of rescue and emergency measures are compiled according to three states, emergency preparation stage, the stage of exclusion of dangers and rescue, and restoration and transition stage.

The emergency preparation stage begins from short-term or confronted prediction of earthquake. In this stage we prepare for earthquake, checking up the workers on duty and taking action of emergency measures. The stage of exclusion of dangers and rescue is about seven days after earthquake. In this stage all officers and workers are at their posts and they arrange the works of rescue, exclusion of dangers, restraint of secondary damages and epedemic, investigation of damages, saving etc. The restoration and transition stage is from seven days to three monthes after earthquake. In this stage normal life and production are strived to restore, overall restoration and rebuilding are prepared, the project of restoration and rebuilding is compiled, and production restores.

3. Evacuation

According to rescue area, people are dispersed to indicated evacuation places from regulative lines. The project requires establishment of throughfares and evacuation places.

4. Propagation and education of knowledge about earthquake

It is necessary to raise the people's quality of self and mutual saving, to train professional workers of damage prevention, to develop education of knowledge about earthquake damages prevention in whole people, and to exercise at proper time.

Post-earthquake Restoration Rebuilding Planning After earthquake restoration and rebuilding planning should be compiled. This planning, which must be combined

with general project of city and developing planning of department, is a long term project.

The urban earthquake resistance and damage prevention projects in several decades cities in China are compiling in order to reduce the earthquake damage in cities.

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