THE ALGORITHM OF THE INTRODUCTION OF THE SEISMIC RISK ASSESSMENT PROCEDURE INTO THE INFORMATION SYSTEMS OF CITY PLANNING

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ABSTRACT

The methods of the possible social and economic losses assessment of possible earthquakes of different intensity are examined and the procedure of the assessment of seismic risk is developed. On their basis, the algorithm of the introduction of the seismic risk assessment procedure into the information systems of the city planning is proposed.

Keywords: assessment, seismicity, information of system, database, algorithm

1. INTRODUCTION

At present the considerable development obtain different information systems. Special position in this row occupy the geo-information systems, developed for the collection, storage, analysis and the graphic visualization of three-dimensional data and of the connected with them information about the represented in GIS objects [geographical...]. According to city planning code of RF the information systems of the city planning (ISOCP) are the systematized set of the documented information about the development of territories, about their building, about the land sections, about the objects of capital construction and other necessary for the realization of city planning information [city planning code, 2005]. In this definition the information system can be both the manual and automated.

In the wide understanding ISOCP - meta-system (system of systems) [Mamysheva E.G., Zagoruyko A.U., 2010], which ensures the information support of the set of the diverse processes of subsistence and development of city. Such integrated system includes several classes of software:

- GIS (geographical information system),
- SED (system of electronic document turnover),
- DBMS (Data Base Management System),
- EAR (control system of electronic administrative regulations),
- CSCI (classification system and coding information), web-portal,
- and also organize access to SIEI (system of interdepartmental electronic interaction).

The purpose of conducting the information systems of the city planning is the provision of government, local authority, physical and legal persons the reliable information, necessary for the realization of city planning, investment and other economic activity, conducting land exploitation.

The information about the seismic danger and the seismic risk of the territories, which are basic in the building in the seismically dangerous regions, in our opinion, occupies special position.

2. REALIZATION

For predicting the possible consequences of the earthquakes or other catastrophes the careful study of the urbanized territories is required. In the end of 20 centuries in the CIS were developed the methods of evaluating the seismic risk of the already existing buildings and construction [Zaalishvili and others, 1999; Zaalishvili, 2000a; Zaalishvili et al, 1999]. These programs considered the numerous objective and subjective factors, which influence the level of the seismic risk of the urbanized territories.
One of the procedures was developed by Prof. S.Yu. Balasanyan in 1991 [Balasanyan and others, 2004]. After eight years of successful works, strategy was approved in 1999 by the government of Armenia as state program. According to this procedure, the greatest contribution to the scale of possible losses, in the case of strong earthquake, introduce following components:

- Seismic danger of territory;
- Population and its density in the zones of high seismic danger;
- The region of the zones, which contain buildings and construction, which have low seismic stability in comparison with the level of seismic danger.

The determination of the risk of seismic losses (RSL) was calculated as

\[ RSL = KR \times KS \times KP \]  

(1)

where KR - rating of risk, which considers the intensity of seismic action.
KS - rating of the vulnerability of the buildings, located in the limits of the site.
KP - coefficient of the vulnerability of people, inside or near the objects being investigated.

The development of the rating assessment of soil conditions and seismic risk of territory is another procedure of forecast. The creation of the united rating estimation of geological engineering, hydrogeological, geomorphological and other special features of soil conditions was for the first time carried out for the capital of North Ossetia. The selected subject of a study was sufficiently large region of Vladikavkaz - Kuybyshev st. and the adjacent to it blocks (Fig. 1).

*Figure 1. Investigated regions and soil conditions in the region of Kuybyshev str.*
Taking into account soil conditions, and relying on the method of the expert estimations [Zaalishvili and others, 2001; Gogmachadze and other, 2003; Zaalishvili, 2003], was determined the rating of the seismic vulnerability of all six blocks. According to the developed approach [Zaalishvili, 2003; Zaalishvili and other, 2006] the totality of soil conditions are divided into several levels of seismic vulnerability. For the present instance were used three such levels. To each level correspond the values of the dangerous factors, which form the seismic vulnerability (table. 1). At the basis of this classification the experience of past earthquakes lies. The so-called expert estimation was used. Further to each value of factor was appropriated its weight rating, also established from the past experience. Each factor was evaluated according to the three-point scale, where 1- corresponds to the smallest influence of this factor on worsening in rating status of section, and 3- greatest (table. 2). In Fig. 1 one can see worsening in the soil conditions upon transfer from the sixth quarter to the first. The worse soils are the soils of the bases of the first and second quarters. The following relationship was used for calculating the rating of vulnerability:

$$W_S = W \times D$$

(2)

The used seismic danger of the territory is the danger, evaluated by level SMZ (seismic microzonation), which forms the calculated intensity or manifestation of the earthquake [Zaalishvili, 2000b]. In other words, the worse the soil conditions of the bases of building, the higher the seismic risk. Thus, completely distinctly is outlined the connection between the soil conditions and the manifestation of seismic danger. Also we determined the rating of the seismic risk of all 6 sections, relying on the method [Of balasanyan and others, 2004]. The rating of seismic risk comprised under the seismic influence of 7 by MSK-64 is: Spring $RSL=0.875$ Balkinskiy the passage- street of pioneers $RSL=0.35$ Street Pioneer- street Lermontovskaya $RSL=1.038$ Street the Lermontovskaya- street of Frunze $RSL=0.43$ Street the Frunze- street of Lenin $RSL=0.92$ Street Lenin- river Terek $RSL=0.95$

Analyzing the obtained values, it is possible to conclude that the use of a procedure [Balasanyan and others, 2004g.] for the territory being investigated sometimes gives not entirely accurate results. Since in this approach soil conditions were not considered completely, then it would be logically to assume that in the section Spring, in which were represented exclusively the buildings of the type D least vulnerable (most earthquake-proof), completely forming building, expected risks will be minimum, which is not confirmed by calculations. In this case adjacent section - Balkinskiy passage-Pioneer street has much smaller value of risk among other worse indices. This unexpected fact is, obviously, connected, first of all, with the fact that the buildings, represented in the section Spring, are encountered nowhere more, what is one of the special cases, in which formula (1) gives incorrect results.
Table 1
Rating indices of the special features of soils in the territory of Vladikavkaz

<table>
<thead>
<tr>
<th>No.</th>
<th>the designation of factors</th>
<th>measurement</th>
<th>measurement seismic vulnerability, D</th>
<th>weight rating, W</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>seismicity of territory</td>
<td>MSK-64,</td>
<td>7 8 9</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>the spatial distribution (density) of break</td>
<td>km/km</td>
<td>&lt; 0.01 0.01 – 0.05 &gt; 0.05</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>active geological processes</td>
<td>-</td>
<td>no average level intense occurrence</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Density of soils ρ, т/m³</td>
<td>1.9-2.1 1.7-1.9 1.4-1.7</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>velocity of propagation of transverse waves in the soils Vs, m/s</td>
<td>&gt;800 400-800 80-400</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>level of ground water hlgw, m</td>
<td>&gt; 10 5-10 &lt; 5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>angle of the slope (relief) degree</td>
<td>&lt; 50 5 – 150 &gt; 150</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Rating estimation of soils in the territory of Vladikavkaz

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Weight rating, W</th>
<th>Seismic vulnerability, D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 block</td>
<td>2 block</td>
</tr>
<tr>
<td>1</td>
<td>3.0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3.0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1.5</td>
<td>3</td>
</tr>
</tbody>
</table>
At the same time use in the calculations of that developed under the management by Prof. V.B.Zaalishvili the rating method [Zaalishvili and others, 2001], as already mentioned above, gives for the conditions in question the reliable and logically valid results.

Thus, on the basis of the expert estimations method, we developed the more advanced procedure of the seismic risk of territory assessment.

Further, the adequate calculation of possible economic and social damage in the information systems of the city planning is completely necessary.

In this case complete economic damage $L$ is calculated as the sum of the separate forms of damage for all zones of different intensity

$$L_i = \sum_{j=1}^{i} S_{ij} \times V_{ij} \times C_{ij}$$

(3)

where:
- $S_{ij}$ - density of a building of the type $j$ in the zone with a intensity of $i$;
- $V_{ij}$ - average vulnerability of separate object;
- $C_{ij}$ - the mean cost of separate object.

For establishing the complete economic damage, we must additionally consider losses as a result of the damage and (or) the destruction of urban infrastructure, and also possible social loss. According to the expert estimation additional damage with the earthquake of 7 MSK will increase by $20\%$, and for eight MSK by $40\%$. 
Social losses during the earthquakes, in essence, are determined by the level of the damage of buildings and construction. At the same time so-called the second consequences in the form of landslides, dilution, soils, flood can become determining and anomalously high, with the specific confluence of negative factors. In recent years, they repeatedly took place of different kind of the emergencies, which can considerably change situation in one or the other urbanized territory. For example, all over the Caucasus are dangerous objects, which can be transformed into the sources of very significant technogenic dangers, with the neglect of the standards of operation.

For calculating the social losses are used known data of the statistical relationships between the number of injured and killed for the contemporary buildings [Poltavtsev and others, 1996; Poltavtsev and other, 1998].

*Figure 2. The algorithm of the introduction of the procedure of the seismic risk assessment into the information systems of the city planning*
For the realization of this procedure, we created information system of city planning of republic North Ossetia - Alania [Zaalishvili and others, 2012], we developed algorithm introduction procedure of seismic risk assessment into any ISOCP (Fig. 2). This algorithm makes it possible to integrate procedures into any ISOCP examined above, which realizes the possibility of calculating the rating of soils and seismic risk for any territory being investigated, making it possible to separate most seismically vulnerable sites.

3. CONCLUSIONS

1. Geo-information systems (GIS) together with the systems of electronic document turnover (SED) are at present necessary component of state administration.
2. The adoption of town-building code led to the creation of many information systems of the city planning (ISOCP). In this case the state cannot separate or introduce its own system ISOCP. At the same time, state can, and must regulate the protocols of the exchange of the data between the systems taking into account the requirements of safety, develop the structures metadata.
3. The use of the procedure of the seismic risk of territory assessment developed by us makes it possible to calculate the rating of soils and the seismic risk of territory.
4. For the realization of this procedure, in the created by us information system of city planning of republic North Ossetia-Alania, we developed the algorithm of the introduction of the procedure of the seismic risk assessment into any ISOCP.
5. This algorithm realizes the possibility of calculating the rating of soils and seismic risk, and also possible social and economic losses for any territory being investigated, making it possible to separate the most vulnerable sites.

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