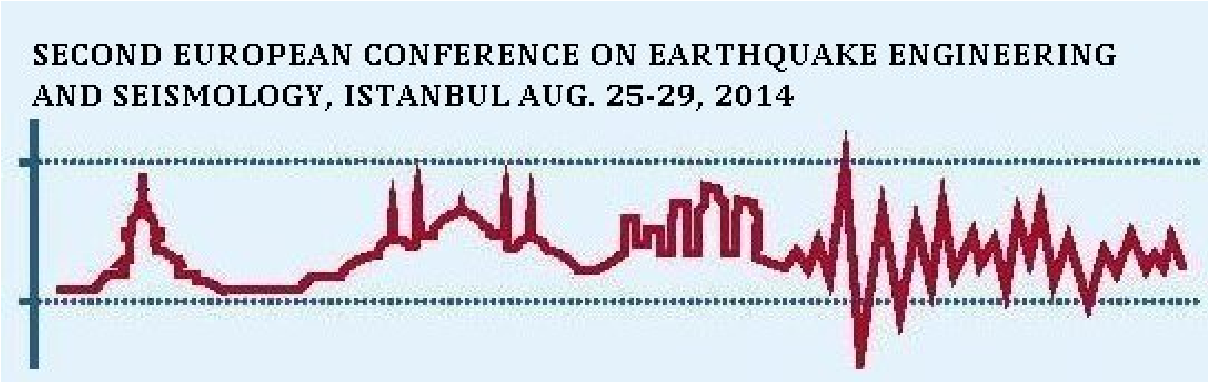

A NEW APPROACH TO BUILDINGS SEISMIC RESISTANCE ASSESSMENT IN UKRAINE

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ABSTRACT

The work is devoted to substantiation and creation of basic preconditions for development of seismic resistance assessment system of existing buildings in Ukraine.

The first part of the paper presents the situation with seismic hazard in Ukraine, the increase of which is caused by introduction of new building codes. The analysis of territory where it is necessary to perform the assessment of buildings seismic resistance described.

The second part of the paper is devoted to general provisions of the Ukrainian seismic assessment system developing, and to analysis of the existing foreign systems .

In the third part the sequence of seismic resistance assessment implementation described.

INTRODUCTION

For today minimum 26,85% of the Ukraine's territory is a seismic hazard area[5] (Ju.Nemchynov et al. 2012). Significant increase of seismic hazard due to the introduction of a new building code DBN B.1.1-12: 2006 "Construction in seismic regions of Ukraine", that has not been taken into consideration in previous codes, led to the fact that the great area of the state has become seismically unsafe.

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[5] Territory analysis takes into account Crimea peninsula

1. ANALYSIS OF TERRITORY WHERE IT IS NECESSARY TO PERFORM THE ASSESSMENT OF BUILDINGS SEISMIC RESISTANCE

As a result of the analysis of the seismic zoning maps for the territory of Ukraine, which was performed under the two building codes, SNIP II-7-81 and DBN B.1.1-12: 2006, we can note a significant change in the distribution of seismic zones with intensity VII, VIII and IX . Comparison of seismic zoning maps is shown in Table 1.

The seismicity of the Ukraine's territory increased in the rank 5.48-74.62 % (for maps A and C, respectively) according to the DBN B.1.1-12: 2006 map selected for analysis. Which signifies that most part of buildings erected in these areas before February 1, 2007(date of DBN B.1.1-12: 2006 enactment), have a deficiency of seismic resistance in comparison with the requirements of the new building code. It is caused on the one hand by the fact that map CP -78 (zoning map in SNIP II-7-81) considers various seismic recurrence periods from once in 100 years to once every 10,000 years , and for most regions is deterministic. On the other hand seismic intensity presented on the CP -78 , which underlies of SNIP II -7 -81 was exceeded several times by earthquakes. So, starting with the Spitak - Leninakan catastrophe in a relatively short period of time on the territory of the former USSR , one after another devastating earthquakes took place. The intensity of those earthquakes exceeded the seismic intensity indicated on the map the CP -78 on 2-3 grades, among them the 1988 earthquake in Armenia, Zaisan earthquake 1990 - Kazakhstan, Racha Djava 1991 - In Georgia , Susamir 1992 - Kyrgyzstan , Hailinsk 1991 and Neftegorsk 1995 - in Russia (Koryak and Sakhalin).

Table1. Ukrainian territory seismicity according to the maps CP-78 и OCP-2004

Intensity (corresponds to EMS-98 scale)	**SNIP II-7-81(CP-78)**	**DBN B.1.1-12: 2006 Map A**	**DBN B.1.1-12: 2006 Map B**	**DBN B.1.1-12: 2006 Map C**
VI	16.52%	17.47%	27.91%	52.39%
VII	4.25%	7.06%	11.18%	30.91%
VIII	0.58%	2.32%	3.34%	8.88%
IX	0.00%	0.00%	1.23%	3.30%
X	0.00%	0.00%	0.00%	0.50%
Total seismic zone	**21.36%**	**26.85%**	**43.66%**	**95.98%**

That is why, the intensity of seismic influences defined by OCP-2004 maps according to DBN B.1.1-12: 2006, significantly differs from the CP-78. For example for regular residential and industrial buildings- map A (recurrence period every 500 years), the seismic zone with intensity VII increased on 66%, with intensity VIII- on 340% For map C for zones with intensity VII and VIII, increase equals respectively 627% and 1431%. Also on maps B and C zones with intensity IX and X appeared (Fig. 1). And it is without taking into account influences of soil type.

The map OCP-2004-C presented in Figure 1 corresponds to a 1% probability of exceeding the calculated intensity for 50 years and the average period of recurrence of such intensities once in 5,000 years. Map should be used for design and construction of buildings, that corresponds to consequence class CC3.

Thus, after the introduction of a new building code that takes into account the real seismic hazard, in Ukraine a situation where the bulk of the buildings constructed before 2007 is not resistant to earthquakes was created. Furthermore, some buildings erected after the introduction of a new code , have a deficit of seismic resistance . Therefore, today there is an urgent need to assess the seismic resistance of buildings in most parts of the Ukraine's territory to develop measures of improving the seismic resistance and to evaluate the earthquakes consequences. And to realize this aim it is necessary to develop the seismic resistance assessment system of existing buildings

In foreign practice such systems are well known. An example of seismic resistance assessment system can be American FEMA-154, FEMA-310, Swiss «Verification of seismic reliability of existing buildings», New Zealand's "Guidelines for Assessing and Strengthening Earthquake Risk Buildings" and others.

The described systems are very similar. The approach implemented in those systems allows to compile questionnaire of the object in the form of a check-list very quickly (up to several hours for a single object) and to determine its degree of seismic resistance. But in all these systems, there are no methods of field tests, so the collected data and calculation results may significantly differ from the actual situation.

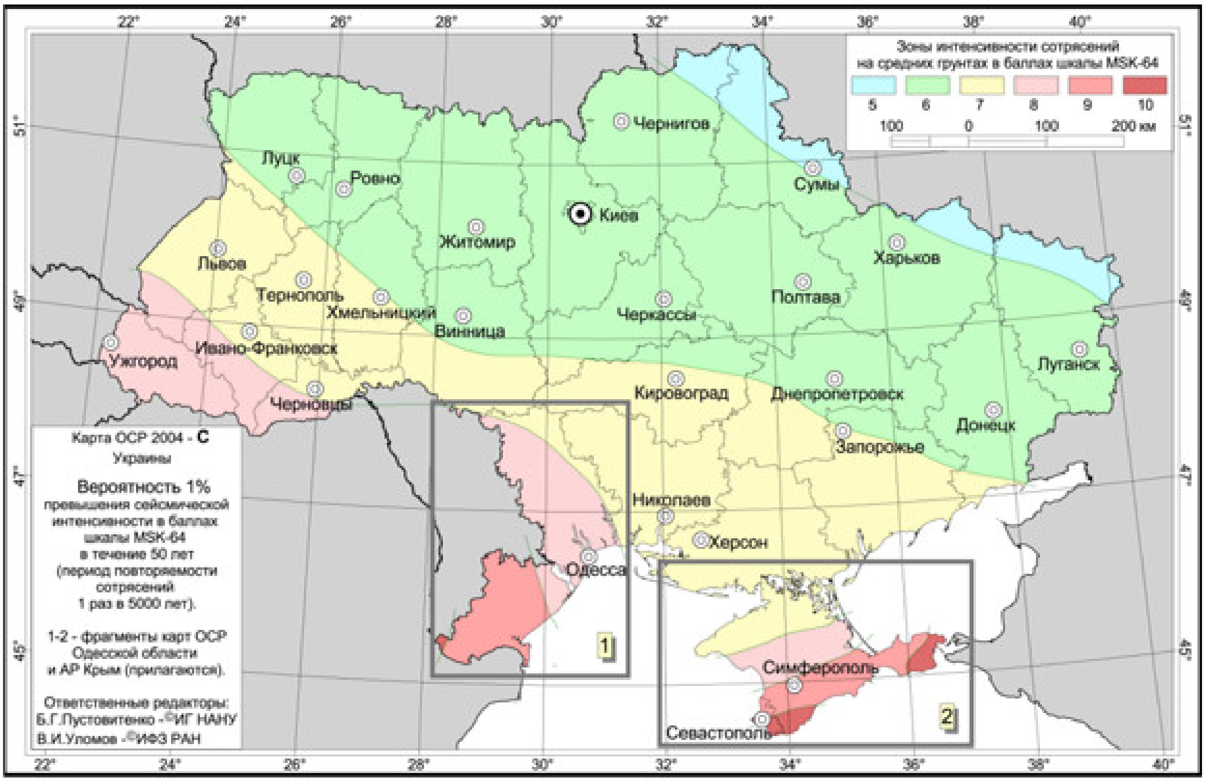

Figure.1. A map of Ukraine's seismic zoning OCP-2004-C

The differences between the described systems are minor and consist in various evaluation criteria, in the amount of factors that are taken into account and, for example, in the Swiss system even the time to perform one or another phase of the evaluation is regulated.

These systems cannot be applied in Ukraine because the structural systems that are offered in described methods significantly differ from those used in Ukraine. Also the connection of these systems to the Ukrainian codes system is very complicated (in such positions as estimated cost of construction, the responsibility of the object, accounting of seismic hazard, seismic stability assessment criteria, and so on). Also in the creation of Ukrainian system it is planned to take the results of field tests.

Therefore, in this situation it is necessary to develop a system that would let to assess the seismic resistance of existing buildings and structures with taking into consideration regional peculiarities of structural systems and building codes.

2. GENERAL PROVISIONS OF THE SEISMIC ASSESSMENT SYSTEM

In this paper, we propose an approach to the evaluation of seismic resistance of buildings. The essence of this approach is that the amount of information needed to define the seismic resistance of an object depends on its consequence class (CC1, CC2 or CC3). To realize this approach we offer to create a three-level system that allows depending on the building's consequences class pick method for determining its seismic resistance. Three level system allows to assess the seismic resistance of a large number of buildings as for mass construction objects, and for unique objects quickly (O. Murashko and O. Adamov (2013).

Main positions of the three-level seismic resistance evaluation system

Assess of actual seismic resistance level 1 (AASR-1). To assess the seismic risk of areas and to create the plan of activities to improve seismic stability, to ensure the required level of reliability, also to elaborate the complex of actions, to eliminate the earthquakes consequences offered an approach in a form, which compiled on the basis of visual inspection (widely used in the world experience methodology).

At this level a minimum amount of information about building is gathering. It includes an assessment of geometric shape, height, protruding parts, and other elements that significantly affects on the seismic resistance. At this level the defects caused by technical condition of constructions are also analyzed.

According to this minimum amount of information the expert makes a conclusion about seismic resistance of the object. If at this stage the lack of seismic resistance of the object detected, then it is necessary to specify it using the second level of system.

ASSR-1 is a questionnaire which looks like on Fema-154 or phase 1 of Switzerland's "Verification of seismic reliability of existing buildings" but adapted to the Ukrainian structural systems, materials and building codes.

Assess of actual seismic resistance level 2 (AASR-2) is a formalized approach of the seismic stability assess in the form of certification, diagnostics and the linear calculation methods for ordinary buildings. This step is required for objects that do not comply with building codes. The result of assessment at this level is a conclusion with recommendations on the appropriate level of design measures to ensure seismic stability. The highly important objects which belong to the consequence class CC3 need additional amount of information that can be obtained by using the third level of system

Assess of actual seismic resistance level 3 (AASR-3). For experimental buildings, especially for responsible and unique objects not only conduction of vibration testing is necessary, but also a verification of building's work using numerical simulation of nonlinear behavior structures under seismic impact that describes it using accelerograms recorded at construction site. Assuming the combination of experimental and calculation operations described above, we can determine the seismic resistance of the object with the actual characteristics of structures and the impact, which has been recorded at the site where the building located. At this stage of analysis all accessible volume of information about the object is considered.

Basic parameters of the AASR system are given in Table 2

Table 2 Structure of the AASR system

AASR system's level	**The method of obtaining information about an object**	**The amount of information that is necessary for the analysis**	**The resulting document**
AASR -1	Visual	Survey of object, analysis of project and as-built documentation (if any)	Filled form of check-list
AASR -2	Visual, Instrumental, numerical	Same as AASR -1 and results of seismometric surveys, development and analysis of numerical model of the object	Certificate of the object's seismic resistance with periodic update of the basic parameters
AASR -3	Visual, Instrumental, numerical	Same as AASR-2	Certificate of the object's seismic resistance with continuous monitoring of the main parameters

3. THE SEQUENCE OF SEISMIC RESISTANCE ASSESSMENT IMPLEMENTATION

Due to the fact that the lack of information about the seismic resistance of buildings is overall (sometimes the district at all), and the implementation of all levels of proposed system requires considerable financial and time costs, it is necessary to develop the sequence of its implementation. (V. Dorofeev et al. 2013)

First of all, it is important to identify seismic resistance for vital facilities[6] and for especially important objects (objects of consequence class CC3) using AASR -1 – phase 1. Secondly, to identify seismic resistance of high responsibility objects (consequence class CC2) – phase 2. And thirdly, to identify seismic resistance of all mass construction objects (class effects CC1) – phase 3. Sequence of the proposed system implementation for other levels of AASR is shown in Table 3

Table 3. Sequence of AASR system implementation

Consequence class of object	**Sequence of AASR system implementation**			**When the seismic resistance deficiency detected it is recommended to**
	1-st phase	**2-nd phase**	**3-rd phase**	
CC1	-	-	AASR-1	Make technical survey
CC2	-	AASR-1	AASR-2	Make Strengthening of constructions
CC3 and Vital facilities object	AASR-1	AASR-2	AASR-3	Make Strengthening of constructions

As a result of the proposed sequence of AASR system implementation in the first phase is a list of objects that need thorough examination to determine the seismic resistance can be defined. However, a decision on the strengthening and development scenarios in the case of the earthquake can be realized only after the implementation of the third phase.

CONCLUSIONS

1. For today for buildings and structures, that are located on part of the Ukraine’s territory in the range 26.85 - 95.98% (depending on the accounted earthquake recurrence period), it is necessary to determine seismic resistance
2. The Approach, in the form of a three-level system will allow to assess the seismic resistance of the existing facilities quickly, and can serve as the first stage of a overall dynamic certification of buildings.
3. The proposed in paper sequence of Assess of actual seismic resistance system implementation allows to determine a list of objects that needs to be checked first of all.
4. The described system currently is under development and it is carried out for all three levels

[6] Vital facilities object is an emergency enterprise, organization, institution, which aims at addressing priority livelihood sufficient to sustain life and maintain health in an emergency peacetime and wartime (ambulance station, fire stations, etc.)

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