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LONG-TERM EXPERIENCE OF ACTIVE DISASTER MITIGATION AND OBJECTIVES OF THE 21ST CENTURY

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SUMMARY

As a result of twelve-year development of Russia Federal Target Complex Programme “Seismoprotection” the authors propose in the article a new integral approach and solution of urban seismic risk (SR) analysis and standardization of the tasks of seismic safety, as well as of SR control in urban areas as whole. Initial importance of a unified professional terminology is emphasized. Parameter “seismic resistance” is considered unsatisfactory as a basic one for codes and it is proposed to make SR a unified, standardized, basic parameter that fits both for newly designed and for existing buildings. The most important stages and corresponding tools for urban SR analysis and control are discussed. Criteria of acceptable SR from a State position on the way to safe and sustainable development are given. It is stated that loss estimation and performance-based design are adjusted on the necessity to estimate, or, on the contrary, to assign maximum permissible (acceptable) states of building and this fact, from the authors’ point of view, must form a basis for future unified standards of seismic safety.

INTRODUCTION

12 years ago when the pressing tasks of preparation for predicted destructive earthquake (EQ) in Avacha Bay urban area (Kamchatka, Russia) appeared, when we came across the matter of certification and strengthening of existing buildings, we realized that scientific and engineering problem of urban seismic safety represented an *odd patchwork*, and on the whole, was practically a "*tabula rasa*".

Actually, there are neither concept and general approaches, nor universal terminology; final goals are not determined, and moreover, are not specified. Efficient ways of the problem solution in precise mathematical formulations are not developed, as well as prompt, essential and sufficient methods and tools for urban seismic risk (SR) analysis and control, etc. But what really of importance is absence of a complex approach, systemic view of the heart of the matter. It was necessary to begin with a unified generalized SR theory.

"Easier said than done" - only now, after 12 years of hard work we can say that we have at last built "a systemic structure" and filled its main cells for SR analysis and control.

JUST NOT MERELY ABOUT TERM AND NOTIONS

It would seem no doubts exist about the fact that mutual understanding of professionals and their fruitful work are impossible without identical comprehension of professional notions and universal terminology. It is especially important in multidisciplinary spheres of activity to which EQ-disaster mitigation belongs.

After our compilation of the Dictionary (1993) the question of universal terminology for Russian-speaking specialists was formally solved. Now we are not troubled by the fact that many seismologists use the term "seismic risk" presuming a "seismic hazard". But let's return to EQ-engineering where professionals use many different notions: seismic stability, seismic capacity, EQ-resistance, seismic reliability, SR, etc. The matching of these terms is necessary not only in a *terminologic* sense but also, and that's the main point, in a *physical* sense. It is especially important also because these terms are used in EQ-resistance design (ERD) and some of them

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claim to be basic parameters in seismic building codes. Now let's speak about these parameters.

In most countries of the world, Russia including, a standardized basic, key parameter reflects EQ-resistance (ER) of buildings and structures. Just the ER appearing as on initially assumed design characteristic measured in intensity grades (MM, MSK, EMS) seems to determine urban seismic safety. We find this parameter unsatisfactory from the point of view of standardization minimum for the following reasons:

a) the magnitude of an EQ disaster is not defined by modern buildings but by old ones designed according to update codes or even without any standards at all. The notions about this or that level of ER for any new building are time-to-time changing, and all advanced standards of ERD of new buildings within the framework of a basic parameter - ER can never be extended as far as existing buildings and structures under operation. Implementation of new construction materials and technologies promoting erection of unprecedented architectural structures is an objective process expanding a precipice between a new and old urban construction;

b) ER has only 3 in intensity grades: C7, C8, C9, and that gives only rough estimations. Not without reason some professionals make justifiable though incorrect attempts to introduce "half-grades": 7.5, 8.5. etc.;

c) ER as the basic parameter of standardization bearing information only about the building does not unite but, on the contrary, separates efforts of seismologists and EQ engineers.

The above said is enough to confirm that ER is a "dead parameter", and cannot be a target fundamental parameter for future codes. Whatever notion, whatever parameter can become fundamental instead of ER? To our opinion, that is SR, and nothing but SR upon which we’ll dwell upon in the next chapters.

ON THE STATE OF BUILDINGS AND FEASIBILITY TO CONTROL SEISMIC RISK

Any existing buildings can be described by combination of its physical (PhS) and operating (OpS) states. The PhS of any building is determined by the complex of its construction type, physical/mechanical properties of construction material, joints, soil condition, etc. Consequently, to control SR by means of the PhS we must, as a rule, update (strengthen) this existing building.

The other way to reduce SR is to change the OpS of a building. Sometimes this way can be rather effective and even free of charge. In 1988 the table 1 was proposed to determine various OpS of existing buildings. Practically, we can change the OpS along the following three direction:

- We can give a new function to a building, i.e. to change its OpS type. In such a way we decrease a required reliability of the given building. For example, a small building of a school is turned into an office;
- We can limit in various degree the level of intensity of OpS, reducing a number of workers, pupils, duration of service per day, etc.;
- We can compare EQ-recurrent period and residual life-time (OpS duration) of building. Thus, we must ask a proprietor in advance for how long he/she intends to operate a building with given PhS and OpS.

Below a current example of application of the 2-d and 3-d directions of the changes in the OpS is given.

A kindergarten building of round-the-clock residence for 280 children has been turned into a standard day-care kindergarten. A number of children was decreased to 180-210. Thereby, the quality of service has been considerably improved. 10 years later building was decided to be pulled to satisfy future city planning requirements.

ON SEISMIC RISK AND ITS ACCEPTABILITY

Seismic risk (SR) represents a scale of potential economic damage and social losses in case of an earthquake. We make attempts to estimate SR, and, consequently, to reduce it. Thus, SR is a target-oriented function of seismic safety, and it would be logical to make it- a basic object parameter in EQ engineering as well, having changed the parameter ER for SR in seismic building code. In this case, a designer, a proprietor, a decision-maker will be able to comprehend directly what and with what probability can take place within the framework of socio-economic damage in this or that urban area or even building under this or that (including rated) earthquake. Here, a question of SR acceptability is emerging. Has acceptable SR been laid in building codes using as a basic targeted parameter ER? In principle, the answer will be "yes" but it is not obvious. We can draw this hidden acceptable SR from the codes in the following way: to design a building in accord with such codes, i.e. to get a building with a standard ER, and then to apply. Loss Estimation Technique (LET) available for estimation of separates buildings. In this case, obtained as a result potential constructive (economic) damage and social losses will constitute the very SR, which is hidden in these codes as an acceptable one (standardized). We carried out such analysis for the codes of the former USSR, Japan, Israel and France. Naturally, obtained acceptable SR estimations were rather approximate but conclusions are common and unique:

1. Variation of implicitly standardized SR is so great that it is impossible altogether to confirm that codes bear some clear acceptable risk criteria (ARC);
2. The reason of Point 1 lies in the following: SR as a target parameter is absent in the codes in explicit form, and transition to it from ER is impeded by numerous coefficients which make difficult description of maximum permissible states of a building;
3. Standardized parameters of acceptable SR within the codes of countries are rather diverse for buildings of different construction types (masonry, RC-frames, with first flexible storey, etc.).

HOW CAN WE EVER GIVE PRACTICAL ESTIMATE OF SEISMIC RISK?

Dozen years of development of methodology and techniques of SR analysis and their active application in Avacha Bay Area Seismic-Prone Urbanization (ABA SPUR) now allow to generalize results and give unified recommendations on SR estimation for any SPUR. Below we give their brief description of [Klyachko, 1994, 1995, 1996):

1. Presentation of the provision programme of *Preventive Seismic Safety (PRESS)* as an indispensable part of sustainable development consisting of 2 successive, recurrent in improved way at every new turn of community development programme – *Programme of Risk Analysis (PRANA)* and *Programme of Risk Management (PRIMA).* At the same time the SR proper is adopted as a basic leading criterion in seismic safety problem which is emphasized to be of practical importance for urban areas, and, especially, for large cities. ER loses its target standard functions and becomes a subsidiary criterion, which is used as an ancillary one in vulnerability estimate of buildings and structures.
2. *Conceptual matrix formulae* (1) & (2) for calculation of probable damage (SR) D as a product of hazard of multifactor impact Ai (as a complex of elementary damage-forming factors – DFF) and vulnerability V_{ik} of Socio-Economic System of Urbanisation (SESURB) possessing economic, social and ecological values.

$$D=A_i \times W_k \times V_{ik} \times T_{st} \tag{1}$$

$$A_i = H_j \times U_i \times I_{ik} \tag{2}$$

where: D - matrix of the complex damage in the SESURB,

A_i - matrix of multifactor actions (impact, influence) on the SESURB, i - index of influence;

W_k - block-matrix of the SESURB's value, k - index of object under influence;

H_j - matrix of hazards (dangers), j - index of danger;

V_{ik} - block-matrix of the SESURB's vulnerability;

I_{ik} - matrix-identificator of influence (weight) of DFF “i” on the object “k” ,

U_i - block-matrix of DFF;

T_{st} - time-operator; s = 1,2,3,4 - season indicator; t = 1,2,...,24 - daytime indicator.

Now we give some remarks following the experience of formulae (1) & (2) application:

a) Forming a matrix of SESURB’s values –Wk gives a clear understanding what SESURB elements are the key ones for SR analysis and control;
b) If function of influence I_{ik} of impact of any DFF “i” on “k” element of Wk matrix is unknown or negligible that means that accounting of this DFF in damage calculation is impossible or inadvisable. The example of this is practical impossibility to take into account so far tectonic maps in SR (probable damage) estimation;
c) Degree of SESURB study (A_i, W_k, V_{ik} matrices filling) determines the accuracy of SR analysis and quality of disaster scenarios (DISC). Most of the worldwide developed DISC, including those within the framework of RADIUS project for developing countries, give only approximate, rather rough estimates of

SR and being aimed, first of all, at risk awareness and initial plan of action for disaster preparedness. Such DISC can and must be considerably improved in the future.

3. For successful realization of almost every stage both risk analysis and risk control, a special mathematical tool was developed which got the name *Method of Expert Logical Estimation and System Analysis (MELESA).* This method is especially necessary for SPURs where experience of damaging and destructive earthquake is insignificant or is practically absent. MELESA is a logical shell of expert approach declared a basic one (especially in vulnerability analysis). The mathematical base of MELESA are “Theory of Fuzzy Sets” and “Theory of Eroded Images”.

4. *Technique and great experience of certification (special inventory) of buildings.* The activities performed in 1988-1990 in ABA SPUR are unique – more than 400 engineers from 50 design institutes of USSR have accomplished in accordance with (Manuel, 1988) a complex certification of 5000 buildings. Organization, systematic and expert supervision including a line of “Informer – Inspector – Expert” was conducted by CENDR. For the first time MELESA was used here, and as result, estimates of Expert Level of ER (EXLER) of building were given. We have to point out here that EXLER is more correct as compared with ERD introduced later in EMS-98 to estimate of which is only one step on the way to EXLER. The documents of certification (passport of a building, cards of PhS and OpS, etc.) became later a basis for determination of vulnerability class of buildings. Stations of engineering-seismometric service have been in operation for more than of 20 years in Petropavlovsk on typical buildings, being in different group conditions (including presently strengthening buildings). Strong and slightly damaging earthquakes occur here every 2-3 years, therefore records of these stations, population interview, examination of buildings following earthquake give a good material for EXLER estimate, and later – for constructional and social vulnerability scores of different buildings. Thus, monitoring of EQ-vulnerability of buildings and population is organized, that seems to be a very important stage in the process of urban SR control. Vulnerability class estimations of some standard buildings are given on the Table 1.

Table 1: LIST OF STANDARD BUILDINGS WITH THE MOST PREVALENT ESTIMATION (CLASSES) OF CONSTRUCTIVE VULNERABILITY

Construction type index according to [Manual, 1990]	Description of the constructions groups under consideration	Prevalent class of vulnerability according to EMS*					
		A	B	C	D	E	F
A-1 (no ERD)	1-4 storeyed masonry buildings with brick or stone walls	O—	—┤				
A-2 (lERD)		├ - -	-O—	—┤			
A-3 (mERD)			├ - -	-O—	—┤		
A-4 (hERD)			├ - -	- - - -	-O—	—┤	
B	Large-concrete-block residential 3-5 storeyed buildings						
B-1	- without welding connections		O—	—┤			
B-2	- with welding connections		├ - -	-O—	—┤		
B-3	- with welding connections and reinforsment			├ - -	-O—	—┤	
C	Most of various large-panel residential 4-5 storeyed buildings with different			├ - -	-O—	———	—┤
KS1	Civil full-precast RC-frame multi-storey buildings of II-04, IIS-04 series. Column grid – 6*6m		├ - -	-O—	—┤		
G1	One-storeyed industrial buildings with RC-frame from 1959 nomenclature of precast concrete products:						
	with standard RC- beams at L = 9, 12,15 m;		├ - -	-O—	—┤		
	with standard steel girders at L = 18, 24, 36 m.			├ - -	-O—	—┤	
KS2	Multi-storey industrial buildings with a column grid = 6*6m made of precast concrete products of IIS-20 series		├ - -	- - - -	-O—	—┤	

(*)We estimate vulnerability according to more detailed 10-grade scale proposed in [Klyachko, 1995].
O – most likely vulnerability; ——— - probable range; - - - - - - range of less probable, exceptional cases.

5. Developed *Damage and Loss Estimation Technique (LET),* abbreviated DAMESTEC, which firstly was aimed at certified building of ABA SPUR, and later ceased to be local and was spread to other typical buildings of the former USSR. That became possible owing to the fact that in the USSR the most part of municipal buildings was performed with the help of typical design on the base on precast concrete construction. Usually [EQ Spectra, 1997], LET has a local character, hence its results are more reliable. DAMESTEC is based on a

preliminary knowledge of EXLER and vulnerability class for any specific constructive type of a building. Further on, assigning intensity of the anticipated EQ the scales – MM, MSK, EMS are applied according to which (in point of fact – in accord with the definition of a notion “intensity”) the most probable degree of building damage (d=1, 2, 3, 4, 5) is determined, and then a direct structural damage and financial losses are estimated. Let’s point at one approximate (and not more than that) rule which sometimes may be useful for a rapid rough estimate of SR and total self-control: on the average, the following correlation are traced: EXLER=7 to C vulnerability class, EXLER=8 to D, and EXLER=9 to E vulnerability class.

We have to point out that in Russia for the last time LET has been under operation which was based proceeding not from a local and global experience of damaging and destructive EQ but set up on the database of military tests of different buildings for explosive and a blast loads. For realization of corresponding models of destruction it is necessary to have a justified correlation between EQ-induced on a building and explosive effect (excessive pressure). The authors of this article are sceptic about the correctness of such model of destruction for the estimate of EQ-induced structural damage but they consider the experience of such tests useful when estimating social sufferings and losses (killed, injured and affected people). Within the framework of DAMESTEC social losses are estimated according to formula 3 with the help of the Table 2.

$$D_s = P \times 10^k \times m \,, \qquad (3)$$

where: P – amount of inhabitants in a building,
k, m – parameters taken from the Table 2 [Klyachko, 1995].

Table 2: AVERAGE PROGNOSTIC ESTIMATES OF SOCIAL LOSSES

Degree of EQ-damage	Construction type of a building according to [Manuel, 1990]	Deaths, k/m	Seriously injured, k/m	Slight injured, k/m	Homeless	Affected, k/m
0	Any	0	0	0	0	-2/1
1	Any	-5/1	-5/4	-4/3	0	-1/1
2	Any	-4/1	-4/4	-3/3	-2/2	-1/7
3	With heavy partitions	-3/3	-2/1	-1/1	-1/2	0/1
	Other	-3/1	-3/4	-2/3		
4	A, B, C, D except for below	-2/3	-1/1	-1/5	0/1	-2/37
	A+ CW, DIO, KS-11, E	-2/1	-2/4	-1/3		-2/65
5	A, B, C, D except for below	-1/3	-1/4	-1/3	-1/7	
	A+ CW, DIO, KS-11, E	-1/1	-1/3	-1/6	-1/9	

For a work with a view to more accurate estimate of losses when each individual house is taken separately the detailed tables referred to more precise description of a structural type with the meanings of "k" and "m" parameters have been developed. It is important to point out here that these parameters give estimate of losses at the moment immediately following an earthquake. Delayed and inefficient rescue and medical measures increase amount of fatal cases at the expense of those who could have been extracted from the debris and rescued.

6. *Application of GIS-technology for developing probable disaster scenarios (DISC).* We work on municipal maps which plane-tables have dimensions 200x200m was taken for a standard information cell of GIS, and promoted filling in the matrices of expressions (1) and (2) and creating DISC of three levels.

- DISC - 1 estimates a direct damage;
- DISC - 2 takes into account secondary and multi-disasters;
- DISC - 3 takes into account lifelines and local preparedness for emergency management.

Many DISC of different levels, of different degree of working out, and, correspondingly, for different purposes have been developed for Petropavlovsk and other cities of ABA SPUR.

HOW CAN WE MEASURE DISASTER AND ITS ACCEPTABILITY AND CONTROL EQ- RISK?

Now, as we know due to DAMESTEC and DISC in numeric and graphic terms which disasters and with what degree of probability can occur in SPUR as a result of this or that earthquake the following questions are arisen:
1. How great is a possible disaster (SR, probable damage and losses)?
2. Is the scale of disaster (SR) acceptability for community?

3. Is it necessary to reduce SR and how much? Are preventive measures necessary to reduce SR and which exactly?
4. Are the measures undertaken to reduce SR, to prevent and mitigate disaster effective and how much?
5. Is it possible to achieve acceptable risk criteria (ARC) and what will be the cost of it for community?
6. We'd like to know current estimates of SR at any moment, i.e. there is a need of urban SR control.

The scheme of SR reduction and control is given in the Fig.1 It gives answers to these questions, but need some comments.

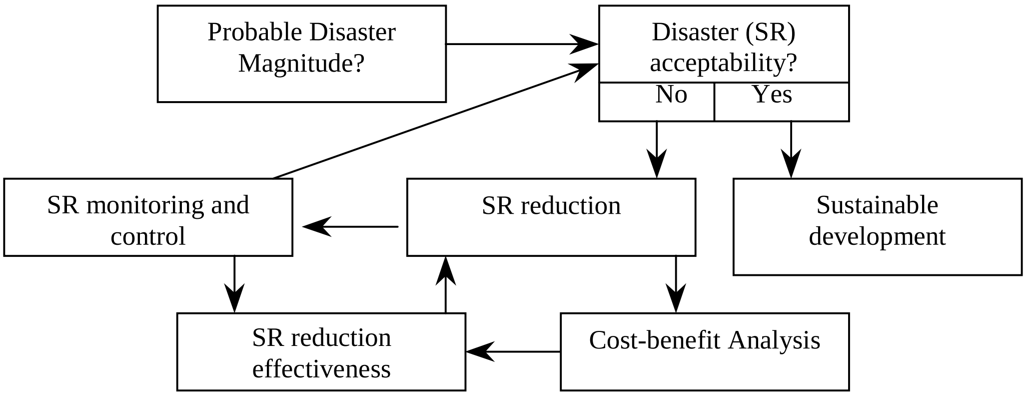

Fig. 1. Scheme of SR reduction & control

To speak about a disaster, and more than that - to prevent, mitigate and control it, is not at the least serious and correct from a professional point of view without knowledge how to measure it. Therefore in 1990-1992 Scale of Disaster Magnitude (DIMAK) was proposed and developed [Klyachko, 1994, 1996b]. A brief description of DIMAK was distributed among the participants of IDNDR Conference (Yokohama, May, 1994). Operating with the adopted basic units – “one fate” and “one loss” logarithmic field of disasters (or plane of social and economic losses) is described. Any point of “disaster field” is presented as a vector with a length – magnitude M_d (characterising, degree of disaster from 0 to 5) and tangent of angle – p (relative social vulnerability index). DIMAK scales estimates (M_d, p) of some recent EQ-disasters are given in Fig.2. DIMAK scale provides for additional characteristics of disaster: index of economic stability of different countries to disaster, relative score of disaster-dm, etc.

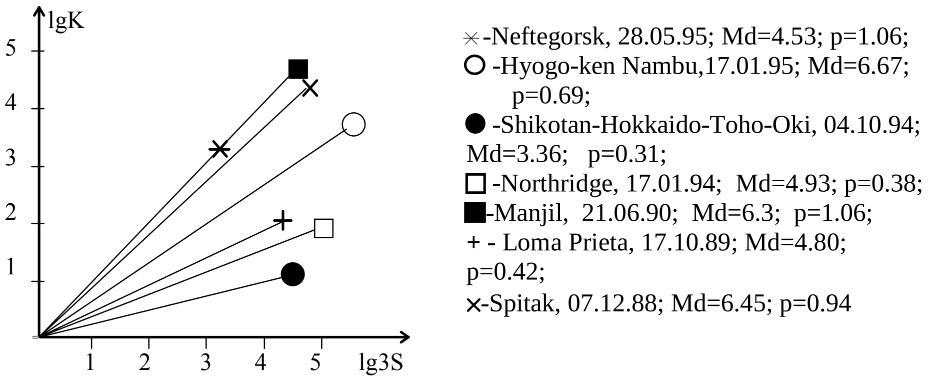

Fig.2. Estimations (Md,p) of the recent EQ-disasters.

Thus, DIMAK magnitude allows to give an answer to the first question about the scale of a predicated disaster, and next in turn there are questions about its acceptability and preventive measures on SR reduction. These questions are solved worldwide, as a rule, on the basis of cost-benefit analysis. Such purely economic approach is quite satisfactory to explain ARC from the point of view of private proprietors or bank-investors. However, a State must have other, more social ARC, which are by no means determined only by a cost-benefit analysis. That’s why we give below proposed earlier [Klyachko, 1995, 1996a] approaches, criteria and conditions of disaster undesirability and permissibility necessary for State regulation of SR.

Disaster must be permissible, i.e. socially acceptable. Loss of property must not be very high and/or should be *insurance compensated.*

Referring to DIMAK scale and experience of past EQ (Fig.2) the following ARC of disaster permissibility were proposed:

Condition 1: Disaster with severe social consequences is unacceptable, i.e. according to DIMAK Scale index of relative social vulnerability p=lgK/lg3S must be $p<[p_1]=0.5$ (for developed countries) or $p<[p_2]=0.75$ (for developing countries).

It is clear that if Condition 1 is satisfied disaster magnitude M_d is mainly determined by economic losses. Thus, *Condition 2* of disaster permissibility is the following: degree of disaster must be below 2, i.e. $M_d<4.5$.

To assess a possible influence of disaster on a given country (state, territory) with various economic power and potential to response to emergency we need additional Condition 3 of disaster permissibility: a relative score of disaster magnitude must not exceed 0.5 (dm<0.5).

A disaster is considered relatively permissible if Conditions 1 and 2 are satisfied. A disaster may be considered as fully permissible or acceptable for any SPUR if all three Conditions are satisfied. An example of this: Shikotan – Hokkaido Toho-Oki EQ (04.10.94) gave rise to permissible disaster: both for Russia and Japan but according to *Condition 3* this disaster was "fully permissible" for better prepared and more economically powerful Hokkaido Island in contrast to Kuril Islands of Russia.

Correspondingly, relatively permissible seismic vulnerability of any SPUR is considered a vulnerability of such SPUR when the impact of designed EQ causes the disaster satisfying Condition 1 and 2. Fulfilment of Condition 3 is required for fully permissible EQ-vulnerability of SPUR.

Thus, we can answer the questions about the ARC, and thereby about the necessity to reduce SR with the help of special preventive measures. State socially-based ARC as standardized ones, will not, certainly, always correspond to economically ARC from a cost-benefit analysis. The best way to remove discrepancy in these estimates of acceptability and to approach their integration is insurance. Further on, after realization of these measures we must "play over DISC" again on the basis of a new situation, use DAMESTEC, and finally, judging from reduction of losses estimate efficiency of the measures undertaken, and for how much we managed to approach an anticipated SR to a desirable, acceptable level.

Periodicity of the indicated procedure provides exactly this control of SR for which we stand up as for an obligatory condition in the policy of sustainable development of any SPUR.

OUR VISION OF SEISMIC CODES OF THE 21ST CENTURY OR FROM LOSS ESTIMATION METHODOLOGY TO PERFORMANCE-BASED DESIGN

Only after regulation of SR analysis and adjustment of seismic safety terminology one can easily speak about prospective unified seismic code.

What give SR analysis and ARC? This is just an ultimate PhS of a building, providing an acceptable level of SR according to design EQ-impact on this building with a previously specified OpS. Ultimate PhS is described by mutually coordinated parameters of vulnerability and damagability (V-class and probable damage degree – d – in accordance with MM, MSK, EMS), parameters of ER and structural reliability, accounting of seismic capacity, etc. Thus, any level of SR (tolerable, allowable, acceptable) [Klyachko, 1995] is in conformity with a strictly definite state of building which can be technically described.

If we make SR a key target-oriented parameter of seismic codes, then for any building with specified OpS we can always assign a target level of SR and PhS corresponding to it. That is just the way from LET to Performance-Based Design, the way of establishing unified (referring to newly designed and existing buildings) seismic code.

CONCLUTIONS

1. Initial important moment is terminology unity and precision of professional definitions in multidisciplinary field of seismic safety and their matching in physical and technical aspects.
2. Parameter "seismic resistance" which is so far basic and target in seismic codes of many countries is in this quality unsatisfactory and must be changed for another one – clear to everybody and really objective parameter – "seismic risk", which satisfies the tasks of standardization of newly built and existing buildings, which can be controlled and guided, which unites efforts of seismologists and engineers in seismic safety provision.
3. Variation of operating states (OpS) of buildings by their types, level of intensity and duration – is a very efficient way of SR reduction in existing buildings.
4. Determining SR (or probability of socioeconomic losses under EQs) as a product of multifactor hazard and

vulnerability, matrix equations are given promoting numerical solution of risk-analysis for any SPUR.

5. Following mathematical “Theory of Fuzzy Sets” and “Theory of Eroded Images” a Method of Expert-Logical Estimations and System Analysis (MELESA) has been developed which application is necessary practically in every stage of SR analysis, especially in case when some data, knowledge and experience base is insufficient and/or lacks reliability.

6. Methods and tools which have been developed, namely: MELESA + DISC-technique + DAMESTEC +DIMAK Scale + acceptable SR criteria (ARC) are necessary and sufficient for urban risk analysis and control.

7. The SR analysis & control results obtained and presented in the article demonstrate:

- a availability for analysis and control of SR for any SPUR;
- a broad variety of activity for further development and improvement of SR-analysis;
- availability possibilities and coming to ahead necessity of transition to new conception of codes based on acceptable SR;
- prompt an extreme desirability of wide discussion concerning the problem of SR analysis and control as specially important.

8. European Macroseismic Scale EMS-98 is a progressive development, first of all, due to introduction of building vulnerability classification; it seems important now in addition to EMS-98 to develop local (national) tables of vulnerability of standard and mass buildings.

9. One of EMS-98 shortcoming is separate consideration of soil conditions at assigning EQ-intensity. From the position of EMS098 application in risk-analysis it is not recommended to consider only superstructure but a system “structure – foundation – soil”, thus considering in vulnerability and risk analysis – seismomicrozonation, as well as soil – structure interaction (including soil stability and liquefaction).

10. It would seem that far from approaches to the he tasks Loss Estimation Technique and Performance-Based Design have a common “point of contact” – Acceptable Risk Criteria (ARC), and correspondingly, some ultimate states of buildings: PhS gives a property damage, and OpS has an effects on social losses. These very state estimated by LET – acceptable, ultimately permissible or even tolerable – have distinct features of performance and present a standardized (desirable) aim in antiseismic design, i.e. the codes.

11. Direct standardization of SR extracts this key & target parameter from a hidden sphere into an evident one, thus attaching to it an engineering and simple for understanding of decision-makers, civil defence staff, etc.

12. Seismic codes of the 21st century are supposed to be elaborated on the basis of ARC, thereby they will be a State unified document regulating urban seismic safety. Decisions on SR control for a number of buildings (hospitals, schools, critical and life-facilities, etc.) must be taken not so much according to results of cost-benefit analysis as on the ground of ARC established by State standards.

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