SEISMIC HAZARD, SEISMIC RISK, PRINCIPLES OF OPTIMIZATION OF REHABILITATION OF EXISTING DWELLING STOCK BUILDINGS

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SUMMARY

This report dealt with questions, connected with evaluation of the buildings and facilities safety during earthquakes from position of seismic risk. We took into account parameters which essentially increased seismic hazard of given territory. Questions of antiseismic strengthening of buildings and facilities with consideration of results of assessment of acceptable and unacceptable seismic risk are pointed out. Methods of technical state control of buildings and facilities, evaluation of damageability, identification of different types of constructive systems by the vulnerability grade, account of broad spectra of seismic hazard parameters aggravation and also measures of optimisation of seismic retrofitting using principles of acceptable risk were used by authors during implementation of Radius project for Tashkent Case Study City.

INTRODUCTION

The earthquake hazard and risk assessment problems acquired at present time a great importance and are urgent issue for all regions of the world, which are situated in the earthquake prone areas. Besides of world wide widely used methods of seismic risk and losses evaluation, constructive systems of buildings and facilities in Central Asia are characterised by own specific features, which are necessary to take into account for obtaining correct results [Khakimov, Ibragimov, 1998;Khakimov, Nurtaev, 1999].

Seismic safety of designed and existing buildings and facilities in the earthquake prone regions are depends on the completeness and correctness of seismological information, adopted methods of calculation and optimisation of antiseismic retrofitting with account of economical and non- economical criteria. One of the main questions is selection of optimal grade of retrofitting of buildings of different constructive systems, widely distributed in Central Asian cities, which are difficult to identificate with structures of another countries of the world. Also it is important to reveal reasons, which can change seismic risk in time for the structures, buildings, facilities and urban territory as a whole. It is clear that the method of seismic risk and damage assessment should take into account the dynamics of system seismic resistance alteration, which may be changed under the impact of natural factors and engineering activity of man. There are a lot of factors influencing on robustness and rigidity of construction elements and systems. It is necessary to select subset of parameters, which played a key role in the region under consideration. This subset depends on the constructive system type, material used and foundation soils properties on site.

For example on the territory of Tashkent City for the same constructive system different factors may be essential. When soils are slumping seismic safety of building may be conditioned by deformations of foundation. If foundation soils are stable (gravel’s), the main influencing factors may be environmental and engineering activity of man

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SEISMIC HAZARD PARAMETERS

From our point of view on the territory of Tashkent city the main factors influencing to the safety of constructions are: slumping foundation, technogenous factors (vibration and so on), temperature impact, reologic effects, medium size earthquake impacts. It should be pointed out that engineering activity of man may play not only negative, but positive role (for example retrofitting of buildings). Not for the all parameters (factors) it is possible to develop mathematical model, so at present time the key problem is accumulation of statistical information as the result of observation and experiments.

Methodology of account of the influence of different factors to robustness and deformational parameters of construction materials, which finally exert negative influence to the safety of constructive systems, is presented below. The equations binding parameters of material with external impacts are presented by kinematics equations, which allows obtaining the evaluation of the construction safety and of the damage for the moment of damage prognosis from an earthquake.

For the case of foundation slumping it is proposed to carry out calculation of structure in non-linear stage based on experimental data or observation under construction performance on slumping soil. As a result of such calculation stress –strain conditions of construction are defined also with robustness and deformational parameters that combined may change the safety of construction in comparison with systems that are not exposed to foundation slumping.

For RC systems the reologic effects are taken into account by the calculation in prolonged time. The methods of calculation in prolonged time used actual properties of construction materials and probability of its alteration in time. Calculation has been carried out by the methods of finite elements (FEM). In the result of reologic processes in construction the change of stress-strained state (SSS) is took place and at moment of damage prognosis during earthquake it may be different in comparison with initial. Characteristic feature of our approach is 2 stage calculation (equations are not integral). At first stage construction is calculated using FEM for static impacts for elastic stage. At second stage calculations are carried out using reological effects. Elements of rigidity matrices depend on parameters, describing reological effects and matrices of free members depend on displacements and forces, obtained during elastic calculation. Forces with account of reologic effects are different from elastic and depend on the time interval of forecast. The difference is from 5 up to 20% and it may influence on seismic safety of construction at the moment of earthquake.

For the damage grade estimation of construction during earthquake, the calculation using accelerogramms has been carried out. Different calculation models (console, planar, spatial) are used for analysis. Calculations are conducted with account of elastic-plastic performance of construction during impacts of different intensities. Calculations are conducted by relative total energy of plastic deformation and by relative plastic deformation.

EARTHQUAKE RISK ASSESSMENT

Present time estimation of seismic risk is possible only on probabilistic level, because earthquake parameters may be forecasted with some probability only. In the proposed method of seismic risk assessment the key role are played by the damageability graphs - intensity, damageability, cost.

Authors are used 2 approach for the graph composition: analysis of data about buildings of different constructive systems tested by earthquakes and theoretical calculations for constructions that are not tested by earthquakes. For loss estimation it is necessary to find the relation between damage of constructive systems with rehabilitation cost of unit area or the building volume. For Central Asia region more than 30 constructive types of residential and public buildings has been distinguished. For every constructive type damageability is defined in dependence with earthquake intensity. It allows carrying out gradation of building constructive type by the grade of vulnerability. Damageability of buildings in relation with designed seismic resistance and earthquake intensity is defined using 5 damage grades according to MSK-98 scale. Definition of damage stage is carried out by probabilistic- deterministic approach.

As an example in Fig.1 presented damageability graph for large panel building in dependence with their design seismic resistance. And in Fig.2 are shown graphs of economic losses in % of rehabilitation cost per 1 m 2 area. Economic losses by constructive types in dependence of seismic intensity are shown in Fig.3 for the same design seismic resistance of building. Buildings from different constructive systems designed for the same seismic intensity have different response to earthquakes. The dynamics of damage grade change with increasing of earthquake intensity can be traced here also.

So, safety of buildings in dependence with their construction types is essentially different. This fact has been taken into account for seismic risk assessment for Tashkent City during implementation of Radius project.

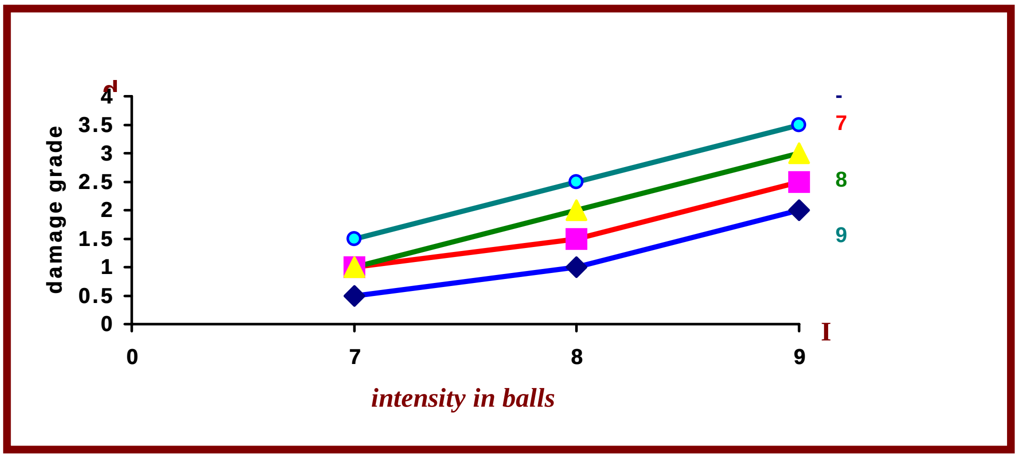

Fig.1 Damage grade in relation with design seismic resistance and earthquake intensity. Frameless building with planar walls bearing elements

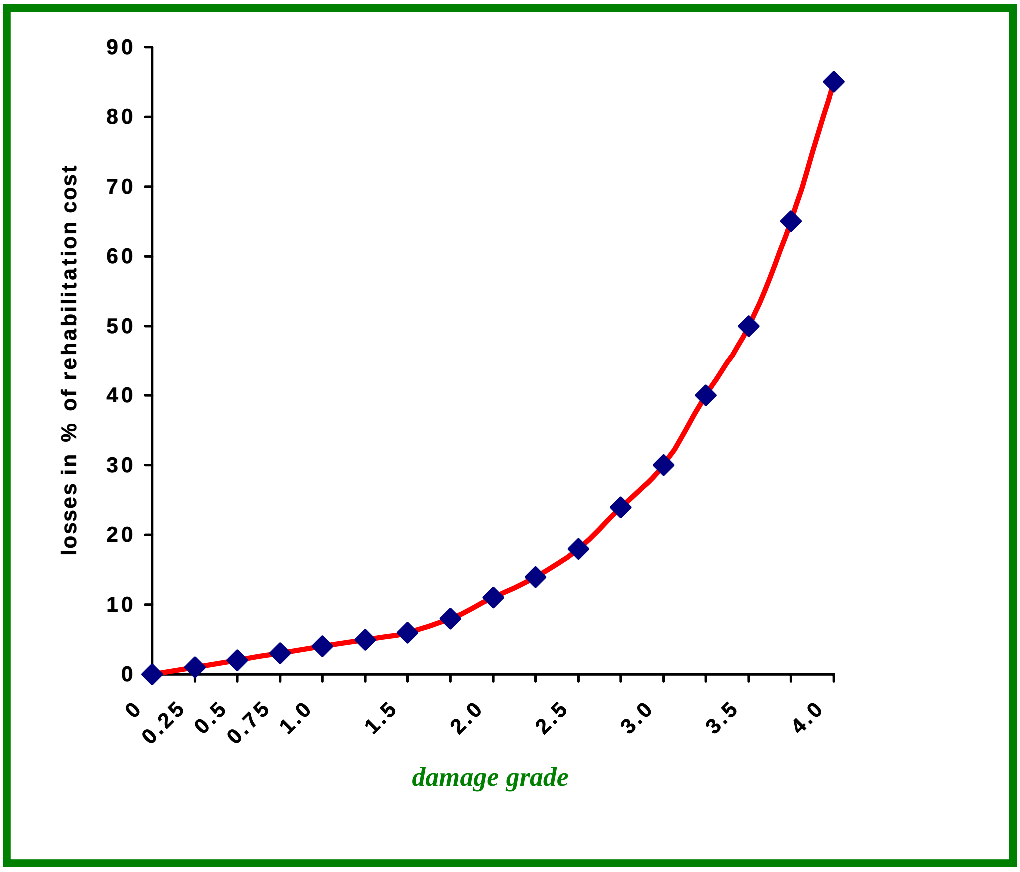

Fig 2 Losses in relation with damage grade for large panel buildings

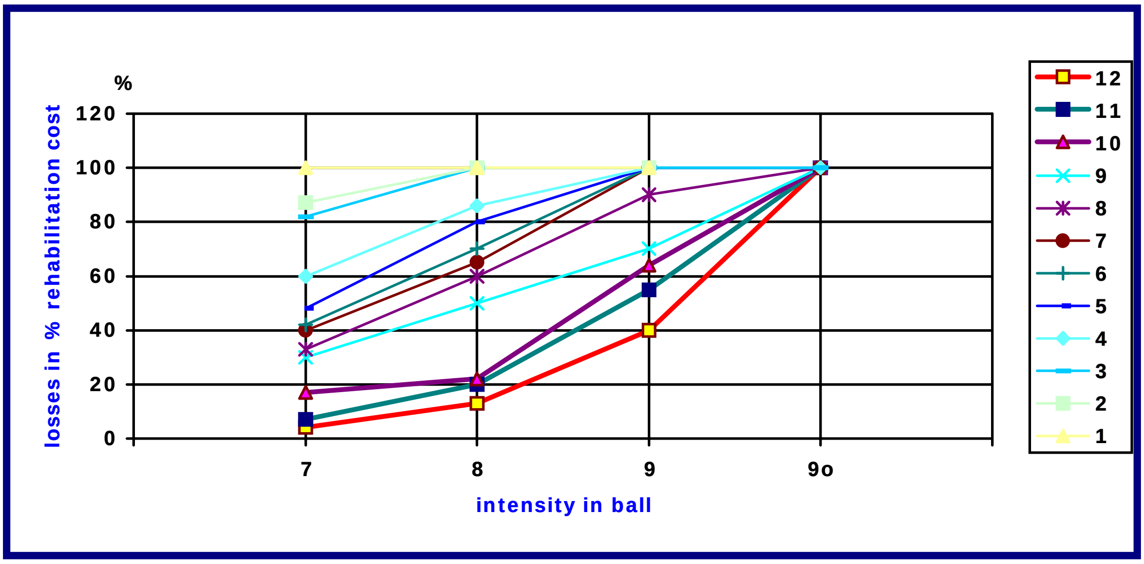

Fig3 Graph of economical losses changes in relation with seismic impacts for buildings of different constructive types with similar design seismic resistance

Buildings constructive types: 1 - 1storey frameless adobe walls (Gualyak); 2- 1 storey frameless walls from adobe bricks; 3- 1 storey frameless walls from pressed adobe (Pahsa); 4 - 1-2 storey brick walls with wooden ceilings; 5-assembled RC frame with welded joints in zone of maximal loads; 6- brick walls with assembled RC ceilings; 7 - 3-5 storey frameless brick buildings with wooden ceilings; 8- brick walls of complex construction (reinforced by RC); 9 – 1-2 storey wooden frame with adobe filling (Synch); 10- monolith RC or metal frame with stiffness core or ribs; 11 – monolith and assembled planar RC walls, for example large panel; 12- 1-2 storey timber houses and metal frame. 9o – zones with liquefaction potential and landslides area during 9 ball intensity earthquake.

PRINCIPLES OF OPTIMIZATION OF ANTISEISMIC STRENGTHENING OF EXISTING BUILDINGS

Optimisation of antiseismic strengthening level of existing buildings which may have inadmissible damage are carried out by the same way as optimisation of strengthening of new designed buildings (minimisation of total expenses which are the sum of expenses for antiseismic strengthening and rehabilitation).

One of the possible approaches for strengthening of building is the choice of optimal reliability using minimisation of total expenses connected with earthquake hazard. This principle may be distributed to the systems with non-economical responsibility, because only state that estimated as damage grade 4 and 5 represents hazard for human life. So, the results of evaluation of systems with economical responsibility in the changes range of damage grade from 0 to 3 will be correct for the systems with non – economical responsibility (limit state of building up to grade 3 is not dangerous for human life)

For optimisation of strengthening of existing buildings it is necessary to take into account conditions, connected with new building construction codes [KMK, 1996]. In process of development of strengthening methods for some constructions it is revealed that all requirements of new building construction codes of Uzbekistan are not possible to satisfy, so we proposed the following conception of strengthening: using minimal cost to retrofit system to the level which do not bring to the loss of life. Retrofitting is carried out by the way which provide damage grade do not exceeding level 3 during design earthquake. Especial attention should be paid to possibility to manage spectra of own oscillation of construction with purpose to shift it from resonant frequencies of probable earthquake.

Described above methods were implemented in the framework of international project Radius in Tashkent.

CONCLUSION

The work carried out show that problem of seismic risk reduction is far from solution and is actual. Obtained results in our work are rough estimations only.

It is clear that seismic risk reduction is complex problem and for complete solution it is necessary to join efforts of many research fields – seismology, engineering seismology, earthquake engineering and many others.

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