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Seismic vulnerability assessments in risk analysis

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The assessment of seismic vulnerability is a critical issue within natural and technological risk analysis. In general, there are three common types of methods used for development of vulnerability functions of different elements at risk: empirical, analytical and expert estimations. The paper addresses the empirical methods for seismic vulnerability estimation for residential buildings and industrial facilities. The results of engineering analysis of past earthquake consequences, as well as the statistical data on buildings behavior during strong earthquakes presented in the different seismic intensity scales, are used to verify the regional parameters of mathematical models in order to simulate physical and economic vulnerability for different building types classified according to seismic scale MMSK-86. Verified procedure has been used to estimate the physical and economic vulnerability of buildings and constructions against earthquakes for the Northern Caucasus Federal region of the Russian Federation and Krasnodar area, which are characterized by rather high level of seismic activity and high population density. In order to estimate expected damage states to buildings and constructions in the case of the earthquakes according to the OSR-97B (return period T=1,000 years) within big cities and towns, they were divided into unit sites and their coordinates were presented as dots located in the centers of unit sites. Then the indexes obtained for each unit site were summed up. The maps of physical vulnerability zoning for Northern Caucasus Federal region of the Russian Federation and Krasnodar area includes two elements: percent of different damage states for settlements with number of inhabitants less than 1,000 and vulnerability for cities and towns with number of inhabitants more than 1,000. The hypsometric scale is used to represent both elements on the maps.

Taking into account the size of oil pipe line systems located in the highly active seismic zones in the Russian Federation the corresponding procedures have been developed. They are based on mathematical modeling of the system elements' interaction: the oil pipe line and ground, in the case of seismic loads. As a result the dependence-ships between the probability of oil pipe line system to be damaged, and the intensity of shaking in grades of seismic scales have been obtained. The following three damage states for oil pipe line systems have been considered: light damage - elastic deformation of the linear part; localized plastic deformation without breaching the pipeline; average damage - significant plastic deformation of the linear part; fistulas in some areas; complete destruction - large horizontal and vertical displacements of the linear part; mass fistulas, cracks; "guillotine break" of pipe line in some areas.