

THE MOST TYPICAL FACTORS OF A DESTRUCTIVE EARTHQUAKE AFFECTING THE ENVIRONMENT (ON EXAMPLE OF THE 1988 SPITAK EARTHQUAKE)

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Summary: *Destructive earthquakes can have a certain impact on the environment, conditioned by both the strength of the earthquake and local conditions, especially at the level of urbanization and seismic risk and the organization of disaster zone recovery. Based on the investigation data of the 1988 Spitak earthquake (intensity 9-10 points by EMS-98, $M=7.0$) these impacts can be divided into two groups based on the destruction of buildings and structures, activation of geological processes, and earthquake zone recovery period. The first group includes the collapse of buildings, activation of landslides, rock falls, soil liquefaction and subsidence's, and activation of other geological processes that lead to changes in the environment. Larger scale earthquakes may have significant impact on the environment. For example, more than 50% of destruction of urban areas (especially buildings), major landslides (millions of tons of mass), collapse of reservoir dams resulting in floods, damages to lifelines (especially the main water supply and sewerage system), etc. The second group includes human activities during the earthquake recovery operations: selection of places to accumulate rubble, creation of temporary residential areas for the homeless and new settlements and districts, construction of new structures and infrastructure (transport, industrial, agricultural, etc.) especially in non-urban areas, destruction of green areas, cutting of trees, use of new areas for keeping domestic animals or setting up households, etc.*

Key Words: *Destructive earthquake, environment, consequences, recovery of earthquake zone.*

Introduction. A strong earthquake, especially occurring in a high seismic risk zone, has a significant impact on the environment. These impacts are conditioned by the earthquake strength, local conditions, especially urbanization and seismic risk levels, disaster management processes, from the good organization of the work to the pace of remediation.[2, 4-8].It is clear that these three possible conditions are different in different seismic regions, and therefore the effect of the earthquake on the environment is different. It is more practical to consider the specifics and factors of earthquake impact on the environment on the example of a particular strong earthquake The example of such an earthquake in this work is the 1988 Spitak earthquake ($M = 7.0$, the intensity at the epicenter 9-10 point by EMS-98, the average depth of the hypocenter -10 km). Here are some important facts about earthquakes and their aftermath. The Spitak earthquake covered an area of about 10,000 km² with one million inhabitants. The area of the destruction zone (8 point intensity and more) was 3000 km². The quake affected 21 towns and 342 villages, completely destroyed 11 towns and 58 villages. Number of homeless people was 514,000. A total of 25,000 people died, of which 17,000 in Gyumri alone. The total lost residential area was 9 million m² (18% of the RA housing stock), of which 4.3 million m² were public sector buildings. Direct material losses are estimated at \$ 15-20 billion. The Spitak city was entirely destroyed- 100%, Gyumri 60% and Vanadzor 30%. From Gyumri alone the ruins of 600,000 m³ of 147 apartment buildings were taken out. Agro-industrial losses in 58 villages: destroyed houses - 21 000, schools - 84, kindergartens - 90, food and trade objects - 2260; 300 collective and state farms, 32 production and 52 construction companies were affected, a 600 km long irrigation line was out of order, 90,000 hectares of land were deprived of water. Damaged lifelines: 40 km railway section, highways in some places, settlements in the epicenter zone deprived of drinking water supply [4, 6].

Environmental changes. These changes are numerous, not mentioning the fact that everything in the devastating earthquake zone changes: from the subsoil to various changes in the earth's surface and in the atmosphere [2-4]. However, these changes occur at different scales and areas. This article will look at the

most significant and large-scale changes, mainly having a negative impact on the environment. These include changes in the earth's surface (relief, engineering-geological conditions, urban areas, including the man-made environment by economy, industry, enterprises, engineering structures), atmosphere (spread of hazardous and toxic substances), aquatic environmental soils, etc and other changes that also affect semi-diversity.

The paper [1-3] cites only damage to natural landscapes and vegetation, and possible massive flooding from dam destruction and waste disposal sites as factors of earthquake impact on the environment. Secondary impacts include consequences of temporarily displaced persons and damage to infrastructure and fuel leakage from storage facilities.

Main factors of a strong earthquake affecting the environment. We have conventionally divided the environmental factors of the 1988 Spitak earthquake into 5 groups. Below we present these groups and the most essential factors.

1. Geological factors and associated effects (factors directly affecting):

- Landslides activation;
- Rock falls, rock collapses,
- Large seismic-gravitational phenomena,
- Changes in riverbeds, formation of ponds due to collapse, etc.

2. In connection with the demolition of buildings and structures, cleaning and relocation of rubble (factors directly affecting):

- Choosing the right place to collect rubbles and preservation of rubbles,
- Impacts due to damage to water line,
- Impact of damage to transport lines, especially highways, railways,
- Factors related to damage to buildings of chemical and other hazardous objects and emissions of toxic substances,
- Consequences of collapse of reservoir dams,
- Impact of large dust retreats on biodiversity.

3. Factors arising from rescue operations and earthquake recover processes:

- Impacts of settlement infrastructure damage during rescue operations,
- Impact of temporary accumulation of building debris in the settlement,
- Destruction of green areas,
- Changes in the living conditions of animals (rodents, birds, etc.),
- Exposure to large amounts of dust during rescue work.

4. Factors related to incomplete reconstruction of the earthquake zone or its delay, creation of new urbanized areas:

- Tree felling, especially for winter heating,
- Occupation of green and other free areas by buildings, residential districts, new settlements with their infrastructure,
- Keeping domestic animals,
- Creation of land plots (vegetable garden, garden) in settlements,
- Changes in wildlife due to the creation of new settlements, districts and temporary districts,
- Increasing groundwater levels and decreasing seismic resistance of buildings due to damage to sewer and water lines,
- Groundwater level rise for the same reason and swamping of areas,
- Factors arising from the construction of new buildings and structures or the restoration and strengthening of their damaged parts.

5. Other:

- Semi-diversity changes due to non-use of agricultural lands,
- Due to environmental changes in abandoned settlements and districts due to population emigration.

Of course, there may be other environmental factors that have little impact on the environment or will not necessarily be the case with all strong earthquakes. For example, changes in semi-diversity due to non-use of agricultural lands or non-functioning of the irrigation system, etc.

Results and discussion. The most important factors arising from the devastating earthquake, especially in the settlements, which may have some impact on the environment, have been eliminated. By origin, they are divided into 5 groups, most of which are typical of any devastating earthquake. The scale of most of the factors, the background and their impact on the environment are due to the intensity of the earthquake, local features, especially urbanization and seismic risk levels, and the processes of earthquake recovery. This data can be used in environmental impact assessment for an area that still needs special study. It will help prevent or minimize the impact of a devastating earthquake on the environment, human health, economic and social development.

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