

## ILLEGAL STRUCTURAL MODIFICATIONS AFFECTING THE SEISMIC VULNERABILITY OF MULTI-APARTMENT BUILDINGS

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**Abstract:** *The results of the study of the consequences of the 1988 earthquake in Spitak showed that many illegal modifications were carried out by the residents in the apartment buildings, which led to the reduction of the seismic resistance of the buildings. For example, the reason for the collapse of at least 10% of stone apartment buildings in Gyumri was also one of those illegalities. This issue remains relevant to this day, so these illegalities must be prevented, and those committed in the past must be eliminated. In this work, we tried to identify the allowed illegal modifications, dividing them into groups according to the danger of affecting the seismic resistance of the building.*

**Key words:** *earthquake, vulnerability, damage, Illegal structural modifications.*

### 1. Introduction

The results of the study of the consequences of the 1988 earthquake in Spitak showed that many illegal modifications were carried out by the residents in the apartment buildings, which led to the reduction of the seismic resistance of the buildings. For example, the reason for the collapse of at least 10% of 147 multi-story residential buildings in Gyumri was also those illegalities, and the number of badly damaged buildings was many times more [1,5,6,7]. Residents had grossly violated almost all the points of the building operation procedure approved by government decisions, which led to the deterioration of the building's technical condition (weakening of the foundations, damage to bearing columns and beams, making openings in the bearing walls and demolishing the inner layer of the row of walls, installing large volume water tanks on the roofs), implementation of additional constructions inside the building, etc.).

In some buildings, the overloading of stairwells, common corridors, attics, and balcony platforms with metal lockers by residents has become a serious problem. During the 1988 Spitak earthquake, some single-entrance, five-story 1-451-20 C type buildings with long corridors collapsed for this very reason [7,8]. Congestion of corridors also poses a problem in terms of the evacuation of residents during earthquakes and emergencies. The installation of heavy water tanks on the roofs also has a very negative impact on the seismic resistance of buildings, which, in addition to additional loading, also causes additional inertial forces due to water fluctuations.

Residents carry out illegal modifications in buildings for various purposes, many times not realizing the consequences of what they have done in terms of reducing the seismic resistance of the entire building or its individual parts. Among the most common purposes of alterations are the constructions of basements and garages, the extension of rooms at the expense of other rooms or corridors and the kitchen, the opening of doors or windows, the demolition of the inner row of stone walls to open cupboards or doors, the "beautification" of an apartment or rooms, the extension of an apartment to outbuildings or balconies, at the expense of opening the exit from the roof slabs to the roof, installing pipes in the walls, which is especially unacceptable in the case of a „midis“ layout, etc.

These illegalities gained a greater scale after the privatization of housing. If we take into account that apartment buildings built in the Soviet years, before 1989, are seismically vulnerable due to poor quality construction and design with reduced seismic risk, the importance of the problem discussed in this work will become obvious.

### 2. The results of the research

In order to clarify the problem, we specially examined 2 apartment buildings of the Akhuryan community, one built before the 1988 Spitak earthquake, and the other after the earthquake. All rooms,

toilets, bathrooms, kitchens, and corridors of the apartments were studied. Let's briefly present the data about the buildings and the detected illegalities [6].

A. **The stone building 83 of Akhuryan highway** (commissioned at the end of 1987, individual project, 4 floors, 3 entrances, 28 apartments, with basement, level of damage 1-2). Conclusions:

- There are no significant changes in the basement floor, even some basements are not used by the owner;
- Almost all the studied apartments underwent various types of modifications. Only one apartment did not undergo any changes;
- Changes according to the degree of danger: a) modifications that do not affect the seismic resistance of the building: balconies on the side of the yard were connected to the kitchen or room by demolishing the partition; connecting toilets to bathrooms by eliminating or moving light partitions. Such transformations are prevalent in almost all apartments; b) changes in shape when partition walls have been demolished or moved. Only two cases have been reported; c) Full or partial demolition of bearing walls to connect apartments. Only one case was observed where 1- and 2-room apartments were connected by demolishing the bearing wall.

B. **New Akhuryan Yu. Ghambaryan street, building 3a** (commissioned in 2000, individual project, 3 floors, 1 entrance, 21 apartments, with basement, no renovation).

The newly built building (after the 1988 earthquake in Spitak). It has a monolithic-concrete skeleton, the exterior walls are brick or stone-lined. There are no modifications or reconstructions in the basement. The building is quality built and the earthquakes that have occurred in the last 21 years have not had any noticeable effect on the building.

The following illegal modifications were recorded: the balconies of the 3-room and 2-room apartments on the first floor were connected to the living room and the kitchen, which do not affect the seismic resistance of the building. There were no modifications in the other apartments examined. Conclusions:

- There are no significant modifications in the basement;
- Only two apartments have undergone transformation;
- These modifications do not affect the seismic resistance of the building;
- Perhaps the residents have learned from the 1988 earthquake in Spitak and the municipal administration did not allow massive changes to be made.

The results of the studies are summarized in Table 1. We have grouped the illegal modifications into 3 groups according to the degree of danger and the difficulty of eliminating the illegalities.

### 3. The most common illegal modifications carried out in multi-apartment buildings

Research conducted by experts, especially after the Spitak earthquake of 1988, when the causes of building collapse were studied, allows us to distinguish the following relatively more common illegalities in apartment buildings. When describing these illegal modifications, we conventionally divided apartment buildings of different types into two groups: **stone and reinforced concrete constructions**. And we have divided the building into three parts according to the floor plan: basement, first, second and higher floors. In the case of such a division, the illegalities found in the same parts of different types of buildings are basically the same.

Table 1. The results of the investigation of two apartment buildings in Akhuryan, regarding the illegal modifications carried out by the residents in the building [6].

N	Address of the building	Modifications that do not affect seismic resistance	Modifications that can be easily eliminated	Modifications, complete or partial demolition of bearing walls	No modifications
1	Akhuryan Highway, 83	77.8%	11,0%	5,6%	5,6%
2	New Akhuryan, Ghambaryan, 3a	12.5%	-	-	87.5%

#### **A. The most common illegal modifications in stone apartment buildings [2,3,4,6,7].**

##### ➤ **Basement**

- Below the foundation of the building, in the immediate vicinity of the load-bearing wall, digging of pits;
- Damage to the foundation of the building, cutting;
- Demolition or relocation of partitions.

##### ➤ **First floor.**

- Excavating pits in the ground below the building foundation (in the absence of a basement);
- Demolition or relocation of bearing walls,
- Partial demolition of the inner row of bearing walls;
- Demolition or relocation of partitions,
- Demolition of bearing walls for access to the outside of the building or to the outbuilding.

##### ➤ **Second and higher floors**

- Partial destruction of the inner row of walls,
- Demolition or relocation of partitions,
- Expansion of living spaces at the expense of balconies;
- Disassembly or damage of reinforced concrete connections.
- Making an opening in the ceiling covering of the last floor.

#### **B. Buildings with reinforced concrete structures**

##### ➤ **Basement**

- Digging holes in the ground in the immediate vicinity of the bearing element below the foundation of the building,
- Damage, cutting of the foundation of the building or the foundation of the pillar,
- Demolition or relocation of basement partitions.

##### ➤ **First floor.**

- Opening pits in the ground below the foundation of the building,
- Damage, dismantling of external wall panels;
- Demolition or relocation of partitions;
- Implementation or demolition of openings in panel walls;
- Damage to load-bearing reinforced concrete columns, opening of cavities in them, cutting of column reinforcements;
- Dismantling or damage of reinforced concrete connections.

##### ➤ **Second and higher floors**

- Demolition or relocation of partitions,
- Damage to bearing or non-bearing exterior wall panels;
- Extension of living spaces to create balconies or to expand existing ones;
- Dismantling or damage of reinforced concrete connections;
- Making an opening in the ceiling covering of the last floor.

#### **4. Conclusion**

1. Research shows that the problem concerns almost all apartment buildings in the Republic of Armenia's settlements, especially during the Soviet years. It has a large scale in cities, particularly in Yerevan. If we take into account that the vast majority of multi-apartment buildings built between 1957 and 1989 have medium and high seismic vulnerability for various reasons, then the critical importance of the problem will become evident, because of the illegal modifications and reconstructions of the structural elements allowed in the buildings increase their seismic vulnerability.

2. The illegal modifications and especially the reconstructions carried out in the buildings in the past, regardless of who did it, on what grounds, and when they are eliminated, can be conditionally divided into three groups:

- a) modifications that do not affect the seismic resistance of the building.
- b) Irregularities that affect the seismic resistance of the building can be eliminated quickly, at a low cost, with the help of non-licensed professionals.

- c) reconstructions that have a significant impact on the seismic resistance of the building and their elimination is mandatory and requires certain financial resources, time, and also the involvement of licensed professional forces (for a project, construction, supervision, acceptance-handover, etc.).
- d) In order to prevent new illegal modifications in multi-apartment buildings, a key place should be given to the strengthening and monitoring of local self-government bodies and councils. It is important to involve the professional forces of the municipal administration, the territorial inspection bodies of the Republic of Armenia, and the seismic service of the Ministry of Emergency Situations of the Republic of Armenia. Emphasize the implementation of explanatory works for residents of multi-apartment buildings.

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