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Post-earthquake mission in Durres, Albania, from science to practice

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Abstract

Following the M=6.4 earthquake that hit Durres in Albania on 26.11.2019, at the request of the Government of the Republic of Albania to the Government of R.N. Macedonia, in coordination with the deputy Prime Minister of the Government of R. N. Macedonia and the Director of the Bureau for Forensic Expertise of the R. N. Macedonia as operational coordinator, teams of experts were established for assistance and support to the local teams in rapid assessment on the structural safety of damaged buildings in the most affected areas. The Institute of Earthquake Engineering and Engineering Seismology - IZIIS (Ss. Cyril and Methodius University in Skopje) was leading the Macedonian mission with four teams composed of 11 experts. Most of the structures that were the subject of inspection were residential, mainly constructed as reinforced concrete structure and flat-slab systems prior the year 2000. Most of these structures suffered major nonstructural damage with negligible structural damages and extensive repairable structural damages. The cause of incurred damages was inconsistent application of recent knowledge in design, construction, and control of earthquake resistant structures. In order to define corresponding technical solutions for repair and strengthening, especially for the vital structures, it is necessary to take additional measures as detailed engineering inspection and science-based analysis.

Key words: Durres earthquake, rapid damage assessment, residential buildings, public buildings

1 Introduction

On November 26, 2019, the northwest part of Albania was hit by a strong earthquake with magnitude Mw =6.4 and epicenter at a distance of 16 km west-southwest from Mamuras. The earthquake lasted 30 sec and was felt in Tirana - the capital of R. Albania as well as in some farther locations (at a distance of over 300 km) in the neighbouring countries, including our country. The maximum intensity in the epicentral area was VIII degrees according to the Modified Mercalli Scale. Until 01.12.2019, the instruments recorded over 1300 minor earthquakes, i.e., aftershocks.
At the request of the Government of the Republic of Albania, IZIIS immediately respond to this request and participated in three post-earthquake missions with 15 experts. In the period 2 – 13.12.2019 IZIIS experts were working with local engineers, inspected and made rapid assessment of a total of 169 structures mainly on the territory of Durres and Shijak (Figure 1).

Figure 1. Location of inspected structures in Durres (left) and Shijak municipality (right)

Most of the structures that were the subject of inspection were residential and represented RC and flat-slab systems mainly constructed prior to 2000 and suffered major nonstructural damage with negligible structural damages and extensive repairable structural damages. The methodology used in the rapid assessment was proposed by the Directorate of the European Commission for Civil Protection and Humanitarian Aid Operations (DG ECHO – UCPM) (Table 1).

Table 1. Classification of damages

Light damage	**Medium-severe Damage**		**Very heavy damage**	
DS1	**DS2**	**DS3**	**DS4**	**DS5**
Grade 1: Negligible to slight damage *no structural damage, slight non-structural damage*	**Grade 2: Moderate damage** *slight structural damage, moderate non-structural damage*	**Grade 3: Substantial to heavy damage** *moderate structural damage, heavy non-structural damage*	**Grade 4: Very heavy damage** *heavy structural damage, very heavy non-structural damage*	**Grade 5: Destruction** *very heavy structural damage*

2 Structures subjected to rapid assessment

Out of the total number of structures, 70 % or 118 are residential, 23 % (39) are residential-business, 5 % i.e., 9 is public institutional buildings – schools, and 1 % are engineering structures - bridges and business buildings (Figure 2 left).

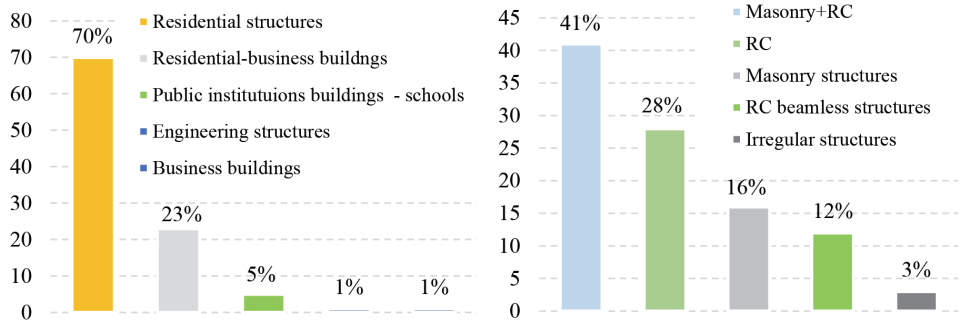

Figure 2. Review of structures according to purpose (left) and according to structural system (right)

According to structural system, the most numerous are combined system (masonry+RC), 41 %, RC buildings with regular frame system of beams and columns and flat-slab structures, each accounting for 28 % of the total number of inspected structures (Figure 2 right). 16 % of the structures are masonry structures including structures with solid brick and stone infill, 12 % represent beamless structures and the least number of structures are irregular frame systems with beams in one direction or structures with a regular system up to a certain level, continuing further with a flat-slab system or beams in one direction. These account for 3 % of the total number of inspected structures.

Figure 3. Structures with major non-structural damage (a, b) and Residential structure GF+1 with major structural and non-structural damage, unsafe for habitation (c, d)

Figure 4. Residential structures: GF+2 (a, b); GF +3 with RC frames at the ground floor and masonry along storeys – visible damages to columns at the ground floor (c, d)

Most of the inspected structures, 64 % of total number were built before 2000, meaning that they are more than 20 years old, while the remaining 36 % of the structures were built after 2000 (Figure 5 left). In accordance with this statement, it can be concluded that most of the structures are of a older date wherefore they are assumed to have been not designed in compliance with the current seismic regulations.

According to assessments made by the commissions (in accordance with Table 1), the expert teams concluded that 6.1 % of the structures suffered slight non-structural damage (Grade 1). 20.4 % of the structures account for those with moderate damage to non-structural elements. However, each third structure suffered major nonstructural damage with negligible structural damages most frequently in the form of hairline cracks in the columns (Grade 3). Almost 35 % of the structures suffered major structural damage that was mainly concentrated in the columns and 9.6 % of the total number of inspected structures were assigned grade 5, meaning that they have to be torn down (Figure 5 right). Photos of damaged structures assigned Grade 3 and Grade 4 are shown in Figures. 3 and Figure 4. More photos of structures are given in IZIIS Report 2019-73.

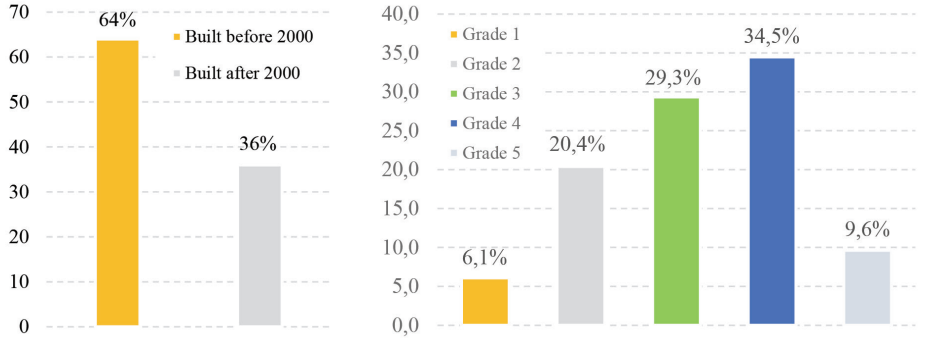

Figure 5. Review of structures according to year of construction (left) and grades assigned to damaged structures upon inspection (right)

3 Statements Arising from the Rapid Damage Assessment

There are several reasons for occurred damages of structures which are generally based on inconsistent application of recent knowledge in design, construction and control of earthquake resistant structures, structural errors in design and construction as well as inappropriate quality of built-in materials. As a result from the performed rapid assessment of structures the following can be stated:

- The most of residential building structures that were the subject of assessment were not designed according the modern seismic regulations or they were not applied on a regular basis
- A lot of assessed structures had built-in concrete with a lower quality
- Numerous structures had visible corrosion of the reinforcement bars
- In most of low rise residential buildings (up to 2 storeys) significant damage was observed in the columns in the ground floor
- Although some of the structures were designed as low rise buildings, they have been upgraded with structures with several more floors

The main reasons for the occurred plastic hinges in residential buildings columns is the unsuitable dimensions or great distance between the stirrups.
The school buildings constructed in the territory of Shijak municipality date back from long ago and are constructed of traditional masonry. These suffered major structural damage (30 % of the inspected school buildings) therefore it is necessary to anticipate solutions for their repair and strengthening for the purpose of providing them with the necessary safety and stability and making them functional as soon as possible.

4 Reasons for incurred damages

The reasons for the occurred damages are:

- Flexible flat-slab or partial beam systems
- Inappropriate and unprofessionally finished expansion joints
- Short columns
- Built additional storeys (up to + 4 storeys) upon already designed/constructed structures
- Plastic hinges in columns as a consequence of low quality concrete and inappropriate dimensions and distance between stirrups
- Warm connection – bridge between two buildings with undefined dynamic response. The structure has 5 storeys, while the bridge is at the top one.

Expansion joints between two buildings where the beams continue from one unit to another.

5 Reasons for incurred damages

The incurred damages to structures are the result of inconsistent application of recent knowledge in design, construction and control of earthquake resistant structures. Structural faults in design and construction as well as inappropriate quality of built-in materials have been observed. 19 % of the structures in the territory of Durres municipality are classified as structures that have suffered considerable structural damage, while 3 % of the structures are anticipated to be demolished. The situation is even more complicated in the territory of Shijak municipality, where 43 % of the structures are classified as structures that have suffered major structural damage, while 13 % of the structures are anticipated to be demolished. All given percentages relate the damaged structures which were observed during the visit of IZIIS team to the Durres and Shijak region.

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