REPUBLIKA E SHQIPËRISË

Building Damage and Usability Assessment after earthquake (BDUA)

TECHNICAL MANUAL

November 2025

REPUBLIC OF ALBANIA
MINISTRY OF DEFENCE

AGJENCIA KOMBËTARE MBROJTJES CIVILE

MINISTRIA E INFRASTRUKTURËS DHE ENERGJISË

TECHNICAL MANUAL

for the Building Damage and Usability Assessment (BDUA) after earthquake

November 2025

English version

Imprint

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Construction Institute, Tirana

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POLIS University
UMT University
Durrës Municipality
Tirana Prefecture
Swiss Earthquake Damage Organization (EDO)

Coordination and project lead:
Construction Institute, Tirana
Project Implementation Unit of the of the BDA-project

Suggested citation:
Technical Manual for Building Damage and Usability Assessment
after earthquake. Construction Institute 2025, Tirana.

Thanks:
This document was prepared with the support of numerous national
and international experts from the institutions listed above.
The publisher would like to thank everyone involved for their constructive cooperation.

Illustrations and photos:
Authors, and Project Implementation Unit of the BDA-project

Main sources:
https://www.babs.admin.ch/fr/documents-sur-la-gestion-devenements
https://www.soe-ods.ch/en/

November 2025

Acknowledgment

The **Technical Manual** is part of the technical framework to conduct and coordinate Building Damage and Usability Assessment (BDUA) services after an earthquake in Albania.

This document has been prepared by the Construction Institute (CI) with the support of the Swiss Agency for Development and Cooperation (SDC) in the framework of the "Building Damage Assessment (BDA) project", implemented by the Construction Institute in close coordination with the National Civil Protection Agency (NCPA).

This technical manual has been developed in concertation with experts from various institutions (Construction Institute, NCPA, Durres municipality, public and private universities) through an interinstitutional working group coordinated by the BDA Project Implementation Unit (PIU) with the technical support of an international expert from the Swiss Humanitarian Aid Unit

REPUBLIC OF ALBANIA
MINISTRY OF DEFENCE

REPUBLIKA E SHQIPËRISË
MINISTRIA E INFRASTRUKTURËS DHE ENERGJISË

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Foreword

Earthquakes are one of the major natural risks in Albania. Although rare, such an event can occur at any time and affect any region of the country. To manage the consequences of an earthquake, disaster risk management institutions at central, prefecture and municipal levels need to cooperate to support the affected region. The same applies to the evaluation of buildings. When many buildings in a specific region suffer significant damage simultaneously, society faces a particular challenge, insofar as the established mutual aid mechanisms are no longer operational or sufficient. On the one hand, the aim is to prevent, if possible, physical injury resulting from the collapse of buildings during aftershocks and, on the other hand, to ensure that the number of people temporarily accommodated is kept to a minimum.

To ensure this national collaboration, the method of post-seismic evaluation of buildings and the training of specialists in this field must be standardized at the national level. Compatibility with international standards, in conformity with the national civil protection emergency plan.

This manual deals with the post-seismic usability assessment method for buildings. Based on this method, qualified experts will be able to make a recommendation regarding the possible reuse of a building and the type of purpose. This recommendation will serve as the basis for the competent authority to decide if and in what form the building can be used.

This manual is accompanied by a form, sort of a checklist summarizing the key elements of the assessment process, aiming to guide the experts during the evaluation of a building. For practical purposes, the form will be prepared in electronic form so that it can be easily adapted to new knowledge.

The Building Damage Assessment Form and Manual, as well as, the corresponding National Operating Manual (NOMA), will be part of the revised secondary legislation on building damage assessment in Albania, to be approved by a decision of the Council of Minister in 2026.

This manual has been developed by Albanian and international experts under the lead of the Construction Institute, and in close coordination with the National Civil Protection Agency, with the technical and financial support of the Swiss development and cooperation agency.

Ms. Blerina Gjini
General Director
Construction Institute

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Terms and definitions

The definitions of the terms provided below are mostly drawn from Albanian legislation and in some cases from international sources such as the UNDRR and the GEM Foundation, while remaining consistent with the national regulatory framework.

Term	*Definition*
BDUA	Building Damage and Usability Assessment. Assessment carried out some days after the seismic event determining the usability of the building.
Detailed BDA	An engineering assessment that includes detailed technical investigation and laboratory tests. It is performed based on DCM no. 26, dated 15.01.2020 “For detailed expertise on damaged buildings”.
Building	Structure that has the provision of shelter for its occupants or contents as one of its main purposes; usually partially or totally enclosed and designed to stand permanently in one place.
Earthquake (main shock)	Earthquake is a term used to describe the sudden slip on a fault and the ground shaking that occurs from the radiated seismic energy during the slipping event.
Hypocenter / Epicenter	Hypocenter is the point inside the earth where the rupture is generated. The corresponding point on the earth's surface is the epicenter.
Intensity (Mercalli scale)	Empirical scale that measures the effects of an earthquake on the environment, people and buildings.
Magnitude (Richter scale)	Instrumental scale that measures the amplitude of ground motion recorded by a seismograph. It is proportional to the energy released.
Structural member	Physically distinguishable part of a structure, e.g. a column, a beam, a slab, a foundation pile (intended to resist forces)
Non-structural element	Architectural, mechanical or electrical elements, system and/or component which, whether due to lack of strength or to the way it is connected to the structure, do not contribute to the overall loadbearing system.
Primary seismic members	Parts of the structural system that resists seismic action.
Secondary seismic members	Members which are not considered as part of the seismic action-resisting system and whose strength and stiffness against seismic actions are neglected.
Structural system	Load-bearing members of a building or civil structure and the way in which these members function together.
Capacity	Capacity of a structure to dissipate energy, through mainly ductile behavior of its elements and/or other mechanisms
Residual capacity	Residual capacity of a structure to dissipate energy after an earthquake event

Structural seismic vulnerability	Degree to which a structure is likely to experience damage or collapse as a result of exposure to a hazard (seismic event), due to its inherent physical characteristics.
Structural retrofitting	Targeted works on an existing building to improve its resistance to seismic forces.
Renovation / rehabilitation	Modernizing the elements within a structure to meet current functional and aesthetic requirements.
Expansion Joints	An expansion joint is a joint provided in a building to mitigate the risk of crack formation due to thermal expansion.
Seismic Joints	Seismic joints are frequently required between adjacent buildings and are often introduced to separate two or more structural units of the same building, whether they are linked functionally. Seismic joints are also frequently introduced to separate wings, or other parts of a single building
European Macroseismic Scale	The European Macroseismic Scale (EMS-98) is the basis for assigning seismic intensities in European countries.

Acronyms

AGRF	Albanian Geodetic Reference Framework
ASIG	State Authority for Geospatial Information
BDUA	Building Damage and Usability Assessment
CC	Coordination Cell
CI	Construction Institute
DCM	Decision of the Council of Ministers
DRA	Disaster Risk Assessment
DRR	Disaster Risk Reduction
EMS 98	European Macroseismic Scale 1998
EU	European Union
GPS	Global Positioning System
IGEO	Institute of Geosciences
INSTAT	Institute of Statistics
KTP	Albanian Technical Design Code (Kushtet Teknike të Projektimit)
KTZ	Albanian Technical Execution Code (Kushtet Teknike të Zbatimit)
NCEP	National Civil Emergency Plan
NCPA	National Civil Protection Agency
NOMA	National Operating MAnual
PDNA	Post Disaster Need Assessment
SAR	Search and Rescue
SOP	Standard Operating Procedure
UN	United Nation
UNDP	United Nation Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
USAR	Urban Search and Rescue
WSG 84	World Geodetic System 84

Introduction

Albania is among the countries with the highest seismic activity in the region, and earthquakes are events that periodically affect the communities residing in various areas across the country.

Based on the World Risk Index 2024 that assesses disaster risks for 193 countries by evaluating their exposure to natural hazards, the susceptibility of the population as well as the coping and adaptive capacities of society, Albania has a high-risk index (6.24) and ranks among the first in Europe and 67th worldwide. The level of vulnerability and exposure to the seismic risk in Albania is the result of a combination of socio-economic and environmental processes, as well as the institutional and political context.

Among the basic factors, are: the increase in population density in the most seismic hazardous areas of the country, due to internal migration after '90; the development of informal constructions; the degradation of natural resources; the Inadequate measures for disaster risk management, as well as insufficient forecasting and prevention techniques; the weak institutional capacities and limited resources for disaster response; the insufficient preparatory platforms for the population linked self-protection measures, and; the low levels of community participation in disaster risk management practices.

The most recent significant seismic event in Albania was the Durrës earthquake of November 26, 2019, which resulted in 51 fatalities and over 900 injuries. The Post-Disaster Needs Assessment (PDNA) [1] report estimated that the overall impact of the disaster across the 11 affected municipalities amounted to €985 million equivalent to 7.5% of Albania's 2019 GDP.

Despite the challenges that our country faced in managing the situation, the November 26, 2019, earthquake prompted a serious reflection focused on strengthening the capacities of the civil protection system in activities related to preparedness and effective response to future events.

From a legal and organizational standpoint, there have been positive developments concerning the establishment and empowerment of the National Civil Protection Agency (NCPA), as well as the approval of sublegal acts needed for the implementation of the law "On civil protection" [2] that was approved few months before the Durrës seismic event. Among the most significant ones, are: Disaster Risk Assessment at the national level [3], National Strategy for Disaster Risk Reduction 2023-2030 [4], and the National Civil Emergency Plan [5]. The preparation and approval of these planning and strategic documents even at the local level and their regular updates remain an important challenge in this regard.

Despite the region's considerable seismic activity, 40-years had passed since the 15 April 1979 earthquake (Mw 6.9), that our country had not faced such seismic events, thereby creating a "gap" in experience with managing earthquake-induced crisis. Focusing on the technical aspects, specifically on the building damage assessment process, the Durrës earthquake found the country unprepared. During the first two weeks following the disaster, experts from the Construction Institute and local teams operated with BDA forms that referred only to basic information regarding building typologies and the types of damages were described with general terminology.

On Dec. 8, 2019, the Interministerial Committee for Civil Emergencies (ICCE) approved Instruction No. 3, "On the coordination of actions for the unified assessment of building damages" which included the approval of the Visual Assessment Form – *On-site verification of structures affected by the November 26, 2019, earthquake*. The approval of this form marked a significant step toward standardizing damage assessment practices in Albania. However, its application revealed several difficulties, caused primarily by:

- The approval of the Building Damage Assessment (BDA) formular few days after the disaster, based on a methodology unfamiliar to Albanian experts.
- The lack of training for assessment teams, affected sometimes the quality and consistency of the assessment process.
- The indirect linkage, that followed through some sub-legal acts, between the Damage Scale (DS) and financial compensation for affected residents [6] [7], put additional pressure on the field assessor.

As a result, the performance of some local assessment teams did not meet the required standards, leading to a loss of trust from the affected communities, who subsequently requested reassessments by international experts or those from the Institute of Construction.

The lessons learned facing main challenges after the Nov. 26, 2019, earthquake, guided the redesign of the Building Damage and Usability Assessment (BDUA) form and the development of this Technical Manual, whose primary objective is to increase the technical capacities of experts who may be involved in similar processes after possible seismic events in Albania.

About the Technical Manual

This manual provides basic concepts for the use of the BDUA Form as a guiding tool used by field experts to perform structured and standardized damage assessments. It offers a step-by-step approach that addresses all key elements critical to this process.

The BDUA Form and the Technical Manual are based on Italian practice (AeDES) [8] and the Swiss one [9], adapted to the Albanian context. Considering that Albania became part of the EU Civil Protection Mechanism in 2023 [10], this well-established methodology already in use in many EU member states, is an added value for the country that ensures effective interoperability between national and international assessment teams in future crisis situations.

The BDUA Manual is structured into three main chapters:

➔ **Chapter 1 - Context and Objectives:**

This chapter analyzes various aspects of the building damage assessment process, presenting the main objectives and benefits of a process that ensures both technical quality and transparency.

➔ **Chapter 2, Technical Aspects of Completing the BDUA form:**

This is the core chapter of the Manual and follows the structure of the BDUA form, providing technical guidance on how to complete the data required in each section. This part includes detailed engineering considerations and, where relevant, refers to the SOP document regarding organizational aspects and the interaction between assessment teams and other operational structures.

➔ **Chapter 3, Annexes:**

- Annex 1 – Building Typology and frequent damage observed: Fact sheets (skeda) providing a detailed description of the main typologies of the Albanian building stock with respective damage patterns observed after important seismic events.
- Annex 2 – Filled BDUA form: Here is given an example of filled BDAU form, for a building that was damaged by the Durrës earthquake in 2019.
- Annex 3 – Overview of Albanian, Italian and EMS-98 damage assessment practices.
- Annex 4 – Main seismic events, seismic design codes and other important documents

1. FRAMEWORK FOR BDUA

1.1 General disaster management cycle

Disaster management focuses on several main phases, which are given in the form of a cycle, depending on the state and the responsible institution at the national level that leads and coordinates the civil protection system. Referring to Albanian legal framework, specifically the current National Civil Emergency Plan (NCEP 2023) [5], this cycle consists of four main phases as given below.

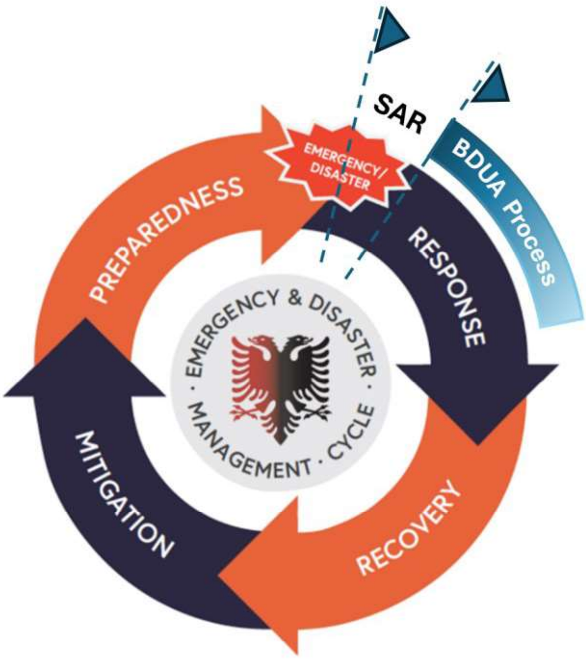


Fig. 1. Disaster management cycle in Albania

Referring to each phase of the disaster management cycle, the civil protection system that consists of institutions at the central and local level, various entities/organizations and the community has defined roles and tasks, the implementation of which significantly affects the reduction of the risk from disasters. The activities undertaken by the civil protection system during the disaster management cycle are not separated from one phase to another but often constitute continuous processes that are interconnected and influence each other.

1.2 Timing of BDUA campaign

As shown in the fig.1, above the BDUA campaign starts few days after the seismic event. The duration of this process depends on multiple factors (size of affected area, no. of BDUA assessors, etc.) and normally lasts from 3 weeks to 2 months.

It must be considered that all the activities related to the drafting of the BDUA Form and the Technical Manual, including relevant training of the experts, are activities linked more with the Preparedness phase, while the use of the BDUA Form (BDUA process) is an activity that is exercised directly after the disaster, in the Response phase.

The recovery process is described as a sequence of interdependent and often concurrent activities that progressively advance a community toward a successful recovery. However, decisions made, and priorities set early in the response process will have a positive/negative cascading effect on nature and speed of recovery progress. In fact, the right decisions taken before a disaster can also positively impact recovery.

The figure below illustrates recovery phase in relationship with preparedness and response activities and outlines the role of BDUA experts within each of these phases.

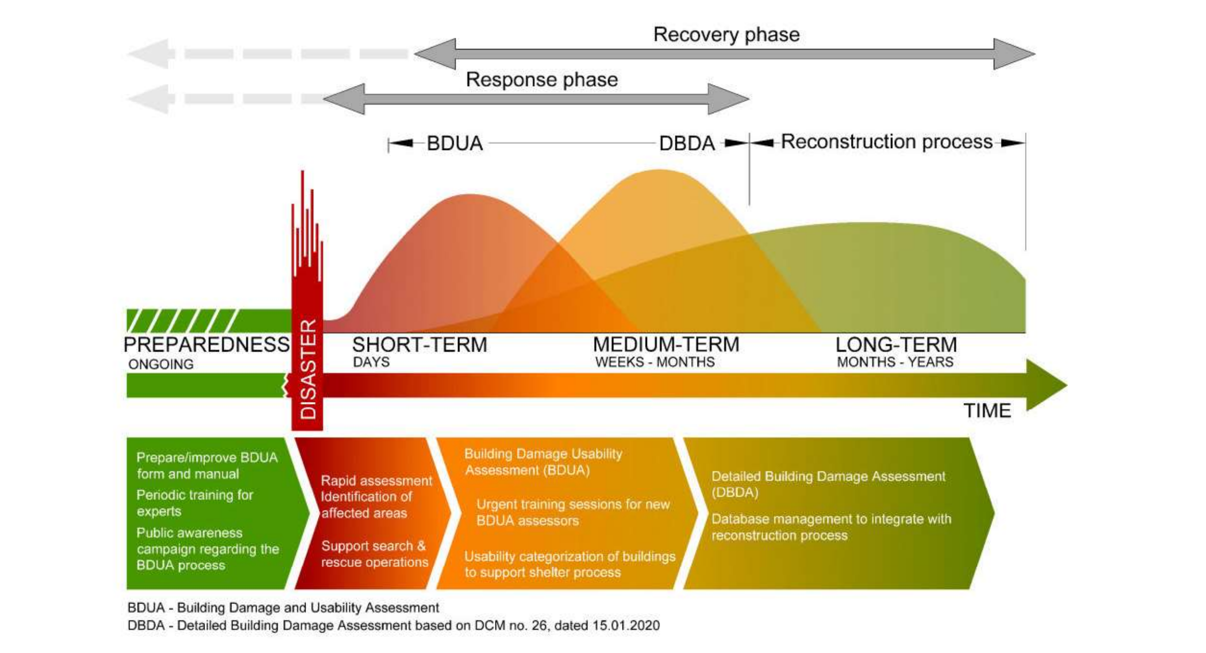


Fig. 2. Post-disaster response and recovery process

Short term period:

The Short-Term Recovery period often occurs simultaneously with response activities. Recovery efforts during this period are focused on stabilizing access to critical needs, such as food, water, sheltering, and critical infrastructure. In this period, the engagement of BDUA engineers can be supporting the SAR teams related to search and rescue operations, determination of the most affected/damaged areas and assessments of the risk of collapse of buildings on the main roads that access the affected zones. In this period of several days, some BDUA experts can be also mobilized to assess the damage to critical public buildings and infrastructures.

Medium term period:

During the Intermediate Recovery Period, the affected population is more stable. Efforts are underway to restore critical infrastructure and businesses to the way they were before the disaster. Short-term solutions to the damage (immediate measures) are being replaced with more permanent repairs. Intermediate Recovery Period can last weeks to months following a disaster. This period, which starts from the first days after the disaster and continues for several weeks, coincides with the phase when the *BDUA is carried out*. According to the identified needs, in the beginning of this period, urgent training can also be organized to increase the number of experts in the field for the BDUA.

Long-term period:

Long-Term Recovery can last from months to years following a disaster. During this phase, communities seek to implement the principle of “build-back better” lessons learned from the recent disaster are applied to community and economic redevelopment strategies. Opportunities to strengthen infrastructure to mitigate the impact of future disaster events are identified and addressed, and efforts to prepare the communities for similar events are undertaken. Community development must be in the focus during long-term recovery. Disaster-impacted communities must avoid rebuilding with the same types of materials, using the same construction methods, and in the same locations that proved to be vulnerable during the major recent disaster. In this way, Long-Term Recovery activities go hand in hand with Mitigation/Prevention and Preparedness phase.

1.3 A uniform methodology throughout Albania

In the case of strong earthquakes, damage can be so severe that an affected region is no longer able to carry out the building assessment using its own resources and has to rely on the help of other regions or even central institutions. To ensure this cooperation efficiently, the methodology must be uniform throughout the country. Meaning that, it must be accepted by Albanian institutions and engineering community and comply with internationally recognized standards to ensure also interoperability with foreign experts in a crisis.

Basic assumptions and principles of the Albanian BDUA methodology:

- must ensure that the risk of residents from expected aftershocks is limited.
- must ensure a quick process to carry out compared to a detailed assessment in accordance with national context.
- should be simple but clearly understandable. In case of doubt, a “conservative assessment on the safe side” is assumed.
- must be structured in such a way that it can be transferred to an IT platform/app with little effort.
- Buildings must be inspected entirely (including the interior if safety is guaranteed).
- Damage must be systematically recorded and clearly identified.
- External risks, e.g. neighboring buildings, must be considered.
- Any immediate measure must be specified.
- The assessment is based on visual observations and the knowledge and experience of the experts.
- The visual assessment does not replace the detailed BDA [11].

1.4 Benefits and applications of BDUA-collected data

Data collected during BDUA process can be used for:

- **Rehabilitation & Reconstruction Planning**
- Prioritize repair of essential public services and housing stock.
- Develop phased reconstruction plans according to severity and community needs.
- **Urban Functionality Restoration**
- Plan to reopen commercial and industrial facilities based on damage data.
- **Social impact costs**
- Support drafting of the Post-Disaster Needs Assessment (PDNA) report and cost-benefit analysis for recovery.
- Support oriented decisions to determine retrofit vs. controlled demolition, based on structural residual capacity.

Potential later benefits of data collected from this process can be also used in DRR and Preparedness activities.

- **Seismic Risk Mapping**

- Prepare / Update municipal and national risk maps following the observed building stock performance.
- **Building Code Improvement & Enforcement**
- Review building codes and construction regulations to address weaknesses identified in damaged buildings.
- **Resilience Planning**
- Support retrofitting programs for vulnerable building stock (e.g., soft-story frames, informal buildings).
- **Public Awareness and Education**
- Use case studies to illustrate real damage mechanisms and mitigation needs.
- Lessons learned from the last disaster situation are used to increase service transparency and public awareness in crisis situations.
- **Scientific Research**
- Improve exposure & vulnerability models to refine seismic risk assessment

1.5 Building categories considered

The present BDUA form and manual focus on common public and private buildings. Below, based on the EC8 [12] table on "Importance classes for buildings" below are shown the buildings that are covered by this BDUA practice. Historical buildings and those of high importance require specific and multi-disciplinary expertise that goes beyond the scope of this manual.

Table 1: Importance classes of buildings and BDUA coverage

Class	Description	Use	BDUA coverage
I	Buildings of minor importance for public safety	Agricultural buildings	Not target
II	**Ordinary buildings, not belonging in the other categories**	**Residential, commercial, office buildings**	**BDUA - target**
III	**Buildings whose seismic resistance is of importance in view of the consequences associated with a collapse**	**Schools, health centers, public administration, theater, assembly halls**	**BDUA - target**
		Historical buildings and heritage monuments	BDUA + spec. expertise
IV	Buildings whose integrity during earthquakes are of vital importance for civil protection	Regional hospitals, firefighters, military buildings, powerplants, etc.	BDUA + spec. expertise

It is to be considered that the buildings selected in the table above - as BDUA target - are directly linked to the primary objective of this service, namely protecting life of inhabitants in the affected areas and identifying shelter needs, where necessary.

So, the use of the BDUA form and the knowledge presented in this Manual are fully sufficient for the structural damage assessment of agricultural buildings. However, these have been considered "not target," as their function does not align with the main purpose of the BDUA service.

Historic buildings and facilities of critical importance require specific, multidisciplinary expertise that goes beyond the scope of this Manual.

A same rationale, but in the opposite sense, applies to historic buildings and those that are critical for civil protection during and post disaster crisis. In this case, their importance is higher, and their usability (which extends beyond simple shelter) often depends on the proper functioning of the infrastructure networks that provide the services for which they are intended. Therefore, in such cases, in addition to BDUA experts, specialized expertise is required to verify and check all infrastructures that provide the necessary services. The following is analyzed a typical case, for the regional hospitals.

It is clear that regional hospitals are a priority, and their importance increases further during emergencies, relative to ordinary buildings. This is because hospitals must remain functional during and after earthquakes, not merely to provide shelter, but deliver public healthcare services. It should be noted that their functionality (usability) depends not only on structural integrity but also on the proper operation of installed networks and infrastructures. In such cases, these networks and infrastructures, although non-structural components, are crucial for the hospital's usability. Consequently, post-earthquake assessment, in addition to BDUA experts (who focus on structural aspects), must also involve specialized expertise to assess and verify the functionality of all systems and networks that enable the normal provision of healthcare services.

Special structures, part of the critical infrastructure, as dams, bridges, roads, antennas, water towers, etc. are out of the focus of the BDUA Form and manual. For these structures special expertise needed.

2. TECHNICAL ASPECTS TO FILL BDUA FORM

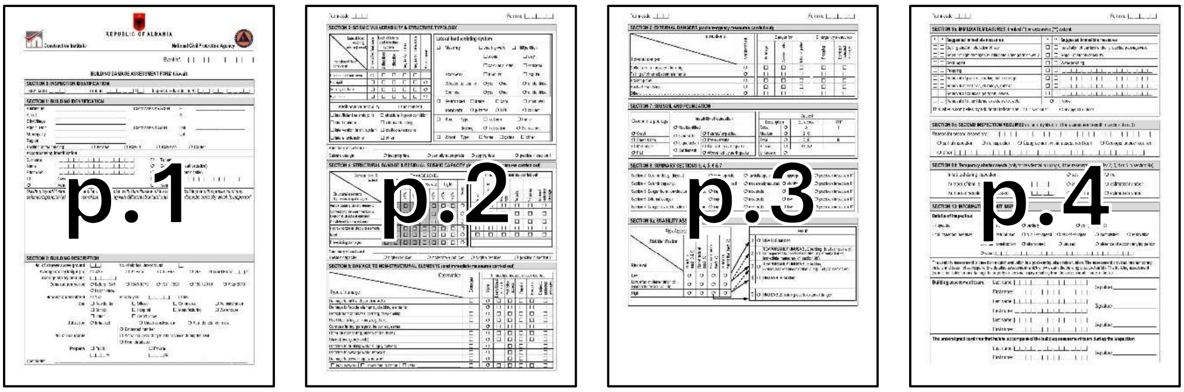
2.1 BDUA Form

The focus of this chapter is to provide technical and operational information to fill in the BDUA form during an inspection. Considering the technical profile of the building damage usability assessment process, the instructions given here also aim to shape the engineering background for the experts involved. Thus, focusing on building vulnerability concepts and understanding of structural damage patterns for different building typology, including secondary aspects, to conclude with clear recommendations for the building usability.

The BDUA form must be considered as a tool that helps the assessors only to follow clear steps (defined in different sections) in a unified and structured manner for each building inspected, but the filling of the form and thereby the assessment itself, remains a product of engineering judgment and interpretations.

The BDUA form is composed of the following eleven sections on five pages (see annex 2):

Table 2: The BDUA form and its 11 sections



p.1	**Section 0:**	Inspection identification
	Section 1:	Building identification
	Section 2:	Building description
p.3	**Section 3:**	Structure typology & Seismic vulnerability
	Section 4:	Structural damage & residual seismic capacity
	Section 5:	Damage to non-structural elements
p.2	**Section 6:**	External dangers
	Section 7:	Subsoil and foundations
	Section 8:	Summary of sections 3-7
	Section 9 a):	Usability assessment
	9 b):	Immediate measures
p.4	**9 c):**	Second inspection required
	9 d):	Temporary shelter needs
	Section 10:	Information about inspection
p.5	**Section 11:**	Additional comments, sketches and/or records

2.2 Judgement of usability

Building damage usability assessment focuses mainly on the qualitative assessment of buildings damages after an earthquake. **Its main objective is to assess the residual seismic capacity and overall safety of buildings in order to protect the lives of the inhabitants in the event of aftershocks, by identifying those buildings that are excessively dangerous.** Always, the competent authorities can choose to prohibit or allow the access to such buildings. Furthermore, the BDUA provides information for planning of immediate measures and the basis for the detailed damage assessment to be carried out subsequently in order to assess the financial aspects.

The assessment of the usability of a building is linked to the need to be able to occupy and use it quickly after an earthquake, minimizing the risk of serious injury to people. For this reason, the verification of usability is not aimed at safeguarding the building from further damage, but only the lives of the occupants in the event of aftershocks. The basic working hypothesis (assumption) is that the building being assessed must be able to withstand a new seismic shock, i.e. an aftershock of the same intensity as the main shock. It is to be emphasized that the expected aftershock intensity, used as a reference for the assessment, must not be confused with the intensity of the design earthquake.

More precisely, it is necessary to consider a potential migration of the main shock epicenter towards the location of the building to be assessed. Ideally, it would be helpful to also consider possible local effects, such as amplification due to the presence of soft soil, for example, but in the absence of reliable information on this subject, it is logical to consider the maximum intensity of the main shock as it is. In this regard, it should be noted that a guided tour of the epicentral zone (of the main shock) is essential for the inspection teams so that the experts can see for themselves the type and level of damage in the epicentral zone.

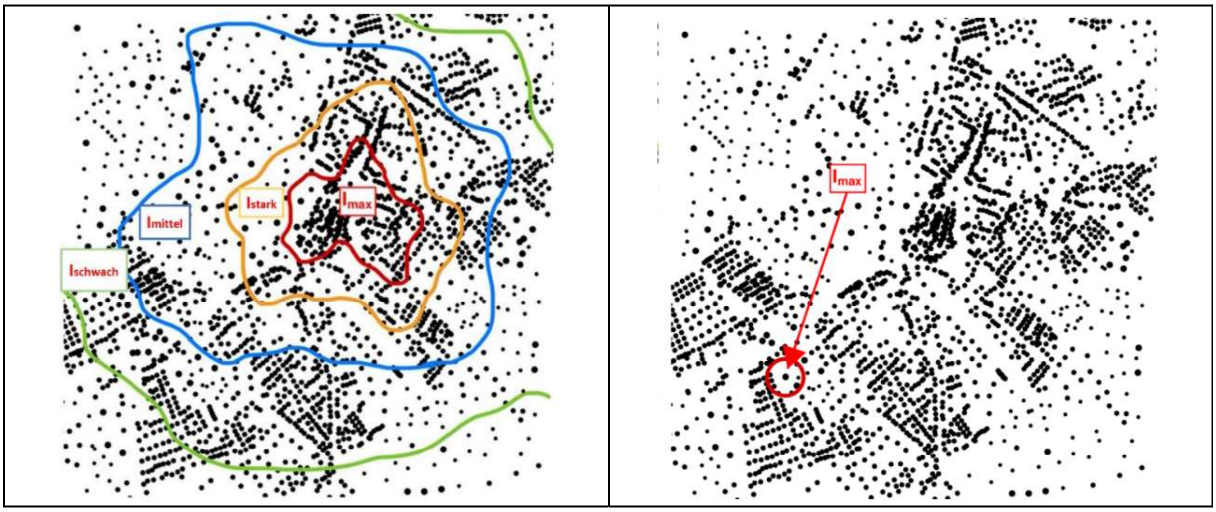


Fig. 3. Left: the intensities recorded after the main shock; Right: the displacement of the epicentre [9]

The assessment is carried out with the help of the BDUA form to classify buildings according to 5 possible categories of usability (see description § 9a of the BDUA form). The translation of the assessment results into a formal decision by the competent authority, which may consist in the placing on the building of signs of the type “green” (unrestricted access), “yellow” (restricted access), “red” (no access) goes beyond the scope of the assessment form and this manual. The responsibility for the decision must be assumed by the authorities based on an overall picture of all the criteria considered.

2.3 General indications

Since the main purpose of using the BDUA Form is to collect information in a unified and structured way, it is very important that assessors are familiar with the technical terminology and graphic elements used. In general, the technical terminology used in each section of the form is explained in the following paragraphs of this chapter. Below, for the graphic elements used in the form, are given respective explanations and how they should be filled out.

Table 3: Indications to fill out the BDUA form

Graphic element	*Way to fill out the BDUA form*
______________	Space dedicated for comments. Write clearly, preferably in capital letters
|__|__|__|__|__|	Boxes dedicated to insert information, that could be: Text: start from the left writing with capital letters inserting in each box only one letter; Integer: enter a number for each box starting from the right
❍	This symbol indicates that only one answer can be chosen
☐	This symbol indicates that you can choose more than one answer or represents the answer "other" when the form does not include the information.
"other"	If the "other" box is checked, complete the information in section 11.

2.4 Inspection / assessment procedure

- ✓ The inspection team consists of at least 2 trained civil engineers from regional pools. International and/or core pool experts can join inspection teams depending on the situation and building importance.
- ✓ In case of private buildings, the presence of the building owner/tenant or other authorized persons is at the same time a criteria to access but also very useful for orientation and taking different information (interventions in structural system, period of construction).
- ✓ **The inspection should start from the outside**. If the exterior damage indicates clearly that the building is unusable, it is advisable not to proceed with the inspection of the inside and thus conclude the assessment. **The safety of the inspection team is a priority**. Despite this, the BDUA form must be filled out till the end. If the danger faced when entering the building is not assessed as excessive, the inspection can continue inside. However, caution must be exercised, as some mechanisms, such as *buckling mechanisms*, are generally not clearly visible from the outside of the building. To ensure their safety, inspectors must always keep in mind the escape route and ensure that the respective doors are open. Equally, the absence of external damage does not necessarily imply the absence of damage inside the building
- ✓ **During the internal inspection**, it is useful to proceed by examining all the floors of the building, from the cellars and the garage to the attic, if the circumstances allow. For example, it is from the attic that it is the best position to observe roof damage. Finally, it is by moving away from the building, when possible, that it is possible to observe the absence of roofing.
- ✓ Rather than a general observation of the building, **it is appropriate to "look for" signs of any damage** in key parts of the building (e.g. at the ground floor).

- ✓ **Distinguishing structural typology**. In the assessment process, prior identification of the building's structural typology is crucial, as it orient the assessor which structural elements require primary attention during inspection.
- ✓ Generally, **it is preferable for each inspector to carry out an individual general inspection to get a first idea of the condition of the building and formulate an initial judgment**. Subsequently, the inspectors can carry out together a complete assessment by reviewing all the important points/issues of the BDUA form to conclude with their final judgment.
- ✓ In some cases, **it is useful to carry out condition surveys** on the mortars removing small portions of plaster that allow the progression of the cracks, to be examined. Sometimes it is necessary to test the consistency of the concrete by removing portions of the concrete cover, for example with a hard-tipped hammer.
- ✓ If the **building requires a second inspection**, for reasons mentioned in section 9c or following a strong aftershock, **it is advisable to have the BDUA form completed during the first inspection** to correctly assess the evolution of the structural damage.
- ✓ **It is of high importance that all fields of the BDUA Form must be completed in order to minimize ambiguity**. Considering that the assessment is visual, many sections provide predefined response options to ensure the form can be fully completed even when observations are uncertain. In particular:
    - "*I don't know*" is available throughout Section 2 when information regarding identification of the building cannot be verified.
    - "*unidentified*" is used for additional seismic-vulnerability features when none are observed.
    - "*None*" must be selected whenever a structural element or an immediate measure is not present or has not carried out.
- ✓ **Additional information**. It is almost impossible to gather in a single form all information and technical details for each building and different damage patterns that can be observed. To document atypical cases, assessors could select the choice "other" and recording supplementary information for relevant phenomena, structural aspects, or clarifications at the dedicated space at the end of each section. Also, Section 11 is dedicated to these additional notes.

2.5 Section 0 – Inspection ID


REPUBLIC OF ALBANIA

Construction Institute

National Civil Protection Agency

BDUA Form 11.2025

Event ref. |__|__| - |__| - |__|__|__|__|__|__|__|__|

BUILDING DAMAGE & USABILITY ASSESSMENT FORM (visual)

SECTION 0: INSPECTION IDENTIFICATION		
Team code |__|__|__|	Form no. |__|__|__|__|__|/|__|	Inspection date (d, m, y): |__|__| |__|__| |__|__|__|__|

Fig. 4. Presentation of Section 0 of BDUA form

2.5.1 ***Event reference***

This field refers to the seismic event that hit the building to be assessed. The first 2 letters are the abbreviation of the region (qark) where is positioned the epicenter of the earthquake (main shock). The third letter indicates whether the shock is the first main shock [A] or one of the subsequent aftershocks [B, C, etc.] and is followed by the 8 digits corresponding to the date of the shock or last aftershock requiring the assessment.

It is to be considered that the BDUA process is repeated only in cases when an important aftershock hits, meaning that can cause additional damage to the buildings in an affected area. Considering the large amount of administrative and field work to be done for the re-assessment, the decision to restart the BDUA process in a specific area, always must be taken by competent authorities. They decide, based on basic information from IGEO, linked with the magnitude of the shock, the judgement of experts but also on field observation of additional damages caused by the specific aftershock. So, it is not meaningful to link the reassessment process with a specific earthquake magnitude. In Annex 4 are presented main important earthquakes that affect Albanian territory [13].

For explanatory purposes of this Manual, for the case of Nov. 26, 2019 earthquake below are considered important aftershocks, only those with Magnitude higher than 5. It is clear from fig.5 that a large number of aftershocks occurred after the main shock (at 03:54 am local time) but only a few of them were of Magnitude >5.0. From the graph below, showing all shocks referring to time (days) and magnitude, we understand that only 4 aftershocks were with magnitude M higher than 5.0 and of those, not all are equally relevant in different locations. Analyzing the important aftershocks, we understand that all of them happen during the first 2-3 days after the main shock, that coincide with the phase of quick response activities of the institutions part of the civil protection system. Meaning that BDUA process didn't start yet.

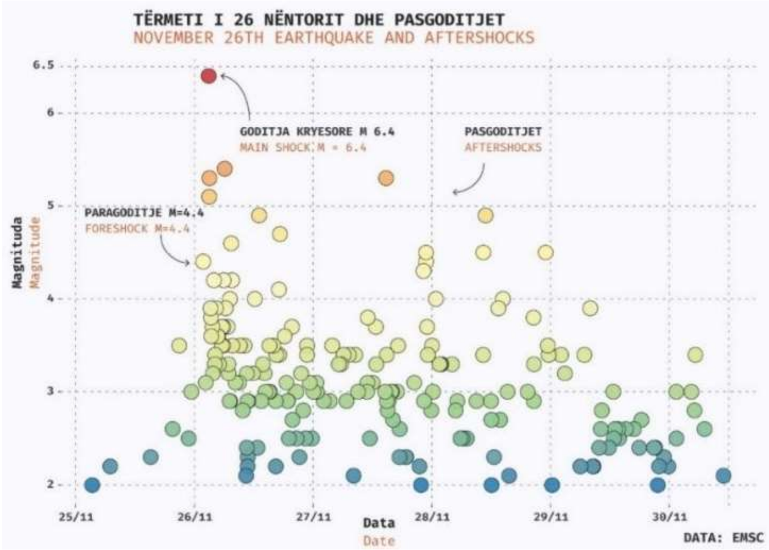


Fig. 5. Main shocks and aftershocks in case of Nov.26, 2019 earthquake [14]

Based on the assumptions referred above, in the table 4 are represented the reference codes and interpretation of all important events in the case of Nov. 26, 2019, earthquake.

Table 4: Examples of event reference

Examples	*Interpretation*
DR-A-26/11/2019	Main seismic shock occurred in the Durrës region on 26.11.2019
DR-B-26/11/2019	First aftershock occurred in the Durrës region on 26.11.2019
DR-C-26/11/2019	Second aftershock occurred in the Durrës region on 26.11.2019
DR-D-26/11/2019	Third aftershock occurred in the Durrës region on 26.11.2019
DR-E-27/11/2019	Fourth aftershock occurred in the Durrës region on 27.11.2019
DR-F-28/01/2020	Fifth aftershock occurred in the Durrës region on 28.01.2020

So, aftershocks are named (as reference events) when it is decided to perform re-assessment. In this case also the affected area where buildings need to be reassessed must be defined.

Fig. 6. Left: Damaged building after the Nov. 26, 2019, earthquake in Durrës. Right: same building, with increased damages due aftershock of Jan. 01, 2020 (photo F. Guni)

Table 5: Abbreviations of Albanian regions

BR – Berat region	FR – Fieri region	LE – Lezha region
DI – Dibra region	GJ – Gjirokastra region	SH – Shkodra region
DU – Durrës region	KU – Kukësi region	TR – Tirana region
EL – Elbasan region	KO – Korça region	VL – Vlora region

2.5.2 *Team code*

The teams of BDUA experts are mobilized, as soon as possible, after the earthquake. The coordination cells (CC) that registers the available experts, instructs the teams and assigns each one a unique identification number.

The team code must be shown on all pages of the BDUA form (printed version).

2.5.3 *Form number*

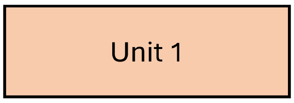
In the electronic version, the BDUA form number is generated automatically by the BDUA application for each building. In special cases when network is missing, and assessors are obliged to use printed version of BDUA form the Form No. will be assigned by CC.

The form no. must be shown on all pages of the BDUA form (printed version).

In cases of buildings that are divided in two or more units (objects) by seismic / expansion joints but have a unique address number, the form number must be followed by a fraction and a letter (1, 2, ...).

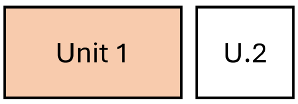
Example: Consider that for the building to be assessed the BDUA form no. is 123

a) Building without seismic joint with a unique address number:

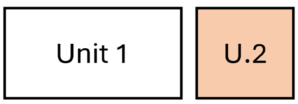


➔ **BDUA form no. | _ | 1 | 2 | 3 | / | _ |**

b) Building with a seismic joint (two structural units) but with a unique address number:



➔ **BDUA form no. | _ | 1 | 2 | 3 | / | 1 |**



➔ **BDUA form no. |_| 1 | 2 | 3 | / | 2 |**

Structural units

Particular attention should be paid to this section of the BDUA form despite its trivial appearance at first glance. It contains the information needed to uniquely identify each structural unit that could behave independently in the event of seismic actions. This means that a building indicated on the online map (in the BDUA app) can consist of one or more structural units. It is essential to fill in a form for each identified structural unit. The number of BDUA form must be the different structural units of the same building.

Within a cluster of buildings, the various structural units to be assessed can generally be distinguished by their construction type, different heights, year of construction, presence of staggered floors, presence of joints, etc. Distinguishing the different structural units is not a straightforward task. This is the case, for example, with adjacent buildings in historic centers or buildings that have undergone renovations or later extensions. In the case of reinforced concrete buildings, the distinction between different units is generally less complicated. In this type of construction, a structural unit is defined by clear spaces or by expansion/seismic joints.

The illustration below shows a unique building that consists of 6 apartments per floor with a seismic joint that clearly creates two structural units. As stated above, for each of them a BDUA form must be filled in. The number of structural units should not be confused with building entrances that in this case are three (E.1, E.2 and E.3). Frequently, the same situation is met when lateral extensions are introduced in a building, even though the "existing" spaces communicate with the "new" ones.

Both seismic and expansion joints are usually developed over the ground level and mostly in RC buildings all structural units have a common foundation and underground level. Saying this, structural units are distinguished better from outside the building and in some cases even inside, but not on the underground levels. Also, in some cases due to construction processes even foundations and underground floors are divided.

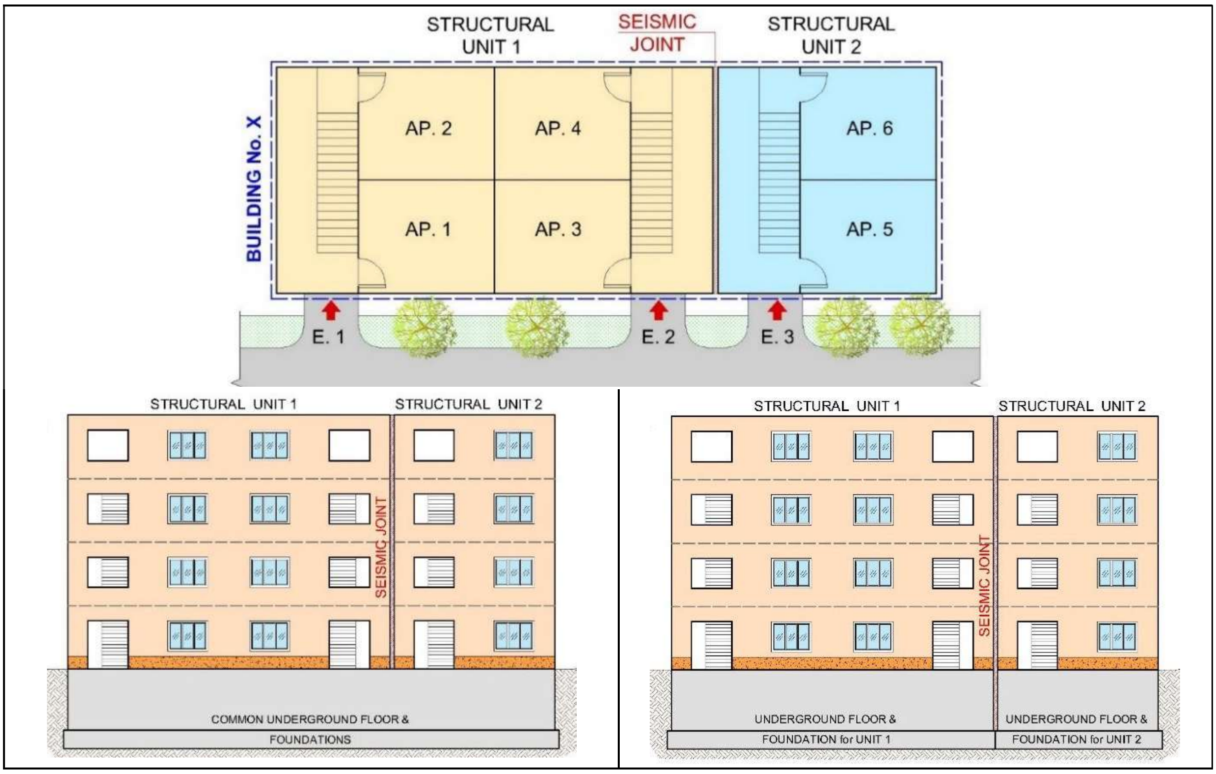


Fig. 7. Building with two structural units. Left: seismic joint till ground level, right: seismic joint till foundations

2.5.4 Inspection date

The inspection date is automatically generated by BDUA application, referring to the exact date that BDUA team perform the building assessment, according to the following example:

Inspection date (d, m, y): |2|2| |1|1| |2|0|2|5|

In special cases when network is missing, and assessors are obliged to use printed version of BDUA form the Form No. will be assigned by CC.

Note: Do not confuse event reference date with inspection date!

2.6 Section 1 – Building identification

SECTION 1: BUILDING IDENTIFICATION

Building no.	______________	Coordinates KRGJSH	E	______________
Street	______________		N	______________
City/Village	______________			
Admin. Unit	______________	Coordinates WGS84	Lon	______________
Municipality	______________		Lat	______________
Region	______________			

Position of the building: ❍ Isolated ❍ Row-in ❍ Row-end ❍ Corner

Accompanying identification

Surname	|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|	❍	Tenant
Name	|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|	❍	Delegate (with authorization)
Phone No	|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|	❍	Delegate (by municipality)
❍	Owner	❍	Other |_|_|_|_|_|_|_|_|_|_|_|_|
❍	Administrator	❍	None

Building layout extracted from online national source with identification of any seismic joints. In case of same building with different structural units, please describe correctly which is inspected in section 11.

Fig. 8. Presentation of the Section 1 of BDUA form

2.6.1 Address

All data linked specifically with the building (Street, City/Village, Administrative Unit, Municipality, Region) are taken automatically from the address system connected with digitalized BDUA form and only in case of using hardcopy form these data must be filled by the team of assessors.

The information referring to the building address comply with requirements of the Albanian address system legal framework [15], [16].

2.6.2 Coordinates

The BDUA form requires the entry of geographic coordinates in the Albanian Geodetic Reference Framework (KRGJSH-2010) format and in the GPS world coordinate format (WSG 84). The survey team indicates the coordinates based on the GPS device used, which is part of the equipment provided, as specified in the NOM.

Albanian Geodetic Reference Framework (KRGJSH-2010) is the unique geodetic base of Albania, issued by the State Authority for Geospatial Information [17]. Below are shown different coordinate system references, including KRGJSH for the Construction Institute.

GPS (WGS 84) coordinates must be entered in the WGS 84 format (World Geodetic System, 1984 revision). These are DD (decimal degree) coordinates with five decimal places. The first figure is the longitude (from 0° at Greenwich to ± 180°), and the second figure is the latitude (from 0° at the equator to ± 90° at the poles).

Fig. 9. Different coordinate systems for Construction Institute building[1]

2.6.3 *Position of the building*

The position of the building serves to highlight its relationship of connections or contact with other buildings, which represents a useful element for vulnerability and structural interaction assessments. Through this information the assessor specifies the position of building (structural unit) in relation to other ones within the same building complex (aggregate). An example is illustrated in the following figures:

Fig. 10. Left: Example of a uniform urban block. Right: Example of fragmented urban complex

In the case of a uniform urban block (left figure), buildings 1 and 3 are corner buildings, buildings 2, 4, and 6 are row-in buildings, and building 5 is a row-end building.

In the case of a fragmented urban complex (right figure), building 10 is isolated, and buildings 7, 8, and 9 are also isolated, if they are separated from each other by seismic joints. Otherwise, buildings 7 and 9 should be considered as row-end buildings and building 8 as a corner building.

[1] Source: State Authority for Geospatial Information (ASIG). https://geoportal.asig.gov.al/map/

2.6.4 Accompanying person

The presence of an accompanying person during the building inspection is strongly recommended to eliminate any risk of accusations of theft or looting against the assessment team. In this section, the team must indicate the accompanying person's first name, last name, and phone number. The number should be entered as follows: +355 XX XX XXX XX

The identity of the accompanying person must be specified by checking the appropriate checkbox on the right (owner, administrator, tenant, authorized delegate, municipal delegate, other, none). If the team is unaccompanied during the inspection, they must check "*none*". Otherwise, any missing information will be interpreted as an oversight by the team.

2.6.5 Building layout

The part of BDUA form between sections 1 and 2 is dedicated to the building layout. The digitalized BDUA form will show an interactive georeferenced map linked with an address system where the assessor can select the building subject to inspection.

2.7 Section 2 – Building description

In this section information concerning metrical data is collected. These data include the age of the building (with indication of the period of construction and eventually of renovation of the building), as well as type of use and exposure. Metrical data must include the total number of storeys including basements, the average story height and the average story area.

SECTION 2: BUILDING DESCRIPTION					
No. of storeys above ground	|__|__|	No. of stories underground	|__|		
Average storey height (m)	❍ ≤2.8	❍ 2.9÷3.4	❍ 3.5÷5.0	❍ >5.0	**Ground Floor** |__|__| m
Average storey area (m²)	|__|__|__|__|__|				
Construction period	❍ Before 1945	❍ 1945-1970	❍ 1971-1990	❍ 1991-2010	❍ After 2010
	❍ I don't know				
Structural intervention/retrofitted	❍ Yes	Specify year |__|__|__|__|	❍ No		
Use	☐ Residential	☐ Offices	☐ Commerce	☐ Administration	
	☐ Education	☐ Health service	☐ Manufacturing	☐ Warehouse	
	☐ Other	☐ I don't know			
Utilization	❍ Inhabited	❍ Under construction	❍ Abandoned/ not in use		
No. of occupants	______	❍ Estimated number ❍ Actual no. according to info received during the visit ❍ From database			
Property	☐ Public	☐ Private	❍ I don't know		
Comments:					

Fig. 11. Presentation of Section 2 of BDUA form

2.7.1 Number of floors above / underground

To specify the number of floors above ground of a building, the attic/loft is also counted if it is accessible. A floor shall be considered underground[2] if it is located entirely or mainly underground, provided that its upper level, measured on the finished floor of the story above the underground one, is not more than 1.0 m above the level of the sidewalk or external terrain in the perimeter of the structure or three of the four facades are completely underground.

Here it can be considered also the definition given for the underground floor in the Territorial Development Regulation [18].

2.7.2 Height and average floor area

The average height and floor area values are estimated during the inspection. Average values refer to those that best represent the overall structure. These values are not explicitly considered in the assessment, but rather hold statistical interest, as they allow, for example, the estimation of the built volume in question.

2.7.3 Construction period/retrofit

This part of the section is used to indicate the age of the building. To do this, in the BDUA form are introduced 5 main construction periods that are linked with important system changes (political and organizational) and approval of design codes in Albania. Four 'important' years linked with socio-economic aspects of the country are selected to define five construction periods as below:

[2] Based on DCM dated 13.5.2015 "On the approval of the territory development regulation", as amended

Table 6: Key dates defining the construction periods in Albania

Year	*Key aspect/change related to the construction sector*
1945	Political and organizational system changes
1970	Widely implementing of the first design code package and setup of seismological service [19], Dibra earthquake, beginning of introducing unskilled workers in construction processes and also important technological development for that time (production Large Panel Buildings and silicate bricks)
1990	Political and organizational system changes shift from a centralized construction sector, totally controlled by the state, to one dominated by free market principles.
2010	Termination of informality in the construction sector (incl. Census 2011, approval of the new territory planning law)

The field under the construction period is used to indicate, if applicable, the period of one of the structural interventions or overall retrofit of the building. It is to be considered that structural intervention made by the owners without a design project may affect negatively the structural capacity by increasing the seismic vulnerability of the building. If the building has undergone multiple interventions / retrofit, the most significant one is indicated or, if they are of similar importance, the most recent one.

2.7.4 <u>Use</u>

The selection of the building's usage is limited, as BDUA form is primarily intended for structures belonging to ordinary buildings (see table 1). Focusing on risk concepts, a warehouse is a space that is not frequently occupied by people. If the proposed list does not include a suitable option for the building in question, the box “other” should be checked, and the purpose should be specified in section 11.

Annex I, of the Territory Planning Regulation [20] can be used as a reference to define use of building also.

2.7.5 <u>Number of occupants</u>

The number of occupants refers to the average number of people who continuously occupied the building for reasons of work or residence. Occupants of secondary residences, used only occasionally, should not be classified as occupants, even if they were present at the time of the earthquake. It should also be specified whether the indicated number of occupants is only an estimate or based on more precise data, such as information from the owner/ accompanying person or a database.

2.7.6 <u>Property</u>

The last part of this section concerns the type of property, distinguishing between public or private. In case of mixed property in a building, the BDUA form allow to check both checkboxes.

2.8 Section 3 – Type of structure and seismic vulnerability

SECTION 3: SEISMIC VULNERABILITY & STRUCTURE TYPOLOGY

Lateral load resisting system / Interstorey/ floor behaviour	Unidentified/unknown	Lack of lateral load resisting system in any direction	Irregularity in plan	Irregularity in elevation	Proper layout
Unidentified /unknown	❍	☐	☐	☐	
Not rigid	☐	☐	☐	☐	❍
Semi rigid / Panel	☐	☐	☐	☐	❍
Rigid floor	☐	☐	☐	☐	❍

Additional vulnerability	❍ unidentified
☐ insufficient seismic joint	☐ structure in poor condition
☐ short column	☐ informal building
☐ intervention in str. system	☐ rooftop extensions
☐ lateral extensions	☐ other

Lateral load resisting system				
☐ **Masonry**		☐ bearing walls		☐ infill/partition
		☐ stone		☐ mud bricks
		☐ clay brick		☐ silicate brick
		☐ hollow brick		☐ concrete block
	Stonework	☐ irregular		☐ regular
	Ties (wood or r/c)	❍yes	❍no	❍ unidentified
	Confined	❍yes	❍no	❍ unidentified
☐ **Reinforced**	☐ frame		☐ core	☐ shear wall
concrete	❍ prefab. frame		❍ LPB	❍ flat slab
☐ **Steel**	Type:	☐ column		☐ frame
	Bracing:	❍ 1 direction		❍ 2 directions
☐ **Wood**	Type:	☐ frame	☐ çatma	☐ other

Summary of section 3 ____________________

Seismic design: ❍ inappropriate ❍ partially appropriate ❍ appropriate ❍ precise in section 11

Fig. 12. Presentation of the Section 3 of BDUA form

Section 3 is used to identify the construction type and understand seismic vulnerability of the load-bearing structure. This chapter is divided into three parts (vulnerability matrix, additional vulnerability and lateral load resisting system), presented below. In general, square checkboxes allow multiple selections for the same item (row). However, multiple selection is justified only if the different elements truly represent the entire structure. If an element is only marginally present, the selection should be limited to the main element. Finally, the items to be checked do not represent an exhaustive list. They have been selected based on representative construction type of the building stock in Albania. If an observed type is not present in the proposed list and its behavior is not comparable to any other, it should be noted in the observations in Section 11.

2.8.1 Vulnerability matrix

One of the basic factors contributing to the proper seismic behavior of a building is a rational design of the structural system in a way that lateral seismic actions (inertia forces) are transferred to the ground without excessive rotations of the building and in a ductile manner. For new designs, there are also some general principles that can lead to the desirable result when they are followed[3]. The god practices for a conceptual design against seismic loadings are:

- Structural simplicity
- Uniformity and symmetry
- Redundancy
- Bi-directional resistance and stiffness
- Torsional resistance and stiffness
- Diaphragmatic action at storey levels
- Adequate foundation

[3] George G. Penelis, Gregory G. Penelis Concrete Buildings in seismic regions, II-ed

As physics is the same for the new and existing building, structures can be evaluated according to the same principles. Existing buildings with layouts that do not incorporate the above-mentioned principles clearly become a source of seismic vulnerability. The rows of vulnerability matrix focus on the diaphragmatic behavior of storey levels as a basic element that affects seismic response of buildings. while fulfilling/lacking other principles is given through the columns. The matrix gives the possibility of different combinations identifying the fulfilling/lack of these principles, so giving a deep understanding to the assessors for the seismic vulnerability of the inspected building.

The vulnerability matrix is the core of this section, if not of the entire form. This part describes the structural elements that enable the absorption of seismic actions. The matrix allows you to check off the identified information for horizontal and gravity (vertical) load bearing systems to qualitatively assess the seismic vulnerability of the entire load-bearing structure.

The “unidentified” checkbox should only be chosen as a last possibility. First, it is essential to inspect all floors of the building. Particular attention should be paid to basement floors. The load-bearing elements of these underground floors are often free of cladding, plaster, gypsum, etc., so that the structure can be inspected in its raw state. It is also recommended to ask the owner or caretaker for any useful information. In case of doubt, the team can carry out verifications, for example, by locally exposing the load-bearing structure with a pick hammer.

More information regarding seismic vulnerability can be found on the book “Inxhinieria Sizmike” [21].

2.8.2 *Gravity load (floor) system*

The matrix rows list various floor typologies (horizontal structures) with regard to their effect on the overall structure. The typologies are listed roughly according to their seismic vulnerability. The latter tends to decrease as one moves down the table. A total of four typologies are available to choose from: unidentified, flexible, semirigid and rigid floor.

a. Floor Rigidity

On one hand, floors must transfer vertical loads to the walls and any supports, and on the other, they should ensure the integrity of the building and the distribution of horizontal loads. The distribution of loads depends on the rigidity of the floors, their connections to the walls, and the direction of any beams or girders. The floor diaphragm in-plane stiffness affects the overall building response to horizontal loads.

A rigid diaphragm is defined as one in which, its horizontal displacements due to the seismic action do not exceed anywhere by more than 10% the corresponding absolute horizontal displacements that result from a rigid diaphragm assumption. A rigid floor (diaphragm) distributes seismic forces to the walls (frames) in proportion to their stiffness in the considered direction.

To be emphasized, is that the resistance of diaphragms may be reduced significantly by large floor openings, especially if the latter are located near the main vertical structural elements.

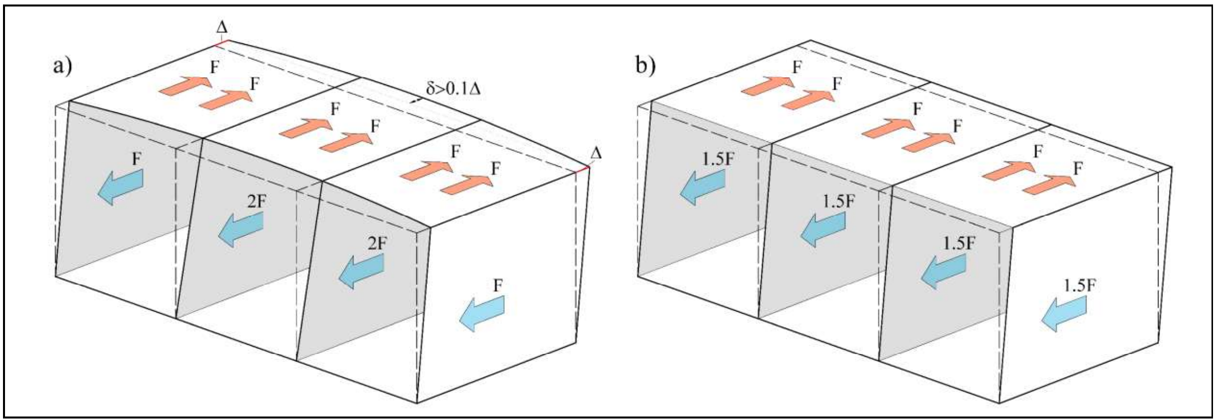


Fig. 13. Effect of diaphragm stiffness. (a) Flexible diaphragm: uneven distribution of forces among vertical elements. (b) Rigid diaphragm: uniform distribution of forces among vertical elements

Below are given some examples and technical aspects that distinguish three types of floors, based on their in-plane flexibility:

✓ **Floor with flexible slab:**

The deformability and/or low strength of this type means that, even if well connected to the vertical structure (a condition which is rarely found), they are not capable of providing adequate out-of-plane restraint to walls, nor of redistributing seismic forces among in-plane loaded walls. As a result, these floors may exert out-of-plane loads on walls, facilitating collapse. Typical flexible floors consist of wooden elements with single or double direction of spanning (beams and joists), with simple wood planks or brick elements (clay tiles), eventually finished with incoherent filling material or debris.

✓ **Floor with semi-rigid slab:**

The stiffness and strength of this type allow them - if well connected to the vertical structure (typically achieved through effective tie beams) - to provide sufficiently rigid restraint to out-of-plane loaded walls (frames) and to redistribute partially the seismic forces among the walls parallel to the direction of action. However, these slabs are not stiff enough to allow redistribution of seismic forces in both directions of the building.

Floors with typical semi-rigid diaphragm behavior are considered:

- Timber floors with crossed double planking, possibly topped with a reinforced concrete distribution slab.
- Floors with prefabricated mixed clay–concrete joists (e.g., SAP type) without an upper reinforced slab.
- Prefabricated panel floors

✓ **Floor with rigid slab:**

The stiffness and strength of this type allow them – if properly connected to the vertical structure – to provide adequate out-of-plane restraint to walls (frames) and redistribute seismic forces among vertical-resisting structural elements, parallel to the direction of the action. This results in a proper box-like behavior of the structure, in which the out-of-plane loaded walls/frames are effectively tied to the slabs, behaving as beams or plates with restrained edges, while the seismic forces are transferred to the ground through both directions of action.

The following floor systems are considered to have rigid diaphragm behavior:

- Solid reinforced concrete slabs.
- Slabs with in-situ or prefabricated clay-concrete joists and an adequately reinforced concrete top slab of at least 4.0 cm thickness.

According to ECec8 requirements, a solid reinforced concrete slab may be considered to serve as a diaphragm, if it has a thickness of not less than 7.0 cm and is reinforced in both horizontal directions.

Fig. 14. Wooden flexible floor

Fig. 15. Floor with prefabricated reinforced hollow clay tile beams with RC ring beams

Fig. 16. Slabs with hollow bricks having rigid diaphragm behaviour

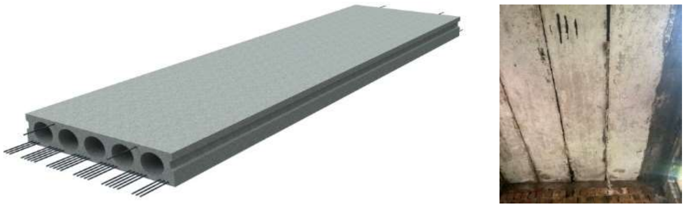


Fig. 17. Prefabricated pretensioned panel

b. Tie beams

Floors play a key role in ensuring the integrity of buildings. This integrity is a prerequisite for a global collapse mechanism, which rigid floors generally fulfill. For floors with a uniaxial load-bearing system and often insufficient connections to the walls, this integrity cannot always be guaranteed. In such cases, local collapse mechanisms cannot be excluded. Ring beams can significantly mitigate this issue and contribute to the overall structural integrity. These elements provide continuity and stiffness at each floor level, enabling the diaphragm to act as a rigid or semi-rigid element and distribute lateral forces uniformly to the vertical load-bearing walls.

Fig. 18. Tie beams

c. Connections floor - wall

In the BDUA form, the quality of the connections between floors and walls is not explicitly listed. It is therefore assumed that the connection between these elements can transfer the resulting forces. If this is not the case, the building assessment team must complete the matrix in Section 3 and add a corresponding note in the “Summary Section” area below the tables.

2.8.3 <u>Lateral load bearing system layout</u>

There is lots of evidence from damage observations after earthquakes that simple and regular buildings tend to behave much better than irregular ones. This is why always seismic building codes (KTP-N2-89 [17], Eurocode 8 [12]) gives great importance to conceptual design aspects such as: structural simplicity, uniformity, symmetry and redundancy. These concepts are analyzed in the columns of the vulnerability matrix, giving a general description of lateral load resisting system of a building. A distinction is made between regularity in the floor plan and in elevation (vertical continuity). The floor plan regularity is ensured if there is good symmetry, if the center of mass and the center of stiffness are close, and if there are no large protruding parts and no openings (setbacks), i.e., if it is a simple and compact shape. The latter is guaranteed when the vertical structural elements of the structure are continuous throughout the height and the stiffness does not change abruptly between different floors.

a. Lack of lateral load resisting system (in 1 or 2 directions)

Structures that have not been conceived to be earthquake-resistant can exhibit significant vulnerabilities, such as the lack of a lateral load resisting system in one or even two directions. Such weaknesses can also arise from renovation works if seismic safety was not considered during the modifications (structural interventions). Typical examples are met during interventions in existing masonry structures to create large openings in existing bearing walls. In Albania, there are a lot of buildings designed and implemented with lateral load resisting frames only in one direction joined together with prefabricated slab panels. In some cases, the frame itself is composed of prefabricated members (columns and beams).

Fig. 19. RC frames in one direction. Left: with prefabricated element. Right: cast in place

b. Plan irregularities

An irregularity in the floor plan exists when the arrangement of the vertical structural elements leads to eccentricity between the center of mass (C_M) and the center of stiffness (C_S). The building is then subjected to torsional stresses, which intensify the loads on the structural elements. Referring to EC 8 [12], for the structure of a building to be considered as regular in plan, there are some conditions that must be fulfilled at all storey levels:

- The distribution in the plan of the lateral stiffness and mass are approximately symmetrical with respect to two orthogonal horizontal axes

- The plan configuration shall be compact. If there are in-plan setbacks (re-entrant corners or edge recesses), we may still consider the structure as regular in plan under the following conditions:
- These setbacks do not affect the floor in-plane stiffness.
- For each setback, the area between the outline of the floor and a convex polygonal line enveloping the floor does not exceed 5% of the floor area.

In the following is analyzed the position of C_M and C_S for a real building. Considering the symmetry in one direction, the structure exhibit eccentricity only in "*x-x*" direction, e_x= 626cm.

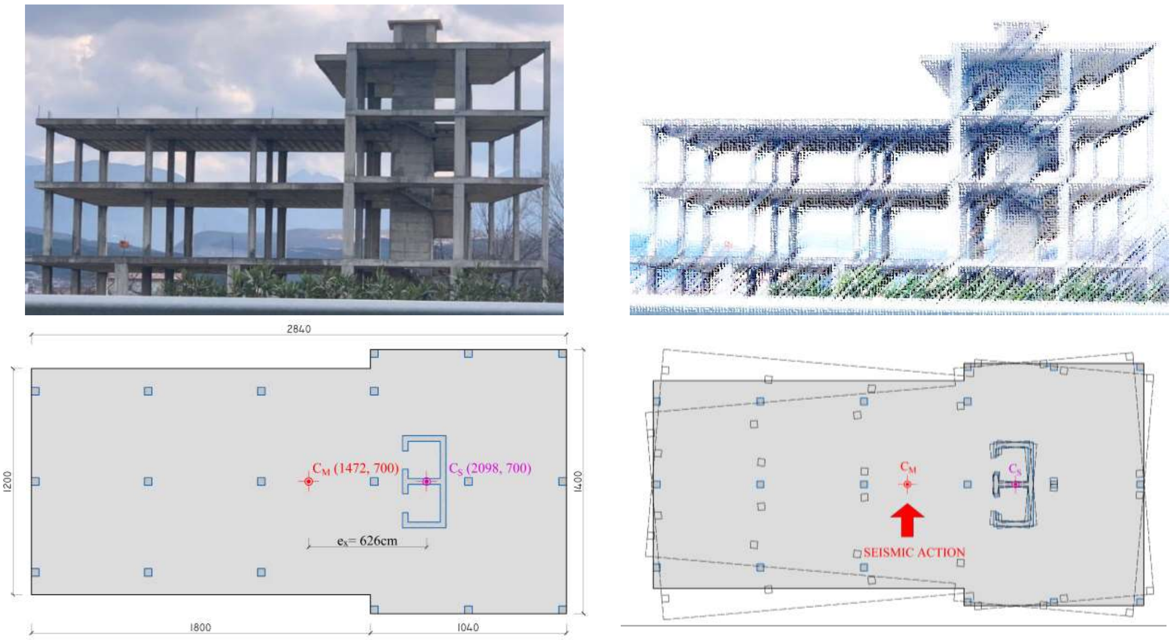


Fig. 20. Example of irregularity in plan

Based on KTP-N2-89 requirements, it is defined that at each story level, the eccentricity measured perpendicular to the seismic action is not considered too large, if it is less than 15% of the building size at that direction.

For the case analyzed, we have L_x=28.4m and e_x = 6.26m, that doesn't fulfil the criteria above (e_x = 22%).

c. *Irregularity in elevation*

Irregularity in elevation is characterized by abrupt changes in structural stiffness and/or mass of the building. Eurocode 8 considers a building as regular in elevation if the building itself and its structure satisfy simultaneously the following five conditions

- The lateral-force-resisting systems (frames and walls) of the building are continuous from the foundation to the top of the building.
- The storey mass and the lateral stiffness are constant along the height or decrease gradually and smoothly from the foundation (or ground level) to the top of the building. This condition can be expressed even with the ratio between storey mass and stiffness remains constant along the height of the building.
- Abrupt variation of the overstrength of the individual storey resulting from the contribution of masonry infills must be avoided
- In buildings with symmetrical setbacks (along the height), the setback on each side and at any floor should not exceed 10% of the parallel dimension of the underlying storey

- In buildings with asymmetrical setbacks, any setback on any floor should not exceed 10% of the parallel dimension of the underlying storey.

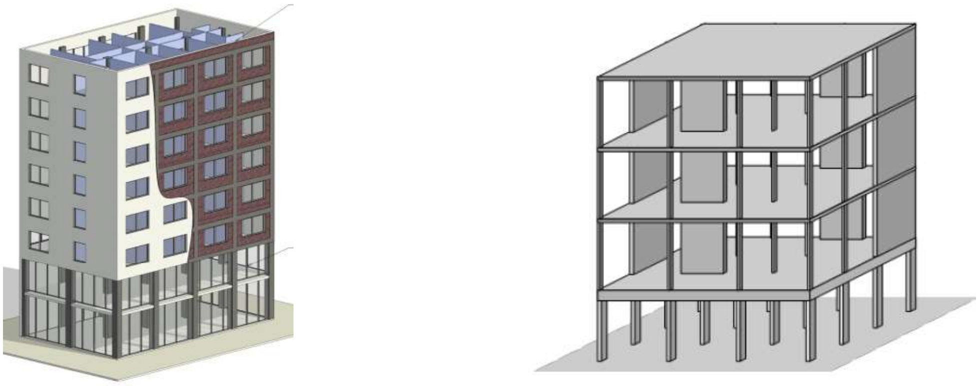


Fig. 21. Left: variable storey height. Right: discontinuity of structural walls in elevation

Fig. 22. Existing buildings with irregularities in elevation – soft storey

d. Soft story mechanism

A frequent situation of non-uniformity in elevation corresponds to the existence of a so-called soft storey, on the ground floor of a building. This may occur when:

- Ground floor height is significantly taller than those above, hence its stiffness is significantly smaller.
- Some of the vertical structural elements are discontinued to obtain open spaces on the ground floor.
- Although not strictly a structural feature, when stiff and strong non-structural elements (infill walls) are placed above an open ground floor.

Note: Same conditions are even for other storeys of the building.

e. Well-designed bearing structure

If the structure does not exhibit any of the described weaknesses, it can be considered well-designed.

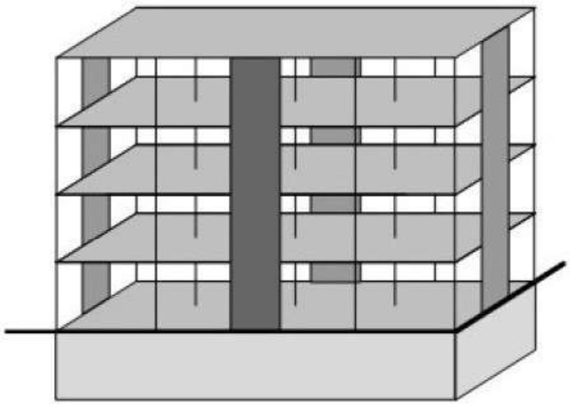


Fig. 23. Example of a well-designed seismic bearing structure

2.8.4 Additional vulnerability

Below the vulnerability matrix, are given some additional factors that can activate different failure mechanisms and as such affecting (increasing) the overall seismic vulnerability of the building. Some of them, such as short columns, incorrectly dimensioned seismic joints, deterioration of construction materials are well-known phenomena / effects that are often encountered in international construction practice. Except them, in this part of the BDUA form, are also given other factors that affect the seismic vulnerability but that are closely related to the Albanian context and the development of the construction sector over the years, such as informal constructions, constructions carried out with voluntary work, etc.

a. Insufficient seismic joints

Seismic joints are introduced to improve in-plan irregular shape buildings, so creating regular structural units but at the same time these joints must be properly dimensioned to prevent them from colliding with each other during the shakings induced by an earthquake (pounding effect). Practically, the width of the joints must be greater than the sum of the horizontal displacements of the adjacent buildings. But usually, we face problems of existing buildings with smaller seismic joints. In these cases, damage due to pounding between buildings cannot be excluded. With rigid floors on the same level, only local damage is to be expected. However, with vertically staggered floors, much greater damage can be expected, even the collapse of buildings. Accordingly, such joints must be classified as poorly designed and so resulting in additional vulnerability for both adjacent buildings.

KTP-N2-89 [17] defines the width of the seismic joints "*a*" as the maximum value of the conditions below:

$$a \geq U_{(1)} + U_{(2)} + 2cm; \;\; a \geq \frac{h}{250}; \;\;\; a \geq 3cm$$

Where: *a* is the width of the seismic joint.

U_1 and U_2 are the overall horizontal displacements of structural units, measured at the highest level of the lower unit (*h*).

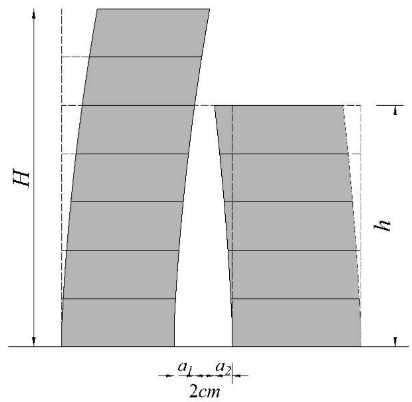


Fig. 24. Definition of seismic joint width based on KTP N2-89

EC8 [12] defines the width of the seismic joint based on the expression below:

$$a \geq \sqrt{U_1^2 + U_2^2}$$

where U_1 and U_2 have the same meaning as stated above.

EC8 [12] determines also that if the floor elevations of the building or independent unit under design are the same as those of the adjacent building or unit, the above referred minimum distance may be reduced by a factor of 0,7.

Fig. 25. Left: Adjacent building with 50cm seismic joint width. Right: damage of building due to insufficient seismic joint width (Nov. 2019)

b. *Short columns*

Short columns are structural vertical elements that are often damaged during strong earthquakes due to structural features that they present. In engineering practice, the phenomenon of "short columns" occurs in two cases:

- Short columns that are foreseen with a reduced length due to steep terrain or columns that are shortened by beams of stair landings, etc.
- Captive columns, when the height of column is "reduced" by the infill walls on both sides. Captive columns are often met in industrial or school buildings, but also in underground floors of buildings, where masonry infills are used to create openings, extending along whole span of the RC frame.

In RC frame structures, short columns are considered if the ratio Lc/ hc <4, where Lc is the clear length of the column, while hc is the largest cross-sectional dimension of the column. In these cases, the entire height of the column should be considered a critical region (Penelis).

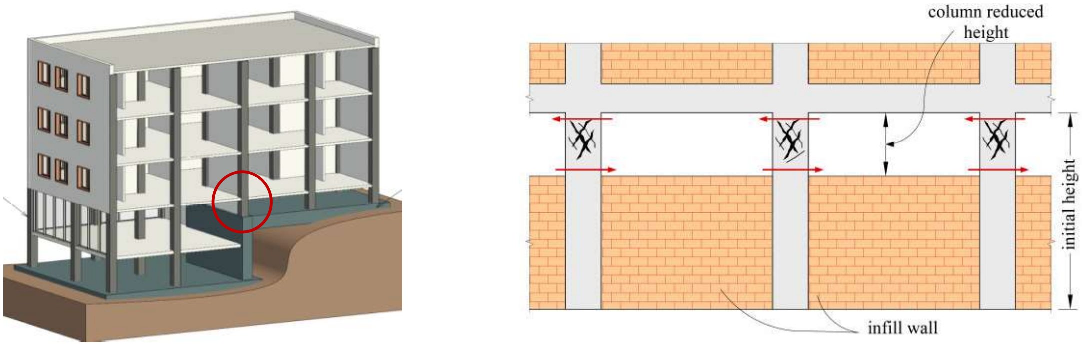


Fig. 26. Left: Short column. Right: Captive columns

These members, reinforced conventionally, have substantially different behavior under seismic (cyclic) loading, characterized by a high vulnerability to brittle failure in a mode of x-shaped diagonal splitting of concrete due to a diagonal compressive field leading to a *premature explosive cleavage shear fracture*. These elements represent an additional vulnerability for the structure and must therefore be specified.

Fig. 27. Short column due to beam of stair landing

Fig. 28. Captive columns – damaged from Nov. 2019 earthquake

In this context, special attention is needed also for parapets or tie-beams, that if not properly implemented, can create conditions for generating “short column” phenomenon, so causing serios damages during earthquake events.

Fig. 29. Left: short column effect. Middle and right: Inappropriate connection RC frame - Tie beam

c. Structures in poor condition:

The deterioration of structures depends on various factors, including the age of the building, property management, etc. Despite these factors, this section will focus on the analysis of the following technical aspects:

- Use of low-quality construction materials
- Improper execution
- Lack of maintenance
- Aging effects, carbonatization (corrosion, mortar joints)
- Raising moisture mostly in masonry buildings

Lack of maintenance is a crucial factor to prevent the accelerated deterioration of structural elements in buildings, so negatively affecting overall structural stability, particularly during seismic events.

It is important to emphasize that the issues addressed in the following section are closely related to the national context and have been predominantly observed in buildings damaged by the November 2019 earthquake.

➢ *Use of low-quality construction materials*

It is important to clarify that the issues related to construction materials, analyzed in this paragraph, do not focus on identifying or comparing the quality of materials used in different periods, since such materials were accepted by the technical codes and standards (KTP, KTZ) in force, at the time of construction. Nonetheless, from nowadays engineering perspective, they present vulnerabilities for buildings.

Another example is the use of plain rebars, as ribbed ones began to be widely used in construction at a later period. However, the absence of ribbed rebars is not treated as a critical issue in this paragraph, even though it is currently considered a minimum standard in reinforced concrete construction.

The factors increasing seismic vulnerability, as identified below, are primarily associated with the use of lower class or unsuitable construction materials compared to the building code recommendations and technical specifications, in force at the time the building was constructed.

- **Poor mortar quality:** This issue is mostly observed in masonry buildings constructed with silicate bricks, typically built through voluntary work before 1990, caused mainly by weak brick-mortar bond. The November 2019 earthquake revealed significant damage in this building typology (notably in the Kombinat area of Tirana), whereas in other areas, the same typology demonstrated good structural performance with minor damage.
- **Poor concrete quality:** This issue is evident in several reinforced concrete frame buildings, where the concrete class is significantly lower than those specified in the technical codes and standards (KTP and KTZ) in force, at the time of construction.

Although the quality of construction materials require laboratory testing to accurately determine their physical and mechanical properties, in many cases - especially in buildings damaged by the earthquake - these aspects can be judged even visually during on-site inspections by the assessment team.

The use of low-quality construction materials is often the primary cause of the deterioration of buildings in a much shorter time than their intended design life.

Special attention should also be paid to the ductile properties of steel rebars. The following example illustrates cracks formed during the bending of the bars on site.

Fig. 30. Cracks in silicate brick masonry showing weak brick-mortar bond

Fig. 31. Low quality of concrete in RC structures

Fig. 32. Cracks in steel rebars

➢ *Poor detailing and/or poor manufacturing of structural elements*

This paragraph focuses on aspects related to improper execution and poor manufacturing of structural elements. This issue is primarily associated with reinforced concrete structures - a relatively new construction technology in Albania - which began to be widely used in the residential housing sector during the 1970s. It is also important to emphasize that these vulnerability elements are more frequently observed in cast-in-place structures than in prefabricated ones.

Below are presented some of the basic requirements for column detailing that were founded not executed correctly in RC buildings, after 2019 earthquake investigations.

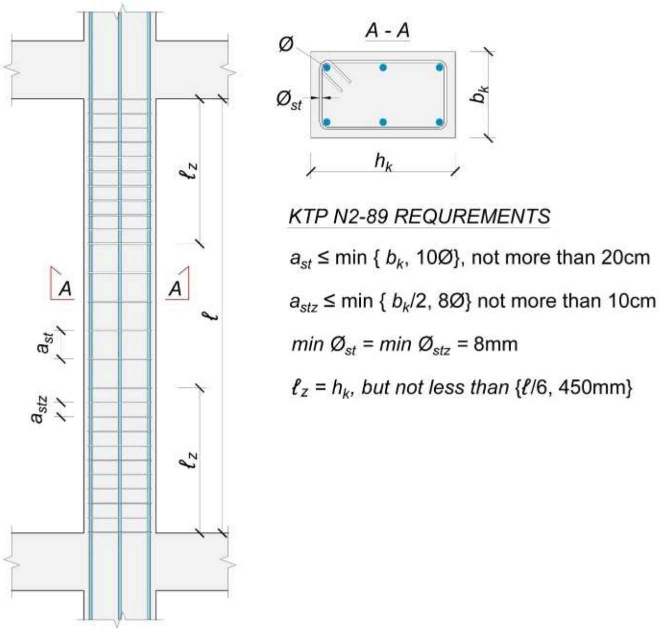


Fig. 33. Basic requirements column detailing referring to KTP N2-89

- **Closed hoop stirrups:** In many reinforced concrete buildings, assessed after the November 2019 earthquake, it was observed that properly closed hoop stirrups are missing and so, not ensuring adequate concrete confinement, despite specific requirements of KTZ 10/1-1978.
- **Stirrups spacing:** Observations showed stirrups placed at intervals of 40 cm, and in some cases even wider spacing.
- **Critical regions:** Lack of sufficient transversal reinforcement in the critical zones of RC columns.
- **Concrete cover:** The lack of adequate concrete cover, especially in areas exposed to aggressive environmental factors, negatively affects the quality of both concrete and reinforcement over time, leading to severe degradation and compromising the integrity of structural elements due to corrosion.
- **Diameter of stirrups:** As shown in the photos above, in many reinforced concrete buildings inspected after the earthquake, the use of insufficient transverse reinforcement leading to the buckling of the reinforcement.

Fig. 34. Left: Closed hoop stirrups as required by KTZ 10/1-1978. Middle: Poor detailing of stirrups. Right: Properly closed hoop stirrups.

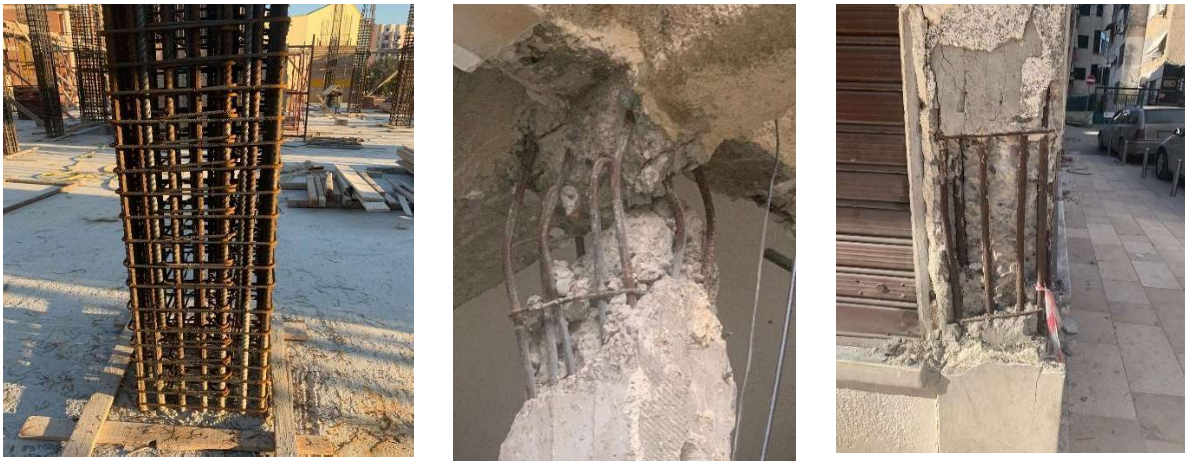


Fig. 35. Left: correctly detailed. Middle and right: Inappropriate detailing in critical regions

➢ *Lack/ inadequate maintenance*

In Albania, particularly in multi-family residential buildings, there is no tradition of regular maintenance. Most periodic works carried out are limited to superficial elements part of interior spaces (mainly repainting). As will be shown in the following paragraphs, even in cases where interventions have been made - mostly with the purpose of increasing usable residential space - they have often resulted in serious structural damage, thereby increasing the seismic vulnerability of the building. Similarly, in public buildings that have undergone renovation, the focus has almost always been on improving facade elements and finishes. In recent years, there have also been cases of energy performance upgrades, but rarely structural improvements.

Summarizing, the building is considered in **poor condition** if lateral load resisting structure has pre-existing damage:

- due to improper dimensioning (excessive cracks, settlements, deformations, etc.).
- due to execution/construction defects (non-conformity of the materials used, non-conformity of the execution details).
- due to lack/ inadequate maintenance (water infiltration, corrosion, etc.).

Typical pre-existing damages are characterized by rusted and corroded rebars. Pre-existing cracks can often be identified by the dark colored dust inside.

Fig. 36. Example of RC elementl with rusted and corroded rebars

Fig. 37. Example of building with damage due to lack of maintenance

- *Buildings constructed with volunteers (before '90)*

Involvement of future occupants of the building (the clients), in voluntary basis, in various stages of the construction process, is a construction practice that was introduced in Albania after Dibra earthquake in 1967 and last till '90 [18], [19]. The participation of unqualified individuals produced improper and incorrect execution of construction details mostly mentioned in this chapter.

There is no official evidence of buildings executed with volunteers in the territory of Albania. Information on whether a building was executed with volunteers can be obtained either from old engineers or from the building's residents. Considering the importance of this information, the assessment team should note this at the end of section 3 of the BDUA form.

d. Informal buildings

From an administrative and legal perspective, informal buildings are those ones which are constructed without a building permit and are under the current legalization process (still ongoing). The phenomenon of informal buildings started is after 1990 and continued a large scale until 2010, although some cases have been observed even after this year.

From the technical point of view, the main issue lies in the fact that these buildings are executed without proper structural design project. As a result, the structural elements and their reinforcement generally do not to comply with the standards required for seismic zones.

Even though legal procedures require that for the legalization of informal building it is needed a report from a structural engineer, which shows the integral safety of the building, there are no evidence of necessary engineering assessments has been performed. In many cases, these buildings were constructed directly by their owners, and the construction process was often prolonged over time, factors that further contribute to the increased vulnerability.

It is also important to note that most horizontal or vertical extensions, as well as structural interventions, fall into this category of informal buildings, regardless of whether they are developed on top of, alongside, or inside existing buildings. As will be analysed in the following paragraphs, these informal elements have their own specific negative impacts on existing structures.

The vulnerability of these building is also evidenced by the high frequency and severity of damage observed after the November 2019 earthquake.

Fig. 38. Development of informal buildings in the Durrës swamp area (Photo source: ASIG)

e. *Inappropriate interventions in structural system*

Inappropriate interventions in residential buildings, mainly in urban areas after the 1990s, are a massive problem for their safety, especially under seismic action. Considering the small size of the dwellings (55-75m^2), part of the typified 3-6 storey masonry buildings constructed before '90, the predominant cases of inappropriate interventions are done by the owners to increase the apartment surface. Based on the main purpose, these interventions can be categorized as below:

- Interventions in ground floor of residential buildings to make them more accessible for business purposes – partial openings of the basement, replacement of windows with doors or even more large openings.
- Lateral interventions (in all storeys) to join existing building with side extension ones – depending on the side extension volume, structural interventions consist in replacement of windows with doors or even more large openings.
- Lateral interventions (casual) to join a room with a balcony – usually large openings to join totally one room of the apartment with the 'closed' balcony.

These interventions reduce the load-bearing capacity of the building, increase the irregularity and decrease the load-bearing capacity of the foundations, all factors significantly increasing the seismic vulnerability.

Fig. 39. Ground floor intervention in masonry buildings

Fig. 40. Opening in a structural wall

f. Lateral extensions of building

Lateral extensions cause direct impacts on the existing building (especially in masonry structures) and reciprocal effects on the extension itself. A primary consequence - affecting seismic vulnerability - relates to the implementation of openings in the facade (at each storey) of the existing building to enable functional connection between the existing and the extension spaces. These openings in the existing structure led to two main issues:

- A reduction of load-bearing capacity in the area where the opening is created.
- An increase of the plan irregularity due to the partial alteration of stiffness distribution.

Other consequences associated with lateral extensions include:

- Pounding effects between the existing unit and the lateral extension - in most cases, seismic joints are either non-existent or insufficient.
- Potential damage to the foundations of the existing building caused by the nearby foundations of the extension.
- Risk of differential settlement and structural damage due to increased stress from the additional weight of the lateral extension unit.

g. Roof top extensions - added floors

Added floors are mainly found in existing 2-5-story buildings, built before the 1990s, although be found in new buildings where roof top extensions are implemented purely for-profit purposes in contradiction with the approved structural design project.

Added floors, except increasing the mass of the building, change the dynamic characteristics (increase the base-shear force and the total overturning moment). In addition, local damage phenomena may also occur due to inappropriate connections between the existing building and the added floors.

Fig. 41. Extension between 2 existing buildings

Fig. 42. Example of roof top extensions

h. Other vulnerability elements

There could be other vulnerability elements that affect the overall seismic capacity of the building, and if any is evidenced during the inspection, it must be mentioned in the BDUA form.

A typical example, that is not so frequent in Albania, are buildings with ***staggered floors***.

Horizontal displacements of adjacent buildings during an earthquake can cause significant damage to each other if the seismic joint width is insufficient. This pounding effect can have even worse consequences if the floors of the adjacent buildings are offset. In this case, the floors will collide with the vertical structural elements of the neighbouring building and can cause severe damage or even cause the collapse building.

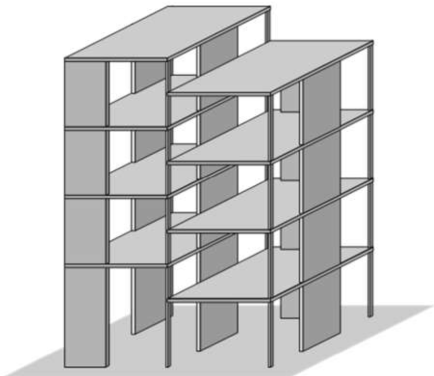


Fig. 43. Adjacent structures with staggered floors [9]

2.8.5 ***Structural typology***

In the right part of Section 3 of the BDUA form, are given different lateral load resisting systems that define main structural typologies of Albanian building stock. In addition to the basic description given in this paragraph for each structural typology (masonry, reinforced concrete, steel, wood), more specific information is referred in Annex 1 of the Manual.

Considering the importance of identifying the structural typology in the process of BDUA in post-earthquake situations, this Annex is structured into five factsheets (skeda's) that provide technical features, including elements of seismic vulnerability and damages observed in significant seismic events for reinforced concrete and masonry buildings, which are the most representative of the building stock in Albania. Specifically, the factsheets describe:

- SKEDA 1 Unreinforced stone masonry buildings (that include traditional buildings)
- SKEDA 2 Brick masonry buildings
- SKEDA 3 Large panel buildings
- SKEDA 4 Reinforced concrete frame system
- SKEDA 5 Reinforced concrete dual system

a. Masonry buildings

For masonry buildings, the BDUA form requires identifying the constituent unit of the masonry, offering six options of the main types found in Albania's building stock: stone, mud brick, clay brick (red brick), silicate brick, hollow bricks and concrete blocks.

Stone masonry and mud brick masonry, as in many countries, represents traditional construction. Clay bricks are found in the buildings before the 1945s, in parallel with the first industrial developments related to the mass production of this construction product. Silicate bricks begin to be produced in Albania after 1966 and as such find use mainly in the period 1970-1990 in 3-5 storey buildings but also in industrial or military facilities. Concrete blocks are found mainly in informal buildings in peri-urban and rural areas and less frequently in urban areas.

Considering main aspects that affect the masonry wall behaviour under seismic forces, in the BDUA form are required if stone units are regular or not and the presence of tie beams (wooden or reinforced concrete). The first input is dedicated only for stone masonry buildings.

In masonry buildings, it is appropriate to assess first the facade masonry walls (in the perimeter), with primary attention to diagonal cracks, movements or activation of out of plane mechanisms throughout the height of the building, and corner openings, mainly on the upper floor.

Fig. 44. Masonry buildings with a) stone (regular), b) mud bricks, c) clay bricks, d) silicate bricks, e) hollow bricks, f) concrete blocks

➢ *Confined Masonry*

Confined masonry consists of masonry walls enclosed within a grid of reinforced concrete beams and columns. It differs from infilled reinforced concrete frames in terms of the construction sequence: in confined masonry, the masonry elements are constructed first, followed by the casting of the reinforced concrete columns and beams. Although the strength and ductility of confined masonry are improved compared to unreinforced masonry, they generally do not reach the performance levels of reinforced masonry.

This typology in Albania having r/c columns at the edge with reinforced concrete tie beams and slabs are called **complex masonry buildings**.

For complex masonry buildings, it is important to assess the condition of the RC confining elements (columns and tie-beams) that frame the masonry and check the joined area (bond) between masonry and RC parts.

➢ *Hybrid buildings*

Hybrid or mixed buildings, from a seismic resistance point of view, are considered as a sub-typology of masonry ones. Three main categories are mainly found:

- with mixed ground floor;
- with reinforced concrete frames on one or different sides of the facade;
- with reinforced concrete frames inside the building.

The first category is designed for urban areas where there is a need for service areas on the ground floors of residential buildings. According to KTP N2-89 [17] these are called "buildings with service areas on the ground floor". This category precedes the development of reinforced concrete frame buildings and despite not having a massive development, we find them in almost all the main cities of Albania. Due to their function, reinforced concrete frames are combined with masonry only on the ground floors. It is emphasized that in the vast majority of cases, masonry elements are accepted as primary elements resisting seismic forces [17].

The second category is rare and is used mainly in buildings with administrative functions. The facade reinforced concrete frames are mainly intended to enable larger window spans.

The third category is used mainly in industrial buildings. Reinforced concrete frames (often plane ones) are introduced inside the building to enable large spaces inside the building.

The assessment of hybrid building should consider first the layout and condition of the RC system, especially when RC frames are present only at the ground floor and also determine whether the RC system acts independently or interacts with the masonry at that level.

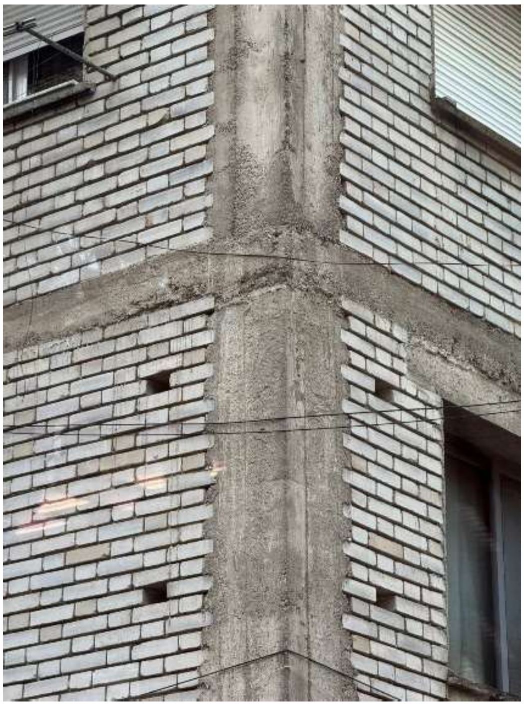


Fig. 45. Complex masonry buildings


Fig. 46.Hybrid buildings

Structural (bearing) / infill / partition walls

In masonry buildings, a distinction is made between “bearing walls” and “partition walls”, as the static function and seismic behavior of these two systems are fundamentally different. Unlike a “load-bearing wall”, the “partition wall” does not have a load-bearing function. The partition wall serves only as a space divider. Under seismic load, the partition walls are unintentionally stressed due to their in-plane stiffness, even though they do not possess the necessary resistance. To avoid ambiguities, the following are given some basic definitions for the walls, based on their function and use:

In masonry buildings are founded

- **Bearing walls:** Load-bearing elements that support and transfer vertical loads to the foundation in addition to its own weight. At the same time, these walls resist horizontal in-plane and out of plane forces, in case of seismic events.
- **Partition walls** are non-load-bearing elements that divide interior spaces within a building. Unlike structural walls, these kinds of walls are primarily used to define areas, provide privacy, or enhance aesthetics.

In reinforced concrete buildings are found:

- **Infill Walls** are non-structural masonry walls placed within the span of a reinforced-concrete moment frame and in contact with surrounding beams/columns. Although not intended to carry gravity or lateral loads, the infill walls interacts mechanically with the frame once lateral deformation occurs and can contribute significant in-plane stiffness and strength, often forming a compression strut between beam–column joints.
- **Partition walls:** Partition walls are also found in RC frame buildings with the same function as described above. Both infill and partition walls are prone of out-plane failure, thereby endangering people beside them.

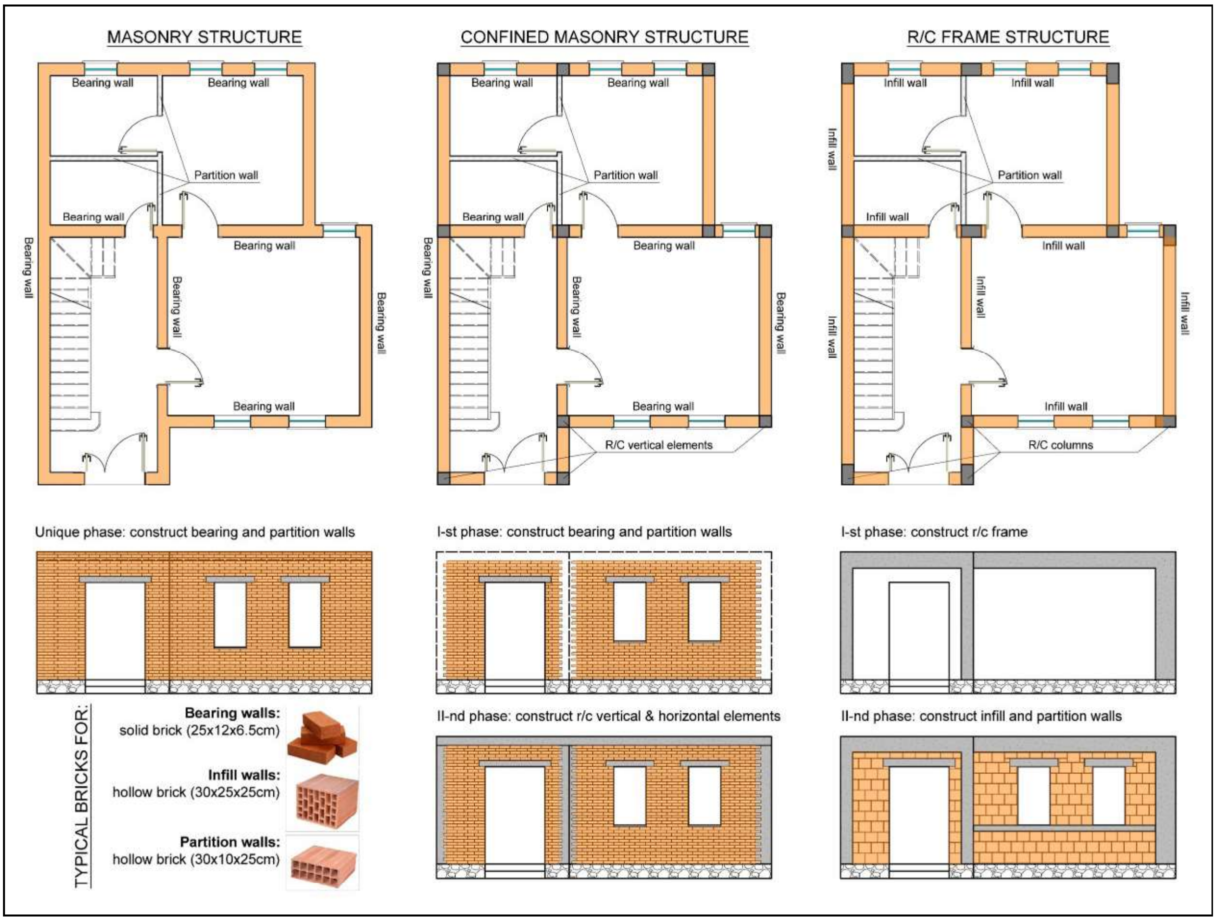


Fig. 47. Types of walls in different structural systems

b. Reinforced concrete RC

Reinforced concrete structures are divided into two main categories, as follows:

➢ *Cast in place structures:*

- Frame system = structure comprising a network of RC columns and beams that forms the structural 'skeleton' of a building.
- Core system = structures comprising RC core, typically enclosing the elevator shafts/ staircases, surrounded by frames.
- Wall system = structures comprising RC walls.
- Column system = RC structures with a column supported slab system

These four different RC-systems are listed with square checkboxes, meaning that the assessor can select all of them, if in a RC structure are founded all these elements.

➢ *Prefabricated structures:*

- P-frame system = prefabricated RC frames
- LPB system = RC Large Panel Buildings

Considering the construction technology in Albania, used mostly in the period 1970-1990, the prefabricated RC structures are preceded by round checkboxes in the BDUA form.

The most used reinforced concrete structural systems are showed below.

Fig. 48. RC frame system

Fig. 49. RC shear wall system

Fig. 50. RC large panel building (LPB)

Fig. 51. Column supported slab system

c. Steel

Steel structures in Albania are used for large public or commercial buildings (airports, train/bus stations, stadium, large hypermarkets). This structure typology is also met in industrial buildings.

Fig. 52. Different examples of steel structure with bracing and steel frames.

d. Timber

In Albania, timber is commonly used for roofs. Due to the light weight and flexibility of the wooden material, the structural damages caused by earthquakes are less frequent for timber structures compared with masonry and reinforced concrete ones, especially for small size buildings.

It should be noted that, in the traditional urban centers of Albania and even in rural ones, 2-3 storey buildings are commonly built with a stone-masonry ground floor and partially timber superstructure for the upper storeys. This traditional construction practice is evidently related to the country’s high seismicity. The infill walls in these buildings are executed as ‘çatma’ that consist of timber laths fixed to the outer side of the wooden columns, with the remaining cavity filled with thermal insulating materials.

In the last years, more and more, timber buildings and being used in touristic places. These are usually small, 1-2 story, with a basement area nearly 50-60m^2.

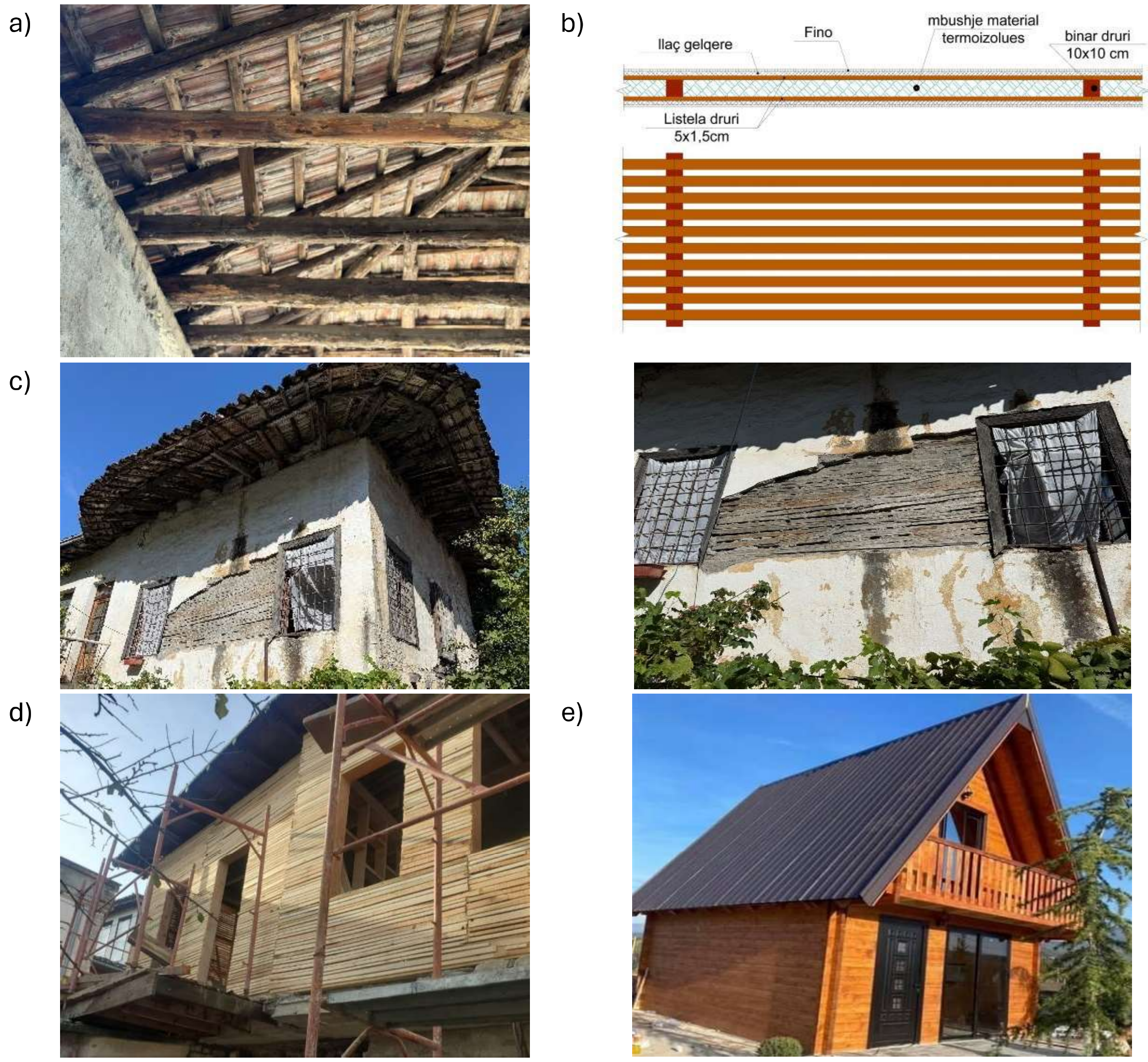


Fig. 53. a) Timber roof, b) Çatma wall details; c) Traditional house with çatme; d) reconstructed building with çatma; e) Timber touristic building

2.9 Section 4 – Damages to the load-bearing structure and immediate measures

By assessing the damage and vulnerability of the building, the structural risk (Section 9a) can be estimated in relation to the change in the load-bearing capacity of the structure compared to the original initial state and original state of accuracy. For buildings that have been designed according to modern standards for earthquake-resistant construction (Eurocodes and KTP), this initial state conceptually should correspond to an accepted minimum level of safety for the standard earthquake impact of a given zone. For other buildings, like informal ones, this level of safety cannot be assumed.

An assessment based on a visual inspection, such as the usability assessment, cannot aim to guarantee a specific absolute level of safety. The knowledge gained from observing and interpreting the visible damage - to the extent that it is visible at all, during an inspection - makes it possible to estimate the changes in the structural elements (section 4) and secondary components (section 5) caused by the earthquake and their influence on the reduction of the building's safety.

If serious damage (obvious separations between slabs and walls, partial collapses, breakage of frame joints) is detected, a building can normally be rapidly classified as unusable due to obvious structural damage. In the case of less obvious damage, however, it is important to understand the type of changes caused by the earthquake and the corresponding failure mechanisms in order to estimate how much structural safety has been reduced compared to the original state, and to understand the general conception of the building to give an idea of the overall adequacy of the structure in the case of earthquake loading.

2.9.1 Determining the damage level

This section is intended to help the assessor become aware of where damage is present and how relevant it is. It is then necessary to distinguish the damage to the structure as a result of the earthquake from that which already existed before, even the general damage situation is considered in the final assessment. In addition, it is only possible to identify the damage visible during the inspection. It must also be considered that the condition of the building before the earthquake is generally classified as safe, even if today's earthquake standards were not applied accordingly.

On the left-hand side of section 4, the visible damages or those discovered through basic inspection tests during the visit must be entered, regardless of whether it was caused by the earthquake or already existed beforehand.

On the right-hand side of section 4, the immediate measures carried out before the inspection are entered, for example those implemented during the acute phase (search and rescue teams). It can be indicated whether:

- Structural components were demolished preventively.
- Tension bands were used, or strapping was carried out - to prevent an out-of-plane fracture mechanism.
- Shoring or propping was installed or whether barriers were erected to protect passers-by.

SECTION 4: STRUCTURAL DAMAGE & RESIDUAL SEISMIC CAPACITY (incl. immediate measures carried out)

Damage level & extent / Structural elements & pre-existing damages	Missing part	DAMAGE LEVEL: Extreme		Severe		Moderate		Light		None	Immediate measures carried out: None	Demolition & removal	Belting and/or rods	Repairs	Propping	Barriers/ protected passage
		>1/4	<1/4	>1/4	<1/4	>1/4	<1/4	>1/4	<1/4							
Vertical primary seismic elements	❍	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐
Connections between vertical & horizontal structural element	❍	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐
Floors / Horizontal structural elements	❍	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐
Roof	❍	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐
Gravity load bearing columns	❍	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐
Pre-existing damages		☐	☐	☐	☐	☐	☐	☐	☐	❍						
Infill / partition walls	❍	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐

Summary of section 4 ____________________

Seismic capacity: ❍ highly reduced ❍ moderately reduced ❍ slightly reduced ❍ precise in section 11

Fig. 54. Presentation of the Section 4 of BDUA form

The first five lines refer to the visible damage to the bearing structure in the following order:

- **Line 1 / Vertical primary seismic elements:**

  Structural components of a building dedicated to resist seismic actions (in masonry structures: *bearing walls*; in reinforced concrete structures*: RC column in frame structures and RC shear walls*).

- **Line 2 / Connection between vertical & horizontal structural element:**

  In masonry buildings, the connections between floors and load-bearing walls are critical in determining the ability of the floor system to effectively transfer seismic loads to the supporting structural elements. These connections are essential to ensure the "box-like behavior" of the building, which enhances its overall seismic performance. To achieve this, ring beams (also known tie beams) are typically used. In reinforced concrete cast in place buildings connections between vertical and horizontal elements, meaning joints between RC column, walls and beams are rarely damaged, and if happening is caused mostly by the missing of the hoops in the joint region. In prefabricated reinforced concrete buildings (LPB) it is also important to check joints between vertical panels and horizontal structural elements

- **Line 3 / Floors and horizontal structural elements:**

  Damage to floors or other horizontal structures that can ensure a diaphragm behavior of the inter-storeys. In this line it can be introduced also the relative sliding or gaps created between slab panels. In this line are introduced also the damages in reinforced concrete beams, if any.

- **Line 4 / Roof:**

  Damage to the roof structure. The last line (line 6) records damage that already existed before the earthquake, like differential settlements, etc. The owner can provide relevant information regarding these damages.

- **Line 3 / Gravity load-bearing columns:**

  Structural elements dedicated to support gravity loads, without being part of the lateral load-resisting system. These columns do not dissipate energy or maintain ductility during earthquake loading. In most conventional reinforced concrete frame buildings, the same column system typically resists both gravity and seismic loads and these types of elements (gravity load bearing columns) are missing. However, in some nowadays structural systems, particularly in dual ones or with in-plan irregular configurations, certain columns are excluded from the seismic force-resisting system and are assigned to carry only gravity loads.

- **Line 6 / Pre-existing damages:**

  Damages that already existed before the earthquake. The owner can provide relevant information regarding these damages.

- **Line 7 / Infill / partition walls:**

  These elements are nonstructural ones, but are included in the structural damage table considering their affect to the overall behavior of the structure,

2.9.2 Damage level

Before assessing the damage, it is first necessary to analyze whether the structural elements listed in the rows of section 4 are present in the building. The focus here is on the presence of the roof and the gravity load bearing columns, since the primary seismic elements, joints and horizontal structures are always part of the building, regardless of their condition. The same applies to the infill walls in the case of reinforced concrete buildings, since in masonry buildings these are absent.

In the BDUA form, the damage of structural elements is classified based on both severity and extent. The severity (DL) refers to the condition of the damaged structural elements and is categorized into four levels: light, moderate, severe, and extreme.

The damage extent is determined by the ratio between the number of damaged elements and the total number of structural elements of the same group, in the building (e.g. damaged columns are compared to the total number of columns). In the form, the threshold of 1/4 (25%) is used to indicate the damage extent, i.e. less than 25% or more than 25%. Rather than calculating the exact ratio [(damaged elements) / (total no. of elements)], this threshold is intended to distinguish whether the damage is local or widespread throughout the building.

The damage classification is simply done by checking the squares of the table relevant for the case under study, with the following considerations:

- Each square corresponds to a given damage grade and respective extension of that damage grade;
- The whole list of structural elements/components must be considered:
  - If no damage is noticed for any one of them, the option 'None' must be checked (circle) and the other square checkboxes in that row should not be checked.
  - If some damage is observed, the corresponding squares should be checked.
- Do not leave rows blank. Based on field inspection, if the element is missing (note it), if has no damage (note it), or if it has damages fill the row based on the rules above
- The rows of section 4 are used to describe the total visual damage to each component at the moment of the inspection, i.e. the visible changes with respect to an ideal original condition of the building, without any damage.
- The sixth row is used to evidence pre-existing damage of the building, in global terms, presumably existing before the seismic event is described.

The extent of damage is quantified by the ratio of the number of damaged elements to the total number of corresponding elements in the building. The threshold of 1/4 (25%) is introduced to distinguish between localized damage and widespread ones.

- For each component, the sum of the damaged relative extensions must not be larger than 1. For example, it is not logic, to associate the damage extension >1/4 to all levels of damage for the same structural element.
- On the other hand, when, in one component, the sum of the relative extensions is less than 1, it means that somewhere in the building that component did not suffer any damage. For example, in case of a r/c frame building, if in row 1, the extension <1/4 is associated both to Light and Moderate and no extension is associated damage level Severe and Extreme, it means that at least 50% of the element of the building did not suffer any damage.

- In case of roofs, the reference for the extension of the damage can be made considering the damaged roof surface (referring to the total covered area).

However, this quantitative criterion may, in certain cases, lead to a misinterpretation of the structure's overall residual seismic capacity. For example, the theoretical example below illustrates two reinforced concrete frames, each with four damaged columns (shown in red). Although the number of damaged elements is the same, their location within the structural system significantly influences the overall capacity. Without going into detailed calculations, it can be accepted that the first frame has a greater reduction in seismic capacity compared to the second one.

Fig. 55. Example of RC frames with same quantity of damaged structural elements but different residual seismic capacity

The example again brings to attention that, in the BDUA process, the main component for an accurate assessment is the knowledge and experience of the expert involved, who during a quick visual inspection manages to read, interpret and classify the damage according to the possibilities given in the form.

Another important aspect is the difference between the degree of damage to structural elements and the structure as a whole. Specifically, the quantitative assessment of damage for structural elements is classified into 4 levels, while the assessment of the overall damage to the structure is expressed through the reduction of seismic capacity which is classified into 3 levels (highly, moderately or slightly reduced).

In cases where no damage is observed during the visual inspection of a building, the BDUA form provides the possibility to mark "None" for all structural elements, meaning that there is no visible damage. But in the "language" of the BDUA form, when assessing the structure as a whole, we must accept that the seismic capacity, in this case, has been slightly reduced, meaning that there is minimal damage to the structure that is not perceived with the naked eye.

a. Damage of masonry elements

There are different types of masonry walls (see Chapter 2.8.6 - Section III of the BDUA form) that are distinguished, both in terms of the materials (brick, stone and concrete) and the way of construction. These differences should be considered when assessing visible damage (e.g. cracks and their extent) in relation to the corresponding structural risks.

- ➔ **Light Damage:** Hairline or fine cracks in plaster or mortar joints; no cracks through the masonry units; no detachment or loss of material; no structural impact.
- ➔ **Moderate Damage:** Cracks along mortar joints and/or through individual masonry units; minor detachment of plaster; limited and localized spalling; the wall retains its structural function but shows early signs of degradation.

- **Severe Damage:** Wide cracks extending through masonry units and mortar joints; partial dislocation or loss of bricks/blocks; localized out-of-plane deformation or bulging; reduction in load-bearing capacity is evident.
- **Extreme Damage:** Large displacements, collapse of wall portions, or complete out-of-plane failure; widespread loss of units; wall stability is critically compromised; imminent risk of partial or total collapse.

DL light: Shear cracks at the masonry spandrel

DL Moderate: Shear cracks at masonry wall

DL Severe: Large cracks at masonry wall

DL extreme: Masonry wall with large displacements

Fig. 56. Example of damage level in masonry walls

b. Damage to reinforced concrete elements

This subchapter provides information to correctly classify the different damage levels referring to reinforced concrete elements.

- **Light Damage:** Presence of thin cracks without spalling; no visible reinforcement; no loss of section integrity.
- **Moderate Damage:** Well-defined cracks with initial signs of localized and superficial spalling; reinforcement remains covered; minor surface deterioration.
- **Severe Damage:** Concentrated wide cracks with significant concrete spalling; reinforcement bars are partially or fully visible; noticeable reduction in section stiffness.
- **Extreme Damage:** Rupture or buckling of reinforcement bars; extensive disintegration of concrete core within the reinforcement cage; structural integrity of the column is compromised. For elements with brittle behavior is common to distinguish light and extreme damage.

DL Light **DL Moderate**

DL Severe **DL extreme**

Fig. 57. Example damage level in reinforced concrete columns

2.9.3 Residual seismic capacity

The table on the left side of section 4 is linked with immediate measures carried out (e.g. by SAR teams) before the team of assessors investigates the building.

While the last part of the section is a conclusion linked with the residual seismic capacity of the structure. Based on quantity and severity of the damaged elements but also in engineering interpretations, the team of assessors must select one of the three choices:

- Highly reduced
- Moderately reduced
- Slightly reduced

Below are given some key definitions for each of them based on basic definitions of international standards (FEMA P-58 Seismic Performance Assessment of Buildings).

Highly Reduced:

- The structure has suffered substantial damage that severely compromises its seismic performance.
- Key load-bearing elements are heavily damaged or failing (e.g., buckled columns, shear failures).
- Loss of global stiffness, strength, and energy dissipation capacity.
- The risk of partial or total collapse under further seismic action is significant.
- Immediate intervention, shoring, or demolition may be necessary.
- Indicative residual capacity: <50%

Moderately Reduced:

- The structure has experienced noticeable degradation in its lateral load-resisting system.
- Damage affects primary structural elements (e.g., beams, columns, or shear walls) in multiple locations, but without widespread instability.
- Redistribution of internal forces has occurred, and ductility demands have increased.
- The residual capacity under future seismic loads is compromised, and targeted repair or strengthening is required.
- Indicative residual capacity: ~50–80%

Slightly Reduced:

- The structural system retains most of its original lateral strength and stiffness.
- Damage is limited to non-critical elements or localized regions.
- Structural continuity is preserved, no significant redistribution of internal forces.
- Expected performance under future seismic events remains close to the original design level.
- Functionality may be partially affected but no major intervention is required.
- Indicative residual capacity: >80%

2.10 Section 5 – Damage to non-structural elements

SECTION 5: DAMAGE TO NON-STRUCTURAL ELEMENTS (and immediate measures carried out)

Observation / Type of damage	Damages	Immediate measures carried out: None	Demolition & removal	Prohibited access	Repairs	Propping	Barriers / protected passages
Damage to facade elements, cladding elements	❍	❍	☐	☐	☐	☐	☐
Detachment of plaster, coating, false ceiling	❍	❍	☐	☐	☐	☐	☐
Roof tiles falling, chimneys, gutters,	❍	❍	☐	☐	☐	☐	☐
Cornices falling, parapets, balconies, eaves	❍	❍	☐	☐	☐	☐	☐
Other objects falling (inside and outside)	❍	❍	☐	☐	☐	☐	☐
Stairs (emergency exits)	❍	❍	☐	☐	☐	☐	☐
Damage to drinking water supply network	❍	❍		☐	☐		☐
Damage to sewage water network	❍	❍		☐	☐		☐
Damage to power supply network	❍	❍		☐	☐		☐
☐ Gas network ☐ Telecommunication ☐ Other ____________		❍	☐	☐	☐	☐	☐

Fig. 58. Presentation of the Section 5 of BDUA form

Secondary (non-load bearing) elements can play an important role in assessing building usability. Certain components may pose a danger to users and passers-by and sometimes mean that a building can no longer be used. For this reason, twelve frequently identified types of damage have been listed in this section. The first seven are types of damage to non-load-bearing components inside the building or on the facade, and the other five are damage to the various connections for supply and disposal (water, gas, electricity, telecommunications). Additional damages can be defined in the last line of the table.

For the listed elements, it must first be mentioned whether they are damaged and whether measures were already taken before the inspection. If this is not the case, the “None” box must be checked. If measures have already been taken, they must be mentioned. The five most common immediate measures are listed for you to check.

The usability of buildings is often impaired by damage to secondary elements. However, the hazards they pose can often be eliminated by simple and quick measures. The recommended measures must be described in Section 9b. In many cases, removal of the damaged component can be an effective measure. Other possible measures are mentioned in Section 9b. Below are some examples of secondary components damage and the risk they pose.

Infill wall out of plane collapsed. The danger could be eliminated by removing the walls

Damage of the chimney. The danger could be eliminated by demolishing & removing the chimney

Facade walls at cantilever volumes. The danger could be eliminated by prohibiting the access below

Detachment of the plaster. The danger could be eliminated by removing the plaster

Collapse of the partition wall. The danger could be eliminated by demolishing & removing the walls

Parapet collapse. Remove the parapet over the entrance and prohibit the access around

Damaged stairs. After verification correctly it can be decided to use the stairs and repair the concrete cover after or install wooden/steel stairs to access

Fig. 59. Example of immediate measures for non-structural elements

2.11 Section 6 – External dangers and immediate measures taken

SECTION 6: EXTERNAL DANGERS (and emergency measures carried out)

Implications / External danger	Not identified	Danger for: Buildings	Danger for: Access paths	Danger for: Internal paths	Emergency measures: Propping	Emergency measures: Barriers / protected passages
Collapse of an adjacent building	❍	☐	☐	☐	☐	☐
Falling of other adjacent elements	❍	☐	☐	☐	☐	☐
Broken pipes	❍	☐	☐	☐	☐	☐
Rockfall / landslide	❍	☐	☐	☐	☐	☐
Other:..	❍	☐	☐	☐	☐	☐

Fig. 60. Presentation of Section 6 of BDUA form

This section deals with hazards in the immediate vicinity of the buildings being assessed. These are mainly dangers due to the collapse of nearby buildings or the breakage of distribution pipes or geological origin (buildings in hilly terrain) or leaks from pipes. For this type of danger, it is first necessary to indicate whether they directly affect the building, the access routes to the building or, in the case of buildings of a certain complexity, the internal routes.

In this section, it is also appropriate to specify whether emergency measures have already been adopted before the inspection.

2.12 Section 7 – Subsoil and foundation

SECTION 7: SUBSOIL AND FOUNDATION

Ground morphology
❍ Crest
❍ Steep slope
❍ Mild slope
❍ Flat

Instability of foundation	
❍ Not identified	
❍ Landslide	❍ Feared/ expected
❍ Liquefaction	❍ Pre-existents
❍ Settlement	❍ Caused by earthquake
	❍ Worsened by earthquake

Subsoil: Description		Eurocode	KTP
Good	❍	A	I
Medium	❍	B, C	II
Poor	❍	D, E	III
Special	❍	S1, S2	
Unknown	❍		

Fig. 61. Presentation of Section 7 of BDUA form

This section does not aim for a detailed geological description of the terrain around the assessed building but rather serves to inform in a very simple way if problems due to the ground and foundations are expected and so indicates if expert investigations are needed (to be indicated in section 9c).

In the first part, the terrain morphology of the site where the building is located is indicated. If the building is on a hill (crest), increased seismic loads can be expected. If the building is on a slope, rock falls or landslides are possible.

In the middle part of Section 7 on the right-hand, various instabilities are listed (landslides, rock falls, soil liquefaction or foundation settlement) while on the left-side, whether the instabilities are “feared/expected”, “pre-existing to the seismic event”, “earthquake related” or “aggravated by the earthquake”.

In the right part of the section, is defined the category of soil on which the foundation of inspected building is located, if known. In the long term this information should be entered automatically by the BDUA application.

2.13 Section 8 – Summary

SECTION 8: SUMMARY SECTIONS 3, 4, 5, 6 & 7					
Section 3	Seismic design (layout):	❍ inappropriate	❍ partially appropriate	❍ appropriate	❍ precision in section 11
Section 4	Seismic capacity:	❍ highly reduced	❍ moderately reduced	❍ slightly reduced	❍ precision in section 11
Section 5	Danger from non-structural elements:	❍ high	❍ moderate	❍ low	❍ precision in section 11
Section 6	External danger:	❍ high	❍ moderate	❍ low	❍ precision in section 11
Section 7	Danger related to subsoil/ foundation:	❍ high	❍ moderate	❍ low	❍ precision in section 11

Fig. 62. Presentation of Section 8 of BDUA form

Section 8 is a summary of the previous sections 3 to 7. The assessor teams are asked to reflect on the info collected and reach a global conclusion. It provides an overall overview of the situation as a basis for the assessment of usability in the following section 9.

It should be noted that the selections (markings) made in relation to sections 3 and 4 should be consistent with the assessment results previously made at the end of each of these sections. As regards the assessment of the issues addressed in sections 5, 6 and 7, the assessment team should make a joint judgement to decide on the level of risk for each case.

2.14 Section 9 – Usability assessment

Once sections 1 to 8 have been filled out, the final assessment of **usability** can be made. The section 9 serves as an aid to do this. The final assessment is based on experience and purely qualitative. It includes all the criteria in the checklist on the damage identified to the structure and secondary components, the environmental hazard, the structural properties and the intended use. Due to the acute risk of aftershocks, a reference earthquake excitation should be considered in accordance with the instructions of the operations management.

The final assessment serves as the basis for the responsible authority to decide on further use or closure. The final decision lies exclusively with the responsibility and authority of the responsible authorities and can therefore deviate from the purely technical assessment result. There can for example be security reasons (policing) to prevent the use of a single, technical usable building, in a quarter of the great destruction. On the other hand, it should not occur that the authorities approve the continued occupancy of a technically dangerous (unusable) building.

2.14.1 Section 9a Assessment of usability

In this section, the final assessment of the usability of the building is carried out based on the tables "Risk assessment" and "Result", into which the results of the previous of sections 3 to 8 are considered.

"Post-earthquake usability assessment is a temporary, rapid evaluation - i.e., based on expert judgment and conducted within limited timeframes, based on simple visual analysis and readily accessible information - intended to determine whether, during an ongoing seismic crisis, earthquake-affected buildings can be used while keeping human life reasonably protected."

For the assessment, one of the five categories listed in the "resulting assessment" table must be selected, whereby the following two steps must be followed.

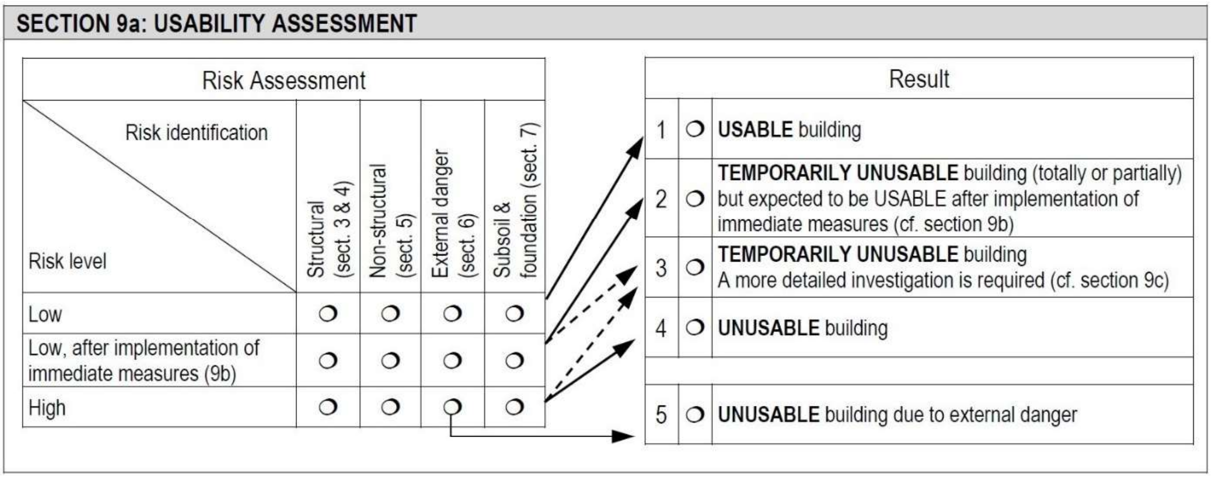


Fig. 63. Presentation of the Section 9a of BDUA form

a. Step 1 - Risk assessment:

As a first step, the results of the previous sections 3 and 4 regarding the earthquake-proof design and the residual load-bearing capacity of the structure, section 5 regarding the risk of collapse of the secondary components, section 6 regarding environmental hazards and section 7 regarding the geotechnical hazards are transferred to the "risk assessment" table.

b. Step 2 – Result:

In a second step, the building is to be classified into one of the five possible categories (1 to 5). Starting with category 5, all categories up to category 1 are considered for the classification, i.e. the most severe damage is considered first. The arrows between the two tables in section 9a show the possible decision directions, with the solid arrows representing the standard case and the dashed arrows representing special cases that, under certain circumstances, show an alternative decision direction.

➔ **Category 5: Building unusable due to external circumstances**

If the field "high" is marked in the "external danger" column in the "risk of collapse" table, the building is to be assigned to category 5 "unusable due to external circumstances". This assignment is made independently of other markings in the "risk assessment" table.

➔ **Category 4: Building unusable**

If at least one field is marked "high" in the columns for structure, secondary components or geotechnics, the building should generally be assigned to category 4 "unusable".

➔ **Category 3: Building temporarily unusable until a detailed reassessment**

If there are serious doubts about the reliability of a “high” marking in the “risk assessment” table, category 3 “temporarily unusable until a detailed reassessment” can be selected as an alternative. However, if several fields are marked “high”, category 4 “unusable” should be retained.

➔ **Category 2: Building temporarily unusable**

If at least one field “low after implementation of immediate measures” is marked in the columns supporting structure, secondary components or geotechnics, the building is generally assigned to category 3 “temporarily unusable until detailed reassessment”.

For buildings in building cat. I with a low number of people, where easy-to-implement immediate measures have been identified as efficient, category 2 “temporarily unusable after implementation of immediate measures” can be selected as an alternative. However, if several fields are marked “low after implementation of immediate measures”, category 3 “temporarily unusable until detailed reassessment” should be retained.

➔ **Category 1: Building usable**

If all four fields are marked “low” in the “**Risk assessment**” table, the building is to be assigned to first category “**usable**”.

Example explanations linked to Section 9:

As a precautionary measure and considering a possible shift of the epicenter towards the building being assessed, **inappropriate** seismic design of the structure to absorb the earthquake forces (section 3) represents a high risk and normally lead to result 4 “**Unusable**”, regardless of the extent of damage to the load-bearing elements.

If the seismic design of the structure is “**partially appropriate**” or “**appropriate**”, it depends on the remaining capacity whether the building is still **usable or not**.

If the seismic design of the structure is “**appropriate**” and the residual capacity seems “sufficient” (**slightly reduced** or even moderately reduced), the result is “**Building usable**” (provided the risk associated with secondary elements is low) or Result 2 “**Building temporarily unusable**” (if emergency measures must be implemented to a limited extent in accordance with Section 9b).

2.14.2 Section 9b Immediate measures

The measures described in this section are intended either to restore the usability of the building or to ensure public safety. They must be able to be carried out quickly, easily and inexpensively. Some measures may be necessary even when the building is usable, if the public safety is at risk. For example, if bricks are likely to fall, they must be removed regardless of the condition of the building (provided the removal can be done with reasonable risk for the workers).

SECTION 9b: IMMEDIATE MEASURES, limited (*) or extensive (**) extent					
*	**	Suggested immediate measures	*	**	Suggested immediate measures
☐	☐	Belting and/or installation of ties	☐	☐	Installation of barriers and/or protected passageways
☐	☐	Repair of light damages to infill panels and partition walls	☐	☐	Repair of supply networks
☐	☐	Roof repair	☐	☐	Waterproofing
☐	☐	Propping	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☐	☐	Removal of plasters, coating, false-ceilings	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☐	☐	Removal of roof tiles, chimneys, gutters	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☐	☐	Removal of cornices, parapets, eaves	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☐	☐	Removal of other internal or external objects	❍		None
This table is completed by additional indications: ❍ in section 11 ❍ in appendix sheet					

Fig. 64. Presentation of Section 9b of BDUA form

It is important to consider that neither the execution nor the monitoring of the execution of the emergency measures are part of the tasks of the building assessment team. The emergency coordination unit is responsible for the implementation of the emergency measures and the organization of the second inspection that allows to confirm the change of the result from 2 "temporarily unusable" to 1 "usable".

The most common measures are listed in the table of this sub-section. The list is intended to provide a quick overview on the one hand and to simplify communication with other disaster relief actors and electronic data processing on the other. The list is not exhaustive. Additional measures that are necessary for a building can be listed in the last four lines. For each measure taken, it is stated whether it is to be carried out to a limited (*) or expanded (**) extent. This serves to estimate the effort and can support the planning of the emergency services.

The measures proposed in the previous steps must be described or outlined in more detail in Section 11, "Further observations, sketches and/or records" in the pre-printed appendix (see Section 11) or on another sheet. If a sheet is used, this must be checked in the appropriate box at the end of the section below the table.

Most measures relate to one of the following activities (listed in order of increasing effort):

- Removing debris
- Repairing
- Reinforcing

It is important to ensure that the proposed measures can be implemented quickly, easily and with limited technical and financial resources, so that they can be carried out without detailed descriptions by qualified people. It is important to keep things brief and not to write down every renovation proposal in detail.

Here are some comments on the measures listed:

- When removing debris (plaster, cladding, suspended ceilings, bricks, chimneys, cornices, parapets, others), the aim is primarily to remove secondary damaged components and not to demolish the building.
- The choice between shoring, tie installation or tension bands/ground anchors depends on the ease of implementation and the space available. Shoring can be implemented easily and often from the outside and is relatively inexpensive. The service life must also be considered. Over time, the effectiveness of wooden bracing decreases. It should be noted that bracing is much less effective in the event of aftershocks. Tie-downs and tie-downs are very effective when the building is in danger of falling apart. They also withstand dynamic forces (aftershocks) quite well.
- Ties and tension bands/ground anchors can prevent collapse and help maintain the structure. They are mostly used when there is a risk that facades could tip over or that facade elements could detach. They are also used for arches, vaults or other roof structures that cause horizontal forces. Round or laminated steel profiles are often used, although other materials can also be considered.
- Temporary repair of a roof structure usually involves also the repair of tiles and waterproofing. It is important to consider recurring phenomena such as wind or snowfall.
- Plaster, cladding, suspended ceilings, bricks, chimneys, cornices, parapets and other elements must be removed as soon as they are in danger of collapsing either inside or outside the building.
- If a publicly accessible area is at risk due to unstable building parts (risk of falling) or other risks such as unstable terrain, barriers or protected passageways must be implemented.
- Repairing the services (electricity, water, wastewater and gas) makes it possible to keep a building usable. If repairs are not sufficient, the place must be secured, and the networks affected must be closed. Since the assessors are on site, it is useful to make an overall judgment, but the network companies must decide.
- Waterproofing the roof structure or the external walls prevents other parts of the building from being affected by bad weather conditions.

Fig. 65. Example of shoring / propping

Fig. 66. Example of belting

2.14.3 Section 9c Second inspection required

SECTION 9c: SECOND INSPECTION REQUIRED (to be only filled in if the assessment result in section 9a is 3)			
Reason for second inspection: |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|			
❍ partial inspection	❍ no inspection	❍ Disagreement within assessment team	❍ Geologist advice required
❍ other: |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|			

Fig. 67. Presentation of Section 9c of BDUA form

This section should be completed only for buildings that are temporarily unusable until a more detailed assessment has been carried out (category 3). The reason for a second inspection should be recorded here. The most common reasons (partial inspection, no inspection, disagreement in the expert group, opinion of a geologist required) are listed as options; other reasons should be noted under "Other". Disagreement within team should be a rare exception because the teams are instructed to strive towards a common understanding of the structure and its risks and therefore to a common assessment result. Specific uncertainties should be described in detail in section 11 so that a later second assessment can be carried out in a more targeted manner.

2.14.4 Section 9d Temporary shelter needs

SECTION 9d: Temporary shelter needs (only for residential buildings, if the assessment results: 2, 3, 4 or 5 in section 9a)			
Inhabited during inspection:		❍ yes	❍ no
Number of families to be relocated:	|__|__|__|__|	❍ actual number	❍ estimated number
Number of people to be relocated:	|__|__|__|__|	❍ actual number	❍ estimated number

Fig. 68. Presentation of the Section 9d of BDUA form

If the building is classified as temporarily unusable (categories 2 or 3) or unusable (categories 4 or 5), the number of households and people to be relocated is to be indicated, whether they are present or not during the inspection. It should also be specified whether the number of users indicated is an estimate or more precise information provided by the owner or accompanying person, or whether this information is based on a database. This will enable the responsible authorities to determine precisely the number of alternative accommodations required.

2.15 Section 10 – Information about inspection

SECTION 10: INFORMATION ABOUT INSPECTION

Details of inspection:

- inspected	❍ outside only	❍ partially	❍ complete (>2/3)		
- not inspected, because:	❍ inspection refused	❍ ruin / collapsed	❍ risk of collapse	❍ demolished	❍ renovation
	❍ under construction	❍ abandoned	❍ unused	❍ absence of accompanying person	
	❍ other: |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|				

The usability assessment is based on a quick evaluation in a post-earthquake crisis situation. The assessment provided has temporary validity and does not correspond to a detailed assessment which show clearly the building structural safety. The building assessment team is not liable for any damage to property or personal injury resulting from the assessments made in this form.

Building assessment team:	Last name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	Signature ________________
	First name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	
	Last name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	Signature ________________
	First name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	
	Last name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	Signature ________________
	First name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	

The undersigned confirms that he/she accompanied the building assessment team during the inspection

	Last name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	Signature ________________
	First name: |_|_|_|_|_|_|_|_|_|_|_|_|_|	

Fig. 69. Presentation of Section 10 of BDUA form

In the section 0 are given general data linked with organizational aspects of the inspection, while in section 10 are presented also technical aspects including the inspection team identification.

The first part can provide a "quantitative" description of the inspection, specifying whether the team assessed only the exterior part (outside), partially or completely the building. As stated in the form, a building is considered fully inspected when it is possible to perform a visual assessment of 2/3 of the building (structural elements).

Regardless of the degree of damage, buildings can almost always be inspected from the exterior and there are very few cases where this is impossible. If the building is not inspected or is inspected only from the exterior, then it is mandatory to specify the reason that made it impossible to perform the assessment. In the following are given basic explanations for the reasons that a building is not inspected. In case that the BDUA form the reason is not listed, then "other" should be selected by showing on the answer.

- **Refused –** inhabitants refused the building inspection. If this happens, the team should only do it from the outside.
- **Ruin /collapsed –** indicates that the building has collapsed due to the earthquake. This is an important aspect to highlight for the shelter needs but also for subsequent statistical analyses related to earthquake consequences.

- **Risk of collapse –** is the case when, the assessment team concludes that entering the building carries a high risk of collapse and in these conditions the inspection process is closed without going inside.
- **Demolished –** specifically when the building is demolished in a controlled way, by the responsible authorities.
- Reconstruction – selected in the case when construction works are in process, and so the building is empty. Focusing on the BDUA, it is important to note that these buildings were not occupied at the moment that earthquake happen and are not expected to be occupied in the following days/weeks. This is a circumstance that does not require to evidence shelter needs.
- **Under construction –** these are buildings for which the process of construction has not yet been completed and as a result they are not expected to be occupied during the crisis management.
- **Abandoned –** information on abandoned buildings is initially assessed during the site visit, where elements that indicate this status can be clearly identified (roof collapsed, missing windows and doors, etc.). However, in these cases, additional information can also be obtained from the neighbors.
- **Unused –** selected for newly completed buildings but which, for various reasons, are not functional, i.e. have not yet started their own operations.
- **Absence of accompanying person –** as referred to in section 1 of the form, this is the reason for not performing the results.

Before the identification of the inspection team, a statement is placed on the validity of the form, describing the main purpose and responsibilities of the experts in this process:

"The usability assessment is based on a quick evaluation in a post-earthquake crisis situation. The assessment provided has temporary validity and does not correspond to a detailed assessment which show clearly the building structural safety. The building assessment team is not liable for any damage to property or personal injury resulting from the assessments made in this form."

Following section 10, there is space for the identification of the experts who conducted the damage and usability assessment, while the final section provides the identity of the accompanying person. It should be noted that the accompanying person, by signing the BDUA form, acknowledges that he/she accompanied the assessment team but does not take any responsibility for the conclusions of the assessment.

2.16 Section 11 – Other comments, sketches and/or records

SECTION 11: OTHER COMMENTS, SKETCHES and/or RECORDS

Fig. 70. Presentation of Section 11 of BDUA

As referred earlier in this Manual, it is impossible for the BDUA form to contain every information for the description of existing buildings and damages that can be observed in the field. Section 11 is foreseen with the aim of including all additional descriptions that are not clearly given in the form, with the possibility of selection, and if necessary, to sketch features or details in order to give a clearer picture of the condition. This is not only for the team inspecting the building, but for any expert who evaluates or uses the BDUA form below.

It is suggested that in this section, each data item be preceded by the number corresponding to the Section for which the additional information is being filled in, in order to make clear addressing of the issue. To ensure that the descriptions are understandable, they should be written in capital letters.

The BDUA application provides the possibility of placing photos related to the information of each section, but if for certain conditions the team of assessors fills in the hardcopy form, then section 11 is the place to place the main photos taken during the inspection showing at least the main facades and details, as well as the most important damages.

This section may also be used to describe or outline immediate measures to be taken, if they are not specifically referred to in section 9b, and to clarify the need for a second inspection if "Other" is selected in section 9c. If there is insufficient space in section 11, additional sheets may be used.

List of Figures

List of tables

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3. ANNEXES

Annex 1: Building typology and frequent vulnerability (SKEDA)

SKEDA 1	**Unreinforced stone masonry**
SKEDA 2	**Brick masonry**
SKEDA 3	**Large panel buildings**
SKEDA 4	**Reinforced concrete frame system**
SKEDA 5	**Reinforced concrete dual system**

UNREINFORCED STONE MASONRY (URM-M1)

Occurrence: **Low**

Vulnerability: **High**

Areas: **Historic centres, rural areas**

Abbreviation:

- **URM-M1:** Unreinforced Stone masonry
- **URM-M2:** Unreinforced clay bricks masonry
- **URM-M3:** Unreinforced silicate bricks masonry
- **Hybrid1:** Ground floor and first floor URM-M1, upper floor partially with wood structure
- **Hybrid2:** URM-M2 + RC-Frame
- **Hybrid3:** URM-M3 + RC-Frame

Storey \ *Period*	< 1945	1945 – 1970	1971 – 1990	1991 – 2010	> 2010
1 – 2	***XXX***	***XX***	***X***		
3 – 5	***X***	***X***			
6 – 12					
> 12					

Frequent vulnerability elements and observed damages

Basic structural vulnerability elements

☒ Lack of lateral load resisting system in one direction

☒ Irregularity in-Plan

☒ Inappropriate connection of walls

☒ Lack of rigid floor diaphragm behaviour

☒ Inadequate connection of tie beams at floor/roof level or lack of them

Frequent additional vulnerability elements

☒ Poor structural material (mud mortar, low mortar strength)

☒ The use of irregular stone units

☒ Lack of wooden tie beam over the wall height

☒ Multi-leave walls without transversal connections

☒ Piers with inappropriate width, between windows and at building corners (width <1.00m)

☒ Material or masonry deterioration (cracking, deformation, moisture, vegetation)

☒ Intervention in structural system (rooftop extension, lateral extension, increasing/adding openings, intervention to the foundation).

Others

☒ Overall stability of the building is affected by: soft soil conditions, landslide, vicinity to a damaged building

☒ Isolated masonry columns/walls or weakly connected to the main building - their failure can cause damage or partial collapse to the main building

☒ Seismic joints in cases when flexible building or lateral extension are attached to the main masonry building

☒ Masonry walls with considerable length (>8.00m): out-of-plan failure

Note: The vulnerability elements presented are based on findings from various buildings and are not necessarily all present in a single one.

UNREINFORCED STONE MASONRY (URM-M1)

Description and characteristics

General

Stone masonry buildings are part of the traditional (historical) housing stock of Albania. Based on their structural characteristics and construction techniques, they can be categorised into several archetypes or sub-typologies.

Archetype / sub-typologies

Archetype based on the masonry wall composition, related to the lateral capacity of the wall:

- With regular/carved stones
- With irregular stones
- Mixed (regular stones in corners/angles and irregular in massive part of the wall)

Archetype based on used mortar:

- Clay mortar
- Lime mortar
- Cement mortar
- Mud mortar

Another feature characterizes stone masonry is the use of wooden tie beams, placed horizontally along the wall, hidden or visible, spacing every 1 meter as well as below and above the windows/doors. They served to confine the masonry wall, especially in cases where mud mortar is used. The following archetypes can be derived:

- Without tie beams
- With hidden tie beams (inside the wall)
- With visible tie beams.

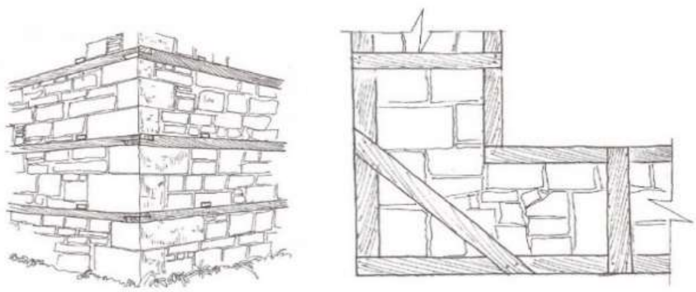


Fig. 1: Visible Wooden tie beams

In multi-leave walls, the wooden tie beams are often placed in transversal direction as well to connect the outer and inner leave of the wall. Multi-leave walls are present mostly in masonry composed by stone units.

Floor / Roof Foundation

The gravity load bearing elements (the floors) are mainly composed with wooden beams supported on masonry walls. The roof is made of wooden elements (truss) and clay or stone tiles.

The foundations are made of stone walls with a width not less than the masonry walls of the ground floor. Can be found cases where the ground floor masonry walls are built directly on bedrock.

Typified model

In line with the tradition and with the regional economic development, the housing stock contain many units sharing common elements related to structural features. In this context, the territory of the country can be divided in three regions (south, centre and north) and each of them characterized by western lowland areas and eastern mountain areas

Design code

Stone masonry buildings are constructed based on local or neighbour countries best practice (most probably using the workmanship learned from previous earthquakes), but not based on a specific design code.

UNREINFORCED STONE MASONRY (URM-M1)

Photos / Illustrations

Sketches of housing units with stone masonry. Source: P. Anastasi, "Nga thesari i arkitekturës sonë", 1984

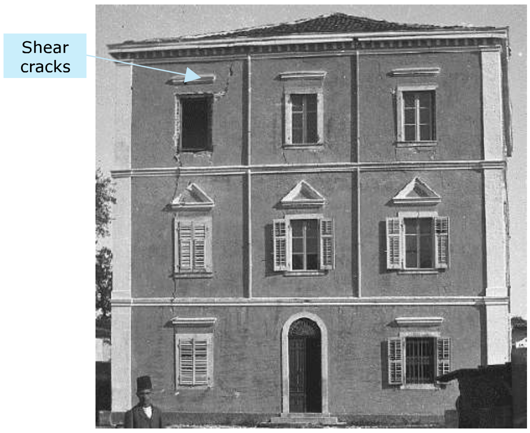
Left: Housing unit with regular stone masonry and the use of wooden tie beams

Right: Irregular stone masonry and corner reinforced with regular stones

Examples from the June 1, 1905 earthquake in Shkodra (Source: Marubi)

*Left: "**Out-of-plan failure**"*

*Right: "**Moderate shear-damage**"*



*Left: December 17, 1926 earthquake in Durrës "**Out-of-plan failure**" (Source: Kosta Korçari, flickr.com)*

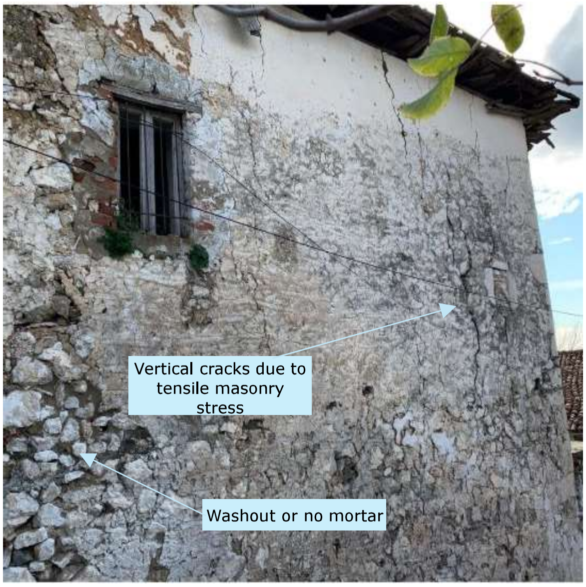
*Right: November 30, 1967 earthquake in Dibra "**Corner failure**" (Source: "Ndërtuesi" Journal, Volume 1, 1968)*

UNREINFORCED STONE MASONRY (URM-M1)

Photos / Illustrations

April 15, 1979 Montenegro earthquake (Source: "Arkivi shtetëror")

November 26, 2019 Durrës earthauqke



BRICK MASONRY (URM-M2 & M3)

Occurrence: **Low**

Vulnerability: **Medium-to-High**

Areas: **All areas, (mid-rise in cities)**

Abbreviation:

- **URM-M1:** Unreinforced Stone masonry
- **URM-M2:** Unreinforced clay bricks masonry
- **URM-M3:** Unreinforced silicate bricks masonry
- **Hybrid1:** Ground floor and first floor: URM-M1, upper floor partially with wood structure
- **Hybrid2:** URM-M2 + RC-Frame
- **Hybrid3:** URM-M3 + RC-Frame

Storey \ Period	< 1945	1945 – 1970	1971 – 1990	1991 – 2010	> 2010
1 – 2	X	XX	XX	X	
3 – 5	X	XX	XXX	X	
6 – 12					
> 12					

Frequent vulnerability elements and damages observed

Basic structural vulnerability elements

- ☒ Lack of lateral load resisting system in one direction (e.g. masonry walls only in one direction)
- ☒ Irregularity in plan
- ☒ Inappropriate connection of walls
- ☒ Lack of rigid floor diaphragm behaviour
- ☒ Inadequate connection of tie beams at floor/roof level or lack of them
- ☒ Low ratio of all resisting walls cross sectional area to plan area

Frequent additional vulnerability elements

- ☒ Insufficient seismic joints
- ☒ Poor structural material (low mortar strength, inadequate brick-mortar bond)
- ☒ Construction by non-specialized teams (voluntary work)
- ☒ Intervention in structural system (rooftop extension, lateral extension, increasing/adding openings, intervention to the foundation).
- ☒ Material or masonry deterioration (cracking, deformation, moisture, vegetation)

Others

- ☒ Masonry walls with considerable length (>8.00m), including inappropriate connection in transversal direction: out-of-plane failure
- ☒ Piers with inappropriate width, between windows & at building corners (width <1.00m)
- ☒ Reduced shear resistance at the upper floors
- ☒ Unreinforced masonry parapet
- ☒ Overall stability of the building is affected by: soft soil conditions, landslide, vicinity to a damaged building
- ☒ Isolated masonry columns or walls or weakly connected to the main building- their failure can cause damage or partial collapse to the main building.

Note: The vulnerability elements presented are based on findings from various buildings and are not necessarily all present in a single one.

Description and characteristics

General

URM buildings with brick units constitute a significant part of the housing stock. They began to be used before 1945 in low-rise buildings and extend more rapidly in the time period 1945-2000, in both low- and mid-rise buildings. After the 1979 Montenegro Earthquake, the use of confined masonry become more popular than simply URM in seismic prone areas.

Archetype / sub-typologies

Based on structural characteristics and construction techniques, can be categorised into several archetypes or sub-typologies:

BRICK MASONRY (URM-M2 & M3)

Archetype based on the masonry wall composition (related to the lateral capacity of the masonry wall):

- Masonry with: a-) clay bricks; silicate bricks; and less used: c-) load bearing hollow clay bricks; d-) hollow concrete bricks; e-) mud bricks/adobe.
- The ground floor is constructed with stone masonry
- The rooftop extension is constructed with lightweight bricks.

Note: Buildings with silicate brick masonry often have limited shear capacity due to the poor bond between the bricks and the mortar. This issue is more evident in cases with construction by volunteers.

Archetype based on used mortar:

- Cement mortar with proper inert
- Cement mortar with inappropriate inert (fine grain)
- Lime mortar
- Mud mortar (only in specific case of stone masonry)

Archetype based on the use of confined masonry or hybrid system:

- Unconfined masonry – URM
- Confined masonry, where the RC vertical elements at the corners and wall intersections and RC tie beams at the floor levels create the frames to confine the masonry walls
- Hybrid system, where RC frame is part of the lateral load resisting system: At ground floor (use for services purpose); At building perimeter or part of it (more transparent facade); Within the building (increase inner spaces).

Archetype based on the floor composition and its role as "rigid diaphragm" in its plan:

- With solid RC slab
- With prefabricated one-way ribbed slab (lack of rigid diaphragm)
- With cast-in place one-way ribbed slab (partial rigid diaphragm)
- With wood beams (no rigid diaphragm)

An important feature is the framing in the horizontal plan and the improvement of the "rigid diaphragm" role is related to the presence of RC tie beams at the floor and roof levels.

Floor / Roof /Foundation

The gravity load bearing elements (the floors) are mainly constructed with prefabricated ribbed/panel elements or with solid slab. Until '70 in rural areas and for low-rise buildings are mostly used wooden floors supported on masonry walls as well. The roof can be found similar to other floors (concrete floor) or made of wooden elements (truss) covered by clay tiles. With reference to "Rigid diaphragm" archetype, most of masonry buildings can be categorised to partial or lack rigid diaphragm. The URM foundation are continues and mainly constructed with stone masonry and/or cyclopean concrete. In cases of Hybrid systems, footings are part of the foundation system as well.

Typified model

In line with the tradition and the regional economic development, the low-rise housing stock contain many units sharing common elements related to structural features. The most used one is named "shtëpi elbasanse". In case of mid-height buildings, in the period '45-'90, typified models were widely used, which are present in many urban areas.

Design code

Until 1952, the buildings were built based on the best practices of the country and border countries. After 1952, the national building codes were used for their design and construction. In the design codes (KTP-78, KTP-N2-89) and the construction codes (KTZ-4,5-79), in line with seismic intensity (VII, VIII and IX) of the construction site are given application rules for URM structures, among which can be mentioned:

- Masonry wall categories depending on: the type of masonry unit, the mortar type and mortar strength class;
- The masonry wall thickness and height;
- The dimensions and mortar strength of piers and spandrels;
- Interlocking of orthogonal masonry walls and at the corners of the building;
- Maximum masonry wall length without the need for transversal connections
- Necessity of placing seismic tie-beam at the floor and roof level

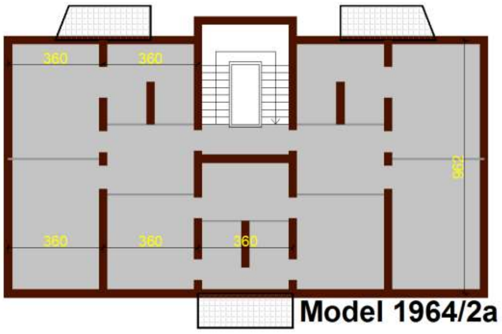
BRICK MASONRY (URM-M2 & M3)

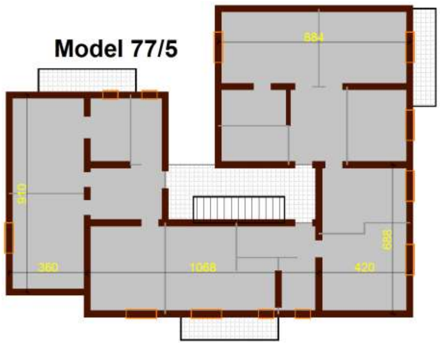
Photos / Illustrations

Layouts of typified URM mid-rise buildings. Source: AQTN

Left: Regular in-plan

Right: Irregular in-plan





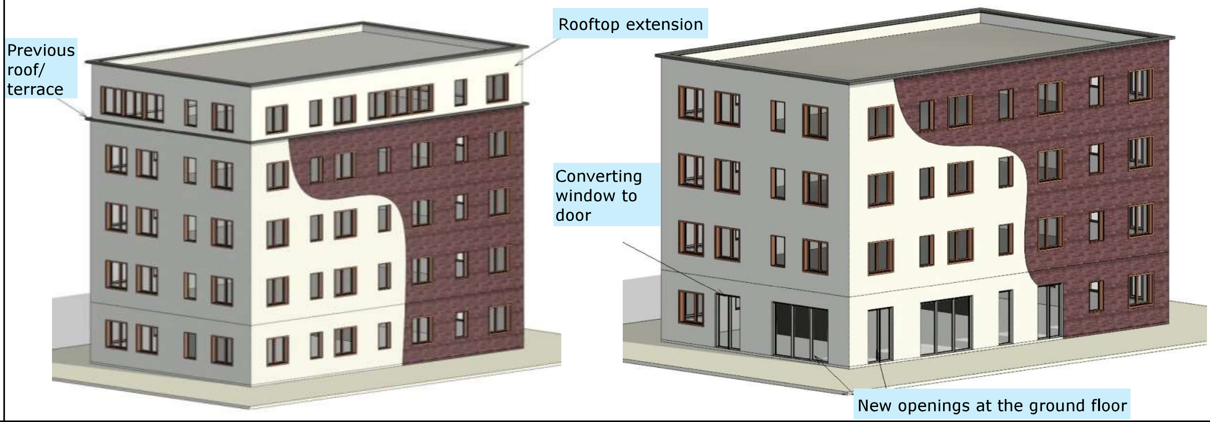
Left: Regular clay brick building

Middle and right: Irregular in-plan silicate brick buildings

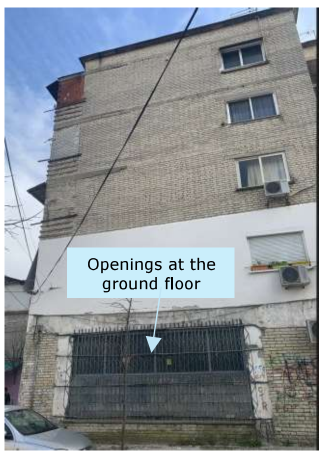
Most common interventions

Left: Rooftop extension

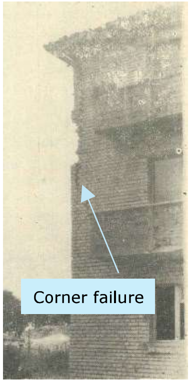
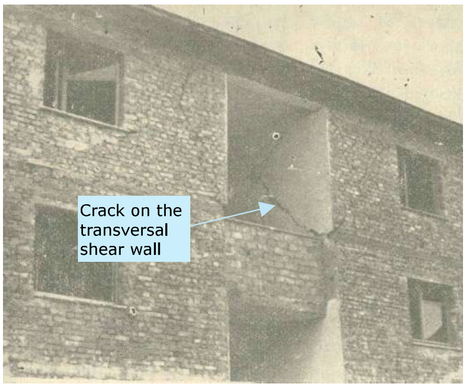
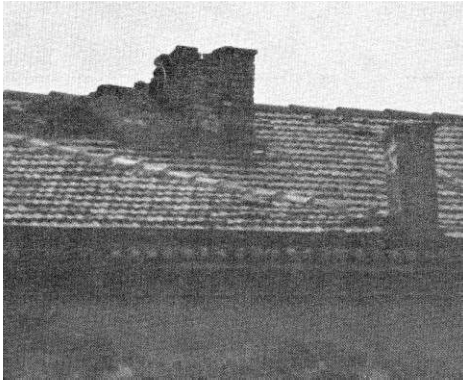
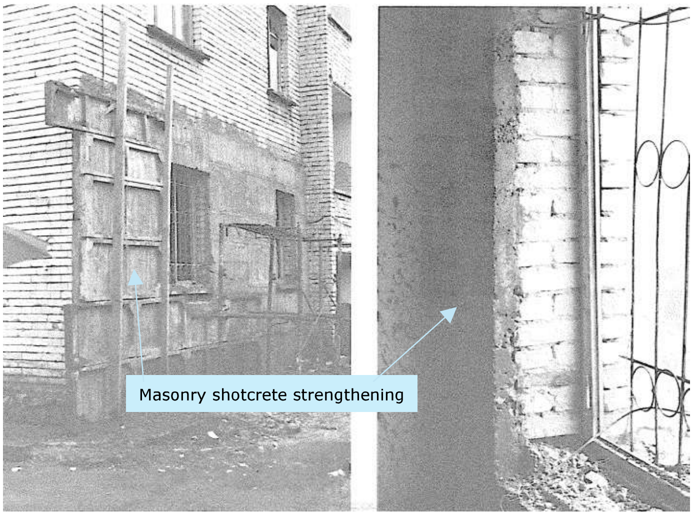
Right: Ground floor oppenings



Interventions to the brick masonry buildings



BRICK MASONRY (URM-M2 & M3)

Photos / Illustrations	
Left: Photos from Montenegro April 15th, 1979 Earthquake. Source:V. Pistoli *Right: Photos from Tirana January 9th, 1988 Earthquake. "**Chimney failure**" Source: EERI*	  
Left: Tirana January 9th, 1988 Earthquake. Strenthening process to an mid-rise silicate bricks masonry muilding Source: EERI *Right: Tirana January 9th, 1988 Earthquake. Repair process to an mid-rise silicate bricks masonry building*	 
Left: Out-of-plane failure *Middle: Masonry wall pier and corner shear failure to a unit belonging to the typology "shtëpi elbasanse"* *Right: Upper corner failure*	  
Left: Pier and spandrel shear cracks *Middle: Masonry pier failure at the GF masonry wall* *Right: Partial collapse*	  

Large Panel Buildings (LPB)

Occurrence: **Low**

Vulnerability: **Medium**

Areas: **Urban areas**

Abbreviation:

- **RC:** Reinforcement Concrete
- **Dual System:** Reinforcement Concrete Frame and Shear wall system
- **LPB:** Large Panel Buildings
- **URM:** Unreinforced masonry
- **Hybrid2:** URM-M2 + RC-Frame
- **Hybrid3:** URM-M3 + RC-Frame

Storey \ Period	< 1945	1945 – 1970	1971 – 1990	1991 – 2010	> 2010
1 – 2			*X*		
3 – 5		*X*	*XXX*		
6 – 12					
> 12					

Frequent vulnerability elements and observed damages

Basic structural vulnerability elements

☒ Moderate capacity of precast panels due to their low rate reinforcement and low capacity of the cast-in-place cyclopean foundation (potential vulnerabilities)

Frequent additional vulnerability elements

☒ Structural materials with moderate performance (mild steel bars, panels with small bar diameter)

☒ Material deterioration (steel corrosion, cracking, deformation, moisture, insufficient concrete cover)

☒ Insufficient seismic joints

☒ Weak connection between panels and panel-foundation

☒ Intervention in structural system: Rooftop extension; Lateral extension; Increased the existing openings in the RC wall or adding new ones and/or intervention to the foundation

Others

☒ Overall stability of the building is affected by: soft soil conditions, landslide, and vicinity to a damaged building.

Note: The vulnerability elements presented are based on findings from various buildings and are not necessarily all present in a single one.

Large Panel Buildings (LPB)

Description and characteristics

General

LPB buildings are part of the existing mid-rise building stock constructed mainly in urban areas in the time period 1970-1990. Their use was driven by: rapid population growth, fast construction technology, and the high-quality preparation precast RC panels. From a social perspective, these buildings offered an improvement in interior living spaces compared to similar URM typologies. Mostly those have typified structure with slight differences from each other.

Archetype / sub-typologies

Based on their specifics, following archetypes can be distinguished:

Archetype based on number of storeys:

- Mid-Rise typified LPB;
- Six storey typified LPB;
- Not standard LPB with more than six storey;
- Mid-Rise experimental LPB

Note: Exists few Hybrid units with more than 6 storey, where ground floor is composed as RC-Frame and the upper floors as LPB system.

Archetype based on used mortar:

- Cement mortar with proper inert
- Cement mortar with inappropriate inert (fine grain)
- Lime mortar
- Mud mortar (only in specific case of stone masonry)

Archetype based on location with reference to seismic zonation:

- LPBs situated in seismic zones with intensity VII or lower;
- LPBs situated in seismic zones with intensity VIII;
- LPBs situated in seismic zones with intensity IX

Note: It is related to the used reinforcement, especially for cast-in-place “columns” between panels.

Archetype based on layout composition of the building:

- LPB with single structural unit;
- LPB with two or more structural unit attached to each other;
- LPB with lateral extension Hybrid unit

Note: It is related to the used reinforcement, especially for cast-in-place “columns” between panels.

Floor / Roof /Foundation

The gravity load bearing elements (the floors) are mainly constructed with prefabricated solid RC panels. The roof structure is the same with other floors.

The foundation are mainly composed by continues cyclopean beam (plane concrete with large stone) followed by a RC tie-beam on top of it. In case of soft soil, increased dimensions are used for foundation

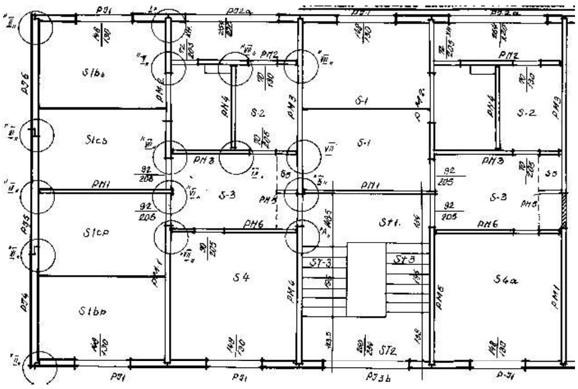
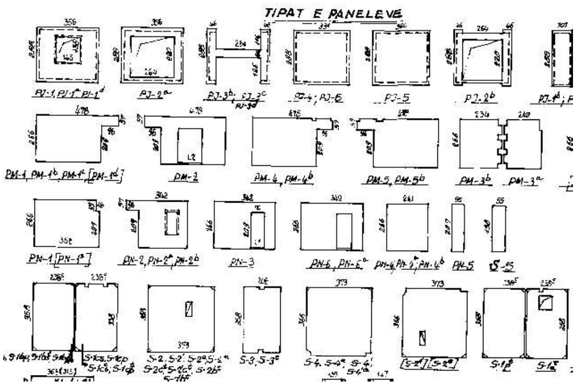
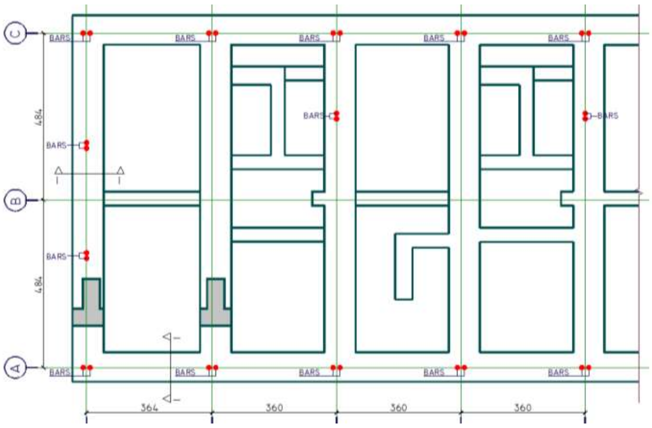
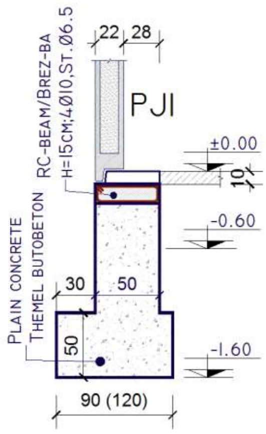
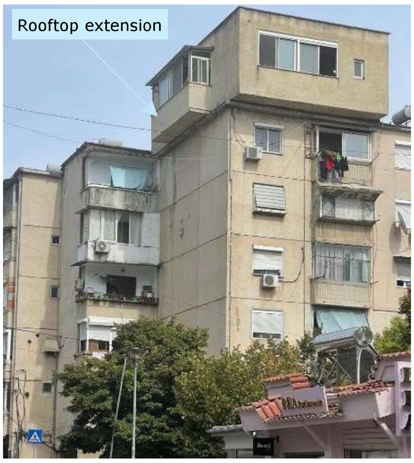
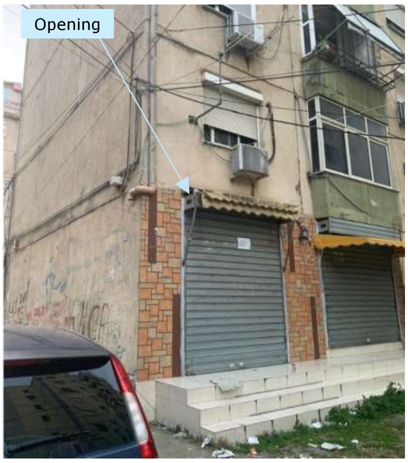
Typified model

Most of LPBs are constructed based on 2 or 3 typified models. Only few buildings with more than six floors are constructed based on specific design. There exists experimental models as well.

Design code

The LPBs were design and constructed based on models previously used in other east countries and considering the national code for their design and construction

Large Panel Buildings (LPB)

Photos / Illustrations	
LPBs during and after their construction. *Source:"Builder" Journal*	 
Typical layout and prefabricated panel elements of LPB. Source: AQT *Left:panel compsition layout* *Right: RC panel shape and dimensions*	 
Typical layout and section of the LPB foundation. Source: AQTN *Left:Foundation layout* *Right: Detail: Cross-section of the foundation*	 
Most common interventions *Left: Rooftop extension* *Middle: Ground floor oppenings* *Right: Lateral extension*	  

Large Panel Buildings (LPB)

Photos / Illustrations	
Photos from Durrës November 26th, 2019 Earthquake. *Left: Diagonal crack on window panel* *Middle: Cracks at the foundation beam* *Right: Shear cracks due to added support*	
Damages due to pounding effect *Left: Insufficient joint.* *Middle and right: Damages to facilities due to pounding effect between LPB unit and its lateral extension*	
Minor damages to the panel joints due to energy dissipation *Left: Deformation to panels joint* *Middle: Vertical cracks to panels joint* *Right: Vertical small cracks @ panels joint location*	

Reinforced Concrete Frame System (RC-Frame)

Occurrence: **Low**

Vulnerability: **High**

Areas: **Urban and rural areas**

Abbreviation:

- **RC:** Reinforcement Concrete
- **Dual System:** Reinforcement Concrete Frame and Shear wall system
- **LPB:** Large Panel Buildings
- **URM:** Unreinforced masonry
- **Hybrid2:** URM-M2 + RC-Frame
- **Hybrid3:** URM-M3 + RC-Frame

Storey \ Period	< 1945	1945 – 1970	1971 – 1990	1991 – 2010	> 2010
1 – 2			*X*	*XXX*	*XX*
3 – 5		*X*	*XX*	*XXX*	*XX*
6 – 12				*X*	*X*
> 12					

Frequent vulnerability elements and observed damages

Basic structural vulnerability elements

☒ Lack of lateral load resisting system, in one direction (planar) or two directions (similar to "flat slab" w.o. proper seismic design)
☒ Irregularity in plan
☒ Irregularity in elevation (including weak storey)
☒ Low ratio of all columns cross sectional area to construction area (similar to ***v*** in EN 1998-1)
☒ Lack of rigid floor diaphragm behaviour

Frequent additional vulnerability elements

☒ Inappropriate structural material (poor concrete, mild steel bars, insufficient concrete cover);
☒ Insufficient amount and/or inappropriate details of columns and beam-column joints hoops – Inadequate shear reinforcement (e.g. small Ø, large spacing, especially at critical region, not 135° hook).
☒ The presence of short columns
☒ Voluntary construction work; Informal Buildings (special attention should be paid to structures similar to "flat slab systems")
☒ Infills and partitions not proper connected to the structure
☒ Insufficient seismic joints
☒ Material or RC element deterioration (steel corrosion, cracking, deformation, moisture)
☒ Intervention in structural system: Rooftop extension; Lateral extension (pounding effect); causing damage to columns, walls or beams.

Others

☒ Overall stability of the building is affected by: soft soil conditions, landslide, and vicinity to a damaged building
☒ Isolated footing without cross-tie beams (often hidden vulnerability)
☒ Significant cantilever volumes

Note: The vulnerability elements presented are based on findings from various buildings and are not necessarily all present in a single one.

Description and characteristics

General

RC frame buildings mostly belong to the period 1980 till now. Prefabricated RC frame archetype generally is used for public buildings. Before '90 mostly are present in urban areas. After '90 most of low-rise buildings are situated in informal areas and most of mid and high-rise buildings in urban and urbanized areas.

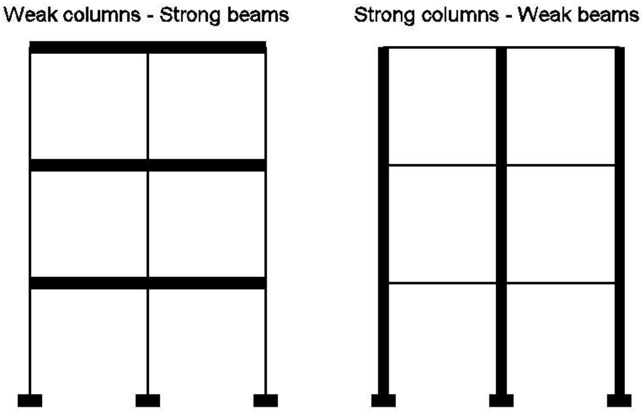
Archetype / sub-typologies

Based on structural characteristics and construction technique, can be divided into several archetypes:
Archetype depending on the RC frame mechanism:

- "Weak" columns;

Reinforced Concrete Frame System (RC-Frame)

- "Strong columns - "weak beams";
- Planar frame
- Frame with concealed beams - Similar to "flat slab" system
- With secondary RC core



Archetype based on the construction method:

- Cast-in-place structure;
- Structure with prefabricated RC frame elements.

Archetype based on structural regularity:

- Buildings with considerable in-plan irregularity;
- Buildings with in-elevation irregularity;
- Structures regular in plan and/or in elevation

Archetype based on the basement floors:

- Buildings with one or more basement floor;
- Buildings without basement floor.

Archetype based on floor system:

- Floors with solid slabs, t=12-25cm;
- Floors with two-way ribbed slabs, cast-in-place (t=20-35cm);
- Floors with one-way prefabricated slabs (t=11-16cm).

Floor / Roof /Foundation

Based on floor system archetypes, the floors are mainly composed with RC slabs, cast-in-place or prefabricate elements. In case of prefabricated slab elements (buildings before '90), the role of rigid diaphragms is not satisfactory. In case of cast-in place slabs (after '90), they fulfil the solid diaphragms requirements, both solid slabs and two-ways ribbed slabs.
The foundations are categorized depending on the construction period and the building height.

- Isolate footings, partially or fully connected with tie beams, are used almost for all buildings constructed before '90 and in low-rise (including cases of mid-rise) buildings, constructed after '90. These foundations are sensitive to soft and variation of soils conditions;
- Continuous foundations (cross-beams/mat/raft foundation) with higher stiffness and resistance than the columns they support are used in mid and high-rise buildings, constructed after '90;
- Deep foundation (Plate/Raft + Piles) are used in specific cases with soft soil conditions.

Typified model

Before '90 and in the first years after '90, the most used structural model type in urban areas was the Model-82 and other similar models. This model is present in both versions, prefabricated and cast-in-place. The Prefabricated RC-Frame Model-82 is characterized by M-200 concrete and a normal amount of longitudinal reinforcement, while the Cast-in-place model is characterized by M-300 concrete and a longitudinal reinforcement amount less than 1%. After '90, structural systems has followed the variation if architectural solutions, but from a structural point of view, can be categorized to: a-) systems similar to the "flat slab"; b-) systems with high normal forces to columns (reduced ductility).

Design code

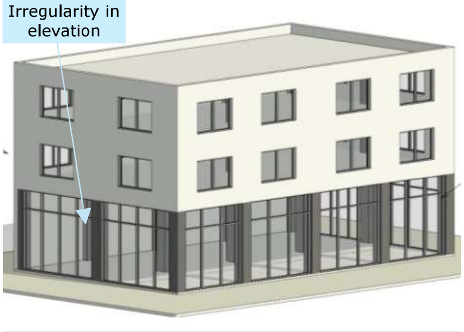
In their construction period, KTP-N2-78 and its improvements of '82 and 89 (KTP-N2-89) have been in force. In the seismic design code KTP-N2-78, there are few rules for RC Frame buildings, while in KTP-N2-89 the application rules for the design of such buildings increase significantly.
Typified buildings (before the 1990s), whether prefabricated or cast in place, were constructed based on the seismic design code KTP-N2-78.
For the seismic design of mid- and high-rise buildings after the 1990s, the KTP-N2-89 code have been in force*. After 2000, for this building typology, the rules foreseen in EN 1998-1 were also partially used.
Most probably, informal buildings are constructed without following seismic code requirements.

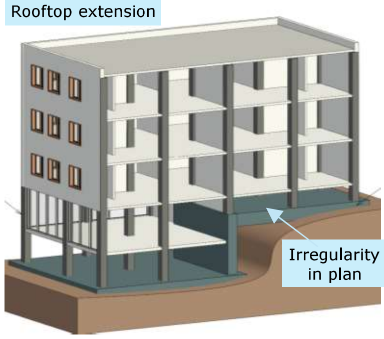
**with reference to inspections after the 2019 Eq., many damage buildings doesn't fulfil KTP-N2-89 requirements.*
Note: Although the rules foreseen in KTP-N2-89 have been satisfactory for the time of its drafting, buildings with a RC frame structure have potential vulnerabilities, such as: a-) Not fulfil the "strong column - weak beam" principle;

b-) lack of criteria for storey drifts limitation; c-) limited shear reinforcement for columns and column-beam joints; d-) high axial forces in columns and a moderate amount of their minimum longitudinal reinforcement (0.5%).

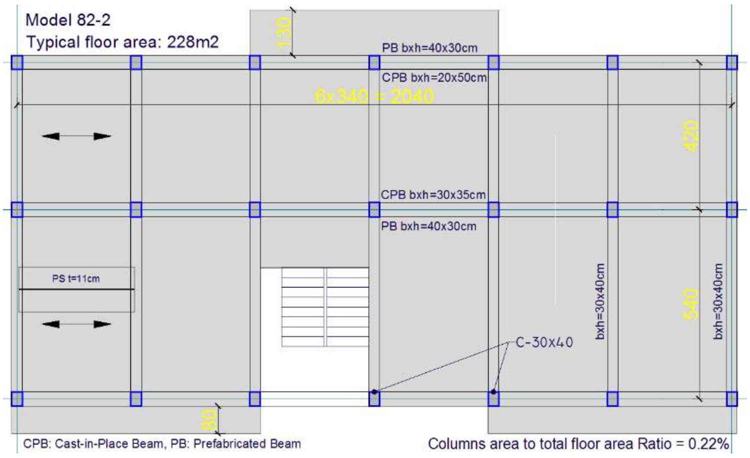
Photos / Illustrations

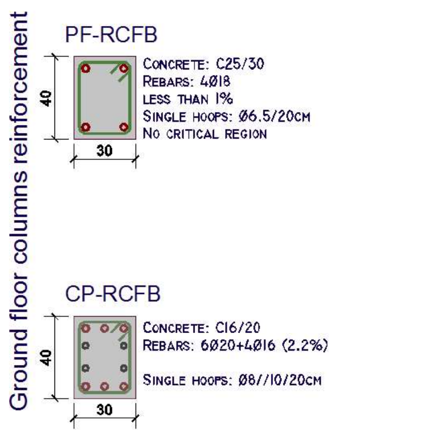
Sketches: RC-Frame buildings with concentrated flexibility at the GF, rooftop extensionand irregularities due to stepped foundation





Typical layout of one of the most damaged RC-Frame typology, Model 82/2. Source:AQTN





Typical mid-rise RC frame building

Left: Similar to "flat slab system" with infills in the upper floors

Middle: "Strong columns-weak beams" system

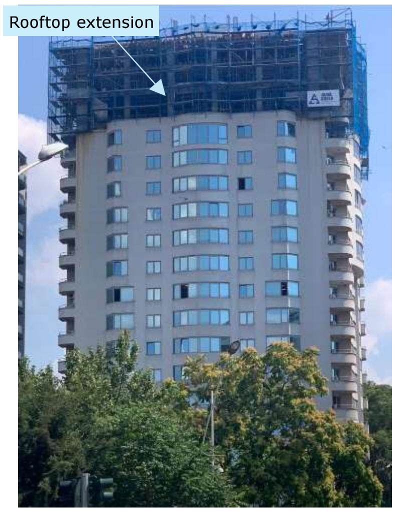
Right: Planar frame system-industrial building

Some typical vulnerabilities to high-rise buildings

Left: Irregularity in elevation

Middle: Pounding effect

Right: Rooftop extension



Reinforced Concrete Frame System (RC-Frame)

Photos / Illustrations

Photos from Durrës November 26th, 2019 Earthquake.

Left: Low-rise building collapse Soft storey mechanism

Right: Mid-rise building collapse Pancake mechanism

Damages to mid-rise RC-Frame

Left: Soft storey mechanism at first floor

Middle: Shear failure at the GF

Left: Shear failure at the GF

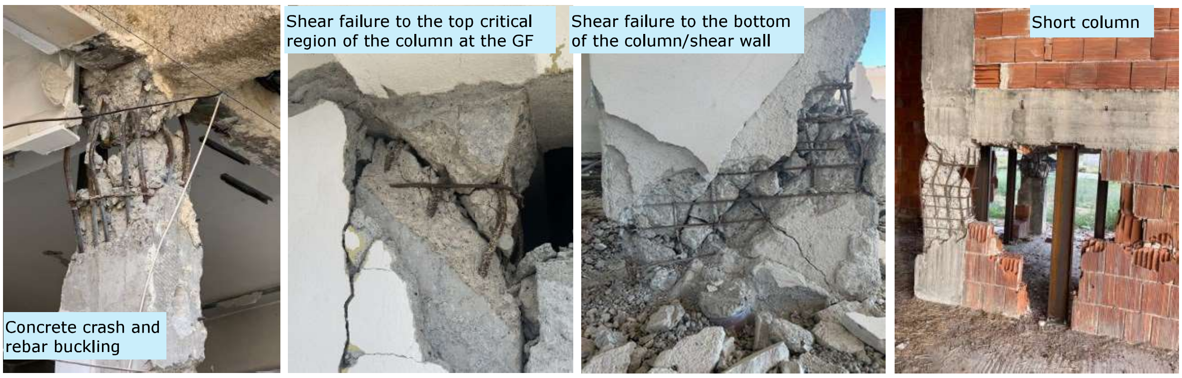
Damages to high-rise RC-Frame

Left: Damages due to high flexibility

Right: Out of plane failure

Most common damages to structural elements

Lack or insuficient hoop/tie details, poor concrete, added shear effects



Reinforced Concrete Dual System (RC-Dual)

Occurrence: **Low**

Vulnerability: **Medium**

Areas: **Urban and urbanized areas**

Abbreviation:

- **RC:** Reinforcement Concrete
- **Dual System:** Reinforcement Concrete Frame and Shear wall system
- **LPB:** Large Panel Buildings
- **URM:** Unreinforced masonry
- **Hybrid2:** URM-M2 + RC-Frame
- **Hybrid3:** URM-M3 + RC-Frame

Storey \ Period	< 1945	1945 – 1970	1971 – 1990	1991 – 2010	> 2010
1 – 2					*X*
3 – 5				*X*	*XX*
6 – 12				*X*	*XXX*
> 12					

Frequent vulnerability elements and observed damages

Basic structural vulnerability elements

☒ Lack of lateral load resisting system in one direction (e.g. shear walls only in one direction and lack of lateral resisting system in other direction);
☒ Irregularity in-Plan
☒ Irregularity in-Elevation

Frequent additional vulnerability elements

☒ Inappropriate structural material (low concrete strength, insufficient concrete cover);
☒ Informal Buildings
☒ Insufficient amount and/or inappropriate details of shear reinforcement;
☒ The presence of short columns
☒ Infill and simple walls not proper connected to the structure

☒ Insufficient Seismic joints
☒ Material or RC element deterioration (steel corrosion, cracking, deformation, moisture)
☒ Intervention in structural system: Rooftop extension; Lateral extension (pounding effect); Damaging columns, walls or beams.

Others

☒ Overall stability of the building is affected by: soft soil conditions, landslide, vicinity to a damaged buildings;
☒ Isolated footing without cross-tie beams (often hidden vulnerability);
☒ Significant cantilever volumes
☒ Torsionally flexible structures (e.g. buildings with small RC concrete core at centre and perimeter frame with low lateral stiffness – often only at elevator shaft and without other shear walls)

Note: The vulnerability elements presented are based on findings from various buildings and are not necessarily all present in a single one.

Description and characteristics

General

RC Dual buildings belong to the period after 2000. These systems are often used in high-rise buildings but there exist cases where this system is used for mid-rise buildings. Can be found all around the country. Mostly are located in urban and new urbanized areas

Archetype / sub-typologies

Based on structural characteristics and construction technique, can be divided into several archetypes:

Reinforced Concrete Dual System (RC-Dual)

Archetype depending on the RC dual system mechanism:

- Dual system, equivalent to Frame system
- Dual system, equivalent to shear wall system
- Torsionally flexible structure
- With concealed beams

Archetype based on structural regularity:

- Buildings with considerable in-plane irregularity due to concentrated stiffness of vertical elements and or due to considerable cantilever volumes;
- Buildings with in-elevation irregularity due to considerable height of the ground floor;
- Structures regular in plan and/or in elevation.

Archetype based on the basement floors:

- Buildings with one or more basement floor;
- Buildings without basement floor.

Archetype based on gravity load bearing system (floors):

- Floors with solid slabs, t=15-25cm;
- Floors with two-way ribbed slabs, cast in place (t=25-35cm).

Floor / Roof / Foundation

The gravity load bearing elements (the floors) are mainly composed with cast-in-place RC slabs. The role of rigid diaphragms often is satisfactory for both cases, solid and two-ways ribbed slabs.
The foundations systems are less in number for this typology.

- Continuous foundations (cross-beams or mat foundation or raft foundation);
- Deep foundation (Mat + Piles) are used in specific cases with soft soil conditions.

Note: For the buildings with underground basement floors, there are cases where, as part of the seismic-resistant foundation system, other structural elements of the basement floors such as: perimeter RC walls, columns, beams, and slabs are taken into account as well.

Typified model

There are no typified models. Nevertheless, many buildings have similar structural features and several archetypes can be distinguished. With reference to concrete strength, these buildings are mostly designed and constructed with concrete class C20/25 before 2010 and with C25/30 after 2010. With reference to the contribution of shear walls, until 2020 most of building stock are designed and constructed with equivalent to frame dual system. With reference to horizontal structure, concealed wide beams are used in many buildings. There are cases where beams with normal depth are used in perimeter frame.

Design code

The structural design of these buildings is based on mandatory KTP-N2-89 and voluntary Eurocode requirements. KTP-N2-89 partially outlines principles and structural calculations for dual systems and for the design of RC shear walls, although it summarize (Table 16 of KTP-N2-89) criteria for the minimal dimensions of the shear walls and their reinforcement. In the construction practice of the 1990-2000 period, when Eurocodes were rare used in design, RC cores (mainly in stair and elevator shafts) were mostly used as supplementary elements to structural system and not as their primary elements.

Note: Some of the issues found after the 2019 earthquakes in the shear walls/cores of buildings with dual systems (somehow related to criteria given in KTP-N2-89 for this typology) are related to: a-) Inappropriate location of RC shear walls/cores in the structural layout (increased structural eccentricity); b-) Low percentage of the RC cores area to the building area – increasing torsional effect; c-) Moderate shear wall transversal reinforcement, often significantly less than the vertical reinforcement.

SKEDA 5

Manual for the post-earthquake building damage and usability assessment in Albania (BDUA)

BUILDING TYPOLOGY AND FREQUENT VULNERABILITY AND DAMAGES OBSERVED

Reinforced Concrete Dual System (RC-Dual)

Photos / Illustrations

Sketches: Dual system buildings with irregularities in plan and in elevation

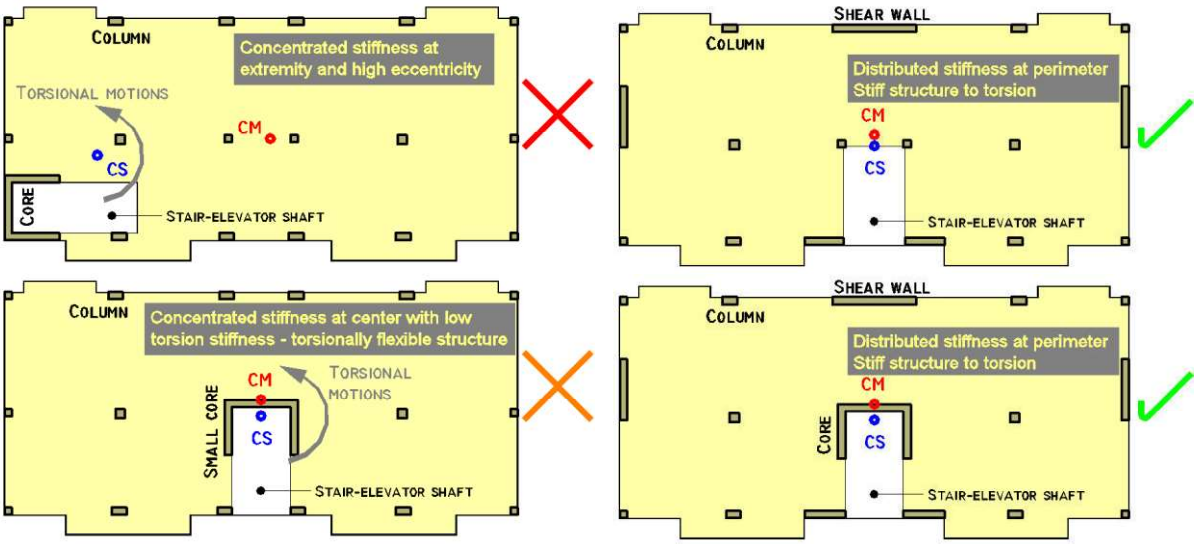
Typical layout of Dual systems

Left-Top: Structures with predominant torsion mode of vibration

Left-Bottom: Torsionally flexible structure

Right-Top: Dual system with high torsonal stiffness

Right: Dual system with high torsonal stiffness and centes RC core



Some typical vulnerabilities to high-rise buildings

Left: Dual system

Middle: Core system

Right: Perimeter wall system

Reinforced Concrete Dual System (RC-Dual)

Photos / Illustrations

Photos from Durrës November 26th, 2019 Eq. Damages to mid- and high-rise Dual system

Left: Extensive damage infills and moderate damage to shear walls and columns at lower floors

Right: Moderate damages to infills

Other damages observed to high-rise Dual systems

Left and middle: Differential settmement and building tilting – few structural and non-structrual damages

Right: Pounding effect and Out of plane failure of infills

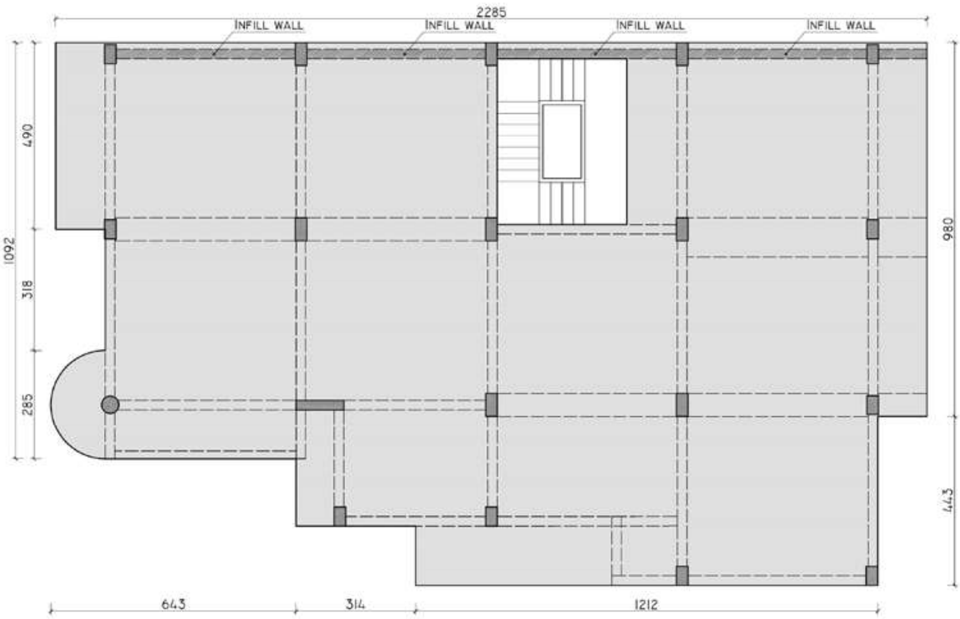
Most common damages to Dual systems, especialy to those with low ratio of shear walls

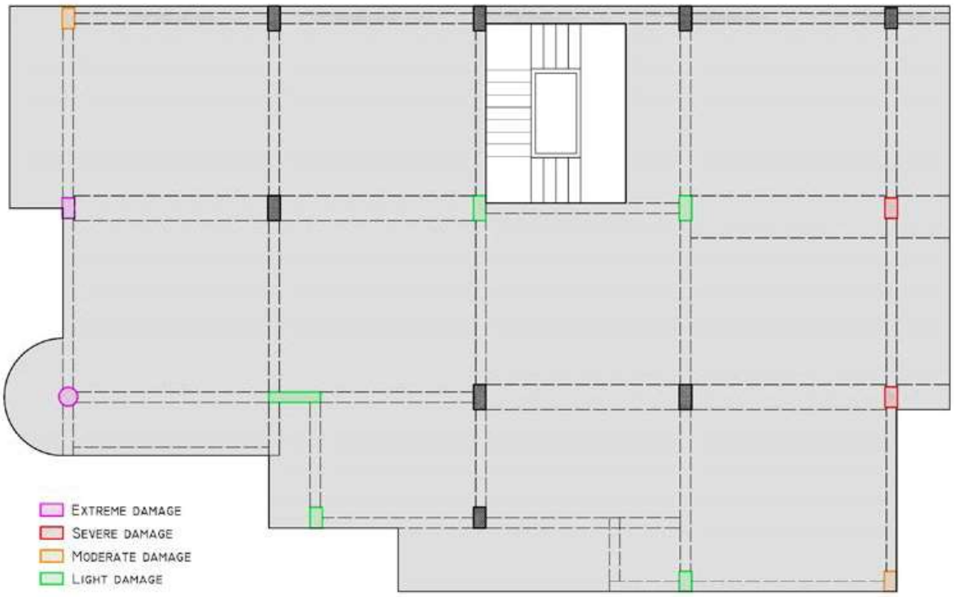
Left:damage and failure of infills and simple walls

Middle and Right: Shear cracks at shear walls

Annex 2: Example of a filled BDUA form

This annex contains a filled BDUA form for an existing building that was damaged during the Durrës earthquake of 2019. The data documented in the form are derived from the official BDA assessment form and supplementary technical reports prepared in the aftermath of the event. The information provided, collected during on-site inspections and discussions between the assessment team and the building occupants, offers critical insight into the technical condition of the structure and supports the rationale behind the decisions made by the assessment team, as documented in the filled BDUA form.

General description	The building is a 6-story reinforced concrete frame structure constructed in 2001. The ground floor was for commercial use, accommodating functions such as a grocery store, restaurant, and storage areas for beach-related equipment. The upper five floors served for residential purposes. Each residential floor has a total area of approximately 290 m², divided into four apartments. Most of these units were furnished and intended for use as secondary homes during the summer vacation period. From communication with the accompanying person, it is mentioned that currently 5 families (23 residents) live in the building.
Building permit	Yes, during the inspection, the accompanying person showed the building permit issued by the Durrës municipality in 2001, authorizing the construction of a five-story structure with an attic. Based on site inspection it was clear that the building was constructed in accordance with a structural design project prepared by a licensed structural engineer and fulfilling the requirements of the construction permit.
Photos of the building from outside	 
Building plan	

Vulnerability aspects	• **Plan irregularity:** The building's configuration and the arrangement of its primary vertical structural elements indicate irregularity in plan. • **Elevation irregularity:** The story height of the ground floor is 4.0 m, so 30% larger compared to the upper floors height (3.06 m), fact that show elevation irregularity of the structural system. • **Nonuniform distribution of infill walls:** On the ground floor, only one of the external frame has end-to-end infill masonry (shown on the plan) while the other frames, on the facade and inside, do not have infill walls. This distribution of infill walls further increases the irregularity in the plan of the structure. On the upper floors, infill walls are more present, with a uniform distribution and so this increased presence compared to the ground floor affects the elevation irregularity of the building. Thus, leading to increased vulnerability due to torsion and promoting "soft storey" behavior. • **The application of decorative reinforced concrete arches** attached to structural columns on the ground floor affects their seismic performance by shifting the critical zones (regions) where the stirrup step is greater and consequently the shear capacity is lower.
Observed structural damages	In accordance with the BDUA assessment methodology - which prioritizes the identification of damage to structural elements as a basis for evaluating the residual seismic capacity of the building - the following data summarize the condition of the vertical primary seismic elements: **No. of vertical primary seismic elements / storey: 19** **Total no. of vertical primary seismic elements: 107 = (19x5 + 12)** Observed damage to vertical primary seismic elements: • light damage 5 elements • moderate damage 2 elements • severe damage 2 elements • extreme damage 2 elements There were no damage clearly observed in the horizontal structural elements, including reinforced concrete slabs and beams. The floor plan below, illustrates the position of the damaged columns. Notably, all damaged elements are located on the ground floor, which plays a critical role in the global stability of the structure. Given the concentration and severity of the damage at this level, the seismic capacity of the building is classified as **highly reduced** in the BDUA form. 

Photos of the structural damages

The following photos, taken during the inspection of the building, show the structural damages associated with the damage level. Here are included also photos of damage to the infill walls (non-structural elements), but as referred to in the Technical Manual they affect the overall behavior of the structure under seismic action.

DL Extreme

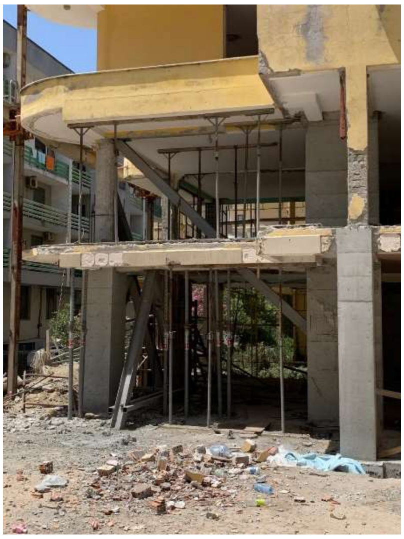
DL Heavy

DL Light

DL Light

DS Severe

DS Severe

Photos of non-structural damages observed	During the inspection, the observed non-structural damages consist mainly in partition walls on the ground and the first floors. There were also some detached plaster on the facade of the building.  
Immediate measures carried out by SAR team	
Immediate measures proposed by inspection team	Proposed immediate measure consist in: • Removal of damaged infill and pertition walls • Removal of plaster in the fasade • Introduce a simple steel structure, till retrofit measures will be in place  

REPUBLIC OF ALBANIA

Construction Institute | National Civil Protection Agency

BDUA Form 11.2025

Event ref. |D|R| - |A| - |2|6|1|1|2|0|1|9|

BUILDING DAMAGE & USABILITY ASSESSMENT FORM (visual)

SECTION 0: INSPECTION IDENTIFICATION

Team code |0|0|1| Form no. |__|__|0|0|1| / |__| Inspection date (d, m, y): |3|0| |1|1| |2|0|1|9|

SECTION 1: BUILDING IDENTIFICATION

Building no.	143	Coordinates KRGJSH	E	457474,59
Street	VENEZIA		N	4574514,85
City/Village	DURRËS			
Admin. Unit	DURRËS	Coordinates WGS84	Lon	________
Municipality	DURRËS		Lat	________
Region	DURRËS			

Position of the building: ❍ Isolated ❍ Row-in ● Row-end ❍ Corner

Accompanying identification

Surname	|H|O|X|H|A|__|__|__|__|__|__|__|__|__|	❍	Tenant
Name	|G|E|R|O|N|__|__|__|__|__|__|__|__|__|	●	Delegate (with authorization)
Phone No	|0|6|8|2|1|2|3|4|5|6|	❍	Delegate (by municipality)
❍	Owner	❍	Other |__|__|__|__|__|__|__|__|__|__|__|__|__|
❍	Administrator	❍	None

SECTION 2: BUILDING DESCRIPTION

No. of storeys above ground |__|6| No. of stories underground |0|

Average storey height (m) ❍ ≤2.8 ● 2.9÷3.4 ❍ 3.5÷5.0 ❍ >5.0 **Ground Floor** |4|,|0| m

Average storey area (m²) |__|__|2|9|0|

Construction period ❍ Before 1945 ❍ 1945-1970 ❍ 1971-1990 ● 1991-2010 ❍ After 2010 ❍ I don't know

Structural intervention/retrofitted ❍ Yes Specify year |__|__|__|__| ● No

Use ☒ Residential ☐ Offices ☐ Commerce ☐ Administration ☐ Education ☐ Health service ☐ Manufacturing ☐ Warehouse ☐ Other: |__|__|__|__|__|__|__|__|__|__|__| ☐ I don't know

Utilization ● Inhabited ❍ Under construction ❍ Abandoned/ not in use

No. of occupants 2 3 — ❍ Estimated number ● Actual no. according to info received during the visit ❍ From database

Property ☐ Public ☒ Private ❍ I don't know

Comments: ____________________________

SECTION 3: SEISMIC VULNERABILITY & STRUCTURE TYPOLOGY

Lateral load resisting system / Interstorey/ floor behaviour	Unidentified/unknown	Lack of lateral load resisting system in any direction	Irregularity in plan	Irregularity in elevation	Proper layout
Unidentified /unknown	❍	☐	☐	☐	
Not rigid	☐	☐	☐	☐	❍
Semi rigid / Panel	☐	☐	☐	☐	❍
Rigid floor	☐	☐	☒	☒	❍

Additional vulnerability ❍ unidentified

- ☐ insufficient seismic joint
- ☐ structure in poor condition
- ☒ short column
- ☐ informal building
- ☐ intervention in str. system
- ☐ rooftop extensions
- ☐ lateral extensions
- ☐ other

Lateral load resisting system

☐ **Masonry** ☐ bearing walls ☒ infill/partition
☐ stone ☐ mud bricks
☐ clay brick ☐ silicate brick
☒ hollow brick ☐ concrete block

Stonework ☐ irregular ☐ regular

Ties (wood or r/c) ❍yes ❍no ❍ unidentified

Confined ❍yes ❍no ❍ unidentified

☒ **Reinforced concrete** ☒ frame ☐ core ☐ shear wall
❍ prefab. frame ❍ LPB ❍ flat slab

☐ **Steel** Type: ☐ column ☐ frame
Bracing: ❍ 1 direction ❍ 2 directions

☐ **Wood** Type: ☐ frame ☐ çatma ☐ other

Summary of section 3 ______________________________________

Seismic design: ❍ inappropriate ● partially appropriate ❍ appropriate ❍ precise in section 11

SECTION 4: STRUCTURAL DAMAGE & RESIDUAL SEISMIC CAPACITY (incl. immediate measures carried out)

Damage level & extent / Structural elements & pre-existing damages	Missing part	DAMAGE LEVEL: Extreme >1/4	Extreme <1/4	Severe >1/4	Severe <1/4	Moderate >1/4	Moderate <1/4	Light >1/4	Light <1/4	None	Immediate measures carried out: None	Demolition & removal	Belting and/or rods	Repairs	Propping	Barriers/ protected passage
Vertical primary seismic elements	❍	☐	☒	☐	☒	☐	☒	☐	☒	❍	❍	☐	☐	☐	☒	☐
Connections between vertical & horizontal structural element	❍	☐	☐	☐	☐	☐	☐	☐	☐	●	●	☐	☐	☐	☐	☐
Floors / Horizontal structural elements	❍	☐	☐	☐	☐	☐	☐	☐	☒	❍	●	☐	☐	☐	☐	☐
Roof	●	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐
Gravity load bearing columns	●	☐	☐	☐	☐	☐	☐	☐	☐	❍	❍	☐	☐	☐	☐	☐
Pre-existing damages		☐	☐	☐	☐	☐	☐	☐	☐	❍						
Infill / partition walls	❍	☐	☐	☐	☒	☐	☒	☐	☒	❍	❍	☐	☐	☐	☒	☐

Summary of section 4 ______________________________________

Seismic capacity: ● highly reduced ❍ moderately reduced ❍ slightly reduced ❍ precise in section 11

SECTION 5: DAMAGE TO NON-STRUCTURAL ELEMENTS (and immediate measures carried out)

Observation / Type of damage	Damages	Immediate measures carried out: None	Demolition & removal	Prohibited access	Repairs	Propping	Barriers / protected passages
Damage to facade elements, cladding elements	❍	❍	☐	☐	☐	☐	☐
Detachment of plaster, coating, false ceiling	●	●	☐	☐	☐	☐	☐
Roof tiles falling, chimneys, gutters,	❍	❍	☐	☐	☐	☐	☐
Cornices falling, parapets, balconies, eaves	❍	❍	☐	☐	☐	☐	☐
Other objects falling (inside and outside)	❍	❍	☐	☐	☐	☐	☐
Stairs (emergency exits)	❍	❍	☐	☐	☐	☐	☐
Damage to drinking water supply network	❍	❍		☐	☐		☐
Damage to sewage water network	❍	❍		☐	☐		☐
Damage to power supply network	❍	❍		☐	☐		☐
☐ Gas network ☐ Telecommunication ☐ Other ______		❍	☐	☐	☐	☐	☐

SECTION 6: EXTERNAL DANGERS (and emergency measures carried out)

External danger \ Implications	Not identified	Danger for: Buildings	Danger for: Access paths	Danger for: Internal paths	Emergency measures: Propping	Emergency measures: Barriers / protected passages
Collapse of an adjacent building	●	☐	☐	☐	☐	☐
Falling of other adjacent elements	●	☐	☐	☐	☐	☐
Broken pipes	●	☐	☐	☐	☐	☐
Rockfall / landslide	●	☐	☐	☐	☐	☐
Other:..	❍	☐	☐	☐	☐	☐

SECTION 7: SUBSOIL AND FOUNDATION

Ground morphology
❍ Crest
❍ Steep slope
❍ Mild slope
● Flat

Instability of foundation	
● Not identified	
❍ Landslide	❍ Feared/ expected
❍ Liquefaction	❍ Pre-existents
❍ Settlement	❍ Caused by earthquake
	❍ Worsened by earthquake

Subsoil: Description		Eurocode	KTP
Good	❍	A	I
Medium	❍	B, C	II
Poor	❍	D, E	III
Special	❍	S1, S2	
Unknown	❍		

SECTION 8: SUMMARY SECTIONS 3, 4, 5, 6 & 7

Section 3	Seismic design (layout):	❍ inappropriate	● partially appropriate	❍ appropriate	❍ precision in section 11
Section 4	Seismic capacity:	● highly reduced	❍ moderately reduced	❍ slightly reduced	❍ precision in section 11
Section 5	Danger from non-structural elements:	❍ high	● moderate	❍ low	❍ precision in section 11
Section 6	External danger:	❍ high	❍ moderate	● low	❍ precision in section 11
Section 7	Danger related to subsoil/ foundation:	❍ high	❍ moderate	● low	❍ precision in section 11

SECTION 9a: USABILITY ASSESSMENT

Risk Assessment

Risk level \ Risk identification	Structural (sect. 3 & 4)	Non-structural (sect. 5)	External danger (sect. 6)	Subsoil & foundation (sect. 7)
Low	❍	❍	●	●
Low, after implementation of immediate measures (9b)	❍	●	❍	❍
High	●	❍	❍	❍

Result

1	❍	**USABLE** building
2	❍	**TEMPORARILY UNUSABLE** building (totally or partially) but expected to be USABLE after implementation of immediate measures (cf. section 9b)
3	❍	**TEMPORARILY UNUSABLE** building A second inspection is required (cf. section 9c)
4	●	**UNUSABLE** building
5	❍	**UNUSABLE** building due to external danger

Team code | 0 | 0 | 1 | *BDUA Form 11.2025* Form no. |__|__| 0 | 0 | 1 |

SECTION 9b: IMMEDIATE MEASURES, limited (*) or extensive (**) extent

*	**	Suggested immediate measures	*	**	Suggested immediate measures
☐	☐	Belting and/or installation of ties	☐	☐	Installation of barriers and/or protected passageways
☐	☒	Repair / removal of infill and/or partition walls	☐	☐	Repair of supply networks
☐	☐	Roof repair	☐	☐	Waterproofing
☐	☒	Propping	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☒	☐	Removal of plasters, coating, false-ceilings	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☐	☐	Removal of roof tiles, chimneys, gutters	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☐	☐	Removal of cornices, parapets, eaves	☐	☐	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
☐	☐	Removal of other internal or external objects	❍		None

This table is completed by additional indications: ❍ in section 11 ❍ in appendix sheet

SECTION 9c: SECOND INSPECTION REQUIRED (to be only filled in if the assessment result in section 9a is 3)

Reason for second inspection: |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

❍ partial inspection ❍ no inspection ❍ Disagreement within assessment team ❍ Geologist advice required

❍ other: |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

SECTION 9d: Temporary shelter needs (only for residential buildings, if the assessment results: 2, 3, 4 or 5 in section 9a)

Inhabited during inspection:		❍ yes	● no
Number of families to be relocated:	|__|__|__| 5 |	❍ actual number	● estimated number
Number of people to be relocated:	|__|__| 2 | 3 |	❍ actual number	● estimated number

SECTION 10: INFORMATION ABOUT INSPECTION

Details of inspection:

- inspected: ❍ outside only ❍ partially ● complete (>2/3)
- not inspected, because: ❍ inspection refused ❍ ruin / collapsed ❍ risk of collapse ❍ demolished ❍ reconstruction ❍ under construction ❍ abandoned ❍ unused ❍ absence of accompanying person ❍ other: |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

The usability assessment is based on a quick visual evaluation of the building, in a post-earthquake crisis situation. The assessment provided has temporary validity and does not correspond to a detailed assessment which shows clearly the building's structural safety and costs for structural retrofit. The building assessment team is not liable for any damage to property or personal injury resulting from the assessments made in this form.

Building assessment team:

Last name: | L | U | K | A |__|__|__|__|__|__|__|__|__|
First name: | R | I | K | A | R | D |__|__|__|__|__|__|__| Signature ____

Last name: | S | H | A | H | O | L | L | I |__|__|__|__|__|
First name: | K | L | A | J | D | I |__|__|__|__|__|__|__| Signature ____

Last name: | H | A | Z | I | R | A | J |__|__|__|__|__|__|
First name: | R | E | N | T | I |__|__|__|__|__|__|__|__| Signature ____

The undersigned confirms that he/she accompanied the building assessment team during the inspection

Last name: | H | O | X | H | A |__|__|__|__|__|__|__|__|
First name: | G | E | R | O | N |__|__|__|__|__|__|__|__| Signature ____

SECTION 11: OTHER COMMENTS, SKETCHES and/or RECORDS

Annex 3: Comparison of damage assessment practices

Overview of Albanian, Italian and EMS-98 damage assessment practices

<table>
<tr><th colspan="3">Albanian</th><th colspan="3">Italian</th><th colspan="3">EMS-98</th></tr>
<tr><th>Damage of Str. Elem Incl. infill wall</th><th>Non-Str. Damage</th><th>Building damage given through Reduction of Seismic Capacity</th><th>Damage of Str. Elem incl infill wall</th><th>Non-Str. Damage</th><th>Building damage</th><th>Damage of str. Element</th><th>Non-Str. Damage</th><th>Damage Grade for building</th></tr>
<tr><td rowspan="2">Light
Extension:
<1/4 | > 1/4</td><td rowspan="8">No classification of damage for non-struct. elements (only Yes/No)</td><td>Slightly reduced</td><td>Slight (D1)
Extension:
(<1/3 | 1/3-2/3 | > 2/3)</td><td rowspan="8">No classification of damage for non-struct. elements (only Yes/No)</td><td>Slight (D1)</td><td>No
Fine cracks in plaster over frame members or in walls at the base.</td><td>Slight
Fine cracks in partitions and infills.</td><td>D1
Negligible to slight damage</td></tr>
<tr><td rowspan="4">Moderately reduced</td><td rowspan="4">Medium – Severe (D2-D3)
Extension:
(<1/3 | 1/3-2/3 | > 2/3)</td><td rowspan="4">Medium – Severe (D2-D3)</td><td rowspan="2">Slight
Cracks in columns and beams of frames and in structural walls.</td><td rowspan="2">Moderate
Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.</td><td rowspan="2">D2
Moderate damage</td></tr>
<tr><td rowspan="2">Moderate
Extension:
<1/4 | > 1/4</td></tr>
<tr><td rowspan="2">Moderate
Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of concrete cover, buckling of reinforced rods.</td><td rowspan="2">Heavy
Large cracks in partition and infill walls, failure of individual infill panels.</td><td rowspan="2">D3
Substantial to heavy damage</td></tr>
<tr><td rowspan="2">Severe
Extension:
<1/4 | > 1/4</td></tr>
<tr><td rowspan="3">Highly reduced</td><td rowspan="3">Very heavy (D4-D5)
Extension:
(<1/3 | 1/3-2/3 | > 2/3)</td><td rowspan="3">Very Heavy (D4-D5)</td><td rowspan="2">Heavy
Large cracks in str. elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.</td><td rowspan="2">Very heavy</td><td rowspan="2">D4
Very heavy damage</td></tr>
<tr><td rowspan="2">Extreme
Extension:
<1/4 | > 1/4</td></tr>
<tr><td>Very heavy
Collapse of ground floor or parts (e. g. wings) of buildings.</td><td></td><td>D5
Collapse</td></tr>
</table>

Annex 4: Main seismic event and related norms in Albania

YEAR	MAIN EARTHQUAKES (Aliaj et.al. 2020)	DESIGN CODES, TECHNICAL GUIDES and IMPORTANT PUBLICATIONS	APPROVED WITH / PUBLISHED BY
	1905 M_s = 6.6 Shkodër		
	1926 M_s = 6.2 Durrës		
	1942 M_s = 6.0 Dibër	1942 Carta Sismica dell Albania (Carlo Morreli)	Reale Accademia d'Italia
1950	1948 M_s = 5.5 Shkodër		
		1952 Seismic provisions for buildings	DCM no. 817, dt. 27.12.1952
		1953 Technical codes for construction works	DCM no. 203, dt. 09.06.1953
	1959 M_s = 6.2 Berat		
1960	1960 M_s = 6.4 Korçë		
	1962 M_s = 6.0 Fier		
		1963 Seismic DC for buildings and setup of seismological service in Albania	DCM no. 206, dt. 04.06.1963
		1966 Earthquake consequences on masonry and reinforced concrete buildings[1)]	TU, Engineering Faculty
	1967 M_s = 6.6 Dibër		
1970	1969 M_s = 5.6 Tepelenë		
		1974 DC for r/c buildings, based limit state theory	DCM no. 31 dt. 07.09.1974
		1978 Design Codes (1-24)[2)]	DCM no. 38 dt. 03.05.1978
		1979 Seismic Zonation Map of Albania	DCM no. 371, dt. 20.12.1979
1980	1979 M_s = 6.9 Mal i Zi		
	1982 M_s = 5.7 Fier	1981 Update of DC-2-78	D. TCMC no. 20, dt. 25.12.1981
		1982 Seismic design of masonry buildings[3)]	TU, Engineering Faculty
		1983 Earthquake consequences on buildings[3)]	AS Seismology Center
		1983 Earthquake of April 15, 1979[4)]	AS, Seismology Center
	1988 M_s = 5.4 Tiranë	1986 Seismic micro-zonation maps for main cities[5)]	AS, Seismology Center
1990		1989 Seismic Design Code N2 1989	D. TCMC no. 40, dt. 10.01.1989
		1990 Guidance for seismic design of construction works[6)]	AS, Seismology Center MC, Design Directorate
2000			
		2001 Approval of standards, design and construction codes for construction works [7)]	DCM no. 68, dt. 15.02.2001
	2002 M_s = 5.7 Kosovë		
	2003 M_s = 6.3 Greqi	2003 Seismic engineering (Niko Pojani)	Publisher TOENA
2010			
		2011 Starting of the adoption of the Eurocode package	DCM no. 511, dt. 06.07.2011
		2012 Design rules for r/c building following EC8[8)]	MPWTT
		2015 Regulations for infrastructure works design and cosntruction[9)]	DCM no. 628, dt. 15.07.2015
	2019.09 M_s = 5.6 Durrës		
2020	2019.11 M_s = 6.4 Durrës	2020 Eurocode package approved as Albanian standards	GDS
		2020 Aktekspertiza e thelluar për ndërtesat e dëmtuara[10)]	DCM no. 26, dt. 15.01.2020
		2024 Design norms for hospitals and healthcare clinics	DCM no. 114, dt. 06.03.2024

Acronyms and clarifications

AS – Academy of Sciences
GDS – General Directorate of Standardization
MC – Ministry of Construction
DC – Design code
Ms – Earthquake magnitude
TU – Tirana University
DCM – Decision of the Council of Ministers
D. TCMC – Decision of Technical Committee of the Ministry of Construction

1) Brochure by Rexhep Faja, prepared after Korça and Fieri earthquakes and evidences the lessons learned by affected buildings "*without sufficient transversal rigidity, without tie beams*", as referred by author.
2) Desing Codes approved in 1978, consist in a package of 24 codes which covers main design aspects for buildings and other construction works. Part of this package is the "Seismic Design Code N2-78"
3) Two publications (first by Vasil Pistoli and the second by Niko Pojani and Roland Poloska) that reflects updated calculation methods that consider seismic action in the design of buildings. Both publications consider observations and lessons learned by April 15, 1979, earthquake.
4) This publication of Seismological Center (Academy of Sciences), gather all papers presented by experts in the fields of geosciences and engineering at the Shkodra Symposium "Earthquake of April 15, 1979, and elimination of its consequences" organised on April 4-5, 1980.
5) Seismic micro-zonation maps are prepared by Seismological Center for main cities of our country: Shkodra, Durrës, Vlora, Tirana
6) Guidance for seismic design consist in 6 volumes that introduce design approaches and numerical examples for different construction works, prepared after approval of Seismic Design Code-N2-89.
7) This DCM this DCM, it lists all Standards, Design & Construction codes and other documents that must be considered for the design and implementation of construction works.
8) Guidance prepared in the framework of "Albania Disaster Risk Mitigation and Adaptation Project", Component III "Development of Building Codes", finance by World Bank and implemented by Ministry of Interior and Ministry of Public Works, Transport and Telecommunication (MPWTT).
9) This sub-legal act refers the use of Eurocodes for the design of road infrastructure works, especially bridges.
10) This sub-legal act, approved after the earthquake of Nov. 26, 2019, provides the structure of the detailed expertise report for earthquake damaged buildings, defining SSH EN 1998-3 as the reference standard for the assessment and structural retrofit of buildings.
11) According to this sublegal act, it is determined that the design of hospitals and health clinics must be based on the structural Eurocodes package SSH EN1990 – SSH EN 1999.