Technical Passportization of Buildings and Seismic Resistance Assessment

Paata Rekvava, Ketevan Mdivani, Ioseb Kakutashvili
National Association of Earthquake Engineering and Engineering Seismology of Georgia
Georgian Technical University, Tbilisi, Georgia, 77 M. Kostava st, 0160
rekvavapaata@yahoo.com
DOI: https://doi.org/10.52340/building.2025.71.02

Abstract: The article discusses the issues of technical passportization of buildings and the assessment of their seismic resistance. Existing passportization methods are analyzed, the main objective of passportization and its results are discussed. A form for the building's passport card is proposed, and the procedure for filling out the passport card for both new buildings and buildings in operation is provided. It is recommended to use the vibration machine BUM-80 for assessing the seismic resistance of buildings, as it allows us to subject the building to conditions as close as possible to real earthquakes and to perform the identification of its computational model under various impact levels. The issue of the wide implementation of modern active and passive special constructions for protecting buildings from seismic impacts in seismic construction in Georgia is raised. The readiness of the National Association of Earthquake Engineering and Engineering Seismology of Georgia for conducting passportization of buildings in Tbilisi, assessing the seismic resistance of existing high-rise buildings, and determining the effectiveness of active seismic protection measures is emphasized.

1. Introduction

In seismic regions, building passportization is the first stage of ensuring the seismic reliability of existing construction objects at a necessary and economically reasonable level. It addresses issues of physical, moral, and seismic wear, seismic hazard changes, and the adaptation of design standards and construction improvements. The passportization of buildings and the assessment of seismic resistance is particularly important in Tbilisi and large self-governing cities in Georgia, where many buildings from the 19th and 20th centuries were built under changing seismic conditions and outdated seismic design standards. Based on building passportization, a passport document should be created, containing data on the building's technical condition, seismicity of the construction site, and its seismic resistance.

2. Main body of the paper

Many problems have accumulated in the housing stock of the Republic of Georgia. Numerous buildings are damaged or in an emergency state. There are also issues with other types of buildings. Unfortunately, some of these buildings are of high responsibility. For example, buildings where large numbers of people gather, or whose damage could lead to significant material losses or human casualties (stadiums, theaters, train stations, military facilities, hazardous materials storage, etc.).

In advanced countries, legislation mandates mandatory passportization for all buildings, which involves examining their technical condition, documenting it in the form of a passport, and controlling it periodically (every two or five years, depending on the category of the building). For instance, according to the building norms of our neighboring countries, the passportization process includes determining the dynamic parameters of the building, among other factors [1].

The main goal of building technical passportization is to extend their normal operational period. The primary objectives of building passportization in seismic zones are:

1. Identifying seismic hazards in buildings that require reinforcement, repurposing, or demolition (destruction), i.e., monitoring the technical condition of buildings.

2. Assessing the probable extent of damage to buildings under different levels of seismic impact.

3. Comparing the actual seismic resistance of buildings, i.e., determining whether specific measures have been implemented according to regulations and identifying any seismic resistance deficits.

A technical passport is a document that contains essential data required for the building's operation and is considered an informational reference document that reflects its actual condition [2].

This data helps reduce labor costs when calculating the scope of repair works for structural elements and calculating material-technical resources for building maintenance and repairs.

The initial materials for passportization are:

- Microzonation maps of populated areas, or if unavailable, seismic hazard zone maps according to the technical regulation "Seismic-resistant Construction" PN 01.01-09 [3].
- Engineering-geological and geomorphological maps of the area, as well as the results of engineering-geological investigations for construction sites.
- Project technical documentation, including design seismicity of buildings.
- Inspection reports for buildings that have previously been impacted by earthquakes.
- Technical documentation based on which the buildings were restored after an earthquake or another emergency situation.

Existing methods for passportization can be classified into three groups:

1. Expert evaluation methods.
2. Calculative-analytical methods.
3. Technical diagnostic methods.

Analysis shows that each method has both positive and negative aspects, and there is no unified, universally accepted standard method. Therefore, it is essential to conduct measurement work on buildings, visual and detailed (instrumental) inspections, identification of structures, and recalculation based on changes in seismic standards.

The investigation results determine the actual seismic resistance of the building and any seismic resistance deficit, which is reflected in the conclusion with relevant recommendations aimed at restoring the building's normal operational characteristics.

The result of conducting passportization is the monitoring and control of the condition of buildings, as well as the creation of a unified system for documenting the state of buildings in order to detect potential hazardous or emergency situations in a timely manner, and to cease the operation of dangerous buildings.

Passport cards are filled out:

- When designing buildings.
- During the preparation of reconstruction projects or when the purpose of a building changes.
- When the seismic situation changes (with the emergence of new information).

Thus, the methodological issue of technical passportization is reduced to a fundamental question: what criteria should be used when assessing the seismic resistance of buildings:

a) Expert evaluation, which reflects the degree of compliance of the building with construction standards and structural requirements.

b) Seismic resistance calculation or analytical assessment, which corresponds to the conditional seismic loads based on seismic-resistant construction norms and regulations.

c) The results of the technical diagnostics of the building.

Experience in investigating the effects of earthquakes shows that the primary material damage and social losses due to earthquakes are usually concentrated in a small number of more severely damaged buildings.

More complete information on damage is used when calculating seismic risk, where the reliability of the calculations depends not only on the selected seismic risk model but also on the completeness and reliability of the results of the buildings' passportization — one of the links in the seismic hazard-damage-passportization-seismic risk-methodological chain.

Therefore, it is advisable that in Georgia, passportization should apply to all buildings of state agencies and individual enterprises, regardless of ownership type, that are located in areas with seismicity of 7, 8, and 9 intensity. Conducting passportization facilitates the thorough examination of the technical condition of buildings and the determination of their actual seismic resistance level. It should be carried out by a specialized organization staffed by highly qualified specialists, who will be responsible for the accuracy of the data entered into the building's technical passport.

It is clear that after the passportization of an individual object, it will be determined whether the building needs to be demolished, repaired, or if no structural intervention is required from the standpoint of reconstruction, for which it is necessary to create a technical passport for the object.

A building's technical passport is considered an informational reference document that reflects its actual condition. It is a document containing essential data necessary for the operation of buildings, which helps reduce labor costs when calculating the scope of repair works for structural elements, and for calculating material-technical resources for building maintenance and repairs [3].

The technical passport includes information about the structural features of the building, design loads, dimensions, area, number of floors, construction date, foundation characteristics, wall thickness and materials, roofing, roof details, date of major repairs, etc. Additionally, this document is accompanied by floor plans and specifications of rooms.

Based on the materials of technical passportization, it is possible to create a passport card (form) in the format proposed below in this article, which should be accompanied by working materials (technical documentation, observation journals, seismic resistance assessment calculations and diagrams.).

For new buildings, the passport card is filled out during the design process by the design organization. For buildings already in operation, the card should be completed when the initial seismic resistance evaluation is carried out. Changes to the passport card are made during subsequent investigations of the buildings.

The passport card should also be filled out in the following cases:

- When developing a reconstruction project for buildings or when changing their intended use.
- When the seismic situation in the area changes (with the emergence of new information).

Passport Card

Building Name: -------------------

N	**Building Passport Data**	
1	Location Name (Region, City, Municipality, Street, Building Number)	
2	Seismicity of the Settled Area	
3	Building Purpose	
4	4.1 Type or Individual Project, Project Code, Design Organization	
	4.2 Building Class	
	4.3 Ecological Consequences of Collapse under Seismic Impact	
5	5.1 Type of Structure	

	5.2 Type of Foundation, Presence of Basement	
	5.3 Structural Particularities of the Building	
	5.4 Main Material of Load-Bearing and Enclosing Structures (Concrete Class, Steel Grade, Type of Masonry)	
6	Seismic Intensity of Building According to the Design	
7	Construction Organization, Years of Construction Start and Completion, Construction Quality	
8	8.1 Building Dimensions (Length, Width, Height), Presence of Balconies, Loggias	
	8.2 Number and Dimensions of Blocks Separated by Anti-Seismic Joints, Presence of Reinforcements	
	8.3 Number of Floors, Floor Height	
	8.4 Balance Value, Initial and Current at the Time of Investigation	
9	Volume-planning and Structural Particularities of the Building Affecting the Seismic Resistance	
10	10.1 Seismic Resistance Development Area (Flat, Sloped, Lowland, Elevated), Type of Filling (Bulk, Cut off)	
	10.2 Groundwater Level, Presence of Protective Measures against Water	
	10.3 Ground Category According to Seismic Properties	
	10.4 Other Geological Features of the Site	
11	Design Seismicity of the Site	
12	Evaluation of the Building's Technical Condition	
13	Conclusion on the Building's Seismic Resistance	
14	Recommendations for the Building's Further Operation	
15	Recommended Period for the Next Investigation	

Chairman of the Commission: --------------
Members of the Commission: ---------------
Passport card filling date ---------------------

It is noteworthy that continuous monitoring is required for bridges, viaducts, overpasses, towers, masts, and other similar structures, where one of the main tasks during inspections is to determine their dynamic parameters, which today are either not carried out at all or are mainly performed inadequately with outdated and imperfect methods.

In the second half of the last century, almost every new type of building structure, its model, fragment, or individual load-bearing structures were subject to natural-experimental testing under both static and dynamic loads. Based on the results of these experiments, the structural perfection of these buildings was achieved and incorporated into construction practice. In the 1980s and early 1990s, in the former Soviet Union, several dozen such experiments were conducted, which contributed to the structural perfection of various types of residential and public buildings. For example, large panel multi-apartment buildings, known as "Tukhareli" type (Tbilisi, Kutaisi), incomplete-frame large-panel multi-apartment buildings (Irkutsk), reinforced concrete residential buildings with an incomplete frame (Leninakani), large-panel multi-apartment buildings with solid concrete cores (Sochi), large-block multi-apartment buildings with cut limestone blocks (Feodosia), and multi-apartment buildings with prestressed reinforcement in construction conditions (Kutaisi, Ashgabat), large-panel multi-apartment building with detachable connections (Tbilisi)were tested.

Unfortunately, these processes have now been halted. However, as mentioned above, during the development of European standard national annexes [4] and the process of building passportization, it will be necessary to conduct natural-dynamic (including vibrational) testing to determine the dynamic characteristics of buildings and assess their real rigidity. Currently, these tests are performed with outdated Soviet-era equipment. The data recorded by these instruments cannot be directly or immediately processed by computers. Consequently, in addition to providing certain inaccuracies when determining specific parameters, the decryption of these records requires significant time and effort, ultimately affecting the quality and reliability of the research.

For conducting experimental natural-vibrational studies, which inherently include testing the seismic resistance (stability) of a building under real earthquake conditions up to 7-8 intensity, our association member, the company "Zniepi," has one of the world's most powerful vibrational machines, the BIM-80. This machine can generate harmonic (sinusoidal) vibrations in the frequency range from 0.5 to 20 Hz and apply an inertial load of up to 80 tons in the horizontal direction per one complete vibration cycle. Depending on the type and size of the building being tested, this allows us to simulate seismic loads equivalent to those of a 6-7 intensity earthquake and study the behavior of the building, its individual structures, and joints in the plastic stage (up to destruction, i.e., when the building's own vibration frequency decreases by 30% or more). This allows us to subject the building to conditions closely resembling a real earthquake, determine the full package of its dynamic parameters (including mode shapes), and identify its theoretical calculation model under various levels of impact (discretization). Using this vibrational machine, most of the above-mentioned residential buildings were tested both in quasi-static and plastic stages.

Considering the increased seismic risks worldwide, the introduction of modern special (active and passive) seismic protection structures in construction is particularly relevant. Much progress is being made in developed countries in this direction, and after each new earthquake, specialists are becoming increasingly convinced of their effectiveness. In Georgia, these structures have mainly been implemented in the construction of several bridges (Tbilisi, Heroes Square). Given the relevance of the issue, the use of this vibrational machine has made it possible to scientifically study modern seismic protection structures and systems, as well as to develop necessary recommendations (technical regulations) for practical use. Currently, our colleagues in neighboring republics are also actively engaged in this type of work.

It is noteworthy that the National Association of Earthquake Engineering and Engineering Seismology of Georgia is ready to participate in the process of buildings passportization in Tbilisi, the re-assessment and evaluation of the seismic resistance of existing high-rise buildings, and the testing of building fragments to determine the effectiveness of active seismic protection measures, under appropriate conditions.

3. Conclusion

Based on the analysis conducted, it is determined that the main objective of the technical passportization of buildings is to extend their normal operational lifespan and to stop the operation of buildings in emergency condition. In Georgia, passportization should be carried out for all buildings of public institutions and individual enterprises, regardless of ownership type, located in areas with seismic activity of 7, 8, and 9 intensity. A building passport form has been developed, which should be completed during the design process for new buildings by the design organization, and for buildings in operation, the card should be filled during the initial assessment of seismic resistance. Changes to the passport card should be made during subsequent investigations of the buildings. The passport card should also be filled out when developing reconstruction projects or changing the purpose of buildings, as well as when there are changes in the seismic situation of the area. The process of passportization and assessment of seismic resistance requires the implementation of natural-dynamic testing of buildings using the vibration machine BUM-80, which is available to the member company of the National Association of Earthquake Engineering and Engineering Seismology of Georgia, LLC "Znieps." The scientific study of modern special active and passive constructions for protecting buildings from seismic impacts, the development of necessary recommendations, and their implementation in Georgia can be carried out using the aforementioned vibration machine.

References:

1. Rekvava P. "Modern Seismic-resistant Construction," Tbilisi, 2009, 241 pages;
2. Rekvava P. "Multifactorial Assessment and Rehabilitation of Building Seismic Resistance," Tbilisi, University Press, 2022, 169 pages;
3. Technical Regulation "Seismic-resistant Construction" (P.N 01.01.-09), Tbilisi, 166 pages;
4. European standard EN 1998-1:2004, Eurocode 8: Design of structures for earthquake resistance, part 1: General rules, seismic actions, and rules for buildings, CEN, European Committee for Standardization, 229 pages.