Vulnerability of existing Buildings in old urban zones of Prishtina, Reasoning of Historical Preservation of area

Prof. ass. Dr. Florim GRAJÇEVCI [1], MA sc. Flamur GRAJÇEVCI [2], Civ. Eng. Hamdi KURTESHI [3],

1Civil Engineering and Architecture Faculty of University of Prishtina, florim20@gmail.com
2Urban 3d, flamurgrajcevci@gmail.com
3Consortium Ingedia-Inocsa, hamdi.kurteshi@gmail.com

1. ABSTRACT

Kosovo is situated in the Alpine-Mediterranean seismic belt comprising the zone of contact between the lithosphere plates of Africa and Eurasia, which extends from the Islands of the Azores to the eastern border of the Mediterranean basin. Its most active part is the Aegean Sea and the surrounding area. In this region ($33^0$43’00”N, $18^0$30’00”E), characterized by almost annual occurrences of at least one earthquake of $M \geq 6.5$, are located Greece, Albania, Montenegro, Kosovo, FYR Macedonia, southern Bulgaria and western Turkey. Using wisely the environmental and topographical advantages (potentials), the old city of Prishtina us a capital of Kosova are made between the two hills. The main compactness structure of city is urban shape of city, narrow road network, the structure of existing building constructed with native construction materials (timber, stone and clay).

In 1807 in Prishtina, main characteristic constructed was fortified fence connected with six feet deep trench. Under the terms of author, Ani BUE (1830), the majority of homes was only ground floors, narrow macadam roads with sidewalks of 45cm length. From larger – toolset facilities mentioned “Tower watch” and 12 mosques, some of which exist today, us are; great Mosque, Jashar Pasha Mosque, etc.

Kosovo is exposed to a range of natural hazards. The main threats are earthquakes. Based on evidence from past earthquakes, the territory of Kosovo is considered to be active from a seismic point of view. The 475 year returned period Seismic Hazard Map of Kosovo now serves as the basis for a micro-zonation study being conducted in Ulpiana (Prishtine neighbourhood). The main problem in Kosovo is the fact that 80-90% of buildings are not built according to the seismic codes. Assessment Vulnerability of existing old urban zones (with constructed buildings us an seismic) in close to the centre of the city, will provide significant development in downtown areas, taking into account the vulnerability of many historic and cultural buildings.

2. INTRODUCTION

During past centuries, the southern part of Europe has been devastated by a great number of large earthquakes, resulting in human victims and enormous material loss. Because of intensive building construction and increasing urban population density for the last two decades, the current consequential effects of such disastrous events would be even more drastic. It is therefore, of great importance to assess the seismic hazard properly, raise public awareness and improve disaster planning and management in the whole region. Important objective of this paper is to improve scientific collaboration between the designers and Municipality.

Kosovo, as a new country, still with weak institutional capacities, it is evident that is failing to cope professionally and in timescale with rapid increasing population in the main cities, especially in the capital city – Prishtina. Consequently we are coping with uncontrolled construction practices and business pressure, leading in using susceptible and unsafe lands and non verified structural systems just for business daily profits. The situation is more critical for former urbanized zones where are activated strength and stiffness degradation practices by removal of selected bearing members of the structures to create spaces for commercial activities.

Prishtina city spreads in North-East part of Kosova, with area 4,334.52 ha. The city surrounded by rolling on three sides, creating a topographical amphitheatre views, on altitude around 535 – 730m. In the last two decades of XX century, Political Social and Economical Changes in Kosovo have very highest poorly effects on development of Urban, Social and Economical. Urban Structure of Prishtina went through phases of restructuring actions influenced by different cultural and political, which have resulted in the loss of cultural and Architectural spirit of the city.

Prishtina city consist with three different urban structures.

- Old part; Historical zone of Prishtina, with the very old of buildings, builds on beginning of the twentieth century.
- Urbanized part; City of zone with social, public and economic compounds made after the second WW.
- Suburban rural zones.

In old urban zone of city the prevailing construction types are the classical masonry residential structures with height from 4 to 6 stories, constructed in early 1960's.

Since the end of the conflict in 1999, Pristine as a capital of Kosovo has experienced an unprecedented construction boom and growth of urban areas. However, authorities do not always adequately control this, even though there is an understanding that illegal constructions pose higher risks to the population.

The regulations for construction in seismically prone regions are commonly given special importance for the purpose of safe construction. Regulations referring to particular countries, i.e., particular conditions of construction, local construction materials and traditional construction practice cannot be thoroughly applied in other countries.

3. THE STUDY AREA

With the passing of time, the development of the city has been embryonic, from the core (centre) towards the outskirts. The old historic buildings are concentrated mainly in the city centre, including religious cult buildings, museums, public schools and many residential buildings that are mainly with a small plan and limited levels. The city has been developed with new buildings on the outskirts. These represent good quality, mainly highly reinforced concrete structures. Also in the city centre, there are small zones of residential buildings that are concentrated in blocks, constructed mainly with structural masonry walls. Apart from these blocks, there are isolated buildings constructed in the same system, with masonry walls, wooden roof structure.

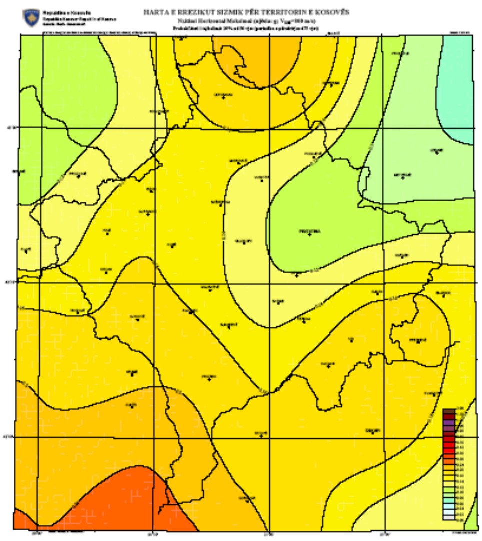

Figure 1. Kosovo Seismic Risk Map

Possibility of earthquake strikes in our country, more precisely in Prishtina, which theoretically, as per available data (from Seismological Report of Kosova), can be of a large intensity. From the above it can be roughly estimated that this existing building category is most vulnerable from possible earthquake strikes, therefore the need for seismic vulnerability assessment for these buildings is necessary

Most of the existing historical monumental structures are, made of masonry, using either stone or brick blocks. These unreinforced blocky masonry structures can not be considered a continuum, but rather an assemblage of compact stone or brick elements linked by means of mortar joints. Seismic events have often caused massive damage or the destruction of such structures with great cultural significance.

The existing of not small area, as part of city of Prishtina, as follow; old zone in middle of city, *tophane*, *muhaxheri* zone, *vellusha* zone, *kodra e trimeve*, mainly are populated with residential home up to 4 stories in Structural system with masonry bearing walls made bay bricks and clay blocs (Figure 2).

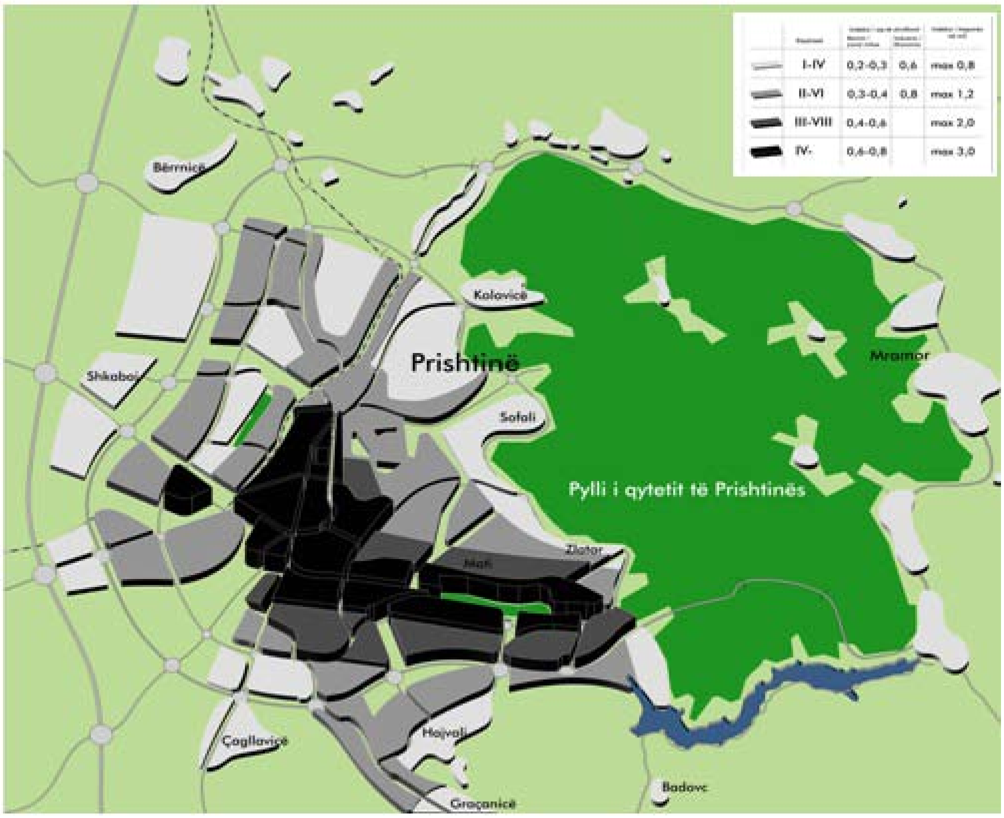

Figure 2. Map of Prishtina city, urban density and number of Stories.

In these areas, existing a lot of historical buildings as are the mosques, museum, schools with very historical importance.

Question are how to kip these areas to be non vulnerable, because of lot of populations and especially the building with very historic importance. The mainly issue are to assessed vulnerability of the existing buildings.

4. CONCEPT FOR SEISMIC RISK ASSESSMENT BASED ON DEVELOPED BUILDING VULNERABILITY FUNCTIONS

The evaluation of the seismic vulnerability of such structures, as is the case for the other types of structures, depends on reliable numerical simulation of their seismic response. Numerical modeling of the seismic behavior of masonry structures represents a very complex problem due to the constitutive characteristics of the structural material and its highly physical and geometrical non-linear behavior when subjected to strong ground motion.

The proposed integral theoretical procedure for seismic vulnerability prediction of building strictures integrates several successive steps formulated based on combined theoretical modelling, relevant experimental evidence and respective engineering considerations. The principal steps can be summarized as follows:

1. Development of analytical hysteretic models simulating realistically nonlinear behavior of building structural (SE) and nonstructural (NE) elements;
2. Development of criteria defining the induced damage level to structural and nonstructural elements based on refined analysis of their bearing and deformability capacity (Fig. 3);
3. Formulation of advanced nonlinear analytical model of integral building based on application of the proposed original hysteretic models of respective (SE) and (NE) building elements;

4. Selection of a representative set of time histories of earthquakes that reflect the local conditions and the expected seismic hazard;
5. Performing of large series of nonlinear dynamic response analyses of the structure under different earthquakes and earthquake intensities;
6. Derivation of relationships between the earthquake excitation intensity and structural response expressed via the relative inter storey drift index;
7. Derivation of specific loss functions for the structural and nonstructural elements depending on the defined damage criteria (Fig. 4);
8. Evaluation of the vulnerability level of structural and nonstructural elements and cumulatively for an integral building, at each storey level; and finally
9. Definition of analytical vulnerability functions for the integral building based on the specific loss functions and the selected set of ground motions.

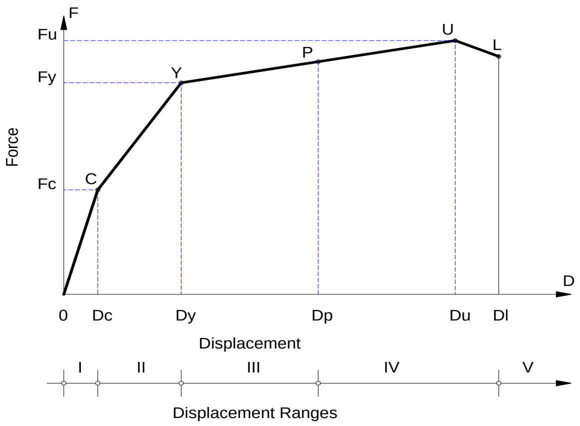

Figure 3. Element Typical Force – Displacement Envelope Curve with Five Specified Ranges

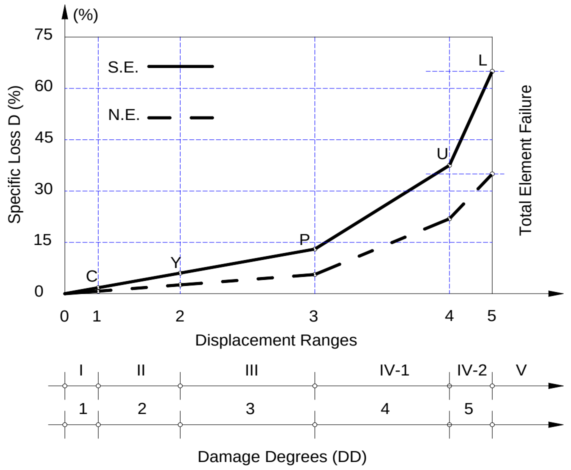

Figure 4. Specific loss functions in structural and non-structural elements

Example 1. Vulnerability Analysis of Secondary School "7 September", *Tasligje* area

Among the numerous school buildings in Prishtina constructed as masonry systems is the public school named *"7 September",Tasligje area.* Immediately after the construction, the building was used as a political school, but now it serves as a secondary vocational school owned by the municipality of Prishtina. It was renovated several times, but there are no structural changes. The building consists of a basement, a ground floor and the first floor. The ground floor and the first floor areas are used for teaching, while the basement serves for storage.

The reason for the selection of this school lies in its floor plan – organization of structural walls and the form of the plan that does not meet the conditions referring to the building center of mass and center of rigidity

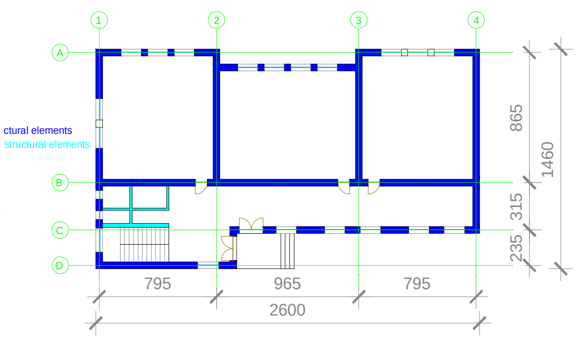

Figure 5. Floor plan and View of the secondary School "7 September"

Structural system is a system with load-bearing walls on both orthogonal directions. Basement walls are with stone and have a thickness of 45cm. Other load bearing walls are with bricks and are 38cm thick. Brick dimensions are 25x12x6.5cm and are bricked with cement plaster. In the longitudinal direction, along the "x" axis, there are five linear load bearing walls, with different distance, and in the transversal y-direction, there are four linear walls with different distances between each other (7.95, 9.65, 7.95)m. The building consists a basement floor (2.98m high), a ground floor and the first floor (3.76m high). The connection points of the load bearing walls are strengthened in both directions with our self. Load-bearing walls are made of stones and bricks. Walls at the basement level are with stones and they are 45cm thickness, and brick walls with a thickness of 38cm are on all other storyes. Unit brick dimensions are 25x12x6.5cm and are usually bricked with cement plaster. Walls are properly interconnected during bricking.

Based on obtained results from the performed seismic vulnerability study of representative models of frame structure bearing walls, new models simulating nonlinear behavior of structural and nonstructural elements have been defined. The formulated non-linear mathematical model is defined as “shear type”, formulated based on systematic implementation of “multi componential” concept. For the (Structure of School) is the formulated mathematical model, consisting of two concentrated masses and of two principal elements for each storey representing non-linear stiffness properties and hysteretic non-linear behavior characteristics of structural and non-structural elements, respectively. Seismic input is represented with adopted set of three recorded earthquakes of different frequency content as follows: Ulcinj - Albatros N-S (1979), El Centro S00E (1940) and Prishtina synthetic.

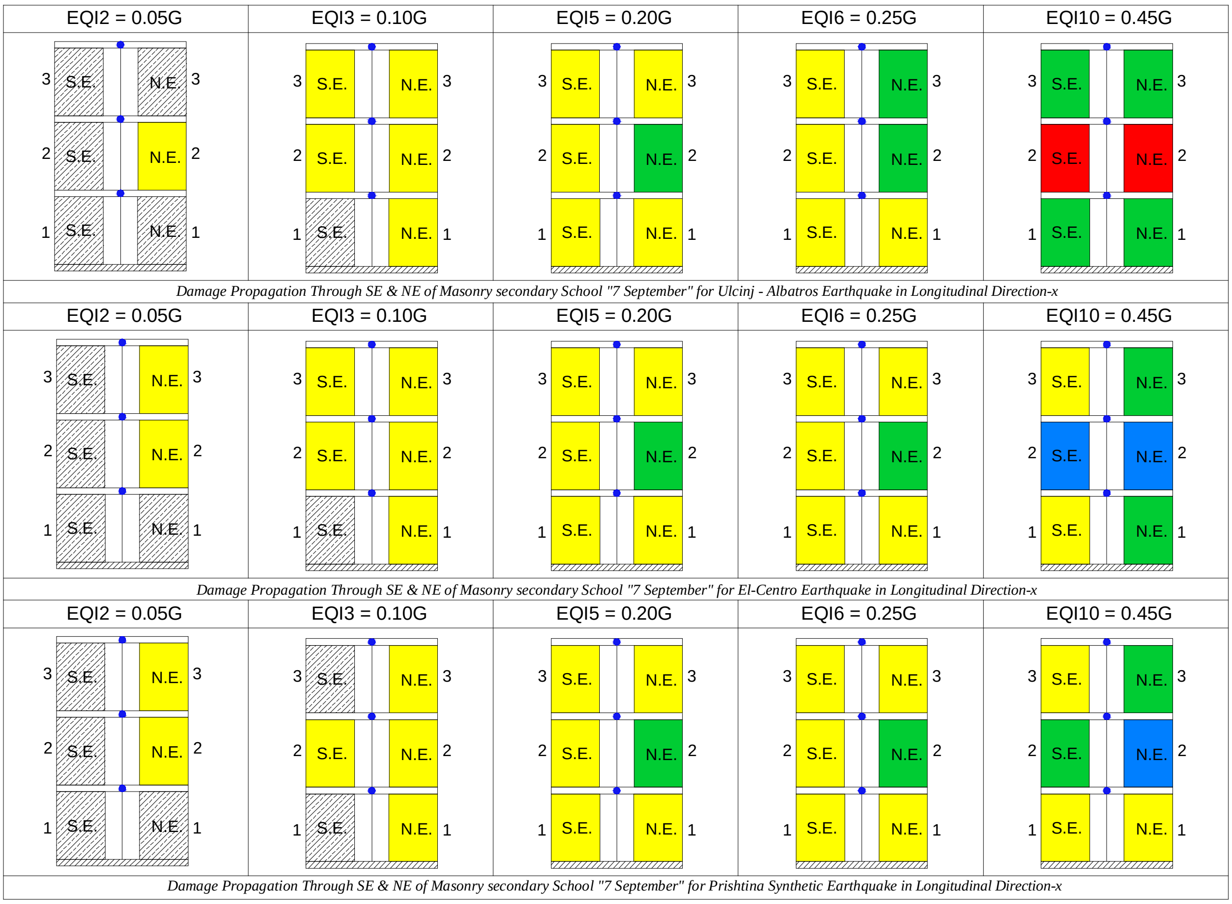

Figure 6. Damage propagation trough SE and NE for Building, secondary School, under three earthquakes in x-direction

Building collapse takes place on PGA = 0.20g in transversal y-direction. This is because of the present different story stiffness and storey strength for directions X and Y. Stiffness and strength is greater in referent longitudinal direction x, therefore collapse of the building happens faster in the transversal y-direction with the lower stiffness and strength. As a result of the large stiffness along the x direction, it can be seen in the damage propagation under El-Centro and Prishtina Synthetic earthquakes that theoretically the building does not collapse, even though the total collapse occurs in PGA = 0.20g.

Figure 7. Damage propagation through SE and NE for Building, secondary School, under three earthquake in y-direction

Example 2. Vulnerability Analysis of former Medical Centre

This Building was initially used as a Medical Center – Hospital, later it is modified and adopted to be used as residential Building. This adopted Building includ removal and re-positioning of several partition walls. New partition walls in general are positioned same in all levels. Building has ground floor, two floors and attic. Assessment was made taking into consideration current condition of the building.

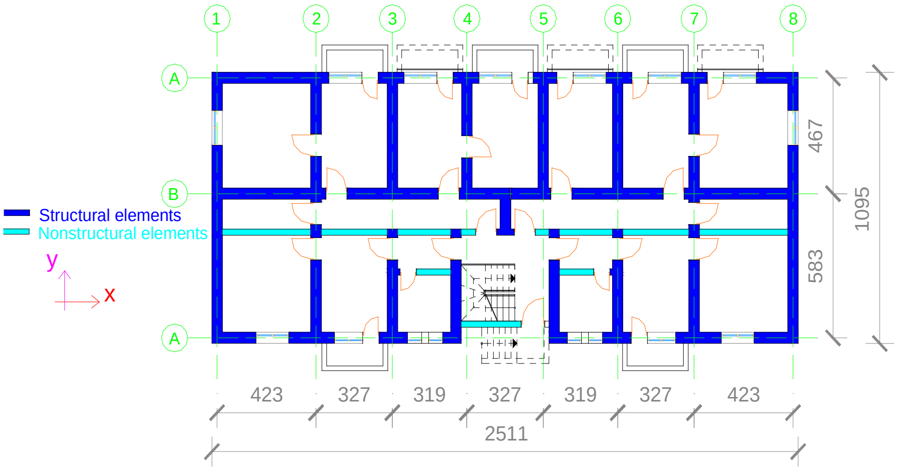

Figure 8. Floor plane of former Medical Centre

The floor plan of the building with dimensions (25.11 x 10.95)m, shown in Fig. 8, has an orthogonal shape with load bearing constructive walls on longitudinal x and transversal y-directions, and partition walls as non-structural elements. In the longitudinal x-direction, there are three linear load bearing walls, 4.67m, and 5.83m apart, and on the transversal y-direction, there are eight linear walls with different distances among each other. The building consists of a ground floor (2.72m high), a ground floor and for the all storyes (4 x 3.05m high).

Figure 9. Damage propagation through SE and NE for Building, Former Medical Centre, under three earthquake in x & y-direction

Along the longitudinal direction x, total collapse takes place under the impact of three earthquakes for the same PGA values, but along the transversal direction y collapse takes place under El-Centro earthquake impact. As far as level of damages is concerned, they are different for each of the earthquake scenarios.

Example 3. Vulnerability Analysis of Residential Building

It is a residential building for collective housing. Building consists a ground floor and the two floors. As in many above mentioned cases, in this building also a ground floor areas are modified for business premises. This conversion included removal of partition walls, as well as braking large openings on load-bearing walls.

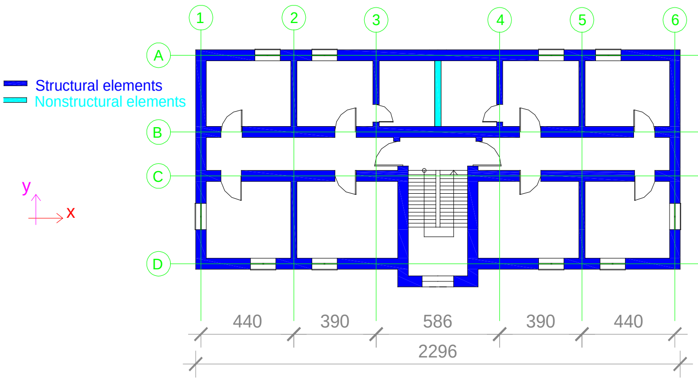

Figure 10. Floor plane and picture of Residential Building

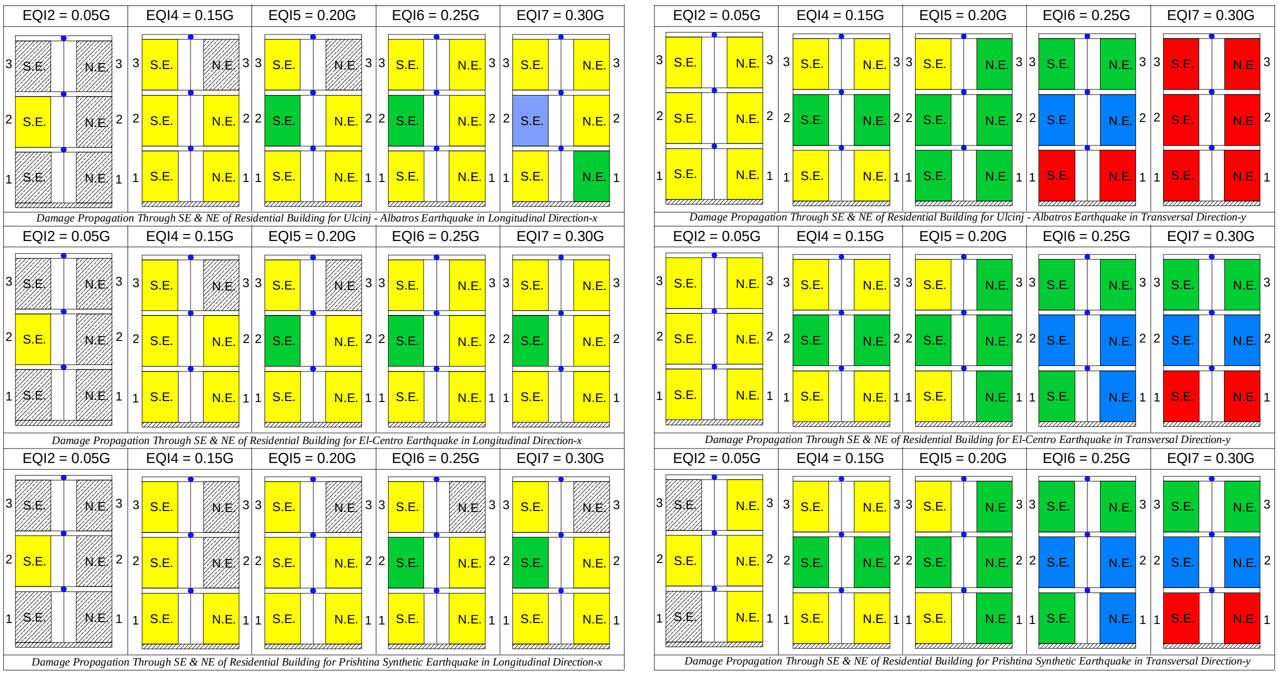

Figure 11. Damage propagation through SE and NE for Building, Residential Building, under three earthquake in x & y-direction

Building collapse happens under PGA = 0.25g in longitudinal x-direction. This is because of the present different storey stiffness and storey strength for directions x and y. Large stiffness along the longitudinal direction x can be visible that under the El-Centro and Pristine Synthetic earthquakes building collapses for final PGA values, even though it reaches total destruction under PGA = 0.25g along the transversal direction y under the impact of Ulcinj-Albatros earthquake.

CONCLUSION

The results obtained from the implemented methodology for calculation of behavior, capacity, damage grade (DG) as well percentage of losses of SE and NE for the calculated buildings, exhibit the possibility for categorisation of these buildings based on number of storeys, dimensions and shape of the building plan as well structural type. One common way to express the damageability of a structure is to utilize a so-called loss function (also referred to as a damageability function, vulnerability function, or damage function). In order to relate physical damage to buildings to other socio-economic issues, damage is expressed in terms of economic loss: the greater the damage the greater the loss. One common measure of damage is the cost to repair the structure divided by the replacement cost of the structure.
The investigations have proved that the local authorities, leadership of Pristina Minicipality, but also authorities of other Kosovan cities, are recommended to issue regulations regarding existing masonry buildings, defining the risk factors regarding their usage, and to take steps towards their reconstruction. For newly constructed masonry buildings, it is highly recommended that along the wall planes exist horizontal and vertical reinforced concrete bond elements

REFERENCES

1. A.K. Chopra. (2005) Estimating Seismic Demands for Performance-Based Engineering of Buildings, *International Conference, Earthquake Engineering in 21st Centry, EE-21C.*
2. Pojani N. (2003). Inxhinieria sizmike, *Shtëpia Botuese Toena*, Tiranë (736 page)
3. F. Grajçevci. (2010). Seismic Behaviour and Vulnerability of Existing Buildings in Prishtina – Kosova, *Doctoral dissertation*
4. M. Tomazevic. (2003). Seismic Rehabilitation of the Seismic Masonry Buildings, Research and Practical Implication.
5. M. Spirollari, IPA Benificiary DRR Needs Assessment, Kosovo, Draft1. Prishtina. 2008
6. Baballëku M., Pojani N.(2008) *"Fragility evaluation of existing typified school buildings in Albania"*, *Acta Geodaetica et Geophysica Hungarica - A Quarterly of the Hungarian Academy of Sciences*, Akademia Kiado, Volume 43, Number 2-3, Budapest, June 2008