SECOND EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING
AND SEISMOLOGY, ISTANBUL AUG. 25-29, 2014

GEO-REFERENCED INVENTORY TOWARD SEISMIC SAFETY OF EXISTING BUILDING STOCK –
CASE STUDY KARPOSH MUNICIPALITY IN SKOPJE

Golubka NECEVSKA-CVETANOVSKA[1], Roberta APOSTOLSKA[2], Veronika SENDOVA[3],
Marija VITANOVA[4] and Julijana BOJADJIEVA[5]

ABSTRACT

In conditions of increasing construction of building extensions in Republic of Macedonia, particularly for the last two decades, the issue of seismic stability and safety of such new “hybrid” structures is posed as an imperative. With the undertakings of different type of reconstructions, building enlargements, adaptations, etc. of existing structures, their structural system and dynamic characteristics are changed. Engineering practice has shown that this exceptionally important problem is not treated appropriately and the level of seismic protection of such structures is often unknown.

Within the frames of the cooperation between the Institute of Earthquake Engineering and Engineering Seismology – IZIIS and the Karposh municipality in Skopje, the projects on definition of a methodology for geo-referenced inventory toward seismic stability and safety of the existing building stock in the municipality are realizing, (Necevska-Cvetanovska et al., 2012, 2013). Based on this methodology, all the investigations that should be realized for the purpose of realistic definition of the seismic stability and safety of the structures are classified into five groups. The performed analyses for the three selected structures, as well as, certain results from the visual screening which has been done on 161 existing buildings are presented in the paper.

INTRODUCTION

The territory of the Republic of Macedonia is situated in a seismically active region characterized by an increasing seismic risk. As many other countries exposed to seismic hazard, Macedonia has also had its technical regulations for design of seismically resistant structures elaborated and adopted, (PIOVS, 1981). The main design philosophy in these regulations is based on protection of human lives in conditions of strong earthquakes and enabling partially controlled damage during the occurrence of the so called frequent earthquakes.

In conditions of an increasing trend of building of additional storeys and enlargements of existing structures, there inevitably arises the question about the seismic stability and safety of such new “hybrid” structures. This is even more emphasised by the fact that, in most of the cases, the existing structures represent masonry structures built prior to the passing of the seismic regulations in the country. After performance of works on reconstruction, enlargement, building of additional storeys, adaptations, etc. on existing structures, their structural system and dynamic characteristics are

---

[1] Professor, UKIM-IZIIS, Skopje,golubka@pluto.iziis.ukim.edu.mk
[2] Professor, UKIM-IZIIS, Skopje,beti@pluto.iziis.ukim.edu.mk
[3] Professor, UKIM-IZIIS, Skopje,veronika@pluto.iziis.ukim.edu.mk
[4] Research Assistant UKIM-IZIIS, Skopje, marijaj@pluto.iziis.ukim.edu.mk
[5] Research Assistant UKIM-IZIIS, Skopje, jule@pluto.iziis.ukim.edu.mk

changed. If such works are designed and realized non-professionally, the seismic stability of the structure could be disturbed. Engineering practice has shown that this extraordinarily important problem is not appropriately treated so that the level of seismic protection of these structures is often unknown.

This current engineering practice has been the motivation for the cooperation between the Institute of Earthquake Engineering and Engineering Seismology–UKIM-IZIIS and Karposh municipality in Skopje within which projects on definition of a methodology for geo-referenced inventory toward seismic stability and safety of the existing building stock in the municipality are being realized (Necevska-Cvetanovska et al., 2012, 2013). This is a pioneering activity at national level whose final goal is to increase the level of seismic protection of citizens and structures in this municipality. The final objective of these projects is definition of a two-level methodology for geo-referenced inventory toward seismic stability and safety of the existing building stock in the Karposh municipality, as well as upgrading of GIS of the municipality with new attributes.

The application of the methodology is illustrated on three selected buildings in the territory of Karposh municipality for which different groups of activities have been suggested in order to define the seismic stability and safety of their structural systems, (Apostolska et al., 2012, Shendova et al., 2012). Selected results from the visual screening of the existing building stock, as well as, from the above mentioned case studies are presented in this paper (Necevska-Cvetanovska et al., 2013).

VISUAL INSPECTION OF BUILDINGS EXPOSED TO SEISMIC HAZARD (Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook - FEMA 154 & 155)

The “Rapid Visual Screening” (RVS) procedure was promoted for the first time in the USA in 1998. Later (FEMA 154&155, 2002), it was modified to include the experience from the catastrophic earthquakes that occurred in the nineties of the last century. Although this methodology has originally been developed for buildings typical for the USA, with certain modifications, it has successfully been applied in many other countries, as well.

The most important characteristic of this procedure is that it enables evaluation of the seismic safety only based on inspection of the structure by an experienced engineer. The evaluation procedure itself is compatible with the GIS databases and enables application of collected data for different needs of urban planning and strategies for mitigation of consequences of catastrophes. The procedure has been developed such that it can be applied without any structural computations. According to the methodology a form consisting of one page which includes description of the building, its plan and number of occupants as well as a rapid evaluation of its seismic resistance was developed. The procedure is based on a grading system that requires from the engineer to: (1) identify the principal structural system for bearing horizontal loads and (2) identify the characteristics of the building that may change the expected seismic behavior. Three main forms have been defined for three seismic hazard levels (low, medium and high). The RVS procedure has been developed for ten different types of buildings, for materials and types of structures that are characteristic for the urban regions. All buildings are divided into six vulnerability classes, from class A (the highest seismic vulnerability) to class F (the lowest) in accordance with the recommendations of the European Macroseismic Scale (EMS-98, Gruntal, 1998). Damages are classified into five categories (1-negligible, 5-collapse) depending on their effect upon the seismic behavior of a building and in compliance with the European Macroseismic Scale (EMS-98, Gruntal, 1998).

Table 1 shows the indications of probable behavior of a building under the effect of a design earthquake. This information can be used as an indicator as to whether a building needs evaluation at a higher level (2 or 3). Generally, a scoring result of $S < 0.3$ points to a high vulnerability and requires a more detailed evaluation and strengthening of a building.

Table 1. Expected level of damage in function of the RVS result

RVS result	Damage potential
S < 0.3	High probability for occurrence of damage 5 Very high probability for occurrence of damage 4
0.3 < S < 0.7	High probability for occurrence of damage 4 Very high probability for occurrence of damage 3
0.7 < S < 2.0	High probability for occurrence of damage 3 Very high probability for occurrence of damage 2
2.0 < S < 3.0	High probability for occurrence of damage 2 Very high probability for occurrence of damage 1
S > 3.0	Probability for occurrence of damage 1

Prior to the beginning of the procedure of seismic evaluation, it is necessary to have the following information:

- Geotechnical report on local soil conditions;
- Defined soil and site parameters;
- Design documentation on the building including drawings (details), specifications and computations;
- Additional information, as for example, evaluation of behavior of a building during occurred earthquakes.

To verify existing information and/or obtain additional information, it is necessary to inspect the considered location. From the inspection, the following should be concluded:

- General description of a building – number of storeys, year of construction and dimensions;
- Structural system – identification of the system for sustaining vertical and horizontal loads, the floor structure, the basement and the mode of foundation;
- Non-structural elements – existence of nonstructural elements that affect the seismic behavior of a building;
- Identification of the building type – (in accordance with the previously performed inventory – typology);
- Level of behaviour – required (necessary) level of behaviour;
- Seismicity of the region – the input seismicity during evaluation;
- Type of soil **-** (in accordance with the previously performed categorization);
- Used area of a building – density of occupants;
- Historic importance (if relevant).

If necessary, a structure can be inspected once again to draw conclusions as to certain specificities and/or perform tests on the quality of built-in material.

The procedure of evaluation of the seismic stability and safety of existing buildings is defined at three levels.

Level_1- visual inspection consists of three sets of control sheets that enable a rapid evaluation of potentially dangerous elements in a building (structural, nonstructural, foundation and geological hazard) as well as the local conditions. The main purpose of the evaluation at level_1 is to define whether buildings correspond to the requirements given in this manual or rapidly detect possible defects.

Level_2 includes complete analysis of a building whereat all the defects detected in the previous level are taken into account. The analysis is carried out by application of simplified linear static and dynamic methods. If the results from the analyses point to certain deficiencies, the next level of evaluation is realized.

Level_3 includes detailed seismic evaluation of existing buildings. The analysis is carried out by application of nonlinear methods and although complex and costly, it leads to savings during construction that multiply exceed the costs of analysis. The application of this level of evaluation must be limited to correspondig (special) cases.

Upon the performed evaluation, a report on the obtained results is elaborated.

METHODOLOGY FOR VISUAL SCREENING, GEO-REFERENCED INVENTORY OF THE EXISTING BUILDING STRUCTURES

The assessment of the seismic stability and safety of existing structures and the undertaking of corresponding engineering measures for reduction of the seismic risk in densely populated urban regions represents the main component of the policy of earthquake risk management. In conditions when detailed assessment (at the level of a structure) is practically technically impossible and extraordinarily costly, simplified methods for assessment of the seismic stability and safety of existing structures are used worldwide. The general frame is most frequently multi-level designed and it includes the following procedures:

(1) Level_1 procedure – Rapid visual screening – involves only visual screening of the structure and provides limited data. This procedure is recommended for all buildings;

(2) Level_2 procedure – Simplified seismic vulnerability assessment – involves limited engineering computations on the basis of data obtained by visual screening and drawings or performed measurements. This procedure is recommended for all buildings with large concentration of people;

(3) Level_3 procedure – Rigorous seismic vulnerability and safety assessment – involves detailed computer analyses, similar and even more complex analyses than those in design of new structures. This procedure is recommended for all important structures and buildings which have to remain functional immediately after an earthquake (hospitals, fire fighting stations, shelters and alike).

World experience has shown that the general frame of the assessment methodologies is the same and is based on the multi-level concept, while the specificities are connected with the traditional construction practice and the seismicity of the region.

The traditional construction practice is reflected upon definition of matrices of typologies of buildings characteristic for the investigated region. The local specificities do not refer to the structural system but the additionally performed interventions of the type of enlargements, additional storeys, reconstructions, adaptations, etc. Such a situation points out that the seismic stability and safety of such new “hybrid” structural systems is unknown and that their definition is a serious and complex task.

For that purpose, it is necessary to make a certain modification of the existing methodologies for assessment of seismic stability of buildings based on national specificities.

An extensive field work aimed at collecting data on the existing building stock in the territory of Karposh municipality has been done in the period August -November 2013, (Necevska-Cvetanovska et al., 2013). A corresponding form for fast screening was elaborated for this purpose. The form contains the following attributes: (1) data and purpose of the structure; (2) screening data; (3) layout and photos of the structure (structural unit); (4) year of construction and interventions on the structural unit that have so far been done; (5) type of structural system, presence of irregularities and whether the structure is seismically designed or not; (6) soil conditions and (7) seismic hazard parameters.

In total, 161 buildings have been inspected. The findings from the visual screening have shown that 60% of the inspected buildings were built before enforcement of the seismic design codes (1965) and 55% need more detailed evaluation of their actual seismic performance.

Based on the data obtained by field screening, five groups of activities have been selected to be realized for the purpose of realistic definition of the seismic stability and safety of the structures, which have been the subject of screening, (Fig. 1). A corresponding group of activities to be realized has been defined for each screened structure depending on its current conditions (existing conditions, enlargements, additionally built storeys, adaptations, demolished parts, combination of the stated). With such uniformly defined groups of activities for each screened structure, the current georeferenced database on Karposh municipality has been updated with new attributes for inventory toward seismic stability and safety of the existing building stock in GIS environment (Fig. 2 and Fig.3). In this way, policy decision makers get relevant data in making their decisions in the procedures of issuance of permits for construction of enlargements, additional storeys, reconstructions, etc. of existing structures.

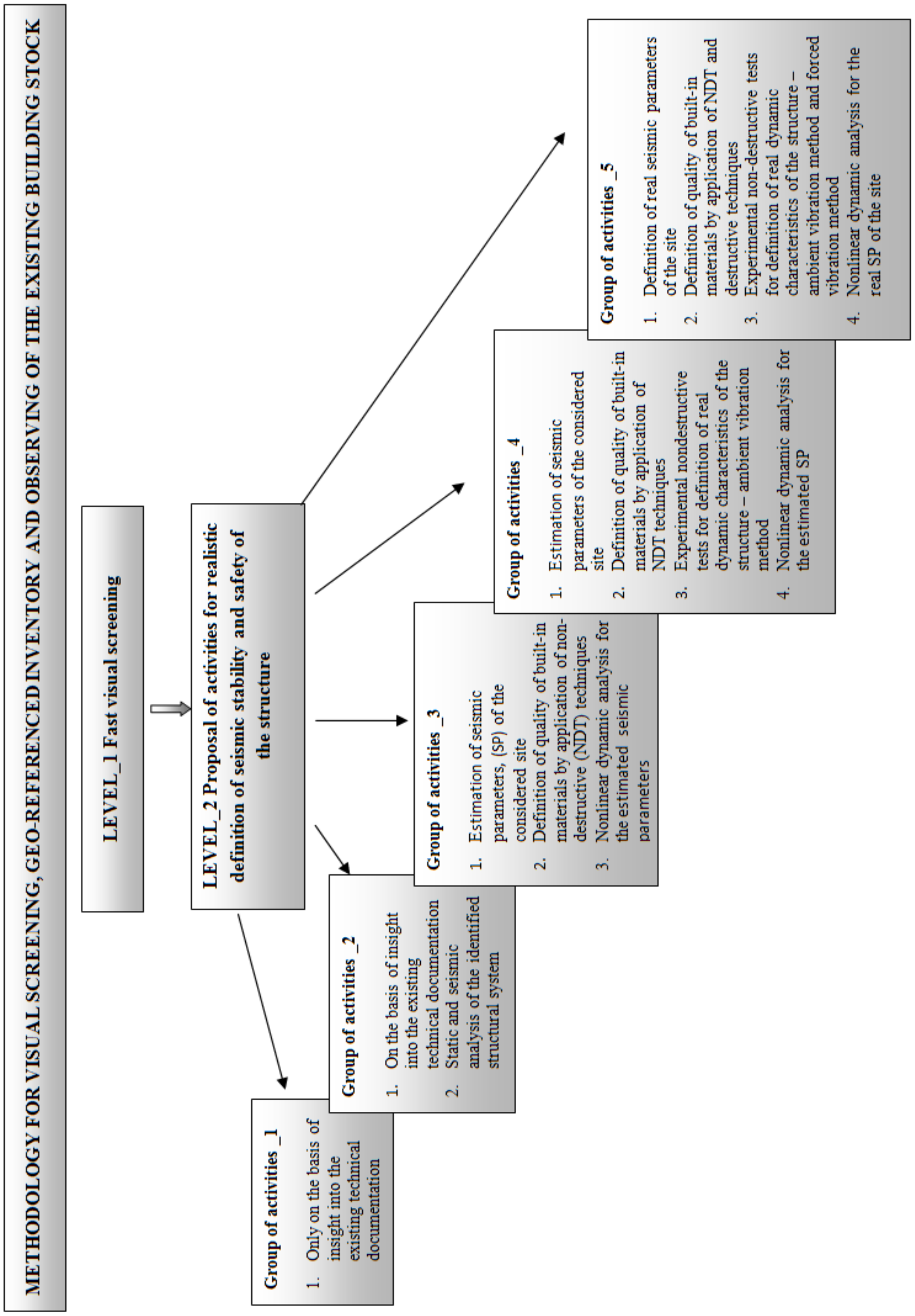

Figure 1. Block diagram of the methodology for visual screening, geo-referenced inventory and observing

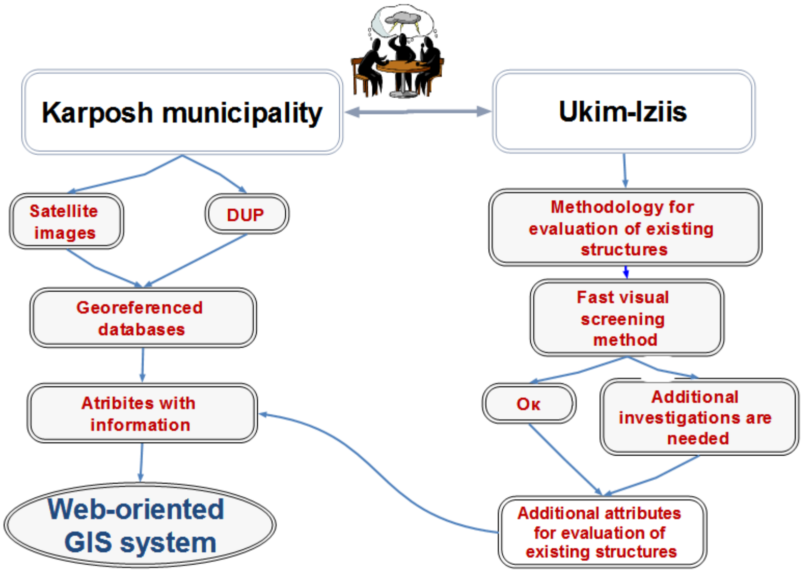

Figure 2. Block diagram of the interaction between IZIIS and Karposh municipality as to the upgrading of the information system on the municipality by new attributes for geo-referenced inventory and observing of the seismic stability and safety of the existing building stock

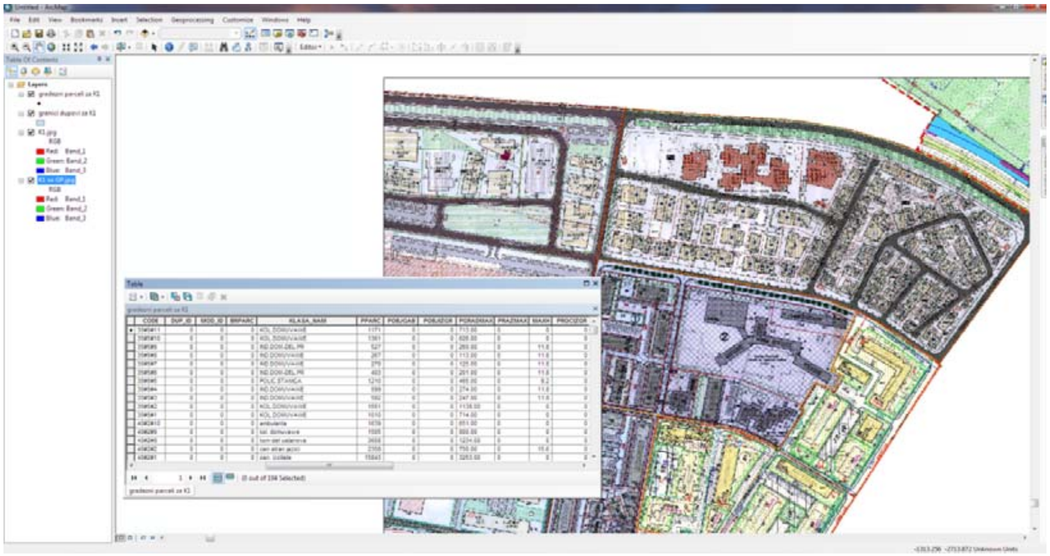

Figure 3. Web oriented GIS system of Karposh municipality

APPLICATION OF DEFINED METHODOLOGY – CASE STUDY KARPOSH MUNICIPALITY IN SKOPJE

The defined methodology presented in previous chapters of the paper has been applied for part of the Karposh municipality in Skopje – Republic of Macedonia. In the course of 2012, several selected structures were analyzed in details. In 2013, professional teams from IZIIS performed visual inspection of the existing conditions of the structures on the considered location. In this phase, part of the territory of Karposh municipality, between Partizanski Odredi Str., Franklin Roosevelt Str. Ilindenska Str. and Nikola Tesla Str. was encompassed. This location consists of 14 individual blocks indicated by: Block 1, Block 2, Block 3, Block 4, Block 5, Block 6, Block 7, Block M1, Block M2, Block M3, Block M4, Block M5, Block M6 and Block M7 (Fig. 4).

Figure 4. Karposh Municipality with marked blocks

Prior to visual inspection of the structures, detailed field and laboratory tests of the local soil as well as detailed analyses of the effects of the local geotechnical media have been performed.

Presented further are: (1) part of the results from the detailed analyses of structures performed in 2012 for the following buildings:

- Enlargement and an additionally built attic on residential structure at Rugjer Boshkovikj str., no. 7;
- Residential building at Blvd. Partizanski Odredi No. 48a;
- Residential building at Rugjer Boshkovikj Str., No. 1.

and (2) results from the performed visual inspection of a total of 161 building structures as well as analysis of the results.

Enlargement and Additionally Built Attic on Residential Structure at Rugjer Boshkovikj Str. No.7

The existing residential structure is situated on cadastral lot no. 1972 with outline proportions 51.48 m/9.52 m and GF + 4 storeys. The structure of the building consists of massive bearing walls constructed from solid bricks and horizontal and vertical belt courses constructed of reinforced concrete. The floor structure is represented by precast slabs with a width of b = 50 cm and thickness of d = 15 cm. The roof structure is constructed of wood – a double strut with a tile cover. The structure is founded on strip foundation and basement walls constructed of reinforced concrete. In 2009, the main project on enlargement and building of an additional attic at level +14.25 on the common residential structure was elaborated. The newly designed structure was designed to have an outline of 51.48 m/14.52 m and number of storeys GF+4+Attic. With the elaborated architectonic solution, enlargement of balconies by their widening for 2.5 m on the north and south side of the structure is anticipated. The structural solution for the balconies is designed as a spatial fixed RC structure consisting of RC shear walls with thickness b = 35 cm along the entire height, longitudinal RC beams at the level of all floor structures and four transverse beams on a "600" platform. At the level of the floor structures, the RC walls are connected with an RC slab with thickness of d = 14 cm. The newly designed structure is planned to be founded on a foundation slab with thickness of d = 120 cm and proportions at plan for the foundations T1 and T2 of L/B = 57.5/3.3 m.

In accordance with the methodology and for the purpose of defining the seismic stability and safety of the enlargement and the additionally built storey, the following activities were realized (Apostolska, Necevska-Cvetanovska et al, 2012):

- Exploration of the entire technical documentation – main project on enlargement and building of an additional attic upon the common residential structure at Rugjer Boshkovikj str. No. 7, Skopje – structural engineering phase, with tech. no. 01/09.
- Additional analytical investigations – static and seismic analysis as well as nonlinear dynamic analysis for expected earthquakes for the structural system of the newly designed structure of the enlargement and the additionally built attic.

Residential Building at Partizanski Odredi Str. No. 48a

The existing residential structure at Blvd. Partizanski Odredi 48a was built in 1958 as a structure consisting of B+GF+3, proportioned 30.70 m/9.50m at plan, (Fig. 4). From structural aspect, the structure represents a massive structure with bearing walls constructed of solid bricks in cement lime mortar in both orthogonal directions and fine ribbed floor structure. According to what the occupants say, during the earthquake of 1963, the structure suffered minimal damage that was repaired in 1964-65. The only interventions for strengthening of the structure involve reinforced concrete elements with a height of 1.5 m constructed in the form of buttresses in the basement of the structure up to the terrain level. The newly designed enlargement and additional storeys of the existing structure consist of a new RC structure that is designed such that it "bridges" the existing masonry structure. For the purpose of enabling communication between the existing masonry structure and the enlargement at individual levels, individual parts of the existing masonry, parapets below windows and new openings were torn down. In such a way, "the new integral" structure is enlarged and two additional storeys are built whereat its total height from the fixation at the foundation to the top is H = 23.12 m.

To define the seismic stability and safety of the integral structure in accordance with the preliminary methodology, the following activities were realized (Sesov et al, 2012), (Krstevska et al, 2012), (Sendova et al, 2012):

- Definition of the actual seismic parameters of the site;
- Definition of the quality of built-in materials by application of non-destructive tests -NDT;
- Experimental non-destructive tests for definition of the real dynamic characteristics of the structure by application of the ambient vibration method;
- Analytical verification of the seismic stability and safety of the structure (static, seismic and nonlinear dynamic analysis for the real seismic parameters) for three different states of the structure.

Based on the performed analyses, it is concluded that, in the case of solutions for enlargement and building of additional storeys by "bridging", the bearing capacity of the existing structure is not taken into account but a solution that will satisfy the requirements by itself is sought in which way a non-economical structure possessing a much greater, but unnecessary, bearing capacity and deformability is obtained. If the existing structure is included in the solution, then the newly constructed RC structure may, at the same time, have the role of strengthening of the existing structure by which a truly integrated structure will be obtained with known and harmonized behavior during future earthquakes.

Residential Building at Rugjer Boshkovikj Str., No. 1

In addition to these two structures, an existing structure, which has not undergone any interventions on its structural system, was analyzed. The structure consists of two identical units (Unit A and Unit B) divided by an expansion joint, whereat the units are proportioned 34.25 m/10.05 m at plan (Fig. 5). The main structural system consists of bearing walls constructed of solid bricks in cement lime mortar, horizontal RC belt courses and a fine ribbed reinforced concrete floor structure. The thickness of the bearing walls is 38 cm, i.e., 25 cm. Identified and regularly placed at individual positions are RC columns proportioned 25 cm/25 cm. Structural damage was not observed upon visual screening.

Rugjer Boskovic str., No.1

Partizanski odredi str., No. 48

Figure 5. View of the structures

To define the seismic stability and safety of the existing structure in accordance with the preliminary methodology, currently the following investigations are completed (Sesov at al, 2012), (Krstevska et al, 2012):

- Definition of the real seismic parameters of the site;
- Experimental non-destructive tests for definition of the real dynamic characteristics of the structure by application of the ambient vibration method.

Analysis of Results Obtained by Visual Inspection

A visual inspection of 161 structures was performed along Partizanski Odredi Str., Franklin Roosvelt Str, Ilindenska Str. and Nikola Tesla Str. This location consists of 14 individual blocks marked as Block 1, Block 2, Block 3, Block 4, Block 5, Block 6, Bock 7, Block M1, Block M2, Block M3, Block M4, Block M5, Block M6 and Block M7.

Out of these, 161 structures, 66 structures (41%) have up to 4 storeys, 52 structures have 4 to 7 storeys (32%) and a total of 43 structures with over 7 storeys (27%), Fig. 6a. Most of the structures, 33 structures (20%) represent reinforced concrete frame structures,28 structures (17%) represent masonry structures without reinforced concrete belt courses, 23 structures (14%) represent masonry structures with rigid floor structures, 21 structures (i.e.,13%) represent a combination of a reinforced concrete structural system and a masonry structure with rigid floor structures, 19 structures (i.e., 12%) represent a mixed reinforced concrete system (frames with walls), while the remaining structural systems are present less than that: 11 structures represent masonry structures with flexible floor structures, 6 structures represent a combination of a mixed reinforced concrete system (frames with walls) and a masonry structure with a rigid floor structure, 5 structures represent a combination of a mixed reinforced concrete system (frames with walls) and a masonry structure without reinforced concrete belt courses, 6 structures represent a combination of a frame structure and a masonry structure without reinforced concrete belt courses, 2 structures represent timber structures, 2 structures are a combination of a mixed RC system (frames with walls, masonry structure without RC belt courses and a steel frame, 1 structure is a concrete structure with unreinforced infill, 1 structure is a combination of a wood structure, a steel frame and a masonry structure without RC belt courses, 1 structure is a combination of a steel frame and a masonry structure with flexible floor structures, 1 structure is a combination of a timber structure and a masonry structure without RC belt courses and 1 structure is a combination of masonry structure with rigid floor structures and a masonry structure without RC belt courses (Fig. 6b).

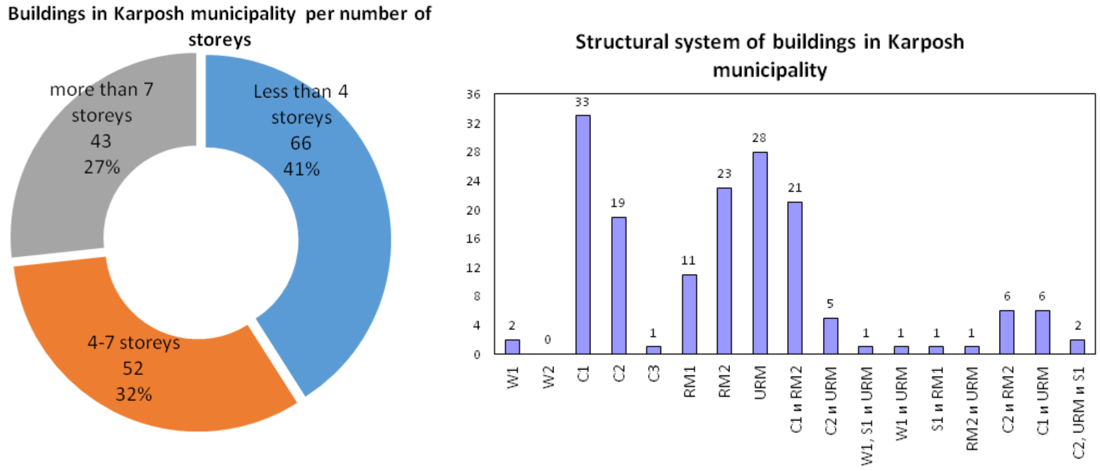

Figure 6: Review of structures in Karposh municipality classified according to a) number of storeys and b) structural system

Classification of the building structures in the Karposh municipality according to the year of construction is presented in the Fig.7a and according to the year of interventions in the Fig. 7b.

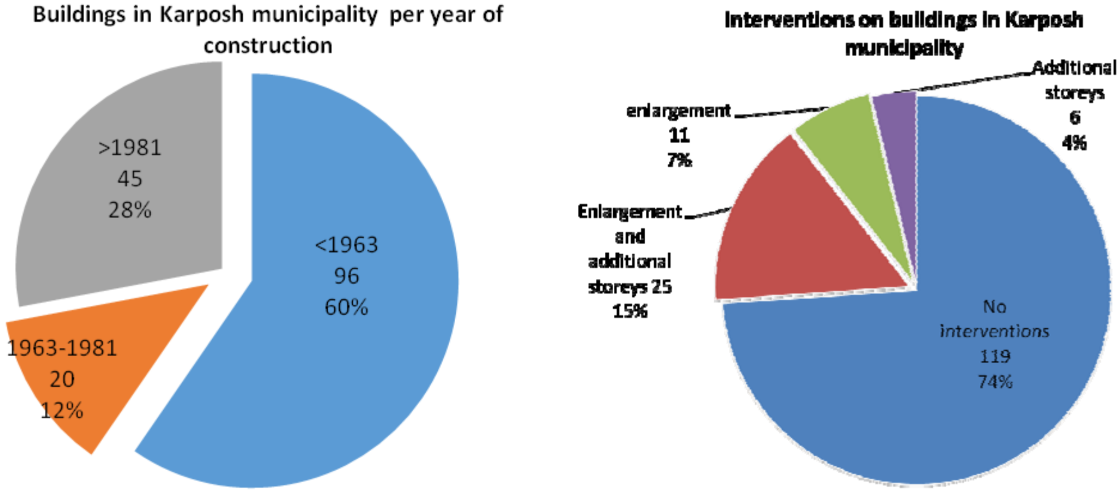

Figure 7: Review of structures in Karposh municipality classified according to a) year of construction and b) year of interventions

Expected damage potential for the building evaluated according to the rapid visual inspection methodology presented in this paper is presented in Fig. 8a. Classification according to whether the structures need a detailed evaluation is presented on Fig. 8b.

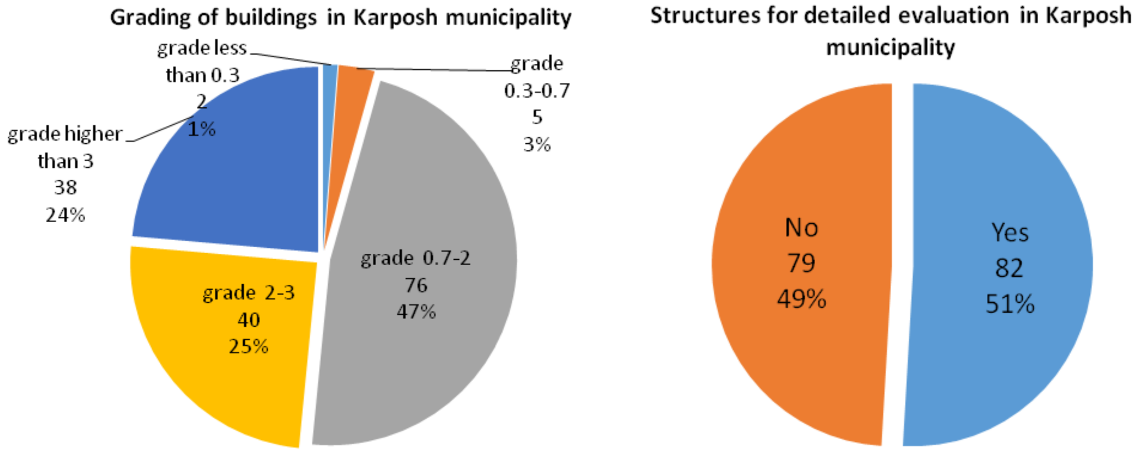

Figure 8: Review of structures in Karposh municipality. a) classified according to grades obtained from the evaluation and b) classified according to whether they need a detailed evaluation

CONCLUSIONS

Within the frames of the cooperation between the Institute of Earthquake Engineering and Engineering Seismology – IZIIS and the Karposh municipality in Skopje, a preliminary methodology for geo-referenced inventory and observing of the state of existing structures along with a corresponding form for acquisition of data from visual screening were defined. Based on this methodology, all the investigations that should be realized for the purpose of realistic definition of the seismic stability and safety of the structures are classified into five groups. The performed analyses for the three selected structures presented in the paper represent a sound basis for the finalization of the proposed methodology.

Acknowledgement. The Institute of Earthquake Engineering and Engineering Seismology UKIM-IZIIS, Skopje, extend their gratitude to the Karposh municipality, Skopje for the entrusted task and participation in the realization of this project.
Roberta Apostolska currently is Seconded National Expert in DG JRC European Commission, Ispra (VA), Italy. Contact email: roberta. apostolska@jrc.ec.europa.eu.

REFERENCES

Apostolska R, Necevska-Cvetanovska G (2012) "Assessment of Seismic Stability and Safety of Enlargement and Additionally Built Attic on Residential Structure at Rugjer Boshkovikj str. No.7, Karposh Municipality, Skopje" (in Macedonian), *IZIIS Report no. 2012-48.*

Apostolska R, Necevska-Cvetanovska G, Cvetanovska J (2010) "Analytical Investigations of Seismic Behavior of RC Frame Buildings with Masonry Infill", *Structural Engineer*, *Journal of the Macedonian Association of Structural Engineering*, pp 624-630.

Handbook for Seismic Evaluation of Buildings – *FEMA 310,* January, 1998.

Krstevska et al. (2012) "Experimental Nondestructive Tests for Definition of Real Dynamic Characteristics of Structure by Application of Ambient Vibration Method-Measurements-the Residential Building Structure at Partizanski Odredi Str. No.48a, Karposh Municipality, Skopje (in Macedonian)", *IZIIS Report No. 2012-49/2.*

Krstevska et al. (2012) "Experimental Nondestructive Tests for Definition of Real Dynamic Characteristics of Structure by Application of Ambient Vibration Method- Measurements-the Residential Building

Structure at Rugjer Boshkovikj Str. No., Karposh Municipality, Skopje (in Macedonian)", *IZIIS Report No. 2012-55/2.*

LESSLOSS – Risk Mitigation for Earthquakes and Landslides, Deliverable 22: Update of Vulnerability Estimate via Monitoring, September, 2005.

Necevska-Cvetanovska et al. (2013) "Upgrading of Information System with New Attributes for Inventorying and Monitoring of Seismic Stability and Safety of Existing Structures in Karposh Municipality – GIS Environment, Volume 1, Visual Inspection and Opinion about Existing State of Structures in Karposh Municipality and Inventorying in the Defined Form", *IZIIS Report no. 2013-47*

Necevska-Cvetanovska, G, Apostolska R, Sendova V, Cvetanovska J (2012) "Methodology for Geo-referenced Inventory and Following of the State of the Existing Building Structures in the Territory of the Karposh Municipality, Skopje (in Macedonian)", *IZIIS Report no. 2012-56.*

Ozcebe G, Sucuoglu H, Yucemen S, Yakut A, Kubin J (2003) "Seismic Risk Assessment of Existing Building Stock in Instanbul – A Pilot Application in Zeytinburnu District", 2003.

PIOVS (1981) Rulebook on Technical Norms for Construction of High-rises in Seismic Areas (in Macedonian), *Official Gazette of SFRY no. 32/1981.*

Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook – *FEMA 154 & 155, Edition 2,* March 2002.

Sesov V et al. (2012) "Definition of Seismic Parameters and In Situ Geophysical Measurements- the Residential Building Structure at Rugjer Boshkovikj Str. No.1, Karposh Municipality, Skopje (in Macedonian)", *IZIIS Report no. 2012-55/1.*

Sesov V et al. (2012) "Definition of Seismic Parameters and In Situ Geophysical Measurements- the Residential Building Structure at Partizanski Odredi str. No.48a, Karposh Municipality, Skopje" (in Macedonian), *IZIIS Report no. 2012-49/1.*

Sendova et al. (2012) "Analytical Verification of Seismic Stability and Safety of the Residential Building Structure at Partizanski Odredi Str. No.48a, Karposh Municipality, Skopje" (in Macedonian), *IZIIS Report No. 2012-49/3.*