NATURAL HAZARDS: A GUIDE FOR THE SAFETY OF PEOPLE AND PROPERTY

Boyko Ranguelov, Ruben Paul Borg, Rumiana Glavcheva, Edelways Spassov, Fathimath Shadiya

SUMMARY

The objective of the Guide for the safety of people and property is to promote specific knowledge about different effects and aspects of natural and anthropic hazards, not considered in regulations. Earthquakes and secondary effects of earthquakes, erosion, landslides (especially deep sliding surfaces), rock falls, abrasion, suffusion, radon and electromagnetic pollution by GSM operators, TV and Internet providers, influence of nearby antennas, electric power lines, icing and disruption especially for the energy and information supply lines (electricity, gas and oil pipelines, satellite transmissions, etc.) are among the hazards which treaten the human lives and the safety of property.. Some of the hazards are considered in regulations (for example eartquakes, winds' loads, electromagnetic and radiation intensity etc.), but most are not. The focus of this study is to promote the concept of a guide for the safety of people and their properties, from the effects of hazards which are not considered in regulations.

KEYWORDS: **NATURAL HAZARDS, SAFETY GUIDE, HUMANS AND PROPERTY**

1. INTRODUCTION

The real estate business is focused on different parameters, including location, view, comfort, size etc. and other factors. Project investors usually refer to codes and construction regulations. (for example vertical and horizontal stability, soil – structure interaction, anti-seismic measures) etc. Property buyers are mainly interested in price, location, size, comfort, etc. of the property on the market. Possible hazards and risks which the property (buildings, land, parks, recreation areas, etc.) is exposed to may be overlooked. This study is focused on the extent of knowledge among different stakeholders including property owners, real estate agents and development companies' The knowledge of different known or less evident hazards has an influence on critical factors including property price, quality and comfort. The perception of risk is an important parameter for property sellers and buyers and in turn affects the safety of property owners.

1.1. The Knowledge Gap

A lack of knowledge about threats to human health and life, and property (buildings, land and other varieties of property) could be an important contributing factor for the cost-benefit analyses as well (for example the local ground condition variations frequently lead to unexpected instabilities). During the last years there havebeen some minor attempts to exploit Hazard Maps and other data to support

buyers in the analysis of the risks of fires, floods and other climatic disasters, when searching for a new house [16] (www.nytimes.com).

Anthropogenic hazards have also been considered in some cases, through methods which help occupants appreciate threats. [17] (www.classicrealtyva.com). However these initiatives are non-exhaustive and not systematic in general.

1.2. Importance of knowledge

The knowedge concerning hazards and risks is critical. The secondary effects of strong earthquakes could include aftershocks, co-seismic faults and cracks, liquefaction, tsunamis, avalanches, activated landslides and stone falls; these may not be included up to now in codes or regulations. The effects of the above mentioned phenomena were frequently observed in the past [3] and in more recent cases [4]: tsunamis for nearshore areas and submarine and on earth surface landslides [5], floods (river beds), winds (tornadoes, hail storms and other meteorological hazards), ocean rips and avalanches, etc. All of the mentioned threats have specific behavior frequently expressed through nonlinear functions [16].

There is a significant lack of knowledge concerning local hazards, and multi-hazards which a property is exposed to during its lifetime [1].

It is difficult to assess the impact of specific hazards, unless there is sufficient knowledge which is provided by experts and specialists in specific fields for different hazards [19]. If this knowledge is available in advance, it will influence the market price of the real estate both for sellers and buyers. It further strengthens the real estate business, supports insurance companies and provides for improved safety of people and property.

2. THE GUIDE – STUCTURE AND RECOMMENDATIONS

The intended Guide is based on wide knowledge with reference to varied specialized expertise in different scientific and practical disciplines – engineers, scientists in the fields of geology, geophysics, meteorology, radiology and so on, experts familiar with codes, rules and regulations, medical specialists, etc. (for example Brouchev et al., [9]).

The Guide must present knowledge in a detailed yet simplified manner which can beunderstood and is suitable for non-specialists (real-estate agents, investors, owners).

The Guide must contain general instructions on how to assess and avoid (when possible) the threats to people and property. It is structued in different key chapters.

Each chapter is intended to include [6]:

- Short, simple and understandable definitions, physical description of the phenomenon – expected magnitude, intensity, size, quantity, etc.;

- Peculiarities of each specific locality and its vulnerability to the existing and expected

hazardous phenomena;

- Possible negative effects to the property and/or the humans (damages, collapses, health problems, psychological consequences, etc.);

- Ways to reveal or investigate the phenomena;

- Ways to avoid and/or to eliminate these negative effects;

- Reflection to the safety, comfort and price of the property.

There are also some new tendencies of the property assessment related to the hazards.

For example:

- Ability of the owners to react adequately to the warnings issued by the early warning systems [20]. The early warning systems are an important innovation;

- Nearest location to the evacuation roads to perform successful evacuation, especially in case of time deficit warnings (for example - earthquakes, nearshore tsunamis, tornadoes, etc.);

- Possibilities to eliminate the negative effects of risks by simple and effective measures given through instructions by specialists.

The idea is to create an understandable guide effective by simplicity, explainability and easy performance in the everyday practice of the real estate agents and companies, as well as buyers and population.

The structure can cover different topics (for example [22]):

- Introduction to risk framework

- Definition of hazard, exposure, vulnerability and risk

- Introduction to hazards – physical properties, measurable units, etc. (including typical significant examples of the past)

- Natural hazards: Earthquakes, Landslides, Cyclones, Tsunamis, Flooding, Storms (hail, snow, wind, dust, sand, etc.), Radioactivity, Volcanic eruptions, etc.

- Anthropic: Fires, Electromagnetic pollution and other anthropogenic hazards.

- The nature of multi-hazards - conditions, complexity and negative effects

- Typology of losses – From single to multiple consequences

- Nonlinearities of the damages

- Hazard assessment, Exposure assessment, Vulnerability assessment
- Integrating the risk framework with impact
- Why, when and how the hazard becomes a disaster?
- How to protect against natural and anthropogenic risks, etc.

3. A CASE STUDY (SOFIA SEISMIC HAZARD AND SECONDARY EFFECTS OF EARTHQUAKES)

In Bulgaria it is reported that there are more than 60 natural hazards and dangerous phenomena [9]. Only 9 out of them (less than 20%) are included in the codes and regulations to the new building constructions. All of the remaining hazards and dangerous phenomena have a wide distribution throughout the country, but their effects and influence on new or existing properties is ignored. Due to this many new owners are unaware of the natural and anthropogenic hazards that frequently lead to a negative impact on their property.

Seismic hazard is considered by the seismic code of Bulgaria [18] and provides protection for constructions to withstand earthquakes with intensity of up to IX MSK degree [21].

There are several threats related to the seismic hazard, unfortunately not assessed or regulated by any code.Without any consideration, these lead to dangerous phenomena, such as liquefaction, activation of landslides or avalanches, appearance of seismic surface cracks and co-seismic dislocations, etc. (Table 1). Table 1 reports the hazardous phenomena/effects and their physical characteristics, together with important recommendations for stakeholders.

The epicenters of known seismic events are presented in Figure 1. The spatial distribution is diffused, with activity concentration along some well-known faults (for example – Vitosha fault) (Йосифов et al., [13]). The Vitosha fault generates the strongest earthquakes during the considered time interval (Glavcheva et al.,[14]).

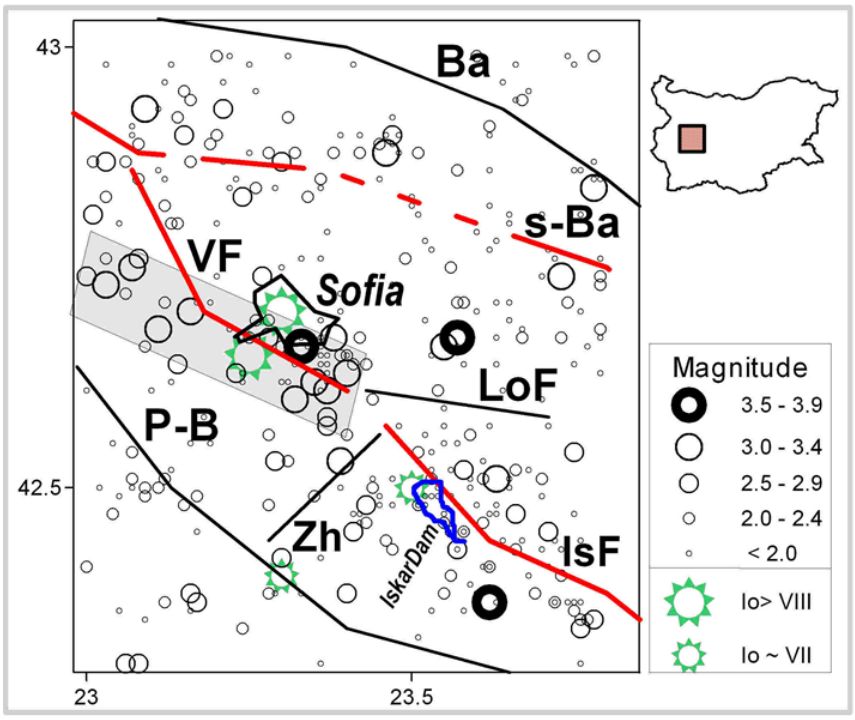

Figure 1. Seismicity of Sofia and surroundings with active faults (Matova, Glavcheva, 2009 [14]).

The depth distribution of seismic sources along the Vitosha fault (Fig.2) shows that the active depth of earthquake generation extends down to 15-18 km. In the same time, such a distribution is useful to assess the depth of past and impending earthquakes. The seismic source depth has a direct effect to the buildings stock; it has been explicitly demonstrated that the shallower seismic events have more destructive potential than the deeper ones.

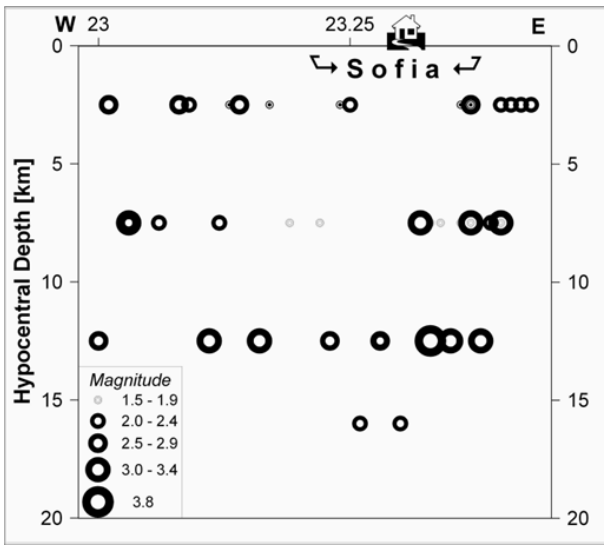

Figure 2. Depth distribution of the earthquake hypocenters along the Vitosha fault (Matova, Glavcheva [14])

Table 1. Seismic danger and related hazards and their parameters for practical use by people

Hazard	Parameter	Vulnerable objects:	Source of information	Rules	Measuring unit	Recommendation
Earthquake	Vibration	Man-made structures and people	Seismic code and intensity	+	Intensity (Ii), acceleration	Lowest value of Vs_30
Earthquake	Surface dislocations	Man-made structures and people	Maps	-	meters	Avoid
Earthquake	Avalanches (winter time)	Man-made structures and people	Monitoring	-	volume	Avoid
Ground conditions	Liquefaction	Man-made structures (then people), Land	Maps Vs_30	-	m/s	High Vs_30
Type of rocks	Hardness	Man-made structures (then people)	Geology maps	+	Rigid modulus	Hard rocks
Underground water	Water level	Man-made structures (then people)	Maps	-	m	Deeper is better
Landslides	Volume, velocity	Man-made structures, People, Land	Maps	-	Size (m^3, m/s)	Avoid slides

It is important to mention that the seismic code does not consider separately the local and regional seismic sources [7]. The local sources are much more dangerous for the building stock than the regional. If the distance is more than 50 km from the known seismic sources in Bulgaria, the probability to expect serious destructions from earthquakes generated by these sources, is rather low. Usually the buildings (man-made structures) are generally equipped to handle vertical forces arising from the dead and live loads, but may not be able to withstand later earthquake forces. Thus horizontal load vibrates walls, floors, columns, beams and the connectors that hold them together. The difference in movement between the bottom and top of buildings creates extreme stress, causing the supporting frame to exceed its capacity and the entire structure to collapse. The important local and regional seismic sources contributing -to the seismic risk in Sofia are systemized in Table 2. The most important parameters are the expected maximum magnitude M_{max}, the depth of the hypocenter (averaged and considered for all sources) and the distance between the seismic source and the interested site. The frequency content of the seismic waves emitted by each source is an important parameter about the expected resonance effects. The important exception is the Vrancea source as indicated in Table 2.

Table 2. Local and far field dangerous seismic sources for Sofia region, expected maximum magnitude and level of seismic risk

Source	Type of source	Distance to Sofia	Depth of source	M_{max}	Frequency content	Risk
Sofia						
Vitosha fault zone	Local	0-20	0-20	6.5-7.0	High	High
Central fault zone	Local	0-10	0-20	6.5	High	High
North fault zone	Local	0-20	0-20	6.5	High	High
Blagoevgrad	Regional	60-100	0-40	7.5-8.0	Middle	High
Plovdiv	Regional	120-150	0-40	7.0-7.5	Middle	Middle
Vrancea	Regional	390-430	90-150	7.0-7.5	Low	Middle

The ground condition is another parameter which increases or decreases the seismic influence – sometimes up to 2-3 intensity degree variation around intensity of earthquake on the average ground conditions determined by geologists. From actual measurements and observations it is proved that hard rocks are much more stable than sediments. The sedimentary rocks also differ in their properties – marbles and lame stones are much more stable than the alluvium and diluvium (not consolidated sand, gravel and silt). To assess the influence of the ground conditions to the seismic hazard the Vs_30 maps are constructed. Such a map for Sofia and surrounding areas is presented in Fig.3. The Vs_30 is an average parameter presenting the velocity of secondary waves (S- seismic waves, the most destructive ones) down to 30 meters depth, including hardness of the rocks, underground water level, ability to liquefaction, etc. The highest velocity means the highest stability of the ground and vice-versa – the lowest velocity means the lowest stability [10].

The simplified approach needs to present in table form (Table 3) the sensitivity of the building types to the influence of the seismic waves on the construction of the building, considering their resonance properties as well. The resonance effect is a heaviest factor responsible for the building stability. Own resonance frequency is strongly magnifying the vibrations of the construction, leading to its destruction.

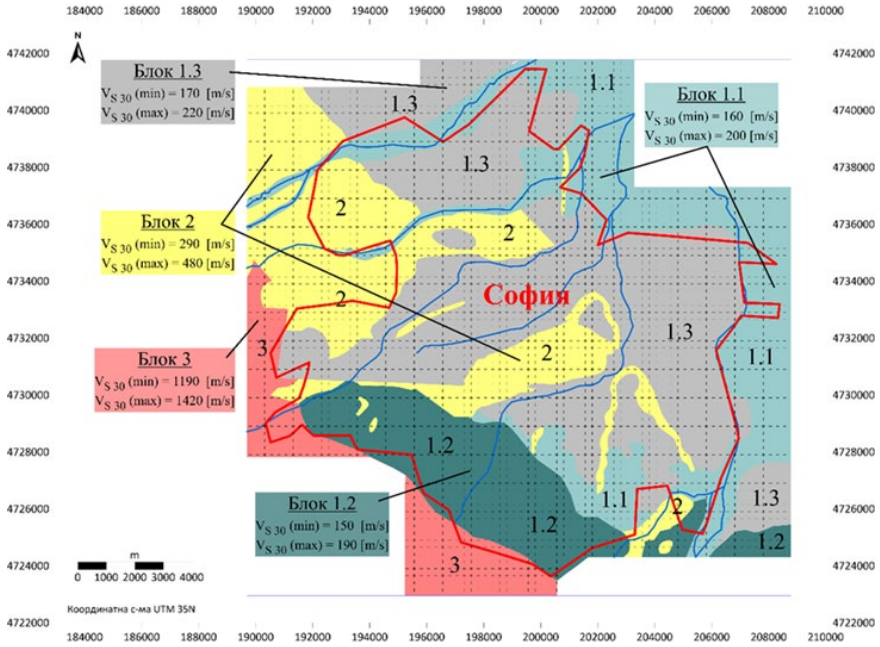

Figure 3. Map of the Vs_30 for Sofia region (Ranguelov et al., [10]).

Table 3. Seismic danger and related hazards and their parameters for practical use by people

Type of structure/Seismic effects	Masonry structures	Large-panel buildings	Buildings with bundled slabs	Buildings with creeping formwork	Wooden buildings	Concrete frame with bricks	Buildings with large-area framework
Local Seismic source effect	High	Low	Low	Low	High	Low	Low
Regional Seismic source effect	Low	High	Middle	Middle	Low	Middle	Low
Ability to resonance	High from local	High from regional	Middle	Low	High from local	Middle	Middle
Vulnerability	High from local	High from regional	Middle	Middle	High from local	Low to Middle	Low

It is important to mention that even if M_{max} is realized, distances larger than 60-80 km from the seismic source guarantee the low level of damages for all kind of structures [8].

As an important issue, with respect to preparedness level of people, the behavior before during and after an earthquake depends on the extent and distribution of knowledge, which in turn relates to the safety of people [11], [12].

4. RECOMMENDATIONS

The Guide is intended to ensure access to knowledge about natural and/or man-made hazards targeted to different stakeholders including the real estate agents, development companies and people The Guide is based on the following principles [2] :

- To create the systematic guides for real estate agents, development companies and a wide public with sufficient information on all possible local threats and hazards. This will improve knowledge and supports users including property owners, sellers, to make informed decisions, to promote safety and confort, whilst increasing preparedness through the knowledge of hazards. This framework supports also the assessment of property through a wide renage of attributes.;
- To suppot training with open educational courses on a platform intended for distant education considering national and international cooperation and wide accessto knowledge [22];
- To support educational programmes and information sessions for stakeholders, based on key basic knowledge on the most critical problems;
- To provide stakeholders including property owners and buyes, with information and knowledge concerning hazards;
- To disseminate information documents including books, booklets and short instruction manuals with clearly structured fundamental knowledge and specific parameters depending on the real situations.

This framework including the Guides supported with training and education programmes and documentations shall lead to a better understanding of hazards, leading to improved safety of people and property.

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AFFILIATIONS

Prof. PhD, Boyko Ranguelov

Mining and Geology University

Sofia, Bulgaria

Email: branguelov@gmail.com

Prof. PhD, Ruben Paul Borg

University of Malta

Msida, Malta

Email: ruben.p.borg@um.edu.mt

Dop. Member, Assoc. Prof. Rumiana Glavcheva

BASA

Sofia, Bulgaria

Email: rumglav@yahoo.com

PhD. Edelways Spassov

Kinemetrics

LA, USA

Email: espassov@yahoo.com

PhD. Fathimath Shadiya

Maldives National University

Male, Maldives

Email: fathimath.shadiya@mnu.edu.mv