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INVENTORY OF BUILDINGS WITH HIGH SEISMIC RISK AND POSITIONING THEM ON A MAP USING ARCGIS ONLINE PLATFORM

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Abstract

Bucharest can be ranked as the megacity having the highest seismic risk in Europe due to occurrences of earthquakes originating repeatedly from the same source. The density of tall buildings built in Bucharest before World War II, many being unconsolidated, require a GIS based inventory that could help an eventual intervention in case of a natural disaster and aid the assessment of high seismic risk buildings.
This paper aims to present the use of ArcGIS online platform developed by ESRI to map the high seismic risk buildings situated in the historic center of the Bucharest, known for its many unconsolidated old buildings, and to highlight the benefits of using the GIS technology.

Key words: *earthquake, GIS, risk, seismic.*

INTRODUCTION

Romania is heavily exposed to seismic hazard, which comes from the subcrustal Vrancea, although there are regions of crustal earthquakes such as Fagaras, Banat, Maramures, but not exceeding 6 degrees on the Richter scale (except Fagaras earthquake of January 26, 1916 the magnitude was 6.4 degrees on the Richter scale). As a result of a statistical analysis of data seismic catalogs, the earthquakes above 7.2 degrees on the Richter scale are repeated about two or three times per century. These earthquakes cause substantial material damage and human victims (Craiu, 2012).
According to the number of people lost in earthquakes during XXth century as well as in a single (March 4, 1977) earthquake during this century (1574 people, including 1424 in Bucharest), Romania can be ranked the 3rd country in Europe. The World Map of Natural Hazards prepared by the Münich Re, 1998 indicates for Bucharest: "Large city with Mexico-city effect". The map focuses the dangerous phenomenon of long (1.6s) predominant period of soil vibration in Bucharest during strong Carpathians Vrancea earthquakes. The Bucharest and Lisbon are the only two European cities falling into Mexico-city category (Aldea et al., 2004). International experts and organizations agreed that Bucharest is the capital city in Europe characterized by the highest seismic risk.
There is a high concern of civil engineers and Romanian Government for the assessment and the reduction of seismic risk in Romania. In Bucharest, the seismic risk is well identified: the most vulnerable buildings are mid and high rise buildings built before 1978 earthquake resistant design code. The buildings before 1941 were built without considering earthquake action, and between 1941 and 1978 the design spectrum was not appropriate for mid and high rise buildings when considering the characteristics of strong ground motions recorded in the city during 1977 and 1986

earthquakes. Romanian Government and local authorities started after 1989 a national program for evaluation of seismic resistance of vulnerable buildings, program that was later integrated into a national strategy for seismic risk reduction. The action of identification of vulnerable buildings is a continuous one. For the buildings for which expert reports are already available, the Seismic Risk Reduction Commission of Ministry of Transports, Constructions and Tourism established priority lists for retrofitting. For example in Bucharest 115 residential buildings were classified as having the highest seismic risk in case of an earthquake similar or stronger to the 1977 one (Vacareanu et al., 2004). Until all the vulnerable buildings will the retrofitted, many of them being part of the Cultural Heritage of Bucharest, a GIS based map is required as it can bring multiples benefits as: a better disaster management, delimitation of the zones vulnerable to earthquakes, a better tool for the real estate industry, etc.
This paper aims to present the possibilities and benefits of using GIS for inventory and assessment of earthquake vulnerable buildings.

MATERIALS AND METHODS

The Bucharest City Hall has published the list of the high seismic risk buildings from Bucharest. From the total of 146 vulnerable buildings we located the main ones from the historic center of the city, the buildings that make the subject of this paper. We have chosen buildings from the most popular streets (e.g. Franceza Street, Lipscani Street, Blanari Street, Selari Street).
A geographic information system (GIS) is a collection of hardware, software, geographic data and personnel, for the acquisition, storage, updating, processing, analysis and display of geographic information in accordance with the requirements of an applied field. GIS is currently the most widely used tool for the analysis and presentation of spatial data from various sources (Doru, 2013).
The chosen GIS platform was ArcGIS developed by ESRI, the free online version (http://arcgis.com) (Figure 1).

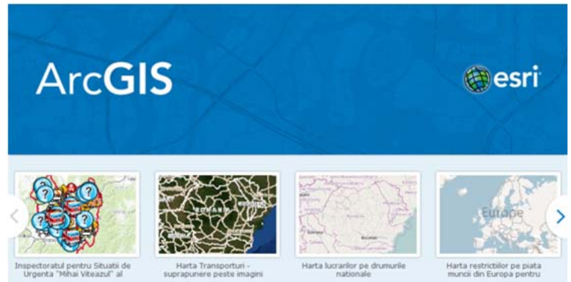

Figure 1. ArcGIS.com website screenshot

The addresses published by the Bucharest City Hall was located on the map, and on the ArcGIS platform we added pictures of the buildings and construction details of them (e.g. construction year, height, number of apartments, area, year of expertise, certified expert) (Figure 2).

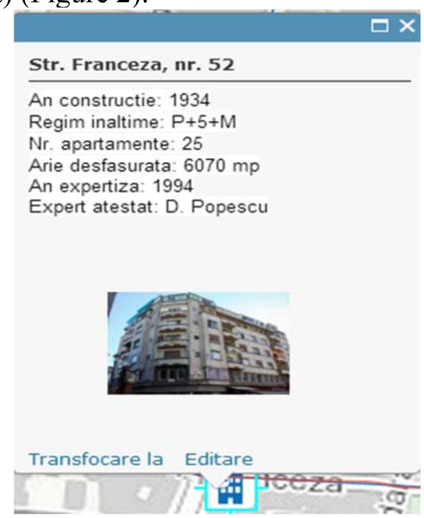

Figure 2. Construction details of a building situated on Franceza St, 52

For the final export we chose the "Map Tour" web application available in the "Share" option of ArcGIS.com website.

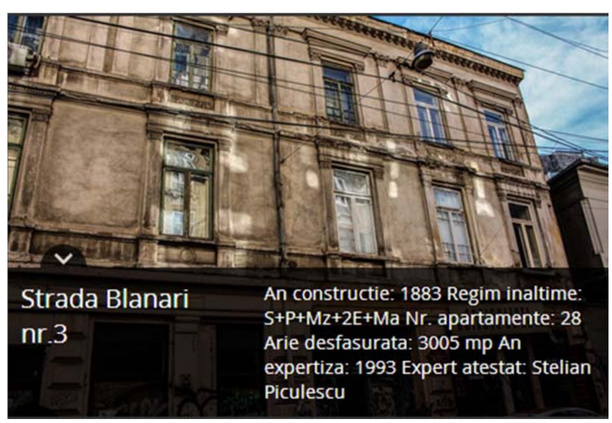

Figure 3. Construction details in the "Map Tour" web application

This application offers the possibility to take a virtual tour of all the buildings with high seismic risk from the database (Figure 4).

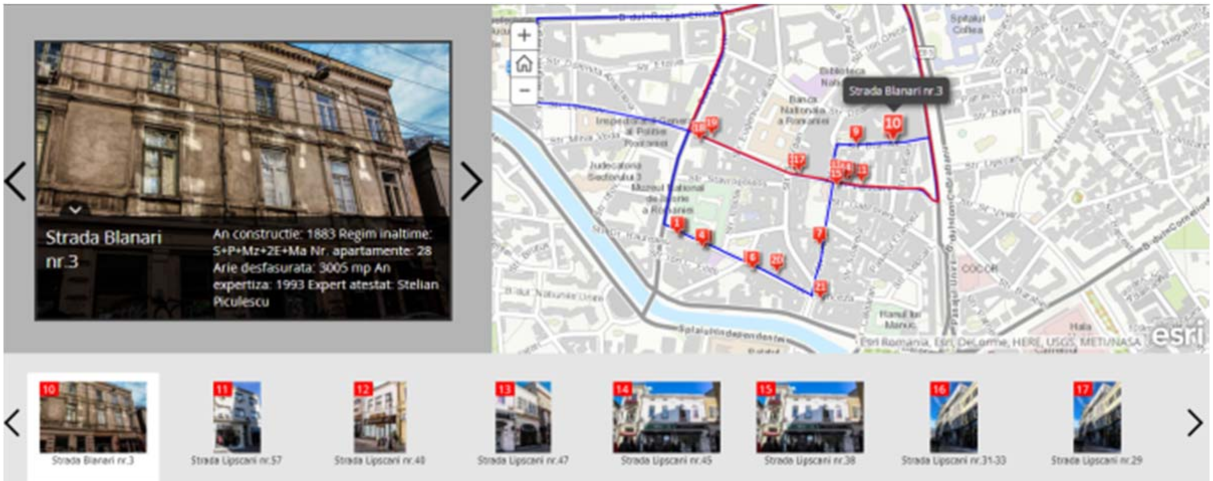

Figure 4. Virtual map tour

RESULTS AND DISCUSSIONS

Earthquakes have a greater effect on society than most people think. These effects range from structural damages to economic impacts and fatalities. An earthquake only lasts for a few seconds and the aftershocks may continue for days, but the damage does continue for years. Residential site safety and earthquake damage assessment studies play a crucial role for developing reliable rehabilitation and development programs, improving preparedness and mitigating losses in urbanized areas.

A GIS based application that could easily store a huge number of vulnerable buildings with all the required information for a fast and reliable intervention in case of a natural disaster is probably the best choice and the cheapest to implement.

Our example, made with the free online ArcGIS platform, is limited to only the positioning of the buildings on a given map and providing information about them, but with a minimal expense it can easily be developed to a very strong database with a huge quantity of information that can provide the user with a numerous ways to do simulations and virtual models of earthquake disasters that could occur, strategies for intervention in case of an earthquake, etc.

The first step that needs to be done to be able to accomplish this powerful database is the census of population in an area vulnerable to earthquake, with which we can sort the buildings by an age-range. By sorting the buildings in a logical manner, by the age of its inhabitants, we can set the intervention priority list based on the real situation of the buildings.

Another step towards this database would be the assessment of all the earthquake vulnerable buildings located on the route of the intervention teams (e.g. ambulance, firefighters, hospitals, etc.) to help us calculate the quickest and safest route for them by calculating the probability that a certain building could collapse in the event of an earthquake and block the road.

CONCLUSIONS

Considering the disaster of 1977 and the density of old buildings with high seismic risk in Bucharest, we can say without any doubt that such an interactive map based on GIS is essential.

It will prove very useful in case of an earthquake like the one in 1977 and an indispensible tool for the intervention teams.

Taking into account the economic disaster that an earthquake could bring to Bucharest, the expenditure necessary for the implementation of a GIS are very small.

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