BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Tomul LIII (LVII), Fasc. 1–2, 2007
CONSTRUCŢII. ARHITECTURĂ

A DIGITAL METHODOLOGY FOR URBAN RISK MANAGEMENT

BY

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While the overall goal is to prevent disasters as much as possible, the goal of mitigation is to reduce the risks. That is why the risk must be quantifiable in the decision support system. Geographic Informations System (GIS) support may be used for all the disaster prevention phases, but what we are concerned with here is the use of GIS for physical planning in the mitigation phase. In this paper we present a methodology and several case studies of using GIS as a tool for awareness and mitigation of seismic effects of possible future events in the urban area.

1. Introduction

The overall goal of disaster management is to prevent disasters from happening. One may distinguish four phases in this work. Long before, while the event causing a disaster is still only a possibility in the unknown future, many potential disasters can be mitigated through thoughtful planning and careful design (building standards and zoning, road and bridge design, evacuation routes, warning systems, etc.). Thanks to alert systems, we may get some minutes to days of warning when the event is imminent. This allows time for preparations, which could include boarding up windows, storing food and water, or evacuation. When the event happens the main concern is of course to survive through it, but immediately afterwards the rescue and clean-up operations start. In these conditions, the reconstruction starts. In the reconstruction after an event one would naturally consider mitigation measures for the next one, which closes the circle. While the overall goal is to prevent disasters as much as possible, the objective of mitigation is to reduce the risks. That is why the risk must be quantifiable in the decision support system [5].

The present urban built space has often a certain degree of damage, and therefore it needs some form of rehabilitation. In order to do this, one should start from seismic hazard maps, which is a problem probabilistically addressed [8]. There is an increasing need to pass from determinist methodologies to probabilistic ones.

2. Methodology Description of Digital Management of Seismic Urban Risk

HAZard USa (HAZUS) [6], initiated and supported by the Federal Emergency Management Agency, USA (FEMA), is a GIS-based sophisticated software application intended for local, regional and state officials contemplating an earthquake loss study. HAZUS is a very powerful and comprehensive Geographic Information System (GIS)-based tool for use in [7]:

a) providing a methodology as a basis for assessing nationwide risks of earthquake losses;

b) anticipating the possible nature and scope of the emergency response needed to cope with earthquake related disasters;

c) developing plans for recovery and reconstruction following such a disaster;

d) mitigating possible consequences of earthquakes.

One of the major components of HAZUS is its exhaustive database of hazard data and inventories. It includes earth science in formation, buildings, transportation and utility systems, hazardous materials, emergency response, etc. The modeling components address issues of damage is due to potential earth-science hazards and induced hazards, casualties, economic, social and indirect losses as well as emergency response.

Our aim in the present paper is to propose an *original methodology*, adapted to the local needs of the decision makers in Romania, and particularly in Jassy. This complex program needs a strategic planning for the methodology of GIS-based management of seismic urban risk. Such a planning has been initially set up by A t a n a s i u and G â l e a [1]. The present research goes on in a Postdoctoral Program supported by Ministry of Education and Research of Romania within the Excellence Program CEEX developed between 2005 and 2007 [2].

Research has begun on an urban sample of Jassy municipality, a city with about 360,000 inhabitants, with a complex urban structure of constructions, from historical monuments as churches and castles from the 15th...20th centuries to residential multi-floor buildings over 40 years of functionality, critical facilities, one-storey residential old houses over one hundred years, etc. This urban area supported only in the last century, sometimes almost without any repairs, two strong ground motions over 7 in magnitude on the Richter scale and an important number of moderate earthquakes under 6 in magnitude due to still ongoing tectonic activities in the Vrancea area of the Romanian Carpathians.

The whole process of digital management for the vulnerability of constructions in built urban environment is an integrated activity with multidisciplinary features, involving civil engineers as well as architects, IT administrators, and the public administration sector.

The strategic objective of this process addresses the following purposes [3]:

a) $P1$ – vulnerability assessment of existing infrastructure for planning the preventive measures of human safety against earthquake;

b) $P2$ – creating instruments for the emergency management of situations based on a possible seismic scenario;

c) $P3$ – education goals for enhancing the social culture in crises management during and post catastrophic events;

d) $P4$ – building of safety patterns to seismic hazard in various urban samples, which will lead to a digital city map for evaluation of seismic vulnerability.

3. Digital Monitoring Methodology

A monitoring methodology is based on a detailed analysis of buildings in the sample area. Several classes of buildings were identified from the point of view of seismic risk: U1, U2 and U3. Lxamples of buildings belonging to these classes are presented in Figs. 1 and 2 [1].

Fig. 1.– Buildings belonging to the U1, U2 seismic risk classes.

Fig. 2.– Building belonging to the U3 seismic risk class.

4. Geographic Information Systems for Risk Analysis

GIS support may be used for all the disaster prevention phases, but what we are concerned with here is the use of GIS for physical planning in the mitigation phase, so as to take the disaster risk into consideration as a fundamental property of the land. This includes assigning appropriate land use, defining building codes for that land use, and providing shelter facilities and evacuation routes as the case may be.

Following our objective of preventing tile effects of the disasters on people's safety from a dense populated urban area, we choose from the digital map of the city, presented in Fig. 3, a generic sample which includes a significant number of different classes of constructions and critical facilities.

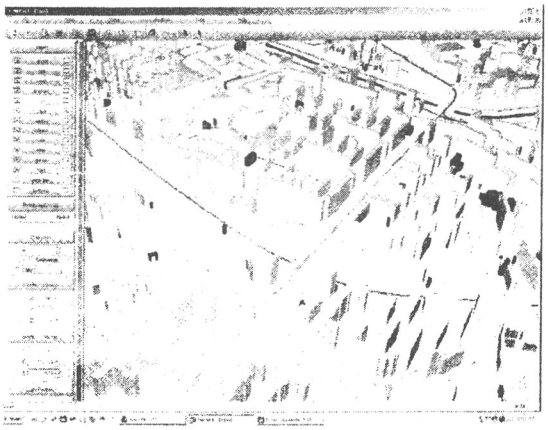

Fig. 3.– 3D map of buildings in Jassy.

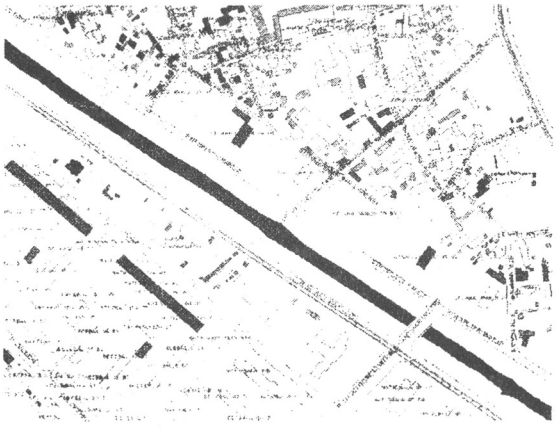

Fig. 4.– A sample of analysed area using NetSET.

NetSET [4] is a GIS system that can be customized especially for viewing and analysing risk data using the map of Jassy city.

By applying GIS technology, the results of the diagnosis presented are visualized on the digital map of seismic vulnerability for the analysed urban sample (Fig. 4).

5. Conclusions

Our analysis methods, presented in this paper, can emphasize the levels of risk vulnerability for each earthquake class. In order to understand more clearly the behavior of the Vrancea seismic region, data mining techniques must be applied to large databases containing information about events for an extended period of time. Using the GIS technology, the results of the diagnosis presented are visualized on the digital map of seismic vulnerability for the analysed urban sample. By generalization, the digital map of seismic vulnerability can be built, which is useful for the risk management of cities requested by various stakeholders at local and national level.

Received, May 12, 2006

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REFERENCES

1. Atanasiu G.M., Gâlea D. (Ed.), *GIS Monitoring of Urban Seismic Risk* (in Romanian). Politehnium, Jassy, Romania, 2005.
2. Atanasiu G.M., Leon F., *Spatial Infrastructure Information (SII) Based Management for Seismic Vulnerability of Built Urban Fund.* Res. Report Grant *3202*, CEEX Program, 2005-2007 supported by the Romanian Ministry of Education and Research, 2006.
3. Atanasiu G.M., Leon F., Gâlea D., *GIS-Based Monitoring of Seismic Vulnerability for a Class of Concrete Structures during Lifetime Serviceability.* Proc. of the Europ. Symp. on Service Life and Serviceability of Concrete Structures, ESCS-2006, Concrete Association of Finland, 2006, 183-188.
4. * * * http://www.datainvest.ro, Data Invest, Iaşi.
5. Erlingsson U., *GIS for Natural Hazard Mitigation: Experiences from Designing the HazMit GIS Expert System Suggests the Need for an International Standard.* GIS Planet 2005, Portugal, http://erlingsson.com/authorship/conf/GISforNatHazMit.pdf, 2005.
6. * * * *Earthquake Loss Estimation Methodology.* Technical Manual, FEMA, HAZUS, National Inst. of Building Sci. for the Federal Emergency Management Agency, 1999.
7. Lavakarc A., Krovvidi A., *GIS & Mapping for Seismic Risk Assessment.* National Seminar on Habitat Safety against Earthquakes and Cyclones, New Delhi, 2001.
8. * * * Official Monitor of Romania (in Romanian), No. *1221* bis, Dec. 2004.

METODOLOGIE DIGITALĂ PENTRU MANAGEMENTUL RISCULUI URBAN

(Rezumat)

Deşi obiectivul principal îl constituie prevenirea dezastrelor ori de câte ori este posibil, obiectivul atenuării dezastrelor îl constituie reducerea riscurilor. Aşadar, riscul trebuie cuantificat într-un sistem de suport al deciziilor. Cu ajutorul sistemelor de informaţii geografice (GIS) se poate facilita analiza în toate fazele prevenirii unui dezastru, precum şi planificarea fizică în faza de atenuare a riscurilor. Se propun o metodologie şi câteva studii de caz privind utilizarea GIS ca instrument de conştientizare a opiniei publice şi a factorilor de decizie şi de atenuare a efectelor seismice ale unor posibile evenimente viitoare în zona urbană.