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DIGITALIZATION OF V_{S_30} FOR LARGE CITIES (SOFIA CITY)

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SUMMARY

This research is presenting the methodology, data sources and mapping of the soil ground conditions reflected by the parameter Vs_30. This parameter is an integral characteristic of the ground conditions used in almost all procedures of the seismic hazard mapping software. The Vs_30 means the velocity of the transverse seismic waves to the depths of 30 meters of the ground layers. It depends of many factors such as density and type of rocks and sediments of the surface earth's strata, surface water level, the strength of the medium, etc. and modifying the influence of the seismic waves to the structures located on the surface. The digitalization of this parameter is the main task solved for several large cities of Bulgaria intended to the seismic hazard and risk assessment. Methodology is largely supported by the archive materials collecting data and information from past measurements and analogue data. Examples of maps and digital data base are presented.

KEYWORDS: **GROUND CONDITIONS, VELOCITY OF TRANSVERSE SEISMIC WAVES, LARGE CITIES.**

1. INTRODUCTION

The mapping of the natural hazards and environmental threats, vulnerability of structures and risk assessment and management are important issues to the prevention of population and the infrastructure [1, 2]. The assessment of the damages and losses is the most important task in case of huge catastrophes and frequently influencing the GDP of any country [3]. The most advanced techniques and technologies are extensively used for the research and assessment of the consequences of the natural and technological disasters such as space remote sensing, high effective communication systems, etc. [4, 5].

The seismic hazard and risk assessment in the recent times are exploited and implemented using different technologies, the most popular of which are models for simulation and risk management. This study is focused to the Vs_30 determination and digitalization as the very important parameter to the seismic hazard modelling.

The Vs_30 means the average velocity of the transverse seismic waves (S-waves) to the depths of 30 meters. This important characteristic is responsible for the S wave's velocity changes in the most upper ground layer and is an essential element included in the most calculus software packages for seismic hazard and risk assessment (HAZUS, EMERCOM, etc.) [6]. Increased difficulties appear when the Vs_30 determination is necessary to be done for the seismic microzonation, seismic hazard and risk assessment, vulnerability of structures in the populated zones, urban areas etc., and have to be performed in large scales [7]. All methods described above are very difficult to perform, due to the complicated measurement conditions. It is absolutely impossible to make regular grid, to perform bore holing and/or to take samples. Due to these difficulties a lot of archive materials have to be extracted, collected, digitized and interpret [8], which is performed in this work.

2. DATA AND MATERIALS

The used materials have mostly the archive origin (the archive information is useful, having in mind that the ground conditions are conservative and did not change a lot in the time domain). In the urban environment frequently this is the only way to obtain reliable primary data and information. The collected and exploited data and materials are as follows:

- Data and information about former direct measurements of Vs_30 (seismic exploration data)

- Data and information about former direct measurements of Vp_30 (obtained by different seismic methods) and the following calculation of Vs_30 using well known relationships.

- Former borehole data extracted by borehole direct (seismic) and non-direct (densitometry) measurements

- Archive information about geology (maps of different scales, layers of petrology composition, age, time of origin, thickness, roughness of the layers overlapping boundaries, lateral inhomogeneities, etc.)

- Hydrogeology information including archive data about depth of the ground waters level, pore permeability, liquefaction potential, etc.

- Laboratory tests data about samples taken earlier (use of the petrophysical properties relationships to determine Vs (when possible), granulometry data, penetration tests, loading tests, etc.)

- Seismological data about macro seismic field of former earthquakes, intensities observed in the area, local inhomogeneities, observed liquefaction, cracks, sand volcanoes, land sliding and subsidence, etc. [8].

- Recent DEM, river’s network, water bodies.

- Other data about former earthquakes, the macroseismic maps, acceleration records, attenuation lows.

- Geophysical maps and data about active faults, block structures, regional geophysical fields, geophysical prospecting information, etc.

In-situ measurements are performed, when possible, including direct seismic methods (Vp, Vs estimation), ground water level measurements, possible landslide surfaces determination, angle of slopes assessment.

To obtain the formal data and information is necessary to discover, transform and use the archives, to transfer the obtained information into recent measurement units and present effectively analogue data collected in former times and not used until now. This is not an easy task. The transformation from analogue format to the digital one is performed using different software and processing platforms. The advantages of digitalization are visible and useful, much easy accessible and effective.

3. METODOLOGY OF DATA PROCESSING

The methodology used for data processing and interpretations includes:

- Graphic presentation of the investigated site as a polygon. This gives a possibility to cover the whole area of the urban territory following the curvature of the city shape.

- Construction of the dense network of longitudinal and latitudinal lines (in different scales, if necessary) and formation of a grid.

- Interpolation procedures and calculation of the investigated parameter as weighted average value (Vs_30).

- Performing the comparative analysis of all available date, processing the information and assessing the reliability of obtained values of Vs_30 as input data introduced.

- Attribution to each sell of the grid the two obtained values of Vs_30 (the minimal and the maximal value). This provides the conservative approach and the user can choose the minimum value, the maximum value or the average one. This gives the possibility of the multiparameter approach for selection of the different variants for further calculations [10].

- Creation of the final map containing all geology units (simplified and presented like blocks for practical use), digital Excel table containing the presented on the map values of Vs_30 (min and max), together with the geography coordinates (in preferred by the user coordination system) thus forming the digital data base for the users [9].

- Presentation of the explanatory notes considering the liquefaction potential, the landslide potential and the possible modification of the amplitudes and velocities of S waves due to the different hardness of the ground [7].

- The data for former earthquakes and their influences are presented as well. It includes, intensities, macroseismic maps, observed secondary effects generated by strong earthquakes (liquefaction, surface cracks, triggered landslides and stone falls, subsidence, generated tsunamis, avalanches and other gravitational phenomena, etc. [11].

Similar approach gives the possibility of the interpreter to select the best fit of the data and information to the task and required elements thus providing flexibility and multi variances. The algorithms and models used consider the scale of the investigated area, the density of buildings and structures, the population distribution, etc., but need most accurate ground condition assessment. Frequently it is not possible to assure such accuracy due to the intensive variability of the ground conditions and needs the use of different approximations and extrapolation. The performance of such methodology is an important achievement of this study. To use earlier data and information needs large xperience, scientific knowledge, logical interpretation, multidisciplinarity, correct visualization, etc.

4. EXAMPLES AND DISCUSSION

The data and the described methodology have been performed for several seismic vulnerable urban areas (cities) in Bulgaria – Sofia, Blagoevgrad, Veliko Tarnovo, Varna, Russe, Plovdiv. The constructed maps illustrate the results obtained to the different cities and the reliability of all calculations. The grid selection (250x250 meters) is dominated by the practical consideration of convenient use and reliable results to the seismic hazard maps generation. Several maps are presented to illustrate the obtained results - Figure 1.

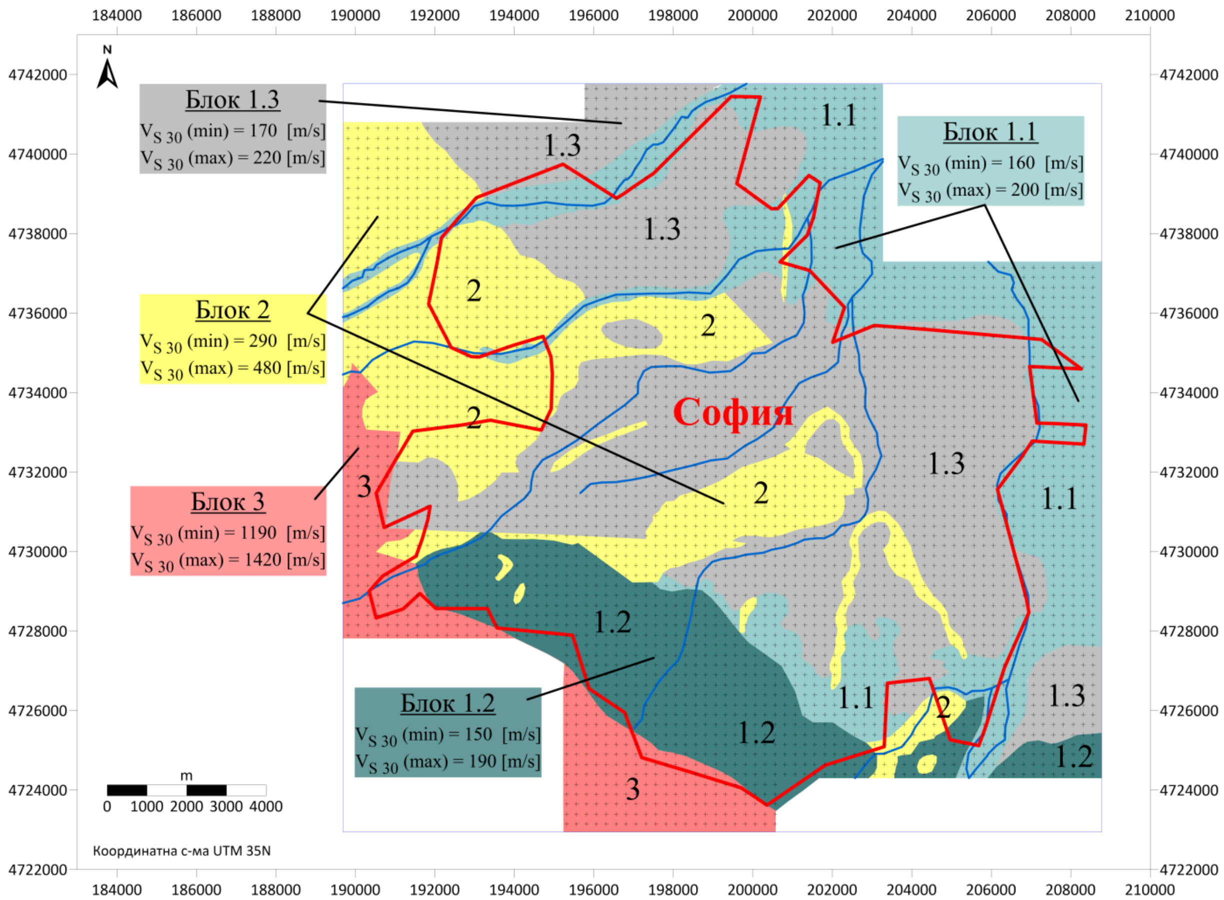

Figure 1. Map of Vs_30 for Sofia city and blocks with similar velocities.

The obtained results, suggested that the used methodology is rather effective and can be performed in cases with different conditions (sizes of the investigated areas do not matter). The methodology is not sensitive to the size of the polygon, geomorphology conditions and scale of the map (the grid in case of digital map is changeable according the users' needs). Vs_30 is an integral characteristic and includes many parameters (thickness, density, geological and petrophysical parameters, ground waters' level, etc.). The presented values can be used for seismic hazard maps calculations [12]. The extension to the risk maps including vulnerability and exposure of the societies is very important but needs increased accuracy for the decision making process [3]. The digital technologies give such possibilities in the seismic risk mapping and now the scale of the maps is less important than before [7].

CONCLUSIONS

The updated digital methodology for assessment of the integral values of Vs_30 is developed for practical purposes. It is intended to be in use for the massive electronic calculations of the digital seismic hazards maps for big cities in Bulgaria. In total six cities are selected (Varna, Rousse, Plovdiv, Blagoevgrad, Veliko Tarnovo and Sofia, located in seismic prone areas), but for the illustration purposes only one is presented (Sofia). The performed methodology including mostly archive materials (but also some in-situ measurements) shows high effectiveness and reasonable results. The new element is the suggestion of the two values of the Vs_30 (Vs_30min and Vs_30max). This provides the users of the newly calculated maps, wide diapason in variability of this parameter and gives the possibility for multi variant approach. The performance in different ground conditions in different case studies and seismic hazards calculations needs near future verification [12].

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