MODERN TECHNOLOGIES FOR MONITORING LANDSLIDE

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Abstract: *The project will provide a technical solution for assessment of environmental parameters needed in landslide risk management using advanced technologies that will allow: - acquisition of data concerning the underground water level (sensors installed inside caissons),specific environmental parameters, data regarding relative displacement of fitted terrestrial bench-marks (sensors for relative displacement) ; - transmission of field data through wireless communication to a risk management center; - modeling and simulation for natural disasters risk assessment; - control and observation of risk factors regarding landslides, based on an advanced decision-support system using GIS technologies and business intelligence; - complex analysis of historic data and meteo and seismic forecasts, in order to identify the evolution trend (during given time periods) and foresee the risk of landslide and also to identify on a map critical areas; - automatic reporting about parameters evolution due to increased alarm/emergency quota; - interactive facilities for creating alarming strategies (actions, tasks, priorities) and generating emergency plans; - automatic alerting via Internet according to an emergency plan; - presenting information (text, maps) to action group members both on fixed (PC) and mobile devices (PDA, mobile phone). Natural disasters, also known as hazards, cause huge damages every year, directly affecting the social and economical development and also taking away human lives. Hazard means the probability of a human/environment harmful phenomenon to occur during a certain period of time. Vulnerability indicates the level of damage caused by a certain phenomenon to humans and their assets. Risk means the probability of the humans and of their assets to be harmed by a phenomenon of a certain size. The elements on risk are the population, the properties, communications, economical objectives in an area. The global cost of natural disasters has grown over 800% in the last four decades being connected to an increasing vulnerability of the population living in high risk areas. Landslides are disasters that destroy villages and towns, damage roads, railways, farm fields and have negative effects on every person that lives in the affected area and generally on society. The causes of these hazards are climate changes, seismic activity, but also incontrollable human activities like abusive land deforestation (not followed by coherent financially supported reforestation strategies). Environment protection problems focus on identifying the causes of natural disasters, preventing possible damages, globaly approaching the effects on short/long term socio-economical development.*

Key words**:** *landslide, risk, natural disasters*

INTRODUCTION

Climate changes are now a certainty, which affect both the planet and the people's lives. Global warming, this burden of the third millennium, began to make its presence felt daily: earthquakes, floods, landslides, drought, etc. are phenomena that occur every year with important material damage and significant loss of lives. Their impact on everyday life, on the economic and social activity, is amplified by the psychological effects that create anxiety and fears and have a devastating effect on the environment and on unpredictable areas with increasingly widespread, especially if no monitoring, analysis and decision system for optimal reduction and annihilation effects of disasters and calamities generated by these phenomena, exists.

1. Finite Element Method Application For Current Models For Monitoring Landslide

The complexity of the monitoring landslide, requires a multi-criteria analysis their calculation in more complex conditions. The classic methods of calculation are outdated as methods of calculation in the imposed the conditions.

The finite element method is currently the numerical method most used to calculate the structures for any type or environment for stress. The element used for discreetisation, Figure 1.1 should (depending on the geometric model) have a large number of nodes. Each node must have a large number of degrees of freedom (Figure 1.2) and the interpolation function must have a large number of parameters for a better approximation.

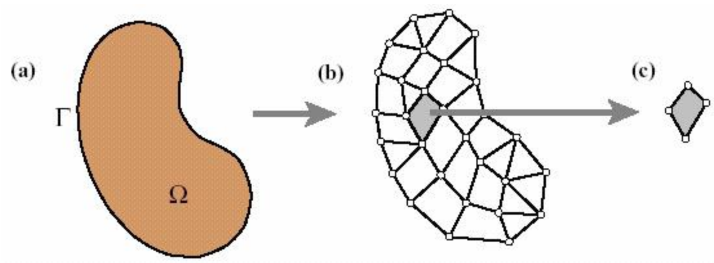

Fig.1. 1. Domain discreetisation (according to PECINGINĂ ş.a. 2002)

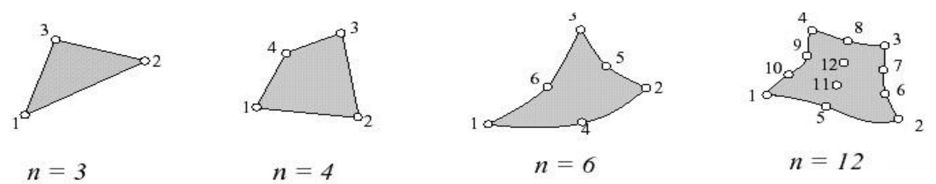

Fig.1. 2. Triangular element /quadrangles, n – number of nodes

The basic principle of the formulation of the finite elements method is the correlation between *part* and *whole* (ZIENKIEWICZ, 1977, SCHWARZ 1980, PASCARIU, 1985, SEREDIUC, 1996). According to the dialectical conception, *the whole* is a *homogeneous integrity*, being composed of *a set of parts* which are subordinated and organic integrated. Unlike the mechanical *approach*, which concerns the *whole* as a *sum of parts*, each part keeping unchanged the individual properties, the dialectic approach recognizes the existence of relationships of interdependence between *the whole* and *the part*. *The finite element* considered *separately*, outside the body as a result of the manifesting of its relative independence, has individual properties that are radically different from the interaction properties that it has when correlated with other elements of *the body* and integrated into it as an element of structure.

1.1.The parting of the analysis domain into finite elements

In this initial stage it is chosen the type of the appropriate finite element to the problem to be solved, which is called the *discretisation* operation. The type of the finite element is defined by several characteristics, such as, for example, the number of its dimensions (uni-, bi-, or three-dimensional), and therefore the number of *nodes* of finite element , the associated *discretisation functions* (hereinafter currently named *approximation function*) and so on.

2. The establishment of the equations of the finite elements

The equations of the finite element known as elemental equations describe the behaviour of elemental material or environment in a finite element, their number being equal to the number of degrees of freedom of each element. These equations can be derived in several ways: directly, by variation, using the residual method and through the energy balance method.By applying this method one can obtain a system of equations of the form:

$K_e\, \Phi_e = p_e$, (1.1)

K_e - *the matrix of the physical-geometrical features of the finite element;* for the calculation of tensions this matrix is called *the rigidity matrix;*

Φ_e - *the vector of the nodal functions* unknown on the finite element;

p_e - *the load vector* on the finite element.

3. The assembling of the elemental equations (the rigidity matrices) in the equation system of the structure

The behaviour of the whole structure is modelled by assembling the corresponding equations systems of finite elements in the structure equations system, which physically can be interpreted: the equilibrium of the structure is determined by the equilibrium of the finite elements. The assembly condition consists of equalizing the unknown function or functions in the common nodes of the considered elements. Assembling these equations is equivalent to assembling the rigidity matrices K_e of finite elements in the rigidity matrix K of the structure and the vectors of load for finite elements in the load vector of the whole structure p. It results the equation system specific to the whole studied object:

$K\, \Phi = p.$ (1.2)

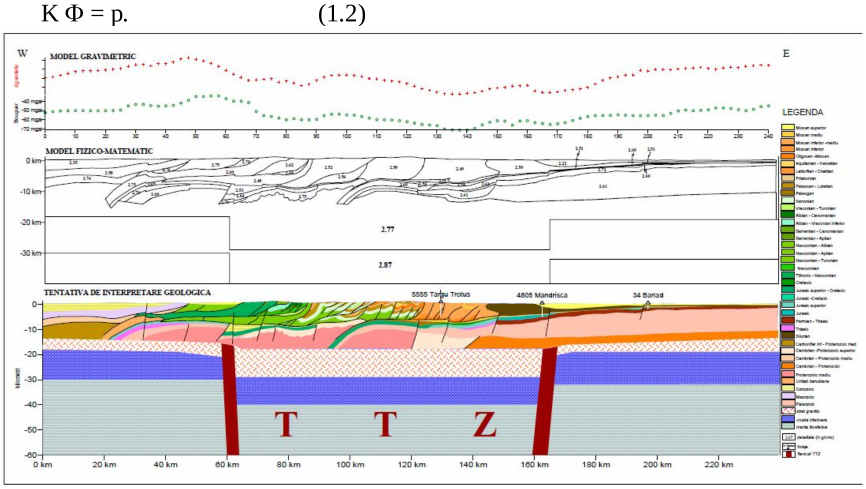

Fig. 1.3. 2D model of the Oriental Carpathians lithosphere based on the gravimetric data, under depth constraint provided by the magneto-telluric probing (according BESUTIU)

The tri-dimensional finite element with six external nodes is the triangular prism. This element is used in that situation in which, besides the geodetic results introduced as the input data one can supplementary appeal to certain final geo-physical data, such as, the density of terrestrial crust.

One of the directions of scientific research which is very actual consists in the determination of the technologies able to achieve prediction of earthquakes, in general, and of those characterized by large magnitudes, in particular, through the study of physical measurable precursors. In this framework, a very important role is to study of recent movements of the crust. Geodesy, through terrestrial technologies and through the space technologies, provides data regarding changes in uniform efforts and specific strains of the earth crust.

The tomographic seismic interpretation that was recently completed (project CALIXTO) allowed special survey of the extent of this phenomenon, a rift that led to the formation of the western basin of the Black Sea , developing in depth beyond the astenosphere and causing the mobilization of masses of the top mantle along major faults such as Saint George, Peceneaga-Camena or Varna-Giurgiu.

2. MODELS FOR THE MONITORING OF LANDSLIDES

The basic principle of building the models is that based on the measurements made during a period of time can be constructed models of behaviour, which can highlight the state of normality of the area, by carrying out surveillance graphics based on previous trends, and forecast a minimum number of calculation values.

To define these criteria of the surveillance in time graphic one can use methods of statistical processing of measurements that have the advantage of assessing the behaviour of area based on the elements that contain the existing link between a variety of processes and phenomena, which are found in an interaction only apparently random. Thus, the statistical model used will appear as an average resultant of many individual actions of the ensemble of phenomena.

2.1.The classical and modern models used in the analysis of the areas with landslides

Landslides can be interpreted as spatial strains of an area affected by the stresses specified above. The classical approach in this case is considered a quasi-static model and the methods of analysis are geometric (NIEMEIER 1988). The determinations based on geodetic measurements in the classical approach, characterize mainly by the slide phenomenon even in the case of a kinematic model in which are emphasized *the speed and the acceleration* of the movements in discrete points located for tracking the area (*tracking marks*) to points located in the stable area (*tracking stakes*).

Classical variation methods have proved unable to resolve a number of important actual issues, in which belong the landslides, it is therefore necessary a *parametric analysis*, a most suitable method for analysis of structures in the slide area and disturbing factors is the finite element method presented in the first part of this chapter. Based on regular-geodetic measurements - that can be characterized as time series -using the *finite element method* to show the changes of coordinates of individual points in the slide area and input parameters that describe the behaviour under the action of the disturbing factors.

For the tracking of sliding behaviour are studied the movements of a set of points located in specific points.

In this domain, it is important to determine precisely the spatial position of characteristic points on various objects, through methods of measurement without direct contact and - possibly - in the shortest possible time.

In most cases, the results of geodetic measurements (e.g. measurement of directions and distances) are part in subsequent calculations aimed to determine the coordinates of points. Since the individual measured values are affected by the random deviations (random errors) represented by the standard deviations of measured values, these deviations will reflect on the calculated function. Deviations on measured values *are propagated* on the measured parameter (*Law of propagation of errors*). (COSARCA A.O.2007)

Geodetic basic methods for monitoring the behaviour in time of landslides have been developed for monitoring distinct behaviour in the plane behaviour and vertical behaviour. These methods require specialized personnel, precision equipment, favourable weather conditions, and appropriate software for processing and interpretation of the measurement results. Data collection in the field requires long time and their processing is done in a later stage.

Geodetic methods have the advantage of providing information about both the sliding and the surrounding land. The geodetic observations system of the landslides is generally composed of two independent networks: a planimetric and an altimetric network. The altimetric system consists of lines of developed geometric levelling.

The planimetric grid points are determined with concrete pillars equipped with forced centre systems, thermic insulated and having the foundation in the basic rock to ensure stability in time.

The GPS technology is not yet a standard method for monitoring movements in the slipping area. Using this technology is still at experimental stage. Compensation of the support network is done through the smallest squares method.

2.3.Matematic-information models for the processing of primary data from measurments regarding the impact of the landslides on the environment

Once the measurement data bases created, one must think over the creation of processing and prognosis models for status indicators of the relevant environment factors.

The external causal factors mentioned above, which are inputs in the system - grouped in: climatological factors, factors of human activity (anthropogenic), biotic factors, natural mechanical factors; other factors involved (may be unknown in the present) can be "sorted" and they can be assigned a weight so as to highlight their contribution to destabilize the slope system and the producing of landslides. This analysis can be achieved using neural network models of specific repeated measurements considered as time series.

The execution of measurements at different times to determine the quantitative characteristics of an observation unit or of an entire zone, the data that we obtain form a time series or a dynamic series.

In practice, the condition of the equal time interval does not appear as a serious impediment. Most series in official publications, such as the series of phenomena of economic, demographic and meteorological, have equal intervals, like days, or nearly equal - the years or, with goodwill, approximately equal – the months.

3.Natural hazards and risk management

The most important disturbance of geo-cybernetics systems may be:

- Natural hazards (earthquakes, landslides, drought, etc.) and natural resources (quality, quantity, purchasing opportunities, etc.);
- Material resources (raw materials, equipment, machinery, technology etc.);
- Human society (organization and management of state, specific policies, etc.) and human resources (specialists in various professional levels with inadequate training, accountability, etc.).

Normal operation of a geo-cybernetic system of management and organization dependents on the environmental information system and minimize the (compensation) perturbation for a better balance of the whole system. It is known that the environment supports the action of extreme events often dangerous with different origin, natural (disaster) or human action out of control (catastrophe), which may cause destructive disturbances or brutal in some systems.

Hazard management involves four phases (stages), often overlapping:

- planning stage of the pre-disaster - decides how they will be addressed and planned by the risk management;

- identification of risk phase and preparation in order to prevent them - determine risk factors that may arise and their documentation, qualitative analysis of risk - making an order of priorities in addressing risk factors (determining priorities in addressing potential risk factors is based on the impact they can have.

- reaction phase - planning response to risk factors by developing procedures and techniques to amplify opportunities and minimize threats;

- recovery and reconstruction phase.

Ideally, hazard management begins with their identification, with a risk estimate based on the recurrence interval (return) of the event and predict the damage consequences, and continues with the increase of the response strategies.

Management action in environmental emergencies involves knowledge and analysis activities that should be undertaken in such cases, according to predetermined procedures at all levels: national, territorial as well as local. Intervention methods consist of research and control of the area or region affected by the disaster, determining the type and severity of the disaster, installations control and networks necessary for intervention (telecommunications, energy network, water, etc.), putting into action the armed forces to maintain order, human protection and their material belongings, protection of crowd panic, organizing traffic routes in the affected area, but also by sending aid to the affected area, by putting into action the means of intervention.

3.1.Evaluation of natural hazards such as landslides

Unlike other risks, landslides are phenomena difficult to locate the in terms of production. Thus, if flooding is localized on the water so that measures may be located, and the destructive effect of earthquake is reflected primarily on construction (which may require regulatory measures, expertise, etc. to prevent disaster), the occurrence of landslides is hard to predicted at macro scale.

Diverse phenomena of global instability of the masses called "landslide", "collapse" or "avalanche" is particularly significant, each case having a specific approach. Depending on the size of the phenomenon of instability feasible economically solutions may vary from those affected for the slope - enhancing soil to abandon location. This leads to the stabilization of costs that vary with scale and cannot be anticipated (budgeted) only post-factum. The only measures that can be taken are indirect, related to systematization.

It should be emphasized here the persistence of bad ideas:

- Treatment of phenomena "symptomatically" can lead to production of disasters. As an example, generally the first approach of the authorities in case of landslide or collapse of rocks affecting communication channels is the release of the material in the affected area.

This is very dangerous in several ways:

- Safety: the phenomenon is active, most of the equipment operators working under unstable masses;

- Acute phenomenon: the removal of the stabilized material occurs when regressive sliding of a higher destabilization of the massive upstream than the original situation;

- Waste of resources: practical removal of the moving-mass will be done sequentially until exhaustion of the whole slipped material, that requires a large consumption of time, labor, fuel, etc.. Right approach in these emergency situations is often the creation of a bypass.

- The idea that a forestation resolves stability is entirely wrong. Indeed, deforestation can cause, in time the phenomenon of instability. Immediately after clearing a wooded area "shaved", safety factor increases as the tree roots remain in place, but the overload brought by trunks is removed. Stability begins to deteriorate as the roots begin to rot forming such channels in the ground water infiltration. Root rot takes about 3-4 years so that replanting of vegetation with root dwarf and castor rot plans is possible. Plants have an important role in preventing landslides by removing a significant quantity of water by evapo-perspiration but they cannot prevent water infiltration into the ground in case of rainfall even as their roots cannot take proper push to depths of disposal plans in 1-2m in deep.

Design effective solutions to guard against landslides cannot be done immediately after the activation phenomenon. From this point of view is required on a sliding scale phases in terms of emergency assistance.

It is important to note that the measures do not apply to singular mode not even after fixed schemes. Engineering solution is an accumulation of measures which are prescribed both quantitatively and qualitatively as a result of numerical modeling.

CONCLUSIONS

Disasters caused by natural hazard still have a growing impact on people around the world. Recent studies shows that more than half of the world population lives in areas with significant exposure to natural disasters and are affected by climate change caused by the frequency or intensity of extreme weather conditions.

With increasing global temperature, it is possible that both the number and intensity of adverse natural phenomena will increase in many regions of the world.

Following the results of the recent World Conference on Climate Change (Bali - 2007, Poznan - 2008, Copenhagen - 2009 and others) should take advantage of them, so that in future years will be able to review all policies in as many areas of protecting the environment, proposing the appropriate measures of protection, given that climate change is one of the biggest challenges which will have to face within our societies.

The risk depends on the nature of changes in atmospheric circulation and local environmental characteristics. Hydrological cycle of Earth is so dynamic that is currently not possible to predict the effects of climate change in some specific area in the future. Phenomena characterized by natural hazard type are highly complex, randomly on the occurrence, intensity, mode of expression, the area of deployment and the production of direct and indirect damage. Identification and preventing of these phenomena can be studied from observations and data recorded, virtually all channels of information obtained.

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