Croatia – Japan project on

Risk Identification and Land – Use Planning for

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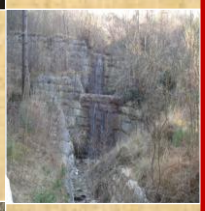

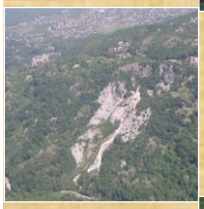

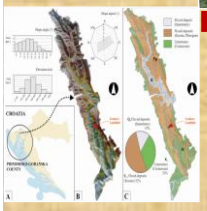

2nd PROJECT WORKSHOP

MONITORING AND ANALYSES FOR DISASTER MITIGATION OF LANDSLIDES, DEBRIS FLOW AND FLOODS

15-17 December, 2011.
Faculty of Civil Engineering
University of Rijeka
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RIJEKA, CROATIA

BOOK OF ABSTRACTS

SECOND WORKSHOP OF THE MONITORING AND ANALYSES FOR DISASTER MITIGATION OF LANDSLIDES, DEBRIS FLOW AND FLOODS

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15-17, December 2011.
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FOREWORD

Development in the Project on "Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia"

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This workshop introduces the latest developments in the Croatian-Japanese joint research project on "Risk Identification and Land-Use planning for Disaster Mitigation of Landslides and Floods in Croatia". Concerning the components on landslide risk assessment, aerial photos and aerial laser scanning images were purchased for selected target areas and landslide risk areas are identified by the interpretation of landslide topography using those photos and images. A portable ring shear apparatus was newly developed and essential shear strength parameters for prediction of travel distance of sliding soil mass for a Kostanjek landslide area in Zagreb was measured using this apparatus. A comprehensive landslide monitoring system using GPS, Total Station, extensometers, inclinometers was installed in Grohovo landslide area near Rijeka. Furthermore, dynamic simulation of landslides and debris flow was carried out on Rječina River valley including Grohovo landslide area. Concerning the components on flash flood risk assessment, systematic observation systems of meteorological and hydrological parameters were installed in selected target river basins such as Dubračina river and Mosčenićka Draga river. On the basis of real time monitoring results in those river basins, hydrological analyses were conducting. Essential tools for the next step of the project were prepared. Results of individual analyses will be appropriately combined for formulation of integrated landslide-flood hazard maps.

Prof. Hideaki Marui
Project Leader

SECOND WORKSHOP OF THE MONITORING AND ANALYSES FOR DISASTER MITIGATION OF LANDSLIDES, DEBRIS FLOW AND FLOODS

15-17, December 2011.
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FOREWORD

Monitoring and analyses for disaster mitigation of landslides, debris flow and floods – Croatian research area

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Project „Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia“ was submitted on the international call of the Government of Japan for scientific research projects in 2008 as one of 10 projects in program Science and Technology Research Partnership for Sustainable Development financed by Japan Agency for Science and Technology-JST and Japan International Cooperation Agency-JICA. Japanese partner institutions in the Project are Niigata University (The Research Center for Natural Hazards and Disaster Recovery), Kyoto University (Disaster Prevention Research Institute, DPRI) and International Consortium on Landslides (ICL). Croatian partner institutions in the Project are University of Rijeka (Faculty of Civil Engineering), University of Zagreb (Faculty of Mining, Geology and Petroleum Engineering and Faculty of Agriculture) and University of Split (Faculty of Civil Engineering, Architecture and Geodesy) and Croatian Geological Survey. Predicted duration of the project is five years.

The main activities of the research groups involved in the Croatian–Japanese joint research Project include investigations of recent landslides using landslide monitoring, the establishment and development of early warning systems for landslides, flash-flood and debris-flow simulation models, development of early warning systems adapted to hydrological and geological conditions in Croatia and the definition of hazard zones using a methodology for assessing susceptibility and hazards based on local geological and landslide conditions. The final objective is the development of risk mitigation measures that can be instituted through urban planning. In the framework of the Working Group on Landslides (WG1) a systematic monitoring in real time, laboratory analysis of soil samples and numerical analysis of the behavior of landslides in static and dynamic conditions on the landslide Grohovo and landslides Kostanjek in the City of Zagreb are carried out. Working Group for Flash-Floods and Debris Flow (WG2) conduct observations of meteorological and hydrological parameters in the analyzed catchment areas in real time; numerical and hydrological analysis of the measured parameters; and the development of simulation models of floods, mud flows and flow, making an early warning system on these phenomena. Selected research areas are in the vicinity of Rijeka and Split. Activities of Hazard Mapping and Land-use Guidelines Working Group (WG3) included the development of inventory of landslides using remote sensing techniques and methods of analyses and hazard zoning. Japan-Croatia workshop - Risk identification and land-use planning for disaster mitigation of landslides and floods in Croatia was held at the University of Niigata in February 2010. In November 2010 the 1st workshop of the Project was organized with the aim of disseminating the project results among the members of the project, but also scientists from other institutions in the region in Dubrovnik, and the 2nd Workshop in December 2011 at University of Rijeka. The workshops will contribute to the establishment and development of regional cooperation, which is important for the sustainability of project results even after the project ends in March 2014.

Prof. Nevenka Ožanić
Deputy Project Manager

SECOND WORKSHOP OF THE MONITORING AND ANALYSES FOR DISASTER MITIGATION OF LANDSLIDES, DEBRIS FLOW AND FLOODS

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WORKING GROUP 1: LANDSLIDES

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15-17, December 2011.
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Lithostratigraphical investigations at the wider area of the Kostanjek landslide: review of existing data and planned activities

Davor Vrsaljko[1], Snježana Mihalić[2], Marija Bošnjak[1], Martin Krkač[2]

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Abstract: Geological model of the Kostanjek landslide was developed by Ortolan in 1996 on the basis of existing geotechnical investigations: engineering geological mapping from 1984; boreholes from 1931, 1972 and 1988; geophysical investigations in boreholes from 1988 and seismic reflection investigation performed in 1989. This landslide model is in use even today as a base for design of remedial measures. In the frame of the Japanese-Croatian scientific joint-research project 'Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia' model of the Kostanjek landslide is in use as a base for design of comprehensive integrated real time monitoring system aimed at landslide risk mitigation. Because of the poor data, the existing landslide model is relatively rough with questionable criteria for spatial correlation of rocks: stratigraphical identification of rocks and plasticity index of marls. Three sliding surfaces in four boreholes from 1988 (KS-2', KS-3, KS-4, KS-5) are interpreted in the following way: (1) Sliding surface with maximum depth of 50 meters is identified at lithological contact between thickly and thinly bedded marls in Upper Pannonian rocks; (2) Sliding surface with maximum depth of 65 meters is identified along thin layer of clay in thinly bedded marls in Upper Pannonian rocks; (3) Sliding surface with maximum depth of 90 meters is identified at lithological contact between thinly laminated clayey marl and coarse grained rocks of Sarmatian age.

In this paper lithostratigraphical column of the wider area of the Kostanjek landslide is given to reconstruct origin of rocks and relative positions of lithological units. Geological column presents informal formations at the surface of the Kostanjek landslide and in the shallow subsurface (0-400 meters) in the following order (from bottom to the top): Bizek fm., Dolje fm., Croatica fm., Kostanjek fm. and Okrugljak fm. Lithostratigraphical units of Miocene Epoch in rank of formation can be considered as unique and homogenous according to lithology. The short description of formations is given to explain geological origin of rocks and soils and to highlight the main characteristics which may influence stability of recent slopes.

Planned geological investigations are given in the last paragraph. The aim of planned geological investigation at the area of the Kostanjek landslides is interpretation of the ground conditions as preparatory causal factors. Geological investigations will encompass: mapping of the lithofacies on the surface of abandoned cut face in marl quarry; exploration of lithofacies in the subsurface by drilling of 1 borehole with coring (100 m deep) and by digging 18 investigation pits (1-1.5 meters deep) at the area of landslide; and reinterpretation of lithofacies from four boreholes from 1988. On the basis of these investigations it will be possible to interpret 3D extent and spatial position of lithofacies bodies which are present at the area of the Kostanjek landslide. Unfavorable rock mass discontinuities (bedding, laminations, unconformities and sedimentary contacts) will be checked as possible sliding surfaces depending on relative position in landslide model and according to reinterpreted kinematic history.

Keywords: *lithostratigraphical units, Kostanjek landslide, Mmiocene sedimentary successions, bedding, unconformities, sedimentary contacts*

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Hydrochemical characteristics of groundwater from the Kostanjek Landslide in Croatia

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Abstract: Field investigation was carried out to collect groundwater samples from the Kostanjek area in order to better understand groundwater behavior in the Kostanjek landslide using hydrochemical data as tracers. Based on the 71 samples' hydrochemical data of major ions expressed as meq/L, ground waters are classified into four types: (1) Ca-HCO_3 type; (2) SO_4-rich Ca-HCO_3 type ($0.28<SO_4/HCO_3<0.40$); (3) Mg-rich HCO_3 type ($0.19<Mg/Ca<0.55$); (4) Cl-rich type (>100mg/L). Ca-HCO_3 type waters predominate over the research area and are closely related to the bedrock geology in this area composed of calcareous strata such as limestone and several types of marls. SO_4-rich Ca-HCO_3 type waters of eight samples are scatted in the northern part and southwestern part of the research area, and are formed by the contamination of Ca-SO_4 component originated from gypsum included in the calcareous strata. Mg-rich HCO_3 type waters of eight samples are limitedly distributed in the northernmost part, behind the head of landslide, eastern part and southeastern part, in front of the landslide, of the research area and are influenced by dolomite or Mg-rich limestone as the source of solute. Cl-rich type waters are scattered in village in the northern part and western part of the research area, and the possible source of Cl is anthropogenic impact. Here we pay attention to the origin of Mg-rich HCO_3 type waters, because there is no dolomite or Mg-rich limestone as the source of solute in this area. On the other hand, the massive dolomite is distributed in more than 1000 m north away from the Kostanjek area and also underlies in more than 200 m depth beneath the Kostanjek landslide mass. Actually, Mg-rich HCO_3 type waters are found in a stream near the Kostanjek area flowing from the massive dolomite and also discharged from fissures in a tunnel bored through the landslide mass. Considering sample locations of each Mg-rich HCO_3 type ground waters, these waters are derived from the deepest aquifer in the landslide mass and are probably one of the key factors on the occurrence of landslide. More detail behaviors of ground waters should be explained by additional geochemical data set such as dissolved minor constituents and environmental isotope ratios of $^{2}H/^{1}H$, $^{18}O/^{16}O$ and $^{87}Sr/^{86}Sr$ in the near future.

Keywords: *Kostanjek landslide, groundwater, hydrochemistry*

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Kostanjek landslide - Analyses of groundwater discharge as a basis for establishment of new hydrological monitoring

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Abstract: Kostanjek landslide is the largest landslide in the Republic of Croatia. It is located in the western part of the City of Zagreb, in residential area at the base of the southwestern slope of Medvednica Mt. In the frame of the Japanese-Croatian five-year scientific joint-research project 'Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia' initial investigations related to hydrological conditions at the landslide area are undertaken in the period 2010-2011. The objectives of hydrological investigations are: study of influence of groundwater movements dynamics to sliding and identification of possible changes of groundwater level and discharge regime during the longer time period - from the end of the eighties and beginning of nineties of the last century. Through several series of simultaneous measurements of groundwater discharge in wider landslide area (tunnel in former marl quarry, spring in Bizek quarry, stream Dolje) during the first half of 2011, initial information necessary for planning of more detailed hydrological monitoring were gathered. It was found that the measured flow at the exit of the tunnel range within values which was already recorded twenty years ago, respectively between 4.8 and 10.9 l/s, and that during this period there were no significant change in the drainage function of the tunnel. It was also confirmed that the majority of flow rate in the tunnel appears as consequence of leakage from springs located in the upper part of the tunnel, while the increase of the flow of approximately 20% towards the tunnel exit is a consequence of further groundwater drainage, probably from the overlying deposits. Measurements in the Dolje stream showed that in all conditions the flow at the spring (Bizek quarry) is 22 to 26% higher than in the downstream profile, even in case when measurements are conducted immediately after the rainfall, when the difference was slightly smaller - about 10%. Results of simultaneous measurements present a good base for implementation of planned continuous groundwater discharge monitoring on wider influential area of the Kostanjek landslide.

Keywords: *Kostanjek landslide, hydrological conditions, hydrological monitoring, discharge*

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Geomorphologic mapping and 3D modeling of the Kostanjek landslide, Zagreb

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Abstract: The Kostanjek landslide is located in the western residential area of the City of Zagreb at the base of the southwestern slope of Medvednica Mt. Since its activation in 1963, this landslide has caused substantial damage to buildings and infrastructure in the residential zone, as well as to factories and commercial buildings. According to the existing landslide model, the total area of the landslide is 1.2 km^2, volume is 3.3 x 10^7 m^3, and maximum depth of landslide mass is 90 m. In the frame of the Japanese-Croatian project it is planned to establish monitoring of the Kostanjek landslide and to develop early warning system for landslide risks.

Three dimensional modeling of the landslide, aerial photogrametric interpretation and site reconnaissance of the landslide features is carried out as a first step of landslide risk assessment. In addition, preliminary geomorphological map of the Kostanjek landslide is interpreted. These studies resulted in the following conclusions:

1) There are several landslides (150 to 200 m width) at the west side of excavation carried out by the cement factory. In the tunnel, located north of the excavation face, it is recognized deformation zone from 84 to 102 m from the entrance, with slickensides oriented N 45° E 30-35° S (at 86 m from the entrance) and wall severely destroyed by external force from NW. No other significant deformation by external force is noticed after this zone to the end of the tunnel.

2) On the basis of orientation (strike and dip), slickenslides are extrapolated to the surface, in the three-dimensional model of the Kostanjek landslide using the software "ADCALC3D". Intersection line between surface and slickenslide plane is located on the place where small landslide block is recorded by engineering geological mapping (west of excavation face).

3) On the basis of stereo interpretation of aerial photographs, one landslide body is assumed on the north side of the excavation with approximate dimensions: 500 m width and 800 m length. However, clearly visible head scarp of this large landslide block does not exist.

4) Inside the contours of existing landslide model, typical landslide topography is not recognized. However, few small landslide blocks are recognized in different positions. Special attention should be given to settlements along northern landslide boundary.

In the frame of the project, the following activities are planned: drilling a deep borehole at the beginning of 2012; installation of monitoring equipment for detecting movements at the surface and in the underground; detailed geomorphological mapping of landslide features with interpretation of landslide bodies. These investigation are aimed at derivation of landslide hazard map of the Kostanjek landslide.

Keywords: *aerial photogrametric interpretation, 3D landslide modeling, Kostanjek landslide, landslide mapping*

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Dynamic simulation of landslide and debris flow in Rječina River valley, Croatia

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Abstract: The watercourse of the Rječina River is about 18.7 km long and its river mouth to the Adriatic Sea is in the center of Rijeka City. Landslide, debris flow and rockfall are the main geohazards in this area. The central part of this watercourse, between the Valići reservoir dam and the Pašac Bridge, is the most unstable part of the wide area of Rijeka. The Grohovo landslide is located on the northeastern slope in the central part of the Rječina River valley just downstream of the Valići dam and is the largest active landslide along the Croatian part of the Adriatic Sea coast. As the effects of heavy rainfall or earthquake, two potential geohazard events could occur. One is that the slope deposits of Grohovo landslide moving towards the channel of the Rječina River will form a landslide dam. Another scenario is that the slope deposits mixed with water will form a debris flow arriving at the City of Rijeka.

In this paper, the two scenarios: the formation of landslide dam and the debris-flow are simulated by two integrated models using GIS to represent the dynamic process across 3D terrains. Landslide dam occur when slope deposits move downhill after failing along a shear zone. Debris flow can be differentiated from landslide by the pervasive, fluid-like deformation of the mobilized material. GIS-based revised Hovland's 3D limit equilibrium model is used to simulate the movement and stoppage of the slope deposits to form landslide dam. The 3D factor of safety will be calculated step by step during the sliding process simulation. Stoppage is defined by the factor of safety much greater than one and the velocity equal zero. GIS-based depth-averaged 2D numerical model is used to predict the runout distance and inundated area of a debris flow. The simulation displays the propagation and deposition and deposition of a debris flow across the complex topography. As a result, about 9 meters landslide dam was formed. The simulated debris-flow takes about 16 minutes to travel about 6 km along the Rječina River valley arriving at the City of Rijeka.

Keywords: *landslide, debris flow, 3D limit equilibrium model, depth-averaged, GIS, simulation*

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Establishment of the Grohovo Landslide monitoring system

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Abstract: The Grohovo Landslide, the largest active landslide along the Croatian part of the Adriatic coast, is located on the north-eastern slope of the Rječina Valley. It was noted that during 19th and 20th century a lot of instabilities on the Rječina Valley slopes were occurred. The last complex retrogressive landslide was reactivated in December 1996, after long time dormant period and about $1.0x10^6$ m^3 were moved down the slope and buried the Rječina river-bed and after initial movements, the landslide was retrogressively developed up the slope. Slip surfaces are considered to be on the contact of superficial deposits and flysch bedrock. In 2009 the Croatian-Japanese research joint project "Risk identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia" was initiated and the Grohovo Landslide was chosen as a pilot area for monitoring system development. A comprehensive monitoring system was designed consisted of geodetical and geotechnical monitoring. Installation of monitoring equipment started in March 2011 and will be complete to the end of 2011. Integrated monitoring system will be consisted of surveying system using GPS and robotic total station, so as geotechnical monitoring using pore pressure gauges, inclinometers, extensometers and seismographs. The establishment of monitoring system was carried out in stages according delivery purchasing and delivery of monitoring equipment. Installation of inclinometer casing and pore pressure gauges was started in March 2011 and foundations and poles for long span extensometers were finished in May 2011. The main part of monitoring equipment was installed in July 2011, when complete geodetical monitoring equipment was delivered and installed. After monitoring system starting up, some problems in equipment operating were observed and equipment re-adjustment was carried out until the end of November 2011. Installation of long span extensometers was completed in same time. In next stages of monitoring equipment installation, the short span extensometers, vertical extensometers, pore pressure gauges data loggers and pluviometer will be installed. In the automated integrated monitoring system until December 2011 are included observation of geodetic prisms with robotic total station and system of 10 GPS rovers (including master unit). Rest of equipment will be included after equipment connection in unique system. In this paper we will described the planned monitoring system so as details from monitoring equipment installation in detail.

Keywords: *landslide, monitoring system, establishment equipment, installation*

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Initial results of the Grohovo Landslide monitoring

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Abstract: The Grohovo Landslide, the largest active landslide along the Croatian part of the Adriatic coast, is located on the north-eastern slope of the Rječina Valley. In 2009 the Croatian-Japanese research joint project "Risk identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia" was initiated and the Grohovo Landslide was chosen as a pilot area for monitoring system development. A comprehensive monitoring system was designed consisted of geodetical and geotechnical monitoring. Installation of monitoring equipment started in March 2011 and will be complete to the end of 2011. Integrated monitoring system will be consisted of surveying system using GPS and robotic total station, so as geotechnical monitoring using pore pressure gauges, inclinometers, extensometers and seismographs. The main part of monitoring equipment was installed in July 2011, when complete geodetical monitoring equipment was delivered and installed. In the automated integrated monitoring system until December 2011 are included observation of geodetic prisms with robotic total station and system of 10 GPS rovers (including master unit). Immediately after starting on of the system, the measurement data from the GPS and robotic total station observations were starting to collect, and it was possible to analyze initial landslide monitoring data. First analyses were pointed to relatively high accuracy and data scattering inside the expected limited values for this type of measurement and high values scattering dependence on local weather conditions. From analyzed measurement results, it is very clearly visible that the collected data are liable to numerous influences such as daily, monthly and yearly temperature and humidity variation and local disturbing effects caused by deformations of poles on whose robotic total station and GPS master unit receiver are installed. It should be necessary minimum one year of data collection that these disturbing effects could be connected with their causes and to establish procedures for calibrating equipment and eliminating effects of weather impacts on measurements accuracy. In this paper we will present the initial monitoring results so as perceived local weather condition implications on values of collected measurement data.

Keywords: *landslide, monitoring system, equipment, data collection, accuracy, weather condition, calibration*

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First Experience with Ground Based LIDAR in Omiš and Duće Areas

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Abstract: Dalmatia region has dozens of registered active landslides and rockfall zones. For this study Omiš and Duće areas are selected as very active and potentially dangerous zones for inhabitants, residential areas and community infrastructure. The cliffs over the town of Omiš are made of limestone, while the slopes over Duće are made of Eocene flysch formation. Although these areas are geologically very different they share one common issue - rockfalls. In periods after heavy rain and/or considerable low air temperature many sudden rockfalls in these areas are often recorded. Stabilizing and managing entire area without localising potential threats would require considerable funding, which private owners and local communities could not afford. One of the possible and more suitable methods for forecasting rockfalls in these areas could be the use of 3D scanning (LIDAR based technology). LIDAR (Light Detection and Ranging) is an optical remote sensing technology that can measure the distance to the target. In this case Optech ILRIS-3D with accuracy of less than 1 cm at 100 meters was used. With such an instrument it is possible to cover large areas and acquire coordinates in numerous points unlike any other geodetic method. By periodically observing and monitoring the proposed zones, it could be possible to determine unstable blocks or even slope movement. Comparison of two or more records could be an efficient way of detecting movement and deformation in the field. Except detecting unstable blocks, this temporal model of surveying can also be applied for observing erosion process in soft rock. Marl, as an example of soft rock, is very prone to weathering so erosion process in this material can be observed in a relatively short period. This article presents the authors' first experience with this technology, methods of site selection, first field measurements, with retrospect to future guidelines and possible applications.

Keywords: *flysch, limestone, rockfall, erosion, LIDAR*

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Checking and Evaluating Inclinometer Data Measurements

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Abstract: Inclinometers provide a measurement of time dependant displacement in a near vertical borehole. They may be installed to check that actual movements correlate to those predicted during the design phase. Also, measurement results of in place inclinometer could be use in early warning system. They are probably the most valuable tool available to a landslide monitoring. Two types of accelerometers are now being used in inclinometer probes: the servo-accelerometer and recently introduced MEMS accelerometer. The servo-accelerometer probes, have the highest resolution of the available inclinometers on the market. A maximum system accuracy of 1,2 mm in 30 m or 1:24000 is possible with this instrument, but is ordinarily closer to 1:4000 without corrections for systematic errors. The resolution is nearly linear and constant at inclinations between ± 30° from vertical. MEMS technology has recently been introduced for inclinometer probes and in-place inclinometers. The primary advantages of the MEMS type are low power consumption, durability, wireless transmission and low cost. Maximum system accuracy can not be reached in field measurements. Slope Indicator Company, on the basis of many field measurements, state that the system field accuracy is ±7.6 mm per 30 m. This accuracy includes a combination of random and systematic errors. Random errors can occur within the sensors, limiting the precision of the probe. Systematic errors occur due to human actions that affect the condition of the sensors–probe and the data collection procedure. Random error is less influential error and it tends to remain constant during the measurements. But, systematic error tends to vary with each measurement. Systematic errors can be corrected using strict procedures but random errors can not be corrected. Random error can be minimized in better installations and with more precise reading procedures. Very often inclinometer accuracy have not been fully explained by inclinometers manufacturer. This paper describes these two kind of errors and how to eliminate them prior to presenting the results.

Keywords: *Inclinometer measurement, accuracy, precision*

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Introduction of one of Methods to Predict Failure Time of a slope widely used in Japan and application to the Kostanjek Landslide

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Abstract: This paper introduces one of the methods to predict failure time of a slope which has been widely used in Japan. Creep deformation of substance is generally described as that it proceeds through three processes (transitional creep, steady creep, and accelerated creep) and finally reaches failure. Slope failure can be also considered that it may follow the same process. Remaining time until slope failure has strong correlation with accumulated deformation semi-logarithmically. In this paper the method to predict failure time of a slope is explained using the actual data of the extensometer. An alarm system is one of the functions of the early warning system. However, when the early warning system is discussed, some time an alarm system tends to be set aside for issuing, because an alarm system may involve societies and become a social scientific aspect.

In the last chapter the general design of the planned integrated monitoring system of the Kostanjek landslide (the city of Zagreb) will be briefly presented. A comprehensive integrated real-time monitoring system will be installed on the Kostanjek Landslide as a part of the research activities in the Croatian–Japanese Bilateral Project. The monitoring system will consist of 36 sensors for geodetic and geotechnical monitoring of landslide movement and monitoring of landslide causal factors. Equipment for monitoring of landslide movement at the surface and in the underground will include: 15 precise GNSS referent stations (GPS), 8 long-span extensometers and 1 vertical inclinometer. Pore pressure gauges in boreholes (3 pieces), water level gauges in wells (3 pieces), sensor for discharge measurement, rain gauge and accelerometers (4 pieces) are aimed at monitoring of landslide triggering factors. GNSS referent stations will be placed on 15 locations at the surface of landslide body with average distance between locations of 200-300 m (total landslide area is 1.2 km^2). Extensometers will be installed at the top of the landside and at a left flank of landslide. Piezometers, inclinometers and vertical extensometers will be installed at one location in the central part of the landslide body. All monitoring equipment will be connected in one system with continuous monitoring and export of the data to a data center. An early warning system for possible landslide movement, which presents landslide risk for houses and structures, will be established, based on the monitoring results. Installation of the extensometers started in November 2011 and it will be finished until spring 2012. Installation of other components of monitoring equipment will start in spring 2012 and it is planned to be finished until September 2012.

Because of the poor data, the existing landslide model is relatively rough. Establishment of the threshold values for early warning system requires additional reinterpretation of the landslide model in order to establish relationship between landslide hazard (velocity and magnitude of landslide displacement) and landslide risk (rate of damaging of endangered houses and acceptable risk). The described methods to predict failure time of a slope widely used in Japan will be applied to the Kostanjek landslide using data from installed extensometers, water level gauges and rain gauges at the top of the landside and at the left flank of the landslide. Collected data from early stages of monitoring together with historical data about landslide movements will enable estimation of possible application of proposed method to the Kostanjek landslide and possibility to develop an alarm system which will be used by OEM - City Office of emergency management.

Keywords: *Prediction method, creep deformation, extensometer, early warning system, alarm system*

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Consideration of early warning system on the Grohovo Landslide

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Abstract: The Grohovo Landslide, the largest active landslide along the Croatian part of the Adriatic coast, is located on the north-eastern slope of the Rječina Valley. In 2009 the Croatian-Japanese research joint project "Risk identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia" was initiated and the Grohovo Landslide was chosen as a pilot area for monitoring system development. A comprehensive monitoring system will be consisted of geodetical and geotechnical monitoring. Installation of monitoring equipment started in March 2011 and will be complete to the end of 2011. Integrated monitoring system will be consisted of surveying system using GPS and robotic total station, so as geotechnical monitoring using pore pressure gauges, inclinometers, extensometers and seismographs. In the automated integrated monitoring system until December 2011 are included observation of geodetic prisms with robotic total station and system of 10 GPS rovers. Immediately after starting on of the system, the measurement data from the GPS and robotic total station observations were starting to collect, and it was possible to analyze initial landslide monitoring data. One of most important aim of the Grohovo Landslide monitoring system is establishment of the early warning system. In designing of early warning system it is necessary: to identify real hazard of further sliding and possible direct and indirect threats, to identify possible movements and landslide widening with high hazard, to select appropriate equipment relating to position in the field and measurement accuracy and to define critical limit values that indicating new sliding appearance and start up alarm. Analyses of the past and prediction of the future landslide behavior are the most important steps in early warning system consideration, while equipment selecting should depend on measurements of appropriate values with required accuracy. In this paper we will present consideration of early warning system establishment on the Grohovo Landslide analyzing all previously mentioned requirements.

Keywords: *landslide, monitoring system, equipment, accuracy, early warning*

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The causes and consequences of landslides, Bogatići, Sarajevo

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Abstract: During the field observation in June 2009, there appeared huge movings and deformations in the upper landslide. Hipsometrical above the object for resting and education, approx. covering area of 1000 m^2, in the field overgrew with a vegetational blanket, woody plants, there has been registrated huge movings and secondary wrinklings coluvial grounds down the slope, with a strong secondary wrinklings, depressions and pushing soil material.

Cracks in the surface of the terrain are large, wide and deep with dimensions up to 10.0*1.0*2.0 m. Microplastic of terrain is totally disrupted, the impression is that the manifestations on the surface of the ground are with huge intensity and strong impact, and the sliding material is in the process of sudden and rapid move (slip), which could be observed during the observation of terrain.

During the visit of the terrain, in the sliding zone of the forest belt, it has been noted that the upper parts of the slope are straining and a clear middle part of the coluvial translation of the material, according to the present belt compress – coluvial pushings of the material. The emergence of the breakout process, shovings in the lower part of the landslide, radically changed the conditions of stability of natural slopes, which threatened the stability of the lower left slope of the river Željeznica.

Causes of landslides in Bogatići, Municipality Trnovo, Sarajevo should be observed in several aspects, and generally can be classified to, geological, geomorphological, natural and technogenic causes. Landslide on the location of MHE Bogatići is caused because of contacts between litothogical different areas of physical-mechanical and water – mechanical characteristics.

It is a complex mechanism with gravitational moving along the slope, built in the lower part of the landslide, made of coluvial creations, while the upper part of the landslide is built from the partial blocks in the moving. The Sliding process has caused subsidence and shifting of material in the longitudinal direction with a clear visible cascading relief. According to observations on the field showed more sliding surfaces as a hint of further propagation of landslides with the possibility of deformation of the dam itself.

Unbalanced schedule inwards, and sandy - clay fraction, then the rock blocks on the move caused a highly heterogeneous composition in horizontal and vertical direction, as well as the privileged directions of movement and accumulation of surface waters during their infiltration into the deeper parts of soil.

All surface waters are flowing uncontrolled over the body of landslide. In the body of landslide, as well as on the ground around it, there are bigger or smaller amounts of physicaly connected, as well as in the free parts of the groundwater. Their origin is related to atmospherical water falling directly on the landslide body, then the surface water from reservoirs river Željeznice, which are very important for the stability of the slope. There are ongoing investigations.

Keywords: *landslide, the process of sliding, the causes, consequences of slipping, level of prevention, landslide remediation*

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Project of urgent mitigation measures on landslide Bogatići

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Abstract: The landslide Bogatići, located close by Sarajevo – Foča road, in Bosnia and Herzegovina, south from Sarajevo about 15 km, at the left side Željeznica river. There is a dam with hydro-power station at foot of the landslide. Active landslide induced in may, 2010, while heavy raining. Reactivation is done also in 2011, in June, while raining. Two houses are total destroyed. Electricity production has been stopped. There is risk that landslide can make undesirable dam in Željeznica river by sliding mass.

The landslide Bogatići is 1200 m long and 80-100 m wide with increasing in foot about 300 m width. Depth of sliding place is about 12-15 m. The main role of the landslide induction is faulting zone with water infiltration from upper parts of terrain. It is estimated that there is a long time instability process at the location. There is some information about fossil landslide. Big blocks of sandstone and limestone are mixed in the sliding mass. Some remedial measures had been done in 1980 at the same location.

The project of urgent mitigation measures includes: a) removing sliding mass at foot as a remedial measure to secondary sliding, b) trenches making as a surface draining and dewatering system, c) terrain planning at the foot and central part of the landslide for cracks stabilization.

Removing sliding mass is part of foot stabilization which has to modify slope angle to prevent secondary sliding and stuff material into dam structure. Removing sliding mass have to be done as cascade form of the new terrain. Cascade has slope with about 30^{o} angle, 2 meters height and flat 5 meters wide with $3\text{-}5^{o}$ slope angle. Total amount of removing mass is 24000 m^3.

Trench making is planned at foot and central part of the landslide. There are systems of trenches with two main trenches alongside right and left flanks and secondary trenchs which will drain surface water from main body. Total length of the trenches is 1800 meters.

Terrain planning for cracks stabilization is a measure part which has to prevent surface water infiltration into sliding mass. Total area of cracks planning is 40000 m^2.

Keywords: *Bogatići Lanslide, urgent mitigation measures*

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Underground and surface water like a one of main landslide trigger with a sample from Bosnia and Herzegovina

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Abstract: The water is probably one of the most caused landslide trigger. Water reduces friction between bedrock and cover sediments, than gravity influence on soil and move them down over slope. In the case where is sand and clay in covering sediments, even small quantity water can trigger landslide. Natural hydrogeology factors it is not only one who influence on soil move, there is huge factor of human impacts, which is presented in uncontrolled water system for take rainfall and waste water. The facts tell us how in the most cases didn't be change in extra ballast on slope or change angle of slope. In the most case we talk about factor intensive surface and underground watering, caused by natural or artificial mode. Those mention activity impact on get a low physic-mechanic properties on slope, increase poring pressure on soil, what have like consequence progressive break and triggering landslide.

However, generally we can say how by increase water consist in side of surface material triggering move soil, form hypsometric high to hypsometric low level. Prove this theory give facts how mostly landslide become active after strong rainfall or in period after snow melting.

Keywords: *water, trigger, landslide, engineering geology process, drainage*

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Montmorillonite clays – one of the main factors for the occurrence of landslides in East Rodops – Bulgaria

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Abstract: The subsidence of eastern part of Rodops mountains during the paleogene period was been related with active volcanic eruptions under the sea level. During this volcanic activities were been postponed different kind of tuffs and zeolites classes of montmorillonite clays. The thicknesses of the montmorillonite clays are extremely different – from several meters up to several millimeters.

Irrespective of the thicknesses of montmorillonites, when they are part of the slopes, they always are one of the main factor for the occurrence of landslides in many cases of Eastern Rodops – Bulgaria. Therefore these clays are studied very carefully, when they are part of landslide surfaces.

The examples which are considered in this report are related with the landslides on the roads: "Beliplast – Stremtsi", "Kardjali – Enchets" and Residential Estate "Borovets". Special attention is paid to the engineering geological properties of the montmorillonite landslides surfaces. It was found that the changes in the water content considerably decrease resistance of the massif – especially angle of internal fraction and cohesion.

The obtained results are used to design special drainage systems and reinforcement constructions for stabilization of landslides territories.

Keywords: *montmorillonite clays, landslides, drainage systems, reinforcement constructions*

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Landslide Umka – The first automated monitoring project in Serbia

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Abstract: In the past decade, there has been a gradual introduction of systematic monitoring on the largest landslides in Serbia by establishing a network of monitoring facilities. The first manual monitoring system was installed near Belgrade on Umka landslide including survey points, inclinometers, piezometers, triaxial deformeters et al. As the rapid adoption of new technologies continues - the natural evolution of equipment for landslide monitoring has started. The technological evolution of GPS based systems creates the potential for automated remote collection of accurate, high resolution data and represents step forward that will increase speed, precision, cost effectiveness and overall quality of landslide investigations.

In March 2010, a completely automated monitoring system was installed at the Umka landslide. Monitoring station was installed on the roof of the house which was estimated to enable the equipment to operate uninterruptedly. Two reference points, Belgrade and Lazarevac were established as stable points. A double-frequency GPS receiver with monitoring and recording the satellite observations every 30 seconds was installed. Automatic upload/download of files of recorded data has been pre-set at every 12 hours, while GSM modem for communication was used for the remote control and download of data, considering that the internet connection was of poor quality. Calculations of 2D and 3D coordinates of the monitoring station every 12h was programmed from both reference stations of Belgrade and Lazarevac, as well as the control monitoring of both stations. Leica GNSS Spider software was used for real time and post processing analysis.

Analysis of the results obtained by automatic monitoring of the landslide movement during one year showed that the movements were continuous and that they cumulatively amounted to 54 cm. During the monitoring, only one leap was recorded when there was a movement of around 2 cm in a single day. A crack in the staircase in the yard of the building was also recorded then. Movement coincided with springtime, during which the amount of movement is usually greater than during the other seasons because of the precipitations and the increase in the water level of the river Sava. For the same period during which the GPS monitoring was being done, the analysis of the effects of precipitations and the level of Sava was not performed, considering the significant distance of the closest measuring stations.

Establishing a fully integrated and equipped system which would be suitable for Umka landslide is still very expensive. However, the experience gained during the first year of monitoring and measuring clearly indicate the advantages of this type of monitoring system as well as the need to also install standard geotechnical equipment apart from the GPS sensors in extra-large and deep seated slow moving landslides. That is the only way to perform complete monitoring and obtain results that will help us in better understanding of the mechanism and dynamics of landslides.

Keywords: *Landslide, GPS, real time, monitoring*

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3D Terrestrial laser scanning and GPS technology for slope stability investigations – Case studies

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Abstract: The detailed three-dimensional characterization of site topography is critical to many geotechnical studies of slope stability. Whether it's a matter of landslides, rock falls or any other failures, understanding how these changes progress over time depends directly on detailed collection of high quality topographic data. A new terrestrial laser system used exploits advancements in technology to collect an unprecedented amount of data in a very short time. For rapidly changing natural slopes or cuts, such as landslides and rock falls, sites can now be efficiently surveyed repeatedly over a period of months, days or even hours. The high resolution of LIDAR data, in combination with the ability to obtain multiple data sets over a short period of time, allows researchers to better understand the mechanics of these natural phenomena and to calibrate models for predicting future change.

The first example refers to the rock slopes on the location of "Letnja Pozornica", Belgrade, in the area of protected natural-geological heritage. The process of the first epoch of scanning was performed with different resolution on the three series of scans. The second example refers to the rock cut in the flysh on the road Belgrade-Čačak, near Ljig town. The data of scanning was exported to computer-aided design applications for additional modelling such as AutoCad, or as a DTM in GIS. Preparation of DTM enables additional modelling (like block size and shape), which can help designers to understand the problems of instability on rock slopes and perform adequte remedial measures. Series of laser scanning can also provide exact volumes and precise location of fallen material in the rock slopes where the rock falls, ravelling and flaking are dominant.

The third case study of TLS application refers to location of active landslide southeast of Belgrade, in the village of Vinča. The first acquisition was done in July 2009. Raw data were processed and used as input data for topographic map and post-failure DTM time series 1. After second reactivation of the landslide in December 2009, scanning with TLS was carried out in April 2010, and post-failure DTM time series 2 was formed. The comparative analysis of DTM time series 1 and 2 defines the landslide volume during the second reactivation. The results of comparative geometric analysis of DTMs time series 1 and 2 showed that new 117 m^3 was moved, and that total landslide volume was 1336 m^3. The results obtained by proposed procedure may be used to estimate the geometry, monitoring activity of small shallow landslides and as a high-quality input data for landslide mitigation. Due to the widespread presence of this type of landslide, the achieved results can be used as the basis for designing GIS application in the form of a data base of shallow landslides.

Keywords: *Terrestrial laser technology, rock slopes, landslides, investigation, mitigation*

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Monitoring and mechanism of motion "Povija" and "Bare Šumanovića" landslides on the railroad Niksic-Podgorica

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Abstract: Landslides "Povija" and "Bare Šumanovića" are located on the left of the steep slopes of deep "Zeta" river valley. Landslides are formed on the steep vally slopes, built of flysch and quaternary diluvial-eluvial sediments, which saturate the water a number of sources which springing at the tectonic contact of carbonate rock masses and impermeable flysch formations. Over two landslides in 1948 was built railroad Niksic - Podgorica. Motion that occur in the zone of landslides in the last 25 years, were dictated to two times a year move in horizontal and vertical direction to correct position of rails. Large quantities of bauxite that is transported by the railway cause train vibration and cyclic load, wich contribute sliding of embankment and teren. Because of the slow movement of teren there is difficulty defining the sliding surface and the main directions of the moving.

The length of the landslide "Povija" is a few hundred meters and width approximately 200 m along the track. Landslide was repaired the first time 20 years ago using surface and deep drainage system. In the first ten years after the end of the landslide repair, motion is calmed down and demanded a rare intervention in the correction of the rail position without significant additional repairing. In the last ten years have been re-activated movements. In order to define the mechanism of slipping and sliding surfaces were carried out geological exploration drilling, set the benchmarks for surveying ground surface displacement and four inclinometers were installed. The first results of three series of measurements are now analyzed. Sanation solution is based on the construction of supporting structures of the piles.

"Bare Šumanovića" landslide covers the area of 1 km along the railroad and about 500 m above and 100 m below the rail. In the area of landslides, in the length of about 450 m, embankment of line is located with maximum height of about 17 m. Embankment was built from diverse materials: pieces of stone, clay, and the slag and the like. In the course of time due to vibration of the trains coming up the embankment settlement and dispersal movements which makes assessment basis on which the embankment rests. The landslide area were carried out geological drilling to define the geological profile of the terrain. In addition, in order to define the composition of the embankment, carried out four geological driling thru embankment. In the landslide area is set to 7 inclinometer and a network of geodetic benchmarks for monitoring the movement of the surface right now. The first results of three series of measurements are now analyzed. Sanation solution is not yet fully defined.

Keywords: *Landslide, monitoring, mechanism of motion, Povija, Bare Šumanovića*

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Application of modern geodetic methods for monitoring of local tectonically caused landslides

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Abstract: In this paper application of contemporary geodetic methods for determination of geodynamic activities is presented. Specially stabilized pillars of Geodynamic Network of the City of Zagreb and newly founded geodynamic points in tectonically most active areas create baseline for investigations of tectonic movements and related seismic activity. In the foothills of mount Sljeme, real estate heaven of Zagreb area, on a larger number of locations landslides occur. It is assumed that some of the slides occur due to tectonic activities.

GPS technology is used for monitoring of movements combined with advanced processing of GPS measurements by Kalman filtering. Precise satellite positioning yielded the accuracy that was by an order of magnitude better than the magnitude of movements.

Another modern geodetic method can be applied to landslide monitoring, laser scanning. In recent years, terrestrial laser scanning is used in various fields including the monitoring of deformations. The greatest advantage of laser scanning as opposed to the classical method is the possibility of analyzing the surface in its entirety. Due to the high criteria of accuracy and precision in monitoring the deformation of these types requires an independent calibration of measuring instruments. Likewise, special attention should be given to the geo-referencing point clouds with a particular perspective to the process of analysis that might detect deformation and also that it is separated from the measurements noise. Data collected by laser scanners can be used for continuous visualization of the landslides, but also for monitoring the deformation of objects located in the landslide area.

Results of geodetic measurements are combined with geologic measurements and results of seismic activity studies in order to give more detailed and more accurate picture of the current situation in the tectonically very active micro location around St. Mary's church in Granešina.

Synergy of contemporary geodetic methods of determination of geodynamic movements with geologic measurements and interpretation of movements is applied to monitoring of local tectonically caused landslides.

Keywords: *monitoring, landslides, GPS, laser scanning*

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Landslide in Brezovo polje on the main road Bijeljina – Brčko, Republic of Srpska

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Abstract: During winter, the 2010th year, was made landfall near the village of Brezovo Polje, on the main road M 14.1 Brčko - Bijeljina. There was a launch mass of rock on the left side of the road, which I spread on the road and damaged the road.

Landslide was created as result of human activity, since the road alignment was done under the larger pool of the pond, where it ruins the natural terrain stability. From the pool to the road, the terrain gently rises and is conditionally stable slope in the natural state of balance. By creating a deficit of rock mass with the development of the pool, while it is not done between the slopes of the insurance pool and the road, led after the first autumn rains and landslides. Landslide slope beside the main road and side-swept part or another part of the slope which was facing the pool. Below the pool or on the north side is the river Sava, whose levels fluctuate during the year a few meters. Under natural conditions of equilibrium, before the construction of the pool, level fluctuations were not important in the stability of slopes. After the construction of swimming pools and occurrence of landslides, increased the level of water in the Sava River water saturated sediments and surface impairs the natural characteristics of the deep infiltration of water into the underground. Top of landslides formed in the surface sediments below the trunk road embankments, and the legs suspended part of the south wall of the pool near the Sava River. The difference between the feet and forehead of landslides is about 8.0 m, with an average natural slope angle of 6 – 7^0. Slip road has been damaged or affected the left lane. Deformation in the horizontal sense, from 1.5 to 3.0 to 1.2 mau vertical m. Damage to road traffic safety is threatened or present a risk of landslides and expansion complete interruption of traffic.

Causes of landslides, in addition to human activities and adverse natural morphological and geological characteristics of the terrain. All this is in adverse weather conditions accelerate the natural processes of disturbance conditional stability of the terrain, which led to the launch of the rock mass in the form of landslides. The importance of roads, required a rapid response, both in terms of temporary repairs, as well as the implementation of certain research fields, in order to have the necessary information for the design of rehabilitation. Identifying the causes that led to the launch of the rock mass and damage to the regional road, the proposal was given the optimal remediation measures that will halt the process of moving rock masses and ground stabilized.

As a first preventive measure of rehabilitation, the area was filling the pool and stop further movement of the masses of Siena, and formation of secondary landslide on a slope. Channels are made for surface water drainage to prevent their infiltration into the underground because of the large number of opening cracks in the landslide body. Of technical measures incorporated a number of piles in the damaged part of the road and are connected by cables underneath the road on the other side of the solid rock. The terrain on the slope is flattened in order to close the gaps opened in the scars of landslides and prevent the passage of water underground, and the destruction or deterioration of the existing properties of rock masses.

The paper will give a landslide features, overview of research activities and preventive manner the field of rehabilitation.

Keywords: *highway, landslide, slope, research, rehabilitation of the terrain*

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Four years of continuous monitoring of an active earth flow

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Abstract: Landslide monitoring has evolved as a crucial tool in civil protection to mitigate and prevent disasters. The research presents a continuous surface monitoring of a large-scale active earth flow. With the data obtained from the system, the landslide can be monitored in near-real-time and the surface displacements can be directly utilized to provide early warning of slope movements and to study the behavior of the landslide, e.g. to predict timing and mechanisms of future failure.

The Valoria landslide (northern Apennines of Italy) was reactivated in 2001, 2005 and 2007 damaging roads and endangering houses. A monitoring system was installed in 2008, which consists of an automatic total station that measuring about 40 prisms located in the landslide to a maximum distance of 1800 m. The displacement data collected in the last four years of continuous operation include five acceleration and deceleration phases of the mass, which are linked with rainfall and snow-melt events. The utilized monitoring system has proven reliable for continuous monitoring of an active earth flow with large deformations ranging up to meters for day also during the paroxysmal phases. Another advantage of the adopted monitoring approach is the wide angle of operation, that allows for full coverage of the landslide.

The aims of the research are to analyze: the relation between the landslide mobility and the rainfall distribution; the time and space evolution of an active earth flow; the acceleration and deceleration patterns of the different earth flow sectors; the mass transfer mechanisms in an active earth flow. All the observed reactivation phases are started after the collapse of a portion of the main scarp. In the crown zone the data have showed a continuous creep separated by acceleration phases, which are linked to humid periods. In the head, track, toe zone the data have showed an "impulsive" behavior (activation separate by suspension) linked to the propagation downslope of the mass. The maximum recorded velocity on the monitoring points has been around 1 m/h. The measured total displacement values varied from > 20 m in the head to > 120 m in the track zone. Topographic monitoring data in different sectors of the landslide were compared with the climatic conditions. The lag time between the rain event and the beginning of deformations is 3-40 days; the duration of each reactivation event is 40-85 days; the delay between the end of a period of precipitation and the termination of movements is 25-100 days. The cumulative rainfall amount from the beginning of rain showers until the initiation of slope failure ranged from 150 mm to 350 mm. Moreover the system allowed to evaluate the propagation of the landslide reactivation in the space and time. For the winter 2009/2010 a complete reactivation was measured in continuous, from source area to the toe zone, for a length of 2.5 km. The data showed a progressive reactivation of the landslide sectors down slope. In general, the time of propagation of the failure varied from 3 to 10 days from the crown to the toe. An analysis conduced on the acceleration and deceleration behavior of the prisms allowed to identify a different and individual pattern for each landslide area. The patterns depend on the type of soil involved, the local morphological conditions and the local hydrogeological conditions.

Keywords: *Earth flow, continuous monitoring, slope evolution*

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WORKING GROUP 2: FLASH FLOODS AND DEBRIS FLOWS

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Monitoring and Analyses for the Working Group II (WG2) in Rijeka Area in Croatian-Japanese Project

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Abstract: Planed hydrotechnical research locations in Croatian-Japanese project - Risk identification and land-use planning for disaster mitigation of landslides and floods in Croatia in Rijeka area are Rječina river catchment area (Grohovo), Dubračina river catchment area (Salt creek catchment area), and catchment area of Moščenička Draga near Opatija. At the Working Group II (WG2), activities are conducted by systematic observations of meteorological and hydrological parameters in the planed catchment areas and river basin (rivers, flash floods and torrential areas) in real time, numerical and hydrological analysis of the measured parameters, and preparing simulation models of floods, mud flows and flow to the areas analyzed for the purpose of making an early warning system for these phenomena, all adapted to the hydrological and geological conditions in Croatia.

The chosen three pilot areas are different in hydrological and geological characteristics, but partly also by the possible consequences: Rječina river catchment area - downstream profile near landslide Grohovo, catchment area of Dubračina river and Moščenička Draga near Opatija. Flood waters from these pilot areas can significantly affect the development of the area in which they are located. In fact, the flood waters of the Rječina river, Dubračina river and debris flow of Moščenička Draga can cause (and in history they are) significant damage to downstream urban areas (Rijeka, Crikvenica and Mošćenička Draga), and pose a high risk of possible future occurrence. Hydro analysis on these pilot areas of research will be conducted based on the results of an integrated monitoring system in real time. The establishment of early warning system will enable the safe operation of existing urban areas and their further development.

In the part of the research within the Working Group II on floods and debris flow (WG2), there was established a permanent measure water levels at two hydrological profiles on Salt creek and Dubračina spring, with minute frequency measurements of water levels. Atmospheric pressure is compensated by the data collected device - Baro Diver. Rainfalls are measured by OTT-pluvio. Mošćenička Draga catchment area is about 11 km^2 and extends from elevation 0 ma.s.l. to 1300 ma.s.l. with a mean altitude of the basin of 563 ma.s.l. The basin is characterized by a large slope, resulting in significant surface runoff during intense rainfall and erosion processes in the basin. During the 1999, Croatian waters designed and performed the regulation of the torrent upstream of the road Rijeka - Zagreb to keep the stream sediment. Because of construction of hotel Mediteran, estuary of stream was paved and too low and there is a matter of time when will happen more significant flood the settlement Mošćenička Draga. One of the purposes of this section of the survey is to assess the dangers of flooding of Mošćenička Draga and the development of a conceptual model of flood protection with possible propagation and accumulation of sediment, and the impact of the construction of hydro construction on sandy beach. The goal of the Project is to investigate the mechanisms of stream sediment deposition, the conditions of its deposition in the water bed or on the beach and sea activities on his motion. The intention is to calculate the trend of extreme sea levels and predict their values for a specific return period. Based on measurements of the heavy rainfall and hydrological parameters we plan to calculate the maximum flood flow of torrent Mošćenička Draga on several hydrological profiles.

In the next phase of the Project we plan to set few more meteorological, precipitation and hydrological stations on all tree research areas, depending on needs.

Keywords: *Rječina catchment area, Dubračina catchment area, Mošćenička Draga catchment area, simulations, flood waters, debris flow, early warning system*

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Moščenička Draga Investigating Sight – Hydrology and Coastal Processes

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Abstract: In this paper are presented Mošćenička Draga investigating sight ongoing hydrological research and sight description. Mošćenička Draga is one investigating sights in the Croatian - Japanese international project - Risk identification and planning of land-use to mitigate the risk of landslides and flash floods in Croatia.
Mošćenička Draga is a small village, situated 15 km SW from Rijeka. It is a famous because of its gravel beach. Gravel beach is formed on the torrential flow mouth by a deposition of torrential sediments. Torrential basin area is about 11 km^2, average basin slope is very high 47%. Highest catchment point is about 1300 meters. Rainfall intensities are very high. Predicted maximum discharge is 90 m^3/s, and that is regulated torrential stream design discharge. Because of catchment and rainfall characteristics runoffs are very intensive and floods were often in the past. Because of that flood defence works have been designed on torrential flow Mošćenička Draga.
Today is a great probability of occurrence flooding because of sediment dam fulfilment and potential landslide in the middle of the torrential flow. This Landslide can cause the formation of natural dam, and water can destroyed those dams. Mošćenička Draga torrential flow mouth increases flash flood risks, because of its improper construction. Beside this, the Mediterranean Sea level rise and more frequent and larger magnitude storms in the future are expected to cause frequent occurrence of extremely high sea levels which will result in additional flood risk increase.

Keywords: *torrential flow, flood, hydrological research*

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Application of Hydro-debris 3D into mountain-zone flood hazards

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Abstract: In order to develop hydrological model suitable for karstic region, the traditional two dimensional approach may not be suitable due to the presence of many cracks and associated percolating water which flow into the surface hydrological regime at a certain distance. Also for the mountain region, hydrological processes in steep slopes are not identical to those in a gentle slope. In this study we propose a three dimensional hydrological modeling approach entitled as Hydro3D which combine 3D networking model for subsurface flow including percolating water and surface 1D-network and 2D shallow water modeling approach. The Hydro3D also include three dimensional hydraulic module which can illustrate lakes and reservoir in the continental region and bays/estuaries at the river mouth. The downsides of this modeling approach are- relative expensive computational resources when generating grids for whole catchment zone, difficulty in assuming appropriate dataset, and grid generation in vertical directions.
The model is applied for by combining three-dimensional debris-flow modules with lagrangian particle tracing to identifying high risky zone of debris-flow hazards. Application of the model into several regions including into Hofu debris-flow hazards, Indonessian case, potential hazard in Croatia and Brazilian debris-flow disaster. In most of the cases impacts of larger particles are expressed by lagrangian particle compared with conventional debris-flow modeling approaches.

Keywords:

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Application of the SOLFEC program for the numerical modeling of suspended sediment propagation in small torrents

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Abstract: This paper describes the Solfec computational code used to simulate multi-body systems with constraints. The Solfec code implements an instance of the Contact Dynamics (CD) method by Moreau and Jean, therefore the constraints are handled implicitly. One of the main goals of the software is to provide a user-friendly platform for testing formulations and solution methods for the (dynamical) frictional contact problem. It also serves as a development platform for other aspects of time-stepping methods (e.g., contact detection, time integration). The code applies several kinematic models (e.g., rigid, pseudo-rigid, finite element), contact detection algorithms, time integrators and constraint solvers (e.g., penalty, Gauss-Seidel).
This paper also describes a method used to develop a computer code written in the Python programming language that is needed to produce a numerical model of suspended sediment propagation. The resulting computer code was applied to data from the Salt Creek stream in the Dubračina River basin. The paper also provides graphical representations of the Mud Flow simulation in the hypothetical example inside of the Salt Creek stream erosional base. Finally, some basic input parameters necessary for an efficient creation and execution of the numerical model are characterized and described in more detail.

Keywords: *SOLFEC program, numerical modeling, suspended material, Salt Creek stream*

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Climate Change Mitigation with Different Tillage Systems

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Abstract: Climate change presents a global warming, the general increase in the earth's near-surface air and ocean temperatures that presents a global problem. To reduce the global temperature, Kyoto Protocol has been adopted on the ***Third Conference*** of the Parties to the United Nations Framework Convention on Climate Change in Kyoto in 1997. The Republic of Croatia has signed the Protocol in 1999 and ratified it in 2007, by which it was committed to reduce its greenhouse gas emissions by 5% in the first commitment period between 2008 – 2012 compared to the base year (1990). Aim of our investigation is to determine the best tillage system with the lowest emissions of carbon dioxide from soil. Field experiment with 6 soil tillage systems common to this area was set up on Stagnic Luvisols in Daruvar (N 45º33´937´´, E 17º02´056´´), Central Croatia. Tillage systems differed in tools that were used, depth and direction of tillage. Investigated variants were: check plot (black fallow) - BF, ploughing up/down the slope - PUDS, no-tillage - NT, ploughing across the slope - PAS, ploughing to 50 cm across the slope - VDPAS, subsoiling to 60 cm + ploughing across the slope - SSPAS. Preliminary soil sampling was conducted in April 2011 when cover crop was corn (Zea mays) and the samples were analysed at the laboratory of Department of General Agronomy, Faculty of Agriculture. In this paper the results of vertical and horizontal distribution of total carbon content, total nitrogen content and the C/N rations are shown. Range of total carbon content was from 0.26% at BF (20-30 cm) to 1.40% at NT (0-5 cm). Range of total nitrogen content was from 0.03% at PUDS (20-30 cm) to 0.16% at NT (0-5 cm). Vertical distribution of total carbon and nitrogen content generally decreased with depth. Range of C/N ratio was from 7:1 at BF (0-5 cm) to 11:1 at PUDS (20-30 cm), VDPAS (10-15 cm) and SSPAS (15-20 cm).

Keywords: *Climate Change Mitigation, Tillage Systems, Total Carbon and Nitrogen Content, C/N ratio*

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Approximation of Flood Wave Propagation by One Dimensional Numerical Integration of Saint-Venant Hydrodynamic Equations

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Abstract: It is well known that during the propagation of a flood wave, for an arbitrary cross section in a river, the measured storage-outflow relationship is characterized by a looped trace. With the primary aim to numerically reproduce, and consequently study, the looped storage-outflow relationship, a numerical integration is performed of a one dimensional form of a Saint-Venant system of equations. The numerical formulation is based on a method of characteristics and is suitable for supercritical flow, i.e. flow characterized by Froude number greater than 1. However, it is assumed that the cross section of a channel is rectangular and constant over the spatial domain, along which the flood wave propagates. Furthermore, the flow conditions are assumed to be in accordance with the shallow water flow conditions, justifying the assumptions that the pressure distribution can be assumed as hydrostatic. Also, the wavelength of a traveling flood wave is such that the wave speed can be approximated by the linear Airy wave theory, by relating the wave speed c with the water depth h. Under these circumstances, the numerical formulation is used to study the influence of friction on the looped storage-outflow relationship, as well as on the flood wave propagation. For an assumed dimensions and flow parameters, the parametric study is conducted by changing the Manning's roughness coefficient n from 0.01 to 0.02, with equidistant intervals of 0.002. The performed numerical analyses suggest that the increasing in n will affect the looped storage-outflow relationship by reducing the span of the loop. Consequently, as n grows further, the looped relationship (characteristic for unsteady flow conditions) collapse onto the storage-outflow curve characteristic for steady flow condition.

Keywords: *Flood wave propagation, Saint-Venant equations, Method of characteristics*

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The roles of Japanese municipalities and Japan Sabo Association to promote Sabo and to protect local areas from sediment-related disasters in Japan

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Abstract: In Japan, central and prefectural governments promote sabo (Erosion and Sediment Control) projects. Also, it is very important for central and prefectural governments to cooperate with municipalities which are responsible for the safety of local areas, to realize the purpose of sabo.

Japan Sabo Association takes a role to support relationship between central and prefectural governments, and municipalities to promote sabo in Japan.

Municipalities are required to carry out the following items to promote the effects of sabo in the local areas:

1) To understand the local condition for sediment-related disasters and to appeal the need of sabo facilities, and to realize the construction of them

2) To construct small facilities to protect houses from small slope failures,

3) To cooperate with designation of sediment-related disaster warning area and special sediment-related disaster hazard area, based on the sediment-related disaster prevention low by the prefectural governments.

4) To promote appropriate land utilization based on the sediment-related disaster prevention low.

5) To establish the warning and evacuation system for sediment-related disasters.

6) To perform regional activation utilized sabo facilities.

Japan Sabo Association mainly supports these roles of municipalities through holding the sabo courses, demand activities for constructing sabo facilities to the central government, publication of the sabo books and so on.

In addition, Japan Sabo Association performs the work to deepen the cooperation with foreign countries through the activities of introducing Japanese sabo to foreign countries and supporting to promote sabo in foreign countries.

Keywords: *Roles of Municipalities and JSA, Warning and Evacuation System, Cooperation with foreign countries*

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Monitoring of Torrential Floods in Serbia

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Abstract: A great part of the territory of Serbia is under soil erosion hazard of different intensities. It is especially significant that 36 % of the territory is attacked by erosion processes of excessive, severe and medium intensities. The results of such intensive processes of water erosion are torrents which, as a result of the perturbed regime of runoff from the watershed, by floods cause enormous damage to economy and society in general (flooding the inhabitted places, industrial objects, traffic lines, agricultural areas etc). More than 12000 torrents have been registered in the area of Serbia. In addition to other damage caused by erosion and torrents (soil loss, water loss, torrential floods, storage siltation by sediment, etc.), erosion and sediment cause huge damage to the environment.

In past 100 years, around 140 great torrential floods have been recorded in Serbia, south of the Sava and Danube rivers, which resulted in enormous material damage and loss of lives.

Particularly destructive were the torrential floods in past 40 years when they caused huge material damages and human casualties: Korbevachka river in 1975, Sejanichka River in 1983, Vlasina in 1988, several torrential rivers in 1999, Ljubovidja in 2001 and 2006, Pchinja in 2010 etc. Increasing number of torrential floods has been observed in the last 20 years not only in Serbia but also in Europe.

Bearing, all this, in mind, Faculty of Forestry (Chair of torrents and erosion) at the University of Belgrade, this year has started the implementation of the research project: Frequency of Torrential Floods, Soil and Water Degradation as the Consequence of Global Changes.

The research will be carried out in four representative torrential catchments. The activities of the research project should be directed to an in-depth study of natural characteristics, erosion processes (distribution and intensity) in the selected representative basins.

The other segment of the research will refer to the study of the genesis and propagation of torrential floods in Serbia and their frequency in the conditions of global changes.

Monitoring of water runoff and torrential floods will be performed in four experimental catchments, i.e.: Topchiderska river, Vlasina river, Banjska river and Vrla river. In addition, the study will include the most efficient methods of the torrential flood prevention.

Keywords: *torrents, soil erosion, torrential floods, monitoring*

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An approach of multi-hazard mapping of water related hazards in hily and mountain regions applicable for spatial planning process Case study: Skopje Region

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Abstract: Generally water related hazards should be classified in two groups: hazards where reason is spare of water and hazards where reason is shortage of water. Habitual steps for hazard reduction are: Pre-event Measures: Measures During the event and Post-disaster Measures. Depending on the nature of the risk and its territorial distribution, several groups of "actors" are involved in the process of Management and Prevention against Natural Hazards as follow: Line ministries, Local municipality administration, institutions for Monitoring, Inspectorates, Emergency response, Planning, Education/science, Finances institutions, NGO's.

An integrated planning is a great possibility that vulnerability reduction measures will be implemented if they are part of a development package. Spatial plan is the most comprehensive plan and a frame for other specific plans (forest management, watershed management etc). Between other, one of the long term principle, incorporated in a plan is: protection from military destructions, natural and technological catastrophes and breakdowns.

The importance of spatial planning related to risk/hazard management could be seen in two main domains: Spatial planning considers all possible hazards, since any plan analyzes natural characteristics of a region (including geology, water resources, climate characteristics etc) but also human activities (such as settlements distribution, economy facilities, building infrastructures etc).

The role of a spatial plan is to combine, intersect and coordinate future actions in order to provide optimal and sustainable development. When preparing spatial and urban plans measures and activities for prevention of major accidents and limitation of their consequences are taken into account, particularly when determining areas where new installations are planned, or changes on the existing installations are made.

A lot of natural hazards can be triggered by a single natural occurrence. The use of Multi hazard mapping is a good way to perceive the effect of the same natural occurrence on the triggering mechanism of different natural hazards.

The aim of this paper is to explain the methodology for development of Multi hazard maps applicable for spatial planning in a GIS environment. The foolowing hazards characteristic for hilly and mountatin region were analyzed: erosion, torrents, land instability, wild fire. The full process of development of a Multi hazard map was described through the theoretical frame of the natural hazards, further on to composition of the single hazards in a multi criteria GIS environment and finally integration of the single hazards in one Multi hazard map.

The chosen study area is the Skopje Region Multi hazard mapping is a good approach for observing several hazards on one place in which each hazard could be observed separately and integrally. This is an effective tool for the decision makers for planning purposes and should be integrated in the operational every day applications.

Keywords: *Multi hazard mapping, spatial planning, GIS, water related hazards*

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Daily variability of salinity and temperature in the Rječina Estuary

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Abstract: Results are presented from a set of measurements that were undertaken to examine daily variability in physical characteristics within the Rječina Estuary in the centre of Rijeka during November and December 2011. This article interprets a salinity and temperature data as a function of tide and fresh-water discharge. Physical parameters discussed here were obtained from conductivity and temperature measurements at 6 different profiles throughout the estuary during high and low tide and several different hydraulic conditions.
Longitudinal distributions of surface salinity depended strongly on tides and freshwater runoff. In the constant hydraulic conditions of both low and medium fresh-water discharge, the surface salinity was lower and the freshwater–saltwater interface (FSI) was located closer to the mouth during low tide, the reverse was true at times of high tide.

Keywords: *Conductivity, salinity, temperature, Rječina Estuary, measurements*

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Land Use Changes for Protection from Torrential Floods in Serbia

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Abstract: Torrential floods are the most frequent phenomenon in the arsenal of "natural risks", in Serbia. Characteristic are torrential floods on the experimental watersheds of rivers Manastirica (June l996) and Kamišna (May 2007). Hystorical maximal discharges (Q_{maxh}) were reconstructed by method of "hydrolics flood traces". Computations of maximal discharges (Q_{maxc}), under hydrological conditions after restoration of the watersheds, were done using a synthetic unit hydrograph theory and Soil Conservation Service methodology. Area sediment yields and intensity of erosion processes were estimated on the basis of the "Erosion Potential Method". The actual state of erosion processes is represented with the coefficients of erosion Z=0.475 (Manastirica) and Z=0.470 (Kamišna). Restoration works were planned in order to decrease yields of erosive material, increase water infiltration capacity and reduce flood runoff. The planned state of erosion processes is represented with the coefficients of erosion Z=0.343 (Manastirica) and Z=0.385 (Kasmišna). The effects of hydrological changes were estimated by the comparison of historical maximal discharges and computed maximal discharges (under the conditions after the planned restoration). Realization of restoration works will help decrease annual yields of erosive material from W_a=24357 m^3 to W_a=16198.0 m^3 (Manastirica) and from W_a=19974 m^3 to W_a=14434 m^3 (Kamišna). The values of historical maximal discharges ($Q_{maxhMan}$=154.9 m^3s^{-1}; $Q_{maxhKam}$=76.3 m^3s^{-1}) are significantly decreased after restoration ($Q_{maxcMan}$=84.5 m^3s^{-1}; $Q_{maxcKam}$=43.7 m^3s^{-1}), indicating the improvement of hydrological conditions, as a direct consequence of erosion and torrent control works. Integrated management encompasses biotechnical works on the watershed, technical works in hydrographic network, within a precise defined administrative and spatial framework in order to achieve maximum security for people and their property and to satisfy other demands such as: environmental protection, sustainable soil usage, drinking water supply, rural development, biodiversity sustaining, etc. The lowest and the most effective level is through PAERs (Plans for announcement of erosive regions) and PPTFs (Plans for protection from torrential floods), with HZs (Hazard zones) and TAs (Threatened areas) mapping on the basis of spatial analysis of important factors for torrential floods forming. Solutions defined through PAERs and PPTFs have to be integrated into Spatial Plans at local and regional levels.

Keywords: *Flood protection, Erosion Control, Plans for announcement of erosive regions and protection from torrential floods, Watershed Restoration*

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Monitoring and Risk Identification caused by High Water, Floods and Erosion Process in Urban Part of Sava Riverbed

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Abstract: Riverbed erosion and bottom deepening are part of natural fluvial processes in the upper stream of Sava River. The increasing gradient of those changes is interconnected with the level of human influence in the river basin and riverbed as well. In time period of last forty years the consequences of riverbed erosion are become serious as well as dangerous and they threaten the stability of hydro technical structures. The increasing value of flow velocity in riverbed in urban part of river section during high water level, mud and debris flow during the floods as well, is especially dangerous for old bridges. This paper contains result of velocity measurements during high waters taken by Hydrological Service of Republic Croatia, load transport monitoring during such events and cross sections in some vulnerable location. In this paper is given one example of Jakuševac railway bridge in Zagreb, heavily destroyed during high water event on the 30 March 2009, recently reconstructed by "Croatian Railways" company.

***Keywords**: Riverbed erosion, flow velocity, mud and debris flow, risk identification, stability of bridges*

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WORKING GROUP 3: HAZARD MAPPING

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The hazard of floods and mass movements in the Rječina Valley during last 160 years

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Abstract: In this paper will be described and analyzed the connection of earthquakes, floods and instabilities of slopes in the Rječina valley. The Rječina River flows through three different geomorphological zones. The first occupies the area from the river source at the foot of the Gorski kotar Mountains to the Lukeži Village. The second zone extends from Lukeži Village to the canyon entrance near the Pašac Bridge, while the third stretches from the entrance of the canyon and the alluvial plain near the river mouth in the centre of Rijeka City.

The slopes around Rječina Valley between Lukeži Village and entrance of canyon are formed in siliciclastic sedimentary rocks with flysch characteristics. The bedrock is mostly covered with unstable slope formations. A limestone rock mass is visible on the cliffs around the top of the river valley.

Lateral erosion of the riverbed and simultaneous erosion of the foot of the slopes, are factors causing mass movements. Historic data for the area of Rijeka, record the occurrence of flood events, (some of which caused catastrophic damage), that are closely related to the timing of mass movements in the study area. Such catastrophic floods of the Rječina River occurred 1849, 1852, 1853, 1883, 1898 and 1899. According to data from the Croatian State Archive in Rijeka, the landslides appeared on the south-western slope in 1885 and 1898, and in 1893 on the north-eastern slope, at the location of the studied landslide. The area affected by mass movements is clearly visible on the map from 1894. Investigation of the whole area of the valley between Valići Reservoir and the downstream canyon entrance reveals the presence of more dormant landslides, some of which were active during the 20th century. The influence of river erosion was reduced after completion of the Rječina riverbed regulation in 1908. Instability on the north-east slope is due to a reactivated landslide, as shown by recorded historic activity. Frequent rockfalls from the top of the limestone cliff accelerated the accumulation of potentially unstable deposits.

Topographic maps from 1981 and 1998 have shown changes in slope morphology. Observation of geodetic benchmarks from 1998 – 2010 highlighted displacements, not only in the part of the slope affected by slippage, but also the formation of a new landside body on the upper part of the slope, indicating further development of the landslide along the slope.

The infilling and therefore damming of the Rječina River is the main risk of further sliding. In a case of heavy rainfall, accumulated water behind any such dam would be at risk of overflow, resulting in rapid water level rise and/or subsequent overflow. After such a collapse, the water wave could cause fatalities and serious damage to infrastructure in the urban area of the City of Rijeka at the mouth of the Rječina River.

Keywords: *Flood, mass movement, erosion, landslide, overflow*

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Geological and geomorphological conditions of the Dubračina River Basin and 3D road slope stability analysis (Croatia)

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Abstract: Dubračina River Basin is located in continental part of Primorsko-Goranska County in hinterland of the Crikvenica City. It is one of the pilot areas in Working Group 3 of Croatian-Japanese joint research project "Risk identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia". The basin covers an area of 43.5 km^2 and stretches northwest-southeast which is parallel to the Adriatic coast. Current land-use at the area of the Basin is as follows: 38 km^2 is forest and semi-natural areas, 3 km^2 is agricultural land, 2 km^2 is artificial surface. Altitude of this area ranges from 1 to 920 meters above sea level (62% of the basin has elevation in the range 1-300 m), and the prevailing slope dip angles (75%) are in range 0-25°. According to unpublished geological map in scale 1:25000 made by Croatian Geological Survey, on the surface of the basin can be found carbonate and clastic rocks. Carbonate rocks are represented by Upper Cretaceus and Paleogene limestones. Together they cover 55% of basin area, 2% of the area is covered with Paleogene transition sediments between carbonate and clastic rocks which are comprised of interlayered marls and limestones. Clastic rocks are represented by Eocene flysch sediments (siltstones, marls, sandstones and biocalcirudites) which are covering only 1% of the surface, Paleogene breccias and Quaternary sediments. Sediments of Quaternary age are covering 42% of the basin surface. They are built of talus breccias, talus unlithified or poorly lithified material (limestone blocks, cobbles, pebbles, and terra rossa), diluvium (sands) and alluvium deposits (gravels, sands, silts and clays). Numerous active and dormant landslides, together with erosion, form the dominant geomorphological processes that are the main geological hazard. Slip surfaces are occurring between quaternary superficial sediments and flysch bedrock due to big difference in permeability of these two types of sediments. Beside sliding, Slani potok (Salty creek) sub-basin is characterized by excessive erosion which is caused by thenardite (Na_2SO_4) crystallization where landscape has appearance of badlands. These geohazards cause significant economic losses by damaging roads, facilities, houses and watercourses.

In this paper, the general data, including geomorphological and geological information and erosion conditions, are presented. The 3D stability analysis of a road slope in Salty creek sub-basin is performed using ADCALC3D. The 3D results are compared with the 2D stability analysis performed by Institute IGH d.d. (regional unit Rijeka) for the purpose of road reconstruction between Blaškovići and Grižane settlements.

Keywords: *Dubračina river basin, flysch, slope, 3d stability analysis*

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Geomorphic characteristics of landslide in Dubračina river area, Croatia

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Abstract: This report is the tentative result of aerial photo interpretation and field investigation of Dubracina river basin Rijeka, Croatia. The field reconnaissance has been carried with professor Benac (University of Rijeka) and project members from University of Zagreb. Since the field survey is carried one day only, it is hard to say that it is enough. Therefore, not all arguments here exceed the region of a preliminary survey. However, about the landslide of the target area, some features considered to be the characteristics of the area were able to be found out. It seems that some hint was obtained when considering future slope disaster mitigation, and when evaluating the risk of reactivation of landslides.

The landform of the area classified to vertical cliff of a karst plateau, coastal mountain land, hill slope, talus slope, fluvial lowlands etc. The landslide topographies distribute among the all kinds of slopes. The remarkable unique landslides have occurs at the hill and at the talus sloping area. The each landslide unit is very small in scale but the number is very huge. The landslide develops the devastated channel such as Salt creek. Doesn't the reason in which the scale of a landslide is very small-scale mean that the intensity of the soil material which constitutes a landslide is very weak? It is required to consider the mechanism in connection with the strength reduction of a soil. Aren't swelling-izing or mobilization of a clod mentioned as the hint? Aren't the geographical feature conditions etc. by which a lot of inclusion of the argillite of a smectite, existence of water, and oxidization are promoted mentioned?

Keywords: *Dubracina river basin, landslide topography, reconnaissance survey, small landslides*

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Historical landslides in the City of Zagreb: landslide distribution analysis and 3D modeling of typical landslides in AdCALC3D

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Abstract: Landslide inventory mapping in the hilly area of the Zagreb City is one of the key objectives of the Japanese-Croatian five-year scientific joint-research project 'Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia'. Landslide mapping will aid development of guidelines for use in urban planning in the City of Zagreb. In order to make reliable maps that predict the landslide hazard and risks in a certain area, it is crucial to have insight into the spatial distribution and temporal frequency of landslides. Therefore, each landslide hazard or risk study should start by making a landslide inventory that is as complete as possible in both space and time.

System of archiving data about neither landslide events nor landslide damages has not been established until today in the City of Zagreb. Existing landslide inventories and landslide susceptibility maps financed by the local governmental authority are shortly presented in the paper: landslide inventory and susceptibility mapping in scale 1:10000 compiled by geotechnical consultancy company 'Geotehnika-Geoexpert' in 1979; and landslide inventory mapping in scale 1:5000 compiled by Croatian Geological Survey in the period 2005-2007. Areas encompassed by landslide mapping in 1979 and in 2007, as well as methodologies of collection of landslide data and landslide distribution, are analyzed for the purpose of getting insight into quality of existing systematic collections of historical data. It is shown that only some of the landslides in the study area are dated and only for some of landslides is possible to find historical documents describing their initiation.

Additional historical data about the most of the investigated landslides are systematically collected from geotechnical reports. On the basis of those data, some conclusions are made regarding ranges of landslide dimensions and types of landslide causes. Moreover, landslide models in the software ADCALC3D are made for few typical landslides to illustrate landslide in 3D.

Keywords: *Landslide inventory, hilly zone of the Medvednica Mt., ADCALC3D, historical data*

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Aerial photo interpretation of landslides for the purpose of landslide inventory mapping in the area of the City of Zagreb

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Abstract: Within the Croatian-Japanese international project 'Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia' there are three working groups. Activities of Working Group 3 (WG 3) are related to landslide mapping. The main project activities of WG 3 at the area of the City of Zagreb are aimed at development of landslide inventory and landslide hazard mapping in the hilly area of Mt. Medvednica. The final objective of the scientific joint research is the development of risk mitigation measures that can be instituted through the system of urban planning and civil protection in the City of Zagreb. Dissemination and use of the results should ensure significant benefits for the local and regional communities that are directly and indirectly threatened by landslides. Aerial photo interpretation of landslides for the purpose of landslide inventory mapping in the area of the City of Zagreb was carried out by using stereo pairs from different periods. As first set of aerial photos, were used photos of Zagreb hilly area from 1962. As a cross check of the obtained data aerial photos from 1998 were used. For this interpretation of aerial photos and a landslide inventory preparation the criteria was setup in a sense of geomorphological properties of various morphological forms (slope's inclination, curvature, direction, position, etc. with curtain accuracy). Interpreted landslides and data about them were organized in a GISdata base. In the data base there are data about: location, geology, geometry, landslide boundary, relative position at slope, features at main scarp, features in landslide body, landslide body toe, vegetation at landslide area, potential of instability and landslide type. The result of interpretation of these photos was compared with historical data from two sources: landslide inventory map from 1979 which was used in urban planning for the City of Zagreb; and landslide inventory map from 2007 which is currently in use in urban planning for the City of Zagreb.

Keywords: *Aerial photo interpretation, landslide, landslide inventory map, database*

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Visual mapping of landslides from LiDAR imagery, Zagreb, Croatia

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Abstract: This paper describes preliminary results of preparation of landslide inventory, as first phase in order to carry out the landslide hazard zonation. One subset of activities of the Japanese-Croatian 5-year scientific joint-research project 'Risk Identification and Land-Use Planning for Disaster Mitigation of Landslides and Floods in Croatia' have been implementing in the pilot area in the City of Zagreb (180 km^2 of the hilly zone of the Mt. Medvednica) in order to develop landslide inventory, landslide susceptibility and hazard zonation. Landslides are significant problem in the hilly area of the Zagreb City, Croatia, and also difficult to identify in the densely urbanized and forested terrain. Landslides in the hilly area of the City of Zagreb are dominantly small and shallow movements of superficial deposits along contacts with fresh soils. Despite this, they cause significant economic losses by damaging houses and urban infrastructure. As most of these landslides are located under forest in hilly region, aerial photograph interpretation usually is not an appropriate landslide mapping method. This study tested the potential of LIDAR (Light Detection and Ranging) images for mapping small and shallow landslides under forest. Landslide inventory map was created for a 24 km^2 area by applying the expert knowledge to LIDAR-derived hillshade, slope and contour line maps in a GIS environment**.** A total of 176 landslides were identified in the first phase of landslide inventory preparation, representing 13.3 percent of the pilot area in the City of Zagreb. Despite some limitations of LiDAR technology, using algorithm-enhanced LIDAR imagery does effectively "remove" vegetation that obscures many landslides, and is therefore a valuable tool for landslide inventories and investigations in forested regions such as the pilot area in the City of Zagreb.

Keywords: *Landslide mapping, LiDAR, inventory map*

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Role of the Office for Emergency Management – City of Zagreb regarding the problem of landslides and floods in Zagreb area

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Abstract: This work presents several segments of the role of the Office of Emergency Management – City of Zagreb regarding the problem of landslides and flood in Zagreb area. One of the segments is analysis of sites for disposal of construction materials from the ruins in the case of strong earthquake in the City of Zagreb. In considering areas for storage of building materials from the ruins of the case of strong earthquake in the Zagreb area, the joint working group of the Office of Emergency Management and the Department of Planning of the City of Zagreb visited the proposed site. The aim of the site inspection was to check the current status of the location, availability of transport due to the necessity of using heavy equipment, and a final assessment of their usability. In the introductory part of the work the role of the Office for Emergency Management in Zagreb in the issue of landslides and floods in the Zagreb area (on-ground upon notification of the landslide, cooperation with other city offices in Zagreb and expert collaboration with Faculty of Mining, Geology and Petroleum Engineering and Faculty of Geodesy - University of Zagreb) was elaborated. The basic tasks of protection and rescue are the evaluation of potential threats and consequences, planning and preparedness for disaster response in the protection and rescue in case of disasters and major accidents and taking necessary actions and measures for elimination of consequences for immediate normalization of life in the area where the event had occurred . The realization of these tasks (identification of hazards, assessment of impacts, assessment of the state of operational search and rescue forces, and making risk assessment and action plans, measures and procedures, keeping records of all sources of risk and danger) is very important. Other tasks such as organization, preparation, training, exercising and training of participants of protection and rescue together with effective monitoring of the activities of dangerous source of potentially dangerous situations and informing the public must be take very seriously. A special emphasis in this work is given to the GIS system analysis for emergency services in the city of Zagreb and interactive Web map of the city of Zagreb (as well as implementation experience during the seminar "Disaster Mitigation, Preparedness and Restoration for Infrastructure" held in July and August 2011 in Osaka and organized by the Japan International Cooperation Agency and the Japanese government).

Keywords: *Office of Emergency Management – City of Zagreb, landslides, floods, GIS, JICA*

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Identification on potential sliding areas in Kosovo basin and possibilities of their prevention

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Abstract: Land slides and floods in Kosovo are not unknown phenomena. Recently, there has been a growing trend of damage caused in the household. In our country, such occurrences are often caused not only by nature, but also by the intensification of mining activities near the settlements. Mining activities in lignite open-pit usage, despite having advantages in relations with other exploitation methods, often can cause sliding, which can take the people's lives away. This primarily applies to the use of lignite open-pit of Sibovc field, near Hade village, which has about 250 homes. The Sibovc field, in terms of energy, has a very great importance, since it contains over 125 million [t] of lignite reserves, out of which about 8 million [t/year] is used to supply the Kosovo Power Plants. These power plants produce 4.9 billion kWh/year. The slope in which lies this field, on the basis of geotechnical researches that were made and are still going on, also the monitoring with modern equipment from an International Professional Commission, in 2003 has been qualified as potential slide area with a high degree of risk, based on more explicit tectonics of geological building that has layers of coal, surface distortions, the presence of self-burning coal, the impact of the old underground workings and waters. This case caused an emergency evacuation of people from about 130 houses, where the security factor was achieved after the emission that has been made at Fs=1.3 according to Bishop and Borovicka methods, with the displaced area of 150 [m]. This problem still accompanies us but now in the other direction, so the purpose of this paper is the presentation of our experience in dealing with such situations by exposing the scale of research in geological-engineering, geophysical, GPS monitoring (total station) terms. Also, in the end we will present the way we manage to preserve the stability of this slope with discharge of mass according to designed geometrizing on the basis of geo-mechanical parameters, as well as through the internal dumping of overburden, as a part of the technological process in the used spaces.

Keywords: *Mining activities in lignite open-pit, landslides*

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Landslides in the Republic of Srpska

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Abstract: Landslides, as products of modern geological processes are very common in the Republic of Srpska. Occurs in specific circumstance and in appropriate geological conditions. It presents a huge problem for sustainable physical planning, projecting and constructing.

Landslides and rockfalls, beside earthquakes, in terms of threat and damage for material resources, the environment and human life, are one of the largest and most significant type of natural disaster in the Republic of Srpska. Unlike earthquakes, which are lesser then landslides in the territory of our Republic, the occurs of instability of slopes, especially landslides are more common.

The Republic of Srpska has numerous landslides, which are distributed throughout the territory, but quite unevenly. They are mostly on the slopes of Neogene sediments, both in mountain and in the hilly, and not rarely in areas with a clay component. A lot of them have in the flysch formations because flysch disintegration material is subject to easily process of landslide and rockfall. Many landslides are in the complex diabase formation.

According to available data, in many municipalities on the territory of the Republic of Srpska is registered with the several hundred landslides, and damage was up to several hundred euros.

The Republic of Srpska significantly affected by instability processes causing very considerable material damage. These processes lead to the destruction and damage of facilities for housing, destroying road infrastructure, leading to accumulation of backfilling, damaging to power lines, cemeteries, reducing the use value of forest and agricultural areas.

Keywords: *Landslides, rockfalls, destruction*

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Landslides map of Tirana Region at scale 1:50000

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Abstract: Landslides are a big problem in Tirana region due to the relief conditions, causing a negative impact in terms of cost and level of inhabitants' life. For this reason Albanian Geological Survey (AGS) this year compiled the Landslides map of Tirana Region at scale 1:50000 and landslide data-base, as needed information for decision-makers to decrease risks in their communities and for land use planning.
The methodology applied to build up the Tirana landslide map is based on: Archive data and field surveys.
1. Archive data: Gathering all information from Central Archive of AGS (Geological map of Tirana 1:50000 studies in the geodynamic phenomena's), from TA of the Ministry of Construction (geological-engineering studies) and Road Directory (technical report for landslides in infrastructure).
2. Field surveys: to evaluate the landslide evolution, present state and activity.
For each landslide, evaluated by field surveys is filled out data sheet. It is organized in five information levels of increasing detail:

- 1st level contains General information (region, municipality, topographic map and geographical coordinates X, Y).
- 2nd level contains data for the Geology of the body to move, the plan of slide and the basement without moving.
- 3rd level provide data on Morphology (lithology, land-use, erosion, cause of activation).
- 4th level contains Hydrogeology data (ground water, underground water level, and springs).
- 5th level contains Geological Engineering data (type of movement, state activity, humidity).

At the first stage the collection of data is necessary, followed by compilation of Lithological map at scale 1:50000 for Tirana Region. Ten groups of lithological/engineering geological unit were defined: 1-Hard limestone rock; 2-Average of stratified rocks; 3-Sandy rocks; 4-Average clay rock; 5-Soft clay rock; 6-Conglomeratic rock; 7-Chaotic soft rock; 8-Soil with cohesion; 9-Soil without cohesion; 10-Soil stratification with and without cohesions.
In this map are marked 133 landslides, according to coordinates and azimuth of the direction of slides.
The data collected from archive and fields as well are entered as inputs in a database that serves to build the map of landslides in the GIS mapping.
Conclusion: The Tirana region covers about 1640 km^2. Throught a field work and archive data are identified 133 landslides. Clay rock was found as the most susceptibly lithological complex (65 landslides).
From previous studies and field surveys it is emerged that the phenomenon of sliding occurs in most cases in slopes with inclination from 5° to 30°. In slopes with an inclination greater than 30° phenomena of topple and falls occur.
Based in this map and analyses of landslide spatial occurrence coming year, will be proceeded in derivation of the Landslides Susceptibility map of Tirana at scale 1:50000.

Keywords: *Lanslide map, lithological map, data base*

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Engineering geology study of slopes subjected to mass movement in the Durresi area, Albania

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Abstract: Last two decades the Albania is characterized by a population's moving to Adriatic and Ionian coastal area, where are associated with many engineering objects constructions like buildings, routes and green parks etc. Mostly of them are built on hills slopes without any engineering geological and geotechnics investigations. In this paper we are treating the engineering geology studies carried out in the Durresi town area for urban planning and development. The studied area is located in western part of Albania along of the Adriatic seaside. For the study of mass movement in the studied area are used field works and laboratory tests. Firstly, an engineering geology mapping on a scale 1:2000 was carried out in the studied area followed by many drillings and Electrical Resistance Tomography-(ERT) profiles in unstable slopes. To determine the slope stability of hills areas are taken a lot of soil and rocks samples for examinations of physical-mechanical properties in laboratory. The results from these studies shows that area is much affected from geodynamics phenomena, which are earth flow types. There are many hills slopes which suffer from earth flows phenomenon, resulting mostly in damages of many buildings and infrastructures. Slope instability activity is related to various influencing factors, which caused earthflow phenomenon in the studied area. The main factors, that have favored the earthflow, are the lithology, morphology, tectonics activity, rains, drainage pattern, manmade works and vegetation cover. The lithology of Durresi hills slopes are built by molasses deposits-soft rocks are a combination of claystones and siltstones layers. In upper part of lithological profile these formations are very much weathered. The weathering crust range from 2.5-3.5 m up to 5.0-6.0 m thick. Also, over this formation are situated soils deposits 2.0-4.0 m up to 6.5-8.0m thick. Both of these deposits are subject of mass movement during rains period. From our investigation is seen that earth flows have occurred on hill slopes dominated by soils and weathering crust of the molasses rocks. They have small-medium size. The slide body consists of inorganic silts and clays with mixture of gravels-sands. The hills slopes have an inclination range 15-20° up to 30-45°. The other factors favor the earth flows in these terrains is attributed to the presence of high precipitations and manmade works (slopes excavation for construction purpose) and tectonics activities, as well. From engineering geological investigations done in this area is concluded that, from intensive weathering of the molasses rocks, presence of soils are situated on slopes 2.0-4.0 m up to 6.5-8.0 m thick, slopes inclination steeper the 20°, the presence of wet climate with high precipitation and manmade construction activities in many areas of Durresi hills slopes have occurred the mass movement belong the earth flow type. From their activities are demolished many building, as well as injured of the main roads and gardens of Durresi hills area. It is very important to emphases that in many hills slopes areas are absolute needs to take the engineering measures against of earth flows and some others the citizens have to move a new place, because of these unstable areas constitute very dangerous places.

Keywords: *earth flows, mass movement, slopes, soils, molasses weathering crust, high precipitation, manmade works, unstable slopes*

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Geological and engineering-geological investigations in Brodsko Brdo area

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Abstract: This study area is very similar to the hilly zone of Medvednica mountain which is one of major pilot areas of Croatian – Japanese project. Research area covers about 10 km^2 and from geographical aspect it is located on the southern slopes of Dilj mountain and belongs to its foothill side. However, from geological aspect, this area belongs to the Sava river valley and it is placed on its elevated part, known as Ivanjić hill (named for the highest point which height is 264 m). This elevated part has W-E direction, from Sibinj on the west to the Tomica on the east. Petnja and Pribudica streams make the northern boundary, and Sibinj – Podvinje road the southern one. The main structural features of study area are longitudinal and marginal faults on its northern and southern side. For this area are prepared new geological (M 1:5000) and engineering-geological map (M 1:5000) showing landslides and gullies. Also, a landslide inventory with 60 registered type of instability was prepared. On the field, samples for laboratory tests were taken (for the confirmation of composition and granulometry), and tests with pocket penetrometer and field shear vane apparatus were performed on site. Geological map was made as a base for engineering-geological investigations. During its preparation the emphasis was on lithology of deposits which are represented in the studied area. Therefore, geological map represent lithostratigraphic units which were recognizable on the field. So the distinguished stratigraphic units were: Pont (M^2_7), Pliocene ($_1$Pl, $_2$Pl) and Quaternary (pr-Q). Regarding engineering-geological features the deposits were divided roughly in two major groups: clayey-silt and sandy deposits, so on the whole area can be distinguished coherent and incoherent soils. Present day topography of landscape was created by engineering-geological processes (as landslides and erosion features). These processes are still active. In landslides which are mainly in sandy sediments the groundwater level is approximately at depth of 7-8 meters. Landslides in such kind of sediments usually have deep sliding surfaces and they are complex. Mitigation of such landslides is difficult and expensive. In clayey-silt sediments the groundwater level is rarely deeper then 1 m. These landslides are simpler, mostly with shallow and slow moving (soil creep) sliding surface. For the determination of the stability of any slope under given conditions is necessary to establish: a) detailed lithological composition and geomechanical parameters, b) thickness of cover and wheathered zone, c) expected depth of shallowest groundwater level, d) slope angle, and e) inclination of sediment layers and their relation to the structure of slope. Purpose of research was to categorize the terrain on the bases of stability which enables making of optimal urbanistic plan that would be economically viable.

Keywords: *geological map, engineering-geological map, landslide inventory, slope stability, terrain categorization*

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The support of PSInSAR™ and SqueeSAR™ data in characterizing landslides and their evolution: from regional to local scale

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Abstract: Permanent Scatterer SAR Interferometry (pSInSAR™) is today one of the most advanced technologies for surface deformation monitoring capable of overcoming most of the limitations of conventional differential radar interferometry. It exploits long temporal series of satellite radar data, acquired over the same area of interest at different times, to identify "natural radar targets" (i.e. the so-called Permanent Scatterers) where very precise displacement information can be retrieved.

Recently, some significant advances have been reported in InSAR data processing that can further increase the quality and the effectiveness of this data source:

(a) the availability of new processing algorithms: at the end of last year TRE developed a new algorithm (SqueeSAR™) which allows a significant increase in the spatial density of measurement points by exploiting signal returns from both Permanent and Distributed scatterers (PS and DS);

(b) the availability of an increased number of satellite radar sensors characterized by higher spatial resolution (down to 1 m), as well as higher temporal frequency of acquisition (down to a few days, rather than a monthly update).

Thanks to its high precision, and to the availability of satellite data archives covering more than one decade SqueeSAR™ analysis can be considered complementary to conventional geological and geomorphological studies in performing landslides inventories at regional scale and supporting the design of early monitoring systems at local scale. The Italian Ministry of the Environment has recently awarded a contract for the processing of more then 12000 SAR scenes acquired o ver Italy aimed at creating the first database of interferometric information on a national level for mapping unstable areas. This is somewhat an evidence of the fact that, in less than ten years from its development, this technology has become a standard monitoring tool.

The availability of surface displacement time series for all the radar benchmarks identified makes it also possible to change the scale of the analysis from regional to local, allowing an in depth study of the evolution of single instability phenomena, supporting the design of traditional monitoring networks, and even verifying the efficiency of remedial works.

Keywords: *InSAR, Permanent Scatterers, Distributed Scatterers, landslide inventory, monitoring*

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Urbanized areas and debris flow risk evaluation in the Western Alps (Piedmont, NW Italy). Multidisciplinary approach based on historical documents and GIS statistical analysis

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Abstract: In the Alps, mud-debris flows are very common processes, very often involving the human settlements located on the alluvial fans. For this reason, in the last decades, these kinds of phenomena have attracted the attention of the scientific community and concern of general public due to the death toll and damage of structures and infrastructures by flooding, erosion, direct impact or sediment deposition. Piedmont (northwestern Italy), with more then 2500 alluvial fans is one of the most vulnerable Italian region. In particular, in the Verbania Province high rate of human settlements (frequently more then 40%) are located on debris flow prone areas.

Adopting a well established methodology, frequently used by CNR-IRPI in the past, this study focuses on: a) geomorphological analysis of the basin and alluvial fan; b) collection of historical information about the frequency of the phenomena and the dynamic of the process; c) evaluation of the past event magnitude and extent of the relating damage; d) reconstruction of the urban growth on the alluvial fan in the last decades.

The above mention methodology has been applied for a case study concerns four creeks in the Druogno municipality (Vigezzo Valley – north Piedmont), which have built up their coalescent alluvial fans onto the nearly level plain of the Vigezzo stream. These alluvial fans, that cover a total area of 0.81 km^2, were selected by taking into consideration the criteria mention above. On the basis of historical data, was possible to gather information about twelve flooding events (including debris flow) in the last century which have caused significant damages for the residential areas located on the alluvial fans. The highest magnitude debris flow event in the recent times occurred on 7-8 August 1978. All four above mentioned creeks moved huge volume of coarse-grained sediments that covered the fans with 0.55 km^2 of debris, with up to 6 m thick deposits in the apex fans. As consequence, about 55% of the buildings and infrastructures were destroyed or suffered remarkable damages.

Using historical maps and aerial photographs emerges that the fastest grow rate occurred between 1950-1970 and exactly the buildings from that period were highly damaged (more then 60% of them) by the 1978 debris flow. After this catastrophic event, the urbanization rate has decreased, but some of the new buildings are still placed in high risk areas.

In the study area, the up-to-date situation (2011) shows that alluvial fans cover 4.4% of the total surface, but being the most suitable terrain for human settlements, an important percentage of residential areas (58%) and infrastructures are located on them. Currently in force, national and regional laws have included the Val Vigezzo debris-flow prone areas into elevated or moderate risk classes. Should be noted that after 1978 event till now no other debris flow has reached the same magnitude: so it appears hard to evaluate if the retention dams and laws provisions will successfully mitigate the risk for a potential high magnitude flow event with a several decades-long recurrence interval.

Keywords: *debris flow, alluvial fan, urbanized area, risk, Piedmont Region*

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Landslide and debris flow hazard assessment at municipal scale (Vrhnika municipality, Slovenia)

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Abstract: This article presents a methodology developed by the Geological Survey of Slovenia, as a tool to elaborate landslides and debris-flows hazard maps in scale 1:25.000 on the municipality level. To achieve this aim we followed certain requirements: expert correctness, reasonable time of elaboration and easy to read and use product.

The municipality Vrhnika represented a pilot area where the methodology was used for producing the maps which served for land management. Vrhnika municipality territory (about 115 km^2) is located SW from Ljubljana. Geology in the Vrhnika municipality is very complex due to the complex tectonic setting, especially in the northern part. Very different types of rocks occur together: Carboniferous and Permian clastic rocks, Triassic carbonate and clastic rocks with some piroclastites, Jurrasic and Cretaceous carbonate rocks, Quaternary alluvial and marsh sediments. Area belongs to the External Dinarides, which has the most prominent structures as folds, faults and thrusts that stretch in NW-SE direction.

The study was conducted on four different steps. The first two steps represent synthesis of the archive data and probabilistic model of geohazard induced by mass movement processes. The univariate statistical analyses (χ2) was used to analyse the landslide and debris – flow in relation to the spatio-temporal precondition factors: lithology, slope angle, slope curvature, slope aspect, distance to geological boundaries, distance to faults, distance to surface waters, flowlenght ad landcover type. Additionally factors for debris-flow map were energy potential related to elevation, 48-hours rainfall data and stream energy potential. The compilation of first two phases into the final maps was next step. In the last phase, the most hazardous areas were checked by field reconnaissance.

The geohazard maps as the final products are directly applicable in spatial planning for local communities.

Keywords: *hazard, landslide, debris-flow, municipality, spatial planning, Slovenia*

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Recent Developments in Assessing Debris-Flow Hazard in Slovenia

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Abstract: This review paper gives an overview of the recent developments in assessing debris-flow hazard in Slovenia and experiences with the debris flow phenomenon. Being a legislative obligation defined in the Slovenian Water Act, debris-flow hazard mapping and debris-flow risk assessment is still under development. The paper brings an overview of the main steps done since the adaption of the Water Act in 2002. As a result of several applied and targeted research projects in the last decade, a methodology for defining hazard areas threatened by landslides and their delineation into zones has been prepared but unfortunately not fully implemented. Useful decision support tools such as an landslide inventory in the form of a digital GIS database called GIS_UJME with more than 4000 geo-referenced landslides out of the estimated 7000 to 10000 slope instabilities in Slovenia has been established and updated from different local and national sources, or such as a landslide susceptibility map in scale 1:250000 and a debris-flow susceptibility map in scale 1:250000 that have been developed using statistical models. The paper brings some main results of these research projects that can be used in the field of assessing debris-flow hazard. Furthermore, some results of selected case studies in the field of debris-flow numerical modeling are shown. A recent and also severe experience with debris flows in Slovenia was in the village Log pod Mangartom in NW Slovenia, where a large debris flow in November 2000 ruined several buildings and claimed 7 casualties. This event was subjected to many studies. After a detailed geotechnical field study and mathematical modeling of new potential debris flows from the Stoze source area, a hazard map for spatial planning in Log pod Mangartom was prepared. After the November 2000 event in Log pod Mangartom there were more then 10 debris flows in other parts of Slovenia. That fact led to further studies of debris flow phenomena and to initiation of the debris-flow hazard assessment. In 2005, a study of different methods for debris-flow magnitude estimation was conducted for more the 20 torrential fans in different parts of Slovenia, yielding a classification of torrential fans. In 2008, a detailed field studies in the headwaters and on torrential fan were carried out on selected torrential fans in the Upper Sava River valley in NW Slovenia. In 2009, a sensitivity analysis of the mathematical model Flo2D was carried out on the Koroska Bela fan. This torrential fan was selected because an active landslide, which could turn into a debris flow, was recognized in its headwaters during previous field studies. Using Flo2D, debris-flow hazard mapping on the fan was conducted. Further development has also been made through an international scientific cooperation in the fields of natural hazards documentation, monitoring of natural hazards, and impacts of natural hazards on infrastructure in the alpine environment. Final step still ahead of us will be the preparation and adoption of a special national legislative regulation on how debris-flow hazard maps must be prepared – a possible way that may be followed is the approach defined by the EU Floods Directive (2007) implemented in Slovenia in the form of the Flood Rule Book (2007) and the Flood Decree (2008).

Keywords: *debris flows, hazard mapping, natural hazards, numerical modeling, Slovenia, susceptibility*

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Spatial distribution on seismic geotechnical hazards general zoning on territory of Macedonia

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Abstract: The subject of this study is the evaluation of the possible kinds of seismic geotechnical hazards and their spatial distribution in the Republic of Macedonia. The territory of the Republic of Macedonia with its wide range of rock complexes of different physical-mechanical and other characteristics in combination with the high seismic potential fits in the category of regions where seismic geotechnical hazards represent a permanent phenomena during the seismic effects, particularly during strong earthquakes. The study comprises two basic types of seismic geotechnical hazards, defined as: direct, i.e., dynamic instability of soil and indirect, i.e., geotechnical effects upon the seismic motion parameters. The occurrence of the direct seismic hazards is considered in case of geological conditions suitable for their occurrence at sufficiently intensive seismic excitation. Therefore, for the evaluation purposes, first, past records on seismic geotechnical hazards occurence are studied, then the geological conditions for the occurrence of direct seismic hazards, as well as the seismic intensity excitation that would cause soil instability are summarized. It has been evaluated that the lowest seismic excitation which under general geotechnical conditions for soil instability occurrence would cause soil instability is the excitation with a maximum acceleration higher of 0.05 to 0.1 g. For the definition of the dynamic instability occurrence potential, a comparison of the geological conditions and the expected seismic excitation within the considered territory is carried out. For the comparison, excitations corresponding to return periods of 100 and 1000 years are applied. As a result, zonation of the territory with definition of the zones of different dynamic instabilities potential is carried out. To have an insight of the potential occurrence of geotechnical effects upon the seismic motions in future earthquakes, classification and zonation of the local geological medium of the territory is performed. As the basis, the classification proposed by the EUROCODE 8, has been considered. The applied methodology for spatial distribution of geotechnical hazards is implemented on the basis of the available data on the region. Thus, the performed zonation is general. With this in mind, occurrence of micro-locations should be expected in each of the represented regional zones, which will deviate from the assumed classifications.

Keywords: *Geotechnical hazard, seismicity, site effects, zoning*

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Landslides management in Albania

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Abstract: The territory of Albania is an area with large contrasts in terms of relief morphology. About 65% of this territory is made of slopes with a diversified origin and construction mechanism.
From previous studies and surveys is emerged that the phenomenon of sliding occurs in most cases in slopes with inclination from 5^0 to 30^0. In slopes with an inclination greater than 30^0 occur phenomena of downfall and rock falls. This is related mainly to the lithology and to physical–mechanical characteristics of rocks and grounds situated on the slopes.

A big role, during last year, in the activation of slides phenomena, has played the human factor, which with its interventions on slopes, often not well studied, has caused the acceleration of these phenomena and made them appearing more dangerous causing a negative impact in the life and cost of inhabitants.

Landslides vulnerability and risk map are no available in Albania. Actually AGS has undertaken a project for compilation of *the map for geodynamics phenomena (landslides)* using traditional methods as well as to the geo-physical methods from which can be mentioned: Vertical Electrical Sounding (SEV) method, Tomography method, topo-geodesic Methods.

To collect storage and update the data of those phenomena small applications is set up using Visual *Basic for Application* (VBA). In the last two years 220 emergency cases are occurred and are inserted on mentioned database. On the other side, GIS department is digitalizing the Engineering geology maps for whole territory in 1:25000 scale. Till now, 61% is covered with the mentioned maps.

The main challenges a front of our institute are: a) The need to improve the risk assessment for inhabitants, infrastructure due to the geohazard phenomena and its management; b) Installation of the monitoring system; c) population of Hazard database with historical data; d) Better coordination with local authorities, public and private bodies to prevent the risk of such kind of phenomena.

Keywords: *landslide, emergency cases, digital map, database*

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Sabo works in JAPAN

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Abstract: Japan has many steep mountains and volcanoes. Many sediment-related disasters and avalanche hazards occur every year because its geological condition is weak and what is more, it has large number of earthquakes, torrential rainfall by seasonal rain front or typhoon and heavy snow.
It is specific characteristic in Japan that sediment-related disaster is a disaster with a high rate of killing human lives among natural hazards.

Japan has continued to make efforts for sabo (Erosion and Sediment Control) projects for 100 years or more since the Meiji Era (1868) in order to prevent sediment-related disasters using “hard” countermeasures such as construction of sabo dams. However, there were about 210000 sediment-related disaster hazard areas that contain 50000 houses, and the percentage of the areas improved is only about 20 %. In addition, the current number of sediment-related disaster hazard areas reaches about 520000, so the prevention of all the areas based on these countermeasures requires immeasurable time and budget.

For this reason, while we promote “hard” countermeasures we will immediately implement “soft” countermeasures such as forecast and prediction of disaster occurrence and establishment of an evacuation system to prevent human lives from sediment-related disaster.

In addition, many landslide dams (or the river blocked dam) were formed by the Iwate-Miyagi Nairiku Earthquake (2008) and the Mid Niigata Prefecture Earthquake (2004). In case of imminent large-scale sediment disasters, such as landslides, landslide dams and debris flows accompanying volcanic eruptions, these disasters may cause serious damage over the wide range of areas, once they occur, and because of the continuously changing their conditions, technical skills are required to understand their risks. For this reason, we amend the law in2010, the central or prefectural governments are required to provide information about the probable areas and time period for damage, so that municipal governments can make proper judgments about the issuance of evacuation instructions to local residents when facing imminent large-scale sediment disasters. It defines legally specify the roles and involvement of the central government in the case of sediment disasters, which require high technical skills, and also those of prefectural governments in the case of other sediment disasters.

We have many landslide dams in Kii peninsula caused by typhoon Talas in this September. Based on the law, we carried out the emergency investigations and the simulation of debris flow in the case of burst of landslide dams to provide notification of information about the probable areas and periods of damage to prefectural government and municipalities. As a result, the prefectural government set the off limit not to enter the dangerous areas, and prevent the second accident.

Keywords: *Disaster management, evacuation system, landslide dam*

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Population vulnerability assessment in hazard risk management: A dasymetric mapping approach

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Abstract: The natural hazards catastrophe loss estimation is unfeasible without both hazard intensity distributions and exposure data as the inputs. The hazard exposure data, such as population and dwellings, are usually accessible on the level of spatially arranged census tracts. Data on population are processed based on the census conducted by states at regular time intervals, most often once in a decade. Demographic census data are mapped as statistical surfaces and most often presented on choropleth maps, i.e. maps, which consist of a number of individual estimated uniform spatial surfaces, separated by clear, crisp boundaries of census polygons. Actually, the model based on a choropleth map is a result of aggregation of data obtained in census districts. In current population vulnerability studies, this spatial incompatibility is often inadequately addressed and a uniform distribution of exposure data within such areal units assumed, which is not the case in reality. The data, like population density, will in such case result in surfaces which do not envisage presentation of uninhabited regions, although they really exist. The only way to overcome this problem, with the aim of making the demographic spatial data modeling as real as possible, is to use spatial bases which indicate the degree of land usage and spatial contents, as well as to take into account the natural factors which are in correlation with spatial distribution of population.

Dasymetric mapping method is one of the possible approaches for solving this problem, dividing the modeled space into zones of higher homogeneity degree, thus reflecting more truthfully the variations in a statistical population layer, with support of additional variables and their correlations. Increasingly available GIS applications, intended for spatial data modeling, create new possibilities in processing and presenting the demographic data. The usage of a GIS tools enables authorities to combine the demographic and other spatial layers to spatially model population distribution and by merging them with hazard intensity distributions data to statistically and visually represent populations at risk within hazard zones.

This paper contains a brief overview on experience of dasymetric mapping in Serbia. Also, the usage of dasymetry in one-hundred-year flood risk mapping of a hazard-prone case study region is presented.

Keywords: *Dasymetric mapping, GIS, flood risk management*

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Analysis of map graphics on the special maps for crisis management

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Abstract: This research discusses the proposal for standardization of cartographic symbols on the maps prepared for use on monitors for early warning and crisis management. In the research questionnaire were used, with the participation of cartographers, experts on crisis management, students and other citizens. Some standard American, Canadian and Australian cartographic symbols for crisis management have been used in research questionnaire. In the preparation process of selection symbols for survey, that same symbols have been simplified and changed to meet the required conditions of user perception. The research was conducted on the Internet. The survey obtained most appropriate symbols for crisis situations, according to participants. There were also taken into account some of the comments obtained from questionnaire before the final proposal for symbol standardization, especially the comments of cartographers and experts on crisis management. After proposition of symbols used for those maps, but another research carried out in the form of interviews, which is aimed at testing the selected symbols, their legibility and perception of the cartographic representation on small handheld devices for this purpose made map. The map is designed as a personal Google map on which we entered the place marked with the symbols resulting from survey conducted before current research. The selected symbols from the survey were used to map the assessment of visualization applications for display on small hand held devices for each symbol. Google Maps enables you to view different surfaces including: Map, Satellite, Terrain, and Earth. These different surfaces influence the visibility and legibility of the signatures themselves. In the interviews conducted we tested the signature on all templates offered. The interview was supposed to demonstrate the level of detection signatures, and their legibility and usefulness of the application. The interviewees are expected to: connect with the signature concepts that are positively assess the readability and uniformity of symbols, accept a variety of frameworks that represent the difference in the appearance of crisis situations, positively evaluate the usefulness of symbols to prevent or reduce accidents.

Keywords: *Cartography, map graphics, standardization, cartographic symbols, crisis management*