UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE BOGOTÁ
FACULTAD DE INGENIERÍA
ÁREA CURRICULAR DE INGENIERÍA CIVIL Y AGRÍCOLA

ACADEMIC PROGRAMS

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CIVIL ENGINEERING

PhD PROGRAM

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DIPLOMA

STRUCTURES

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TRAFFIC, DESIGN AND ROADS SAFETY

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SANITARY ENGINEERING

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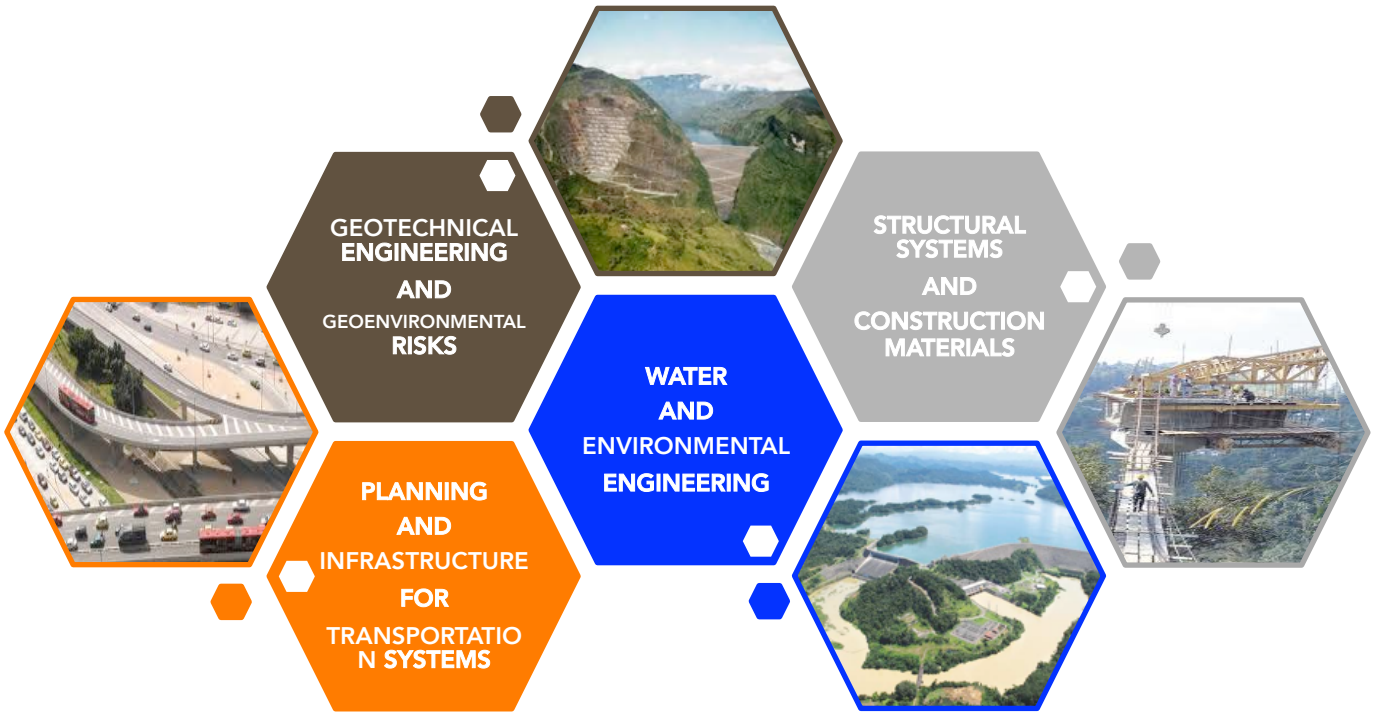
FACULTAD DE INGENIERÍA
ÁREA CURRICULAR DE INGENIERÍA CIVIL Y AGRÍCOLA
DOCTORADO EN INGENIERÍA - INGENIERÍA CIVIL

Civil Engineering
PhD Program
2015

The PhD Yearbook contains an abstract of each of the theses in progress in the PhD Program in Civil Engineering at Universidad Nacional de Colombia



PhD Program
in CIVIL ENGINEERING

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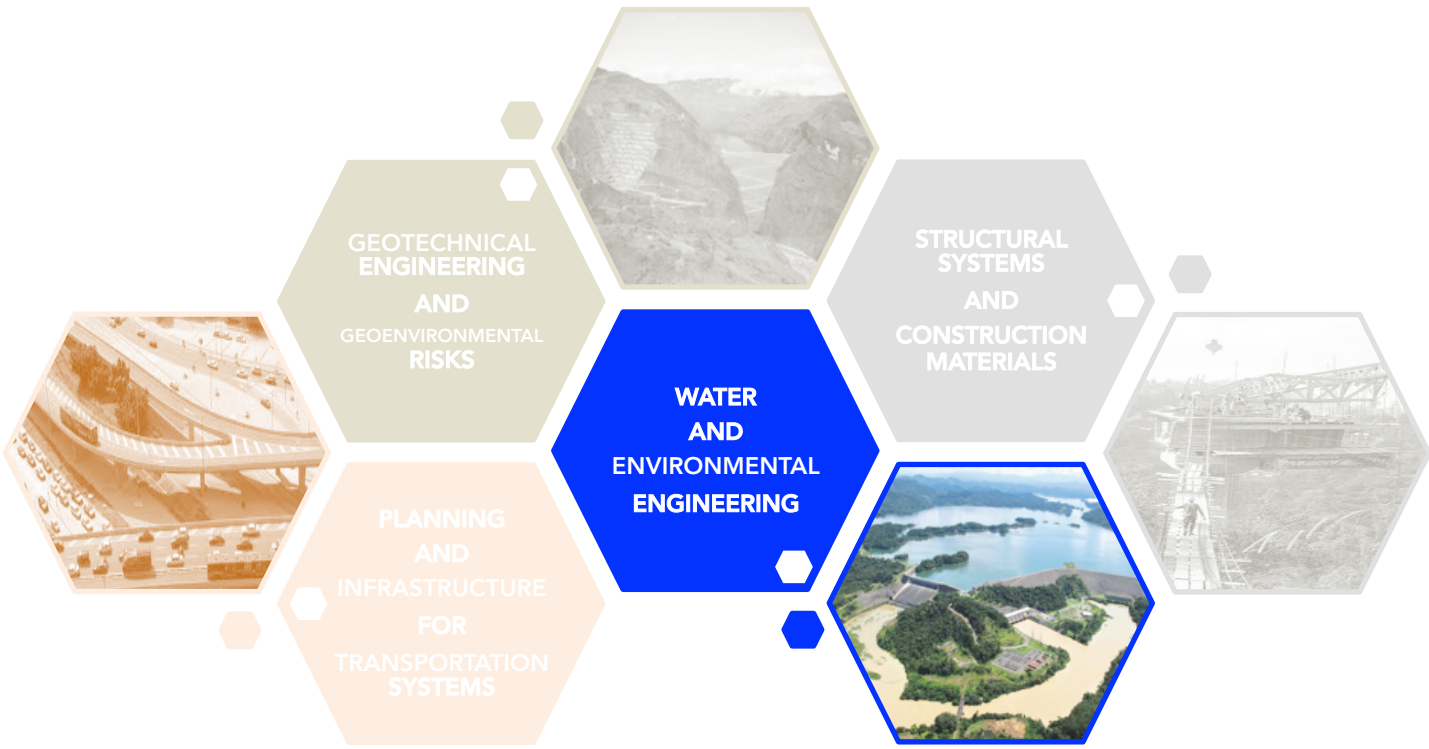

WATER AND ENVIRONMENT ENGINEERING

Angélica CORZO

Feasibility of using plastic support media in high rate artificial wetland for treatment of industrial effluents

Industrial processes generate the largest amount of wastewater with high organic load, and its treatment is usually developed with conventional technologies with a high cost in both construction and maintenance. As an alternative to these technologies, there are available several soft technologies, which are characterized by high contaminant removal, minimal or no environmental impact, low operating and maintenance costs. Sustainable treatment systems implemented worldwide correspond primarily to constructed wetlands with horizontal subsurface flow. The analytical results obtained so far by various authors reflect the advantages and disadvantages of these systems. Advantages include its simplicity of operation, limited to gardening and waste removal, moderate operating costs. Between the disadvantages is the clogging of support media, the worst problem encountered so far. Although the efforts of the scientific community around this technology have advanced considerably in the treatment of domestic and municipal wastewater with low to medium organic loads, there have been few experiences in using this technology for wastewater treatment from various sources, with high organic load. With this outlook, the development of an optimized model for biofilm formation is proposed, testing its use as a support media in artificial wetlands, determining issues such as organic load range that can receive the system, macrophyte species associated with better pollutant removal efficiencies, its hydraulic behavior in service, the detoxifying capacity of the system, and its hydraulic evolution, that permit its design and implementation. It is expected that the results obtained allow to easily performing the design of this technology, and can be implemented massively for wastewater treatment with high organic load, especially industrial type.

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Entre las áreas de interés se encuentran el acople entre modelos de circulación atmosférica y modelos hidrológicos de gran escala, en particular el estudio de la interacción suelo-atmósfera-vegetación, la aplicación de Sistemas de Información Geográfica como una herramienta para la Modelación Hidrológica de Cuencas y la Modelación Matemática en Hidrología Urbana.

Líneas de Investigación:

Hidrología Urbana
Hidrología e Hidráulica de ríos de montaña
Modelación Matemática en Hidrología

Research Group:

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INGENIERÍA DE RECURSOS HÍDRICOS

Antonio PREZIOSI

Hyporheic flow model for high slope rivers in the andine region of colombia

The Hyporheic Zone is the place where matter and energy exchanges between groundwater and surface water occur. The study of this zone and its flow has been growing up since the 1960's. Furthermore, the articles related with the Hyporheic Zone began to attract other branches of knowledge, that have demonstrated the importance of Hyporheic Zone for ecology, hydrology and hydrogeology.

Nowadays, the Hyporheic Zone study is bonded with the concept of Integral Management of Water Resources (IMWR), that looks for the integration of surface water and groundwater as an unique resource, and the actions taken on any of those two sources affect the other one and the processes occurring in the Hyporheic Zone, that acts as an exchange phase.

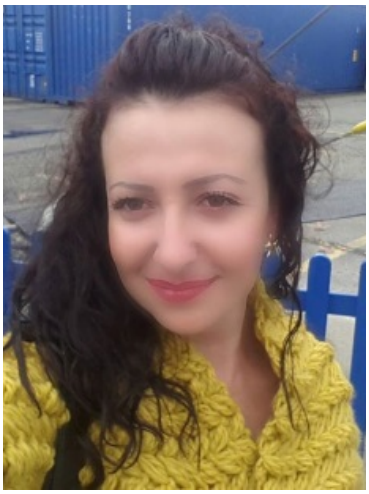
This investigation aims to propose a model of Hyporheic Flow that helps to determine the ways in which the exchange between groundwater and surface water of high slope rivers, characteristic from the Andine Region in Colombia, takes place. In order to achieve this development, the study will be divided in three phases. First, I will build a lab model where the Hyporheic Flow will be characterized with the simulation of the high slope rivers conditions. The lab model uses a channel with a transparent wall where water will flow to measure the effects of transient storage in the channel's bed.

After that, a theoretical phase is proposed in order to develop an analytic/numerical model that calibrates the lab model built in the first phase of the study. This phase pretends to describe the Hyporheic Flow of the high slope rivers according to the bed morphology, the mean flow velocity and the characterization of the aquifers connected to the streams that are being studied.

Finally, the results obtained in the previous phases are going to be validated using a small stream in the mountains. This phase serves as a test for the hypothesis that emerged in phase one and two of the research. The steam that will be used has a piezometric network around and has the instrumentation needed to make the comparison between the results obtained in the field with the ones that result from the model created in the previous phases.

Maria C. ARENAS

Hydro-Economic Model Process Hydrocarbon Exploration and Production in Colombia



In the specific case of Colombia, the water resource is limited not only in human consumption but also in agricultural production, which involves using different water sources to develop the industrial, agricultural and urban areas, thereby prioritizing conservation aquifer is regulated under Decree 1729 and part of the National Development Plan for the Conservation of Environmental Sustainability to the criteria of exhaustion or contamination by human actions and the existence of conflicts by the use of groundwater, both of which are evident clearly they occur in Colombia where operating activities Oil predominate. The existing current regulations contemplated in the implementation of environmental management plans the diagnostic phase of the aquifer, which aims to characterize the identified problems and conditions presented by the water resources in the area, proposing the consolidation of a conceptual hydrogeologic model evaluate the offer and water demand, checking on them the quality of the aquifer.

In this situation, this project will optimize the use of water resources through the design of a hydro-economic model which may propose management strategies that optimize and conserve groundwater reserves as initial consolidation phase to preserve environmental management dispositions the oil present in different parts of the country water resources and social development of the surrounding community. This research aims to contribute to the planning of strategies to protect groundwater and be a reference for future research in areas of major hydrogeological complexity of these areas.

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Javier ALDANA

Uncertainly analysis for policy design in irrigation projects

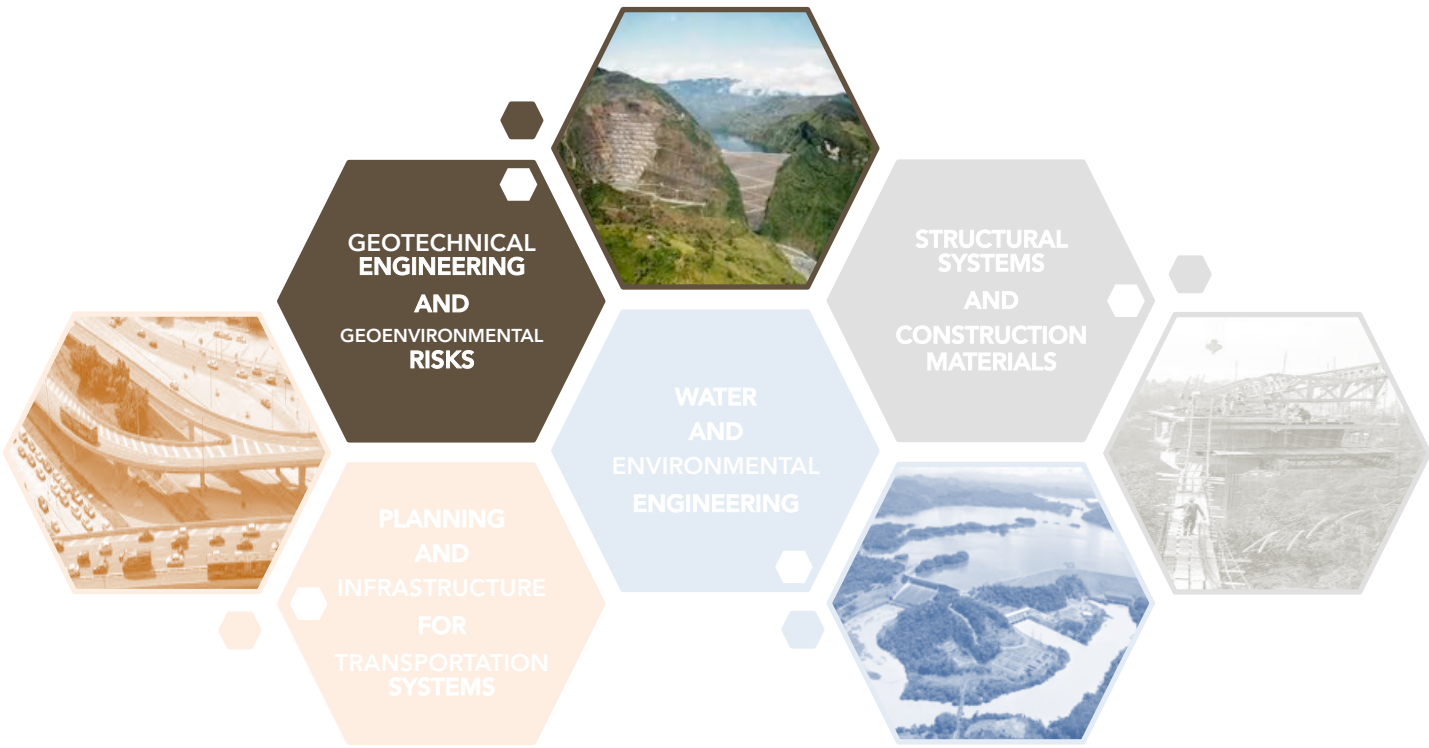
The eartH_2Obsrerve Project will integrated Earth Observations available for different satellital missions, in situ observations available for different sources and mathematical models from last generation for the Global Reanalysis construction of the hydraulics resources, with the objective of increment available information about of hydraulics resources and envelop the knowledge about of state and the current pressure in front of water global available for the most of all components of Hydrologic Cycle (Precipitation, Soli Moisture, Transpiration, and Rainfall), incrementing the possibilities in the investigation, politics and economic possibilities for the evaluation of quantity and quality of hydraulics resources in several basins. Particularly for the Colombian Case will be proposed work in the Chenche River Basin in the research of uncertainty analysis for policy design in irrigation project.

David ZAMORA

Resilient making decisions for watershed management through modeling ecohydrological-hydroeconomic coupled

A detailed understanding of the systems and environmental strategies for proper management, is gaining increasing importance as we are faced with more complex problems arising from global climate change, population growth and socio-economic development. In order to develop strategies for sustainable use and management of such systems, usually complex interactions of its underlying elements are evaluated from a variety of data from different sources and disciplines, such as remote sensing, hydrology, ecology, geomorphology or economic sciences, which are integrated and managed.
However, the ubiquity of the influence of human activity on the water world, geochemical and biological dynamics, poses many challenges for the maintenance of these natural processes, and thus for the projection of ecosystem services and human societies. To help resolve these significant problems in the hydrosphere an approach that recognizes the human nature united and biophysical systems is required.
Thus, the regional programs for watershed management focused the development of its management in multidisciplinary resources that address the change and climate variability, dynamics of the hydrological regime, water availability, management of related risk with water and social vulnerability, among others.
However, although different information sources, have not always achieved the diversity that characterizes each of the elements in the scenario generation and decisions are intended to take into account.
Thus, diversity is the main characteristic of complex systems and the synergy of its variables is the one that produces the states of a system.
In this line, forecasts of short, medium and long term are defined towards a rational, sustainable and integrated use of water resources, involving a number of synergies that from modeling and evaluation of scenarios, have for aim, in most of cases satisfy increased in the demand without regard to the shortage sensitive parameters, which characterize ecohydrological metabolisms involved in the spatial organization of the hydrological dynamics of the basins and social metabolisms in framework of equitable distribution of water resources, combining the benefits of river networks and economic demands spatially distributed in the basins.
On the other hand, the results of the coupling and/or ensemble ecohydrological or hydroeconoomics models,

evaluated the uncertainty and sensitivity of the models which have previously been subjected to a process of optimization in order to establish the state of the system in which the benefits are maximized, but isn't evaluated always equity with which are distributed the main economy activities arising from the use of water resources. Based on this information decision makers and / or planners responsible for making recommendations to policymakers and responsible researchers predict the likely future impacts of possible decisions, which are facing increasing uncertainties the farther you look into the future. However, everyone makes decisions that affect future events that require informed judgments about plausible future, even though are uncertain. Thus analysts present their results on probabilistic descriptions, but getting to interpret the results is not a task that it is easy to understand for the end user. So how to adapt to future decisions propagation of uncertainty and how to generate elements to translate the complexity of a process a posteriori to the decision in simple language, but robust for that its interpretation is done in a simple way by the end user or decision maker?



GEOTECHNIS AND GEOENVIRONMENTAL RISK

Christian GARCIA

Development and application of a coupled geomechanics model for two-phase flow through elastoplastic porous media using artificial intelligence tools

Cuando se presenta un flujo de uno o más fluidos dentro de un medio poroso de origen geológico, como lo son los suelos y las rocas, se presenta un cambio en los esfuerzos efectivos que experimentan este tipo de material geológico. Al haber un cambio en los esfuerzos efectivos se producirá una serie de deformaciones y desplazamientos dentro del medio poroso lo que conlleva a un cambio en las magnitudes de la porosidad y permeabilidad iniciales. Tradicionalmente cuando se realizan simulaciones numéricas de flujo en medios porosos, se establece como simplificación, que la porosidad y la permeabilidad permanecen constantes durante todo el espacio de tiempo, lo que trae como consecuencia que los resultados de la simulación (i.e. los valores de presión y saturación en el tiempo) sean incorrectos. La interacción que existe entre el flujo de fluidos y la deformación del medio poroso son estudiados con la ayuda de los modelos de acoplamiento flujo - geomecánico. El objetivo principal de estos modelos es tomar en cuenta los cambios que experimentan las propiedades físicas del medio poroso y que influyen en los fenómenos que ocurren cuando se presenta el flujo (i.e. subsidencia, compactación, asentamientos, consolidaciones, producción o inyección de fluidos, etc.). Durante los últimos años se han realizado numerosas investigaciones sobre el tema. Estas investigaciones han creado una serie de modelos acoplados que han tenido aplicación en diversos campos de la ingeniería, pero muy pocos han incluido las características elastoplásticas que poseen muchos de los medios porosos que son utilizados en el día a día en la ingeniería. Este estudio creara un modelo de acoplamiento geomecánico que tome en cuenta las características elastoplásticas de los materiales de origen geológico usando herramientas de inteligencia artificial. Se analizara los beneficios que se pueden obtener del uso de herramientas de inteligencia artificial como lo son las Redes Neurales, la Lógica Difusa y los sistemas Neuro – Fuzzy, en la implementación de los modelos de acoplamiento. Estas técnicas intentaran optimizar las simulaciones numéricas de diversos tipos de problema de flujo bifásico en medios porosos elastoplástico, que sean de gran interés de la ingeniería.

Para la obtención de los objetivos de esta investigación se realizaran una serie de simulaciones numéricas con ayuda de un programa de modelamiento matemático, donde se simularan diversos problemas de flujo y se comparan con los datos de la literatura existente. De ser necesario se realizaran una serie de experiencias de laboratorio sobre diversos tipos de medios porosos que existan en el territorio colombiano y que brinden una serie de datos útiles tanto para las simulaciones numéricas como para los análisis de comparación de resultados. Al final de esta investigación se quiere obtener una serie de aplicaciones computacionales que tengan aplicación en el estudio de flujo que involucre suelos no saturados y rocas que se encuentren en reservorios de petróleo y gas.

Carlos SAINEA

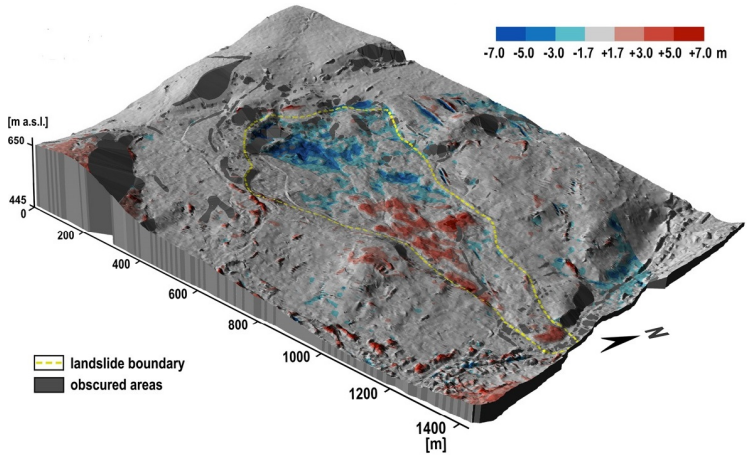
Probabilistic analysis of deep excavations in soft soils

In densely populated areas, to optimize costs and space, it is common to take advantage on subsoil by using various types of infrastructure in which deep excavations are required. In the construction of the excavations temporary support systems are installed to prevent excessive ground movement, which may cause damage to neighboring buildings and infrastructure. The analysis and design of deep excavations in soft soils supported by diaphragm walls is a complex problem due to aspects such as soil spatial variability, soft soil behavior, uncertainty in the model parameters used in the analysis, the existence of buildings or nearby structures, the support system chosen, the soil-structure interaction, the geometry of the excavation and its construction process. The theory of random fields is used to include the effects of spatial variability and uncertainty of model parameters, and a specialized modelling software, based on the Finite Element Method (FEM) is used with suitable constitutive models for materials and interfaces. From the models the ground displacements associated with the construction of the excavation are obtained and compared with damage criteria established for buildings in previous research. The above is included in performance functions andreliability analysis are made by using several available methodologies, expressing the response in terms of reliability indexes; also is proposed the updating of the reliability indexes obtained from field measurements made in the various stages of construction. The presented methodology is applied to a problem of deep excavation in soft soils in Bogota for which are compared the results of displacements and settlements obtained in the numerical analysis and in field measurements.

Nixon CORREA

Method for preparing inventories of landslides with semi-automatic procedures

Landslides are one of the main natural hazards, causing significant damage to property, life and the engineering projects in all the mountainous areas of the world. The threat by landslide and risk management, begins with the detection and mapping of the landslides – inventory - to determine its spatial and temporal occurrence; and, are the most important source of information for the zoning of the quantitative susceptibility, threat and risk by sliding. Traditionally the landslide mapping is done through interpretation photogeology from images; but this manual method is slow and requires a hard expert work;



Result of research of removed materials and accumulation in the study area, obtained by differences of Digital Elevation Models (DEMs) prepared from a time series of aerial photographs in the region of the Carpathians (Slovakia). (Prokešová, Kardoš, & Medveďová, 2010).

In addition, the high cost limits the number of sites that can be studied in detail. The automatic analysis of images of satellite of high resolution, is brought in the recent investigations, like an alternative to identify and mapping slides to local and regional scale. Nevertheless; the state of the art of the hardware of analysis of images, used for the cartography of the slides, they cannot manipulate the new levels of spatial detail given by the images of high resolution and; additionally, the only and simple method does not exist for the identification of the slides across remote sensors. Therefore, new methodologies of analysis of remote sensors have to be implemented for the slides cartography with spatial methods.

This proposal of research based on the hypotheses: a) very high resolution satellite images contain sufficient spatial detail to display geomorphological attributes of the surface and b) the digital analysis of the ground from high-resolution topographic data, have the potential to differentiate the morphological components of a landslide; It seeks to extract automatically processes of landslides and characterize them based on spectral properties and morphometric that differentiate them from the context, from the current space technology

Treatment zone slopes of volcanic ash on shale formations. Slope terracing and a planted screens anchors in Manizales - Honda, PR 20 approx.

Rodrigo HERNANDEZ

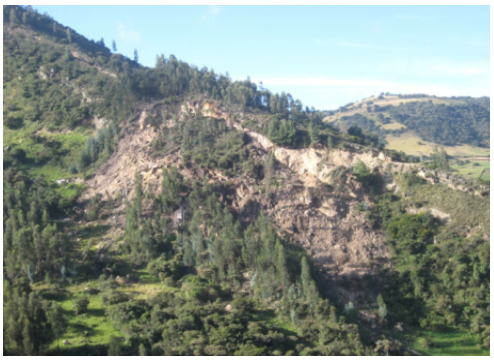
Reliability assessment of rock slopes by random discontinuous deformation analysis

One of the key issues in rock mechanics is modelling the rock mass response, since its behavior is highly influenced by rock discontinuities. Hence, modelling the rock mass as an equivalent continuum is not accu- rate in many problems, especially when relative movement of blocks is large enough to change the contact's setup, either because new contacts appear or existing ones disappear. On the other hand, in rock masses there is a high variability of both geometric and geomechanic properties. The uncertainty induced by this variability is not considered by determin- istic models developed to assess rock slope stability; therefore, reliability assessment should be considered to take the uncertainty into account. Nevertheless, this assessment requires a high number of deterministic cal- culations, which could be extremely time consuming and computationally expensive, when advanced numeric techniques are implemented. The main objective of this research is developing a realistic rock slope sta- bility reliability assessment, in order to provide reliable information during the design process. With this aim, the discrete nature of the rock mass is taken into account by modelling the rock slope stability with the dis- continuous deformation analysis (DDA) method, capable of modelling the effect of discontinuities. This method has a high computational cost and is very time consuming. In addition, reliability assessment is performed by random sets theory, which allows computing stepped envelopes of cu- mulative probability functions from discrete intervals of its corresponding inputs. This method reduces the number of times that the model has to be run under variable conditions to perform reliability assessment com- pared with well-known techniques as Monte Carlo simulation. Reliability assessment results are expected to be a useful and reliable design tool in engineering and mining projects, considering that are based on a realistic model.

a.

b.

Excavation process



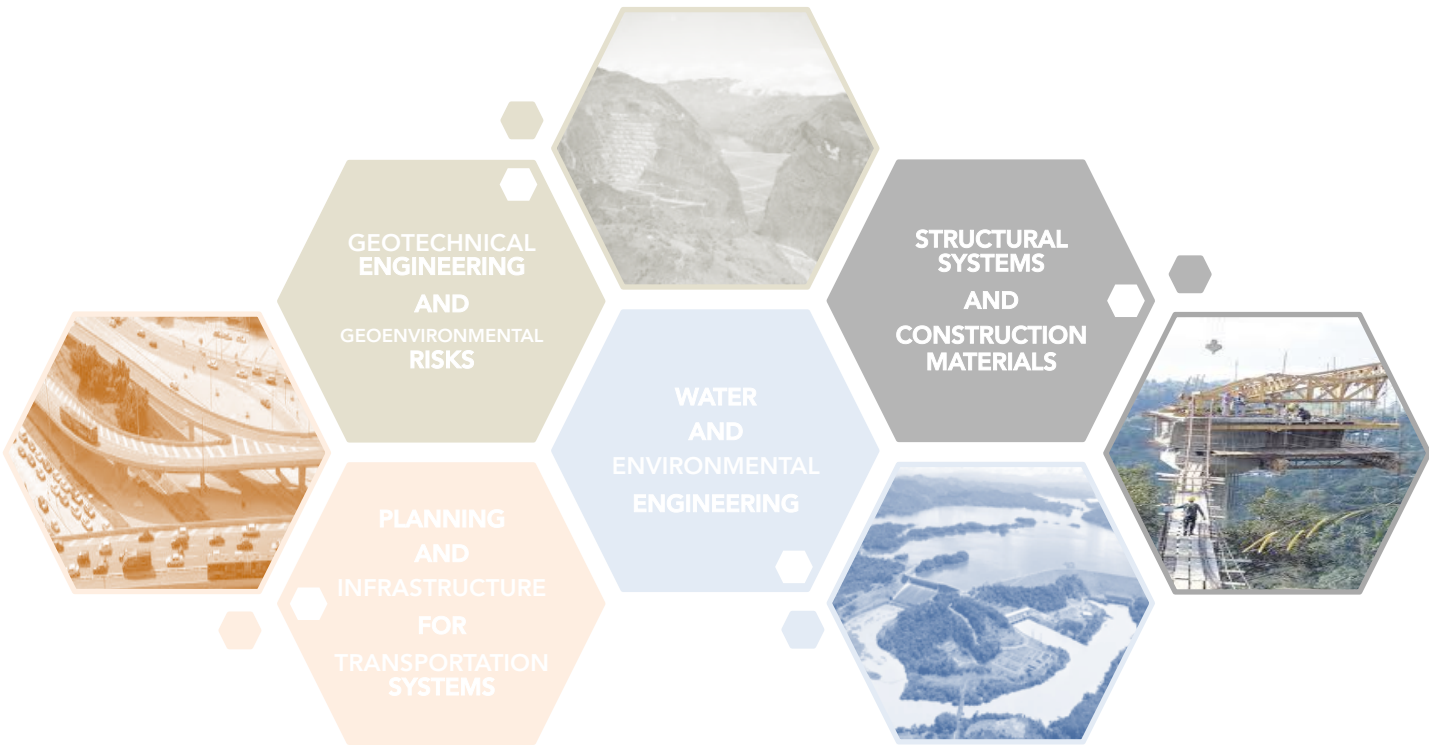
c.

d.

Rock mass features

Rock slope failure

a. Vertical joint set in a limestone mine. Duitama Boyacá. Dip direction slightly changes from one joint to the next one
b. Rock slope in a limestone mine. Duitama, Boyacá.
c. Phosphate mine. Rock slope failure due to underground tunnel excavation. Firavitova, Boyacá
d. Rock slope failure in a limestone mine, controlled by the vertical joint set. Limestone mine.



STRUCTURAL SYSTEMS AND CONSTRUCTION MATERIALS

Patricia LUNA

Mechanical behavior of a composite material with polyester matrix using Guadua angustifolia bamboo fibers as reinforcement

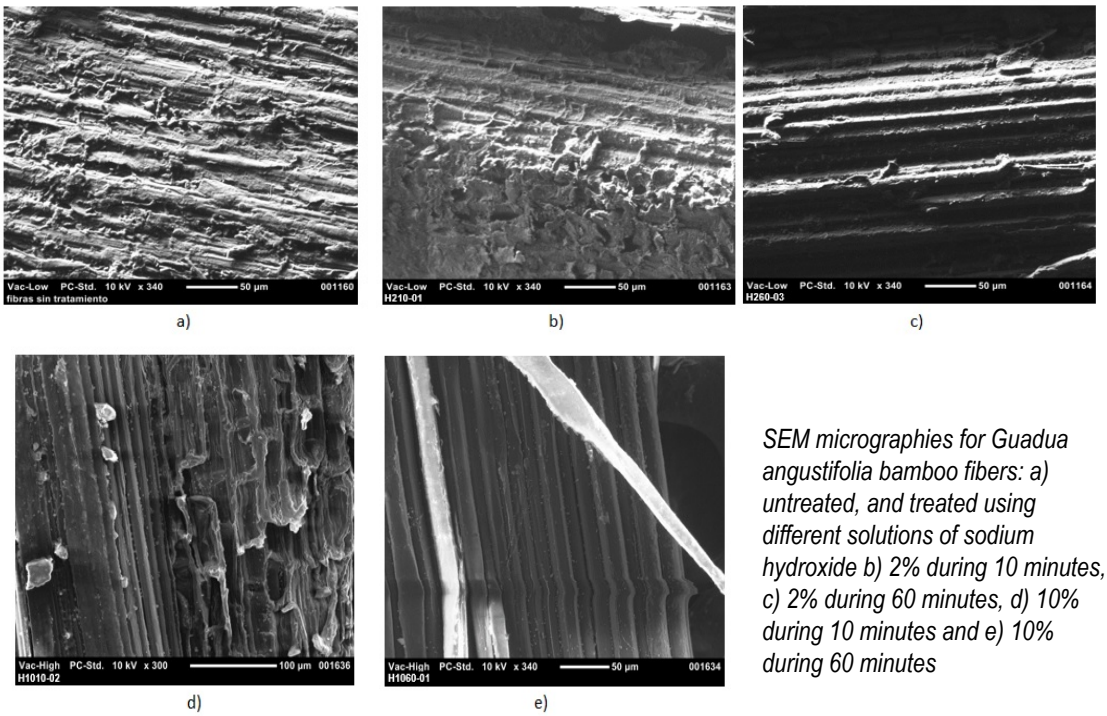
Mechanical behaviour of composites depends on the individual properties of each component; however, bonding between fibers and matrix plays a predominant role in the material performance. The interfacial region, which is considered as a zone of property gradients, determines the stress transfer between the bonded fibers and the matrix. A well establish interface linkage assures an adequate mechanical behaviour of composite materials.

The main disadvantage for using natural fibers as reinforcement of polymeric matrices is the physicochemical incompatibility between fibers and matrix. Because of the hydrophilic character of fibers and the hydrophobic character of resins, it is necessary to treat both materials in order to improve the final properties of composites, avoiding premature and delamination failures.This research pretend, from technical-scientific point of view, provide elements for industrial use of polymeric composite material using natural fibers as reinforcement. For this, will be obtained and characterized some physical, mechanical and chemical properties of *Guadua angustifolia* bamboo fibers and fiber/polyester composite. Due to fact that literature has no report about a specific methodology for bamboo fiber extraction, it is proposed to develop extraction methodology that can be used at industrial level. Two different techniques of compatibilization will be carried out: first, standard baths of sodium hydroxide as coupling agent will be applied to fibers, and second, a novel plasma treatment will be implemented for natural fibers.

It will be characterized the mechanical behavior of composite material through compression, shear, flexural, tensile and pull-out tests.

In addition, it will be established an analytical reinforcement model which describes the macromechanical behavior of composite under tensile loads. It is proposed determine the surface electrokinetic potential of extracted and treated bamboo fibers, in order to infer the bonding between fibers and matrix.

For bamboo fibers, physical properties to be determined are density, humectability, cross section area, and morphological analysis using a scanning electron microscope (SEM); for composite material are hardness, abrasion, dimensional stability for condition of pressure and temperature, and morphological analysis using a scanning electron microscope (SEM).



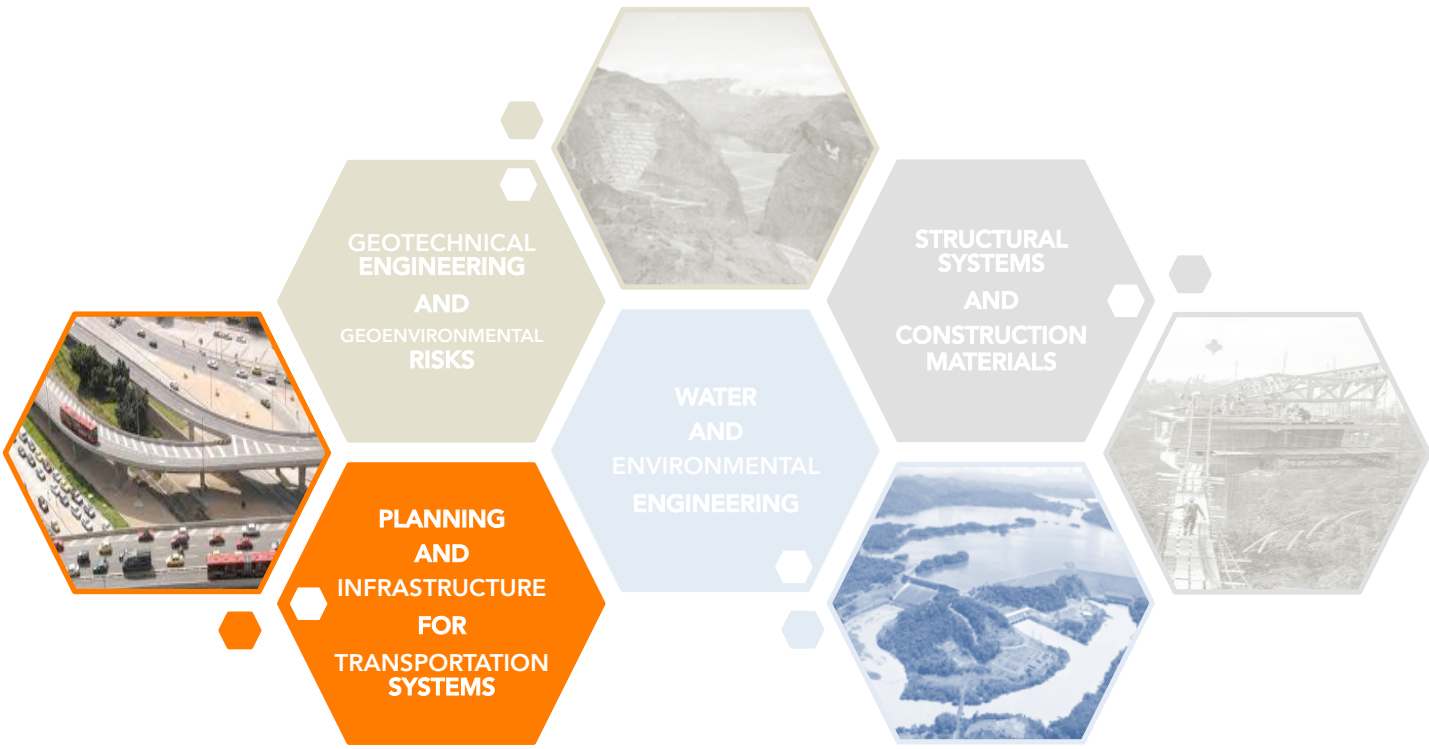
SEM micrographies for Guadua angustifolia bamboo fibers: a) untreated, and treated using different solutions of sodium hydroxide b) 2% during 10 minutes, c) 2% during 60 minutes, d) 10% during 10 minutes and e) 10% during 60 minutes

Julián PUERTO

Nanosilica effect on rheological and mechanical properties of concrete

The objective of this research is to analyze the effects generated by Nano amorphous silica on the rheological and mechanical properties of concrete having the potential to be applied in the rehabilitation of structures, studying the concrete in fresh and hardened state, and applying electro-migration and electro-deposition techniques of silica nanoparticles in concrete.

The first phase of the research is to obtain and characterize nano amorphous silica which is produced chemically in the laboratory with potential for use in fresh concrete and then evaluate the rheology. The second phase aims to develop a suitable method that can be reproduced in order to treat samples and structural elements through a process of electro-migration and electro-deposition of nano silica particles in the hardened concrete and then evaluate their mechanical and transportability properties (Electrokinetics). Finally, in the final phase, the aim is to model the transportability of a colloidal suspension of silica nano through a porous matrix of concrete.



TRANSPORTATION

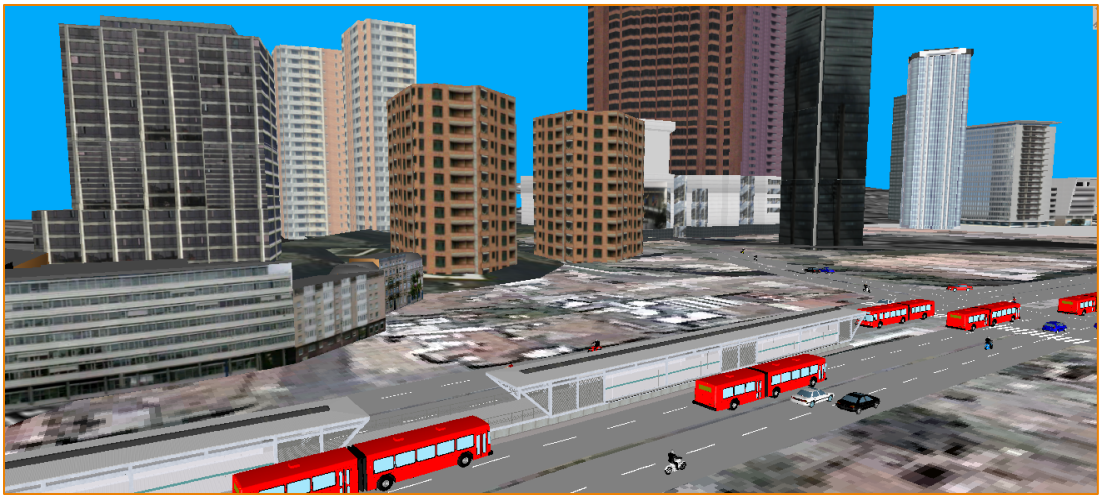
Lenin BULLA

Methodology for identification, quantification and management of road safety risk in BRT transportation systems

This thesis is part of the research line in Planning and Infrastructure for Transportation, particularly focused on road safety.

Proposed study concentrates on Bus Rapid Transit (BRT) transportation systems due to massive growth of these systems, increasing number of passengers, interaction between system's vehicles and other means of transport by using of art technology on traffic microsimulation, digital imagery processing for vehicle tracking and multivariate statistical methods. New tendencies on road safety studies focus on identification and analysis of crash surrogate events such as near-misses; those would allow observing and experimenting with the operational behavior of a road network. Furthermore, road network safety would be assessed without the occurrence of crashes, under a preventive approach. This research seeks for a correlation between the number of near-misses per unit time, surrogate safety measures, environmental and infrastructural characteristics. All of them synthesized in a risk index. Given that road safety studies must consolidate databases for improving traffic conditions, a risk index should represent the operational circumstances in the period of study. Moreover, risk index must be sensitive to engineering methods seeking improvement or modification of traffic conditions; in other words, index sensitivity needs to be validated. In this research, validation is performed by formulating countermeasures or treatments that correct or mitigate the risk factors detected. Effectiveness of those formulations can be checked by recalculating risk index for the newly proposed operation conditions. New conditions are studied using microsimulation models.

Rear-end crash between BRT vehicles in Bogotá.
Fuente: www.lafm.com.co [noviembre de 2014]



BRT corridor microsimulation model