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85 Research And Application On Earthquake Prediction And Seismic Risk Mitigation: Study Of Structure And Non-Linear Dynamics Of The Earth

BACKGROUND

The Group "Structure and Non-Linear Dynamics of the Earth" (SAND Group) is based at the Abdus Salam International Centre for Theoretical Physics (the Abdus Salam ICTP) in Trieste, Italy. The SAND Group studies were initiated in 1991 to carry out research and educational activities in Physics of the solid Earth.

OBJECTIVES

The main objectives of the group are: 1) to develop a new theoretical base and computational framework for the study of critical phenomena in the Earth's lithosphere, with special attention to their predictability, 2) to develop a new approach for seismic risk mitigation on the basis of 3-D modeling of Earth structure and earthquake sources, through the study of wave propagation in three-dimensionally heterogeneous, inelastic and anisotropic media; 3) to transfer the developed methodology to scientists of the developing countries, which is achieved through joint research, with special attention to training the potential leaders, and by combining the workshops with subsequent individual projects.

ACTIVITIES

The research activities are divided into two main lines: *Non-Linear Dynamics of the Earth's Lithosphere* (led by Prof V.I Keilis-Borok, International Institute of Earthquake Prediction Theory and Mathematical Geophysics, IIEPT, Russian Academy of Sciences, Moscow, Russia) and *Structure of the Earth with Application to Seismic and Volcanic Risk Mitigation* (led by Prof. G.F. Panza, Department of Earth Sciences, University of Trieste, DST-UNITS, Italy).

The activities within the framework of the first line are aimed at development of a theoretical base for the study of critical phenomena in the Earth's lithosphere with special attention to earthquake prediction. They include: *numerical modelling of the lithosphere dynamics* for different time scales millions of years (solving the inverse problem of mantle convection with temperature-dependent viscosity) and thousands of years (modelling of block-and-fault dynamics); *study of mathematical models of non-linear systems* and prediction of critical transitions in them: *earthquake prediction studies* development of new algorithms for short-term earthquake prediction, launching experiments aimed at earthquake prediction for specific regions.

The activities within the framework of the second line are aimed at the development of theoretical grounds for seismic and volcanic risk mitigation on the basis of 3D modelling of Earth structure and earthquake sources through the study of wave propagation in three-dimensionally heterogeneous, inelastic, and anisotropic media. They include, simulation of seismic source radiation and tsunamis induced by inland/coastal earthquakes, and studies of empirical isoseismals: calculation of synthetic seismograms in 3D laterally heteregenous media with the modal summation technique and numerical modelling of surface wave focusing effects; multiscale tomography of the Earth interior and related volcanism; and multiscale modeling of the dynamics of the continental deformation.

The methodologies are transferred to scientists of the developing countries through training of potential leaders and joint research.

ACHIEVEMENTS

- The new earthquake prediction methodology named "Reverse Detection of Precursors" (RDP), in which short-term precursors are considered in conjunction with intermediate-term ones (appearing years in advance), in the reverse order of their appearance. Successful advance predictions of the major Hokkaido earthquake (25.09.2003, M = 8.1) and the earthquake in Central California (22.12.2003, M = 6.4) have been made during the initiated test of RDP for short-term earthquake prediction.
- The prediction experiment aimed at a real-time intermediate-term middle-range earthquake prediction for the Italian region
- Application of the intermediate-term prediction algorithm CN to the zone of Mt Vesuvius for the prediction of weak earthquakes: all 7 earthquakes with $M \geq 3.2$ are

predicted with 33% of alarm time.

■A new method for solving the inverse problem of mantle convection with temperature-dependent viscosity The method has been applied to reconstruct a model of upper mantle plumes.

■The methodology for modelling of block structure dynamics and seismicity. It has been applied to Vrancea (Romania) and Italian regions

■Realistic modelling of the seismic input as a pre-disaster orientation. The methodology has been applied in several countries and principal megacities worldwide.

■A program code that generates a realistic approximation to a wideband source function of an earthquake and input for subsequent Green's function calculation. It can be used as a component of a package capable for the assessment of ground motion and seismic hazard.

■ The representation (for the tsunami synthesis) theorem for an incompressible liquid layer with a boundary of arbitrary shape and in a homogeneous gravity field It shows that not only offshore, but also inland earthquakes in the vicinity of the coastline may generate tsunamis

■The analysis of macroseismic data with the purpose to explain the shape of empirical isoseismals in terms of the velocity structure and the source geometry of an earthquake

■Numerical modelling for surface wave focusing effects using the recent global tomographic maps for the fundamental Rayleigh mode (60 to 150 sec).

■Set up of a methodology for the retrieval of the 3D structure of the Earth's interior, through multiscale surface wave tomography and non-linear inversion, from the scale of an individual earthquake fault zone or volcano to the scale of the deforming plates The methodology has been applied to the Mediterranean, Scotia Region (Antarctica) and Caribbean.

■Dynamic modeling of the deformation either induced by viscoelastic relaxation in the crust, at the scale of the fault zone, or by buoyancy forces, at the scale of the plate boundary

■Study of the genesis of the recent volcanism, integrating geophysical, petrological and geochemical data, and investigation of possible interactions between different volcanic edifices and assessment of the volcanic risk.

In 1991-2003 seven workshops on non-linear dynamics and earthquake prediction and six workshops on 3D modeling of seismic waves generation, propagation and their inversion have been organized at the Abdus Salam ICTP. These series of the workshops will be continued in future as well as the researches listed above.

LESSONS

The major lesson is the realistic modelling of the earthquake hazard as a pre-disaster measure The main challenge is to bridge physics and statistics of the earthquake prediction to establish reliable scenarios

FUTURE

■Promote closer interactions between the seismological and the engineering communities,

■Integrate fundamental earthquake research and earth observation technology.

CONTACT DETAILS

Prof. G.F. Panza. SAND Group

The Abdus Salam ICTP.
Strada Costiera 11, 34014 Trieste, Italy

Tel: +39-040-5582117
Fax: +39-040-5582111,+39-040-575519
panza@dst.units.it

86 Experimental Research And Its Field Application: Liquefaction Of Soils With Silt And Clay Particles

BACKGROUND

The liquefaction of soils has resulted in severe damage and disaster during several earthquakes (such as Niigata, Japan). Assessment of liquefaction potential at a site is the first step in adopting appropriate design procedures for preventing liquefaction associated damage. The phenomenon of liquefaction has been extensively studied for the case of cohesion-less soils under seismic loading conditions The state of the art on liquefaction behavior of cohesion-less soils has progressed to a stage that reasonable estimates of liquefaction potential can be made based on laboratory investigations or on simple in-situ test data such as standard penetration values or cone penetration data and the experience during the past earthquakes Fine-grained soils such as silts and clays and even sands with fines did not receive the same attention and they were even regarded as not likely to liquefy The observations following Haicheng (1975) and Tangshan(1976) earthquakes resulted in several investigations on liquefaction of sands with fines, silts and silt-clay mixtures .

OBJECTIVES

The main objective of this program was to make a detailed investigation of the liquefaction behavior of fine-grained soils such as silts and silt clay mixtures under seismic loading. This information is expected to help in creating awareness about realistic behavior of such soils in seismic areas and eventually lead to disaster reduction by including remedial measures at the design stage.

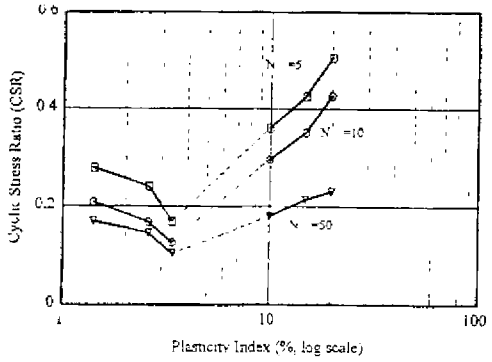
ACTIVITIES

The activities included collecting available information on liquefaction susceptibility of sands, sand-silt mixtures and silt-clay mixtures Based on this information a laboratory test program was developed. Cyclic tri-axial tests were conducted on samples of silts with clay as fine fraction. Both undisturbed and reconstituted samples were tested The behavior of samples of silts and silt-clay mixtures subjected to cyclic loads was compared with that of sands with regard to (i) development of pore water pressures with number of load cycles and (ii) rate of deformation or axial strain with number of number of load cycles The effect of soil's plasticity on liquefaction susceptibility was also investigated over a wide range PI (plasticity index) values from 1 to 10

ACHIEVEMENTS

The results of this study made several contributions in understanding the liquefaction behavior of fine-grained soils Some of the significant findings are given below:

- The test results indicate that the pore water pressure buildup and deformation in silt-clay mixtures under cyclic loading are remarkably different from that for sands.
- The increase of the PI decreases the liquefaction resistance of silt-clay mixtures in the low range of plasticity In the high plasticity range, the liquefaction resistance increases with an increasing PI.
- The soils with low plasticity (PI < 7) may be as prone to liquefaction as sands each situation needs investigation



LESSONS

One the lessons learnt from this study is that the assumption of fine-grained soils as being non liquefiable may lead to unsafe situations Also, the usual criteria for liquefaction as used in case of sands may not be applicable to silts and silt - clay mixtures as the behavior of hese soils under cyclic loads is different from sands. both with respect to build of pressures and strain development. Also, no acceptable guidelines

are presently available for liquefaction assessment for silts and silt-clay mixtures, each case needs careful evaluation using experimental and analytical techniques

FUTURE

- There is need developing acceptable criteria for liquefaction of fine-grained soils.
- The effect soil fabric, aging on liquefaction of fine grained soils also needs investigation .
- The nature of pore fluid can also alter the plasticity of clays and its effect on liquefaction of such type of soils should be investigated.

CONTACT DETAILS

Dr Shamsher Prakash
Professor Emeritus
Dept. Civil Engineering
University of Missouri
Rolla, 65401
praksh@umr.edu

Vijay K. Puri
Professor
Civil and Environmental Engineering
Southern Illinois University
Carbondale, IL 62901
puri@engr.siu.edu

87 Case Study Of Global Blueprints For Change

BACKGROUND

The Global Blueprints for Change are documents produced by teams of world class professionals with a goal of integrating knowledge and best practices into consensus, authoritative "works in progress." Because they are a relatively new to the world's professionals, they have yet to reach their full potential and usage as tools to facilitate education for sustainable development. The ongoing activity to create and implement Blueprints for Change began in 2001 under the leadership of the Global Alliance for Disaster Reduction, a NGO comprised of over 1,000 professionals working in the field of disaster reduction in 70 countries and the seven geographic regions of the world. Thirty-five percent of GADR's members are "Blueprinters." Since 2001, they have produced Blueprints for Change on six themes and forty-two topics on natural and technological hazards. With a balanced consideration of the social, technical, administrative, political, legal, and economic (STAPLE) factors, the root causes of flaws in public policy, the Blueprints have the potential for opening new windows of opportunity for changing the culture of disaster reduction from one of reaction to one of anticipation.

OBJECTIVES

The goal of the Global Blueprints for Change is to facilitate building a culture of disaster resilience through innovative usage of formal and informal educational processes, including training. The objective is to overcome the universal barriers of ignorance, apathy, disciplinary boundaries, and lack of political will in every community and to transform ignorance into enlightenment, apathy into empowerment, disciplinary boundaries into seamless programs that accelerate technical and political capacity building on community, national, and regional scales, and lack of ;political will into political enablement

ACTIVITIES

Blueprints for Change, such as those listed below in the next section, have been under development since 2001 for use by professionals to form a sound technical and political basis for new and expanded programs and thousands of new projects on a community scale The goal is to equip professionals in every nation and to engage them in disaster reduction programs that will: 1) close gaps in knowledge, understanding, and implementation of best practices, and 2) significantly increase disaster resilience in every community by2015

ACHIEVEMENTS

The Blueprints for Change have been developed under six broad themes that address urgent needs of communities in every nation of every geographic region. They are:

- **Theme A: Living With Natural and Technological Hazards.** These Blueprints provide guidance that will assist communities throughout the world in becoming resilient over time to the threats posed by the disaster agents generated by droughts, floods, severe windstorms, volcanic eruptions, landslides, tsunamis, and wildfires and related technological hazards The focus is on long-term, coordinated anticipatory planning and collaborative actions by community stakeholders and policy makers
- **Theme B: Building to Withstand the Disaster Agents of Natural and Technological Hazards.** These Blueprints provide guidance that will assist communities throughout the world in making their built environments disaster resilient. The focus is on improving hazard assessments and professional practices of sitting, designing, and construction of the built environment so that all elements are resilient to the disaster agents of natural and related hazards.
- **Theme C: Learning From Natural and Technological Disasters.** These Blueprints provide guidance that will assist communities throughout the world to acquire valuable new knowledge and to take ownership of important lessons from disasters. The focus is on using disasters as a laboratory and applying new insights gained from them in public policies and programs that benefit the community.
- **Theme D: Implementation.** These Blueprints provide guidance that will assist communities in the implementation of new

and/or improved public policies and professional practices to reduce physical, enterprise, and social vulnerabilities in their community The focus is on initiating and sustaining ongoing multi-faceted processes of adaptation in the community that will over time make it disaster resilient.

■**Theme E: Education.** These Blueprints provide guidance for improving knowledge management and education on community, national, and regional scales. The focus is on building a culture of disaster resilience on community, national, and regional scales.

■**Theme F: Technology.** These Blueprints provide guidance for transferring ownership of new and emerging technologies for disaster reduction to those who need them

LESSONS

Creating a culture of disaster resilience is urgently needed, because millions of people and their livelihoods and communities are threatened in every geographic region. Natural and related disasters are robbing every nation of scarce resources that could be better used for improving infrastructure, education, and the quality of live. World leaders in every element of disaster reduction (education, science, engineering, medicine, technology, international development and relief agencies, insurers, and policy makers) recognize the need to work together and take coordinated actions as quickly as possible to reduce potential losses on community, national, regional, and global scales. People in many communities (e g , megacities) have already become trapped into living with overwhelming unacceptable risk to themselves, their livelihood, and their community infrastructure. Without concerted actions to become disaster resilient, they face almost certain death, injuries, economic losses, environmental impacts, and loss of homes, jobs, and community infrastructure

Blueprints for Change that have been tailored for specific community usages, increase the capacity of professionals to contribute more vigorously and effectively to specific disaster reduction activities New Blueprints for Change are urgently needed now in communities of developing nations to increase public awareness of hazards, vulnerability, and risk, and to expand technical and political capacity for disaster resilience in every community.

SUGGESTIONS

The Decade on Education for Sustainable Development (2005-2014, and beyond), provides an unprecedented opportunity to realize the full potential of the Blueprints for Change This decade is the best time ever for enlisting, equipping, and engaging young and emerging professionals and linking them with mature professionals to engage in a concerted and sustained effort in every community to move towards effective disaster reduction and enhanced human security.

CONTACT DETAILS

Dr. Walter Hays

Executive Director, Global Alliance for Disaster Reduction
238 CARC Building, University of North Carolina at Charlotte, Charlotte, NC 28223

704 678-3520
walter_hays@msn.com