



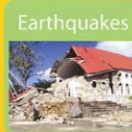
**THE UNIVERSITY  
OF THE  
WEST INDIES**

In collaboration with the Secretariat of



# Global Earthquake Model **CARIBBEAN REGIONAL PROGRAMME WORKSHOP**

KAPOK HOTEL, PORT OF SPAIN,  
TRINIDAD & TOBAGO, WEST INDIES  
2 - 4 MAY, 2011



SEISMIC RESEARCH CENTRE

**PROGRAMME & BOOK OF ABSTRACTS**



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# PREFACE

## Dear Participants,

Welcome to this Special Three-Day Regional Workshop to formally launch GEM in the Caribbean!

GEM was launched with assistance from the Organisation for Economic Cooperation and Development (OECD) at the beginning of 2009 and is a global collaborative effort that brings together state-of-the-art science, national, regional and international organisations and individuals aimed at the establishment of uniform and open standards for calculating and communicating earthquake risk worldwide. The development of Regional Programmes (RPs) is the main mechanism through which the GEM tools will be transferred with a view to creating a uniform globally used standard. The RPs involve local experts using GEM software and tools, who generate local data and validate the data and standards that are being created on the global level. Further details can be found at [www.globalquakemodel.org](http://www.globalquakemodel.org).

The Institution of Structural Engineers (Caribbean Division) hosted a presentation of the GEM project at the Normandie Hotel in Trinidad on 15 October, 2010. Presenters included Anthony Farrell and Tony Gibbs of IStructE (Caribbean) and Dr. Richard Robertson, Director of the Seismic Research Centre, UWI. The wide-ranging audience of about 60 persons included mainly engineers, architects and insurance personnel from Trinidad, Barbados and Guyana.

In January 2011, the **GEM Foundation** (hereinafter referred to as GEM) engaged **The Seismic Research Centre (SRC) of The University of the West Indies**, to promote the GEM vision in the Caribbean. In March 2011 I was appointed GEM Operational Manager and I hope to collaborate with all players/stakeholders from the Caribbean community like yourselves, to spearhead the implementation of the GEM initiative in the Insular Caribbean and the effective functioning of the GEM Caribbean Regional Programme.

This special 3-day Workshop will launch the GEM Caribbean Regional Programme. You, along with the other important players/stakeholders in the region, will be introduced to the GEM goals and discussions will be held to establish a strategy for achieving those goals within the context of the Caribbean Region. It is also hoped that gaps in existing knowledge in the Caribbean Region in respect of earthquake hazard, vulnerability and earthquake risk can be identified and the necessary research prioritized in order to make full use of the GEM software and tools in the Caribbean Region.

Without the co-operation and financial support of many firms, organizations and individuals, this Special Three-Day Workshop would not have been possible and the Organising Committee wishes to place on record their most sincere thanks and appreciation for such kind and generous support.



In closing, I would like, on behalf of the Seismic Research Centre and GEM, to thank you most kindly for attending this important endeavour, which will undoubtedly help in reducing the human and economic losses from severe earthquakes such as the one that struck Haiti on 12 January, 2010 and Japan on 11 March, 2011 throughout the Caribbean.

We look forward to your active participation in this very important initiative so that it may prove to be a resounding success.

Sincerely

Myron W. Chin, PhD, CEng, FStructE, FICE, FAPETT  
Chair, Organising Committee and  
GEM Operational Manager for the Caribbean  
Seismic Research Centre, UWI, St. Augustine, TRINIDAD



# WORKSHOP ORGANISING COMMITTEE

Myron W. Chin – Chair

Richard Robertson

Joan Latchman

Lloyd Lynch

Walter Salazar

Stacey Edwards

Patricia Joseph

Monique Johnson

Clevon Ash

Tony Gibbs

Richard Clarke

Rui Pinho

Marco Pagani

Helen Crowley

Nicole Keller

Please note that all information in this publication was correct at the time of printing. Any abstract included in this publication and/or opinions expressed therein do not necessarily reflect the views of the UWI Seismic Research Centre (SRC) but remain solely those of the authors.



# WORKSHOP PROGRAMME

## THREE-DAY REGIONAL WORKSHOP TO LAUNCH GEM CARIBBEAN REGIONAL PROGRAMME

KAPOK HOTEL, PORT OF SPAIN, TRINIDAD  
2<sup>ND</sup> TO 4<sup>TH</sup> MAY 2011

### MONDAY 2<sup>ND</sup> MAY 2011

08.00 – 8.30	<b>Registration at Conference Centre - Kapok Hotel</b>	
08.30 – 09.15	<b><u>OPENING CEREMONY</u></b>  *****SEE SEPARATE PROGRAMME*****	
9.15 – 09.45	<b>COFFEE BREAK</b>	
09.45 – 10.30	<b><u>TECHNICAL SESSION 1</u></b>  Introduction to GEM and Regional Programmes	<b>Chair</b> <b>Dr. Richard Robertson</b>  Rui Pinho Secretary General
10.30 – 12.00	<b><u>TECHNICAL SESSION 2</u></b>  Status of Hazard and Risk Activities in GEM (Global Components, OpenQuake, Modeller's Toolkit)	<b>Chair</b> <b>Dr. Richard Robertson</b>  Marco Pagani Helen Crowley
12.00 – 13.30	<b>LUNCH</b>	
13.30 – 15.00	<b><u>TECHNICAL SESSION 3</u></b> - <b>Seismic Hazard Assessment I</b>  Potential Earthquake Risk Reduction Opportunities for GEM Caribbean Programme  Presentations by Representatives from the Caribbean on "The Status of Seismic Hazard Models"	<b>Chair</b> <b>Dr. Joan Latchman</b>  Lloyd Lynch

	Development of Seismic Hazard Maps for; - Eastern Caribbean  - Hispaniola	Walter Salazar Elisa Zuccolo Julio Garcia
15.00 – 15.30	<i>Q&amp;A Discussion</i>	
15.30 – 17.30	<b>COFFEE BREAK</b>  <b><u>TECHNICAL SESSION 4</u></b> - <b>Seismic Hazard Assessment II</b>	<b>Chair</b> <b>Mr. Lloyd Lynch</b>
	Development of Seismic Hazard Maps for; - Jamaica - Cuba - Central America - Venezuela	Lyndon Brown Julio Garcia Alvaro Climent Victor Cano
17:40 – 18:00	<i>Q&amp;A Discussion</i>	
18:15	<b>PARTICIPANT GROUP PHOTO</b>	
19.00 – 21.00	<b>DEPART HOTEL FOR COCKTAIL RECEPTION</b>  <b>COCKTAIL RECEPTION – OFFICE OF THE CAMPUS PRINCIPAL</b>	

08.30- 10.00	<p><b><u>TECHNICAL SESSION 5</u></b>  <b>- Regional Seismic Source Model</b></p> <p>Global Earthquake History - Global Component  <i>Q&amp;A Discussion</i></p> <p>Global Instrumental Catalogue - Global Component  <i>Q&amp;A Discussion</i></p> <p>Global Strain Rate  <i>Q&amp;A Discussion</i></p>	<p><b>Chair</b>  <b>Dr. Marco Pagani</b></p> <p>Marco Pagani</p>
10.00 – 10.30	<p><b>COFFEE BREAK</b></p>	
10.30 – 11.30	<p><b><u>TECHNICAL SESSION 6</u></b>  <b>- Regional Ground Motion Model</b></p> <p>The Faulted Earth - Global Component  <i>Q&amp;A Discussion</i></p> <p>Global GMPEs - Global Component  <i>Q&amp;A Discussion</i></p> <p>Assessment of Applicability of Existing GMPEs for the Caribbean  <i>Q&amp;A Discussion</i></p> <p><i>Discussions about data availability in view of Caribbean shared regional datasets creation, and the possible relations and collaborations with the GEM Global Components.</i></p>	<p><b>Chair</b>  <b>Dr. Marco Pagani</b></p> <p>Marco Pagani</p> <p>Derek Gay</p>
11.30 – 12.00	<p><b><i>Final discussions on Regional Hazard Activities</i></b></p>	
12.00 – 13.30	<p><b>LUNCH</b></p>	
13.30 – 15.00	<p><b><u>TECHNICAL SESSION 7</u></b>  <b>- Design Considerations and Building Codes</b></p> <p>Structural Vulnerability</p> <p>A Review of CROSQ – Caribbean Building Code Project</p>	<p><b>Chair</b>  <b>Dr. Myron W. Chin</b></p> <p>Richard Clarke</p> <p>Darryl Thomson &amp; Errol Rampaul</p>

	The Status of Building Codes in Cuba and other Spanish speaking countries in the Caribbean	Carlos Llanes Buron
	The status of earthquake provisions for Jamaica	Wayne Adams
15.00 – 15.30	<b>COFFEE BREAK</b>	
15.30 – 17.00	<b><i>TECHNICAL SESSION 8</i></b> - <b>Status of Risk Activities</b>	<b>Chair</b> <b>Dr. Richard Clarke</b>
	Disaster Risk Reduction Centre Risk Atlas Project	Walter Salazar
	World Bank Risk Management Projects in the Caribbean - Multi Hazard Risk Modeling Work in the Eastern Caribbean	Sahar Safaie
	Presentations by Representatives from the Caribbean on <i>"The Status of Seismic Risk"</i>	

08.30 – 10.00	<p><b><u>TECHNICAL SESSION 9</u></b>  - <b>Regional Vulnerability &amp; Building Inventory</b></p> <p>Presentation of global datasets</p> <p><i>Discussion and contributions on available regional data related to vulnerability functions and building inventory.</i></p> <p>Status &amp; Challenges of Spatial Information in the Caribbean</p> <p>Building and Managing Spatial Databases of Built Assets in Support of Earthquake Risk Assessment in the Caribbean: Opportunities and Challenges</p>	<p><b>Chair</b>  <b>Dr. Helen Crowley</b></p> <p>Helen Crowley</p> <p>Rafi Ahmad</p> <p>Jacob Opadeyi</p>
10.00 – 10.30	<p><b>COFFEE BREAK</b></p>	
10.30 – 12.00	<p><b><u>TECHNICAL SESSION 10</u></b>  - <b>Panel Discussion - Architecture and the Safety and Vulnerability of Buildings in Earthquake Zones</b></p>	<p><b>Chair</b>  <b>Mr. Tony Gibbs</b></p> <p>Jenifer Smith  Robert Woodstock  Gary Turton</p>
12.00 – 12.15	<p>Remarks by Secretary-General of GEM</p>	<p>Rui Pinho</p>
12.15 – 13.30	<p><b>LUNCH</b></p>	
13.30 – 15.00	<p><b><u>TECHNICAL SESSION 11</u></b>  - <b>Panel Discussion with All Session Chairs as Panelists</b></p> <p>Identification of Action Items</p> <p>Establishment of a Regional Working Groups for;</p> <ul style="list-style-type: none"> <li>- Hazard and Hazard Coordinators for Seismic Source Model and Ground Motion Model</li> <li>- Risk and Risk Coordinators for Vulnerability and Building Inventory</li> </ul> <p>Drafting of project proposal for funding agency</p>	<p>All Panelists</p>
15.00 – 15.30	<p><b>Closing Ceremony - Closing Remarks</b></p>	<p>(TBA)</p>
15.30 – 16.00	<p>Refreshments</p>	



# ABSTRACTS OF TECHNICAL PRESENTATIONS (IN ORDER OF PRESENTATION)





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## **STATUS OF HAZARD AND RISK ACTIVITIES IN GEM (GLOBAL COMPONENTS, OPENQUAKE, MODELLER'S TOOLKIT)**

**BY**

**MARCO PAGANI, HELEN CROWLEY  
GEM EXECUTIVE COMMITTEE**

The Global Earthquake Model (GEM) initiative aims to develop a global model of earthquake risk as an open source, community-driven project. In order to begin this in a structured way, a number of Global Components that cover the scientific modules of the model have been defined, and Requests for Proposals have been released, requesting international consortia to bid to lead these projects. This presentation will outline a summary of the status of the 10 ongoing global components (5 in hazard and 5 in risk).

GEM has set up a Model Facility (MF) whose mandate is to undertake the development of the OpenGEM platform (and its underlying OpenQuake software) that will integrate hazard, risk, and socio-economic impact assessment tools and data. OpenGEM will provide these to the community, and will enable and support all modelling developments related to the mission of GEM. A first sandbox version (v0.2) of the software that will power OpenGEM – OpenQuake – was released in January 2011 through an open source development platform (GitHub), allowing for further development of the engine (and in a later stage other software features) by a community of developers and experts. An introduction to OpenQuake and its current and soon to be implemented features will be provided.

The Modeller's Toolkit (MTK) is a second critical component of OpenGEM that will aid users in building models to input into OpenQuake. The current focus of the MTK is on the development of PSHA input models, and will allow users to visualize and process data from:

- \* Earthquake catalogues
- \* Active faults
- \* Strain Rates

The tool is also intended to provide the user with some basic GIS tools. With the above capabilities – for example - the user should be able to make a selection of a region containing earthquake activity (from the earthquake catalogue) and fault sources (observations) and, selecting from a list of pre-coded algorithms, generate (in a logic-tree format) PSHA input models.



## **POTENTIAL EARTHQUAKE RISK REDUCTION OPPORTUNITIES FOR GEM CARIBBEAN PROGRAM**

**BY  
LLOYD L. LYNCH**

The Latin America and Caribbean Seismic Hazard Project (1988-1993) was undoubtedly a major step in the ongoing effort to improve earthquake safety in the Caribbean region. Improved and updated earthquake databases, regional PGV and PGA hazard maps, and software to manipulate seismic instrumental catalogue and carry out hazard computations were among the primary products generated by the project. Investigations were conducted by engineers and scientists attached to or associated with national and regional institutions from South America, Caribbean, Central America and Mexico. Results were presented at several workshops which facilitated a high level of peer to peer interaction among the participants. The project not only advanced the state of knowledge in the hazard potential of earthquake source regions in the Caribbean but also provided important benchmarks on the progress made to date.

Another useful outcome of the project was the recommendation of specific measures deemed necessary to extend the accomplishments of the project, to improve future hazard assessments as well as measures to facilitate use of the hazard assessment products by a much wider community of professionals. Since the completion of the project the level of success in implementing these recommendations has been measured and variable in the Caribbean region. However, in the same period a steady migration away from response oriented approach to disaster management was witnessed with adoption of the CDM strategy and more recently HFA guidelines. This move, along with a series of global and regional misfortunes have provided impetus for bolstering monitoring networks, early warning systems, capacity in disaster management institutions and education and outreach programs in the region.

Notwithstanding the above accomplishments, there still remain a lot to be done to harness the rising trend of earthquake risk in the region. Individually, Caribbean nations lack capacity to develop and sustain an effective framework necessary to provide reasonable levels of earthquake safety. There is urgent need for a regional earthquake safety program and improved collaboration in both research and practice. The Global Earthquake Model (GEM) which seeks to provide an authoritative standard for calculating and communicating earthquake hazard and risk has the potential to stimulate collaboration and activate Caribbean professionals towards raising risk awareness and promoting cost effective mitigation actions.

This submission seeks to review some of the key developments in earthquake safety across the Caribbean over the last two decades. It highlights current and future challenges that the GEM Caribbean program will need to overcome to make a positive impact on reducing earthquake risk in the region.





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## **PSHA AT THE EASTERN CARIBBEAN ISLANDS**

**BY**

**ELISA ZUCCOLO AND WALTER SALAZAR**

### **Purpose**

The scope of this work was to perform a state-of-the-art probabilistic seismic hazard analysis aimed at producing probabilistic seismic hazard maps and Uniform Hazard Spectra for the Eastern Caribbean region, which includes the islands from Anguilla to Trinidad and Tobago.

### **Methodology**

The analysis has been conducted using a standard logic tree approach which allowed taking into account the epistemic uncertainty and its influence on the computed ground motion parameters. Two different computation methodologies have been adopted: the standard Cornell-McGuire approach based on the definition of appropriate seismogenic zones and the zone-free approach developed by Woo, which overcomes the ambiguities related with the definition of seismic sources.

### **Findings**

The study has shown that the Eastern Caribbean islands are exposed to a medium-high seismic hazard. The horizontal PGA expected on rock for 475 years return period ranges between 0.208g and 0.382g. The Leeward Islands are turned out to be characterized by higher seismicity than the Windward Islands. Moreover, the hazard is found out to be dominated by the deep seismicity of intraplate zones.

### **Practical implications**

Spectral accelerations at 0.2s and 1.0s for 2475 years return period have been calculated to allow the definition of seismic hazard in the region of study according to IBC. The good agreement found between the computed hazard spectra and the spectra adopted by IBC makes this study useful for seismic code purposes and seismic design of structures in the Eastern Caribbean region.



## **SEISMIC HAZARD ASSESSMENT FOR CUBA AND SURROUNDING REGION**

**By  
JULIO GARCIA**

This presentation provides an overview of the seismic hazard studies conducted in the past for the Cuban territories and the surrounding areas (Hispaniola, Jamaica and Cayman Islands). The evolution of seismic hazard estimations from a non-zoning approach based on felt historical intensities to a full probabilistic seismic zoning of Cuba using a classification procedure with logical - combinational algorithms is shown. The experiences accumulated through years and the main results obtained for the entire region are discussed. At the end, details about what we are doing at present time, and our ideas to improve the seismic hazard estimations in the future are given.

**Keywords** – seismic hazard, seismic zoning, Cuba





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## DEVELOPMENT OF A SEISMIC HAZARD MAP FOR JAMAICA

By

LYNDON BROWN

Previous works assessing Jamaica's seismic vulnerability have used historic catalogues as a means of developing seismic probabilistic models. The first probabilistic ground motion models for the Kingston area were proposed by Shepherd (1971) and Shepherd and Aspinall (1980) using macroseismic data from the Tomblin and Robson (1977) catalog. Intensity observations were converted to acceleration by Shepherd and Aspinall (1980) using the Gutenberg and Richter (1954) relationship. Further work by Wiggins-Grandison and Reid (1993) review the development of earthquake ground motion models for Jamaica and the Kingston Metropolitan area during the last 40 years with uniform seismic moment magnitude values which provided Peak Ground Acceleration (PGA) of approximately 30%g in eastern Jamaica and a gradual decrease to less than 14% g in western Jamaica for hard rock sites with a 10% probability of exceedence in 50 years. The values for the Kingston Metropolitan area are approximately 28% g. Further probabilistic assessment using macro seismic data and additional geophysical data by Wiggins-Grandison (2007) proposed an update of the seismic codes for the proposed Jamaica building code. More recent probabilistic assessment in Jamaica (Brown & Williams, 2010) after the Haiti 2010 event assesses ground acceleration along a hypothetical event with epicentre along the Plantain Garden Fault in St. Thomas. From these work the site specific geological and geophysical properties were assumed for attenuation relationships. A more detail study is required to obtain site specific properties that can help to improve resolution of attenuation model.

**Keywords:** Probabilistic PGA, Kingston, Jamaica



## **NEW SEISMIC HAZARD IN CENTRAL AMERICA (2008)**

**By**

**BENITO, B., LINDHOLM, C., CAMACHO, E., CLIMENT, A., MARROQUIN, G., MOLINA, E.,  
ROJAS, W., TALAVERA, E., ESCOBAR, J.J., ALVARADO, G.**

A new evaluation of seismic hazard in Central America has been carried out, as part of the cooperation project RESIS II, under the auspices of the Norway Cooperation Agency (NORAD). Seismic hazard experts from Costa Rica, Guatemala, Nicaragua, El Salvador, Panama, Honduras, Norway and Spain participated in the study, which was aimed at obtaining results suitable for seismic design purposes. The analysis started with an exhaustive revision of the national seismic catalogues of each country from which a catalogue for CA has been configured and homogenised at moment magnitude,  $M_w$ . Seismotectonic models proposed for the region were revised and a new regional zonation was proposed, taking into account seismotectonic data, seismicity, focal mechanisms, GPS observations and other evidences useful for defining seismic sources. In parallel, attenuation models for subduction and volcanic crustal zones were revised and the more suitable models were calibrated with Central America strong motion data. Then, a seismic hazard analysis was developed in terms of peak ground acceleration, PGA and spectral accelerations  $SA(T)$  for periods of 0.1, 0.5, 1 and 2 s, through the PSHA methodology (Probabilistic Seismic Hazard Assessment). As a result, different hazard maps were obtained for the quoted parameters, together with Uniform Hazard Spectra (UHS) for the capital cities of Central America. This is the first study developed at regional scale after 10 years. This new generation of hazard maps will be useful for the improvement of the national seismic codes.





# **DEVELOPMENT OF SEISMIC HAZARD AND MICROZONIFICATION MAP IN VENEZUELA**

**By  
VÍCTOR H. CANO P.**

This paper objective is to show Venezuela strengths in research on seismic risk, with emphasis in Microzonification studies.

## **1. Methodology**

The national seismological network in Venezuela has 35 BB Seismic Stations equipped with Guralp sensor and digitizer, additional to 40 short period seismic stations grouped in 5 local networks. These networks provide information on seismic events and data for seismic hazard analysis. Currently have the seismic hazard map national valid from 2001, also carried seismic microzonification projects in major cities of Venezuela.

Seismic hazard map for building code, show designs spectra vary only due to soil classifications for the upper 50 m, but no consideration of basin effects. The microzonification search details of the seismic hazard in the main cities look while it considers those local soils, to have basic information for integrated urban development plans.

## **2. Findings**

The results to date are the microzonification of the city of Caracas and in the process cities: Barquisimeto, Valencia, Maracay, Barcelona, Cumana, Puerto La Cruz, Merida, etc.

## **3. Results**

In existing buildings using in parametric evaluation of vulnerability of buildings considering age and number of stories; need for study on the distribution of buildings regarding the respective microzones and definition of priorities for reinforcement studies and political guidelines for their implementation. For new buildings; application of response spectra for each microzone and training of engineers; supervision mechanisms; definition of methodological standards for other cities.

**Keywords** - Seismic, Hazard, Microzones, Seismological network, Strong motion network.



## **REGIONAL SEISMIC SOURCE MODEL PRESENTATION OF GLOBAL DATASETS**

**By  
MARCO PAGANI**

Five Global Components are currently activated by GEM in the hazard sector with the following objectives:

- Global Instrumental Catalogue: to create a homogenised catalogue of events instrumentally detected;
- Global Earthquake History: to produce a catalogue of earthquakes that have occurred in historical times;
- Geodetic Strain Rate Model: to calculate a global homogenised strain rate model from geodetic measurements;
- Faulted Earth: to compile a global database of active faults, covering more areas than before;
- Global GMPEs: to develop a harmonized suite of ground motion prediction equations (GMPEs) that can be used at both global and regional level.

A Request for Proposals (RfP) for a sixth Global Component on site effects is under definition. A preliminary RfP is available for comments on the GEM website until the end of April 2011; successively, the revised RfP will be issued and the bid opened.

The consortia leading these global components will be required to define standards and best practice related to the methodologies used in the collection and storage of data needed therein. This talk will go through each of the global components in hazard, by illustrating main tasks and by describing current activities with some preliminary examples.





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## **DESIGN CONSIDERATIONS AND BUILDING CODES**

By

**MYRON CHIN**

The three principal integrated modules within the GEM scientific framework are:-

- Seismic Hazard
- Seismic Risk
- Socio-Economic Impact.

The Seismic Risk Module calculates damage and direct losses and damage is calculated by combining building vulnerability, population vulnerability and exposure.

This Technical Session 7 will examine building vulnerability analysis with particular reference to one of the most common structural systems in Trinidad and Tobago and possible strategies for vulnerability analysis of Caribbean construction systems within the GEM Caribbean Regional Programme.

The session will also review the status of building codes in both the English speaking and Spanish speaking countries of the Caribbean with particular reference to the CROSQ building code project with a view to identifying those countries in which sustainable building codes need to be introduced and where there is a need to enhance/improve existing codes. This is in keeping with one of the objectives of GEM by which earthquake risk is reduced by promoting the introduction of sustainable building codes.



## **STRUCURAL VULNERABILITY**

**By**

**RICHARD P. CLARKE**

The rudiments of seismic vulnerability analysis are presented. The key terminology and main methods are discussed, with an emphasis on the analytical approach using Incremental Dynamic Analysis. As an example, a review of a vulnerability analysis of the most common structural system used in Trinidad and Tobago – the unreinforced masonry bearing wall system for residential structures, is presented, along with elementary consideration of possible strategies for vulnerability analysis of Caribbean construction for the GEM Caribbean Project.





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## CARIBBEAN BUILDING CODES PROJECT

By

ERROL RAMPAUL & DARRYL THOMSON

### **Purpose**

This presentation gives an overview of an ongoing project to develop a building code for the Caribbean, with the objective of improving the quality of buildings and their survivability in the face of likely regional natural hazards. It is proposed that this building code be an adoption of the International Building Code, supported by Caribbean Application Documents outlining regional and local variations.

### **Methodology**

This Caribbean Development Bank funded project is being executed by the Caribbean Organization for Standards and Quality, which has partnered with several regional bodies and national standards bureaus. Specialist consultants will be engaged to produce the Application Documents for specific technical areas which will then be first peer reviewed by professional associations and subsequently reviewed by national technical committees established in each member states.

### **Findings**

The project has already completed the development of rainfall intensity duration curves and flood hazard maps which will be incorporated into the finalized CADs.

### **Implications**

Upon completion, the CADs in conjunction with the IBC will form the basis for a Caribbean Building Code. It is expected that regional governments will adopt the completed Code as National Building Codes in order to ensure building safety and quality. It is also anticipated that the regional harmonization of building requirements will facilitate the expansion of the regional construction industry.

### **Keywords**

Caribbean, building, code, standards, seismic, engineers, architects.



## **STATUS OF BUILDING CODES IN JAMAICA EARTHQUAKE RESISTANT ASPECTS**

**By  
WAYNE ADAMS AND ALFRICO ADAMS**

The Jamaica National Building Code has been revised in 2009 to adopt documents produced by the International Code Council including provisions for earthquake resistant design.

Document JS 305 is the application document developed corresponding to the International Building Code. The document governs requirements for larger structures.

Document JS315 is the application document corresponding to the International Residential Building Code. The document governs requirements for single storey single family residential occupancy structures.

Document JS310 is the application document corresponding to the International Existing Building Code. The document governs requirements for existing buildings.

A brief discussion is given of aspects of the administrative process to implementation and a summary description of the particular application document provisions with application to earthquake loads.

Also a select summary of some essential comparative earthquake resistant code provisions of other English speaking Caribbean territories is proposed, gathered from the knowledge of some the region's structural engineers.





# **STATUS OF EARTHQUAKE RESISTANT BUILDING CODES IN CUBA AND OTHER SPANISH SPEAKING COUNTRIES IN THE CARIBBEAN**

**By  
CARLOS LLANES BURÓN**

The disasters combine the extreme events with the vulnerability, the inadequate perception of the risk and the lower capacities in order to protect. Such events become disasters when they burden the vulnerable populations, interrupting the operation of the communities that they could not cover the environmental losses with their materials and human capacities. In the last times have been come producing a marked tendency to the increase in the number, costs and impact of the disasters. This is not necessarily because they take place more earthquakes, hurricanes or any another extreme event, but because there are physically more people in the way to the natural hazards or catastrophes caused by the man, and many of those people are vulnerable to the disasters due to the poverty and a marginal standard of living.

When it is made a Study of Risk of Disasters, two important factors intervene; the Hazard and the Vulnerability. From the first an approach of the probability could be made that a hazard event happens during the useful life of the analyzed work, but it is not many in general what one could make in order to avoid it and in many cases the negative human work in the environment it makes more critic the situation. However the second component of the risk, the Vulnerability is going to depend of multiple factors inside which they stand out, the physical, economical and technical between another. It is in fact on these factors of vulnerability on which one could act in order to reduce the risk of disasters. It is inside the technical factor where the existences of building codes are framed. They allow to design and analyze the structures considering approaches of Management of Risk, which allow preventing and mitigating the natural disasters.

In this work is presented a synthesis of the current Earthquake Resistant Cuban Code and other earthquake resistant codes from the Caribbean are valued to show the state of the art of the codes with relationship to the international standards (ISO), seeing that they fulfil the world tendencies in this thematic. Also, the paper of the earthquake resistant building codes in the strategy of the Management of Seismic Risk is considered.



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## DRRC RISK ATLAS PROJECT

By

**WALTER SALAZAR, RICHARD ROBERTSON, MACHEL HIGGINS, CASSANDRA LA BARRIE, LLOYD LYNCH, JOAN LATCHMAN, ALIA JUMAN, JILLIAN ST. BERNARD**

The plate tectonic setting of the Caribbean region makes it susceptible to geological hazards such as earthquakes, the impact of which can be intense and widespread, as demonstrated by the 2010 Magnitude 7.0 earthquake in Haiti. Most of the earthquakes that have occurred in the past that could have caused significant damage have been centered away from densely populated areas, but increased vulnerability and our present-day understanding of the seismic hazard of the Caribbean region indicate that the earthquake threat is indeed very significant. As the islands of the regions pursue their individual developmental agenda an increasing percentage of its building stock, population and infrastructure will become exposure to the seismic risk. Implementing mitigation measures and reducing vulnerability are the most effective mechanisms to reduce the potentially devastating impact of future strong and major earthquakes.

In this presentation we report on the progress made during the first three months of the “*Development of Caribbean Risk Atlas for Earthquake Hazards*” project, which is being implemented by the Seismic Research Centre on behalf of the UWI Disaster Risk Reduction Center DRRC at Mona campus, Jamaica. The primary objective of the project is to develop a methodology for seismic risk assessment in the Caribbean for three pilot States: Jamaica, Grenada and Barbados. It aims to provide guidelines and open-source software for the estimation of earthquake loss using available socio-economic data. This presentation highlight: the progress made; problems encountered and attempted solutions to these problems.

**Key Words:** Seismic Hazard, Vulnerability, Building Stock, Open-source software.





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## **WORLD BANK RISK MANAGEMENT PROJECTS IN THE CARIBBEAN - MULTI HAZARD RISK MODELING WORK IN THE EASTERN CARIBBEAN**

**By  
SAHAR SAFAIE**

The Latin America and Caribbean Disaster Risk Management (LAC DRM) team at The World Bank has been working in the Caribbean region for many years. The DRM projects cover a wide range including physical and operational capacity building of relevant national and regional institutions, infrastructure construction or retrofit, hazard assessments, and risk financing.

At this session, LAC DRM team representative will discuss the ongoing projects of WB in the Caribbean region including the "Eastern Caribbean Multi-Hazard Probabilistic Risk Modeling and DRM Applications" project. The objectives of this session are to highlight the applications and importance of Probabilistic Risk Modeling as a tool in Disaster Risk Management practice and decision making for various governmental sectors and non-governmental institutions, importance of Open Data, and to discuss the opportunities for synergy and collaboration between World Bank risk modeling efforts and GEM in the Caribbean.



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## **REGIONAL VULNERABILITY & BUILDING INVENTORY MODEL PRESENTATION OF GLOBAL DATASETS**

**By  
HELEN CROWLEY**

Within the risk domain, 5 Global Components have been identified, with the following objectives:

- **GEM Ontology and Taxonomy:** to define the framework for calculating seismic risk and classify the components therein.
- **Global Earthquake Consequences Database:** to collect post-earthquake data such as loss of life, injuries, damage and economic loss into a common web-based repository.
- **Global Exposure Database:** to construct a global building and population inventory.
- **Global Vulnerability Estimation Methods:** to define levels of damage and loss as a function of ground motion intensity, for a global taxonomy of buildings.
- **Inventory Data Capture Tools:** to support the population of the exposure and consequences databases through innovative open-source tools.

The consortia leading these global components will be required to define standards and best practice related to the methodologies used in seismic risk assessment and in particular the collection and storage of data needed therein. This talk will go through each of the global components in risk, focusing in particular on the vulnerability and exposure databases.





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**BUILDING AND MANAGING SPATIAL DATABASES OF BUILT ASSETS IN  
SUPPORT OF EARTHQUAKE RISK ASSESSMENT IN THE CARIBBEAN:  
OPPORTUNITIES AND CHALLENGES**

By

**JACOB OPADEYI**

Information on the location, structural characteristics, replacement cost and number of occupants of built assets is very important to effective risk management measures. Of equal importance is the information on the bio-physical characteristics of the sites on which these assets are located. This information enhances the ability to undertake meaningful risk assessment, disaster response management, and damage assessment in times of unlikely catastrophic events. Challenges in accessing this information in the Caribbean, is an indication that our risk management measures are still at the infancy stage.

This paper explores the need for a comprehensive regional spatial database of built assets along with the uses and users of this database. It also presents conceptual and logical designs of the database in an enterprise information system environment. The paper also advances techniques for rapid data collection and data management using geoinformatics technologies. The paper concludes by proposing an implementation plan for developing a regional built asset database.



## **ARCHITECTURE AND THE SAFETY AND VULNERABILITY OF BUILDINGS IN EARTHQUAKE ZONES**

**By**

**TONY GIBBS**

**PANELLISTS – ROBERT WOODSTOCK, GARY TURTON, JENIFER SMITH**

Buildings are designed by architects and engineers. In reality, in most cases, buildings principally for human occupancy are designed conceptually by architects. That is to say that architects are the ones principally responsible for the configuration of buildings for human occupancy.

Configuration has to do with the shape and size of the building. Inevitably shape and size to a large extent determines (or greatly influences) the type, shape, arrangement, size, location and most other aspects of the structural concept. Also, the architectural configuration determines the location and nature of non-structural elements of the building.

In the words of Geoffrey Wood (one of the five founding partners of Ove Arup & Partners):  
“Earthquake-resistant design is really a problem for architects.”

The architect determines the conceptual design of the building and in so doing largely determines the type and effectiveness of the earthquake-resisting systems which can be used by the structural engineer. Because of this, it is of paramount importance for the architect to have a better-than-usual knowledge of the basic principles of the conceptual design of earthquake resisting systems. Alternatively, the architect should involve the structural engineer in the initial discussions and development of the building concept.

The Tri-services Manual of the USA Army, Navy and Air Force states:

“A great deal of a building’s inherent resistance to lateral forces is determined by its basic plan layout. . . .

“Engineers are learning that a building’s shape, symmetry and its general layout developed in the conceptual stage are more important, or make for greater differences, than the accurate determination of the code-prescribed forces. . . .”

Structural engineer William Holmes, writing in 1976, states:

“It has long been acknowledged that the configuration, and the simplicity and directness of the seismic resistance system of a structure, is just as important, if not more important, than the actual lateral design forces.”





Henry Degenkolb (the late engineer well known to many Caribbean engineers) is emphatic in stressing the importance of configuration, but also recognizes that seismic design is but one of many influences on the shape of the building:

“If we have a poor configuration to start with, all the engineer can do is to provide a band-aid -- improve a basically poor solution as best he can. Conversely, if we start off with a good configuration and a reasonable framing scheme, even a poor engineer can't harm its ultimate performance too much. “This last statement is only slightly exaggerated. Much of the problem would be solved if all structures were of regular shape, but economics of lot sizes and arrangements, various planning requirements for efficient use of space, and aesthetically pleasing proportions, require the structural engineer to provide for safe constructions of various shapes.”

The nature of the problem has been well stated by the Nicaraguan architect José Francisco Terán, who studied the effects of the Managua (Nicaragua) earthquake of 1972:

“The question arises as to whether the building should be designed to meet the functional, social, and aesthetic needs and then be implemented for structural safety or if in seismic areas like Managua, the special problems of stability and overall integrity should condition the design process by which the elements of form such as mass, symmetry, modulation, etc, are decided.

“If we agree that such is the case, how can architects, engineers, owners, and the whole community develop a common design attitude for a phenomenon that occurs critically at considerable time intervals during which many of the design parameters actually change?”

Those quotations above warrant discussion among the various disciplines involved in the design and building processes. Terán's recommends that buildings be “simple, continuous, symmetrical, straightforward, and repetitive”. This advice is given not as an absolute, but as a qualitative factor that influences the reliability of the structure. Terán asks for understanding and knowledge among the disciplines, not the imposition of mandatory constraints.

The panel will examine the problems for the architectural designer when confronted by the earthquake hazard and some of the possible solutions to those problems. In shining a light on those problems, the vulnerability of the existing building stock in the Caribbean (and elsewhere) would be better appreciated. It is also hoped that the GEM regional programme would have a measurably positive influence on reducing the vulnerability of future buildings.

The panel discussion will be accompanied by a significant amount of graphics, as befits the subject.

# APPENDIX

## BIOGRAPHY OF CHAIRPERSONS & PRESENTERS



### **Rui Pinho**

Rui Pinho serves as the Secretary General of the GEM Foundation, acting as its CEO. He graduated as a Civil Engineer, and then obtained Masters and Doctoral degrees in Earthquake Engineering in the UK. In 2001 Dr Pinho joined the Structural Mechanics Department at the University of Pavia, where he still holds a position as Assistant Professor of Structural Design.

Before joining the GEM Foundation, Dr Pinho served as Head of the Seismic Risk Section of the European Centre for Training and Research in Earthquake Engineering (EUCENTRE), Deputy Coordinator of the LESSLOSS 46-partner European research network, Manager of the Centre for Post-Graduate Training and Research in Earthquake Engineering and Engineering Seismology (ROSE School), Deputy Coordinator of the international Erasmus Mundus Masters course in Earthquake Engineering and Engineering Seismology (MEEES) Manager of the IUSS Press, Co-founder and Technical Director of Seismosoft (Software Solutions for Earthquake Engineering).

Dr Pinho has authored more than 200 publications and supervised more than 100 undergraduate and postgraduate research theses and dissertations, mainly on the topics of seismic risk and loss estimation at variable geographical scales, assessment and mitigation of seismic vulnerability of reinforced concrete structures, development of advanced analytical tools for analysis of structures subjected to seismic action, validation of innovative earthquake-resistant design/assessment approaches. He is also peer reviewer and/or editorial board member of 20 international scientific journals, has been guest speaker in a number of conferences, workshops and short courses, and is the recipient of a number of awards, including the 2008 EERI Shah's Prize for Innovation.



### **Marco Pagani**

Marco Pagani obtained a Master degree in Geological Sciences in 1997 from the University of Milan. He then started a collaboration with an engineering seismology research Institute of the Italian National Research Council (IRRS-

CNR) on the implementation of several Seismic Microzonation studies. Between 1999 and 2002, Marco served as a PhD fellow at the University of Milan focusing his activities on the development of a PSHA code.

After obtaining his PhD he spent several months working on probabilistic seismic hazard analysis at CETE Méditerranée in Nice, and immediately after he joined the Istituto per la Dinamica dei Processi Ambientali (IDPA-CNR) where he worked on seismic microzonation and development of clustering and data analysis techniques with applications in Information Retrieval, Earth and Material Sciences. In February 2009 he joined the Swiss Seismological Service at ETH, where he coordinated the hazard component of the GEM1 project, which laid the foundations for many of GEM's activities. Marco participated in a number of national and international research projects in the field of Seismology, Engineering and Information Technology. He authored several papers in the field of engineering seismology and data analysis and currently serves as a reviewer for several international journals with topics ranging from geographical information science to seismic hazard.

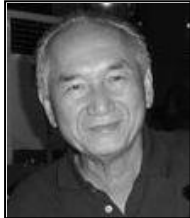


## Helen Crowley

Helen Crowley currently serves as the Risk Coordinator of GEM's Executive Committee and as the Scientific Coordinator of the GEM Secretariat. She trained as a civil engineer at Imperial College London, with a strong emphasis on structural engineering, and then went on to obtain both Masters and PhD degrees in Earthquake Engineering at the ROSE School in Pavia, Italy. Through her research and self-motivated study, she has also become very conversant over the recent years with the field of engineering seismology. She has developed a broad and deep knowledge of the state-of-the-art in ground-motion prediction and seismic hazard analysis. The EGU recently recognised Helen's "outstanding contributions in the fields of earthquake risk assessment and seismic risk mitigation and in the neighbouring fields of structural engineering and engineering seismology" by awarding her the 2009 Plinius Medal.

Since 2005, whilst working in the Seismic Risk Section of the EUCENTRE, Helen has been responsible for the coordination of national and international research projects, mainly in the areas of seismic vulnerability of buildings and the evaluation of seismic risk and economic loss. Dr Crowley has also played a fundamental role in the daily running of the ROSE School, in the management of LESSLOSS, in the execution of a number projects commissioned by the Italian Department of Civil Protection, and in the co-supervision of over 30 postgraduate students. Helen is currently on the Teaching Board of the ROSE School and is a Senior Academic of the Willis Research Network, the world's largest

partnership between academia and the insurance industry. Dr Crowley has authored more than 60 publications in the field of earthquake engineering, has an H-Index of 8 and serves as editorial board member or peer-reviewer for a number of international journals.



### **Myron W. Chin**

Myron W. Chin is presently a Senior Research Fellow and GEM Operational Manager at the Seismic Research Centre, UWI having been a Senior Lecturer in the Department of Civil Engineering, University of the West Indies, St. Augustine, Trinidad from 1977 to May 2001. From January 1993 to May 1993 he was a Visiting Professor in the Department of Civil Engineering, University of Toronto, Toronto, Canada. He served from August 1989 to July 1992 as Head of the Department of Civil Engineering in the Faculty of Engineering, University of the West Indies (UWI), Trinidad. From 1972 to 1991 he served as Chairman of the Extension Services and Continuing Education Committee of the Faculty of Engineering, UWI. From 1977 to 1978 he served as Assistant Dean of Engineering. He was a member of the UNESCO International Working Group on Continuing Education of Engineers and Technicians from 1977 until the formation of the International Association for Continuing Engineering Education (IACEE) in 1989. He was a member of the Executive Committee and Council of IACEE from May 1989 to May 1995 and Chairman of the Commonwealth Board on Engineering Education and Training (CBEET) of the Commonwealth Engineers Council (CEC) from November 1988 to March 1996. From May 2005 to September 2005, he served as Pro-Tem. Director of the National Emergency Management Agency (NEMA)/Office of Disaster Preparedness and Management (ODPM) of Trinidad and Tobago and from October 2005 to December 2005 he was Technical Consultant to the ODPM.

Dr. Chin graduated with First Class Honours in Civil Engineering from Loughborough University in the UK in 1962 under a Shell scholarship award and received his Ph.D. in Structural Engineering from Manchester University, England, in 1966 under a Commonwealth Scholarship Award. Prior to joining the UWI in 1972 he spent six years with the Shell Oil Company in Trinidad initially as a Project Engineer and then as Plant and Inland Distribution Manager and has worked throughout the Caribbean, extending from Suriname in South America to Tortola in the British Virgin Islands in the North. In 1986 he was a Senior Fulbright Research Fellow at Lehigh University, Bethlehem, Pennsylvania, U.S.A. where he gained experienced in Expert Systems Technology, Prestressed Concrete, Foundation Engineering and Earthquake-Resistant Design of Structures. Dr. Chin is a Chartered Civil and Structural Engineer and holds Professional Membership in the American Society of Civil Engineers (Life MASCE) and is a Fellow of the Institution of Civil Engineers (FICE), the Institution of Structural Engineers, UK (FIStructE), and

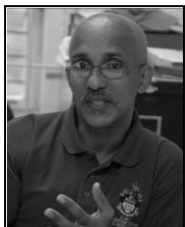


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the Association of Professional Engineers of Trinidad and Tobago (FAPETT). He is a Registered Engineer of the Board of Engineering of Trinidad and Tobago (BOETT). In 2007 Dr. Chin received the Award of Career of Excellence in Engineering from the Association of Professional Engineers of Trinidad and Tobago (APETT).

Dr. Chin is the author of a number of technical papers and co-author (with Professor M.R. Horne) of British Constructional Steelwork Association Publication No. 29: Plastic Design of Portal Frames to BS 968, and was Chairman of the First Caribbean Conference on Earthquake Engineering held in Trinidad in January 1978. He served as Project Manager of a Government funded Research Study into the Construction Industry in Trinidad and Tobago from 1975 to 1978.

He was Project Manager for the development of the Caribbean Uniform Building Code (CUBiC) from 1983 to 1986 which is used as a model building code throughout the various West Indian islands. He was directly responsible for developing the Earthquake Load provisions of CUBiC. He was the Team Leader from May to November 2002 of an Association of Caribbean States (ACS) funded project on Updating Building Codes of the Greater Caribbean for Wind and Earthquakes. He served as Secretary General of the Council of Caribbean Engineering Organisations (CCEO) from 1980-1984 and was President of the Association of Professional Engineers of Trinidad and Tobago from 1984-1985. He also served as Treasurer of the IStructE's Caribbean Division from January 2004 to December 2005. He was the first Chairman of the Building and Civil Engineering Works Sectional Committee of the Trinidad & Tobago Bureau of Standards and was also Chairman of the Specifications Committee on Loading of the Trinidad and Tobago Bureau of Standards (TTBS). He was the Chairman of the BOETT/APETT/TTBS Structures Codes Committee from September 2006 to December 2007. He served as Regional Chair for the Caribbean for the First, Second and Third World Congress on Expert Systems which were held in Orlando, USA in December 1991 and in Lisbon, Portugal in January 1994 and Seoul, Korea in February 1996 respectively.



### **Richard Robertson**

Originally from St. Vincent, Dr. Richard Robertson joined the staff at the Seismic Research Unit (now Seismic Research Centre) in 1993 after serving for six years as Head of the local volcano-monitoring unit in St. Vincent (the Soufriere Monitoring Unit). Since joining the Seismic Research Centre he has been involved in a variety of projects including: the ongoing eruption of the Soufrière Hills Volcano in Montserrat; the establishment of volcano monitoring networks (mainly geodetic) and ongoing public education and outreach programmes throughout the Eastern Caribbean. He

served several tours of duty as Chief Scientist of the Montserrat Volcano Observatory during the period 1995-1999 and was its Director from October 1998 - March 1999. Dr Robertson was appointed Head of the Seismic Research Unit in July, 2005 and Director of the Seismic Research Centre in July 2008. In St. Augustine, Dr. Robertson has assisted with the field supervision and lecturing of geoscience students. He was one of the editors of the Volcanic Hazards Atlas for the Lesser Antilles. Since 2008 he has been the main coordinator of the SRC and IPGP operations at the Montserrat Volcano Observatory.

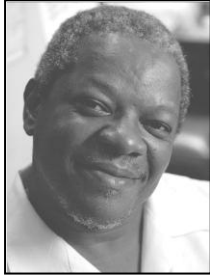


### **Joan Latchman**

Joan Latchman was born in Trinidad and joined the Centre in 1972 as a seismology technician. From 1977-1980, a flexi-time arrangement allowed her to work full-time and pursue a full-time Natural Sciences degree programme. She graduated in 1980 with a B.Sc. (Hons.) in Mathematics and Computer Science. An earthquake sequence near Tobago in 1982, for which the relevant authorities were put on alert, started her interest in Tobago seismicity. In 1988, from an international cadre of seismologists, she was selected to join the team of seismologists at the International Seismological Centre in the United Kingdom, for two years, to analyse global seismicity. In 1998, she completed an M.Phil. degree, which examined “The Seismic Potential of the S.W. Tobago Fault System. In 1999, she was appointed to the academic staff at the Centre and in 2009 completed her Ph.D. looking at “Tobago and Earthquakes”.

Joan’s primary research interest involves earthquake forecasting from analysis of changing  $b^*$ -values – she is a member of a team with successful forecasts of strong earthquakes near Tobago; North American-South American plate boundary identification using seismicity (stress waves and plate boundaries); and the impact of strong earthquakes on groundwater; spectra of volcanic earthquakes in diagnosing the status of a volcano. Current Projects include partition the Eastern Caribbean into zones for the purpose of analysing piecewise gradients of the Gutenberg-Richter Law, with a view to recognising the imminence of significant seismic activity. This study also has made accessible previously unavailable statistics of earthquake activity associated with the islands of the Eastern Caribbean. In 2003, the piecewise  $b$ -value technique applied to a global dataset suggested that an earthquake of magnitude greater than 8.5 was possibly imminent. It was for that reason the paper was submitted for publication, with a measure of urgency, on 1<sup>st</sup> December, 2004. The Sumatra mega-earthquake occurred just over 3 weeks later, on 26<sup>th</sup> December. This technique was developed at the Centre while analyzing the 1982 and 1997 Tobago earthquake sequences. Work continues on the piecewise  $b$ -value technique to explore its general applicability, with the most recent manuscript looking at the San Andreas Fault system. Additionally, she is working on establishing radon monitoring in

south-west Tobago to explore its utility in earthquake forecasting. She is also looking at the possible correlation between Eastern Caribbean volcanic episodes, and stimulation by large regional and extra-regional earthquakes.



### **Lloyd Lynch**

A native Jamaican, Mr. Lynch began his career at the Seismic Research Unit (now Seismic Research Centre) when he joined the Mona, Jamaica branch as an Electronic Technician in 1981. At the Unit in Jamaica his primary duty was to maintain the seismic network. In 1982, after completing his B.Sc. degree in Computer Sciences and Applied Physics he was promoted to Scientific Officer with the additional responsibility to oversee the local operation. In 1983 he transferred to St. Augustine, Trinidad to take up the post of Junior Research Fellow with responsibilities to maintain the eastern Caribbean Seismograph network and upgrade its design. Lloyd was promoted to Research Fellow in 1989. Between 1989 and 1991 the Unit lost two Heads of Department in quick succession and Lloyd served as interim Head. Between July 1995 and June 1997 he spent in excess of 40 weeks in Montserrat as one of the chief scientists.

Lloyd is currently pursuing part time graduate studies. He and his team continue to undertake projects that are geared at improving the monitoring services that the Centre provides to the local and regional communities. Lloyd is also one of three representatives from the Seismic Research Centre actively involved with the Caribbean charter of the Inter-Oceanic Commission's (IOCARIBE) effort to develop a tsunami warning system for the Caribbean Basin and Adjacent Regions.



### **Walter Salazar**

Walter Salazar was born in El Salvador and obtained the Bachelor Degree in Civil Engineering in 1994 at the Central American University (UCA). He initially worked in a private consulting company as a structural designer and supervisor at construction building sites. Later, he participated in a Seismic Risk Project at UCA supported by the European Economic Community, compiling an earthquake catalogue and performing seismic hazard assessments for El Salvador; simultaneously he participated in the installation and maintenance of a digital strong motion network which successfully recorded in 2001, the destructive subduction and upper-crustal earthquakes of M 7.8 and M 6.5 in El Salvador, respectively. From 1995-1998 he was a visiting researcher at the Imperial College of London.



Dr. Salazar began his Earthquake Engineering Postgraduate studies on 1998 at the International Institute of Seismology and Earthquake Engineering (IISEE) in Tsukuba, Japan. His interest in this field led him to continue studying at the Tokyo Institute of Technology, gaining the Doctoral Degree as an Engineering Seismologist in 2004. He focused his research on the site-effects evaluation via-application of inversion techniques on strong ground motion data. Later on he was appointed Coordinator of the Civil Engineering Career at UCA. He was a lecturer and thesis supervisor of the following subjects since 1995: Mechanics of Solids, Linear and Non-Linear Structural Analysis, Engineering Seismology and Earthquake Resistant Design. He also provides engineering consultancy for structural design and seismic hazard assessments for specific sites.

At the UWI Seismic Research Centre, Dr. Salazar leads the Seismic Hazard/Risk Assessments projects. He has worked closely with the EUCENTRE in Pavia-Italy to produce the first peer-review Seismic Hazard Maps for the Eastern Caribbean Islands. He is also in charge of the World-Bank funded Seismic Risk Atlas Project for three pilot states in the Caribbean: Jamaica, Barbados and Grenada. This project is being implemented by the UWI Disaster Risk Reduction Center (Mona campus). Dr. Salazar is expected to strengthen and provide direction for the science/engineering interface between the University of the West Indies (UWI) and the SRC and to enhance the accelerograph digital signal processing and inversion schemes tutoring Master Students in the Caribbean Region.



### **Julio Antonio Garcia**

Julio Garcia was born February 8, 1970, in Havana, Cuba. In 1993, he received a B.S. in geophysical engineering from the Higher Polytechnic Institute “José Antonio Echeverría”, at Havana, Cuba; in 2007 he obtained a Ph.D. in geophysics from the Institute of Geophysics and Astronomy and the National Council of Sciences, Havana, Cuba. For more than 15 years, he worked as a researcher at the National Centre for Seismological Research (CENAI) of Cuba, leading several studies about seismic hazard assessment and seismic risk estimation of Cuban territories. In 2008, Julio joined the National Institute of Oceanography and Experimental Geophysics (OGS) in Trieste, Italy. His research interests include the whole spectra of seismic hazard assessment and seismic risk estimation problems.



### **Alvaro Climent**

Alvaro Climent is a national of Costa Rica with a degree of Engineer from the School of Civil Engineering, University of Costa Rica, 1982 and a

specialization Diploma in Earthquake Engineering from the International Institute of Seismology and Earthquake Engineering, Tsukuba, Japan, 1992. His current position is Engineer related with studies in seismology and earthquake engineering field applied to develop electric generation projects at 1982-2011. His principal contributions to seismology and earthquake engineering include;

- (1) Develop a spectral strong motion attenuation relation for Central America, as part of the project " Reduction of Natural Disaster in Central America, Earthquake Preparedness and Hazard Mitigation, Seismic Zonation and Earthquake Hazard Assessment". Project funded by the Norwegian Agency for Development Authority (NORAD).
- (2) Studies of soil dynamic behavior in San José, Costa Rica. As same as the point above
- (3) Studies of seismic hazard in Costa Rica



### **Victor H. Cano P.**

Victor Cano of Venezuela began his studies in 1994 – 2001 in Engineering Geology at the University of Central Venezuela, Faculty of Engineering, School of Geology, Mines and Geophysics. He continued his studies in the Study and Management of Geological Risk at the University of Geneva, Switzerland, Center of Geological Risk (CERG) and at the University of Girona-España. He obtained his Masters in Geographic Information Systems. He holds a Post graduate Diploma in Geoinformatics in Geohazards from the Indian Institute of Remote Sensing.



### **Richard Clarke**

Richard Clarke is a structural engineer and has authored papers in leading international journals and symposia in the areas of seismic retrofitting, hysteresis modeling, seismic nonlinear structural dynamics, and vulnerability analysis. He is the current Head of the Department of Civil and Environmental Engineering of the University of the West Indies where he lectures in earthquake resistant structural design, structural engineering, performance-based seismic design, and allied topics.



## **Errol Rampaul**

Errol Rampaul is the Head of the Standardization Division at the Trinidad and Tobago Bureau of Standards (TTBS) and a Civil Engineer by profession; however he actually began his working life as a secondary school teacher. After obtaining his BSc. in Civil Engineering from the University of the West Indies in 1982, he joined the Engineering Consulting Firm of Lee Young and Partners and became actively involved in the structural design of steel and concrete buildings in Trinidad, Tobago and in the Eastern Caribbean. After this initial period in the private sector, Errol enjoyed a brief stint in small-scale construction before entering the public sector through the Ministry of Local Government. There, he headed a team of technical officers and was responsible for coordinating the design, tendering and construction of various facilities for the Regional Corporations. During this time he also became involved in the roll out of the Municipal Corporations Act (1990) and maintained a cordial working relationship with the Building Inspectors throughout the country.

In 1994, Errol joined the Trinidad and Tobago Bureau of Standards (TTBS) where he assumed primary responsibility for the development of Codes and Standards relating to the construction industry. During this initial period at the Bureau, he was involved in several joint TTBS/BOETT Code development activities including development of the Small Building Guide. While involved in standards related project, he continued to be involved in the practical aspects of construction including building maintenance and repair, and coordinating an 8 million dollar, 27000 s.f. expansion project involving new office space and associated roads and car parks. In 2006 he assumed the position of Head, Standardization Division and, as part of the Bureau's Leadership Team, is now involved in efficiency improvement initiatives and in charting the strategic direction of the organization. His responsibilities at TTBS include oversight of the standardization portfolio and the professional development of 9 technical officers involved in national, regional and international standardization and related conformity assessment activities. Other responsibilities at TTBS include serving on a number of Cabinet-appointed committees and representing the organization at regional and international standards-related Committees and fora. Errol has had additional training in project management, quality management and standardization and is still a registered Engineer maintaining membership in the Board of Engineering of Trinidad and Tobago.



## **Wayne Adams**

Wayne Adams is a civil engineer specializing in structural engineering. He completed undergraduate studies in Civil Engineering from the University



of the West Indies, St. Augustine Trinidad in 1987 and a Master's Degree in Earthquake Engineering and Structural Dynamics from the Imperial College's Faculty of Civil Engineering, University of London, U.K. in 1991. He worked for 14 years with the structural engineering firm SMADA Consultants Ltd. A firm whose principal has a history of involvement with building code development in Jamaica and the Caribbean and. In 2001, he established SMADA Consultants LLC in Altamonte Springs FL USA practicing structural engineering in Florida and the Caribbean and is the current principal. Special areas of interest and experience are earthquake engineering hurricane resistant design and port engineering.



### **Carlos Llanes Burón**

Born August 24th 1953 at Havana, Cuba, Professor Buron is a Civil Engineer, PhD. in Technical Sciences, Titular Professor from the Department of Civil Engineering in the Faculty of Civil Engineering from the Higher Polytechnic Institute "José Antonio Echeverría", (Cujae) at Havana, Cuba. He is also Director of the National Center of Reference for the Prevention and Mitigation of Disasters (PREMIDES) since their foundation in the 1996 and Head of the Line of Research Management and Prevention of the Patrimony for the Construction and Tropical Architecture Study Center (CECAT). He is main Professor at Dynamic of Structures, member of the Commission of Scientific Degrees of Technical Sciences, the National Tribunal of Constructions and Hydraulics, and the PAHO/WHO Disaster Mitigation Advisory Group (DiMAG). He is a National Expert of Engineering for the attention of the problems due to Disasters since 1995 and Member of the Advisor Technical Committee of Ministry of the Construction (MICONS), of the Latin American Center of Medicine of Disaster from Ministry of Public Health (MINSAP) and of the Agency of Environment from the Ministry of Science Technology and Environment (CITMA).

Advisor of nine thesis of doctorate (PhD) two finished, 25 of Master (17 finished) and 121 Thesis and Projects of Diploma on several topics of interest, participates in National and International Projects in the thematic of the disasters in the area of the Great Caribbean and is a Permanent Member at the National Committee of Normalization of Structural Calculation of Concrete (CONCEH) since 1985 at the subcommittees of Wind and Earthquake being president of both ones. He has given courses of postgraduate degree, conferences and worked as expert abroad in several occasions at countries such like Czechoslovakia, Belgium, Mexico, Costa Rica, Argentina, Brazil, Venezuela, the Dominican Republic, Colombia, Bolivia, Martinique, Barbados, Trinidad and Tobago, Guadalupe, Guatemala, Honduras, Panama, Peru, St. Vincent and the Grenadines, Jamaica, El Salvador, Honduras, Chile and Ecuador. He has been selected National Vanguard in multiple

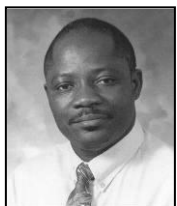


occasions and obtained numerous prizes and badges between other distinctions they stand out those of the Academy of Science, Distinction for the Cuban Education, the Be Prepared to the Defense, the Order Carlos J. Finlay higher distinction that confer the Council of State of the Republic of Cuba to a research or scientific for their excellent results.



### **Sahar Safaie**

Sahar Safaie is a Disaster Risk Management Specialist at The World Bank Latin America and the Caribbean Disaster Risk Management team (LAC DRM). With the LAC DRM, Sahar's focus is the Caribbean region where her projects include the "Caribbean Risk Atlas" and the "Eastern Caribbean Multi-hazard Risk Assessment and Applications in DRM". Sahar is an earthquake engineer with experience in structural design, product management, earthquake risk mitigation, and risk modeling. Prior to joining the World Bank she has worked as a product manager at Risk Management Solutions Inc. (RMS) focusing on probabilistic earthquake risk models of Mexico, Central and South America. Sahar is also part of the Labs team, at the Global Facility for Disaster Risk Reduction (GFDRR), which has the mission of using science, technology and innovation to inform decision making; to reduce the vulnerability of the developing world to disasters in a changing climate. In past few years, Sahar has been involved in various initiatives on promotion of earthquake resistance construction at Earthquake Engineering Research Institute (EERI).



### **Jacob Opadeyi**

Jacob Opadeyi is the Coordinator of the Centre for Geospatial Studies of the Engineering Institute, Faculty of Engineering and Technical Adviser of the UWI Disaster Risk Reduction Centre. He holds a PhD and MEngg degrees from the University of New Brunswick, Canada; and MBA from The University of the West Indies, and an MSc (Surveying) from the University of Lagos, Nigeria. He is a Fellow of the Royal Institution of Chartered Surveyors and the President of the Commonwealth Association of Surveying and Land Economy

He has conducted research and published in the following areas: GIS applications in environmental analysis and modeling; natural hazard and risk mapping; land management; watershed management. His current research include: GIS modeling heavy metal and sediment in watersheds, natural hazard mapping techniques, land cover change monitoring, telephonic flood hazard early warning systems, and water quantity and water quality modeling.



## Tony Gibbs

Tony Gibbs is a civil engineer specializing in structures and practising mainly in the Caribbean. He did his undergraduate studies at The Queen's University of Belfast and he was a Commonwealth Scholar at The University of Leeds. His engineering career included assignments with Norman & Dawbarn at the UWI campus in St Augustine; Ove Arup & Partners in London and Caribbean Construction Company in Jamaica. He is now a Consultant to Consulting Engineers Partnership Ltd with active offices in four Eastern Caribbean islands.

He is Past President of The Barbados Association of Professional Engineers; Past Vice President of The Institution of Structural Engineers (IStructE, UK); Fellow of The Institution of Civil Engineers (UK); Fellow of The American Society of Civil Engineers, Fellow of the Royal Society of Arts and Fellow of the Royal Institute of Chartered Surveyors. Mr. Gibbs has acted as Associate Project Manager for the Caribbean Uniform Building Code; Chairman of the Barbados Metrication Board; Deputy Chairman of the Barbados National Council for Science & Technology; Chairman of the Barbados Building Standards Authority Advisory Committee; Director of the American Association for Wind Engineering; Member of the General Assembly of The International Association for Wind Engineering (IAWE); Member of The International Codification Forum of the IAWE; Chairman of the Caribbean Division of The Institution of Structural Engineers. He is currently Secretary General of the Council of Caribbean Engineering Organisations; Executive Board Member and Trustee of the IStructE and a Member of Scientific Planning Group on Natural Hazard Risk Reduction of the International Science Council (Latin America and Caribbean). He was a member of the Joint Board of Moderators (UK) 1995 team assessing the UWI BSc Civil Engineering degree programme.

Mr. Gibbs' special interests are in the fields of reinforced and prestressed concrete; thin shell and folded-plate structures; collaborative design in multi-disciplinary teams and designing against the natural hazards of hurricanes and earthquakes. He is particularly interested in the interrelationship between engineering and insurance. He has devoted much of his time to the particular problems related to the structural design of hospitals in areas subject to hurricanes and earthquakes.

In 1991 he received the International Award "For (his) Very Significant Contributions to Hurricane Loss Reduction and Hurricane Safety in the Caribbean" at the US National Hurricane Conference; and an award "In Recognition of (his) Contribution to the Advancement and Promotion of Structural Engineering in the Caribbean" from The Barbados Association of Professional Engineers. In 1998 he received the award of "Career of Excellence in Engineering" from the Association of Professional Engineers of Trinidad &

Tobago. In 2003 Mr. Gibbs received the Lewis Kent Award from The Institution of Structural Engineers (UK) for services to engineering and to The Institution. Mr. Gibbs received the UN-ISDR Sasakawa Award for Disaster Reduction in 2007.



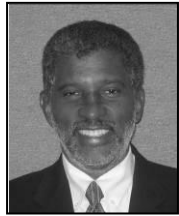
## Jennifer Smith

Jenifer Smith obtained her Degree and Post-Graduate Diploma in Environmental Design and Architecture from the Bartlett School of Architecture at University College, London University. Her postgraduate studies were completed in 1984 and full professional status acquired in 1987. Jenifer worked on the design of the extension to the concourse for the Sydney Opera House with Hall, Bowe & Webber in Sydney, Australia before joining Armstrong Associates in London, England in 1986. She became an associate in 1988 and an equity partner in 1990. The practice worked on commercial, residential and cultural projects, including shops, offices, galleries, private houses and master planning. The firm's work was widely published and won numerous awards for design excellence. The practice achieved international recognition by winning the open and anonymous competition for a Japanese cultural center 'La Maison de la Culture du Japon' in Paris, France. This building of 100,000 sq. ft. located on the Seine, was to be a showcase for Japanese culture. Jenifer Smith established the office in Paris in 1992 and remained there for 5 years, overseeing the project from conception through to final completion. President Chirac inaugurated the building in 1997 to critical acclaim, winning a prestigious Architectural Award from the Royal Institute of British Architects in 1998.

After returning to London, Jenifer worked for Foster & Partners on the Great Court of the British Museum, a building that has been recognized as a public and critical success. In 1999 she formed Industry Architecture & Design Ltd. This firm advised on all aspects of development, marketing and management of projects as well as the process of design and implementation. Completed schemes included restaurant and leisure facilities in central London as well as high quality residential developments.

In 2001, Jenifer Smith returned to set up practice in Trinidad after more than 15 years of international experience. Work to date includes commercial, educational, recreational industrial and residential projects. In 2007 Jenifer Smith Architects won 2 of the Abel Bestcrete Caribbean Building Awards. One of these projects has also been selected for Phaidon's Atlas of 21<sup>st</sup> Century Architecture. Currently the practice is involved in the design and supervision of residential, commercial, industrial and educational facilities including most recently the concept design for the UWI St. Augustine - South Campus.

Jenifer has taught and reviewed projects at both post and undergraduate level at the Bartlett School of Architecture in London England and the Graduate School of Design at Harvard University, Cambridge Mass. She has taught at the Creative Arts Centre at UWI and participated in the recent UWI symposium on Art Design & Architecture in our Space. She is currently the Vice-President of the Trinidad & Tobago Institute of Architecture.



### **Robert Victor Woodstock**

Robert Woodstock is a Jamaican architect with over thirty one (31) years experience practising architecture in Jamaica and more recently, the eastern Caribbean. He is a principal in the firm Harold Morrison+Robert Woodstock Associates Limited, a design-oriented architectural, planning and interior design firm operating from Jamaica and Barbados. He was the recipient of a Jamaica Government Scholarship to study architecture at Cornell University, Ithaca, New York, U.S.A. where he graduated with a B. Arch., Professional Degree in 1979. There he received the American Institute of Architects School Medal and the Certificate of Merit from the Henry Adams Fund for Excellence in Design and the Study of Architecture, for coming first in the class of 1979. After graduation Mr. Woodstock returned to Jamaica to work for the Government of Jamaica at the Ministry of Construction (Works), rising from Intern Architect to Deputy Project Director for an architectural, civil/structural and electrical/mechanical engineering team in a special projects unit formed to design and manage a number of foreign funded projects.

Mr. Woodstock joined Harold Morrison Associates in 1985 and has been with the firm ever since. The firm has won numerous awards in the Jamaican Institute of Architects' Awards Programme including the The Governor General's Award for Excellence in Architecture, (the top prize for Architecture in Jamaica) for Sunshine Village/Singles Negril, and the Caribbean Building Awards, Award for Excellence in Architecture Health/Education/Sports Category for the UWI Archives Building project 2006.

Mr. Woodstock is a Past Chairman of the Association of Commonwealth Societies of Architects in the Caribbean (ACSAC), Former Vice President (Alternate) for the Commonwealth Association of Architects (CAA), Past President, Fellow and Past Treasurer of the Jamaican Institute of Architects (JIA), Member of the Barbados Institute of Architects (BIA), and Past Chairman of the Joint Consultative Committee for the Building and Construction Industry of Jamaica (JCC) now CIC. He is currently the Chairman of JIA Membership and Practice Committees as well as Adjunct Design Tutor for the Master of Architecture Programme and Visiting Design Critic at the Caribbean School of Architecture



(CSA), University of Technology. Mr. Woodstock also serves on the Advisory Board of the CSA and the Cultural Advisory Council of the University of Technology. Mr. Woodstock is also the recipient of the Caribbean Building Awards Honorary Award for “Outstanding Contribution to Architecture” in the Caribbean and an Honorary Membership Award from the Trinidad and Tobago Institute of Architects for his regional contributions and exceptional leadership in the field of architecture.

Mr. Woodstock has been an Adjudicator/Arbitrator for construction contract disputes since 2001 and Juror for international architectural competitions in the Bahamas, Jamaica and Trinidad. Mr. Woodstock is also a member of the American Society for the Advancement of Project Management (asapm). He has presented a number of papers on architectural and urban design, construction contracts and contract administration. His work/drawings have been featured in a number of publications including “Jamaica Architect” and “Award Winning Architecture International Yearbook”.



### **Gary Turton**

Gary was born in Trinidad and Tobago and received his Master of Architecture degree at the State University of New York at Buffalo. Gary worked as a graduate architect in New York City for large architectural practices such as Kohn Pederson Fox and Perkins Eastman Architects until becoming a licensed architect in New York State and subsequently a member of the American Institute of Architects.

Gary returned to Trinidad in 1996 and became a member of the Trinidad and Tobago Institute of Architects and registered Architect with Board of Architecture of Trinidad and Tobago. He practiced as a sole trader to continue the architectural work of his cousin, the late Roger Turton, until 2000, when he merged his practice, Turton Architects, with 2 other practices including architectural giant Anthony C Lewis Associates and formed acla:works ltd. as director and shareholder.

This new practice’s vision is to provide innovative architecture for discerning clients and their mission is to be the prominent architectural firm in the Caribbean by 2020 in terms of image, perception, service level and delivery and has won several awards over the years. acla:works has been responsible for the design of a number of public and private projects including the BG building in St Clair, Citibank HQ Queens Park East, Republic Bank’s new Trincity and Gulf View prototype branches, the current Office of the Prime Minister in St. Clair and the Twin Towers to name a few. Gary is the Chief Marketing Officer for acla:works as well as principal-in-charge of several projects. As the firm thinks regionally and



internationally, it has established strategic partnerships with architects in the US, UK, as well as the Caribbean Region.

Gary also plays an active role in the profession and served as President of the Trinidad and Tobago Institute of Architects (TTIA) between 2008 and 2010, during which time the TTIA was involved with the Commission of Enquiry into the construction sector and the practices of Udecott. He currently serves on the executive board of the TTIA as immediate Past President and chair of the Website Committee. Gary served as a director of the Trinidad and Tobago Coalition of the Services Industries (TTCSI) between 2008 and 2010, where he contributed to Services Week workshops for the architectural services sector on the Economic Partnership Agreement, the upcoming Caricom Canada Trade Agreement and meetings with the Ministry of Trade. Gary is also currently a member the Caribbean Architects Mutual Recognition Agreement Committee (CAMRAC) as a representative of the Association of Caribbean Societies of Architects in the Caribbean (ACSAC) whose purpose it to pursue the execution of a mutual recognition agreement between architects from the EU and the CARIFORUM region (CARICOM + Dominican Republic and Haiti)



## LIST OF PARTICIPANTS

Addison Workman	
Alia Juman	Seismic Research Centre
Allan Stewart	Tobago Emergency Management Agency
Alvaro Climent	ICE – Costa Rican Electricity Institute
Anishka Ramhit	Hanover/ Trinidad Engineering & Research Ltd.
Anthony Farrell	Institution of Structural Engineers (ISTRUCTE)
APETT Chairman	Association of Professional Engineers Trinidad & Tobago (APETT)
Asha Kambon	ECLAC
Azad Mohammed	UWI - GELM
Barbara Carby	Disaster Risk Reduction Centre
Carlos Llanes Buron	Consultant
Cassandra Rogers	IDB
Cassandra La Barrie	Seismic Research Centre
Cecil Shillingford	USAID/OFDA
Clevon Ash	Seismic Research Centre
Dana Van Alphen	Pan American Health Organisation (PAHO)
Darryl Thompson	Trinidad & Tobago Bureau of Standards
Dave Williams	Ministry of Local Government
Derek Gay	Dept Civil Engineering UWI
Desire Joseph	Office of Disaster Preparedness and Management
Didier Deris	ANCO Martinique
Dwight Pollonais	PRUDECON
Eduardo Gonzalez	Association of Caribbean States
Elisa Zucolo	EUCENTRE
Eric Calais	UNDP
Eric Lewis	Lauriston Lewis Associates
Errol Rampaul	Trinidad & Tobago Bureau of Standards
Firdaus Kamalodeen	Hanover/ Trinidad Engineering & Research Ltd.
Garth Arch	Cayman Society of Architects, Surveyors and Engineers
Gary Turton	acla: works architecture + interiors
Gladys Christophe	ANCO - Martinique
Greg Parris	Consulting Engineers Partnership Ltd
Helen Crowley	Global Earthquake Model
Jacob Opadeyi	Dept Surveying and Land Info UWI
Jenifer Smith	Jenifer Smith Architects Ltd.
Jillian St. Bernard	Seismic Research Centre
Joan Latchman	Seismic Research Centre
Julio Garcia	CENAS
Kahlis Ramsbhag	APR Associates Ltd.
Lloyd Lynch	Seismic Research Centre
Lyndon Brown	Earthquake Unit - UWI
Machel Higgins	Seismic Research Centre



Marco Pagani	Global Earthquake Model
Margarita Leonard	Lauriston Lewis Associates
Mathieu Fontanaud	Association of Caribbean States
Michelle Mohess	KS & P Limited
Monique Johnson	Seismic Research Centre
Myron Chin	Seismic Research Centre
Pat Joseph	Seismic Research Centre
Rafi Ahmad	Mona Geoinformatics
Richard Clarke	Dept Civil Engineering, UWI
Richard Robertson	Seismic Research Centre
Robert Woodstock	HMRW Associates Ltd.
Rod Stewart	Seismic Research Centre
Rui Pinho	Global Earthquake Model
Sahar Safaie	World Bank
Savitree Singh	KS & P Limited
Shahiba Ali	Consultant
Sharon Lans	Association of T&T Insurance Comp
Stacey Edwards	Seismic Research Centre
Tetteh-Kojo Salandy	APR Associates Ltd.
Tony Gibbs	Institution of Structural Engineers (ISTRUCTE)
Victor Hugo Cano Pacheco	FUNVISIS
Walter Salazar	Seismic Research Centre
Wayne Adams	SMADA Consultants LLC





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## THE UNIVERSITY OF THE WEST INDIES SEISMIC RESEARCH CENTRE

The University of the West Indies (UWI) is the largest and most longstanding higher education provider in the English-speaking Caribbean, with main campuses in Barbados, Jamaica and Trinidad and Tobago, and Centres in Anguilla, Antigua & Barbuda, The Bahamas, Belize, British Virgin Islands, Cayman Islands, Dominica, Grenada, Montserrat, St Christopher (St Kitts) & Nevis, Saint Lucia, and St. Vincent & the Grenadines. The UWI is an international university with faculty and students from over 40 countries and collaborative links with over 60 universities around the world. Through its seven Faculties, the UWI offers undergraduate and postgraduate degree options in Engineering, Humanities & Education, Law, Medical Sciences, Pure & Applied Sciences, Science and Agriculture, and Social Sciences.

Established in 1952, the Seismic Research Centre (SRC) is a Centre within the UWI. The SRC operates the largest network of seismographs and other geophysical instruments in the Caribbean region as well as manages the Montserrat Volcano Observatory jointly with the Institut de Physique du Globe de Paris. The SRC monitors earthquakes and volcanoes for most of the English-speaking Eastern Caribbean and close links are maintained with similar monitoring organisations in the region. Additionally, the Centre is part of a regional effort to establish a tsunami warning system for the Caribbean and Adjacent Areas. The Centre also works closely with national disaster management agencies and the formal education system to increase public awareness of geo-hazards.



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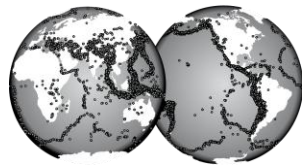




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