ICUS/INCEDE NEWSLETTER

International Center for Urban Safety Engineering

Institute of Industrial Science
The University of Tokyo

VOLUME 1 NUMBER 2
JULY - SEPTEMBER 2001

Traditional Architecture in Saint Lucia and Seismic Responses

By

Anne L. D. French

Deputy National Disaster Coordinator, Saint Lucia

INTRODUCTION

Saint Lucia is an island country located in the southern section of an archipelago of volcanic islands, which comprise the Lesser Antilles. The island is about 500 km north of Venezuela and is 616 km^2 in size. A mountain range forms the backbone of this volcanic island with the highest point at Mt. Gimie (height =1040m).

The island is 30 km long and is made up of pliocene to recent basalts and andesitic basalts, which originate from largely unknown and strongly dissected centers. This means that the island is made up predominately of igneous rock. The other rock type to form the island is sedimentary. This type of rock shows distinct layering and can be folded or fractured by movement of the earth's crust. The stratification and layering of permeable and impermeable beds is frequently responsible for slope instability.

Over 43% land of the island has a gradient of more than 30^o. As a result, much of the island's structures are on stilts. This design feature is popular for its ability to provide additional storage on the underside or to allow for expansion at a later date.

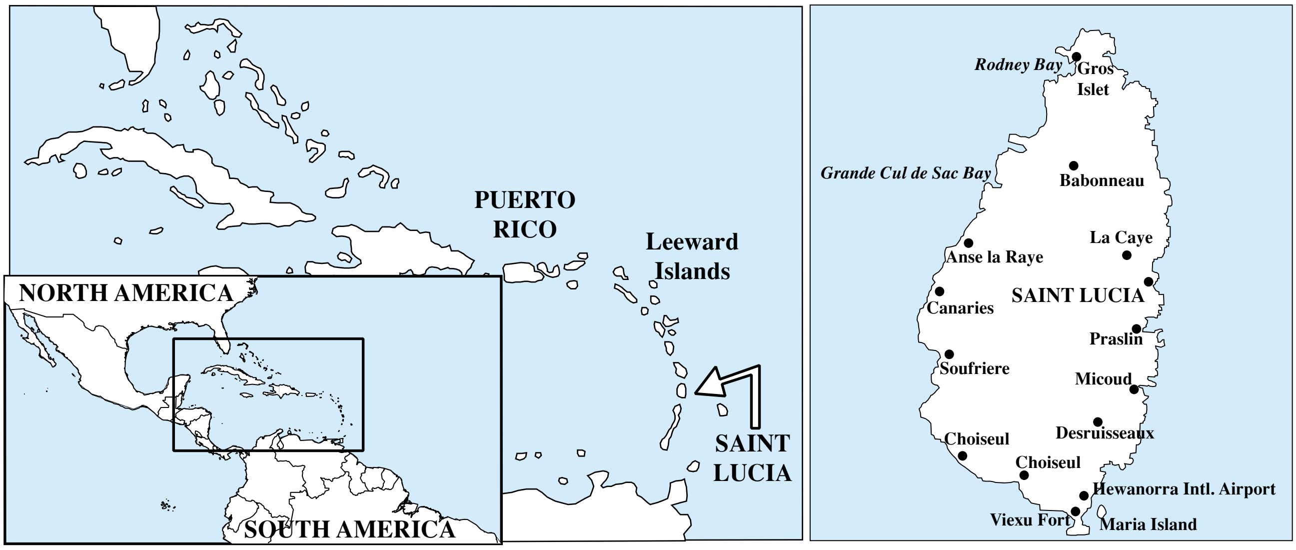
SEISMIC ACTIVITY IN SAINT LUCIA

The Caribbean plate runs through Guatemala in Central America to the east between Jamaica and Cuba, around Hispaniola and Puerto Rico in the Caribbean, joins the boundary east of the Caribbean islands and follows the archipelago. In the Southern Caribbean near Trinidad, the eastern boundary joins the southern boundaries along the pacific side of Central America.

Tectonic plate boundaries are not neatly cut lines of activity, but dispersed zones of movement. Of the three types of motion: 1) sliding past each other; 2) converging and 3) diverging where the plates move apart; the islands of the eastern Caribbean, are an example of plates that are sliding past each other.

The Caribbean plate is moving slowly eastward, in relation to the North and South American plates. These plates are made up of land (continental crust) and ocean (Atlantic Oceanic crust) masses. As the Atlantic Oceanic crust is denser than the Caribbean crust, the Caribbean along the eastern Caribbean chain of island is driving down the Atlantic. This movement gives rise to earthquake and volcanic activity. The primary cause of damage to buildings by earthquake results from the ground shaking which is generated by the movement of tectonic plates.

The historical records of Saint Lucia contain many references to tremors and earthquakes felt by the island as the written records coin-



Location Map of Saint Lucia

cided with the arrival of Europeans in the mid 1600s. Although, the instrumental records are less than 100 years old, and they carry strong evidence of seismic activities in the region.

Damage due to earthquakes is rather small in Saint Lucia when compared to other neighbouring islands. A quick examination of past events indicates that Saint Lucia's concern should be for the cumulative effects of frequent tremors. History shows that the island is not exempt from major earthquakes. A 7.0 magnitude earthquake had hit the island on February 16, 1901, another earthquake of magnitude 7.5 occurred on March 19, 1953. In recent period, between 1990 to 1995 the island has experienced continuous earthquake activity with the highest registering earthquake of magnitude 4.5 on May 19, 1990 (refer to the tables in the right side and next page).

VOLCANIC HAZARD RISK

The most active volcanic center on the island is the Qualibou Caldera, which is located in the Southwest. This Caldera was formed over 35, 000 years ago. There are several volcanic domes within the Caldera Region. The only site of historic activity is at the Sulphur Springs. All descriptions of this area indicate that salfataric and funarolic activity has continued at a fairly constant level through historic time.

The one-recorded incidence of great disaster was observed in 1789. It seemed to have been a small pheratic eruption. Because the last explosion of this volcano dates back over 20,000 years ago, it is considered less likely to erupt in the near future as in the case of volcanoes in Saint Vincent, Martinique and Guadeloupe.

Despite the lack of recent explosive activities, there is evidence of activity at shallow depths below the region. This gave rise to the occurrence of several earthquake activi-

Earthquakes of magnitude 3.5 and above occured between February 1990 and November 1995 in Saint Lucia

Year	Month and date	Magnitude
1990	February 5	4.0
1990	May 19	4.5
1990	May 23	3.6
1990	July 2	3.5
1990	July 25	3.5
1991	July 18	3.9
1991	November 27	3.5
1992	May 5	3.8
1992	September 20	3.6
1992	September 20	3.6
1992	November 1	3.5
1993	July 30	3.7
1993	September 23	3.7
1994	January 5	3.6
1995	March 5	3.7
1995	November 8	4.3
1995	November 25	3.8

ties through out the decades. The most recent one started in May 1990 and went on afterwards for about 14 months.

Several thousand people actually live within the Caldera and a few km away from the Soufriere Springs. The population of Soufriere at the 1990 census was 7683. The vulnerability factor therefore is high. The hazards posed by the volcano are all associated with its violent eruptions.

EXISTING HAZARD MONITORING SYSTEM

The Seismic Research Unit in Trinidad maintains four high sensitivity seismographic stations on the island. While *Le Observatoire Volcanoloqiue de la Montagne Pelee* in Martinique maintains one station. These are sufficient to detect initial abnormal conditions. By means of this system, the relevant authorities can be provided with advanced notice so as to evacuate threatened population.

TRADITIONAL ARCHITECTURE

The traditional architecture, though lacking in pretensions, are collectively a monument no less important to a once strong native building tradition which we have virtually lost. The architectural tradition of Saint Lucia and her sister islands come from many sources through a long period.

One of the main sources was Amerindian people. Amerindians were sea faring people. The modern fisherman's hut, canoe, fishing nets and baskets of Saint Lucia are all influenced by Amerindian culture. Their construction style made their houses cool, rainproof and flexible, which were the elements needed on an island that can experience constant earth tremors, sweltering heat and hurricanes. This construction style is referred to as "*fuchette en terre*" this is where a 'Y' shaped piece of wood was dug deep into the ground and the 'Y' end support the roof.

Next comes the influence of Europeans. The time frame of influence of the Europeans ranges approximately from 1600 to 1950. This covers about three hundred and fifty years of European architectural influence. Saint Lucia became more valuable as the years went by, mainly because of the magnificent natural deep-water harbor at Castries, which was and still is protected on three sides by hills. Today the areas surrounding Castries are dotted with numerous military buildings. These once impressive and imposing structures have been converted and absorbed into civilian life.

The main building material of historical structures in Saint Lucia were stone. They have withstood wars, fires, hurricane and earthquakes. However, the combined onslaught has begun to have an effect on the structures.

The earliest Churches on the island were usually built of timber with a thatch roof and stone paved floor, reminiscent of Amerindian construction. These Churches were damaged or destroyed by the devastating hurricane of 1780 except the Church at Dauphin, which was constructed of stone. The Churches were rebuilt using stone to resist hurricanes and the earth tremors. Despite this precaution, cracks occurred in many Churches due to tremors.

Not long after the Europeans settled themselves in the Caribbean, the slave trade began. The Africans were discouraged from bringing with them their languages, religions, music or anything remotely cultural. In reviewing the architectural aspect of the island's African heritage, it is a miracle that anything remotely African remained to influence society. At the time of emancipation, many of the slaves were not

Earthquakes of 1990 in Saint Lucia

Month and date	Magnitude
February 5	4.0
March 18	3.0
April 16	3.3
May 18	3.4
May 19	4.5
May 23	3.0
May 23	3.6
June 1	3.3
July 2	3.5
July 7	3.9
July 25	3.5
August 1	3.2
August 25	3.4
September 9	3.3
September 30	3.2
October 13	3.3
October 25	3.2
October 26	3.0
November 4	3.0

directly from Africa, but born and raised in Saint Lucia. In 1838, when slavery was finally and completely over, two-thirds of Saint Lucia was under virgin soil belonging to the crown. Land was readily available for the people for construction.

The hillside houses (known as Tapia) evolved and remains an identifiable feature in Saint Lucian society. These structures are made of timbers. Small saplings made the frame of the structure while mature trees were held in place by the dead weight of the structure, forming the foundation. The splitting of further trees provided the cladding. The floor, which is also of timber, is raised slightly off the ground to allow for ventilation of the beams and to avoid moisture penetration while accommodating the gradient of the island. The material of choice was timber not stone, as timbers were readily available. Without the proper tools, stone is a difficult material to manipulate, while timber is fairly malleable and can resist both hurricane and earthquake forces. As time moved on, hand cut saplings were replaced by machine cut lumber and piles of stones were replaced by concrete blocks or reinforced columns. Individual lots became hamlets and then communities. With each new building erected, the design of the structures became more sophisticated. Interestingly, timber remained the material of choice. The Tapia dwelling can be seen almost everywhere on the island, from Gros Islet in the north to Vieux Fort in the south, even in developed areas such as Castries.

With the advent of modernism, many buildings on the island are made of reinforced concrete with flat roofs and large glazing. The design of most of the office buildings in Saint Lucia are influenced by this modern style. Due to large destruction of hurricane Allen August 1980, the Saint Lucia had to be rebuilt in a short period. Due to the short period of constructions, many schools were constructed of pre-stressed concrete slabs. Most of these new buildings were ground floor structures, which are considered to be relatively safer during an earthquake. However, many of the new buildings in the city are of reinforced mass concrete erected on reclaimed land. These new buildings are very much vulnerable to earthquake and soil liquefaction.

PROBLEMS

The tendency to build on reclaimed land is increasing in Saint Lucia, although the trend is not yet rampant. Such land heightens ground movement e.g., the vibrations of heavy goods vehicle can be felt by the occupants of nearby structures. Therefore, the effects of an earthquake on structures placed on such soil are magnified many times over.

Destruction from earthquakes in Saint Lucia could be worse than it is at the moment given the lack of seismic design standards for virtually all construction. Added to this deficiency is the probability of major landslides being triggered by these quakes.

Another concern is design of structures in areas prone both to hurricane and earth tremors, with two kinds of movements. Hurricane forces move in a horizontal fashion while earthquake forces move in a vertical fashion. It is difficult to design a structure for both. Therefore, despite the inevitable earth movement, Saint Lucians have decided that the annual hurricane season, from June to November, is more of a threat. Despite statistics, which could prove otherwise, the reality of Saint Lucia's situation is that residents do not consider the island as " earthquake country" and therefore they design for the perceived threat from hurricanes and not from earthquakes.

RECOMMENDATIONS

A disaster upsets infrastructure and ecosystems and puts strain on the already limited resources of a developing State like Saint Lucia and her citizens. Such a situation can set dangerous precedents of dependency and underdevelopment. Sustainable development for a society like ours is not possible without addressing the damage done to development as the result of a disaster, particularly earthquakes in case of Saint Lucia.

How one responds to or during an earthquake is not something to be decided during the event. Preplanning or preparedness is the key. Mitigation against any disaster requires cooperation. As such, there should be cooperation between social, economic and political actions from local, regional and international governments. Also the communities and their corresponding groups can play an important role and so must be encouraged to take part in such actions.

Some approaches that can be taken to mitigate earthquake effects are:

Culture: The mitigation activities of a community must be acknowledged and incorporated into any action plan. Many people execute a tradition without knowing why. Traditional buildings have the ability to withstand both earthquake and hurricane forces. In addition to which it is cheap and easy to build and in many cases, this is the main concern of individuals. Mass concrete or concrete blocks replace many timber structures as these materials are perceived as stronger and are used as a measure of an individual's financial success.

Information: It must be ensured that the public is aware of alternate traditional construction practice, emergency plans, what they entail and what their role is in the plan. Attempts have been made to educate and inform the various publics on response actions to an event. One must ask though is it enough? Does the public know how to react during an earthquake? Creating the posters and flyers and distributing them may not necessarily mean that the message is being perceived or received. Sectors such as the media, construction industry, schools etc., must be sensitised. Is interest in an event only triggered by the event? In other words, will members of the population only be interested in earthquakes the next time a series of quake occurs?

Preparedness: It must be acknowledged that the successful management of a risk is dependent on the level of preparedness of the area to be affected. Many craftsmen are still available in the community and are willing to hand down the skills as they were handed down to them. This should be encouraged.

Cooperation between Sectors: Disaster Managers need to be incorporated into the planning process while Planners should be involved in disaster reduction in an effort to forge a closer working relationship for a more comprehensive and holistic approach to development.

Development Control: The examination of landslide prone areas should become a material consideration for developments. Environmental Impact Assessments (EIA) are already required for certain developments, however governmental EIA for state property would provide a representation of the risk factor of the area under consideration for development.

Landuse: Development of areas should be based upon hazard and mitigation plans. Development in high-risk areas should be firmly discouraged. Should such land need to be developed, it should be reserved for projects considered as least critical facilities.

Building Codes: In the absence of a national building code, a suitable code for interim use is the Caribbean Uniform Building Code (CUBiC). CUBiC places Saint Lucia in a Z factor of 0.75, which equates to a zone 2 and 3 of the USA Uniform Building Code (UBC). The level of activity is Saint Lucia is thus moderate but not to be ignored. A structure built using seismic building codes is expected to fare better then one that does not. One of CUBiC's many recommendations are that the buildings should be symmetrical. This is a feature common among the vernacular architecture of Saint Lucia and a practice that of late is being exercised less and less.

Government Control: Land with high landslide risk should be declared to potential investors. Such declarations would have resulting consequences in the banking and insurance sectors.

Insurance: Insurance should be related to the level of hazard under consideration and the mitigation steps being taken. The important issues such as proper consideration of building regulations in structure design are to be incorporated in insurance policy. Such policies will motivate people to adhere the strict building design codes in construction practice.

CONCLUSION

Saint Lucia has been blessed with infrequent fatal events of earthquakes. However, it experiences frequent tremors of low magnitude. The last earthquake of significance was in 1990 when the island experienced a quake of magnitude 4.5. It caused the collapse of a bridge. Due to long intervals between major earthquakes, developments spring up in areas which are vulnerable against major earthquakes. Awareness of citizens should be increased against such infrequent but catastrophic events. Design codes should be improved to consider such adverse affects. There are lessons to be learnt from the traditional construction practices and these lessons should be utilized in present day construction of the fast paced modern world.

***From Editor's Desk**: This article was originally submitted to INCEDE Newsletter by Dr. French, Who is our network member. Due to unavoidable circumstances, it remained unpublished. We have decided to publish it in ICUS/INCEDE Newsletter.*

Second ICUS/INCEDE Open Lecture on January 24, 2002

On January 24, 2002, ICUS/INCEDE is going to organize an open lecture titled 'Towards the Safe Cities in 21st Century' by inviting some prominent Japanese researchers and decision makers as speakers. The main speakers in this event will be Dr. T. Katayama, Director General, National Research Institute for Earth Science and Disaster Prevention; Mr. T. Takahashi, Director for Disaster Management, Cabinet Office, Government of Japan (and Visiting Professor at ICUS/INCEDE) and Prof. S. Murai, Professor Emeritus, University of Tokyo. The speakers will focus on various aspects of urban risk management in their presentations.

The Lecture will be held from 13:00 - 17:30 at the Seminar Hall of the Institute of Industrial Science, University of Tokyo. This will be the second Open Lecture organized by ICUS/INCEDE. The series of Open Lectures are organized with the aim at building a forum for sharing knowledge and information between experts and general public. You are most welcome to participate in the second ICUS/INCEDE Open Lecture.

ICUS/INCEDE Workshop on Urban Safety Engineering in Thailand

Prof. T. Uomto, ICUS/INCEDE Director, during his opening speech

ICUS/INCEDE organized a workshop on 'Urban Safety Engineering 2001' at the Asian Institute of Technology (AIT), Thailand during September 21-22, 2001. The workshop mainly focused on three areas: 1) the tools: Remote Sensing, GIS, GPS, etc., 2) the object of risk of urban structures, and 3) the management and mitigation policy of disaster. The major objectives of the workshop were: 1) promoting better understanding between the researchers from prominent research institutes in Thailand and ICUS/INCEDE in the areas of urban safety engineering and environment, and 2) identifying possible areas for future collaborative research. The future collaborative research works are expected to emphasize on: a) development of the inspection method and enhancement of durability of urban structures; b) preparation of synthetic hazard map and development of the real-time monitoring technology; and c) preparation of the effective disaster-prevention manual.

The first day of the workshop was designed as plenary meeting with distinguished speakers from the University of Tokyo, AIT, Chulalongkorn and Thammasat Universities of Thailand. The workshop was kicked off with two opening speeches from Prof. Worsak Kanok-Nukulchai, Dean of School of Civil Engineering, AIT and Prof. Taketo Uomoto, Director of ICUS/INCEDE. It was followed by technical presentations. A total of 14 technical papers were presented by the researchers from Japan and Thailand. The workshop was attended by about 50 participants including the researchers and students from AIT. At the end of first day of the technical sessions, a technical visit was arranged for the participants to the laboratories of the School of Civil Engineering and Asian Center for Research on Remote Sensing (ACRoRS) for demonstration on the their research facilities and ongoing projects.

The second day was devoted for a close consultation on proposed activities of ICUS/INCEDE for collaboration with Researchers from Thailand, which hopefully can be extended to include a full international network in future. First, the participants introduced the research topics of their own interests and it was followed by a lengthy discussion to identify the most important research issues in urban safety engineering in Thailand where ICUS/INCEDE can participate as a collaborative organization and can support in transfer of knowledge and technology. The areas identified as the focal areas for future collaboration are grouped into three categories:

Participants pose for a group photo at the end of the workshop

1) improvement of sustainability of urban structures, 2) prediction, assessment and management of natural and artificial disasters, and 3) information technologies and systems for urban safety.

Finally, a resolution was made by the workshop participants where it was agreed that continued cooperation between researchers and practitioners in participated institutes be encouraged, and mechanisms for improved technology exchange and sharing be explored, and based on the results of this workshop, opportunities for collaborative research and information sharing should be further explored, and potential funding sources for such collaborative research should be identified and contacted within Japan and Thailand. The participants recognised the need to closely monitor the work identifying joint projects and share information. To this end, it was resolved that the next meeting of the research team may be held in 2002.

A report of the proceedings of the workshop is currently being prepared at ICUS/INCEDE. Those who are interested to receive a copy of the report may contact us.

(By D. Dutta)

International Events participated by ICUS/INCEDE Staff

Prof. T. Uotomo, Director of ICUS/INCEDE participated in two international conferences: 1) International Conference on Fibre Reinforced Plastic for Reinforced Concrete Structures (FRPRC-5) which was held in Cambridge during July 15-20, 2001, and 2) Second International Conference on Engineering Materials held in San Jose, California, USA during August 16-21, 2001.

Prof. Y. Yasuoka participated in the Eighth Asia-Pacific Regional Space Agency Forum held during July 23- 25, 2001 in Kuala Lumpur, Malaysia. In this forum, he chaired a session "Earth Observation - Integrated Monitoring System", and gave a special lecture "Integrated Monitoring System for Environment and Disaster Management with Earth Observation Satellite".

Dr. K. Meguro participated in the "Peru-Japan Joint Workshop on Earthquake and Tsunami Disaster Mitigation in the Asia and Pacific Region" held during July 19-20 in Lima, Peru and carried out site investigation of Atico earthquake.

Editor's Note

By the time this newsletter reaches you, we will step into the dawn of 2002. I would like to take this opportunity to express my best wishes to all the readers for a happy and prosperous new year.

With a decade long experience of INCEDE in disaster mitigation engineering, ICUS/INCEDE expands the center activities to urban safety issues. Together with the expanded research areas, we are continuing many of the activities initiated by INCEDE, one of those is the publication of this quarterly newsletter. We also continue the INCEDE networking with various members around the world. The main article of this newsletter was originally submitted for INCEDE newsletter by a network member. We hope to receive the contributions of the network members to this newsletter as before.

Many of us have the illusion that once the buildings and infrastructures are built, they will last long without any maintenance. In reality, urban structures are not safe and long lasting without proper maintenance. We have got the proofs in Japan through many recent incidents such as, falling of concrete in tunnels, etc. With the rapid urbanization, our cities are getting full of structures. We have to find out the ways to maintain the safety of our urban environment. ICUS/INCEDE carries out research on finding innovative methods for urban safety. Recently, we have organized a workshop on Urban Safety Engineering in Thailand. Through this workshop, we have identified many common areas of interest for future collaboration with the researchers from Thailand. We would like to work together to share our experiences with the research communities from other countries too. We encourage you to write your ideas to us. Let us work together for urban safety.

(D. Dutta)

ICUS/INCEDE, Institute of Industrial Science, The University of Tokyo
4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan
Tel: (+81-3)-5452-6472, Fax: (+81-3)-5452-6476, http://icus-incede.iis.u-tokyo.ac.jp/

International Center for Urban Safety Engineering, ICUS/INCEDE
Institute of Industrial Science, The University of Tokyo
4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan