Wind Engineering
in the Caribbean Disaster Mitigation Project

Tony Gibbs[1]

Abstract

The Caribbean Disaster Mitigation Project (CDMP) lasted for 6 years (1993-99). It was funded by USAID and managed by the OAS. CDMP addressed the full range of issues related to natural hazard disaster mitigation - hazard studies, vulnerability analyses of existing facilities, demonstration retrofitting projects, post-disaster assessments, development of standards and codes, short courses and other training exercises. One of the more prevalent hazards in the Caribbean is the hurricane hazard. CDMP activities in this sphere included the development of wind hazard maps incorporating the specific topographic characteristics of the Caribbean islands; vulnerability analyses, post-disaster assessments and design recommendations for electricity transmission systems; vulnerability analyses and the development of procedures for retrofitting hurricane shelters; insurance-related loss reduction incentives. A feature of CDMP was the interaction of scientists, practising engineers and administrators. Another feature was the significant involvement of Caribbean professionals alongside specialists from North America. The paper deals principally with the wind engineering components of CDMP.

Introduction

"Every street was impassable, every roof was gone, every lane closed up, shingles and immense pieces of wood, stone, and bricks were knee deep in the streets.... The greater number of the houses were levelled with the earth or unroofed; the largest trees were torn up by the roots, or their branches were twisted off them.... The wind rushed under the broad verandahs, tore off the roofs, demolished the walls, and the pillars were levelled in rows.... The country villas were no more, and the once beautiful and smiling scenery was now also gone. No vestiges remained of the woods and the groves of palms, and even the soil which produced them was washed away; almost all the public buildings were razed to the ground."

This description of the 1833 hurricane in Cuba by James E Alexander[2] could so easily (with some poetic license) be applied to Dominica after David in 1979, to Jamaica after Gilbert in 1988, to Montserrat after Hugo in 1989 and to Sint Maarten after Luis in 1995. *Plus ça change, plus c'est la même chose*. But now we intend to make a difference. Changes should now come about because of improved hazard mapping, better design standards documents, legislated and enforced codes, more training of professionals and technicians and the cooperation of the catastrophe insurance industry.

I am grateful to the organisers of this Conference, and to the Organisation of American States, for giving me the opportunity to describe the wind engineering aspects of the Caribbean Disaster Mitigation Project whose six-year life came to an official end in 1999.

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[2]Transatlantic Sketches, 2 vols. (London 1833), 1:171-72.

Justification

Insurance

In the early 1990s property insurance rates in the Caribbean rose to intolerably high levels. Although there have been significant reductions since then (except in the north-east Caribbean) the current rates are still substantially higher than they were ten years ago. Certainly, at the inception of the planning for the Caribbean Disaster Mitigation Project (CDMP) the high insurance premiums provided a significant incentive for serious action to be taken.

Tourism

Tourism is the economic life blood of the Caribbean region. With the exception of Trinidad & Tobago (with its oil, gas and related industries) the major source of foreign exchange earnings for the islands is tourism. Typically, tourist facilities are located in the very vulnerable coastal zones of the islands. There was, and continues to be, a clearly perceived need for the better protection of tourism properties from hurricanes and other natural hazards.

Hazard Mapping

The few existing hazard maps of the region were generally outdated and of limited use at the start of the project period. Those who wished to take rational approaches to the design of buildings and other facilities, resistant to natural hazards, did not have sufficient reliable information in the appropriate form for rigorous analysis.

Now, at the formal end of CDMP, the region has a greatly expanded range of hazard maps with greater detail and of much improved reliability. This activity is also continuing after CDMP, and as a result of CDMP.

Small Island States

Then there are the special concerns of small islands which comprise most of the states in the Caribbean. Small islands can be impacted totally by a single event such as a hurricane and an earthquake. Hurricane Gilbert affected the whole of Jamaica in 1988. In 1974 the whole of Antigua was affected by a single, moderate earthquake. In a small, isolated island there is no place to hide. Small islands are likely to have one referral hospital, one deep-water port, one large airport, one major power-generating plant, one external telecommunications centre. The isolation of such islands makes for more difficult logistics in receiving assistance after a national disaster. The logic is that such critical facilities in small islands should be designed to safer standards than similar assets in larger countries with multiple facilities.

Recent Events

Hurricane David swept through the Caribbean and into North America during the period 27th August to 4th September 1979. In the Caribbean the devastation was particularly severe in the Commonwealth of Dominica and in the Dominican Republic. In the Commonwealth of Dominica the losses amounted to more than 100% of the gross domestic product (GDP). Hurricane Gilbert caused severe structural damage in the Caribbean and North America during its passage from 11th to 19th September 1988. The Caribbean country most affected was Jamaica where the losses amounted to about 65% of GDP. Hurricane Hugo was the sixth hurricane of the 1989 Atlantic season. It hit the Leeward Islands in the Eastern Caribbean causing serious damage to Dominica, Guadeloupe, Montserrat, Antigua, St Kitts, Nevis and The British Virgin Islands. Hurricane force winds lasted from 14th September to 23rd September. In Montserrat direct losses amounted to about 200% of GDP. Hurricane Andrew was a fast-moving, compact storm of great intensity (Category 4) which impacted on The Bahamas. In the wealthy island of Cat Cay (Bahamas) the losses to expensive homes amounted to about 50% of the property values. Hurricane Luis was a classical Category-4 hurricane of near-perfect shape. It affected several of the islands in the north-east of the Caribbean. Wave and water damage to infrastructure was significant in Dominica, St Kitts and The British Virgin Islands. Wind damage was most severe in Antigua & Barbuda, Sint Maarten and Anguilla. In Antigua the overall damage was of the order of 65% of GDP. Direct losses in Sint Maarten amounted to 100% of GDP with indirect losses adding another 100% of GDP.

Overview of CDMP

Predecessor Programme

In the decade of the 1980s the Caribbean benefited from the first regional large-scale programme having to do with "disasters", mainly those attributed to natural hazards. That programme was called The Pan Caribbean Disaster Preparedness and Prevention Project (PCDPPP). As the name implies, PCDPPP had a specific damage mitigation mandate. However, during the course of its ten-year life, preparedness activities gradually became dominant over prevention activities. A programme such as CDMP was necessary to redress the balance.

CDMP was aimed at building on past and present regional initiatives. Certainly the work of PCDPPP provided part of the foundation for CDMP.

Period and Management

The Caribbean Disaster Mitigation Project (CDMP) lasted for six years (1993-99). It was funded by the United States Agency for International Development (USAID)[3] and managed by the Organisation of American States (OAS) through its Unit for Sustainable Development and Environment[4].

The original five-year period for the project, with the addition of a sixth year, provided unusual opportunities for implementing a flexible programme which benefited from feedback of participants and other stakeholders. This local and regional interactivity created the necessary conditions and made it possible to cater for changing needs. The flexible approach and long project period also permitted follow-up activities to the earlier programmes within CDMP. In a few cases CDMP activities were tested by hazardous events before the end of the six years.

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[3]USAID - Office of Foreign Disaster Assistance (OFDA) and, in particular, the Regional Disaster Advisor based in Jamaica

[4]OAS - Unit for Sustainable Development and Environment (USDE) and, in particular, the Caribbean Division team

Notwithstanding the six-year period and the reasonably large funding, it would not have been possible to execute significant percentages of the programmes needed by the region. Therefore, the CDMP approach was to carry out pilot projects or demonstration projects in sufficient detail and sufficiently well documented that they could be replicated more widely using other resources during and after the CDMP six-year period.

Components

Training of professionals, technicians and artisans was an important aspect of the CDMP programme. Training exercises were carried out nationally and regionally.

Institutional capacity building played an important part in CDMP. The programme management early on recognised the need to address the persistent obstacle of institutional weakness if significant headway was to be made in reducing the vulnerability of the region to its several natural hazards.

CDMP addressed most of the natural hazards of the Caribbean - earthquakes, landslides, hurricanes, waves, storm surge, torrential rains. Volcanic activity and tsunamis were not specifically addressed. (In such an environment life is uncertain, hence in the Caribbean we eat desert first.) Particular emphasis was placed on hurricane winds, waves, storm surge. This paper will deal principally with the hurricane hazard.

CDMP addressed the full range of issues related to natural hazard disaster mitigation - hazard studies, vulnerability analyses of existing facilities, demonstration retrofitting projects (in sixteen countries), post-disaster assessments, development of standards and codes, short courses and other training exercises. It also addressed community-based preparedness (including the provision of handbooks on hazard-resistant building practices), the promotion of damage mitigation in the insurance industry and damage mitigation in post-disaster recovery.

The Caribbean Disaster Mitigation Project is likely to have a lasting impact on the region.

The Hurricane Hazard

The Common Threat

The most prevalent hazard in the Caribbean is the hurricane hazard. CDMP activities in this sphere included the development of wind hazard maps incorporating the specific topographic characteristics of the Caribbean Islands; vulnerability analyses, post-disaster assessments and design recommendations for electricity transmission systems; vulnerability analyses and the development of procedures for retrofitting hurricane shelters; insurance-related loss reduction incentives; and support for the adoption of formal standards and codes.

Hazard mapping formed one of the more-important components of CDMP. Mapping was also carried out for the seismic hazard but it is the hurricane hazard that will be dealt with in this paper. The principal tool used for hurricane hazard mapping was The Arbiter of Storms (TAOS).

The Arbiter of Storms (TAOS)[5]

[5] Assistance in the preparation of this subsection was provided by Dr Jan Vermeiren, OAS, Washington.

TAOS was developed in the early 1990s as a computer-based numerical model for tropical storm hazard assessment, producing estimates of maximum sustained surface wind vectors and maximum still-water surge and wave heights for any location in the Caribbean basin. The model relies on a generic data base structure, using US Geological Survey digital data for deep ocean bathymetry, US Defence Mapping Agency digital data for land boundaries and rough topography, satellite imagery for foreshore bathymetry and land cover and the National Hurricane Centre data base for storm data. Model runs can be made for any historical storm or for probable maximum events associated with different return periods. Model outputs can be exported to common GIS formats.

A technical description of the TAOS model is available in the document "Design, Implementation and Operation of a Modular Integrated Tropical Cyclone Hazard Model"[6]. The statistical approach to return period estimation is discussed in detail in the document "Hurricane Return Period Estimation". A more detailed description of CDMP applications of the TAOS/L model is available in the document "The TAOS/L Storm Hazard Model and CDMP TAOS/L Applications". All of these documents can be viewed on the OAS/USAID-CDMP website: www.oas.org/en/cdmp

The TAOS model has evolved dramatically since the early days of the CDMP. TAOS is now a storm hazard modelling platform which consists of multiple modules addressing various aspects of the storm hazard modelling problem, such as wind fields, wave generation and propagation, damage functions, *etc*. These modules can be combined so that the appropriate methodology for the problem at hand is used to generate the products desired by the user. The number of modules and combinations has grown over time as new advances in wind field, wave and surge modelling are "modularized" and added to the system. At present there are 12 primary wind modules, 5 storm surge modules, 3 rain and surface runoff modules and 4 wave modules available within TAOS.

These modules range in sophistication from simple parametric approaches which it can execute in seconds to full 4D physics models requiring days of run time on a 32 parallel-processor supercomputer. If various module options are included, such as surface friction methods, dune erosion, damage functions, orographic enhancement code, infiltration modules, *etc*, there are literally thousands of possible solutions for a single event.

Applications of TAOS

In 1997, for the Montego Bay (Jamaica) Coastal Hazard Assessment, TAOS results were used within a statistical framework to estimate surge heights for various return periods. The return-period approach developed for Montego Bay was subsequently used to develop return-period-based maps for the State of Florida and, as part of the Kingston Multi-hazard Assessment, similar information was produced for that city and its environs. In conjunction with the Kingston assessment, regional storm hazard information for the entire Caribbean basin was developed. This data set contains estimates of maximum surge, wave height and wind speed for 10-, 25-, 50- and 100-year return periods. These estimates are available for each cell in the Caribbean grid at 30-arcsecond (approximately 1 km) intervals. The products of this work are now available in electronic form.

The specific use of TAOS for mapping wind speeds over land is dealt with at the end of the following subsection.

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[6]Charles C Watson Jr and Mark E Johnson, Watson Technical Consulting Inc, Rincon, GA; University of Central Florida, Orlando, FL; presented at the 23rd Conference on Hurricanes and Tropical Meteorology of the American Meteorological Society, Dallas Texas, 1999.

Topographic Effects on Wind Speeds

Of particular interest is the development of wind hazard maps incorporating the specific topographic characteristics of the Caribbean Islands.

Recent hurricane events in the Caribbean have demonstrated the significant influence of topography on the levels of damage caused by the wind. When Hurricane David struck the island of Dominica in the Eastern Caribbean in August 1979 the most dramatic damage was experienced in the Roseau Valley. The winds parallel to this valley were accelerated to such an extent (by the Venturi effect) that some reinforced-concrete structures were totally destroyed in a manner more reminiscent of severe earthquakes. When Hurricane Marilyn struck the island of St Thomas in the US Virgin Islands in September 1995 the most dramatic damage was experienced along the ridges of the mountain ranges. Although Hurricane Marilyn was only a strong Category-2 or weak Category-3 event, the damage along the ridges was such that the local population was convinced that St Thomas had experienced a Category-5 event.

Although most modern wind-loading standards provide guidance and procedures for addressing this issue, the adjustment factors given in these documents do not fairly represent the range of effects experienced in the dramatic topographies of many Caribbean islands. The topography factors (applied to wind speeds) in the present Caribbean standards range from 0.9 for sheltered areas to 1.1 for exposed areas. Experience has shown that the latter factor should be of the order of 1.2, leading to an additional 20 percent or so (for wind forces) over the present "high-exposure" factor.

There is important past and ongoing research addressing the issue of topographic effects on wind speeds. Some of the research has been by model testing but most of it has been theoretical. Most of the studies have been two-dimensional but there is some three-dimensional work for which the results are available.

In 1985, as part of the CUBiC project, The University of Western Ontario (Davenport, Georgiou, Surrey) carried out wind tunnel tests on a model of the Eastern Caribbean island of Nevis. Nevis is a small island with dramatic but relatively simple topography. A 1:3000 scale model was mounted on a turntable at the Boundary Layer Wind Tunnel Laboratory of The University of Western Ontario (BLWTL-UWO). Wind speed measurements were made at several locations representative of different topographic conditions on the island.

The wind hazard assessment in the TAOS regional storm atlas was produced on a multi-processor computer, using a modified SLOSH[7] wind module, which includes surface friction and orographic factors. The TAOS wind module uses simple storm parameters such as maximum surface wind speed, central pressure, radius of maximum winds and forward speed to compute the wind distribution through the storm. Winds are computed at a specific location of interest via a boundary layer model that incorporates surface terrain and topography upwind of the target location. Therefore, wind effects such as orographic enhancement, wind shadows and valley effects are simulated. The opportunity should be taken to compare the 1985 model-test results with those generated theoretically by TAOS.

Electrical Power Systems

[7]SLOSH = Sea, Lake and Overland Surges from Hurricanes

General

Highly specialized facilities, such as ports and electrical power generation networks, require specialized treatment as well. CDMP has assisted the Caribbean Electrical Cooperative (CARILEC) and its member utilities by the development of the "Manual for Caribbean Electrical Utilities Addressing the Issue of Mitigation of Damage Caused by Natural Hazards to Civil Works"[8], and by conducting vulnerability audits for hydroelectric power facilities in Dominica, electrical power facilities in St Lucia and transmission and distribution systems in St Vincent and the Grenadines. Subsequent to Hurricane Luis, CDMP undertook a case study of its effects on the Antigua Public Utilities Authority. Further information on these studies is available on the CDMP's Papers and Publications web page.

Two of these sub-projects are of particular interest to the wind engineering community.

St Vincent Electricity Services Ltd (VINLEC)

Applied Research Associates (ARA) carried out a hurricane risk study for the electrical power transmission and distribution (T&D) system on the island of St Vincent. The study included the modelling of the hurricane hazard including the effects of wind direction, topographic and terrain effects on the hurricane wind speeds, wind load and response estimates of the T&D structures and the prediction of annual failure probabilities and annual failure costs associated with failure of parts of the system in hurricane winds. The study modelled the entire transmission system on the island combined with an approximate modelling of the distribution system. Benefit-cost estimates were performed where the cost of upgrading portions of the system were compared to the future benefits expected as a result of fewer failures due to hurricane winds. The report also discussed in detail the methodology used to estimate the response of the transmission and distribution system to wind loads, as well as discussing the methodology used to estimate the probability of failure given the occurrence of a particular wind speed.

The study of the St Vincent T&D system undertaken by Peter Vickery of ARA is believed to be the first comprehensive study examining the reliability and potential vulnerability of electric power systems to hurricanes in the Caribbean.

Antigua Public Utilities Authority (APUA)

In 1995 Consulting Engineers Partnership Ltd (CEP) carried out field surveys and analyses of the facilities of the Antigua Public Utilities Authority's Electricity Section (APUA-Elec) which were impacted by Hurricane Luis. The buildings and the transmission and distribution systems were investigated. Recommendations were given for future action so as to reduce vulnerability to hurricanes. In particular, specific standards were prescribed for rehabilitation and for future capital works projects. Notwithstanding the damage suffered by APUA-Elec, the results of Hurricane Luis in Antigua indicated clearly that success is possible. By success is meant the limiting of losses in Category-3 hurricanes to tolerable levels (low, single-digit percentages) and ensuring that Category-4 hurricanes do not lead to national disasters with losses approaching the GDPs of these small countries.

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[8]Tony Gibbs, Consulting Engineers Partnership Ltd, 1996

Emergency Shelters[9]

General

Throughout the world, including the Caribbean, natural hazards cause as much damage to educational facilities as they do to buildings of less importance. This is both regrettable and avoidable. Educational facilities deserve special attention because of their roles during the active periods of hurricanes and also as post-disaster assets.

It is traditional for schools to be used as hurricane shelters. It goes without saying, therefore, that the damage and destruction of schools would put the sheltered population at risk during severe storms. Also, the use of school buildings for temporary housing after hurricanes would not be facilitated by damage and destruction of such schools. The longer-term problem of loss of educational facilities is arguably even more severe. If the children are not at school the parents' work is often adversely affected (in part because of "baby-sitting" problems). There is also the inevitable disruption of the pupils' educations.

It is often said that safe buildings may not be affordable, especially in relatively-poor developing countries. This is a fallacy. Particularly with respect to hurricane resistance, safe buildings are not only technically feasible but also achievable at very modest cost. This thesis has been tested and confirmed on several occasions over the years.

In most countries throughout the Caribbean, it is difficult to obtain information about the condition of school buildings. The record-keeping systems often do not allow easy access to basic information about school or shelter buildings such as the date of construction, design type, as-built drawings, or the donor institution that financed the construction. Before the problem of vulnerable school buildings can be addressed, the first step is to create a database or profile of the existing stock of school buildings. It is necessary to know what types of hazards are prevalent in the area and how the building will perform if faced with these hazards.

Vulnerability Assessment of Shelters in the Eastern Caribbean

The CDMP carried out qualitative evaluations of ninety properties (mainly schools and community centres) earmarked to be used as emergency shelters in five Eastern Caribbean states (Anguilla, Antigua & Barbuda, Dominica, Grenada, and St Kitts & Nevis).

In carrying out the evaluations for vulnerability to the wind hazard, use was made of the Wind-Rite software produced by the Insurance Institute for Property Loss Reduction[10]. It was found that final assessments required a considerable amount of judgement to be applied to the Wind-Rite results. This was due, in part, to the inapplicability (building categorisation, damage curves and materials) of the software to regions outside of the USA.

The CDMP programme was originally aimed at assisting the target states in selecting properties for retrofitting using implementation funding from the Caribbean Development Bank (CDB).

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[9]This project was undertaken in collaboration with the European Community Humanitarian Office (ECHO).

[10]Since 1997 it is known as the Institute for Business and Home Safety (IBHS).

As part of this sub-project, a master manual[11] of standards for the evaluation, retrofitting or construction of schools/shelters and for estimating the costs was developed. This manual, as well as the individual reports describing results of the property surveys, are available on the CDMP website.

At the end of the sub-project a workshop was held in St Kitts to present the work to a broader audience from the sub-region.

Tourism

Tourism is central to the economy of many countries in the Caribbean. To help secure this critical economic lifeline, CDMP collaborated with the Caribbean Hotel Association/Caribbean Tourism Organization (CHA/CTO) in the 1998 update to the Hurricane Procedures Manual. CDMP developed the structural vulnerability reduction chapter for his Manual.

The Manual is being widely used, especially in the north-east of the Caribbean which has suffered repeated losses in the past decade. This programme is beginning to make an impact. The CHA holds workshops on vulnerability assessments and promotes surveys of properties.

Small Homes - Pilot Retrofit

General

Through pilot projects in several Eastern Caribbean countries, beginning in 1994/95, the Caribbean Disaster Mitigation Project (CDMP) aimed to assist large and small contractors, artisans and others working in the formal and informal building sectors in adopting effective natural hazard vulnerability reduction measures. Assistance to the local building sector was provided through training workshops for builders and artisans, safer construction manuals and minimum standards checklists and the provision of revolving loan funds for supporting housing retrofit work. CDMP safer housing activities were coordinated by local non-governmental organizations, with technical assistance from the Cooperative Housing Foundation, a US-based international NGO[12].

National Programmes

Through national pilot projects, the CDMP has developed, tested and disseminated the technical know-how to make homes secure enough to withstand even Category-3 hurricanes. To be effective, however, these ideas need to be implemented and financed at the national level. In September 1999, the CDMP organized a regional workshop on safer housing, to provide a forum for national policy makers, housing practitioners, and financial institutions to discuss the incorporation of hurricane resistant housing techniques into national housing policy initiatives and to examine financing options that will make funds available to the greatest number of families. By including these techniques at the national level, the majority of families will be able to have the information for safe construction methods, but more importantly they will have the necessary financing to build or

[11]"Vulnerability Assessment of Shelters in the Eastern Caribbean - including Retrofitting, Terms of Reference for Consultants, Standards, Global Estimates" by Tony Gibbs, Consulting Engineers Partnership Ltd

[12]Non-governmental organisation

improve their homes to withstand the catastrophic winds and rain of the Caribbean's potentially-deadly hurricane seasons.

Standards and Codes

CUBiC and National Standards

In the Commonwealth Caribbean standards for the design and construction of buildings are provided in the Caribbean Uniform Building Code (CUBiC). These technical standards are being incorporated by reference in most of the national building codes in the region.

As a matter of particular interest, the wind loads section of CUBiC was developed by Professor Alan Davenport. The ISO standard 4354 and CUBiC:Part-2:Section-2:Wind-Load were drafted contemporaneously in the 1980s by Davenport. Whereas CUBiC became a published standard by 1985, the ISO standard remained in draft form until 1997. Because of the contemporaneous drafting by the same person, it is not surprising that there are great similarities in format and approach in the two documents. ISO 4354 is not, however, a complete standard. It is a standard to guide those who are preparing their own national standards. For example, no listing of basic wind speeds (or pressures) is given. In CUBiC such information is provided in the form of "reference pressures". Of course, these reference pressures are themselves derived from basic wind speeds. In both ISO 4354 and CUBiC basic wind speeds are assumed to be 10-minute averages. In both ISO 4354 and CUBiC guidance is given for the conversion of wind speeds with different averaging times to10-minute averages.

These standards provide for two approaches - simplified and detailed. Most buildings can be dealt with by the first method. The detailed method is intended for wind-sensitive structures.

Organisation of Eastern Caribbean States (OECS)

In the Eastern Caribbean, a model building code, based on CUBiC standards, has been developed to facilitate the introduction of national codes. National codes and accompanying guidelines have been adopted (or are close to being adopted) in Belize, St Kitts & Nevis, Antigua & Barbuda, Dominica, St Lucia and Grenada. The CDMP has assisted in this process which was started by UNCHS/UNDP[13]. The CDMP also produced an updated and expanded set of drawings for the companion Building Guidelines documents which are aimed at residential construction. These drawings are available in both graphical and AutoCAD formats and on the CD-ROM[14] of CDMP.

Dominican Republic Wind Loads

An important exercise was undertaken in the Dominican Republic by way of the preparation of a new standard for the determination of wind forces for structural design. Following Hurricane David in 1979, with the loss of over a thousand lives, the Dominican Republic enacted a wind-loading standard. In 1998 Hurricane Georges struck the south coast of the Republic. Although the loss of

[13]United Nations Centre for Human Settlements and United Nations Development Programme

[14]Available from the Unit for Sustainable Development and Environment - see the website www.oas.org/en/cdmp

life was not nearly as great as in 1979, there was significant damage to engineered structures. These included telecommunications and lighting towers, sports stadiums, hotels, apartment buildings, luxury homes and well-known tourism facilities. A review of the 1979 standard revealed its almost complete inadequacy for dealing with the wind-loading requirements for consciously engineered structures. The CDMP sponsored the writing of a new standard based on the approach of ASCE 7-98[15]. The work was undertaken by a knowledgeable and enthusiastic group of Dominican engineers based at INTEC[16] and assisted by engineers from Puerto Rico and the Commonwealth Caribbean. Details of this exercise are being presented at a subsequent session of this Conference.
It is now left to the authorities in the Dominican Republic to ratify and mandate the standard.

CUBiC 2000

Earlier in this paper mention was made of the Caribbean Uniform Building Code. This "code", essentially a set of technical standards, was first published in 1985. There has been no revision since that date.

After a hiatus of several years, CCEO[17] has recently embarked on a complete revision (or rewriting) of the Caribbean Uniform Building Code.

At the Caribbean and Central American Forum on Building Codes and Economic Development held in San Juan, Puerto Rico from 30 September to 02 October 1998, a Declaration of Cooperative Action was adopted in which specific initiatives on uniform codes and code adoption were agreed to. These included "Mount a regional effort to fund updating and maintenance of CUBiC in coordination with regional harmonization processes".

The CDMP sponsored the project-development work for the new CUBiC. That preparatory work is now complete and the project has been submitted to the Caribbean Development Bank for funding. A recent meeting at the CDB indicated that a favourable response is likely in the near future.

It has been decided that the revised and updated CUBiC should be regarded as a set of technical standards and should take the form of a Caribbean Application Document (CAD). The CAD would be based on a chosen, comprehensive, English-language set of standards. The short list includes the International Building Code (IBC) 2000 of the International Code Council (ICC), the Eurocodes (ECs), the International Standards Organization (ISO), the Canadian Standards Association (CSA) and the Australia/New Zealand standards (ANZ). The front runner at present is IBC2000.

The Barbados Building Authority

Since 1993 Barbados has had a formal and official National Building Code published by the Barbados National Standards Institution. However there are no laws nor mechanisms to administer and monitor the standards incorporated in that Code. The CDMP, at the request of the Barbados Government, provided a short-term consultant[18] to assist the Government in the setting up of a

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[15]The wind loads section (Chapter 6) of Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers

[16]Instituto Technológico de la Santo Domingo - the team was headed by Daniel Comarazamy

[17]Council of Caribbean Engineering Organisations

[18]Alwyn T Wason, wason@attglobal.net

Building Authority to carry out those missing functions. All documentation is now with the relevant minister and positive action is expected within a year.

Working with the Insurance Sector

CDMP has been actively involved with the promotion of loss-reduction incentives and damage mitigation in the property insurance industry. This was included as one of the goals of the Caribbean Disaster Mitigation Project from its inception. The CDMP worked with the Caribbean insurance industry on various actions aimed at easing the property insurance crisis in the region. Among these actions are:

X Support for national associations of insurers in organizing technical conferences and in disseminating hazard and risk information

X Production of hazard and risk maps and information to promote safer location of development

X Promotion of loss reduction initiatives on the part of the insurance industry

National workshops to address the issue of natural hazards and insurance were held, with the support of CDMP, in the Bahamas, Belize, the Dominican Republic and Jamaica. CDMP has also actively supported hazard mapping and vulnerability assessment work, including storm hazard modelling projects, in Antigua, Belize, Dominica and Jamaica; a multi-hazard assessment in Kingston Jamaica and estimates of probable maximum losses of public sector infrastructure from a hurricane event in selected countries in the Eastern Caribbean.

Beginning in 1998, Barbados-based United Insurance Company Ltd introduced a programme in which homeowners and businesses could qualify for significant reductions in insurance premiums by retrofitting homes and buildings to withstand better the hurricane wind forces. These and other recommendations are included in the 1994 Report of the CARICOM Working Party on Insurance and Reinsurance[19]. This report also identified challenges facing the Caribbean insurance industry in promoting natural-hazard damage mitigation, including an ineffective regulatory environment, low retention of insurance risk in the region and temporary softness in the reinsurance market.

Multi-disciplinary Approach

A feature of CDMP was the interaction of scientists, practising engineers and administrators. In addition, CDMP sought the active involvement of architects, bankers, builders, artisans, professional associations, insurance and reinsurance companies, finance institutions, governmental agencies, non-governmental organisations, community groups and business people in its various programmes.

There was significant involvement of the private sector. Private sector participation was not limited to passive attendance at meetings and as recipients of the products of CDMP. It also collaborated with CDMP, invested in some sub-projects and shared the cost of other sub-projects with CDMP.

Of course, CDMP collaborated with the various regional and international agencies currently active in the field of natural-hazard damage mitigation in the Caribbean, including the Caribbean Disaster

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[19]The principal technical adviser on the insurance side was Arthur F S Evans, Business Consultant, 1485 Willow Oaks Drive, Matthews, NC 28104, USA. (CARICOM = Caribbean Community)

Emergency Response Agency, the Caribbean Institute for Meteorology and Hydrology, CDB, CHA, CARILEC, UNCHS/UNDP, The University of the West Indies (UWI) and ECHO.

Multi-national Approach

Another feature of CDMP was the significant involvement of Caribbean professionals alongside specialists from North America. The process of technology transfer was integral to the whole of CDMP. Because of the collaborative nature of the project, with regional and extra-regional participation, the transfer of technology took place in both directions. In other words, the professionals from the USA were also the beneficiaries of CDMP and are now better able to deal with disaster mitigation problems in the Caribbean and in other similar areas of the world. This is as it should be.

The active involvement of regional players also heightened the sense of ownership, which is so important if the objectives of CDMP are to be pursued after the formal end of the project. The significant involvement of regional professionals was also a cost-effective strategy.

Continuing Work

Although CDMP came to a formal end in 1999 its work continues, including technical improvements of programmes initiated during its project period of 1993-99.

X The hazard mapping of meteorological phenomena is now being presented at a larger scale with higher resolution.

X Standards development continues and the new CUBiC seems likely to get off the ground later in the year 2001.

X Negotiations continue in the Dominican Republic for the formal adoption of the new wind-loading standard.

X Actions towards code legislation continue in Grenada, Barbados, St Lucia, Dominica and Belize.

X there is a follow-up sub-regional[20] programme funded again by USAID and once again managed by OAS. It is the Post Georges Disaster Mitigation Project. Among its activities are a Multi-hazard Building Design Course for professional designers and training workshops for building inspectors.

X Other courses for professionals include the current Coastal Design, Construction & Maintenance training programme being conducted by UWI and managed by the OAS.

Assessment of the Project

If the need for the project was clear when it was conceived, its need became clearer during the course of its six-year life. Now that the formal project is finished, and not withstanding its success, there is

[20]Focussed on St Kitts & Nevis and Antigua & Barbuda

the need for its programmes to be continued and deepened and propagated even more widely throughout the Caribbean.

The timeliness of the project, especially with respect to the hurricane hazard, was fortunate. Long-term forecasters indicate that the North Atlantic, including the Caribbean, is likely to experience about two decades of heightened hurricane activity, starting in the mid-1990s. The project also coincided with increased concerns on the part of primary insurers and reinsurers about mounting property losses from natural hazards.

The funding and the timescale for CDMP permitted several of the critical issues to be addressed in depth. This contrasts with most of the similar predecessor exercises in this field of natural-hazard damage mitigation in the Caribbean.

The interaction of persons and organisations from different disciplines and different countries was generally effective and led to much of the success of the project. The direction and management of the project provides an effective model for future similar exercises in the Caribbean and elsewhere.
The continuing obstacles to success in this field of mitigation are public fatalistic perceptions of inappropriately-called "natural disasters", political expedience and short-term perspectives, and institutional weaknesses. All of these obstacles are nevertheless of reduced importance now than they were at the start of the project, due in no small measure to the CDMP.

The project is unusually well documented which facilitates the dissemination of the products of the programme and of the lessons learned in pilot projects. As indicated earlier, all the information is on a CD-ROM which also contains other related materials not specifically part of CDMP. In addition there were videos, manuals and training course materials produced during the project. Lastly, the Internet site provides convenient access to detailed information.

To facilitate local sustainability of the initiatives of CDMP, long-term monitoring tools were developed, national and regional institutions were enlisted as partners and support was given wherever convenient to existing personnel in partner institutions as a method of moving those agencies and institutions towards self-sufficiency.

Conclusion

The Caribbean is located in an area of the world exposed to multiple hazards. If sustainable development is to be achieved, there is no other option but to counteract these natural hazards by designing and constructing resistant buildings. Widespread failure must not be tolerated. If success is to be achieved at affordable cost, appropriate conceptual designs must be adopted. This would be facilitated through the adoption and mandating of good standards and the continuing education of engineers and architects in the requirements for designing against earthquakes and hurricanes in particular. Most of all, support must come from governments, financing agencies and the catastrophe insurance industry.

The vision is of an area where the occurrences of hurricanes would be experienced as fascinating (even awesome) natural events which may cause some damage and inconvenience but which would not lead to disastrous disruption of the normal community functions and of the economy.