Climate Change and Wind Speeds for Structural Design

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The principal meteorological hazards in tropical and sub-tropical regions are high winds, rainfall, wind-driven waves and storm surge. The hazards of waves and storm surge are related to wind speeds. With increases in speeds it is reasonable to conclude that waves and storm surge will pose more intense threats in coming years. These threats will be further amplified by rising sea levels. Most of the economic activities of many tropical islands are located in coastal areas. Therefore the issues of global warming, rising sea levels, increased wave energy, more severe storm surge and increased wind speeds are of critical importance to the long-term sustainability of the economies of such regions. As a consequence, structural engineers living, and working on projects, in such regions have a vested interest in all efforts worldwide to mitigate anthropological-induced climate change. Torrential rains may be affected by climate change. However, this issue is not associated with wind speeds.

Hurricane Catarina made landfall in the north of Brazil on 27 March 2004. This was the first hurricane ever recorded in the South Atlantic. Hurricane Ivan struck the island of Grenada on 07 September 2004 with peak gust winds of 135 mph (60 ms -1). According to the USA National Hurricane Centre Ivan was "... the most intense hurricane ever recorded so close to the equator in the North Atlantic". On 30 August 2008 a new world surface wind gust record for hurricanes was registered at the Paso Real de San Diego meteorological station in Pinar del Rio (Cuba) during Hurricane Gustav. The Dines pressure tube anemometer recorded a gust of 211 mph (94 ms-1). Are these isolated incidents or portents of future climate?

In 2008 the World Bank funded a multi-faceted project of which one component was the investigation of the possible effects of climate change on wind speeds for structural design in the island of St Lucia in the Eastern Caribbean. The project was executed by the Caribbean Community Centre for Climate Change and the actual work was done by the International Code Council (a wholly USA organisation) using the services of Georgia Institute of Technology (principal researchers Judith Curry and Peter Webster), Applied Research Associates Inc (principal researcher Dr Peter J Vickery) and Tony Gibbs.

Hurricane activity in the North Atlantic (including the Caribbean) follows multi-decadal cycles. The current warm phase of the Atlantic multi-decadal oscillation is expected to extend to the year 2025. By that time it is expected that the sea-surface temperatures would have risen by 1°F (0.56°C). The region experiences historically more hurricanes, and more severe hurricanes, during warm phases of Atlantic multi-decadal oscillations.

The number of tropical cyclones in the North Atlantic has averaged 10 per year in the past 50 years and 14 per year in the past decade. This is projected to rise to 15-20 per year by 2025. The combination of greenhouse warming and natural cyclical variability of the climate will produce unprecedented tropical cyclone activity in the coming decades.

During the past 50 years, the evolution of wind speeds for structural design in the Commonwealth Caribbean (which consists of 17 former (and current) British colonies in the Caribbean) is as follows:

- "Early 1960s - CP3: Chapter V: Part 2:1952 (This did not address hurricane force winds)
- "Mid to late 1960s - South Florida Building Code (The procedures were very elementary.)
- "1970 - The first Council of Caribbean Engineering Organisations (CCEO) standard. (This followed the philosophy of the then yet-to-be published CP3: Chapter V: Part 2: 1972. The meteorological work was done by Harold C Shellard, formerly of the UK Meteorological Office and attached to the Caribbean Meteorological Institute 1967-70.)
- "1981 - Revision of the CCEO standard (It has since been adopted as the Barbados standard BNS CP28. The meteorological work was done by Basil Rocheford of the Caribbean Meteorological Institute (now Caribbean Institute for Meteorology and Hydrology).)

- "1985 - Caribbean Uniform Building Code (CUBiC) Part 2: Section 2 (The meteorological work was done by Prof Alan Davenport, Dr David Surry and Dr Peter Giorgiou of the Boundary Layer Wind Tunnel Laboratory, University of Western Ontario.)
- "2008 - Caribbean Basin Wind Hazard Study. (The principal researchers were Peter Vickery and D Wadhera of Applied Research Associates, Inc.)

Tony Gibbs was directly involved with all of the listed work from 1969-70 to the present.

For conventional buildings (i.e. Category II in the American Society of Civil Engineers standard ASCE 7-05) the proposed Caribbean standard (based on ASCE 7-05) will adopt a 700-year return period wind speeds and for important buildings (*ie* Categories III and IV in ASCE 7) the 1,700-year return period wind speeds will be adopted. (These return periods provide 'ultimate' or failure wind speeds.)

There could be an average of three to four Category 4 and 5 hurricanes per year by 2025 in the North Atlantic (note these categories are of the Saffir-Simpson scale for hurricanes, not to be confused with the building categories in ASCE 7). This incidence of hurricanes represents a 210 to 280 percent (average 245%) increase in the number of Category 4 and 5 hurricanes compared to the long-term (1944-2007) average of 1.4 Category 4 and 5 hurricanes per year. If this turns out to be the case, the basic wind speeds for conventional buildings in St Lucia would be increased by about 12 to 14 percent (25 to 30 percent increase in forces), and the basic wind speeds for important buildings would be increased by about 10 percent (21 percent increase in forces).

Although the studies were carried out specifically for St Lucia, the results are probably valid for most of the Eastern Caribbean and are generally indicative of what is in store for much of the North Atlantic. This work carries an important message for all countries. Serious consideration should now be given to modifying wind speeds in other countries where national codes may be based on out-of-date wind speeds.

BIO

Tony Gibbs is a civil engineer specializing in structures and practising in the Caribbean and elsewhere. He did his undergraduate studies at The Queen's University of Belfast (BSc Civil Engineering, 1961) 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 HQ in UK); Fellow of The Institution of Civil Engineers (HQ in 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 University of the West Indies 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. In 2010 he was named as a *Caribbean Icon in Science, Technology & Innovation* by the National Institute of Higher Education, Research, Science and Technology (Trinidad & Tobago).