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Editorial

There is now conclusive evidence that extreme weather events and drastic climate changes can prove to be the costliest occurrences in the service life of civil engineering infrastructure. Experience tells us that we shall never know the precise cost of repair, rehabilitation and regeneration following the damage and destruction to infrastructure caused by hurricanes and other meteorological events and geological upheavals like the recent earthquake in Pakistan and India, and the Boxing Day Tsunami in Asia last year. Destruction of our built environment, whether due to natural or manmade activities, occurs extremely rapidly and very dramatically, but repair, rehabilitation and regeneration invariably take many years to complete and often cripple the social and economic fabric, and the political development of a country for many decades.

All climate change events pose severe challenges to the civil engineering and construction industry, and material scientists and design engineers need to reflect intensely and deeply as to how we can minimize the severity of damage caused to our infrastructure. What are the material and structural implications, for example, of these extreme weather events? We need to understand the process of damage inflicted by these unpredictable and immense dynamic forces if we are to produce effective material and structural designs and solutions capable of absorbing and accommodating the consequences of climate change with little loss of life and limited damage to the infrastructure. But one conclusion is certain and undeniable—that the present philosophy of designing materials and structures for ultimate strength is fundamentally invalid, irrelevant, and indeed flawed, if we are to meet the challenge of the effects of climate change on our infrastructure. Design for climate change has now become imperative, and a necessity. Experience of the damage caused to our infrastructure during their service life in the last three/four decades tells us that we need to adopt a Holistic approach to design, focussing on material stability and structural integrity, rather than merely on strength. Perhaps it would be appropriate at this stage to reflect briefly on the structure and composition of hurricanes and other similar events, from an engineering point of view, and analyse how they impact on civil engineering infrastructure that stand in their way.

Radar images reported from the National Hurricane Centre in Miami tell us, for example, that hurricanes are huge covering large areas, and whip up winds in excess of 200 km/h. Hurricane Katrina, for example, was initially some 500 km wide, with winds in excess of 250 km/h such that towns and cities, houses and buildings that stood in its way had no option but to face the brunt and the onslaught of its immense and unpredictable dynamic forces. High winds are not the only danger facing those that stand in the way of a hurricane. The low pressure at the heart of the hurricane can swell the waves, and make the ocean rise up and create potentially devastating storm surges that are dragged along by the hurricane. We are told that such storm surges can sometimes be as high as 8 m. The high winds also produce huge surface waves on top of the storm surge, and exacerbate the damage further caused by the storm surge. With Hurricane Katrina, it is reported that surface waves were in excess of 6 m on top of the storm surge.

How do we then design structures that have to resist such huge and unforeseen dynamic forces from high winds and the resulting floods? How do we design flood defence schemes to resist such unpredictable forces? The massive storm surges arising from Hurricane Katrina destroyed two major highway bridges. The Biloxi bridge lost more than 50 spans whilst the bridge spanning Lake Pontchartrain lost nearly one half of its deck where the storm surge lifted the deck sections off pier supports. Both Hurricanes Katrina and Rita are reported to have destroyed some 109 oil platforms and five drilling rigs in the Gulf of Mexico—and serious and extensive damage was caused to some 50 platforms and 19 drilling rigs. It is clear that high winds + heavy rainfall + storm surges + high tides can totally destroy houses, buildings and flood defences over a wide area in a very short time. How do engineers assess the probability of the occurrence of such extreme weather events in the present context of so many unknowns and other imponderables? How do we assess effectively and efficiently the damage to foundations, ground swelling, subsidence, damage to gas, sewer and water pipes, contamination by sewage and toxic chemicals, oil and gas leaks from petrol stations, ground movements, damage to and destruction of highways and roads, ...??? Buildings could be contaminated by sewage and toxic chemicals—and they may need environmental cleaning. What about the structural integrity of the buildings left

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standing?—and damage to submerged fabric such as plaster, timber, concrete??

In a week of hurricane-related heavy rains, mudflows and mudslides in Central America and Southern Mexico, towns and villages disappeared under a thick apron of mud estimated to be up to 12 m deep. How many structures will remain firm, solid and stable under such an onslaught? What do engineers do with land where bodies are buried, and corpses decompose?—how do we renovate and regenerate such land? Heavy and constant rain falling on deforested hills—how do we stabilise soil before rebuilding?

Persistent heavy rains and the resulting flash floods are known to wreak similar widespread havoc and destruction to our infrastructure. Bridges have been known to have been washed away and smashed; network of roads have been ripped up and washed away. In southern India recently three days of particularly heavy rain caused three reservoirs to breach their banks, triggering flash floods. In another area, these flash floods washed away a portion of a railway track, causing a train to derail and plunge into a rain-swollen river! Intense rain storms in southern Italy washed away a section of a railway embankment causing the trailing locomotive of a high speed train poised over empty space—the floods had washed away the earth and the rock beneath the railway line for about 20 m. European satellite data show heavy environmental pollution in China, and it is reported that some 70% of the rivers and lakes are reported to be so full of toxins that they can no longer be used for drinking water!

The ASCEs 2005 Report Card for American's Infrastructure calls attention to the parlous and deplorable state of US Infrastructure, and the need for urgent action to prevent its slide toward failure. The ASCE gave an overall grade of D to the nation's infrastructure, and it is now estimated that an investment of $1.6 trillion is required to raise the quality of infrastructure to a satisfactory level.

We need investment—but we also need a new Holistic approach to DESIGN. And above all, we need to rethink the fundamental basis of the education and training of civil engineers for the twenty-first century.