Climate Change is the New Gravity

Sustainability and Resilience as Architectural Design Constraints

INTRODUCTION

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Beijing's skyline in smog, 2017

An increase in carbon emissions is initially causing a global increase in temperature that in turn will trigger other climatic changes. Many of these predicted outcomes, including increased polar ice melts and more frequent and intense storms such as Hurricane Sandy, are already being observed.

In October 2012, Superstorm Sandy, the largest Atlantic hurricane on record, pummelled the East Coast of the United States. In New Jersey alone, Sandy caused US$30 billion in damages, killed 39 people and left 2.7 million homes and businesses without power, 350,000 of those needing repair or reconstruction.[1] The Federal Emergency Management Association (FEMA) responded with regulations that mandated construction above the floodplain. This was a sensible technical solution, but disastrous from an architectural and social standpoint in that it would lift many buildings well above street level, disrupting longstanding existing neighbourhoods with entrenched and vibrant living patterns.

A small group of architecture and engineering students led by faculty from Stevens Institute of Technology in Hoboken, New Jersey, countered with the SU+RE House, a new paradigm for coastal housing and the winning entry in the US Department of Energy's 2015 Solar Decathlon competition. Hoboken sits on the Hudson River across from Manhattan, and in 2012 Sandy had flooded the city. Just months later Ecohabit, Stevens' entry in the 2013 Solar Decathlon, was being built by students in a parking lot adjacent to the Hudson as a storm threatened to flood the river again. As an emergency measure, the building had to be craned out of the danger zone. When Stevens decided to enter the 2015 Decathlon and utilise the same parking lot for construction of the SU+RE House, it seemed clear that the design challenge had to be an intelligent, replicable response to Sandy. The result was the development of a building system that allows for construction in the floodplain, thereby reclaiming a densely populated site condition currently being lost worldwide to more frequent and severe flooding. Through conscious envelope design, the house also requires only a fraction of the energy to run compared to its conventional counterparts, its roof-mounted photovoltaic system producing considerably more power than the building requires. During a storm-induced grid failure, the system 'islands' itself to continue producing power, becoming an oasis of energy to supply standby electricity to the neighbourhood.

The SU+RE House is a good touchstone for this issue of *AD* because it is a very straightforward example of a specific act of design that in order to succeed needed to be generally applicable to a problem of ecological scale. This is the essence of sustainable and resilient design.

A Complex Problem With a Simple Solution

Superstorm Sandy's particular 'problem of ecological scale' is climate change. Human-induced climate change is very real, ravenous, and happening faster than anyone initially predicted. Though projecting the intricacies of its course is a complex modelling exercise, the causes are mechanistic and well understood. We are introducing materials into the air (collectively called greenhouse gases) that are intensifying the mechanism through which solar heat is trapped by our atmosphere, thereby altering the process responsible for creating the delicate temperature range that has engendered and supported life on earth for the last 3.5 billion years. The main culprit is carbon dioxide produced from the combustion of fossil fuels. The initial result is a general warming trend, the infamous 'global warming', which has already begun to trigger a domino effect of changes to other environmental variables such as global ocean and air currents, carbon sinks, and precipitation patterns to name a few. As a result we are moving into uncharted climatic waters.

Stevens Institute of Technology, SU+RE House, Hoboken, New Jersey, 2015

bottom: As a counter argument to the FEMA regulations, the SU+RE House maintains the existing neighbourhood texture while providing energy independence and a community resource in the wake of future storms. As a result, a catastrophic event is taken as an opportunity to simply design a better building system.

Federal Emergency Management Association (FEMA) mandated renovation, Bayhead, New Jersey, 2014

below right: FEMA regulations made in response to Superstorm Sandy required that all rebuilding and new construction be set above the base flood elevation. However, this straightforward technical solution does not take into consideration livability and the existing social fabric.

Predicted results that will drastically affect human society are already being observed. Global ice-melts leading to sea-level rise will threaten the coastal communities where a majority of the most populated human cities are situated. Extreme weather, including more frequent and furious storms, droughts and floods as well as general warming, will cause species migrations and degrade iagriculture in ways that will deeply impact human development all over the world. Though no one knows the exact trajectory, generally accepted projections conclude that there will come a point when a feedback loop will be triggered after which our actions will not be able to affect the outcome.[2]

Remember, this is not the plot of a dystopian Hollywood blockbuster. These conclusions are derived from observation, study and modelling all tested and refined through the scientific method to the point where there is almost unanimous agreement on the veracity of the core conclusions from climate scientists worldwide.[3] Facts are slippery, but the reality of human-induced climate change is about as factual as facts get. The summary is that it is happening, it is serious, and we have to deal with it collectively and rapidly.

The good news is that climate change is a complex problem with a very simple solution: stop burning fossil fuels. We are after all the big-brained mammals that learned to fly, tamed the atom and invented chocolate. This should be an easy one. Of course our industrial society is built on fossil fuels so we cannot just turn off the gas and keep on trucking. We need some time to rethink and retool, but we must not hesitate. Projections based on the same science that uncovered the problem give us good benchmarks to work with in terms of how much carbon we can still afford to emit and over what period of time.[4] Such theorising is admittedly inexact. Outputs vary and are constantly under revision. Still, even a conservative analysis points to the need for swift and profound reductions in carbon emissions, so much so that the synopsis 'as much as possible as quickly as possible' is almost exactly accurate.

The Mandate for Quantitative Sustainable and Resilient Design Systems

This is where architects and building engineers enter the picture. Buildings are a big part of the equation with their operation alone making up 30 to 40 per cent of industrial society's worldwide carbon footprint (see Graham Wright's article on pp xx–xx of this issue). And this brings us into familiar territory: the discussion of the complex intersection between the built and natural environments. What should we call it in this case? Definitely our subject falls under the broader mantle of sustainable design, but if you have been to a conference on that topic, chances are you did not come away with a clear definition of what it is or how to do it. Sustainability is often a vague concept deployed as everything from a moral argument to an emotional plea to a marketing strategy. In fact sustainability is easily defined. It is the process of maintaining something at a given level. If we can agree that in this case the thing is life on earth and the level is industrial human society, then at least for now sustainability becomes quantifiable and the metric is carbon. Design on the other hand is simply to devise for a purpose. It does not seem controversial that we need to design such that advanced industrial society can continue. Clarified with these simple definitions, sustainable design becomes a mandate, and a project's success or failure can be quantified through carbon emissions.

Gehry Partners,
Marques de Riscal
Hotel,
Elciego,
Spain,
2006

Humans have become so adept at dealing with gravity as a design constraint that we are now often just riffing with structural parlour tricks and formal gags. It is time for a new challenge.

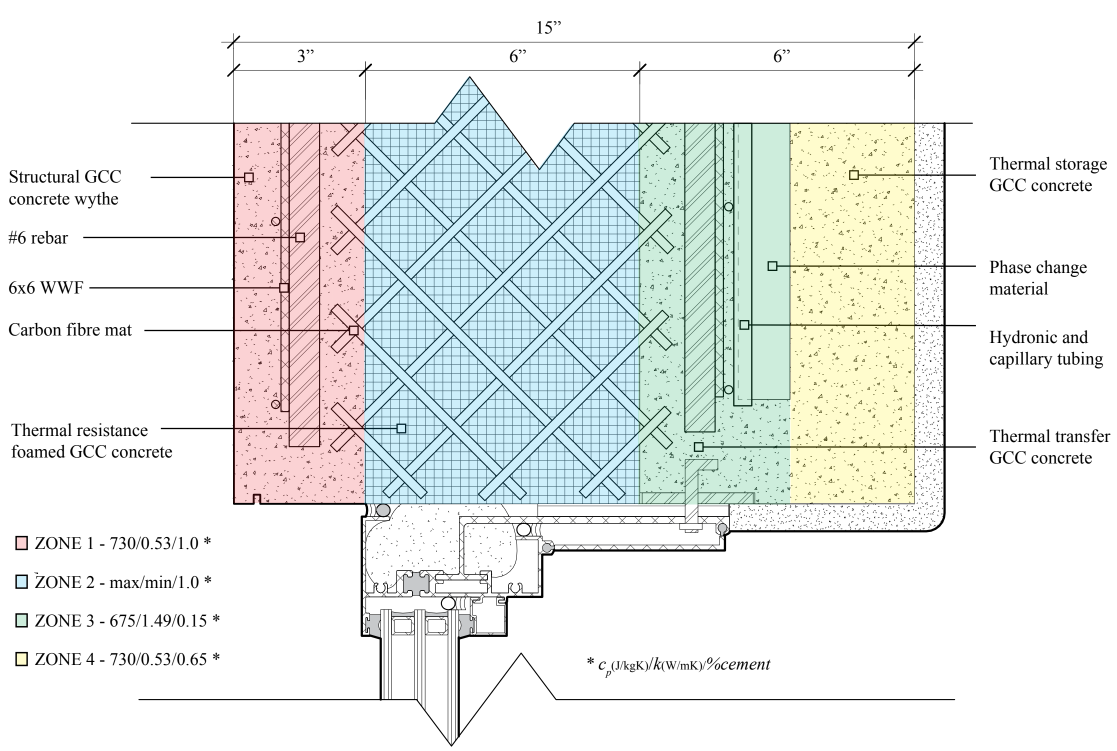
And this is where many architects start to chafe because they interpret this discussion as constraining to freedom of expression. But in fact as designers we know that it is the constraints that generate the beauty. If we were not small animals glued to the ground, what would be the interest in building up and out and over. Would there be gothic sanctuaries built of stone but made of light? Or the frantic, graceful race to scrape the sky of the 20th-century skyscraper? Or the contemporary penchant for massive cantilevers, voids and structurally counterintuitive forms riffing again and again on the groove: 'I'll bet you didn't think this could stand up'?

The challenge of gravity has not mandated limits but created opportunities. It has generated beauty. Climate change must become the new gravity. We simply have to accept that climate change is the new normative baseline design constraint for the built environment. As with the last 5,000-plus years of gravity-focused architectural design, our grappling with climate change will create beauty, but there is a difference. Gravity as a design constraint guides compliance through immediate feedback. Climate change will not baby us. We have to define its parameters for design and create our own short-term feedback inputs. Carbon as the metric of that feedback will not limit our expression any more than gravity. The only thing that has really changed are the stakes.

But sustainability is not enough. As the climate changes, so does the site. Solar intensity, temperature, wind speed, drought, flood and sea level are just some of the site-specific variables that are changing. As we work to stem the cause, we therefore have to react to the effects. To respond, a design process is required that seeks to integrate resiliency by building-in the capacity to absorb the impacts of these disruptive events and adapt over time to further changes while simultaneously being part of the solution to the problem itself. To build sustainably in a world with a changing climate, we must now integrate resiliency.

Laboratory
for Innovative
Housing,
Passichanical
wall system,
University of
North Carolina
at Charlotte,
North Carolina,
2013

Carbon reduction as a design constraint has informed new architectural creativity focused less on the facade and more on the volume of the building envelope. Here, by utilising four distinct concrete mixes optimised for specific thermal characteristics, a conventional precast concrete assembly is re-envisioned as a low-energy heat storage and dissipation machine.



Architype, The Enterprise Centre,
University of East Anglia,
Norwich, UK, 2015

Using a variety of simulations tools, the Enterprise Centre was designed as a low-energy building for both current and projected future climatic conditions on site. The technology to create a very low-carbon built environment that adapts to a changing climate is already here and being implemented. The challenge is scale. To get the needed results, we all have to do it.

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HD Architekten, RHW 2 Raiffeisen Bank Tower, Vienna, 2013

The form and materiality of ubiquitous neomodern office buildings typically come with a high carbon price tag due to building envelopes that require profligate operational energy use to maintain interior comfort. This does not have to be the case: the RHW 2 tower meets the German Passivhaus standard, one of the most rigorous building energy standards in the world.

This issue of *AD* is less about the ‘what’ and more about the ‘how’ of this new synergy of sustainable and resilient design forged by climate change.

Peter Ruge Architekten, Passive House Bruck, Changxing, China, 2014

Quantifiable sustainability in architecture is a collective, worldwide endeavour. This apartment block in China was also built to meet the German Passivhaus standard.

Hemsworth, BC Passive House Factory, Pemberton, British Colombia, 2014

This low-energy factory was built using the components it produces for use in the construction of low-energy buildings, creating a feedback loop of carbon reduction.

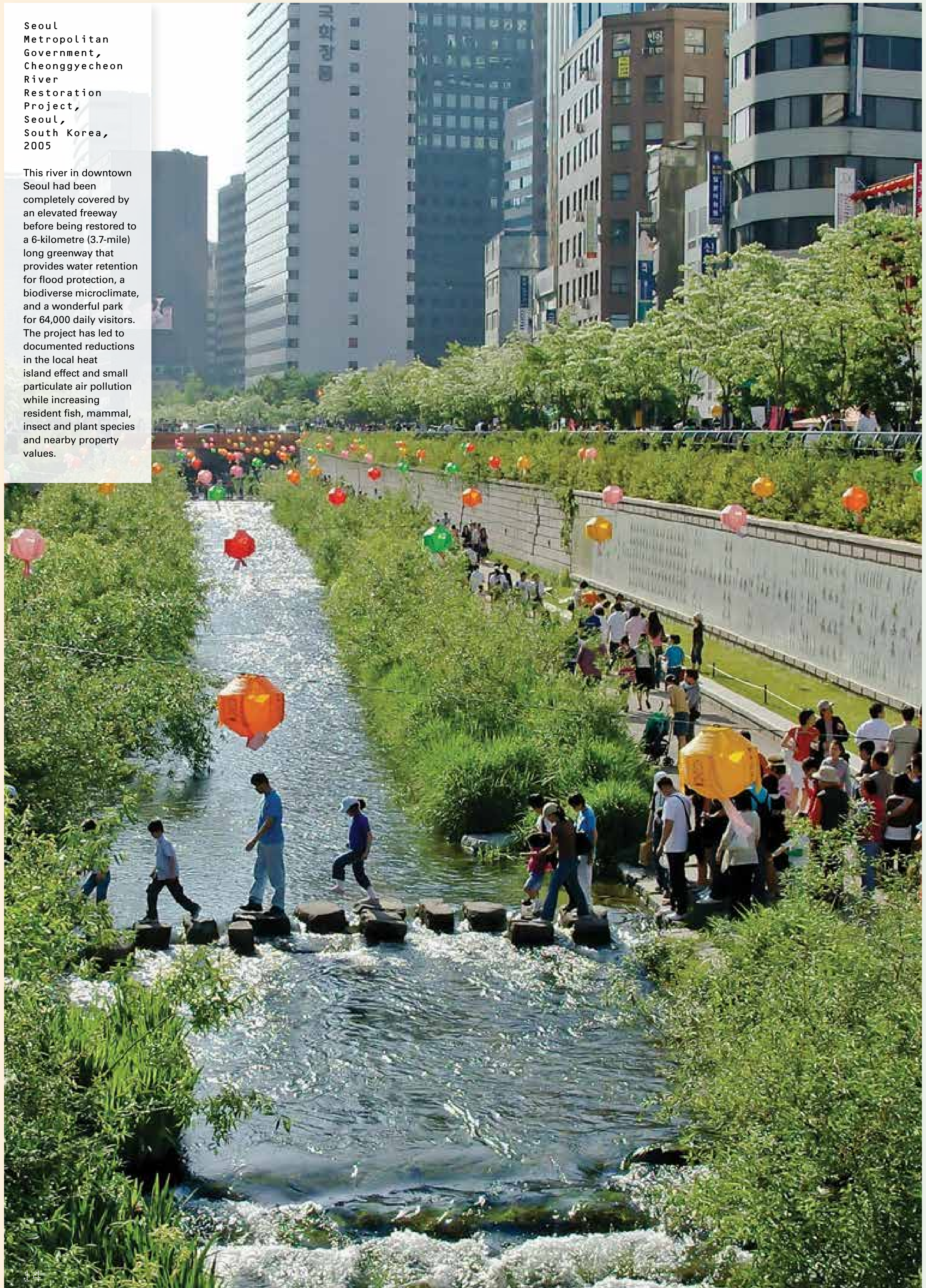
The Nuts and Bolts: Energy Demand, Production and the Changing Site

This issue of *AD* is less about the ‘what’ and more about the ‘how’ of this new synergy of sustainable and resilient design forged by climate change. Its direct genesis is the SU+RE House, a project the guest-editors undertook together as architecture faculty at Stevens Institute of Technology. Stevens has been immersed for three centuries in the science and engineering of its local climate, pioneering steam-ferry technology and transportation in the 1700s, developing competitive yacht design and racing (the New York Yacht Club and America's Cup) in the 1800s, spearheading military warship prototyping and design during the First and Second World Wars, inventing mechanical wave dynamics modelling in the post-war 20th century, and currently researching real-time monitoring and predictive computational modelling of the physics of the coastal ocean in the 21st century.

When Superstorm Sandy hit Hoboken in 2012, it was in the context of this long history of local climate-driven research/engineering/design/build iterative loops that Stevens decided to respond with the SU+RE House. The project serves as an appropriate poster-child for this issue because it delivers sustainability through measurable carbon reduction, and resilience through a replicable design system.

The issue outlines a practical strategy for this systems approach to sustainable and resilient design. In his article (pp xx-xx), Graham Wright sets the sustainability stage with a more detailed examination of fossil fuels as a context for climate change, and introduces the argument that the sensible response for building designers is to switch focus to operational load reduction. Ken Levenson (pp xx-xx) lays out the nuts and bolts of this load-reduction strategy through a primer on passive building design basics, while Bronwyn Barry (pp xx-xx) grapples with mainstream architecture’s reluctance to embrace the low-energy envelope as a metric of beauty. Adam Cohen (pp xx-xx) outlines a practical approach to delivering low-energy buildings at market rates through increasing the efficiency of the architectural delivery process. Terri Peters (pp xx-xx) investigates how post-occupancy feedback provided through integrated building sensoring can improve performance and drive an iterative design process that leads to more sustainable and resilient buildings, using case studies from the international practices Skidmore, Owings & Merrill (SOM), FXFOWLE and 3XN.

To offer a more in-depth case study, the guest-editors focus on the SU+RE House by first setting it in an environmental, social and educational context (pp xx-xx), then discussing its practical approach to sustainability and resilience as a combination of hybridising existing technologies and a plug-and-play approach to innovation (pp xx-xx and xx–xx). At the core is a quantitative feedback loop of multi-platform modelling generating real-time design iteration (pp xx-xx). In related articles, Karin Stieldorf (pp xx-xx) expands on the educational context while Brady Peters (pp xx-xx) considers the architectural representation of building performance simulation with examples from the work of Bjarke Ingels Group (BIG) and BuroHappold.



Seoul Metropolitan Government, Cheonggyecheon River Restoration Project, Seoul, South Korea, 2005

This river in downtown Seoul had been completely covered by an elevated freeway before being restored to a 6-kilometre (3.7-mile) long greenway that provides water retention for flood protection, a biodiverse microclimate, and a wonderful park for 64,000 daily visitors. The project has led to documented reductions in the local heat island effect and small particulate air pollution while increasing resident fish, mammal, insect and plant species and nearby property values.

In the context of life on earth, humans are a tiny blip, almost an afterthought. Yet in our short collective life we have skyrocketed to the top of the food chain by developing an impressive skill set for amassing and applying knowledge.

Stevens Institute of Technology, SU+RE House, Solar Decathlon, Irvine, California, 2015

The guest-editors working to install the SU+RE House on the Solar Decathlon exhibition site. The house was initially constructed and tested on the Stevens campus in Hoboken, then shipped cross-country and reassembled for the competition in Irvine. Its permanent home is in the grounds of the Liberty Science Center in Jersey City, New Jersey.

The fact that climate change demands a broader concept of project scope is also examined. Alexander Washburn (pp xx-xx) introduces city-scale resilient design as an equation-defining risk, and makes the argument through case studies that increased risks brought on by climate change can actually generate great rewards through thoughtful action. Illustrating the work of her practice WXY architecture + urban design, Claire Weisz (pp xx-xx) describes the challenge of large-scale resilient design – something she calls 'the practice of designing environments for climate change' – as a potential for growth in that it requires an evolution from design to systems thinking and a consequent focus on interconnection. Using the example of a partnership between OMA and the City of Hoboken, Ann Holtzman (pp xx-xx) discusses how sustainable and resilient design must be supported through policy if change at the scale of the city is to be possible.

Architects as the Executive Directors of Creative World-Saving

In the context of life on earth, humans are a tiny blip, almost an afterthought. Yet in our short collective life we have skyrocketed to the top of the food chain by developing an impressive skill set for amassing and applying knowledge. Unfortunately our wizardry at innovation far outstrips our ability to extrapolate the effects of long-term application. As a result, we have studied, calculated, invented, designed, driven, flown, fought and built our way into a corner. Imagine human industrial society riding in a brakeless bus careering down a gravel road towards an enormous, growing gorge. Clearly the only option is to jump all the way across. All partial efforts, no matter how profitable or graceful, will result in the same fiery wreckage on the canyon floor. We can measure the gorge and study its rate and profile of change to plan the technology of our jump. This is the easy part. The difficulty lies in the fact that really for the first time we all have to agree and act together.

For architects and engineers that agreement entails accepting climate change as the normative design constraint for the contemporary built environment. Sustainable and resilient design is not a moral mandate. It is simply a practical imperative if the goal is to continue designing at all. Aesthetic whining and formal gnashing of teeth aside, the fact is that good architecture has never worried about choosing design constraints, but instead focused on responding to them. Seen through this lens, climate change is an exciting context within which to design. It turns out that the new job description for our chosen creative career is to save the world as we know it. All that is required is to see existential design constraints as opportunities. Luckily we have a proven history of doing just that. ⅅ

Notes

1. Jarrett Renshaw and MaryAnn Spoto, 'Christie Administration: Cost of Hurricane Sandy's Damage to N.J. Nearly $30B', The Star-Ledger, 23 November 2012: www.nj.com/politics/index.ssf/2012/11/christie_administration_cost_o.html.
2. The body of scientific knowledge quoted here is huge. A very good single source summary of the salient points is Rajendra K Pachauri and Leo A Meyer (eds), Climate Change 2014 Synthesis Report, Intergovernmental Panel on Climate Change (Geneva), 2014.
3. John Cook et al, 'Quantifying the Consensus on Anthropogenic Global Warming in the Scientific Literature', Environmental Research Letters, 8 (2), 2013, pp 1–7.
4. Pachauri and Meyer, op cit, pp 58–63.