05

Designing Structures of Coastal Resilience

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5.1 Introduction

What is 'resilience'? What is resilient design and what does it 'look' like? To answer this question, the Rockefeller Foundation recently asked a group of architecture and design critics to share their thoughts about the term.[1] And though the responses covered both historical and current examples—everything from the rebuilding of Lisbon in the aftermath of the 1755 earthquake, to one of the first known uses of the term (by the architect George Martin Huss in 1924), and finally to the chilling footage of Toyo Ito's Sendai Mediatheque withstanding the successive shocks of a 9.0 magnitude earthquake—all seemed to agree that 'resilience' described the ability to survive amidst environmental and natural catastrophes. To view resiliency in such a manner is to view our buildings and cities as first and foremost responsive to change. This is the approach informing the spectrum of Rockefeller Foundation projects centered on the concept of resiliency, from '100 Resilient Cities', to 'Rebuild by Design', and this project, Structures of Coastal Resilience.

Structures of Coastal Resilience (SCR) is a collaborative research study bringing together architects and landscape architects with engineers and climate scientists. The purpose of the project is to promote a design-based approach to resiliency based on the latest and best scientific thinking related to climate change and storm modeling to develop strategies and structures to resist the effects of catastrophic coastal flooding. The work is undertaken in collaboration with the United States Army Corps of Engineers (USACE) and is intended to provide alternative designs that incorporate nature and nature-based infrastructures as well as structural and non-structural measures.[2]

5.2 The USACE and Technical Expertise

The USACE has been at the forefront of Federal initiatives to develop appropriate and robust coastal risk reduction strategies as well as responsive frameworks to climate change. On 18 September 1930, the Office of the Chief of Engineers issued Special Order No. 72, authorizing the formation of the Beach Erosion Board (BEB), a sub-agency dedicated to providing technical assistance on beach erosion matters. Special Order No. 72 also established the Shore Protection Board (SPB), entrusted with investigating the efficacy of shore protection and USACE dredging projects. From the 1930s, throughout the Second World War, and until the early 1950s, the BEB established its leading role in coastal risk reduction by building hydrodynamic testing facilities and issuing a series of pioneering technical manuals related to issues of shore protection. These manuals, beginning with Special Bulletin No. 2 of the BEB (1953), through Technical Report No. 4, or TR-4, 'Shore Protection and Design' (1954), continued to be published even as the US Army Coastal Engineering Research Center (CERC) replaced the BEB in 1973.[3] The CERC published its own series of 'Shore Protection Manuals' from 1977 until 1984, many of which are still in use today. And with the establishment of the Coastal Hydraulics Laboratory and Engineer Research and Development Center, this work has continued primarily through the publishing of a comprehensive Coastal Engineering Manual (CEM), last updated in 2008.[4]

The USACE's technical expertise in coastal risk reduction matters also came on the heels of a developing engagement with issues of global climate change. From 1953 to 1956, Chief Engineer Lt. General Samuel D. Sturgis, Jr. developed policy priorities for conserving coastal and internal waters. This continued into the 1960s, with the creation of the Institute for Water Resources (IWR), which initiated groundbreaking studies in 1977 and 1992 concerning hydrological changes caused by climate change. And today, the USACE's latest on this matter is a document entitled 'Coastal Risk Reduction and Resilience: Using the Full Array of Measures' (CRRR) that sets a framework for coastal protection strategies that take into account waves and surges associated with sea level change and catastrophic storms.

5.3 USACE Terminiology

Currently, the USACE uses the terms natural, nature-based, non-structural, and structural in its CRRR publication to outline different methods for confronting coastal flood risk and erosion. These terms are different from the definitions used by White House and the Environmental Protection Agency (EPA), such as green infrastructure, and are meant to provide greater precision to an evolving terminology. The terms continue to be employed in the North Atlantic Coast Comprehensive Study (NACCS) and associated USACE workshops. These terms and concepts are to be used alongside each other.

Natural Features are features that are 'created and [that] evolve over time through the actions of physical, biological, geologic, and chemical processes operating in nature.'[5]

Nature-Based Features are features that "may mimic characteristics of natural features but are created by human design, engineering, and construction to provide specific services such as coastal risk reduction. Nature-based features are acted on by the same physical, biological, geologic, and chemical processes operating in nature, and as a result, they generally must be maintained in order to reliably provide the intended level of services."[6]

Nonstructural Measures are measures that comprise "complete or partial alternatives to structural measures, including modifications in public policy, management practices, regulatory policy, and pricing policy. Nostructural measures essentially reduce the consequences of flooding, as compared to structural measures, which may also reduce the probability of flooding. Nonstructural measures addressed by the USACE National Nonstructural Floodproofing Committee include structure acquisitions or relocations, flood proofing of structures, implementing flood warning systems, flood preparedness planning, establishment of land use regulations, development restrictions within the greatest flood hazard areas, and elevated development."[7]

Structural Measures are measures that can be designed "to decrease shoreline erosion or reduce coastal risks associated with wave damage and flooding. Traditional structures include levees, storm surge barrier gates, seawalls, revetments, groins, and nearshore breakwaters. The purpose of levees, seawalls, and storm surge barrier gates is to reduce coastal flooding, while revetments, groins, and breakwaters are typically intended to reduce coastal erosion."[8]

Integration is a term referring to "reducing coastal risks and increasing human and ecosystem community resilience through the full array of natural, nature-based, nonstructural, and structural measures, including combinations of measures. The types of measures employed, their configuration within the network of features, and the USACE has long recognized the planning and engineering approaches that are applied in developing the integrated system will depend on the geophysical setting, desired level of risk reduction, constraints, objectives, cost, reliability, and other factors."[9]

This terminology and the carefully defined options that are described in the CRRR report—from oyster and coral reefs and dunes and beaches, to floodplain management and building codes, and to levees and storm surge barriers—have yet to be integrated into combined structures or into methods of design and analyses that can be confidently applied to provide reliable coastal protection and resilience, especially in the context of climate change and sea level rise. In principle, a structure of layered protection is possible that can attenuate wave energy as a storm surge advances over offshore reefs and breakwaters, across wetlands, beaches and dunes before reaching structural barriers, seawalls or levees with diminished impact. One can envision this 'tri-layer' approach to combined structural and nature-based systems such that the performance might satisfy a set of three performance criteria such as:

For a storm with a 82 to 64% probability of exceedance in 50 years (30 to 50 year average return period) there would be no damage to offshore reefs and breakwaters, limited dune and beach erosion, and no on land flooding behind structural barriers, seawalls or levees. Recovery would take a matter of days.

For a storm with a 39 to 10% probability of exceedance in 50 years (100 to 500 year average return period) there would be some damage to offshore reefs and breakwaters, considerable dune and beach erosion, and a foot or less of on land stillwater flooding behind structural barriers, seawalls or levees. Recovery would take a matter of weeks.

For a storm with a 5 to 2% probability of exceedance in 50 years (1000 to 2500 year average return period) there would be considerable damage to offshore reefs and breakwaters, complete dune and beach erosion, and several feet of on land stillwater flooding behind structural barriers, seawalls or levees. Recovery would take a matter of months.

A performance-based design approach such as this is common in earthquake and wind resistant design and could also be applied to coastal protection and resilience design. The notion of combining energy dissipation and damping with more static structural means of protection has also been successfully applied in earthquake resistant design and to reduce and attenuate the wind induced vibrations of structures. In this sense resilience is provided across the two axes of (1) the range of demands associated with moderate to extreme, low probability storms and (2) the depth of protection provided by wave attenuating offshore features as well as static barriers.

5.4 Designing Coastal Resilience

Though the USACE has been in the business of creating specifications and planning technical solutions for coastal resiliency for over 80 years, its approaches and procedures often invoke a language that is virtually unrecognizable to architects and landscape architects. Consistent throughout early USACE manuals and even until the CEM is the depiction of the design of structures as a conjunction of 'planning and design' or 'functional planning.' This terminology resulted from a trend towards depicting design projects as technical, as opposed to aesthetic or intuitive solutions. During the Second World War, the design professions were mobilized in service of the war effort, and often the term 'planning' was used not just as code for 'postwar planning', but also for design as a kind of technical expertise to be used in the reconstruction of cities of the development of national and international infrastructures. This kind of expertise evolved, however, into something different with the advent of microcomputers from the 1950s until the 1980s. During this time, a preference for sophisticated modeling techniques meant that the creation of design narratives, a kind of expertise or shared domain between architects and landscape architects, was abandoned in favor of data generation and scenario planning.[10]

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5.5 Structures of Coastal Resilience

The term 'Structures of Coastal Resilience' was inspired by Todd Shallat's authoritative history of the first century of the USACE. Called 'Structures in the Stream: Water, Science, and the Rise of the US Army Corps of Engineers' (1994), this remarkable book provides an expansive interpretation of 'structures.' It considers the USACE's engineering methods as literal and figurative interventions, all part of a systematized techno-bureaucratic means of ordering the landscape and the waters as well as the very institutions that give shape to the landscape and waters.[11] To paraphrase Carl Schmitt, the law is a structural system[12], and it is in this sense that Shallat uses the word 'structure.' For him, a structure can be a revetment, bulkhead, or levee, but it can also mean the United States of Congress or the USACE. In any of these cases, these are structures that encountered and overcame hydrodynamic and institutional resistance. Also embedded in this notion of 'structures' is a conflict between architecture (or landscape architecture), engineering, and their respective institutional backgrounds.

This expansive notion of 'structures' is central to SCR's purpose and goals. The four design teams that are part of this study bring an unparalleled level of expertise skill and intelligence to bear on sites in Rhode Island, New York, New Jersey, and Virginia. Though their methods may vary, and though they deploy their own visual language in order to present their research and analysis in the following sections and in the design appendices, their designs should not be construed as comprising four separate projects. Instead, they should be considered as four balanced approaches that together will not only augment and complement previous USACE work in Rhode Island, New York, New Jersey, and Virginia, but that will also do so while keeping in mind the 'full array of measures' as described in the CRRR report.

5.6 References

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