Surf and Turf: Integrating Resilient Design Early in the Curriculum

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Recent reports paint an increasingly grimmer picture about the pace of climate change. While we cannot back off from efforts to reduce carbon, we now recognize it is too late to stop the coming changes. Therefore, it feels ethically necessary to modify our teaching strategies to train future architects early on not just how to build more sustainably, but also how to deal with harsh environmental conditions they will encounter in coming decades. This paper describes pedagogical revisions that link a second-year studio and a building technology course with the goal of introducing and applying principles of resilient design at both the ocean shore and a rural wooded setting to cover a range of possible strategies.

The first project, SURF; Resilient Design on the Coast is sited on the ocean to focus on methods to combat the effects of rising seas, storm surge and hurricane-strength winds on a building; such as a raised concrete structure and impact resistant facades. The second project, TURF; Resilient Design in the Woods, is set on a natural site to focus on resilient design issues such as extreme temperatures, strong storms, drought and forest fire. Concurrent lectures in the tech course on passive heating and cooling, daylighting, thermal transfer and insulation, and non-combustible cladding and roofing materials support the studio project. To connect the 2 courses each student creates a color rendered wall detail that describes the resilient design strategies employed.

INTRODUCTION

Resilient Design (RD) in buildings can be approached in different ways. On one hand, architects can design buildings that are flexible enough in the programming of the spaces and structure that they can adapt to new uses over time. This way the building will not be demolished for a new structure, saving embodied energy and materials and reducing landfill waste. The most sustainable building is the one that isn't built, but rather, reused. On the other hand, resilient design now has a newer meaning of buildings that can survive and bounce back from catastrophic weather events and rising seas related to climate change. Buildings that do both exhibit the qualities of resilience and adaptation.[1] In the first century BCE, Vitruvius promoted the virtue of Firmitas or Firmness; advocating architecture that is well-built. Barring intentionally temporary structures, architects usually want their buildings to survive for many years so try to design them as durably as the budget allows. Similarly, in building technology education, we strive to teach ways to construct buildings that will last; not only because they are physically durable but also because they are well-loved (Vitruvius' virtue of Delight) and people will want to preserve them. The virtue of Delight is similar to the Fourth Bottom Line factor that goes beyond the triple bottom line of People, Planet and Profit, to include the less tangible aspect called Purpose, measured by how happy or joyful we feel. When found in architecture, it describes buildings that have meaning to our culture and thereby are loved and appreciated. These buildings that will be reused for generations are one of the best forms of sustainable architecture.

We introduce sustainable construction concepts in the second year of our architecture program. In the past we have focused on methods to reduce the waste of materials, water and energy; and creating durable, reusable buildings is one way to achieve this. But the looming effects of climate change are causing us to rethink how we teach durability in architecture. Only recently have we begun to think about designing buildings, outside of high seismic and hurricane zones, that need to be able to withstand catastrophic weather events. The October 2018 Intergovernmental Panel on Climate Change came as a loud wake-up call to an already dire situation. That report painted an increasingly grimmer picture about the pace of global warming, warning that we have as few as 12 years to make drastic changes to our carbon emissions to avoid a dangerous rise in global temperature.[2] While this has greatly raised awareness and concern, little action has occurred. We surely cannot back off from efforts to reduce carbon emissions, but we now recognize it is too late to stop some of the coming changes. Therefore, it seems imperative we modify, or rather expand, our sustainability teaching strategies to adjust to this new reality. We should consider how to train future architects not just how to build well for functional adaptation and reuse, but also how to build resilient net zero energy architecture that will be able to withstand harsh environmental conditions in the coming decades.

Back in 2013, the website *inhabitat*, influenced by the recent destruction caused by Hurricane Sandy, posed a question in the title of its article: Resilient Design; Is Resilience the New Sustainability? The slap-in-the-face dose of reality delivered by the hurricane triggered the realization that there might be issues of sustainability that needed greater consideration that they were receiving.

> "While building with pure "save-the-earth" ecological motivation is certainly important, low-VOC-paints and LEED points don't matter much if a building becomes uninhabitable due to flooding, earthquake, power outages or some other natural or manmade disaster. That's where resilient design comes into play.....As climate change turns our attention to the possibility of increasingly likely disaster scenarios, resilient design serves to remind us to design for durability over time." [3]

While all aspects of sustainability are important, should we look beyond the low hanging fruit of bike racks and bamboo to emphasize issues of resilient and energy-efficient design that may have the most relevance and importance in the future? According to the Resilient Design Institute (RDI) , Resilient Design is defined as the intentional design of buildings, landscapes, communities, and regions in order to respond to natural and manmade disasters and disturbances—as well as long-term changes resulting from climate change—including sea level rise, increased frequency of heat waves, and regional drought.[4] The Institute defines their 10 Principles of Resilience as:

1. Resilience transcends scales
2. Resilient systems provide for basic human needs
3. Diverse and redundant systems are inherently more resilient
4. Simple, passive, and flexible systems are more resilient
5. Durability strengthens resilience
6. Locally available, renewable, or reclaimed resources are more resilient
7. Resilience anticipates interruptions and a dynamic future
8. Find and promote resilience in nature
9. Social equity and community contribute to resilience
10. Resilience is not absolute

While all these principles should be considered by students, trying to apply each in one second-year studio is unreasonable. So, for the design projects, we focused on 3 principles that most directly relate to the content learned in their first two building technology courses; structural integrity and passive, energy-efficient design. Tech 1, taken the previous semester, teaches about the forces and materials involving structural systems, so we focused on 5th principle that increased durability enhances resilience and the RDI strategy to design and construct buildings to handle severe storms, flooding, wildfire, and other impacts that are expected to result from a warming climate.[5] In their Tech 2 course, taken concurrently with this Design 4 studio, students learn about building envelope and passive energy systems and therefore their design projects incorporated the 6th principle of reliance on abundant local resources, such as solar energy, as well as the 4th principle that simple passive systems are more resilient.[6] To test these principles, they were asked to create buildings that would maintain livable conditions in the event of extended loss of power or heat through energy load reduction strategies, reliance on passive heating, cooling and daylighting strategies (passive survivability).

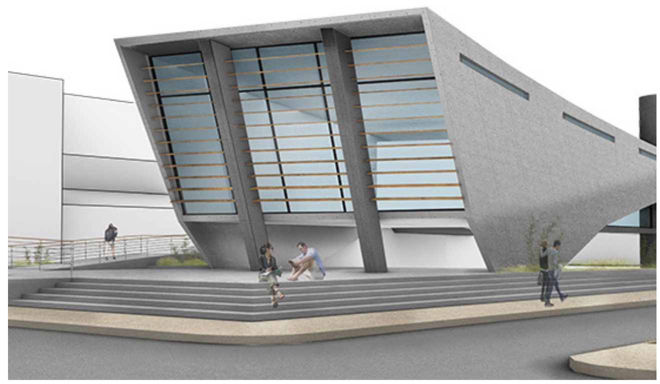

Figure 1. SURF Project Design, Chris Casserly.

Resilient Design strategies can vary greatly depending on location. So, to address a range of issues, the projects were divided into 2 distinct building site locations that are both accessible from our college location. SURF - Resilient Design on the Coast is sited on the New Jersey shore to explore issues related to effects of rising seas, storm surge and high winds on a building. TURF; Resilient Design in the Woods, is set on a natural site in the woods close to campus to focus on issues of extreme temperature, strong storms, drought and forest fire. This studio also has an additional responsibility of covering accreditation criteria for Site Design and Universal Design which were incorporated differently in each project. A summary of the issues addressed in each project are further described in the narratives that follow.

SURF

The first 5-week studio project, SURF - Resilient Design on the Coast is sited on the ocean shore, to focus on ways to combat the effects of storm surge and high winds mainly brought on by hurricanes. Conveniently, the topic of the then current ACSA Concrete Competition was on resilient design so we used their competition brief for a Recreation and Disaster Control Center and sited it on the New Jersey shore. The program required sports and educational facilities that would be used 99% of the time but could easily be converted into a control center and storm shelter in case of a natural disaster. Concrete as the main material was a logical choice because of its durability against high winds and storm surge. However, the paradox of using concrete, a very structurally resilient material but one that is a major contributor to of CO2 and global warming, was discussed at length. Project requirements that were critical to the design of a resilient building along the sea coast, included the following topic areas.

Elevated Floor – The main floor had to be located at least 10' above ground level to protect against storm surge flooding linked to hurricanes and rising seas.

Water Resistance – The structural system had to allow for and withstand the directional free flow (both inward and outward) of storm surge water below and/or around the building.

Wind Resistance – The structure, exterior finishes and especially the fenestration had to be designed to divert and withstand high winds and wind-borne debris. Lateral forces played a larger role than gravity forces in this project.

Resilient Systems – Since elevators don't work without power, ADA approved ramps were required to access the main floor and plaza from the sidewalk. This requirement intentionally gave the ramp extra importance as a major design element and not just as an afterthought; a goal of Universal Design.

Because the practice of resilient building design is very new, there are few precedent studies to reference. But students did research examples, including the Brock Environmental Center in Virginia Beach and the Coastal Studies Institute in North Carolina, to learn about coastal related strategies they could incorporate into their design. Some common strategies emerged in the various student solutions. The main thrust from a hurricane of both storm surge and high winds would come from the same eastern direction off the ocean. So, concrete structural systems and building shape were often oriented in an east-west direction with a thin face to the ocean to minimize the lateral wind loading and to allow water and wind to pass around, above or below the elevated floor structure easily. The knowledge of concrete structural systems and lateral load resistance that they acquired the previous semester in the Tech 1 course were very useful for this first project. Windows facing the ocean provide a great view and excellent southeast sunlight for heat and daylight, but also present a vulnerable glass façade towards the worse wind conditions in a storm. Therefore, several students incorporated heavy-duty operable louver or screen systems that could shade against summer sun but also be closed in a hurricane to resist impact of flying debris.

TURF

The second 7-week project in the Design 4 Studio Course, TURF; Resilient Design in the Woods, is set in a natural site in the forest to primarily focus on the RD issues of extreme temperature swings, loss of power, damage from strong storms and forest fire. The program of an Archeology Institute was partly chosen to address site design issues of topography by requiring them to dig into the earth, but also allows student to take advantage of the ground's constantly moderated temperature for energy conservation. The building was also required to be able to continue to operate even in in case of a loss of power or storm damage. Additional resiliency requirements based on this specific site location in the woods included:

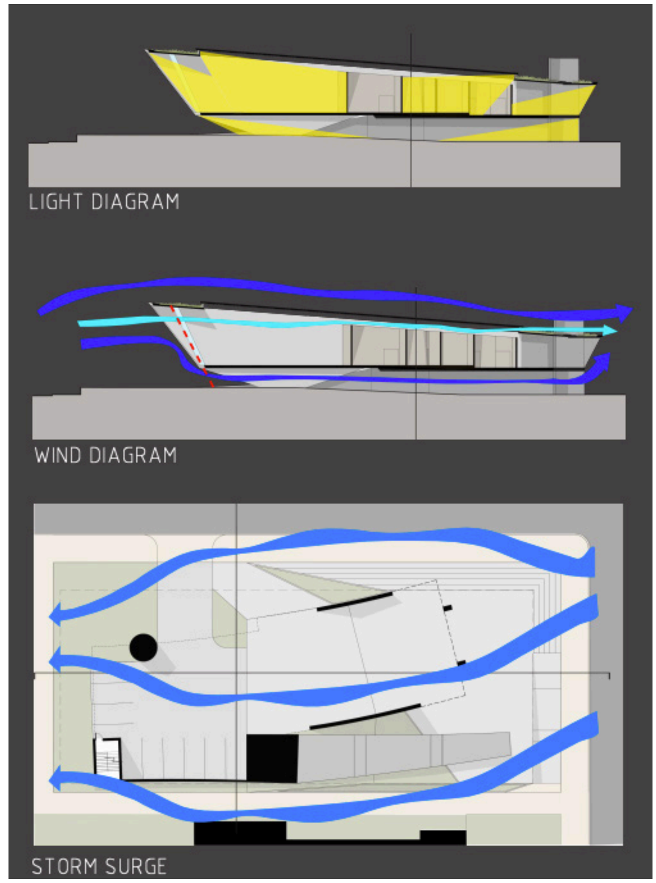

Figure 2. SURF Proj. RD Diagrams, Chris Casserly

Earth Sheltering – To take advantage of earth cooling and insulation, a portion of the building volume was to be located below existing grade. The highly sloping site was favorable to this requirement. It also supported the studio site grading objective of learning how to recontour the land.

Energy Use – The building had to be very well-insulated and able to stay relatively hot or cool (depending on the season) for extended periods with only a minimal energy source. Students were asked to incorporate passive solar heating, natural ventilation, and Passive House principles of insulation and air-tightness into the design as much as possible.

Storm and Fire Resistance – The site was in the middle of a mature forest so the structure had to be strong enough to resist the weight of falling trees caused by violent storm winds. Exterior wall and roof finishes had to be non-combustible to resist forest fire.

Daylighting – Natural daylighting through windows and/or skylights had to be incorporated into each habitable space in case of loss of grid electric power.

The sloped topography of the site and the program of a dig site made it easier for student designs to incorporate a portion of the building into the ground to take advantage of temperature moderation through earth sheltering. Landscape-based buildings like the Brooklyn Botanical Gardens by Weiss Manfredi Architects were used as precedents to demonstrate how to integrate landscape and architectural design. For practically all the student designs, the north, east and west walls and roof were thick, heavily insulated and with few windows, while the south walls overlooking the valley were mostly glass, shaded by roof overhangs and louvers optimized to take advantage of solar heating, shading and daylight Roof and wall primary structures were typically made with heavy-duty glulam and concrete frames to protect the inhabitants from falling trees. Wood is a common exterior finish found on woodland buildings but since no combustible finish materials could be used on the skin, roofs were mostly standing-seam metal and walls were usually made of brick masonry, stone, or metal panels.

TECH COURSE CONNECTIONS

In the first half of the Tech 2 course, which they take concurrently with this studio, students learn about passive energy strategies such as: highly-insulated and air-tight skins, passive solar heating, sun shading techniques, natural ventilation, earth-cooling, and daylighting. The second half of Tech 2 course teaches about building envelope systems, including heat transfer, insulation, glazing, wall cladding and roofing. Students were asked to apply this acquired knowledge to their design project to demonstrate they understood how their material choices could create a resilient structure and envelope. Therefore, for the final Tech project, each student created a color-rendered detail of their TURF project where the wall meets the roof on a southern façade; the point at which the heavy-duty structure, thermal insulation, fenestration, sun-shading, cladding and roofing systems meet.

In the first project in Tech 2, students used the Sephaira software to study the before and after effects of energy efficiency and daylighting in a building. Using an existing work of architecture (a Case Study House) they added sun shading devices and modified envelope insulation to try to meet preset Passive House and Daylighting standards.

While it would have been nice to apply this to their own projects, the software had strong limitations, time was short and the projects were too complex to be tested quickly. However, they were able to apply the principles they learned and demonstrate them through R-value calculations and sun angle diagrams to show their intent. The following 5 envelope system criteria were addressed by each project:

Structure – Students selected a heavy-duty resilient structural system with lateral bracing to protect the building from strong winds and falling trees. Steel, concrete, stone and mass timber were allowed but no light gauge steel or wood studs could be used.

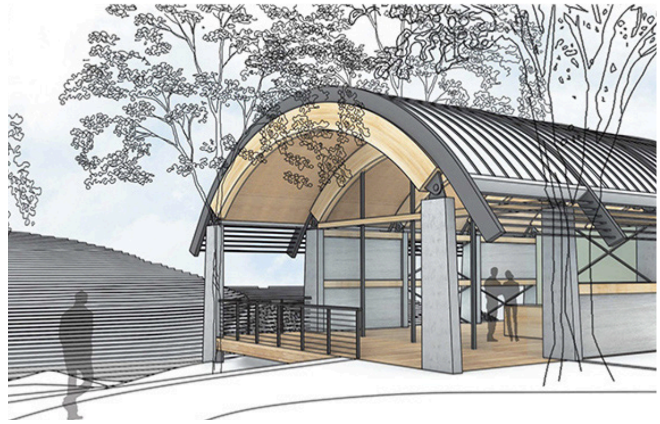

Figure 3. TURF Project Design, Jessica Radomski

Cladding and Roofing – Students chose fire-resistant cladding and roofing systems and detailed their attachment and flashing methods. The material was of their choice but had to be fire-resistant and embellish their design parti.

Fenestration – Students selected and detailed a thermally-broken, insulating glass, aluminum storefront glazing system from industry product libraries and detailed the flashing and sealant required to keep water and air out.

Solar Shading – Students designed a custom horizontal Sun Shading Device in front of the south windows. Following a lab we did in class, they had to size and space the shades to graphically demonstrate how the shading device would prevent entry of all southern sun on September 1 at noon and allow most of the sun to penetrate on December 21 at noon.

Insulation – Lastly, they created highly-insulated wall and roof envelope assemblies with minimal thermal bridging. Insulation had to add up to a minimum R-30 for walls and R-45 for roofs. Using the R-value chart from a previous lab worksheet, they labeled the materials and showed their R-value calculations.

This exercise additionally ties the 2 courses together by serving both as a final project for the tech course and as part of the final studio boards to give greater depth to their design project. The detail drawing examples below document student's RD strategies of noncombustible metal roofs, heavy-duty glulam and concrete structural frame, sun-shading louvers and heavily insulated roofs.

CONCLUSION

While a second-year studio is too early in the curriculum to address all areas of resilient design, it is not too early to introduce the main ideas of the topic. We have a robust building technology and structures curriculum of 7 courses; several of which integrate sustainability and technology with a design studio in the later years, so the topic of resilient design will be readdressed. By continually linking design, sustainability and

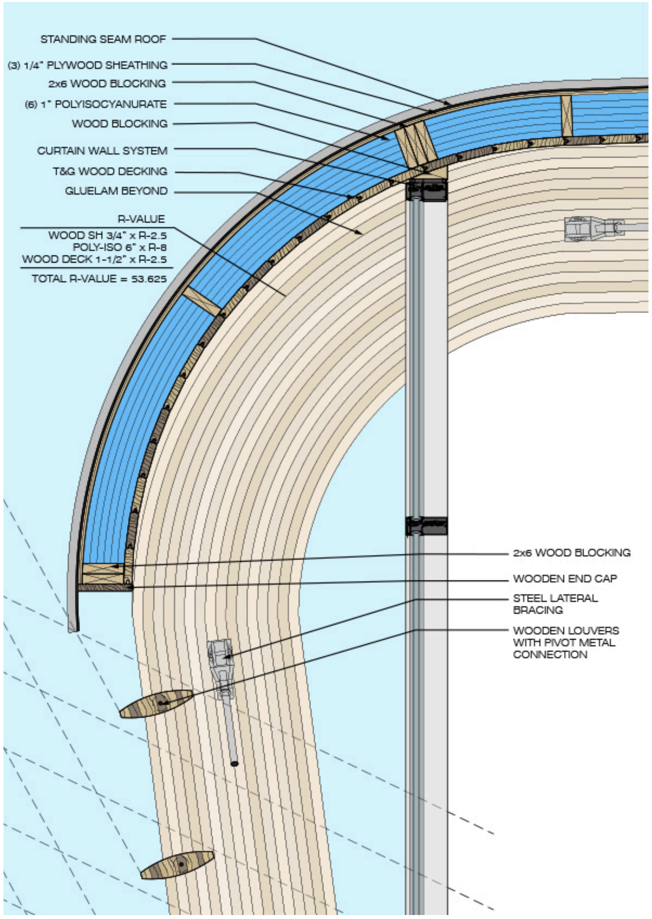

Figure 4. TURF Proj. Detail, Chris Casserly

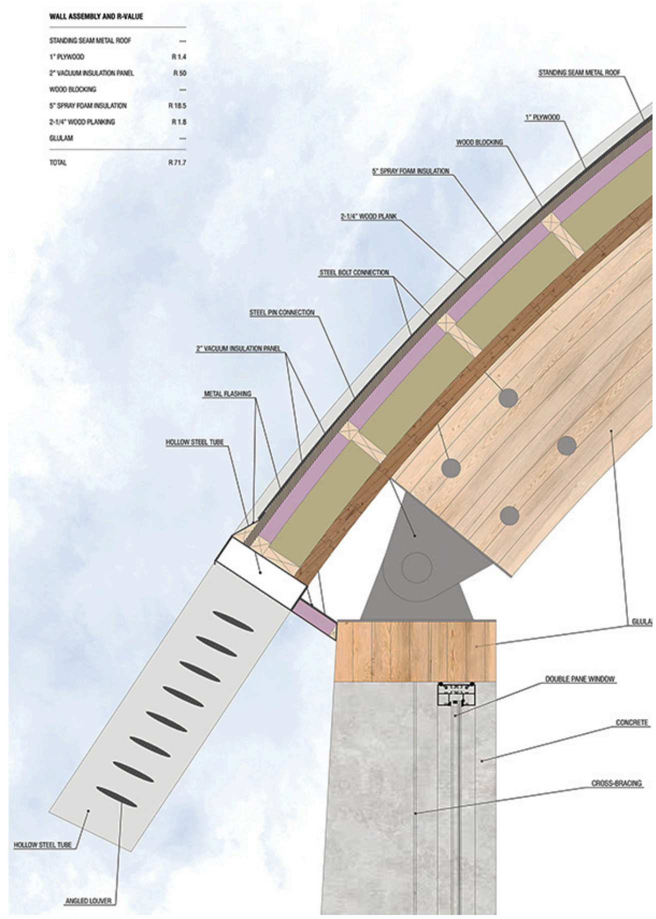

Figure 5. TURF Proj. Detail, Jessica Radomski

technology together, it reinforces our school's assertion that these are not separate disciplines; that you need to consider all at the same time to solve critical environmental issues such as climate change. One shortcoming of this pedagogy is the difficulty in maintaining a strong link between the Studio and Tech course projects. The lab portion of the tech course did not allow enough time or feedback from the instructor to fully develop the detail. Students who had the same studio and tech course professor, were able to get more critique time from them, including during studio class time, for the better results. But for students who had different studio and tech instructors (mostly adjunct), there was less time spent developing the details and the results were understandably under-cooked. Unfortunately, this is a common issue when trying to link projects across separate courses.

The potentially devastating effects of climate change make it necessary to bring the concept of resilient design more clearly into the foreground. The priorities of sustainable construction have changed so we should accordingly change the way we teach it. By introducing the idea of resilient design early in the curriculum and at the same time as other aspects of sustainability, the students should be able to achieve greater depth with the subject in the remaining three years of their education.

ENDNOTES

1. Sustainable Design for the Built Environment, Rob Fleming and Saglinda H Roberts, Routledge, 2019
2. Global Warming of 1.5°C; October 2018 Intergovernmental Panel on Climate Change, https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf
3. Resilient Design: Is Resilience the New Sustainability? inhabitat Website, https://inhabitat.com/resilient-design-is-resilience-the-new-sustainability/
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