Building Resilient Communities in the Aftermath of Natural Disaster: A Demonstration Home in Joplin, Missouri

Our cities of today and tomorrow need to be built more sustainably to withstand the devastating effects of natural disasters. In the news each day, we see the deadly effects of disasters impacting communities across the globe. Typhoons, hurricanes, earthquakes, tsunamis, wild fires and tornadoes are leaving hundreds to thousands dead, injured or displaced without homes. Businesses and communities are destroyed and rebuilding is slow. Construction techniques often repeat the same mistakes leaving exposed a vulnerable community for the next disaster.

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According to the Intergovernmental Panelon Climate Change, "an increase of greenhouse gases in the atmosphere will probably boost temperatures over most land surfaces, though the exact change will vary regionally. More uncertain—but possible—outcomes of an increase in global temperatures include increased risk of drought and increased intensity of storms, including tropical cyclones with higher wind speeds, a wetter Asian monsoon, and, possibly, more intense mid-latitude storms. But even as a warming climate might decrease the overall number of storms that form, it could increase the number of intense storms. As temperatures continue to rise, more and more water vapor could evaporate into the atmosphere, and water vapor is the fuel for storms." The article also states that although the frequency of storms may not change, an increase in water vapor in the atmosphere caused by increased evaporation at higher temperatures could cause storms to become more intense. "If we are creating an atmosphere more loaded with humidity, any storm that does develop has greater potential to develop into an intense storm," says Tselioudis." The article goes on to suggest that the location of the storms affected by the increase of temperature on the planet will be in the mid-latitude areas, the most populated areas of our planet.

On May 22, 2011, Joplin, Missouri, located in a tornado prone area of the central plains in the United States, sustained a multi vortex, ¾ mile wide, EF-5 tornado with wind speeds in excess of 200 mph. This storm traveled 13 miles, left 161 people dead and damaged over 7,500 homes and 800 businesses. 9,200

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people were displaced and 586 family units were placed in FEMA shelters. Destruction was heavy due to the intense wind speeds and the slow (10mph) movement of the storm across the city. The path became a debris field in excess of three million cubic yards. Total cost of the 2011 storm reached an estimated $2,017,564,600.

These numbers were devastating for the people of Joplin and ultimately affect us all as tax payers, donors and volunteers. Unfortunately, higher statistics of death and destruction are recorded in cities across the planet each year as intensity of storms increases each year.

Whether or not we believe that global warming is to blame for increased frequency or intensity of tornadic storms, we can and must prepare and build better to protect ourselves from future natural disasters and the inevitable loss of life and property. Building in a way that produces three million cubic yards of debris in the wake of a tornado is not responsible or sustainable. Our landfills cannot continue to consume numbers of this magnitude from one storm.

The debris in Joplin was hazardous both physically and environmentally. The air was full of hazardous dust and particles that prompted an EPA recommendation that residents and volunteers working inside the tornado impacted area wear NIOSH-approved N-100, P-100 or R-100 respirators as a health precaution. Soil disturbed in old mining areas tested above safe levels of lead and cadmium. Many sites had to be stripped up to 3' of soil and new soil brought in.

With the prevalence of natural disasters and the negative impact they have on our environment and well-being, teaching students disaster mitigation strategies and how to rebuild resiliently should be an important component in architectural education.

In response to the 2011 Joplin event and vulnerability of the area to tornado events, The Center for Community Studies in the Hammons School of Architecture at Drury University was the ideal place for students to design the Monarch Eco-House, Greentown Joplin's education center for sustainable living demonstration home and bed and breakfast. GreenTown Joplin is a unique nonprofit, whose mission is to educate communities on sustainable building practices and life style. GreenTown Joplin was launched by Greensburg GreenTown, a nonprofit organization working in Greensburg, Kansas since May of 2007 to help the town realize its dream of rebuilding as a model green community after the town was destroyed by an EF5 tornado.

Figure 1: Joplin Debris Removal, cjonline.com.

Figure 2: Joplin Debris Field; davideulitt.com.

Over the course of a semester, students developed and employed sustainable practices from passive solar design strategies to active photovoltaic thermal systems, various green technologies, safe rooms and leading edge technologies to withstand catastrophic damage from the next tornado. Engaging Joplin, MO residents, working with disaster resistant materials manufacturers and an ongoing dialog with the C.A.R.T. (Citizens Advisory Recovery Team) to better understand lessons learned in the aftermath of the storm gave students a sense of urgency and necessity to create more innovative disaster resilient, sustainable communities.

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Figure 3: Drury Architecture students collaborating on design.

The Eco-Home serves three distinct functions for the client. It houses the offices of the not-for-profit, it is an educational center on sustainability open to the public and the bed and breakfast gives those seeking the opportunity, first-hand experience of living in a sustainable, resilient, net-zero home. This complex program along with the goal of creating a net-zero disaster resistant structure and working with a real client proved to be quite challenging for the students.

This demonstration home employs disaster resilient and sustainable products and practices. An innovative building material was used to create a wall system able to withstand impacts up to 250+ miles per hour. ICF-Insulated Concrete Forms by TF Forming System with helix reinforcing, calculates to withstand winds up to 250 mph. This wall system 8” concrete with 2 ½” insulation on each side, thermal break, is also rot and termite resistant. This product not only will sustain lives, but will protect the entire structure and greatly reduce the volume of projectiles during the storm, subsequently reducing the debris field and the load on storm related landfills.

“With its steel-reinforced (helix) concrete core, TransForm and ThermoForm are well known for being extremely rigid and resilient building systems, allowing walls and floors to be built with strict prescriptive methods to prevent structural failure during a terrorist or catastrophic event. In addition to its concrete core, TF Concrete Form walls are sandwiched with anywhere between 2” and 6” of polystyrene exterior foam, acting as a cushion. When air pressure hits the wall,

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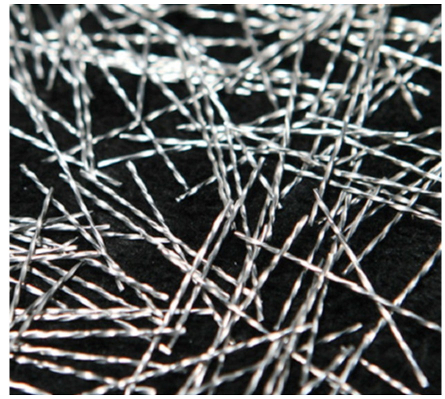

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the foam absorbs air pressure and spreads the energy generated by an explosive event over a larger surface area of the concrete wall greatly increasing its resistance to damage."

While the demonstration home was specifically designed for its location in "tornado alley" in the mid-western United States, concepts and strategies used in the design can be applied to the diverse natural disasters that are occurring so frequently across our planet. In addition to storm resistance, energy efficiency and sustainable materials and practices were equally important for the students to explore. Some of the strategies proposed were:

- Photovoltaic thermal (PVT) array, with individual panels at a size of 3'x 5', uses the front side to collect energy through photons captured by the sun for electricity while the back of the panel pulls the heat off the panels and circulates it through water or a coolant away from the panels to heat usable water or even the radiant floors in the winter
- The daily exposure of the sun is maximized by placing the PVT panels on the highest south facing roof to prevent the panels from ever being shaded. While designing for Joplin we used the optimal angle of 37 degrees to capture as much energy as possible throughout the day and seasons
- Radiant floor.

The storage of solar energy in "thermal mass," comprised of building materials with high heat capacity such as concrete slabs, brick walls, or tile floors. The energy is then naturally distributed back into the living space, when required, through the mechanisms of natural convection and radiation:

- Calculated roof overhang.

A calculated roof overhang on the south side of the house allows for shading in the summer, and heat gain in the winter. This in combination with the thermal mass allows for the use of solar energy:

Figure 4: Helix, Actual size, TF Forming Systems.

Figure 5: Helix additive, TF Forming Systems.

- High Performance triple pane windows
- Low operable windows in the Southern side of the double story room with high operable windows on the North side. Capturing primary southern wind which is primary in Joplin
- High performance ceiling fans will help circulate the air
- Mini split ductless air conditioner with heat pump offers quiet operation, eliminates noisy compressors and ductwork and allows individual control of rooms or areas
- Materials used are reclaimed, recycled, reused, or produced with Eco friendly methods
- Installing low energy high efficiency appliances
- Collecting and using rain water for irrigation, including a rain garden
- Underground cistern to collect gray water for flushing toilets
- Trellis to allow vegetation growth to help shade the south facing rooms in the summer.

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Figure 6: Night Render of Eco House, by Drury Students.

The project was hosted in a 3rd year, Community Design Studio as part of the core curriculum in the 5-year Master of Architecture program in the Hammons School of Architecture at Drury University in Springfield, Missouri. Twelve students spent one semester (15 weeks) for the design and completion of construction documents in this Center for Communities Studies course.

Program development with client and students began with a field trip to see the demonstration Eco-House in Greensburg, Kansas where many residents and businesses owners rebuilt to LEED (Leadership in Energy and Environmental Design) standards after a 2007 EF5 tornado wiped out 95% of their town. Greensburg boasts to have the most LEED certified buildings per capita in the world.

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Students met with the nonprofit, GreenTown - Greensburg who lead the charge to rebuild sustainably, several residents, business owners and had tours of homes and businesses that built to LEED standards.

Design Development included client input and multiple meetings with community stakeholders in the Joplin area and the client, GreenTown – Joplin. A final presentation to the client and stakeholders was open to the public and drew 70+ participants.

Lessons learned and Best Practices for a successful design project with a local nonprofit organization with potentially strong community impact include:

Lessons Learned:

- Group dynamics at the 3rd year level can be difficult at times depending on the personalities and maturity level of the individuals. Projects for real clients with potential of construction are best suited for upper level students with more maturity, experience and ability.
- Site acquisition prior to students beginning design process is essential.

Best Practices:

- Faculty and nonprofit stakeholder need to have a strong level of trust, common goals and clear communication of expectations of one another developed before students become part of the process
- Based on your school's academic calendar and framework for design, the project must be ready to go on day one of classes and ready to be finished by the last day of class.
- Stakeholder needs strong community connections for broad community input into design and criticism
- Majority of donations (in-kind and cash) for construction need to be committed before and during design phase.

Figure 7: Gift Shop, Render by Drury Students.

Figure 8: View From Stairs, Render by Drury Students.

ENDNOTES

1. The Earth Observatory; part of the EOS Project Science Office located at NASA Goddard Space Flight Center webmaster: Paul Przyborski | NASA official: Charles Ichoku.
2. Fact Sheet, City of Joplin; Lynn Iliff Onstot, Public Information Office 602 S. Main Street Joplin, Missouri 64801 417-624-0820 Ext. 204 www.joplinmo.org.
3. International Business News Sunday, May 18, 2014 As of 10:12 AM EDT Report: The Ten Most Expensive Natural Disasters In 2013, Kathleen Caulderwood, January 15 2014.
4. Joplin, Missouri, Tornado Response; Particulate (PM10) Air Monitoring Results; EPA, Region 7.
5. Joplin gets EPA funds to clean up contaminated soil exposed by tornado; The tornado in May 2011 stirred up lead- and cadmium-contaminated soil; October 04, 2012; Linda Russell, KY3 News.
6. TF Forming Systems; http://www.tfsystem.com/Benefits/DisasterResistance.aspx.
7. TF Forming Systems; http://www.tfsystem.com/Benefits/DisasterResistance.aspx.
8. Greensburg, Kansas home page: http://www.greensburgks.org/.