KSU Mini Pavilion: A Constructed Ecology and A Didactic Tool for Learning

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ABSTRACT: *The KSU Mini Pavilion Project consists of an inter-disciplinary team that includes faculty from computer engineering, construction management and architecture as well as administrators from the county's school system (see acknowledgements) with a focus on STEM and its intersection with elementary school education. The project began in 2019 with a vision to construct an exhibition space that would demonstrate to elementary students the connection between safety and sustainability at the Cobb County Safety Village (CCSV) in Marietta, GA. The CCSV is an eight-acre campus the replicates a reduced size village that teaches students of the county subjects like fire safety and crime prevention. In recent years, local businesses and institutions have constructed mini versions of themselves to represent their contribution to the community. Our mini pavilion will represent Kennesaw State University, the largest university in the county and the third largest post-secondary institution in Georgia.*
The philosophy of the Mini Pavilion project echoes the thoughts of the Tokyo-based architect, Kengo Kuma and his notion that architecture of the 21st century must be less monumental and more environmental. Kuma suggests in his writings and work that buildings echo the local geography and ecologies and merge with the environments, so they become less formalistic, and more performance driven. Performance that is not only technological but also a kind of visual performance that contributes to the cultural identity of a place. It is hope that the project is a built realization of this philosophy and that it engages the imaginations of both young and old for vision of future that is not only safe and sustainable but regenerative in the Age of Man in the Epoch of the Anthropocene.

KEYWORDS: Sustainability, Safety, Community, Constructed Ecologies

THE PROJECT

The KSU Mini Pavilion is a five hundred and seventy-six square foot interactive exhibit space that will demonstrate to elementary students the interconnection between safety and sustainability through both the building's design as well as its interactive VR/AR displays. The pavilion will be constructed at the Cobb County Safety Village (CCSV) in Marietta, GA, an eight-acre interactive safety facility that is a microcosm of a typical American town complete with roads, traffic lights, a civic central square and neighborhoods (Figure 1). The CCSV serves as an educational tool for elementary school students to learn about safety through a variety of experiences offered onsite. The mini-pavilion projects sited at the CCSV are an integral part of the hands-on safety learning experience for target audiences of K-12 students and adult seniors.

The project has a dual nature. Not only is it an interactive classroom, but it will also be an annex building for KSU that both faculty and graduate/undergraduate students can use for their research. One can imagine the pavilion embedded with electronic sensors that measure heat transfer through a wall assembly, the amount of electricity generated by the roof-mounted photovoltaic arrays or the rainfall that percolates through custom designed pervious concrete tiles installed on site. We envision the pavilion as a place that can foster new interdisciplinary capstone design projects for our undergraduate students and be a key resource in the development of new courses developed around cutting-edge technologies installed upon or embedded within the mini-pavilion's walls, roof, floor, or surrounding landscape.

Our project seeks to build a platform that provides KSU and our external partners the ability to connect with our local community. We intend to establish a physical space in the community that can be used as research infrastructure for our faculty, while providing a positive branding image to the public as our testament to progress and innovation in safe and sustainable communities. In the big picture, the pavilion becomes part of a university's research infrastructure that improves the competitiveness of KSU, a Carnegie-designated doctoral research institution (R2), placing it among a group of only 7 percent of U.S. colleges and universities with an R1 or R2 status.[1]

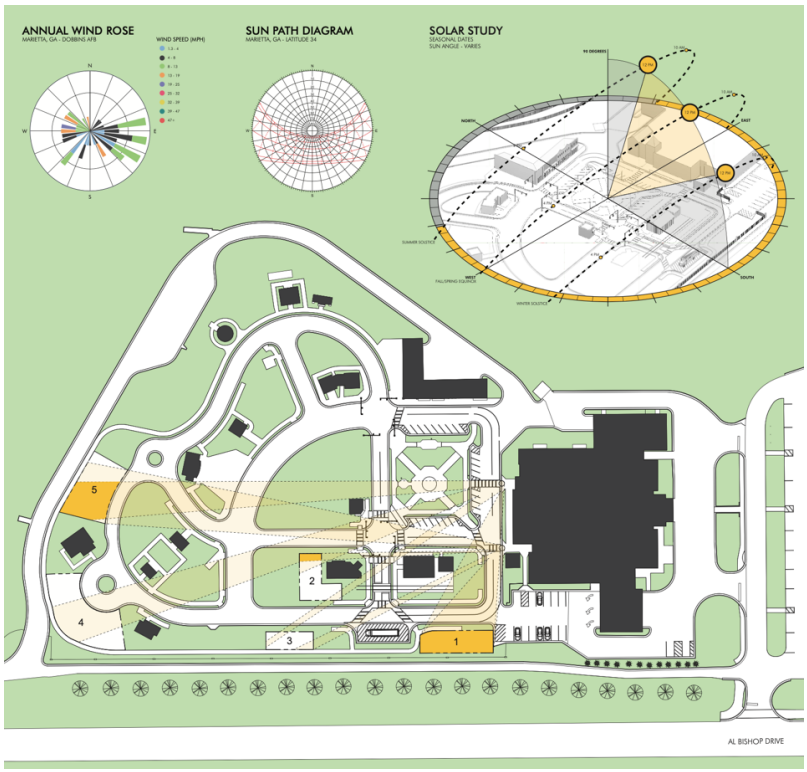

Figure 1: Site Plan of Cobb County Safety Village with Initial Solar/ Isovist and Wind Rose Analysis. The Elongated Yellow Box #1 Indicates the Location of the KSU Mini Pavilion. (Michael Carroll 2021)

PORCHES, DOG TROTS, AND THE SOUTHERN VERNACULAR

Given that the project represents a university with an emphasis on innovation regarding its research and teaching, it was important that the architectural expression of the pavilion was forward thinking and contemporary in its tone and incorporated, where possible, cutting-edge building technologies. Given its objective to be sustainable, it was also paramount that the project addressed the rich architectural vernacular of the region. Given that the vernacular, as a typology and as a way of building is inherently in sync with the climate, the materials, the topography, and culture of a place, it was a key point of departure in the design of the KSU Mini Pavilion. From the project's initial sketches, both the dog-trot plan typology and the porch (Figure 2) were referenced as key ingredients of a southeastern American vernacular and were incorporated in the generation of the pavilion's design. Both the dog-trot's breezeway and the open porch provide buffered semi-enclosed spaces that are conducive to passive ventilation in moderate climates with varying degrees of relative humidity. The dogtrot is referenced in the project's plan with its entry breezeway. It provides a sheltered space where students can gather and queue before entering the exhibit space. The porch along the pavilion's north elevation provides shade, shelter from rain and thermal buffering but most importantly signals social interaction. One can imagine the porch as an ideal location where students and their teacher can gather for a group photo, a memento of their afternoon outing to the CCSV.

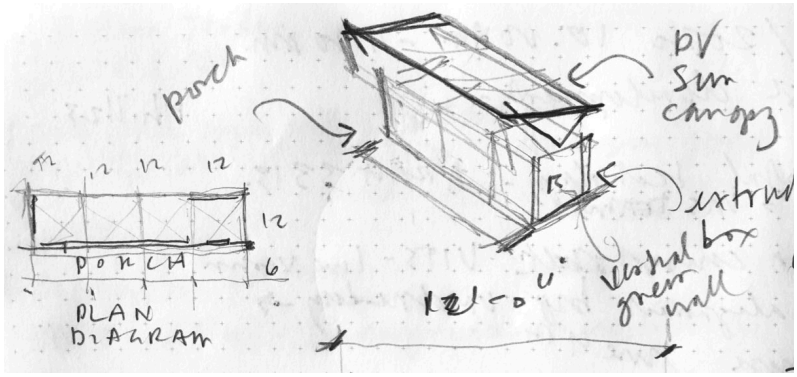

Figure 2: Schematic Design Sketches (Michael Carroll 2021)

Figure 3: Rendered View: KSU Mini Pavilion, Breezeway/Entry Court (Michael Carroll 2022)

ELONGATED FORM AND THE 12’-0” BAY

The 48’-0” x 12’-0” foot elongated form of the pavilion that is oriented directly south, maximizes its solar and wind exposure. The plan of the building is regulated by its four 12’-0” by 12’-0” bays (Figure 4). The 12’-0” bay size minimizes material waste in platform frame construction with wood studs that have an 18” on-center spacing and sheet material that is available in 4’-0” by 8’-0” formats. Three 12’-0” x 12”-0” x 12’-0” cubic bays encompass the pavilion’s exhibition space and classroom. The final bay is split in two to create a partially covered entry breezeway and vestibule. The other half is a dedicated electronics’ room that can house equipment as well as display monitors that can produce real-time data that can be read by the students as they gather in the pavilion’s entry breezeway. A large rolling door ensures the security of the entry area as well as contribute to dynamic and interactive character of the building. One can imagine a motion sensor, with a manual override, that opens and closes the perforated metal sliding door.

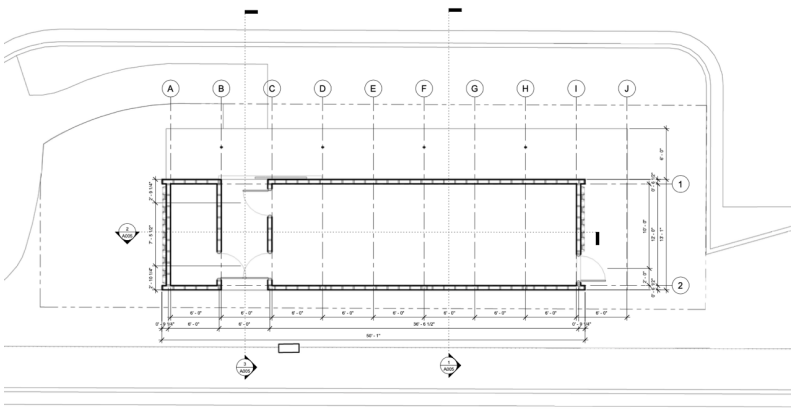

Figure 4: Ground Floor Plan: KSU Mini Pavilion with Dimensioned Structural Grid (Michael Carroll 2022)

CROSS SECTIONS, PV CANOPIES, AND THE SOLAR CHIMNEY

In terms of project’s volumetric qualities, the overall dimension of the cross section of the main room is 12’-0” wide and 12’-0” high. The high ceiling ensures that projectors and other equipment for the VR/AR installation can be accommodated. The roof is sloped slightly to drain to a rain gutter installed along the south eave. At the end of each gutter is a laser cut acrylic chain that will direct water to be collected in a sub-terranean water cistern. Water from the cistern will be used to irrigate the two vegetal walls that comprise both the east and west elevations.

To accommodate the photovoltaic arrays, a skeletal metal frame is anchored to the project’s nominally flat roof. Once the PVs are mounted on the frame, they will help shade the roof and induce cross ventilation which not only increases the efficiency of the PVs but also helps reduce any heat island effect. Along the northern side of the building, the open skeletal frame extends 6’-0” past the building’s enclosure to create a semi-enclosed porch. This design move also increases the project’s overall massing along pavilion’s north elevation. The linear bulkhead above the porch is an ideal location for the branding and signage as it has a high visual exposure from the CCSVs main building.

To help passively vent the exhibition space, a solar chimney which measures approximately 6'-0" x 6"-0" was incorporated with the pavilion's design and can be seen in the project's longitudinal section (Figure 6). The glass faced Trombe wall that forms the top of the solar chimney is oriented directly south. Using the greenhouse effect, the air between the glass and the dark metal surface is heated. This hot air is exhausted in a vent at the top of the solar chimney and contributes to the overall stack effect that helps vent the warm air the accumulates in the exhibition space. This air from below rises through the linear slot at the base of the solar chimney. Once installed the movement of the air will be monitored and adjustments can be made to the solar chimney to optimize its performance.

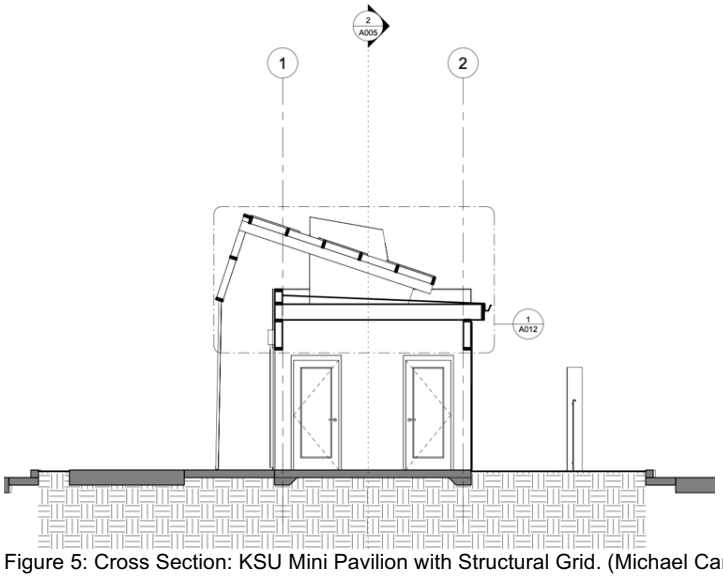

Figure 5: Cross Section: KSU Mini Pavilion with Structural Grid. (Michael Carroll 2022)

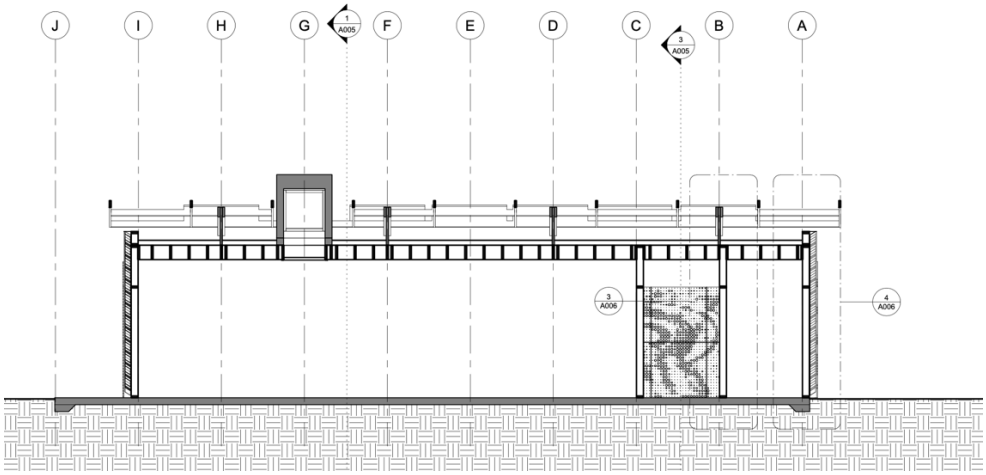

Figure 6: Longitudinal Section: KSU Mini Pavilion with Structural Grid. (Michael Carroll 2022)

SENSORS DEVICES AND EMBEDDED TECHNOLOGIES

As previously mentioned, beyond the basic enclosure of the building, a second phase of the project will entail the implementation of research activities that use the CCSV pavilion site as a testbed to perform experiments related to building-integrated renewable energy generation and energy efficient smart-building technologies. Arrays of novel low-power, multi-sensor devices will be installed at strategic locations inside and outside of the pavilion to monitor ambient, environmental conditions, and human activity for improved energy efficiency and safety of the building. As well, high performance photovoltaic arrays and bladeless wind energy harvesting devices can be installed, and their energy efficiencies can be calculated. The acquired sensor data and energy data will be used to optimize the energy output of the renewable system and energy efficiency of the building through machine-learning and deep-learning algorithms.

In terms of experimentation with sensor device, in the Fall 2021 semester, architecture and computer engineering students from Professor Carroll's and Professor Kihei's[2] classes collaborated in a fifth-year design

studio project that resulted in a series of interactive architectonic objects that were mounted and displayed on the rooftop gallery of the KSU Arch Gallery in December 2021.

In this process, twenty-two Computer Engineering (CPE) students learning about the Internet-of-Things (IoT) were matched with fourteen architecture (ARCH) students. The multidisciplinary teams proceeded to design a series of installations that were welcoming to children and featured embedded sensors and connectivity. Visitors to the rooftop were able to interact with the projects using a local Wi-Fi network. A QR code provided a link to the exhibit landing page where visitors could select the project of their choice and view the output of the sensors graphed on the webpage. This provided an experimentation environment of how the connected embedded sensors could be used to enhance the performance. Visitors were delighted with the transformation of the projects from daytime to nighttime, enjoyed the playfulness of the interactivity of the projects, and were intrigued with the sensor values streaming in real-time to their mobile devices. Post completion of the performance, the ARCH students were asked to evaluate their consultant teams which directly affected the CPE student grades and provided constructive feedback to them.

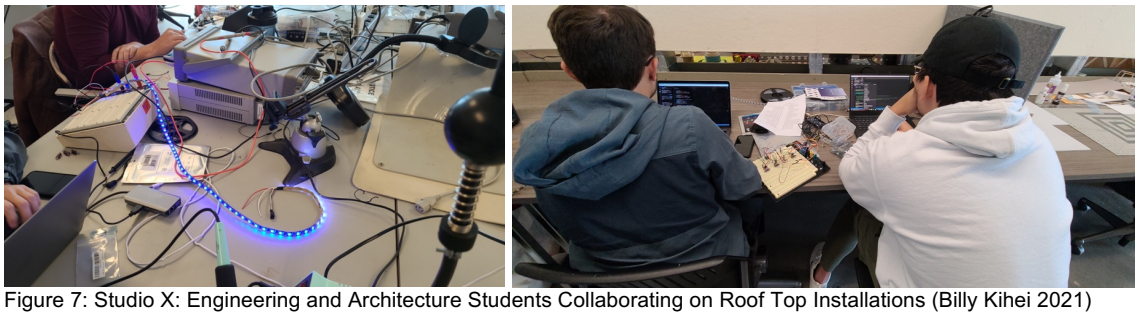

Figure 7: Studio X: Engineering and Architecture Students Collaborating on Roof Top Installations (Billy Kihei 2021)

Most of the architectonic objects fabricated used laser-cut edge-lit and mirrored sheet acrylic and were assembled using 3-D printed mounts and fasteners (Figure 7). An inspiration for this project a 1:50 scale model in the NYC MoMA collection of the Hotel Habitat Project sited in the L'Hospitalet de Llobrega area of Barcelona, Spain.[3] The hotel project designed by Eric Ruiz-Geli of Cloud 9 (Barcelona) and Acconci Studio (New York) features a cubic like form enveloped in a netting embedded with sensors and lights (Figure 8).

Figure 8: Studio X: Interactive Architectonic Objects: Roof-Top Exhibition (Michael Carroll 2021)

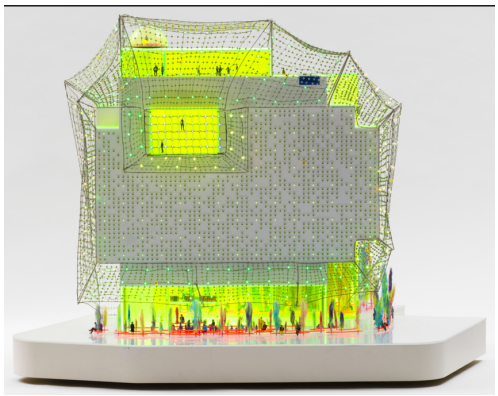

Figure 9: 1:50 Scale Model, Hotel Habitat Project, Cloud 9, and Acconci Studio 2004-08 (NYC MoMA Collection) https://www.moma.org/collection/works/100415

WATER, RAIN SCREENS, AND THE BUTTERFLY EFFECT

Water is a central theme of the pavilion project. As previously indicated, rainwater is collected from the roof and directed to water cisterns where it is stored. This water is used to irrigate 12'-0" x 12'-0" vegetal walls that line the east and west elevations of the pavilion. The green wall system specified for the project was designed and fabricated by, GrowUp a company based in Vista, California[4]. As a test run, a 4'-0" x 6'-0" section of the GrowUp wall was installed by fifth-year undergraduate architectural students as a design/build project in the KSU MAT_Lab in September 2021 (Figure 9). It is the intention that the plant specification for Pavilion's vegetal walls include those that attract butterflies, bees, and birds. Therefore, the project's green wall is not seen as a static entity but instead it is a living ecosystem. One can imagine the sensory delight of an array of plants like lavender, salvia and others that are not only attractors but also have a calming effect for humans and contribute to a sense of well-being.

To further reference water, the north and south elevations of the pavilion feature yellow powder-coated metal panels perforated in a dot-matrix pattern derived from a photographic image of water droplets (Figure 10). Performing as a rain screen, the Alucobond panels hover an inch in front of a Blueskin house wrap which forms a vertical drainage plane. Water collected at the base of the rain screen is collected in a channel and directed to the water cisterns used for irrigation.

Figure 10: GrowUp Wall Mock-Up, MAT_Lab, KSU Architecture (Michael Carroll 2021)

PAVILIONS, PATTERNS, AND THE BUTTERFLY EFFECT

The façade's photographic image of droplets of water and the resulting wave interference pattern on the surface of a pond hopefully attracts the eye of CCSV visitors. As butterflies hover on the nearby vegetal wall, maybe imaginations are sparked with visions of the butterfly effect – a concept in which patterns and butterflies collide. The butterfly effect is a reminder that seemingly insignificant changes in initial conditions can have large and unanticipated impacts within larger systems. The micro and the macro systems are inter-related as observed by Edward Lorenz, the mathematician and meteorologist who invented the term. In his observation

the flapping of a butterfly's wings in Brazil could, in theory, set off a chain of events that could ultimately lead to a tornado in Texas. This is an important lesson for the pavilion project in terms of the inter-connection of safety and indeed sustainability. The smallest action here can have bigger unanticipated results elsewhere. Safety requires us to consider how the slightest movements or trivial distractions can have much bigger results – in an instant our fate can change for the better or for the worse.

This may resonate with an elementary student who begins to realize that turning off a water faucet while brushing their teeth or picking up pieces of plastic on a beach may have a real effect in creating communities that are safer and more sustainable globally. Saving water locally may help areas of drought in sub-Sahara Africa or collecting and recycling plastic may improve the overall health of sea life and in turn the planet. The connections between the micro and the macro, the local and global, the individual and the community are key. Maybe butterflies and the butterfly effect and their interconnection with the KSU Mini Pavilion are not so distant. Afterall the word pavilion, is derived from the word pavilion comes from the Latin papilionem meaning tent or literally butterfly.

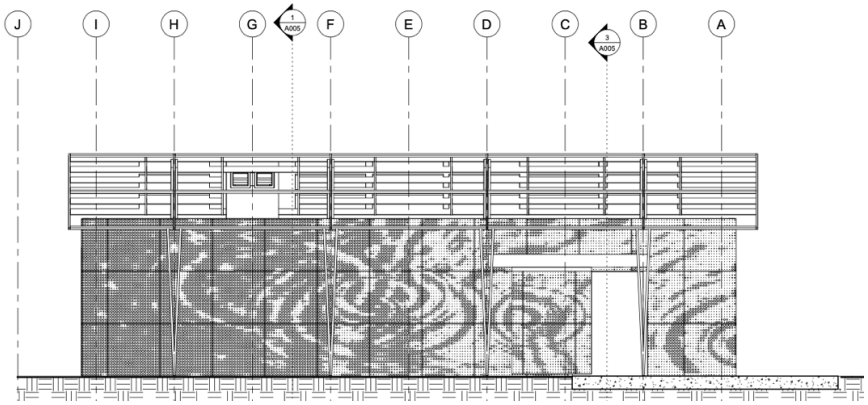

Figure 11 North Elevation: KSU Mini Pavilion (Michael Carroll 2022)


Figure 12 Rendered View: North Elevation with Perforated Rain Screen + Vertical Vegetal Wall (Michael Carroll 2022)

CONCLUSION: FROM OBJECT TO FIELD_ARCHITECTURE AS ENVIRONMENT

The KSU Mini Pavilion is a project that has a philosophical position centered on the idea that the architectural work is not an object per se, but a constructed environment with varying degrees of enclosure that engages both its physical location as well as the minds and imaginations of all who visit it. Although the exhibition room is essentially a black box optimized for it digital displays, the overall tone of the project is open-ended and experimental. The pavilion's perforated façades, mirrored panels, skeletal frames, PV arrays and vegetal walls (Figure 12) are elements that help it merge with its surroundings. As Japanese architect, Kengo Kuma might say, it is more anti-object than object. Inspired by his work and writings, Kuma has emerged as a leading figure in 21 century architecture. Known for his use of traditional Japanese materials and techniques in his designs, and for his commitment to sustainable architecture, his works are also resolutely contemporary as they test the limits of possibility in architecture, certainly in terms of their material and spatial porosity. Kengo Kuma discussed his position of time, space, and existence as they relate to architecture in an interview produced and curated by The European Cultural Centre, in collaboration with global consulting agency

PLANE—SITE. The following is an excerpt of that interview with Kengo Kuma in which he articulates where architecture has been and where it is going. He states:

> "Time, Space, and Existence is a definition of three things that are slowly changing, from architecture as monument to architecture as environment; from 20th century to 21st century; from industrialization to post-industrialization. We cannot control time. Time is always flowing. Architecture also should be part of that kind of flow."[5]

It seems clear that Kengo Kuma suggests that architecture in the 21st century should prioritize environmental sustainability and move away from monumental, large-scale buildings that have a high impact on the environment. This seems especially apt in age of the Anthropocene, the geological epoch that is used to describe the current time, in which human activity is the dominant influence on climate and the environment. As we address the emerging challenges of climate change and the rise of the human population in the coming decades and indeed centuries, it seems apt that we would be more aligned with the goal of designing and creating spaces that are in harmony and attuned to their surroundings using materials that have a lower environmental impact, and prioritizing the comfort and well-being of the people who use them.

Although the KSU Mini Pavilion is indeed small in scale, its objectives are ambitious. To create a place where we impart these lessons of safety, well-being and sustainability to elementary students as well as create a laboratory where environments and materials can be monitored with a variety of sensing devices, so we can create better and more responsive buildings in the future. Although not yet constructed, it is the hope that the KSU Mini Pavilion can be part of a butterfly effect and be part of a larger movement where buildings begin to merge and resonate with their environments and begin to make a difference not only with the well-being of an individual but with the larger society – a movement that is essentially cultural and not merely technical.

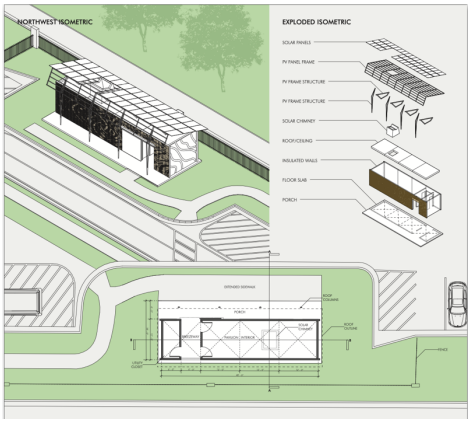

Figure 12 Projection, Ground Floor Plan + Exploded Anoxometric (Michael Carroll 2022)

ACKNOWLEDGEMENTS

In the context of this paper, it is important to acknowledge the KSU Mini Pavilion's interdisciplinary team comprised of Michael J. Carroll (Principal Investigator), an architect, and an Associate Professor at KSU Architecture and Dr. Billy Kihei (Co-Principal Investigator), Assistant Professor in the Department of Electrical and Computer Engineering at Southern Polytechnic College of Engineering and Engineering Technology. The project team also involved undergraduate student-assistant, Daryl Rowe, in the production of the digital and physical model of the pavilion as well as content for the exhibition *KSU_Mini Pavilion: Deploying Research Infrastructure @ Cobb County Safety Village*. Throughout the design process the team met on regular basis with the director of the Cobb County Safety Village, Alison Carter. The KSU Mini Pavilion project was launched by a grant from the Verizon Foundation secured by Dr. Kihei. In Fall 2021, architecture and computer engineering students from Carroll's and Kihei's classes collaborated in a design studio project that resulted in a series of interactive architectonic objects that were displayed on the rooftop gallery of the KSU Arch Gallery. This was an experiment to explore a range of electronic sensors that can be incorporated in architectural design project, a key goal in the research agenda of the KSU Mini Pavilion project.

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END NOTE

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Professor Kihei is Co-PI of the project. Please see acknowledgements.
https://www.moma.org/collection/works/100415
Cloud 9, Barcelona, Acconci Studio, New York, Ruy Ohtake, Enric Ruiz-GeliHotel Habitat, L'Hospitalet de Llobregat, Barcelona, Spain, Scale model 1:502004-08
https://www.growup.green.
https://www.youtube.com/watch?v=ttTh29iq_gE
The European Cultural Centre, in collaboration with global consulting agency PLANE—SITE, has produced and curated an interview series presenting the ideas and practices of the internationally renowned architects selected for the 2016 TIME SPACE EXISTENCE exhibition at Palazzo Bembo and Palazzo Mora. Touching on theoretical and philosophical concerns, as well as personal trajectories, each interview presents a candid discussion of where architecture has been and where it is going.