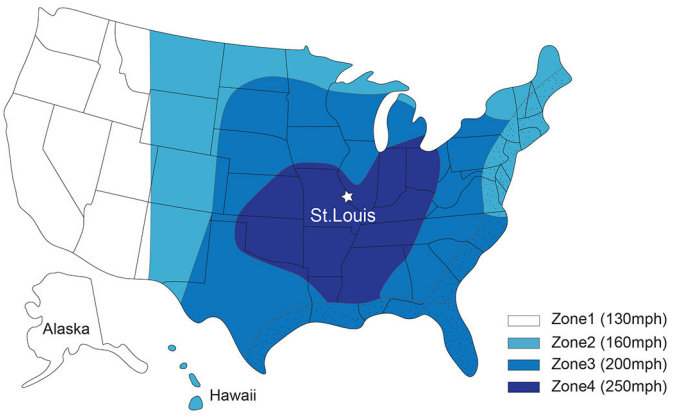
CRETE house

ARCHITECTURE

MISSION STATEMENT

CRETE house is a model for advanced technology, resiliency, and livability. The project is designed as a demonstration of integrated advanced building technology, featuring an innovative precast concrete panelized system used in homes as a compelling alternative to traditional wood light frame construction. High performance precast concrete structures are inherently resilient, protecting against fire, moisture and mold, insects, seismic events, extreme weather conditions and man-made phenomena such as blasts, force protection and acoustic mitigation. Like many cities in the midwest, St. Louis is in the tornado risk zone, and CRETE house is designed to withstand the force of strong storms while keeping its occuapants safe.



TORNADO RISK MAP

THE SITE

After the competition, CRETE house will be permanently located at Tyson Research Center, an internationally renowned biological field station for environmental research and education uniquely sited on 2000 acres of native landscape in Eureka, Missouri.

As a part of Washington University in St. Louis, Tyson provides scientific outreach

TYSON RESEARCH CENTER, EUREKA, MO

and educational programs as an "outdoor classroom" for students K-12 in addition to university level academics. The goal is to promote interdisciplinary research to confront the challenges that face us in energy and sustainability on a global scale.

TYSON RESEARCH CENTER
RESEARCH. EDUCATION. COMMUNITY.

Washington University in St. Louis

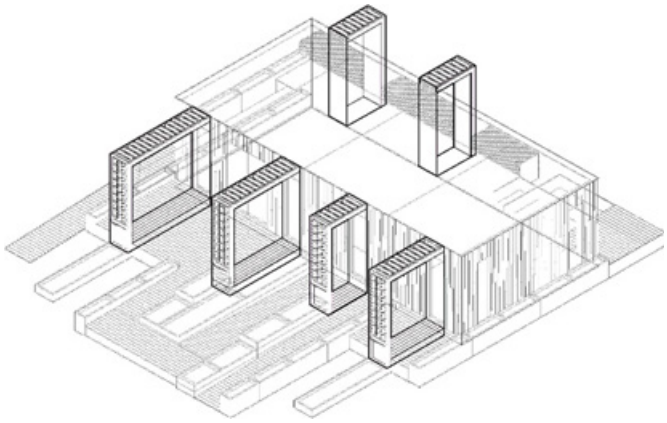
Tyson Research Center, is currently developing a master plan to construct an eco-village of net zero energy buildings. The CRETE house will be the first building constructed at the site and will serve as a model for all future on-site construction.

MASSING

CRETE house consists of a single precast concrete rectangular volume, treated as an elegant massing which engages its surrounding landscape,.

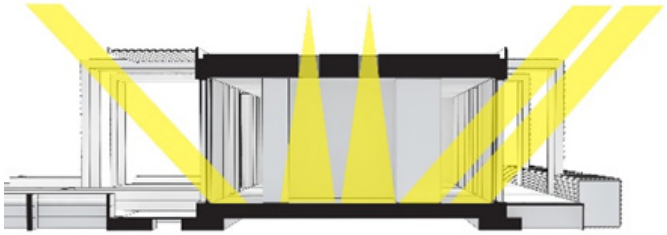
It is a 2:1 rectangular volume, with an east-west orientation. The north and south walls are modulated with concrete "gutters", each of them exists as a displacement of the façade's openings to create a transitional partially covered exterior

space. Where the gutters are pulled out from the concrete box, openings are created, forming full height windows and doors allowing natural light and cross-ventilation through the short side of the massing. The central core contains two Solatube skylights to provide natural light to the bathroom during the day.



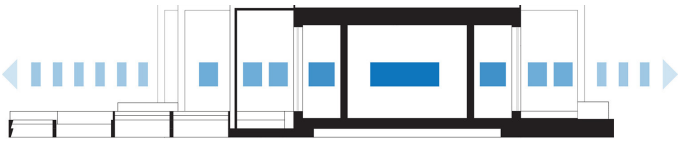
FRAMED OUTDOOR SYSTEM

The concrete gutters create a framed outdoor space operating as a mediator between interior and exterior spaces. Users can enjoy this transitional areas, which extend out of the rooms, especially during the enjoyable fall and spring seasons in the St. Louis area. The creation of the outdoor spaces located between the delicate gesture of the gutters and the solid stance of the interior concrete box gives users the opportunity to expand their living and working spaces into the natural environment.



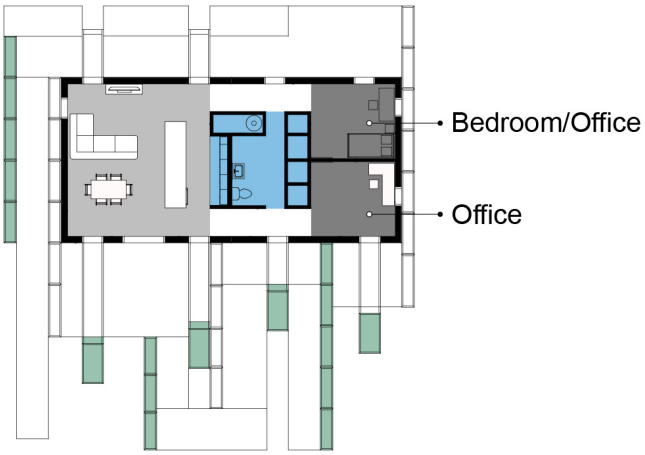
NATURAL LIGHT STRATEGY

In addition to creating a framed outdoor space, the gutters perform multiple functions: working as water collector, vertical planting surface supporting a hydroponic system, and sunshade for the corresponding windows behind.

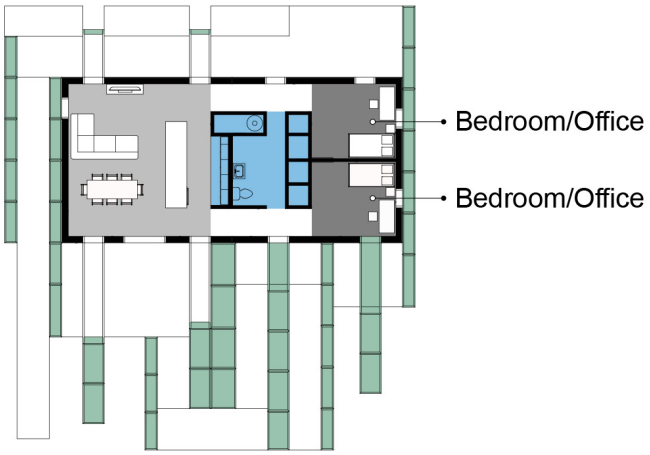


TRANSITIONAL MEDIATOR SPACE

The gutters and planters, as a collective unit, will serve as a productive device allowing for the cultivation of vegetables for consumption, while also serving a formal role as safety and privacy barriers for the inhabitants and their visitors.



LIVING SCENARIO 1
SINGLE RESEARCHER/ YOUNG PROFESSIONAL
MINIMAL TO MEDIUM PLANTING



LIVING SCENARIO 2
TWO RESEARCHERS/ YOUNG PROFESSIONALS
MEDIUM TO MAXIMUM PLANTING

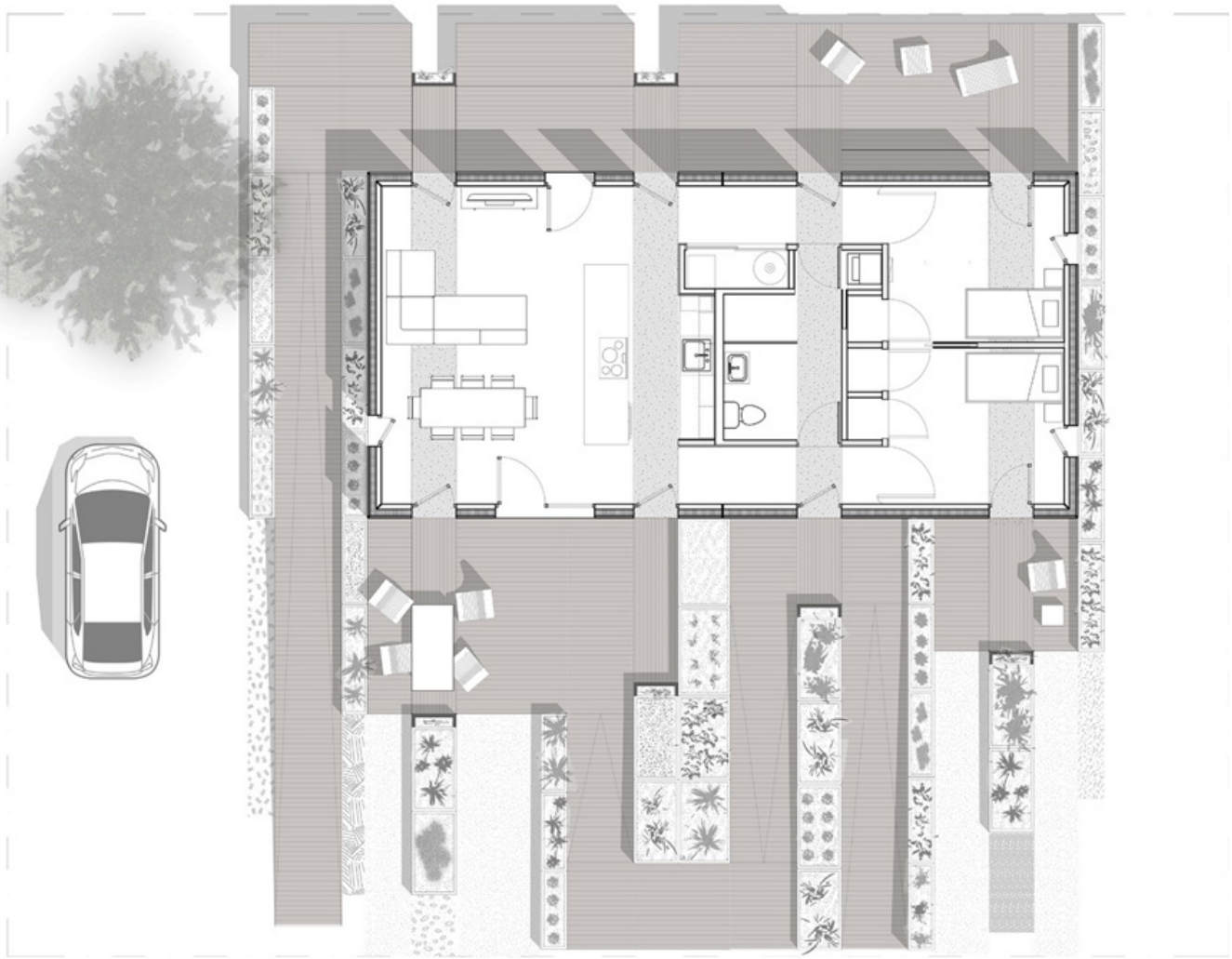
THE USER

CRETE house is designed as a short-term residence for one or two research scientists. It will allow researchers to inhabit and analyze several areas within Tyson and will provide them with the necessary resources to remain at the site throughout the duration of their research.
The house is designed to adapt to the changing needs of the residents; it provides flexible space configurable for two primary life scenarios:
1: a single researcher / young professional,
2: a team of two researchers / young professionals.
The diagram above explains our design approach, the design balances living and work. The building service core and furniture maximize flexibility, switching easily from a home to a workplace to a modern mixed-use residence.

The flexibility of the design is reflected in the maintenance of these horizontal and vertical green elements as they can be as much or as little of a time and financial demand as the user sees fit, The full capacity planters allow the users to grow enough food to accommodate a basic diet, and low capacity planters allow for minimalist landscaping. Therefore, this project is not only flexible to the function of the user, but also to the financial or urban context this house could reside in.

INTERIOR SPACE

The house contains a central core that divides the 995 sq. ft. interior area into private spaces: two rooms and public spaces: living/dining/kitchen. The core contains all services: mechanical, electrical, plumbing and fire suppression systems. The rhythm that organizes strips across the volume of the house is expressed in the exterior as concrete gutters and planters while in the interior, as windows and doors which correspond with the gutters and are aligned with floor and ceiling strips.



CRETE house FLOOR PLAN

This is part of a strategy Team WashU implemented to hide the joints between floor and roof concrete slabs. In addition, all light fixtures of the house are located along the ceiling strips. The modulation of the building's massing is structured by the flow of these bands which organize the house as sources of natural and artificial light, nartural ventilation, circulation and the outdoor productive landscape.

The vast majority of the house is built out of precast concrete panels. The finishes have been developed based on the properties of the different types of concrete utilized in the project. The exterior envelope uses UHPC with an off-white pigment (more on this in the next topic, the envelope). The surface of the roof interior is form finished structural concrete. The Interior wall surface is mechanically troweled grey concrete finish, this type of finish provides a very smooth wall surface while exposing patchy uneven grey tones. The interior floor finish uses a lighter cement with exposed aggregate with a polished finish and a glossy protective coating.

CRETE house, INTERIOR VIEW FROM LIVING ROOM

The kitchen island and countertop are also made out of concrete with a dark pigment in the mix with a polished finish surface exposing the aggregates. For the surface of the central core, which contains the bathroom, kitchen, mechanical room and storage we are using a paneling system from TAKTL®, which is another type of advanced Ultra High Performance Concrete (UHPC). This product is very durable and exposes a very smooth and shiny white tone. It resists oil, gasoline, water, and UV rays providing a surface that is very easy to clean up with soap and water. The team has also developed concrete furniture using GFRC (Glass Fiber Reinforced Concrete) as part of a furniture class adapted for this competition; all exterior seating was designed and manufactured by students using white GFRC in combination with aluminum and lamboo (laminated bamboo).

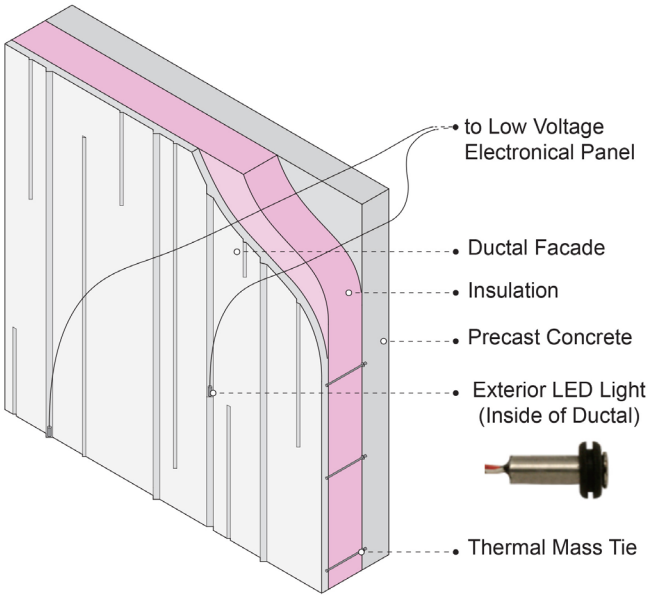
As described, Team WashU chose materials that contain concrete with very different finishes and showcase the versatility and unlimited potential of concrete. In all cases, these finishes require low maintenance and demonstrate maximum durability.

In order to balance the amount of interior surfaces containing concrete, the team decided to complement these spaces with other materials, which adds warmth and some variation. Team WashU have chosen to use Maple for the kitchen cabinetry and bedroom doors. The ceiling paneling consists of perforated aluminum sheets with a felt on the back to minimize acoustic reverberance in the interior spaces. For the bathroom walls, we have chosen tiles made out of natural stone: marble and travertine tiles. These tiles exhibit very high durability, require low maintenance and contain 100% natural material.

THE ENVELOPE

Team WashU developed a precast concrete sandwich panel for the exterior walls, which consist of 4" of standard concrete for the interior wythe of the assembly, 5" of insulation and 1-1/4" ultra-high-performance-concrete (UHPC) exterior layer.

The thin exterior layer significantly reduces the overall thickness and weight of the wall, as compared to traditional precast sandwich panels which lowers the overall embodied energy. It also lowers the cost and energy related to shipping the panels to the jobsite.



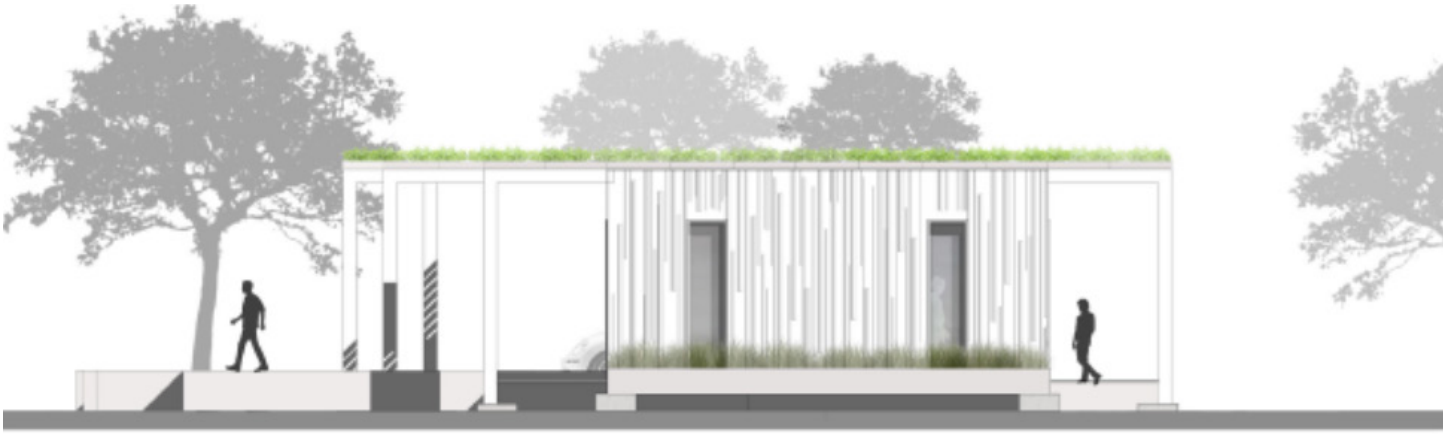
WALL ASSEMBLY DETAIL

CRETE house, ERECTION ON CAMPUS

UHPC CHARACTERISTICS

CRETE house uses durable and insulated robust Ultra High Performance Concrete panels manufactured in a factory and assembled on-site with specially designed dry connection methods using bolts rather than traditional field welds. A concrete house will require much less up keep and repair with a much longer life cycle than typical wood frame construction, 100+ vs. 30 years respectively.

Team WashU developed a system using Ductal, an innovative material which is a type of ultra-high-performance-concrete (UHPC) with exceptional mechanical properties and characteristics that are applicable specifically to building envelopes. Ductal is a very dense, high quality cementitious material and it is defined by its exceptional high strength and durability. The material provides compressive strengths up to 29,000 pounds per square inch (psi) and flexural strengths up to 7,000 psi. It is six times stronger when compared to traditional concrete, which provides an average of 5,000 psi compressive strength.



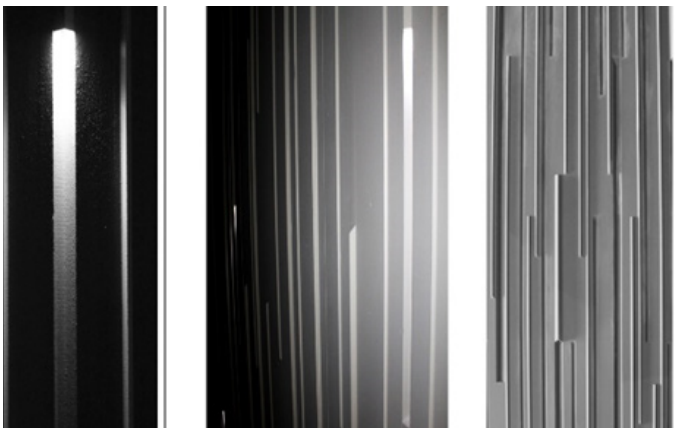
EAST ELEVATION

This allows thinner and lighter structures. Ductal is mixed with metal or polyvinyl alcohol (PVA) fibers, not requiring steel rebar reinforcing. In addition, UHPC's inherently waterproofing characteristics makes it a very viable alternative for exterior layer of the building's envelope.

The concrete envelope has the ability to use thermal mass and thermal storage for comfort and energy savings; its high specific heat capacity allows the building to perform as an "active thermal battery."

FACADE PATTERN AND INTEGRATED LIGHTING

With concrete as our main material, Team WashU explored various patterns on the facades to create visual interest and harmony between the house and its context - the forest at Tyson Research Center. The patterned wall stretches upward, following the direction of the surrounding tree trunks and plants. It also emphasizes the notion of verticality, complementing the vertical presence of the gutters that are pulled from the home's exterior. Varying in depth, width, and length, each reveal allows the exterior finish to become dynamic, creating subtle shadows that change throughout the day. The largest reveal, extruding 3/4", develops the exterior lighting strategy. Within each of those extrusions are soft LED lights that point down, when lit. These lights accentuate the facade pattern by creating slivers of light across the surface at night. In this way, exterior lighting is seamlessly integrated into the precast concrete envelope highlighting its innovative formwork. The exterior Ductal is an off-white pigment using white ductal material.

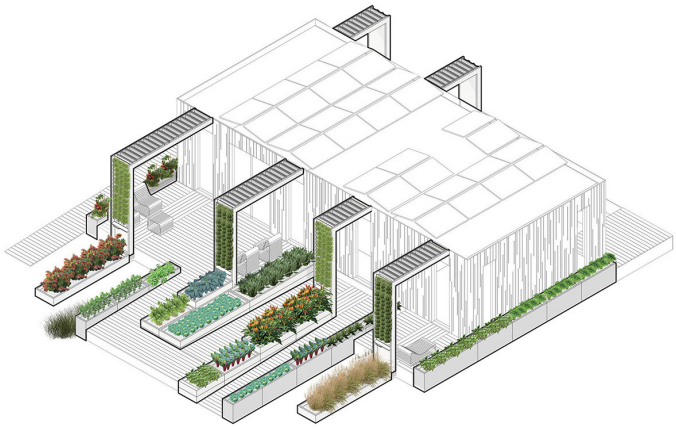


FACADE INTEGRATED LIGHTING

Winco, a local window manufacturer, donated all of the windows to the project. Additionally, outboard of the windows CRETE house employs an exterior venetian blind system which, when closed, creates an additional layer of protection for the opening in addition to adding privacy and controlling glare and solar gain.

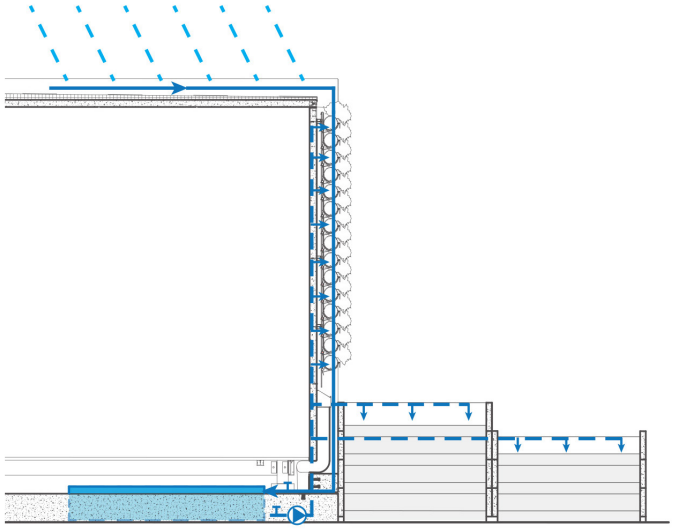
PRODUCTIVE LANDSCAPE

CRETE house offers food supply through a home garden system. As part of an ecological lifestyle, the house provides nearly year-round vegetables, fruits and spices cared and harvested by the residents. If this house were to be integrated into neighborhoods within St. Louis, a sustainable edible garden could be a place of community, collaboration and self-sufficiency for food deserts (areas that do not have quick access to produce and grocery stores). Implementation and influence of CRETE house within St. Louis neighborhoods is a long-term goal by nature of its prefabrication and modular capabilities. At Tyson, the house will accommodate researchers living and working at the ecological center. The landscaping and edible gardening may remain or adapt to the needs of these residents. For example, the plants may alter to species the researchers are examining or trying to preserve.



LANDSCAPING STRATEGY

The team designed a hydroponic growing system for food production, with vegetated modular vertical planters and ground planters watered with tube drip lines. The irrigation tubes are integrated into the vertical pieces and connect to the water storage tanks beneath the decking.



IRRIGATION SYSTEM

A rainwater harvesting system is implemented collecting rainwater from the roof, through the gutters to the tank below. This water will then be pumped from the water storage tank to the vertical and horizontal planters when needed.

CONCLUSION

CRETE house addresses self-sufficiency in terms of energy, water and food production and provides an attractive outdoor space integrated with varying capacities of the exterior to grow food sustainably. A test-bed for technological advances in architectural design, materials and construction, Team WashU's entry showcases precast concrete home as a viable housing market option that is efficient, safe, durable and resilient. The team's ultimate goal is to demonstrate innovative design and solutions that positively influence the building industry, and to provide the next generation of architects and engineers with new feasible options to minimize the impact of buildings to our planet.

PRECAST WALL PANELS READY TO SHIP

PLACING FOOTINGS ON SITE

PLACING PRECAST FLOOR SLABS ON SITE

PLACING LIGHT GAUGE STEEL CORE

PERECTING PRECAST WALL PANEL

BRACING FIRST PRECAST WALL PANEL

PRECAST ENVELOPE ERECTED

DYNAMIC FACADE PATTERN CHANGING WITH SUN

CRETE house IN PROGRESS

CRETE house IN PROGRESS