MIT 4.184 **CASTAWAYS BRICK FOGON FABRICATION**
Instructor: **Prof. Sheila Kennedy**
Email: **Sheilak@mit.edu**
Target audience: **MArch advanced students in Architecture, Fabrication and Computation**
Units: **3-0-9;** Grading method: **Letter Grades**

The Castaways Brick Fogon Fabrication Workshop is a direct extension of the spring 2024 Spoon Climate Studio & Workshop exploring the material properties and circularity of excess and 'waste' brick. The Fall 2024 Fogon Workshop will be specifically focused on the design development, detailing and fabrication of a collectively scaled a fogon, an ancient typology of Mesoamerican wood fired stove used for traditional cooking. The Workshop will advance a selected design from the studio that was developed over the summer and will work with waste brick and a digital twin inventory of scanned waste brick from industrial and artisanal brick factories near Puelbla, Mexico that utilize kaolin and clays extracted from the Trans-Mexican Volcanic Belt.

The fogon will be constructed by the Workshop team with local cooks, traditional chinampero farmers and members of the Xhochimilco community in Mexico City. The Workshop will partner on this effort with Cocina Colaboratorio, a local non-profit that addresses the relationship between traditional cooking practices and ways of life that are being threatened by the pressures of globalization and the rapid expansion of Mexico city. Cocina Colaboratorio will facilitate online reviews and discussions among the workshop students and community who will use the *fogon*. The *fogon*, a traditional open hearth and wood cooking stove has its origins in Mesoamerican Nahuatl culture and family life. The development and fabrication of the waste brick *fogon* that the workshop students will fabricate raises intriguing challenges. The Castaways *fogon* must mediate heat for different forms of cooking, it must provide spaces for multiple cooking stoves and cooking utensils, and it must safely minimize smoke and channel it away from people. Not least, it must be structurally stable and be up-scaled in size to provide an inviting collective, shared space for inter-generational cooks to prepare and share traditional food for community events.

The Workshop offers a hands-on opportunity for students to learn how an unconventional material--broken and irregular waste brick—can have new value. Students will explore hybrid approaches of "high" and "low" technology through onsite tools and jigs as well as computational based design and fabrication techniques developed in the Castaways Studio and the MIT Digital Structures Lab. Students will collectively detail and fabricate a functional fogon prototype that can be replicated and adjusted as needs be on additional sites in San Gregorio. Students will produce detailed fabrication documents, brick jigs and layout tools and innovative instructions for building the fogon. The Nahuatl language has no word for 'waste,' which inspires a larger scale circularity project that represents how this 'waste' brick *fogon* could include local brick makers, undervalued forms of wood for fuel, and excess food harvested from local restaurants and chinampas. The Workshop is funded to travel to Mexico City during a portion of the IAP period in January 2025 to build the fogon prototype on site.

Workshop Deliverables
It is anticipated that the students in the Workshop will produce a set of detailed drawings and innovative instructions jigs and tools to guide the on-site fabrication of a community fogon that utilizes upcycled, local waste brick produced in the nearby town of Puebla, a center of brickmaking in Mexico. Some smaller metal components will be fabricated at MIT and brought to the site.

MIT 4.185 FOGON FABRICATION WORKSHOP
Select Background References

Cocina Colaboratorio
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https://colaboratorykitchen.com/

Chinampas amapola
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Aztec pottery, overview
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13000 year old kiln found in Mexico
https://www.foxnews.com/lifestyle/1300-year-old-kiln-found-in-mexico

MIT 4.185 FOGON FABRICATION WORKSHOP – OUTLINE SCHEDULE

THURS SEPT 5
Planning & Kick Off, Define areas for design development

THURS SEPT 12
Mike Hatfeild, Justa stove discussion
Share class fogon research and explorations

THURS SEPT 19
Review class decision tree, fogon placement and overall geometry options
Define physical models and test mock ups

THURS SEPT 26
Present PDF Iteration 1.0 ZOOM SESSION
Synthesize feedback, define next steps and refinements

THURS OCT 3
Review and discuss physical models and test mock ups
Finalize design of metal components, brick bonds

THURS OCT 10
Discuss PDF Iteration 2.0 in progress
Review and discuss physical models and test mock ups

TUESDAY OCT 15 * Class time to be rescheduled
Present PDF Iteration 2.0 ZOOM SESSION
Synthesize feedback, define next steps for structure and refinements

THURS OCT 24
WORK SESSION

THURS OCT 31
Structural / thermal review w Eduardo (Edu) Gascón Alvarez and Prof. Caitlin Mueller
Present Material Sourcing diagrams

THURS NOV 7
Focus on prototypicality, what aspects of the design can be adjustable, parametric? (Keith Lee)

THURS NOV 14
Discuss PDF Iteration 3.0 in progress
Finalize Mexico January Travel Dates, collect student travel information

THURS NOV 21
Present PDF Iteration 3.0, ZOOM SESSION (Design Development Completion)
Synthesize feedback, define refinements

THURS NOV 28
THANKSGIVING BREAK, NO CLASS

THURS DEC 5
WORKSESSION

THURS DEC 12 Final Class & Wrap Up
Share Final PDF Presentation, Instructions, Tools & Equipment

AN MIT student scans waste bricks at the COMEXTESA factory in Puebla, Mexico (this image).

PHOTOGRAPHY: © MIT ODDS & MODS INITIATIVE

You Spin Me Round

Advances in circular construction could help address the climate crisis and reshape the built environment.

BY MATTHEW MARANI

THE BUILDING industry has a waste problem. According to the Ellen MacArthur Foundation, a British nonprofit focused on accelerating the transition to a circular economy, upward of 50 percent of demolition-materials waste ends up in landfills. It is a great squandering of financial and materials resources and their associated embodied carbon, with the manufacture of steel and cement alone accounting for over 15 percent of annual global emissions. But there is an alternative path, through the reuse and recycling of building materials in a process dubbed circular construction. That practice is nothing new; the Romans even had a term for it, *spolia*, for the stone elements taken from old structures and reused for structural or decorative applications. Matters are more complicated in the modern age, with fine-tuned building systems and rigorous codes; and, with global supply chains geared toward take-make-waste (or linear) models, optimal logistical infrastructures to deliver circular-construction projects at scale are often lacking. However, designers and educators are exploring different avenues to utilize these mountains of debris, and are developing

ONE TRITON SQUARE, in London, was originally designed by Arup in the 1990s, and the firm led its comprehensive retrofit more than two decades later (top). The curtain wall was disassembled and refurbished at a temporary fabrication site in the metropolitan region (above).

design strategies to reduce waste in the first place, such as adaptive reuse and design for longevity or for ease of disassembly.

Arup, the global engineering giant, is no stranger to developing novel solutions for seemingly intractable problems. In 2022, the firm, in collaboration with the Ellen MacArthur Foundation, launched the Circular Building Toolkit, which offers designers a comprehensive framework to reduce the use of virgin and nonrenewable products and improve material efficiency, among other strategies. For Arup Americas chair Fiona Cousins, the Toolkit is also an open-access platform that helps architects, and the overall construction market, differentiate between the subject of circular construction, which focuses on where materials come from and where they are going, and the larger conversation of embodied carbon and how materials are made.

A framework is only as good as its implementation, and Arup is rolling out practices outlined in the Toolkit, such as material passports, which log information about materials, products, and components, within BIM models, across a range of projects. Notably, according to Frances Yang, Arup associate and leader of its sustainable-materials practice in the Americas, the firm focuses those efforts toward high-value or higher-churn building components, like ceiling tiles and door systems, where greater impact can be had. "Overall, we realized that you need to be strategic about the documentation, and to avoid an all-or-nothing approach that is daunting for clients and burdensome in terms of data collection."

London has emerged as a testing ground for putting these ideas into practice owing to the city's rollout in 2022 of mandatory circular-construction guidelines (preceded by a set of voluntary instructions in 2019). The regulations require whole-life-cycle carbon assessment and circular-economy statements to receive planning approval for large buildings, with the aim of furthering London's goal to reach net zero emissions by 2030 through discouraging demolition and encouraging reuse. One Triton Square, a commercial building designed by Arup and completed in 1998 as the First National Bank of Chicago's London outpost, now follows these principles, having wrapped up an all-encompassing retrofit at the tail end of 2021. The retrofit of the limestone-and-glass-clad concrete building was also led by Arup, for developer British Land, which committed to a circular approach to the

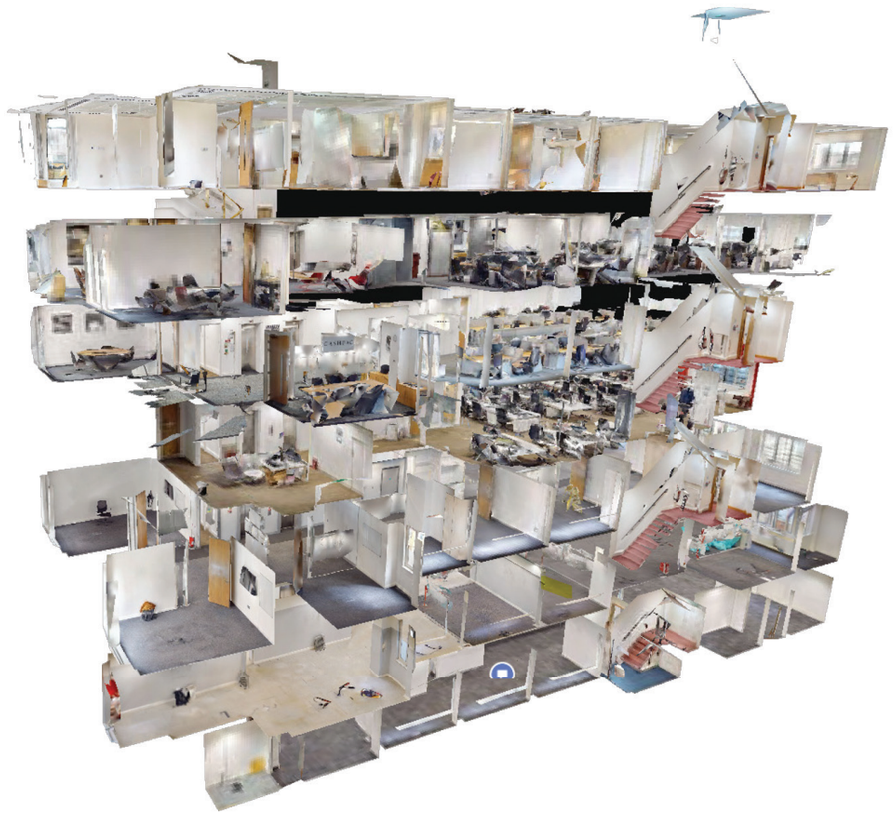
PHOTOGRAPHY: © SIMON KENNEDY

THE MARK will consolidate and build over existing buildings a few blocks from the Tower of London (right); 3XN scanned the buildings to produce digital models (below, right).

project. It helped that Arup kept drawings of the building's original systems and materials, reducing the cost and time associated with development of a digital twin BIM model from an entirely new building survey.

The redevelopment of 1 Triton Square included the addition of three stories to the existing six, with substantial expansions to the floor plate within the building's atrium. The design team supported the additional load by expanding the diameter of the structural columns from 8 to 10 inches and, in several circumstances, wrapped them in fiber-reinforced polymer for further strengthening. At the exterior, the original aluminum-and-glass curtain wall system was disassembled, and was refurbished with new gaskets and glass coatings, for greater thermal efficiency, at a pop-up factory less than 30 miles away, and reinstalled. For new construction, the design team sourced lower-carbon cement replacements (blast furnace slag makes up 70 percent of binder used for the concrete) and successfully integrated updated mechanical infrastructure within previously allotted m/e/p channels. In total, the retrofit of 1 Triton Square saved some 35,000 tons of concrete and nearly 2,000 tons of steel that, with additional measures, translated to 40,000 tons in carbon dioxide savings—while, at the same time, reducing the project budget and construction schedule as compared to new construction.

GXN, a research studio founded by Danish architecture firm 3XN in 2007, is also leading the way in circular construction, with several projects on that model in London. The group, which works with its parent firm, recently received planning approval for The Mark, an approximately 320,000-square-foot commercial project that will combine four existing buildings into a single entity. "We are increasingly working in London around these new policies, and, in advising clients, we help determine which materials they should focus on and how they can use them in their own scheme, or in others," says Kåre Stokholm Poulsgaard, GXN partner and head of innovation. "A large part of this is developing the workflows that align with the needs of the client, the contractor, the cost consultant, and the material conveyer. What kills off circular projects are the unknowns."



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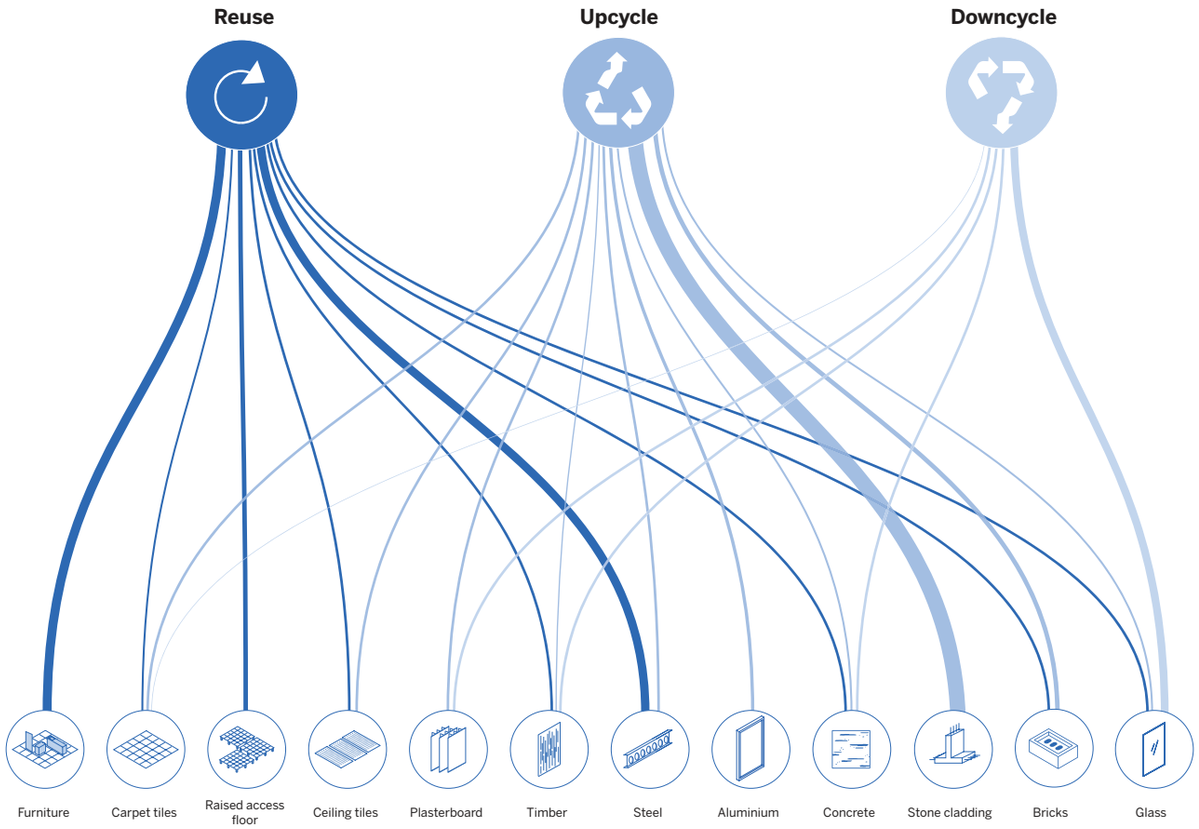


THE MARK WASTE-CYCLE DIAGRAM

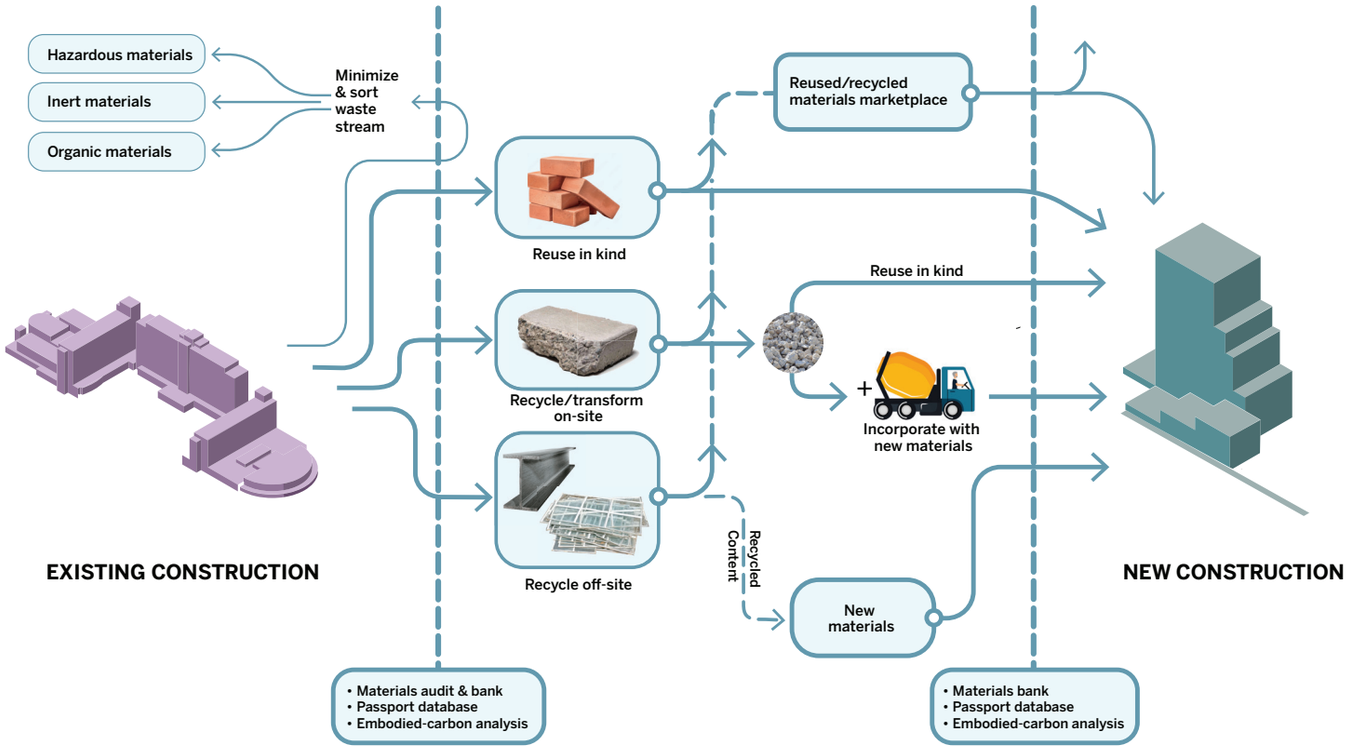
THE MARK has been soft-stripped of materials like raised access floors and carpet tiles (above).

Work began in May 2022 with a pre-demolition audit using Matterport, a 3D-mapping application, which informed, with the help of their own in-house software, the design team's identification of areas for the greatest reuse and recycling potential. Soft stripping, or the removal of nonstructural elements, began in early 2024 with such items as raised-access flooring, and ceiling and carpet tiles, among others, offered on the Excess Materials Exchange, a digital platform for salvaged materials; the design team's aim is for most of those items to be reused on other London construction sites. In addition to maintaining the structural frame, they are also investigating the reuse of materials found on-site for new purposes, such as placing the original stone facade as flooring in the front-of-house areas.

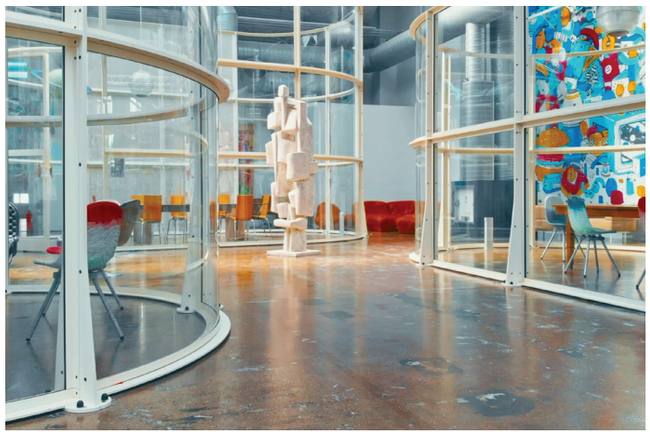
London is not alone in its attempt to become a global circular-construction hub. This year, the New York City Economic Development Corporation (NYCEDC) launched its own circular-design guidelines, to be implemented across its expansive $9 billion portfolio of capital projects starting in 2024. The guidelines are ambitious and aim for a 50 percent reduction in embodied carbon, largely through circular practices, such as reducing construction, and deconstruction material for disposal, by 75 percent; reusing or recycling 95 percent of concrete and soil generated by either construction or deconstruction for highest-use value; and for 25 percent of all virgin materials used to be low-carbon, such as mass timber. The goal, according to NYCEDC's chief strategy officer Cecilia Kushner, is not only to support New York's green transition, but to harness the economic heft of the NYCEDC to engender a larger market of circular construction for private actors across the city.

The Science Park and Research Campus (SPARC), in the Manhattan neighborhood of Kips Bay, will serve as a five-acre laboratory for the NYCEDC's guidelines. The 2 million-square-foot project, to be designed by Ennead and Dattner Architects, with structural-engineer Buro Happold and master-planner SOM, will replace the existing Hunter College Brookdale Campus. The design team was awarded the project in March 2024 and, at this nascent stage, has not developed a completed scheme for

IMAGE: © 3XN GXN



PRELIMINARY SPARC KIPS BAY MATERIAL-REUSE DIAGRAM

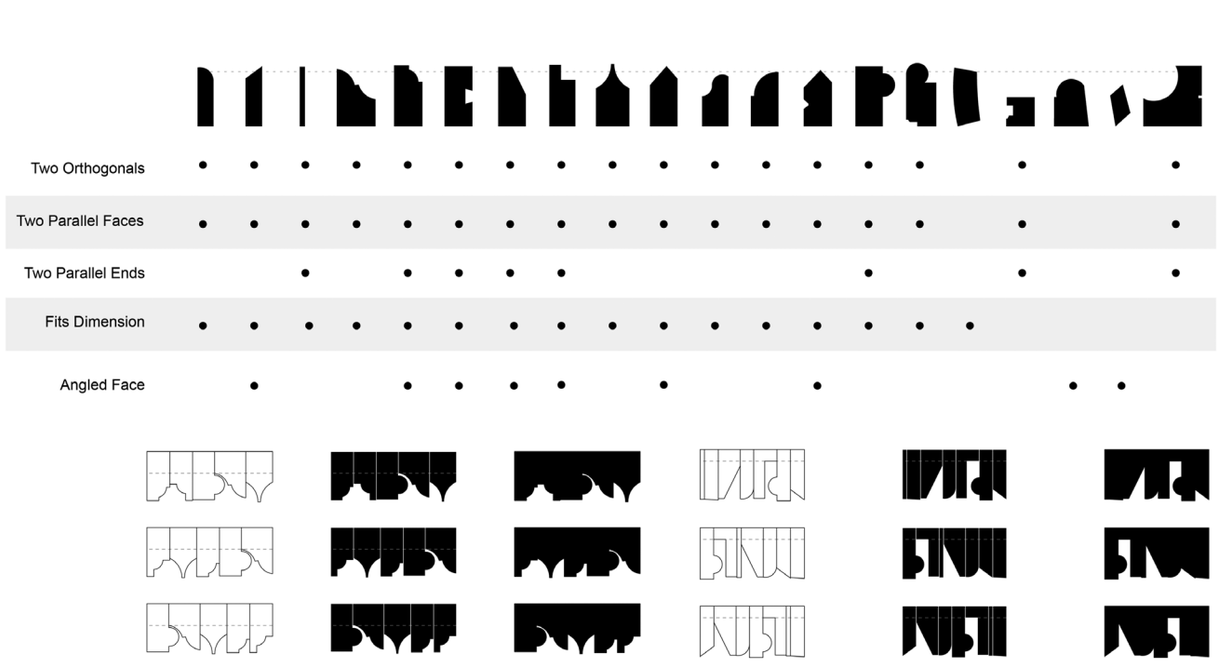


IMAGES: © ENNEAD & DATTER (TOP); SOM (BOTTOM, LEFT); MAXIMUM ARCHITECTURE/ALEXANDRA ATTIAS (BOTTOM, RIGHT)

SPARC Kips Bay, though the existing-building survey, with digital scans, has commenced. With that information in hand, the team will do an audit to best determine the project's circular-construction opportunities and begin deconstruction during summer 2025. Construction is scheduled to begin by 2026 and should be complete in 2031.

There are also opportunities to be had in harnessing dismantled-building components for new construction, should a more robust marketplace and the related infrastructure be developed. ETH Zurich's Circular Engineering for Architecture (CEA) lab, founded in 2022 and led by Catherine De Wolf, is making advances in that area. According to De Wolf, as it stands, circular construction is mainly confined to large but niche projects, such as The Mark or the renovation of Centre Pompidou, where De Wolf led a team that salvaged the structure's distinctive curved glass panels for use as office partitions. In many circumstances, it is limited by the ambitions of individual clients, and greater subscription by the construction sector requires the build-out of an entirely new marketplace,

SPARC Kips Bay is a full-block site (above, left). The Centre Pompidou's curved glass panels were reused as office partitions (above, right).



IRREGULAR-BRICK CHARACTERIZATION, AGGREGATION, AND FIGURATION DIAGRAM

A MOCK-UP built of wood for a castaway-brick pavilion (above).

one that can match salvaged materials to the broad specifications of individual projects. De Wolf's interdisciplinary team, ranging from experts in civil engineering to industrial ecology, is attempting to do just that, using AI-powered software. "Anyone involved in material reuse currently has to know and source from local retailers, find the appropriate storage facilities, and have knowledge of which platforms to look into, and then screen all of them to find suitable materials for their project," notes De Wolf. "What we are trying to do is create a matchmaking service, not unlike dating apps, between people who have materials available for reuse and buyers, developers and skilled workers familiar with disassembly and reassembly, and other services within circular construction."

In Cambridge, Massachusetts, MIT School of Architecture's Spoon Climate Studio, led by professors Sheila Kennedy and Caitlin Mueller, is probing similar questions. "There has been such an emphasis on standardization and uniformity of materials in Modernism, and we have inherited those assumptions on their benefits," notes Kennedy. "But we're beginning to see the end of that particular regime, certainly in terms of supply-chain problems, and in terms of the cost of extracting new material resources and delivering them to new building sites." The Studio's Odds & Mods course probes that paradigm by sourcing waste streams from different factories across North America—mainly bricks—for students to develop into architectural prototypes that reflect the inventories and stockpiles available in specific locales. Notably, according to Kennedy and Mueller, the initiative has received enthusiastic buy-in from domestic brick manufacturers like Glen-Gery and Morin Brick and, farther afield, from some in Mexico's Volcanic Belt. They otherwise are impelled to discard up to 15 percent of their production due to slight imperfections, such as being the wrong color.

It is, of course, preferable to stem the creation of those waste streams in the first place, and, to that end, Mueller is leading a team of researchers—Keith Lee, Pitipat Wongsittikan, Jenna Schnitzler, and Inge Donovan—in collaboration with manufacturer Holcim and the real-estate investment trust Prologis—to develop design and computation strategies to allow concrete building elements to be disassembled and rebuilt multiple times. The post-tensioned system called PixelFrame uses concave concrete modules of varied strength, sans rebar. They slide onto a central steel core without the need for grout or mortar, which often poses

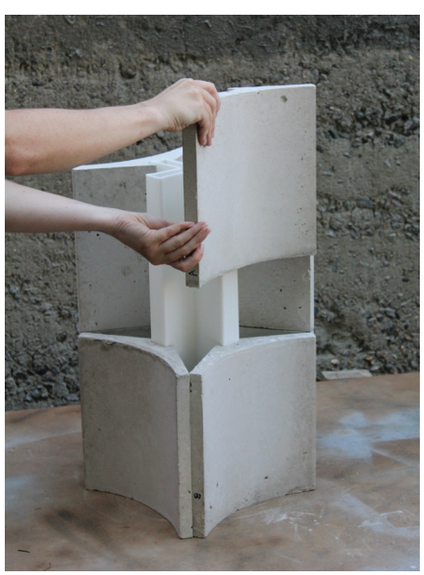
IMAGE: © KVA MATX

THE Tscherninghuset incorporates a multitude of recycled materials (left). The PixelFrame system is modular (below, left), and can be used for columns and beams (below, right).

an obstacle to reusability. According to Mueller, the PixelFrame system allows for more than 50 percent up-front embodied-carbon savings as compared to traditional reinforced concrete, which compounds further with each additional reuse.

On a larger scale, the shift away from uniformity and toward diversity in design could look like the 3XN-GXN-designed Tscherninghuset in Hedehusene, Denmark. The approximately 180,000-square-foot interior project is, fittingly, the new headquarters for Tscherning, a demolition company. The design team sourced nearly 90 percent of the materials, including recycled concrete slabs and aggregate for load-bearing walls and decks, from the client's many building sites. Within, a panoply of finishes, from charred wood to terra-cotta shingles and reclaimed brick, renders something of a village-like environment, albeit for corporate programming.

While there is an abundance of construction materials available for reuse, the building industry, and society, is in a race against time to reduce carbon emissions. As outlined by the 2015 Paris Agreement, greenhouse gas emissions must be reduced by 45 percent by 2030, and net zero must be reached by 2050, to avoid global warming's worst impacts. The tools and techniques are steadily developing to advance circular construction as a potent instrument to address the building industry's complicity in the climate crisis. But, at the end of the day, the road to less-wasteful construction may be through legislation, providing regulations for procurement of reused materials and mandating building deconstruction rather than demolition. In order to have a circular economy, advises Arup's Cousins, "you have to make the link between the beginning and the end." ■



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CONTINUING EDUCATION

To earn one AIA learning unit (LU), including one hour of health, safety, and welfare (HSW) credit, read the circular-construction article, review the supplemental material found at architecturalrecord.com, and complete the quiz at continuingeducation.bnpmedia.com. Upon passing the test, you will receive a certificate of completion, and your credit will be automatically reported to the AIA. Additional information regarding credit-reporting and continuing-education requirements can be found at continuingeducation.bnpmedia.com.

Learning Objectives

1 Understand the role of construction in carbon pollution and explain how circular practices can reduce such emissions.

2 Describe strategies for the reuse of numerous materials, including structural and enclosure components and finishes.

3 Identify policy decisions that could further develop the marketplace for circular construction.

4 Explore emerging software applications that aim to support circular construction.

AIA/CES Course #K2406A