Circularity as the Next Phase for Sustainable Buildings
Center for the Built Environment, Berkeley

Scaling Circular Construction: From Research to Practice

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AAP Cornell Architecture Art Planning

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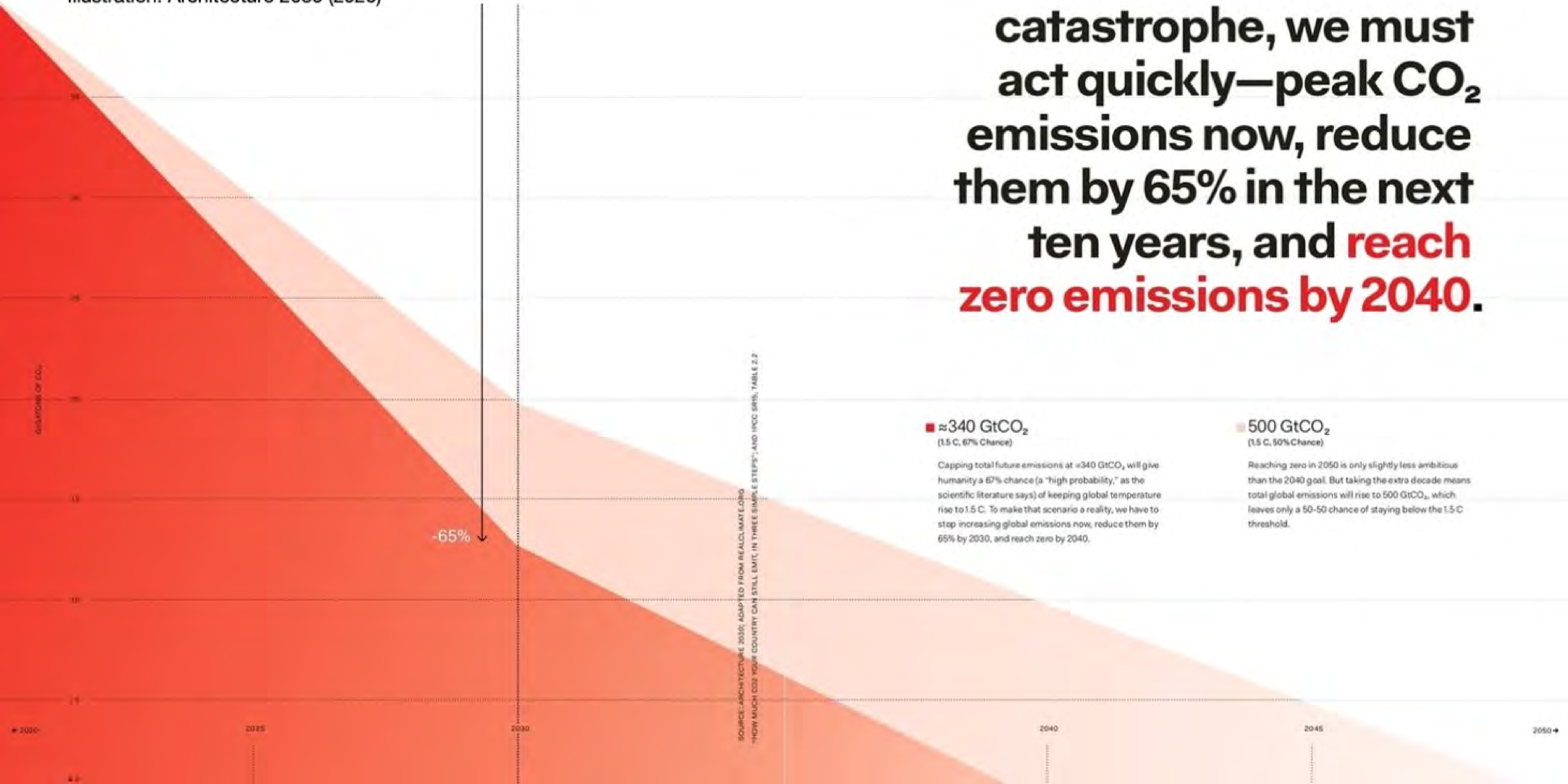
Linear Economy

Images: Edward Burtynsky

Carbon Emission Reduction Scenarios

Illustration: Architecture 2030 (2020)



To stave off a climate catastrophe, we must act quickly—peak CO_2 emissions now, reduce them by 65% in the next ten years, and reach zero emissions by 2040.

≈340 $GtCO_2$
(1.5 C, 67% Chance)

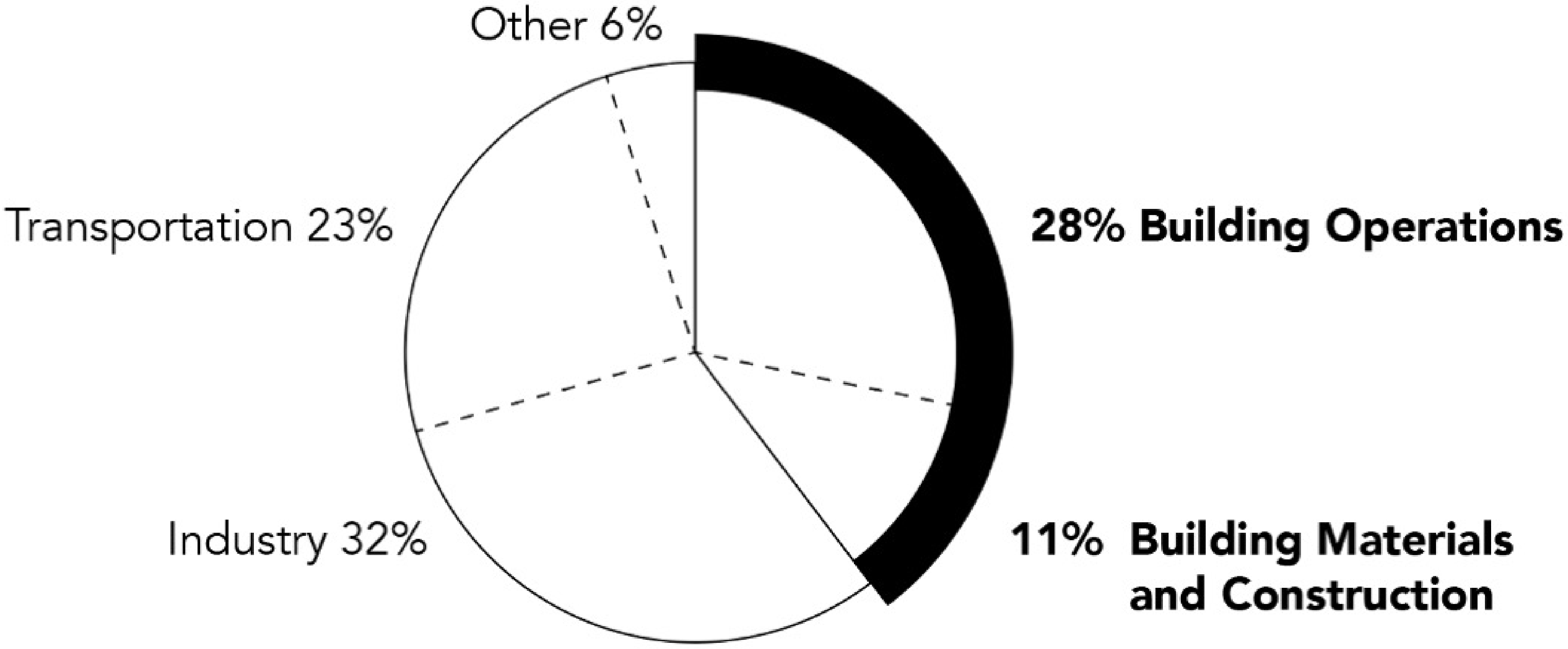
Capping total future emissions at ≈340 $GtCO_2$ will give humanity a 67% chance (a "high probability," as the scientific literature says) of keeping global temperature rise to 1.5 C. To make that scenario a reality, we have to stop increasing global emissions now, reduce them by 65% by 2030, and reach zero by 2040.

500 $GtCO_2$
(1.5 C, 50% Chance)

Reaching zero in 2050 is only slightly less ambitious than the 2040 goal. But taking the extra decade means total global emissions will rise to 500 $GtCO_2$, which leaves only a 50-50 chance of staying below the 1.5 C threshold.

Global carbon emissions from building construction and operation

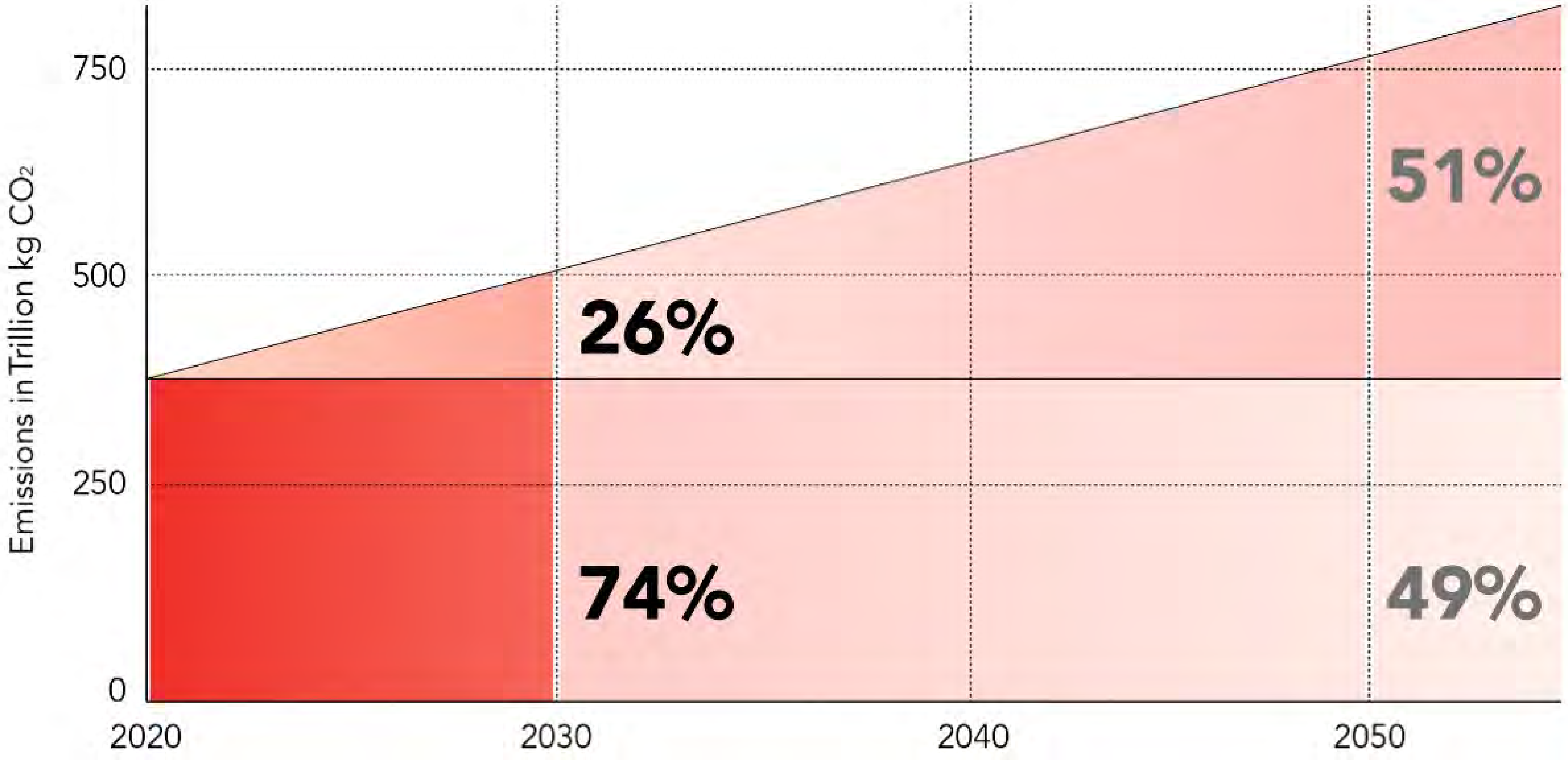
Source: The Carbon Issue (2020)



Global CO_2 emmissions by sector

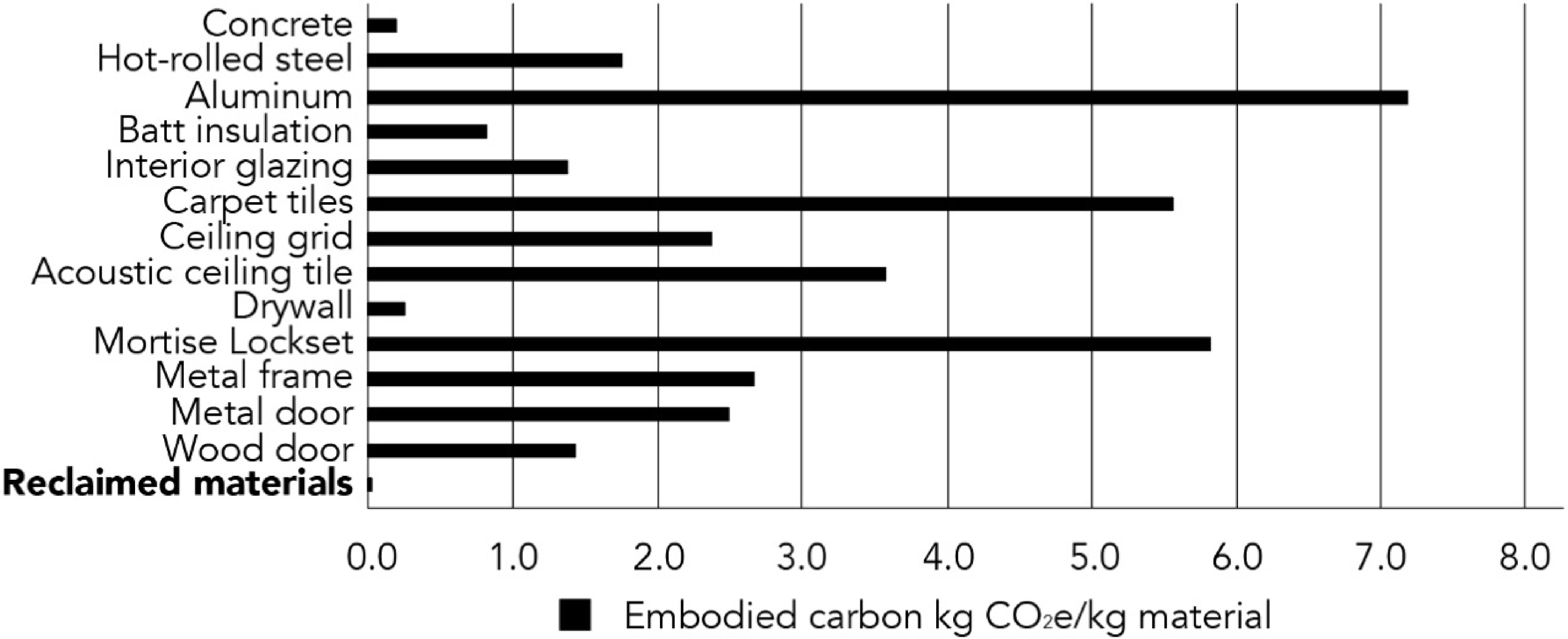
Global carbon emissions from new construction (2020-2050)

Source: Architecture 2030 (2020)



Embodied carbon of selected building materials

Source: Doors Unhinged (2020)



Current End-of-life Scenario: Demolition (and Landfilling)

Image: Felix Heisel (2021)

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Circular Construction Lab, Cornell University

http://ccl.aap.cornell.edu

Closing the loop through design and engineering.

The Circular Construction Lab (CCL) houses a design research program that advances the paradigm from linear material consumption towards circular economy within an industrialized construction industry.

The Circular Construction Lab is directed by Assistant Professor Felix Heisel.

MISSION STATEMENT

The Circular Construction Lab (CCL) in the Department of Architecture at Cornell AAP houses a design research program that advances the paradigm shift from linear material consumption towards a circular economy within an industrialized construction industry. At the intersection of architecture, engineering, material and computer science, as well as economics, the lab investigates new concepts, methods, and processes to (1) design and construct buildings as the material depots for future construction, and (2) activate the potential of the built environment as an 'urban mine' for today's construction. CCL understands architecture as part of a regenerative and restorative cycle and sees design as a vehicle that can advance this ambition with excellence in teaching and research. Through close collaborations with academic, industrial, and legislative/ political partners the lab ensures the relevance of its work and promotes the direct and full-scale implementation of research results towards a more sustainable, low/ no-carbon, circular construction industry.

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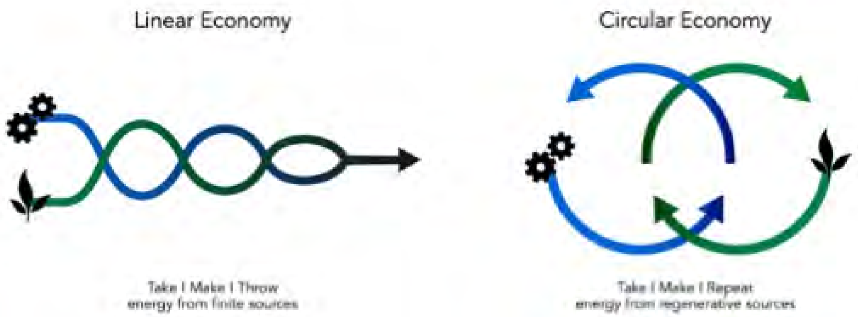
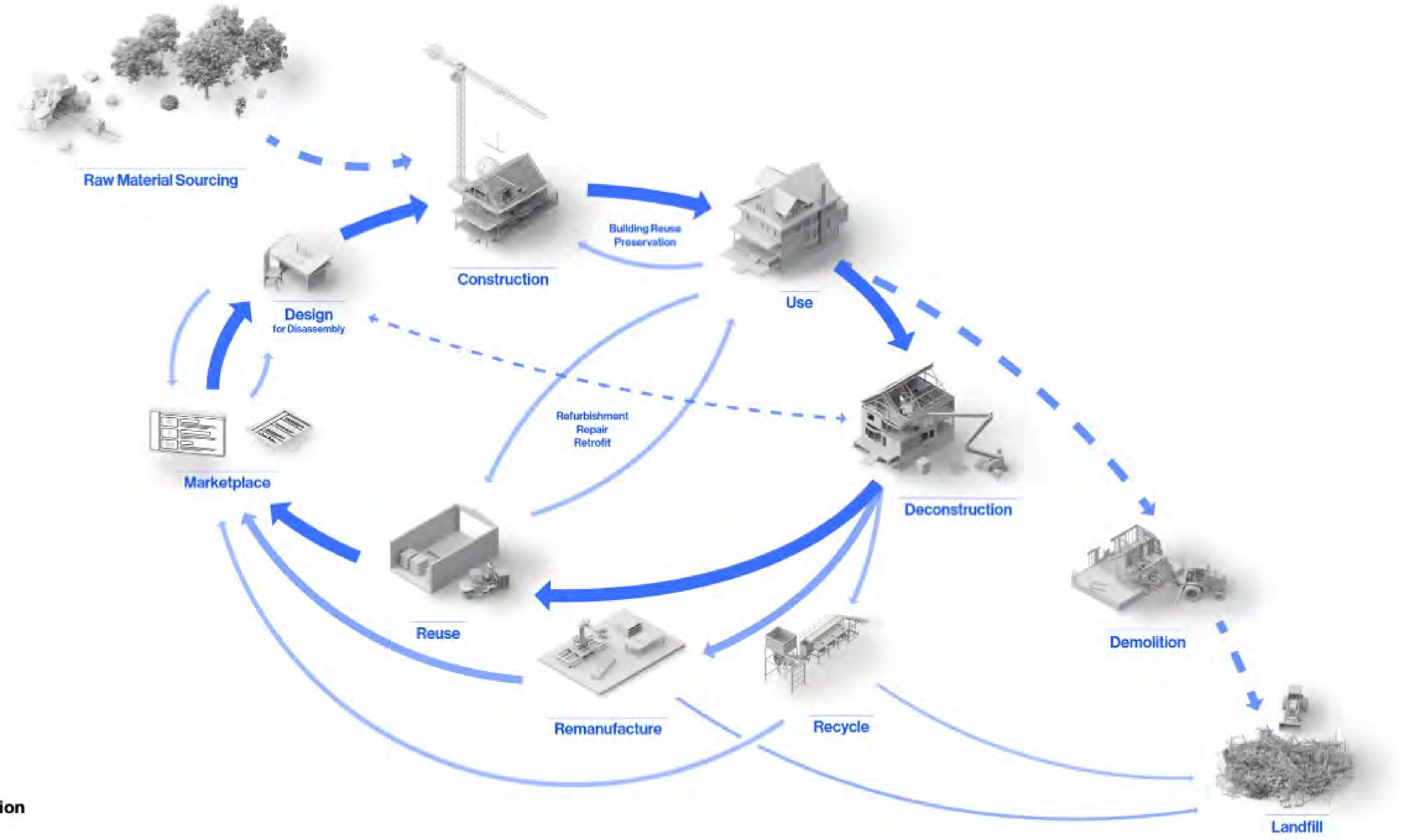


Circular Ecosystem

Source: Heisel, Perovsek (2024)



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Panelized Deconstruction

Image: Felix Heisel (2022)

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Catherine Commons Deconstruction Project

Image: Joseph McGranahan (2022)

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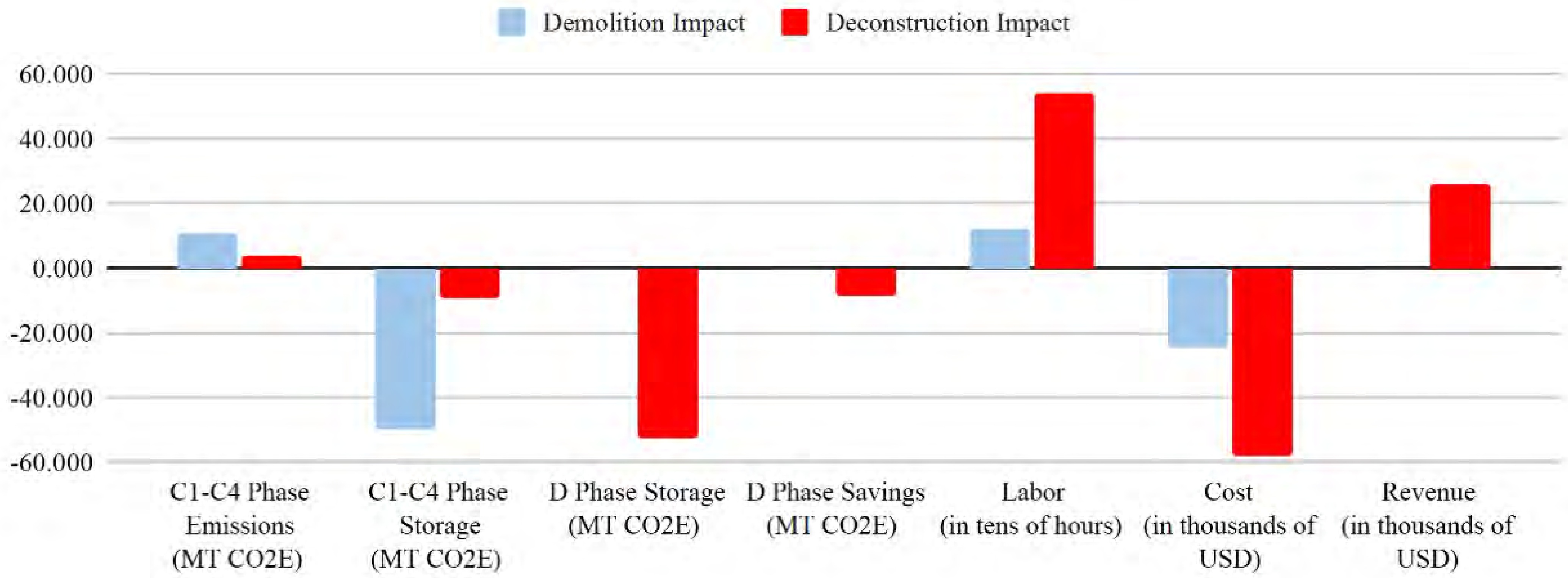
Demolition vs Deconstruction

Illustration: Circular Construction Lab (2023)



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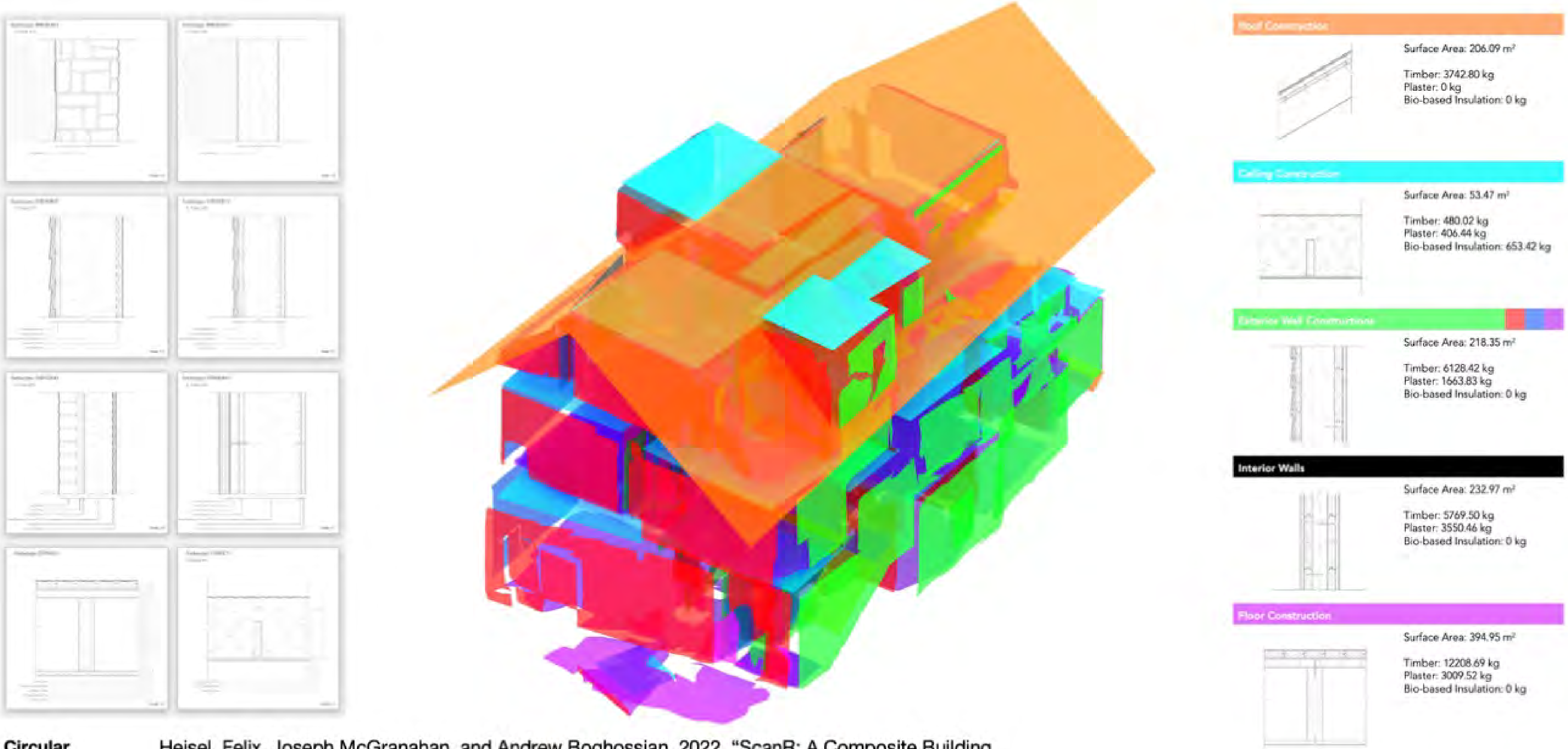
Heisel, Felix, Joseph McGranahan, Alysson Nicole Lucas, Diane Cohen, and Gideon Stone. 2023. "Carbon, Economics, and Labor: A Case Study of Deconstruction's Relative Costs and Benefits Compared to Demolition." In *Journal of Physics Conference Series*. CISBAT 2023, Lausanne: IOP Publishing.

ScanR Deconstruction and Salvage Scan Analysis

Source: Circular Construction Lab (2022)



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Heisel, Felix, Joseph McGranahan, and Andrew Boghossian. 2022. "ScanR: A Composite Building Scanning and Survey Method for the Evaluation of Materials and Reuse Potentials Prior to Demolition and Deconstruction." *IOP Conference Series: Earth and Environmental Science* 1078 (1): 012012.

Reuse Capacity Building

Image: Jason Koski (2022)


Deconstruction Workshops
Image: Jason Koski (2022)
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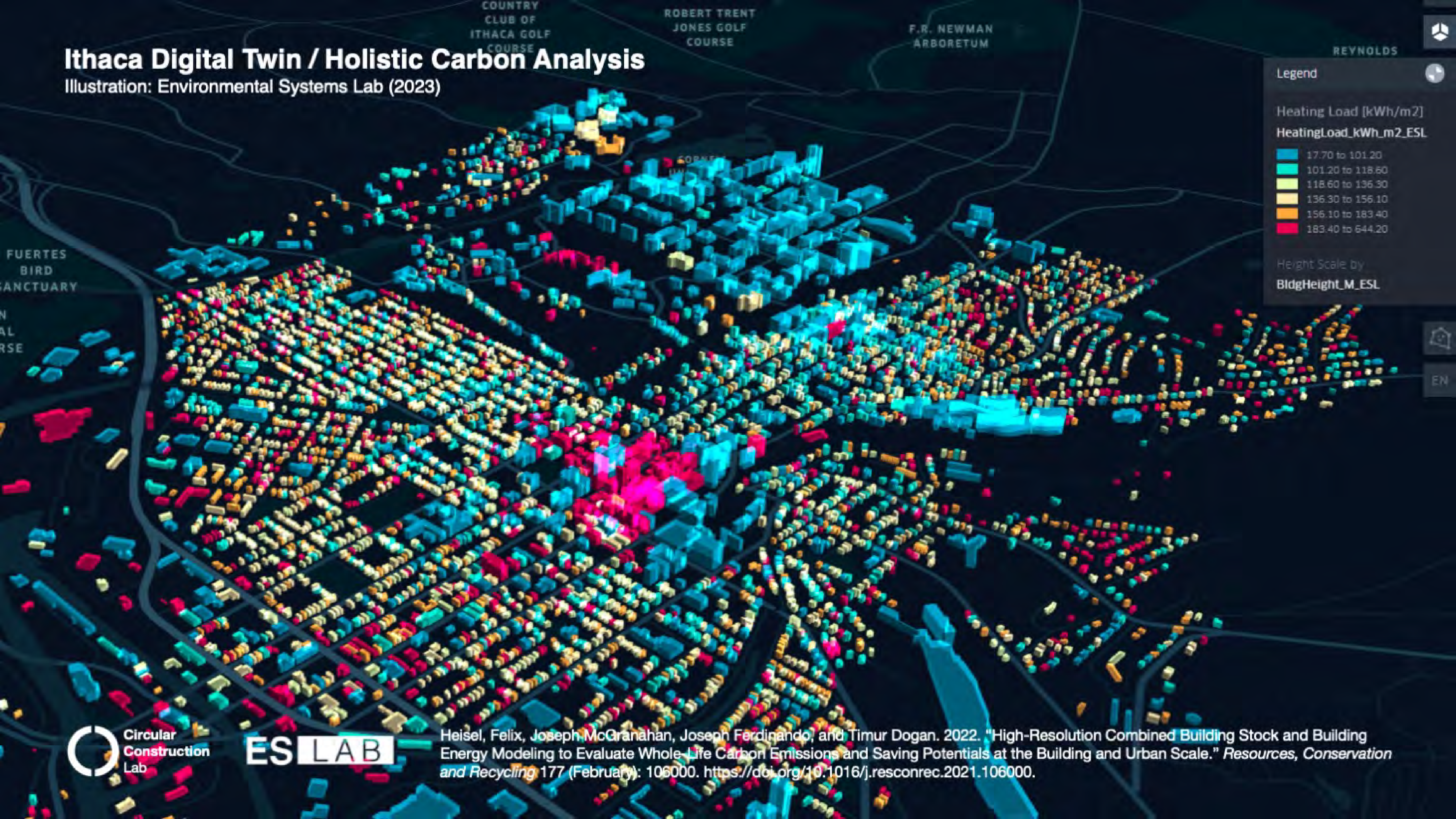
Ithaca Digital Twin / Holistic Carbon Analysis

Illustration: Environmental Systems Lab (2023)



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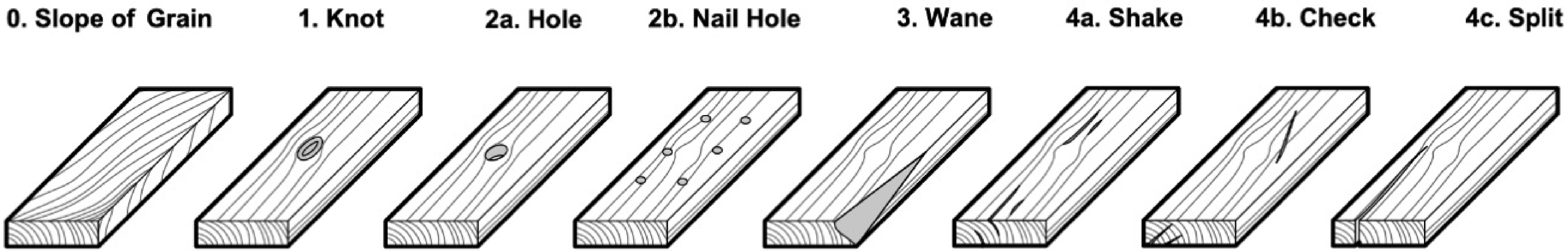
ES LAB

Heisel, Felix, Joseph McGranahan, Joseph Ferdinando, and Timur Dogan. 2022. “High-Resolution Combined Building Stock and Building Energy Modeling to Evaluate Whole-Life Carbon Emissions and Saving Potentials at the Building and Urban Scale.” *Resources, Conservation and Recycling* 177 (February): 106000. https://doi.org/10.1016/j.resconrec.2021.106000.

Types of lumber defects related to grading

Source: Jasper Owen and Anye Shi, Circular Construction Lab (2025)



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Shi, Anye, Dan Bergsagel, Jasper Owen, and Felix Heisel. 2025. "Scalable AI-Driven Automation for Visual Lumber Grading.". *Journal of Cleaner Production Volume 533 (November): 146986*

Grading standards in the United States

Source: Jasper Owen and Anye Shi, Circular Construction Lab (2025)

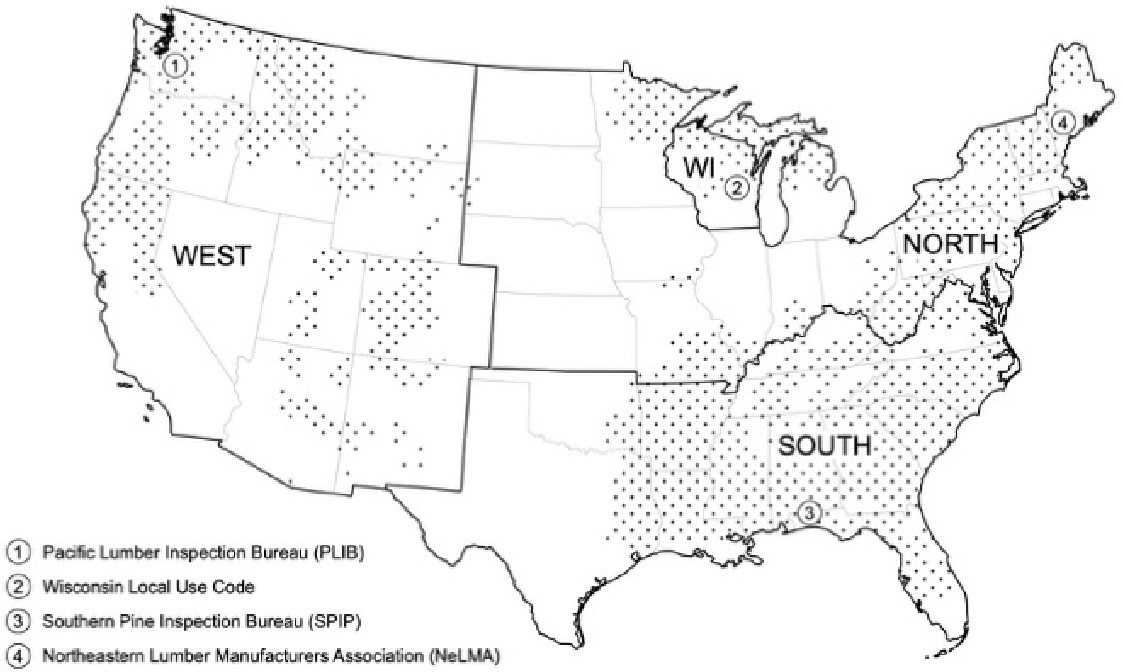

Table 1: Summary of Visual Lumber Grading Criteria for Structural Light Frame (SLF) with Grade 2 or higher.

The strictest grading standard among the four systems is highlighted in the figure for comparison.

Size: 2×4 (SLF) Grade: No. 2	**(1) Pacific Lumber Inspection Bureau (PLIB)**	**(2) Wisconsin Local Use Grade**	**(3) Southern Pine Inspection Bureau (SPIB)**	**(4) Northeastern Lumber Manufacturers Association (NeLMA)**
Wood Species	Douglas Fir; Hem Fir; Western Red Cedar; Spruce-Pine-Fir; Softwood species	All species in Wisconsin	Southern Pine	Eastern Spruce; Balsam Fir; Eastern white pine; Eastern Hemlock; Aspen
Slope of Grane	**1 in 8**	**1 in 8**	N/A	**1 in 8**
Knots	1-1/4" at edge of wide face; 2" at centerline of wide face	**1/4 of face width** (0.875" on wide face; 0.375" on narrow face)	**36% of narrow face** (0.54")	1-1/4" at edge of wide face; 2" at centerline of wide face
Holes	1-1/4" per 2 lin. ft.	**1/4 of width per 2 lin. ft.** (0.875" per 2 lin. ft.)	1-1/4" per 2 lin. ft.	1-1/4" per 2 lin. ft.
Wanes	**1/3 (thickness/width)**	**1/3 (thickness/width)**	**1/3 (thickness/width)**	**1/3 (thickness/width)**
Splits	**Equal in length to 1-1/2 times the width (5.25")**	Equal in length to 2 times the width (7")	**Equal in length to 1-1/2 times the width (5.25")**	**Equal in length to 1-1/2 times the width (5.25")**

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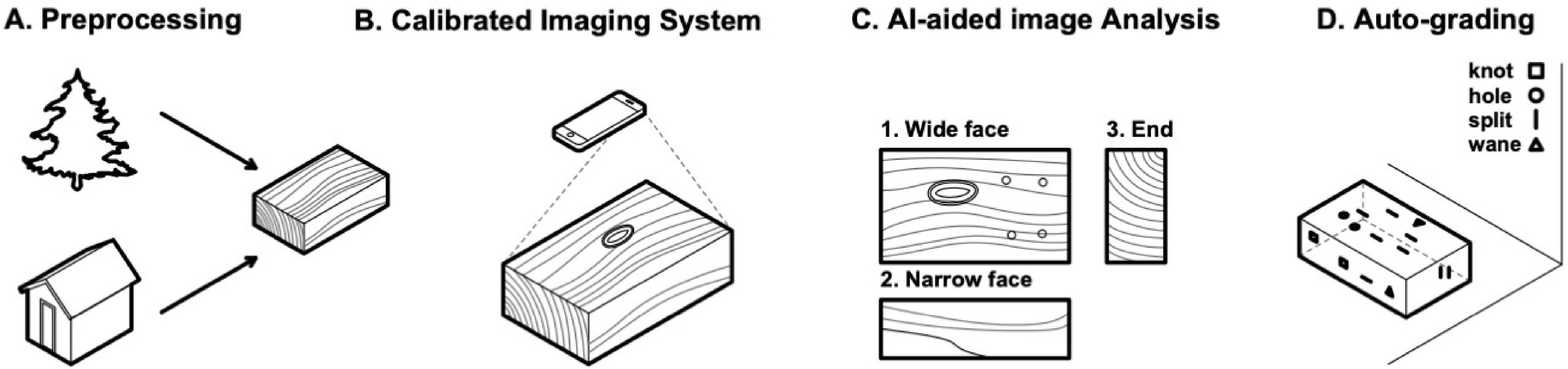
Shi, Anye, Dan Bergsagel, Jasper Owen, and Felix Heisel. 2025. "Scalable AI-Driven Automation for Visual Lumber Grading.". *Journal of Cleaner Production Volume 533 (November): 146986*

AI-supported visual lumber grading steps

Source: Jasper Owen and Anye Shi, Circular Construction Lab (2025)



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Timber reuse legislation

Source: NYS Senate and House (2025)

The New York State Senate

Assembly Bill A3029

2025-2026 Legislative Session

Establishes standards for the reuse of deconstructed building materials

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3029

2025-2026 Regular Sessions

IN ASSEMBLY

January 23, 2025

Introduced by M. of A. KELLES -- read once and referred to the Committee on Governmental Operations

AN ACT to amend the executive law, in relation to establishing standards for the reuse of deconstructed building materials

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Paragraph c of subdivision 2 of section 377 of the executive law, as added by chapter 707 of the laws of 1981, is amended to read as follows:

c. permit to the fullest extent feasible, use of modern technical methods, devices and improvements which tend to reduce the cost of construction, including the reuse of deconstructed building materials, without substantially affecting reasonable requirements for the health, safety and security of the occupants or users of buildings;

§ 2. Section 378 of the executive law is amended by adding a new subdivision 19-a to read as follows:

19-a. a. To support the goal of zero on-site greenhouse gas emissions and help achieve the state's clear energy and climate agenda, including but not limited to greenhouse gas reduction requirements set forth within chapter one hundred six of the laws of two thousand nineteen, also known as the New York state climate leadership and community protection act, the uniform code shall set standards for the use of solid-sawn lumber in construction and for the grading of used solid-sawn lumber.

b. The uniform code shall provide that used solid-sawn lumber in good condition and devoid of areas of decay not meeting the requirements of sections 2303.1.1, 2303.1.1.1 or 2303.1.1.2 of the 2020 building code of New York state shall comply with the following:

(i) dimensional lumber that has a nominal thickness of two inches with a nominal width of six inches, or less, shall be assumed to be spruce-pine-fir stud grade and shall have structural properties assigned in

Design for Reuse / Circulating Matters

Image: Joseph McGranahan / CCL (2022)

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Circulating Matters

Images: Felix Heisel, Albert Vecerka / Esto (2022)

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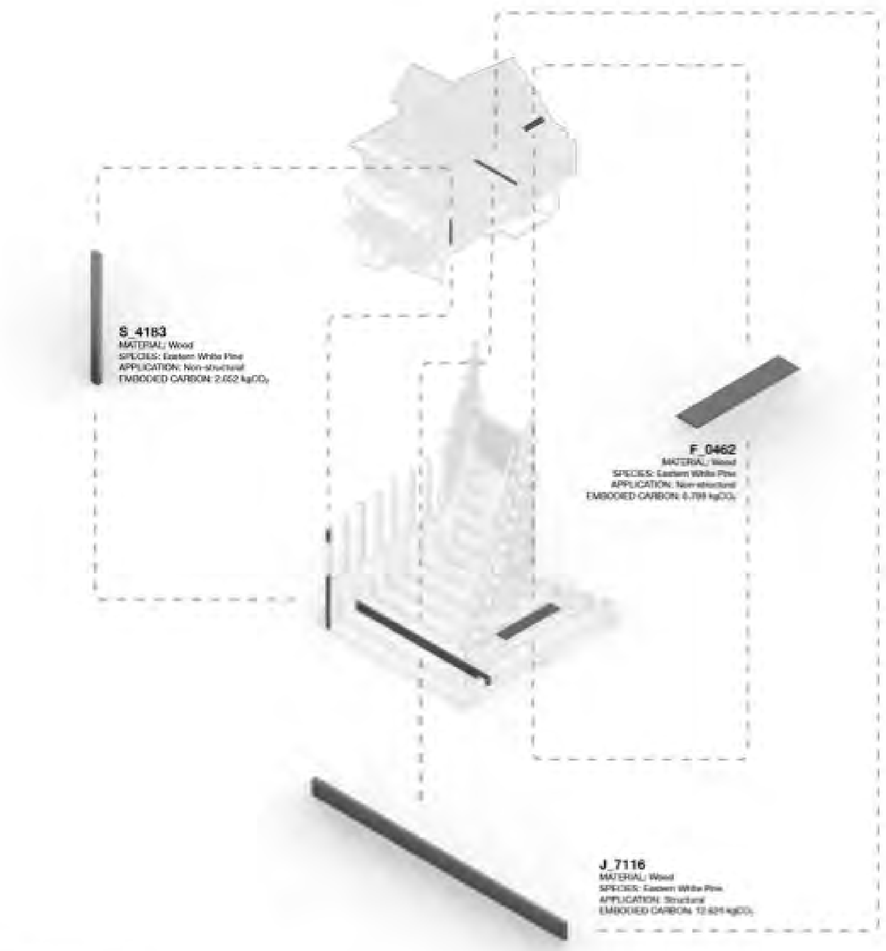
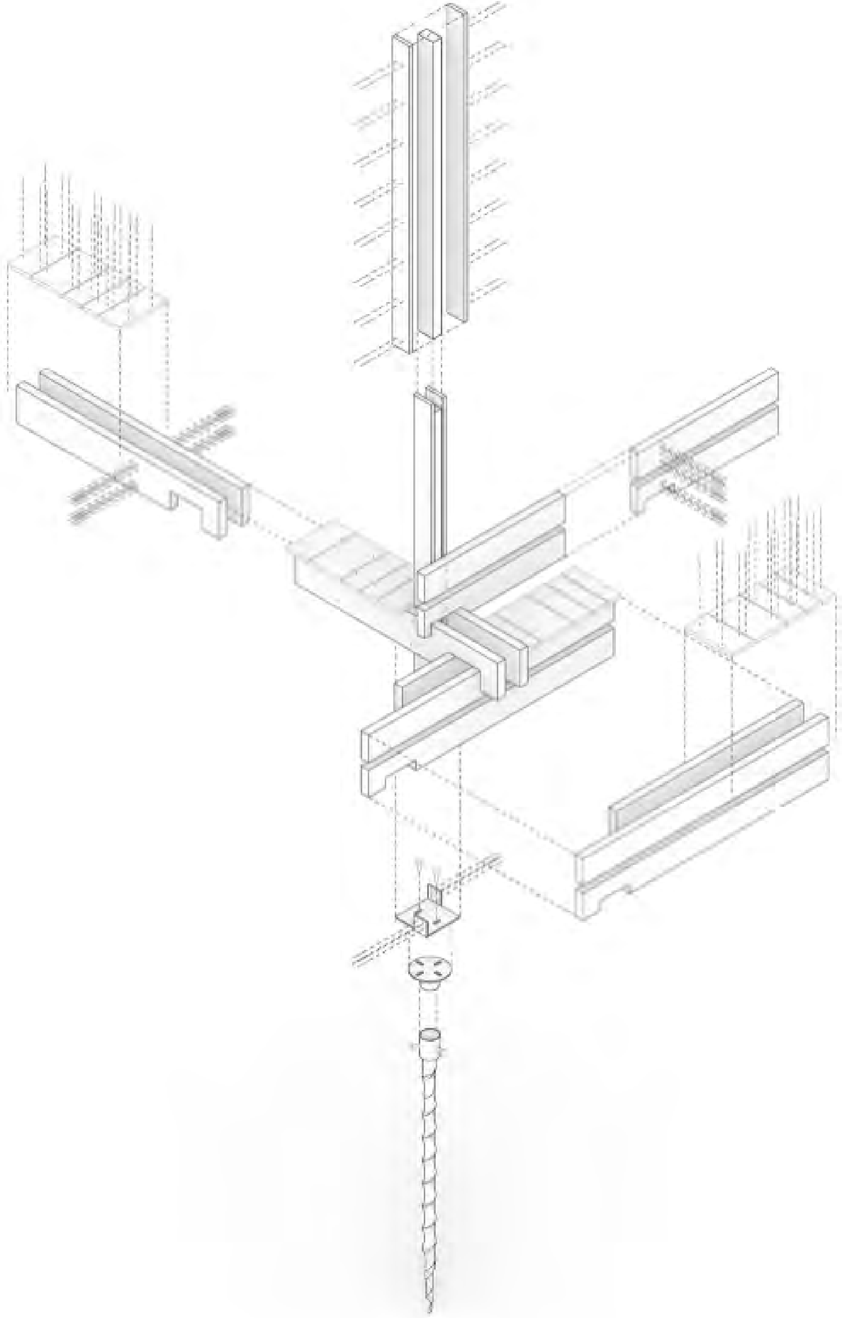
Circulating Matters

Illustration: Circular Construction Lab (2022)





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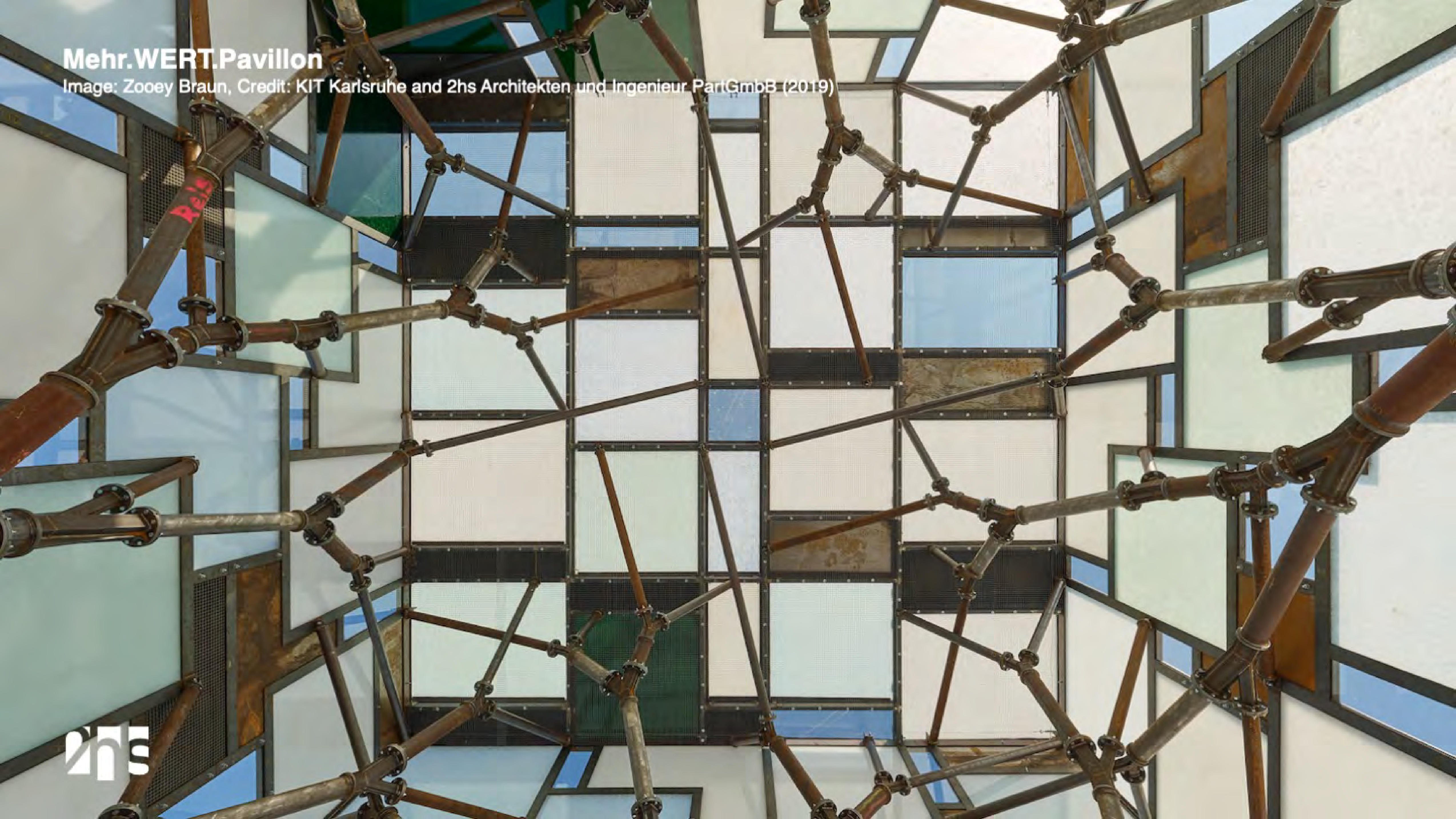
Mehr.WERT.Pavillon

Image: Zooey Braun, Credit: KIT Karlsruhe and 2hs Architekten und Ingenieur PartGmbB (2019)



Mehr.WERT.Pavillon

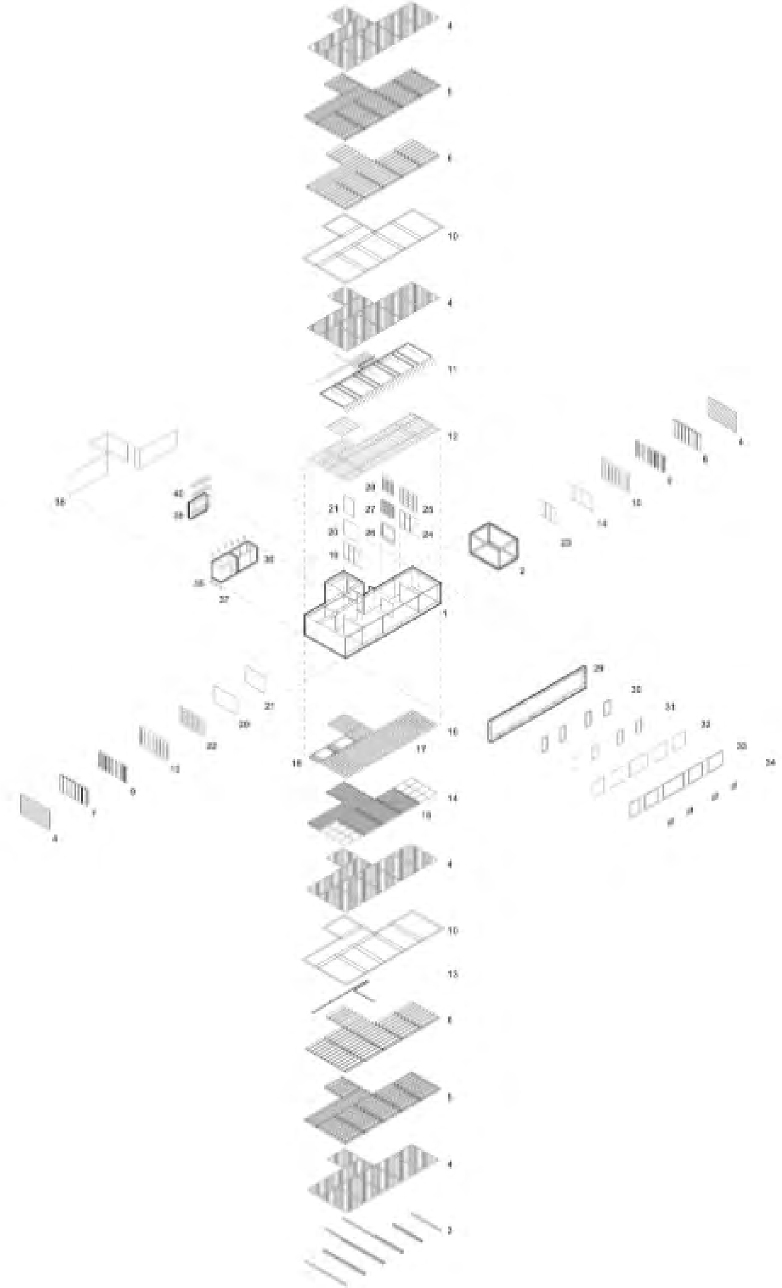
Image: Zooey Braun, Credit: KIT Karlsruhe and 2hs Architekten und Ingenieur PartGmbB (2019)

Urban Mining and Recycling (UMAR)

Image: Zooey Braun, Credit: Werner Sobek with Dirk E. Hebel and Felix Heisel (2018)

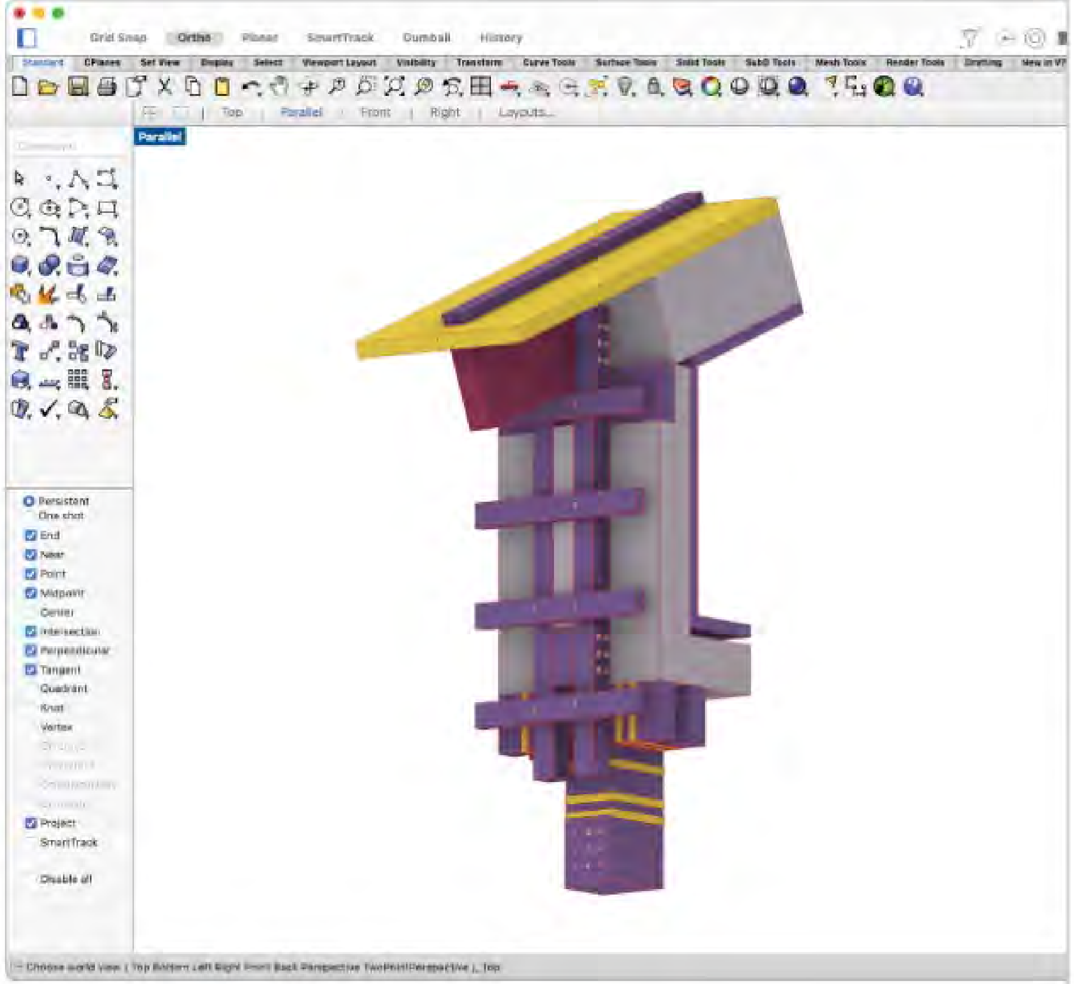
Modular Construction

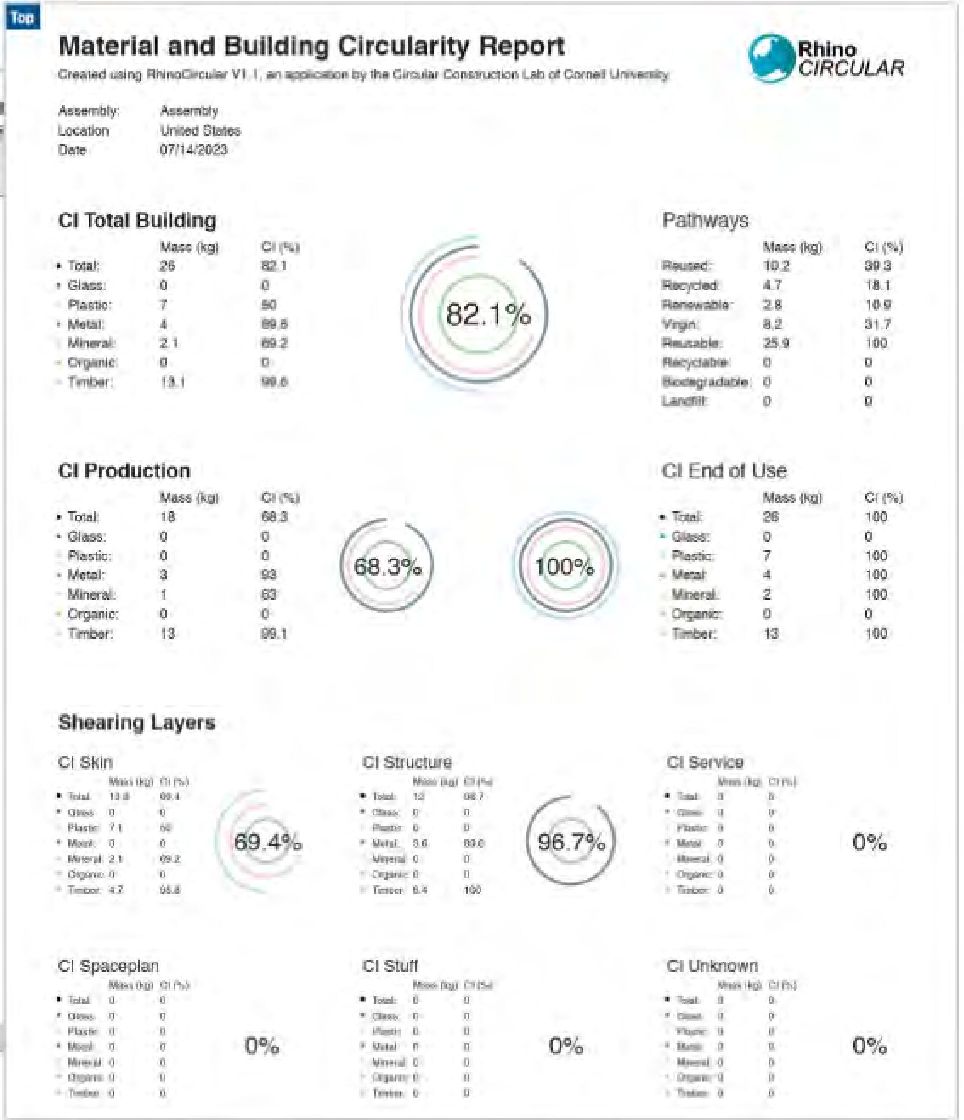
Image: Wojciech Zawarski, Illustration: Sara Schäfer, Felix Heisel



Design for Reuse: Rhino*Circular*

Illustration: Circular Construction Lab (2023) / Free Download: food4rhino





Material and Building Circularity Report

Created using RhinoCircular V1.1, an application by the Circular Construction Lab of Cornell University

Rhino CIRCULAR

Assembly:	Assembly
Location	United States
Date	07/14/2023

CI Total Building

	Mass (kg)	CI (%)
Total:	26	82.1
Glass:	0	0
Plastic:	7	50
Metal:	4	89.6
Mineral:	2.1	69.2
Organic:	0	0
Timber:	13.1	99.6

82.1%

Pathways

	Mass (kg)	CI (%)
Reused:	10.2	39.3
Recycled:	4.7	18.1
Renewable:	2.8	10.9
Virgin:	8.2	31.7
Reusable:	25.9	100
Recyclable:	0	0
Biodegradable:	0	0
Landfill:	0	0

CI Production

	Mass (kg)	CI (%)
Total:	18	68.3
Glass:	0	0
Plastic:	0	0
Metal:	3	93
Mineral:	1	63
Organic:	0	0
Timber:	13	99.1

68.3%

100%

CI End of Use

	Mass (kg)	CI (%)
Total:	26	100
Glass:	0	0
Plastic:	7	100
Metal:	4	100
Mineral:	2	100
Organic:	0	0
Timber:	13	100

Shearing Layers

CI Skin

	Mass (kg)	CI (%)
Total:	13.8	69.4
Glass:	0	0
Plastic:	7.1	50
Metal:	0	0
Mineral:	2.1	69.2
Organic:	0	0
Timber:	4.7	95.8

69.4%

CI Structure

	Mass (kg)	CI (%)
Total:	12	96.7
Glass:	0	0
Plastic:	0	0
Metal:	3.6	89.6
Mineral:	0	0
Organic:	0	0
Timber:	8.4	100

96.7%

CI Service

	Mass (kg)	CI (%)
Total:	0	0
Glass:	0	0
Plastic:	0	0
Metal:	0	0
Mineral:	0	0
Organic:	0	0
Timber:	0	0

0%

CI Spaceplan

	Mass (kg)	CI (%)
Total:	0	0
Glass:	0	0
Plastic:	0	0
Metal:	0	0
Mineral:	0	0
Organic:	0	0
Timber:	0	0

0%

CI Stuff

	Mass (kg)	CI (%)
Total:	0	0
Glass:	0	0
Plastic:	0	0
Metal:	0	0
Mineral:	0	0
Organic:	0	0
Timber:	0	0

0%

CI Unknown

	Mass (kg)	CI (%)
Total:	0	0
Glass:	0	0
Plastic:	0	0
Metal:	0	0
Mineral:	0	0
Organic:	0	0
Timber:	0	0

0%

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Rhino CIRCULAR

Thank you!

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AAP Cornell Architecture Art Planning

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