



**CONCRETE
INNOVATIONS**

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SESSION 37

April 15, 2026

11:00-13:00 eastern

Beyond Decarbonization: Concrete Material Agency and Multi-functionality



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From Designing Buildings to Designing Intelligence

“We design buildings as if they stop changing the day we finish them”

Material Agency

From Object to Process



The dominant model of construction assumes completion. A building is “finished” at substantial completion. Liability transfers. Performance is assumed. Materials are frozen in time. But this is a legal fiction.

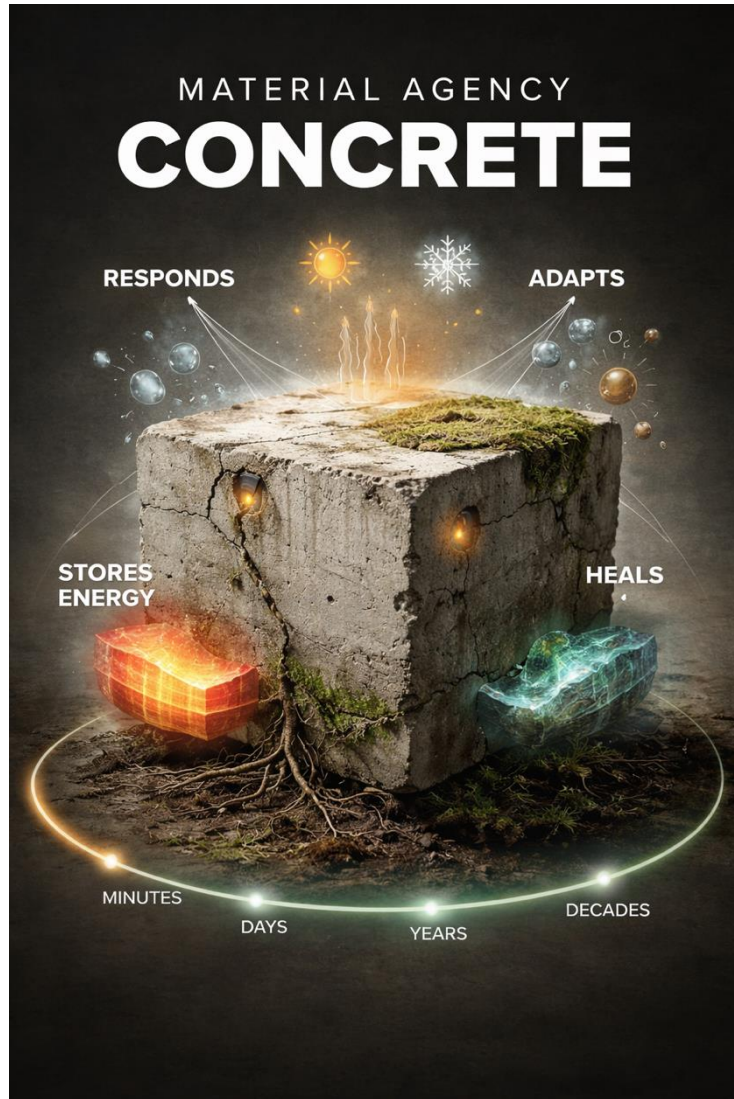
- Concrete continues to hydrate.
- Steel continues to fatigue.
- Glass continues to expand and contract.
- Assemblies continue to negotiate with climate.

“Concrete is not a product. It is a process stretched across centuries.”

Material agency begins when we abandon the idea of completion.

**A building is not an object.
It is a temporal system.**

Material Agency



Material agency is the capacity of a material to influence outcomes over time through its own properties, behaviors, and interactions with its environment.

Not just *what it is*—but *what it does*, and continues to do.

EVOLUTION

1. Matter as Passive (baseline)

Key idea: materials = neutral carriers of form

2. Material as Experience

Key shift: materials affect perception, atmosphere (Peter Zumthor — *Thinking Architecture*.)

3. Material as Active

Key shift: matter has agency (Graham Harman — *Object-Oriented Ontology*)

4. Regenerative Design

Key shift: materials participate in ecosystems (Bill Reed & Daniel Wahl)

5. Agentic Architecture

Key shift: materials as goal-seeking systems (Michael Levin & Neri Oxman)



The New York Times.
"Daring and Dazzling, a New LACMA Floats Above Los Angeles."
April 14, 2026.
<https://www.nytimes.com/2026/04/14/arts/design/lacma-peter-zumthor-los-angeles.html>.

Material Agency

AEC
INDUSTRY
THINKING

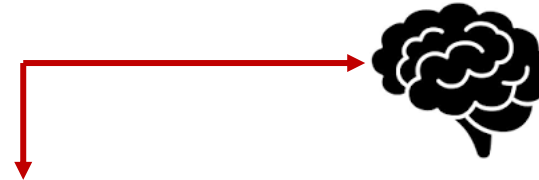
EVOLUTION



Regenerative Design

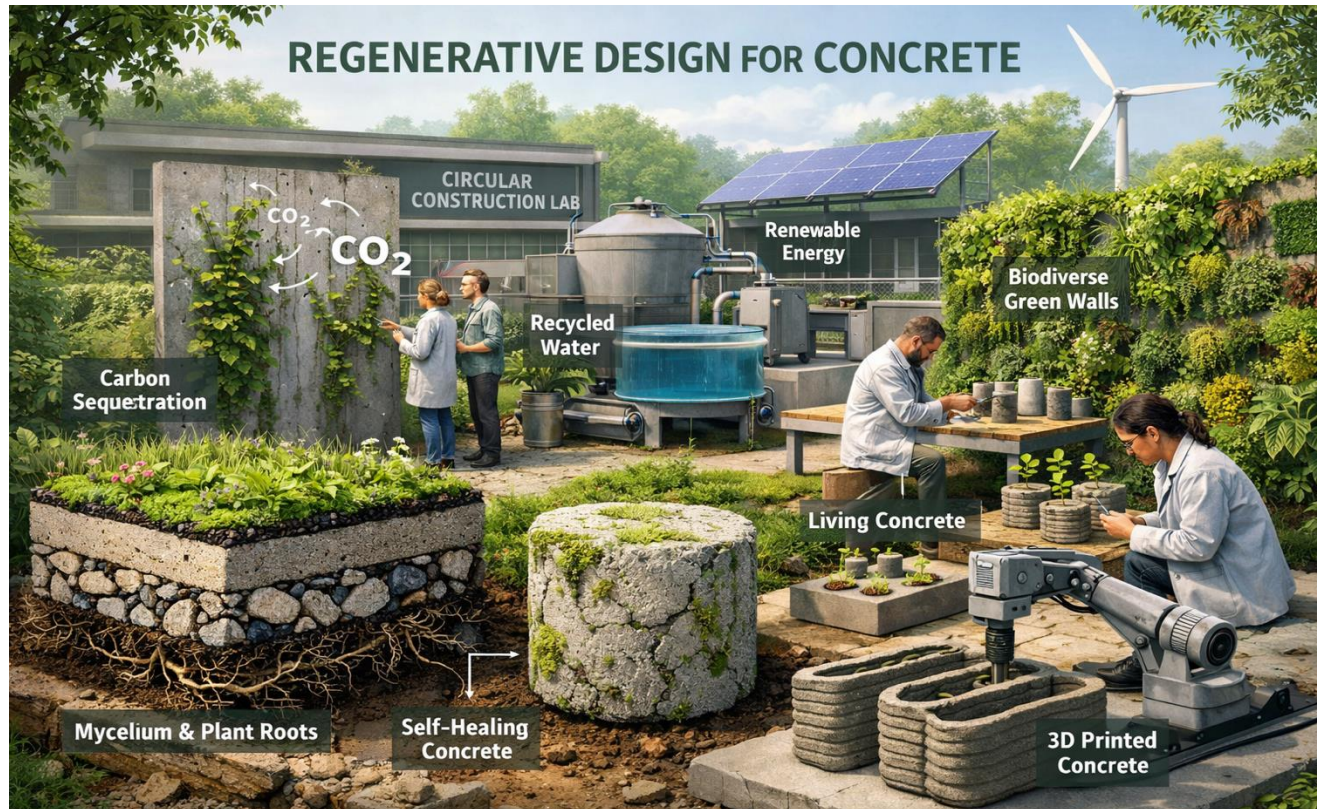


If materials act over time
 → buildings participate
 in systems
 → This is regenerative
 design



Feature	Sustainability →	Regenerative Design	Agentic Architecture
Core Objective	Maintain: Balance resource use to reach net-zero impact.	Restore: Heal and replenish ecosystems for net-positive outcomes.	Execute: Perform complex, multi-step tasks autonomously.
Primary Focus	Efficiency and reduction of waste/emissions.	Integration with living systems and biodiversity.	Logic, goal-oriented reasoning, and task automation.
Philosophy	"Do less bad".	"Do more good".	Goal-driven autonomy.
Common Metric	Carbon footprint, LEED certification, net-zero waste.	Biodiversity net-gain, energy generation, water purification.	Task completion rate, reasoning accuracy, tool-use efficiency.
System Type	Closed or protective systems.	Open, co-evolutionary living systems.	Self-correcting, adaptive digital systems.

Regenerative Design



Regenerative Design is a system-based approach that moves beyond "sustainability" (maintaining a neutral state) toward the active restoration and co-evolution of human and natural systems.

It treats the built environment as a **living participant** nested within an ecosystem, aiming for **net-positive impacts** where buildings actively improve the health of their surrounding watersheds, communities, and bioregions.

Regenerative Design

Buildings as Anthropogenic Archives

Insurance Costs



Deep Time Performance:

Moving beyond the "28-day strength" metric to view concrete's performance over centuries.

Concrete Buildings:

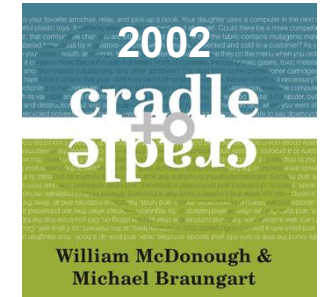
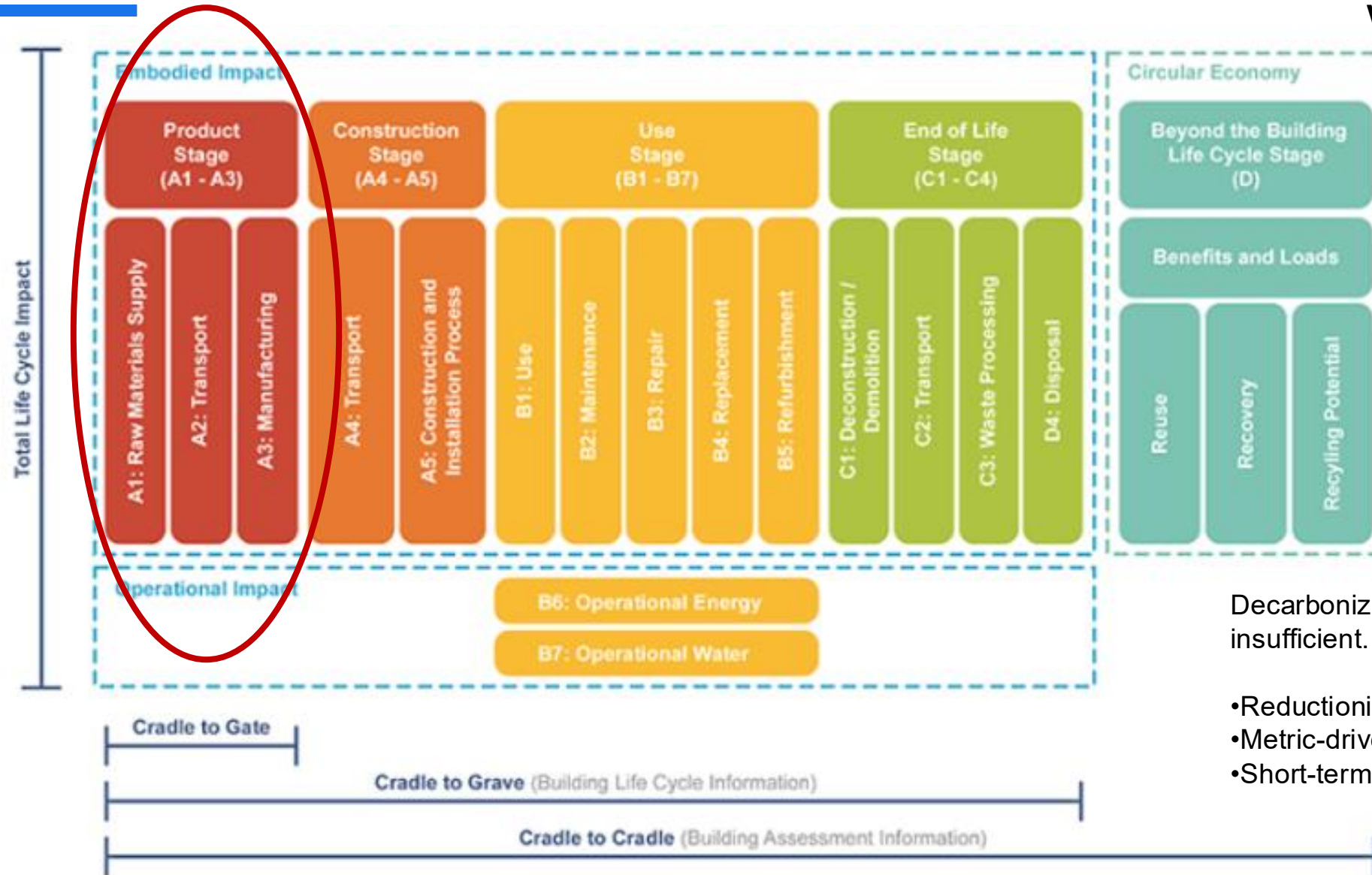
- Age (materials weather, degrade, strengthen)
- Adapt (to HVAC cycles, to occupancy patterns shift)
- Accumulate data (maintenance, energy use, carbon uptake)
- Interact with environment (heat, moisture, carbon, biology)
- Acts as an Urban Quarry (reuse after life of structure)

Concrete is not discarded → it is stored structure
Buildings are not obsolete → they are material reserves
Cities are not static → they are quarries in waiting



Decarbonization is Insufficient

The Failure of Only Using Decarbonization as a Frame when we Select Materials



Decarbonization is necessary—but insufficient. It remains:

- Reductionist
- Metric-driven
- Short-term

Decarbonization is Insufficient

CLIMATE CHANGE

How this “green” building could fail New York’s climate laws

ROSE MARY PETRASS 30 MAY 2022



Hailed as “green” when it was completed in 2010, the \$1.8 Bank of America Tower in New York City is now set to fail the city’s ambitious emissions laws by an estimated 50 per cent in 2024. Those behind the failure claim that electrifying the tower could be disastrous.

The Architect's Newspaper

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BEER Goggles And MisLEEDing Readings

New York’s proliferation of green building rating systems raises the question of what’s being measured

By Bill Millard • September 7, 2021 • Architecture, East, Feature, Featured, Sustainability



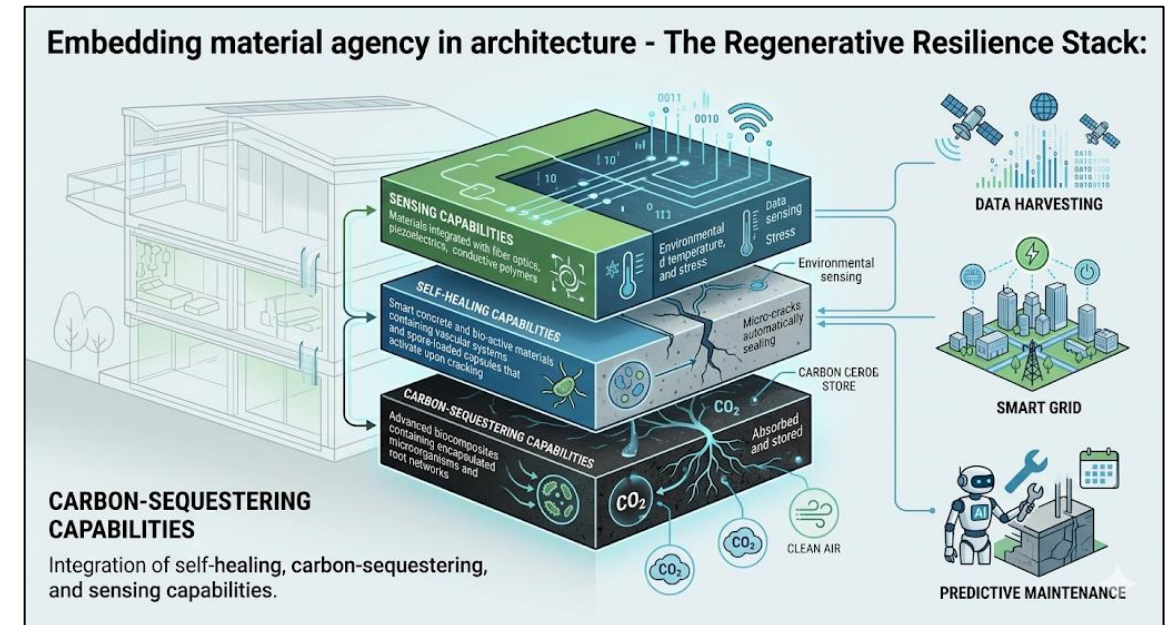
A telling juxtaposition? New York’s Building Energy Efficiency Ratings and LEED, side by side (John Hill)



From Sustainability to Systemic Resilience

The Regenerative Resilience Stack

Layer	Primary Function	Material Agency (The "Active" Role)	Key Performance Indicators (KPIs)
Sensing & Adaptive	Data Interface: Real-time feedback on structural and environmental health.	The Nervous System: Materials (fiber optics, piezoelectrics) communicate their state to the digital twin.	<i>Data Accuracy, Latency, Energy Output.</i>
Self-Healing	Maintenance: Autonomous repair of micro-cracks and structural fatigue.	The Immune System: Bio-active agents (bacteria, polymers) trigger "healing" without human intervention.	<i>Crack Closure Rate, Strength Recovery.</i>
Carbon-Sequestering	Regeneration: Active capture and storage of atmospheric CO_2 .	The Respiratory System: Advanced biocomposites and mineralized concrete act as a permanent carbon sink.	<i>kg CO_2e/m^3, Carbon Longevity.</i>



From Sustainability to Systemic Resilience



From (Static/Component)

To (Dynamic/Systemic)

Structural Capacity

Functional Continuity

Internal Redundancy?

Code Compliance

Adaptive Capacity

Self-Healing Concrete?

Risk Prevention

Recovery & Regeneration

Carbon-Sequestering Concrete?

Material Durability

Lifecycle Resilience

Anodic/cathodic Sensors?

Individual Components

Interdependent Systems

Thermal Mass Battery?



Key Point

Material Multifunctionality and Material Agency is the Foundation of Regenerative and Agentic Architecture

The traditional metric of material performance is strength.
But strength is a narrow and incomplete measure.

- Thermal mass → **energy stability agent**
- Acoustic mass → **urban comfort agent**
- Fire resistance → **passive life safety agent**
- Hurricane resistance → **civic resilience agent**
- Ability to hold electrical charge → **energy storage agent**
- Ability to absorb carbon → **carbonation agent**
- Ability to be AI sensing and adaptive → **agentic-architecture**

This leads to a new concept:

The Material Stack

Material is not single-purpose. Material is **multi-agent**.

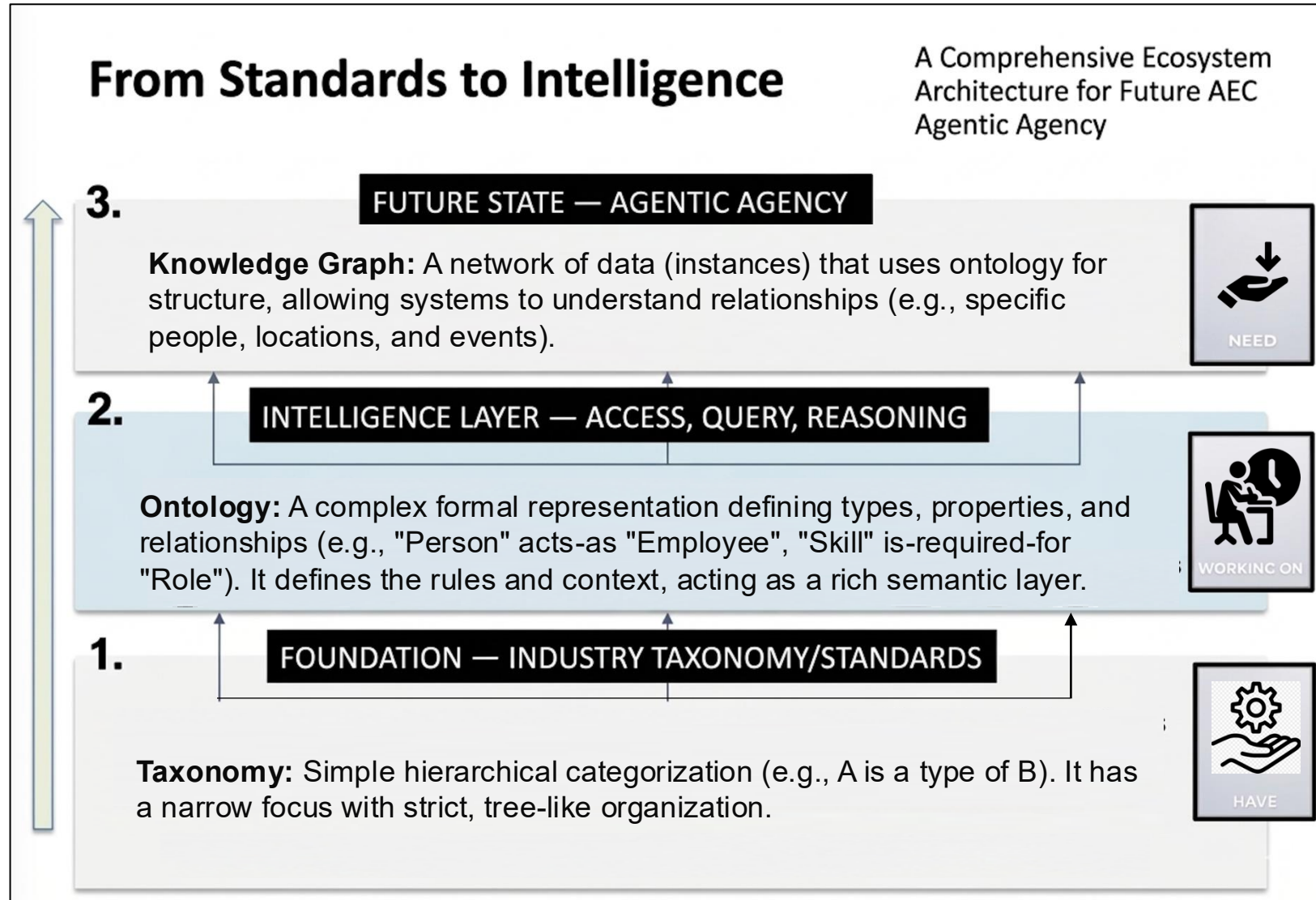
Concrete is simultaneously:

Structure | Climate regulator | Safety system | Infrastructure substrate



Using Agentic Intelligence to Close the Loop

Materials are not “building blocks,” but **active participants in performance and time-based systems**



Agentic Architecture



**Descriptive, Informative,
Predictive and able to Tune**

Digital Twin (collective intelligence)

To move from a static BIM model to a true **Digital Twin**, the data must transition from a "snapshot" of the past to a "prediction" of the future. This grid maps the evolution of the digital twin as it interacts with the **Regenerative Resilience Stack**.

Maturity Level	Primary Function	Interaction with Material Agency	Operational Value
Level 1: Descriptive	Visual Record: A 3D "as-built" model of the physical asset.	The Map: Identifies where carbon-sequestering or self-healing materials are located.	Simplified handover and asset documentation.
Level 2: Informative	Live Monitoring: Integration of IoT sensors (temperature, stress, CO_2).	The Voice: The material "speaks" its current health and environmental state.	Real-time alerts for structural fatigue or energy spikes.
Level 3: Predictive	Simulation: Using historical data to forecast future performance.	The Oracle: Models how materials will age or "heal" under specific stress scenarios.	Shift from reactive proactive maintenance schedules.
Level 4: Comprehensive	Autonomous Tuning: Bi-directional control between twin and building.	The Mind: The twin triggers building systems to optimize for material performance.	Maximized ROI and verifiable ESG/Carbon Credit reporting.

Multifunctionality and Agency as the New Frontier

Concrete sensor manufacturer Wavelogix receives \$500K grant from National Science Foundation

Funding from 1-year SBIR grant will enable the company to refine, scale Rebel concrete strength sensing system

Can Digital Twins and Agents Optimize all this?

MIT News
ON CAMPUS AND AROUND THE WORLD

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Concrete "battery" developed at MIT now packs 10 times the power

Improved carbon-cement supercapacitors could turn the concrete around us into massive energy storage systems.

Andrew Paul Laurent | Concrete Sustainability Hub
October 1, 2025

PRESS INQUIRIES

An electron-conducting carbon concrete (ec²)-based arch structure integrates supercapacitor electrodes for dual functionality. The prototype demonstrates both structural load bearing and the ability to power an LED, with the light's intensity varying under applied load, highlighting the potential for real-time structural health monitoring via the supercapacitor.

Image courtesy of the MIT EC² Hub.

Wavelogix founder and Purdue University professor, h...
estimates of in-place strength of concrete structures. ...
iversity photo/Grata Bell)

DECEMBER 16, 2025

How cement 'breathes in' and stores millions of tons of CO₂ a year

by Andrew Paul Laurent, Massachusetts Institute of Technology
edited by Stephanie Baum, reviewed by Robert Egan

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Could Self-Healing Concrete Reshape Global Construction?

By Libby Hargreaves
January 05, 2026 • 4 mins

...concrete and modern bioengineering, self-healing materials could cut emissions

THE RESEARCH

Microbes in concrete could help detect damage to bridges and highways early.

by Dario D'Elia

A Japanese study confirms that microbes present in concrete can monitor the deterioration of civil infrastructure.

APRIL 11, 2026, AT 10:39 AM

Biological sensors are nothing new—just think of the rose bushes placed at the beginning of vineyard rows—but no one had yet thought of using the microbes present in concrete as sentinels. A group of researchers from Hiroshima University and Kyoto University discovered that when concrete is mixed—for example, to build bridges, highways, or even sidewalks—different raw materials are used that naturally host different types of microbes. Not only do these microbes remain trapped and form communities, isolated from the outside world, but they could

Nov 10, 2025 3:59 PM Eastern Standard Time

Malibu and Pacific Palisades Leaders Unveil a Resilient Vision for Residential Rebuilding

Share

MALIBU, Calif.--(BUSINESS WIRE)--A group of state and local officials, fire-impacted Malibu and Pacific Palisades residents, architects, builders and trade association representatives gathered in Malibu's Sunset Mesa on November 8 to unveil a vision for a more resilient, cost-effective and sustainable California built of non-combustible materials such as concrete.

GULFSHORE LIFE DESIGN STYLE ARTS + CULTURE PEOPLE GUEST LIST THINGS TO DO WELLNESS

Rethinking Resilient Coastal Design on Florida's Gulf Coast

Three hurricanes reshaped how Southwest Florida builds, shifting the focus from resisting nature to homes designed to respond during and after a storm.

BY ANNAMARIE SIMOLDONI HOME + DESIGN JAN. 10, 2026 12:48 A.M.

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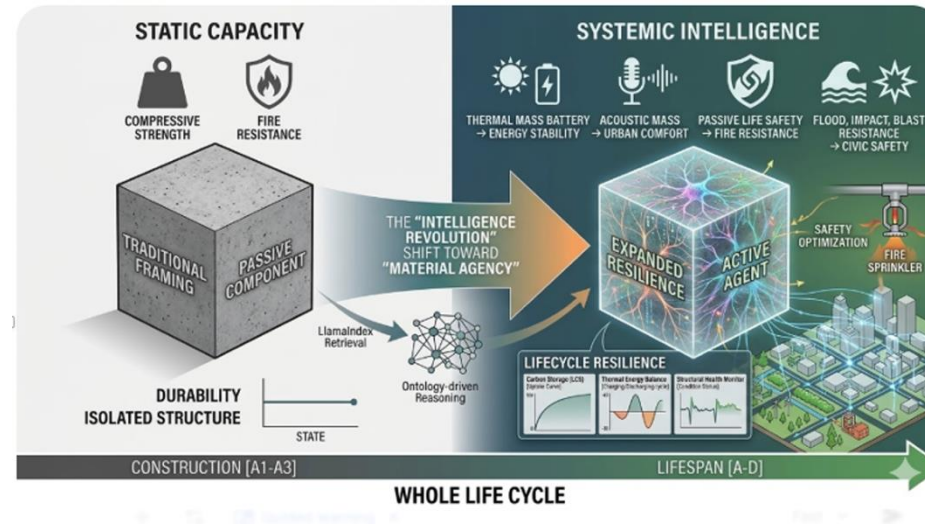
BUILD WITH STRENGTH

Ethics: From Specification to Stewardship

Material agency, regenerative design & Agentic Architecture introduces new responsibilities. Not as compliance.

But as **custodianship across time**.

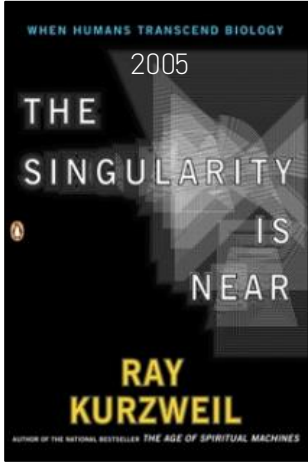
- Designers → lifecycle stewards
- Owners → material trustees
- Engineers → risk translators



Comparison of Roles		
Feature	Ownership	Custodianship
Primary Goal	Asset Maximization	System Resilience
Time Horizon	Short to Mid-term	Intergenerational
Success Metric	Personal/Corporate Gain	Collective Wellbeing
Authority	Absolute Control	Conditional Trust

Toward a New Practice

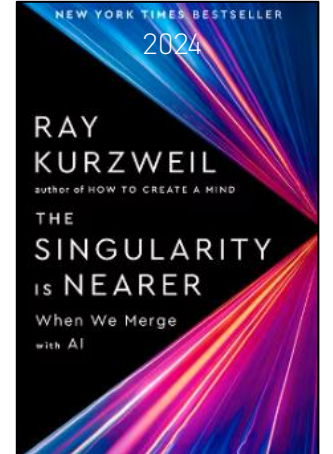
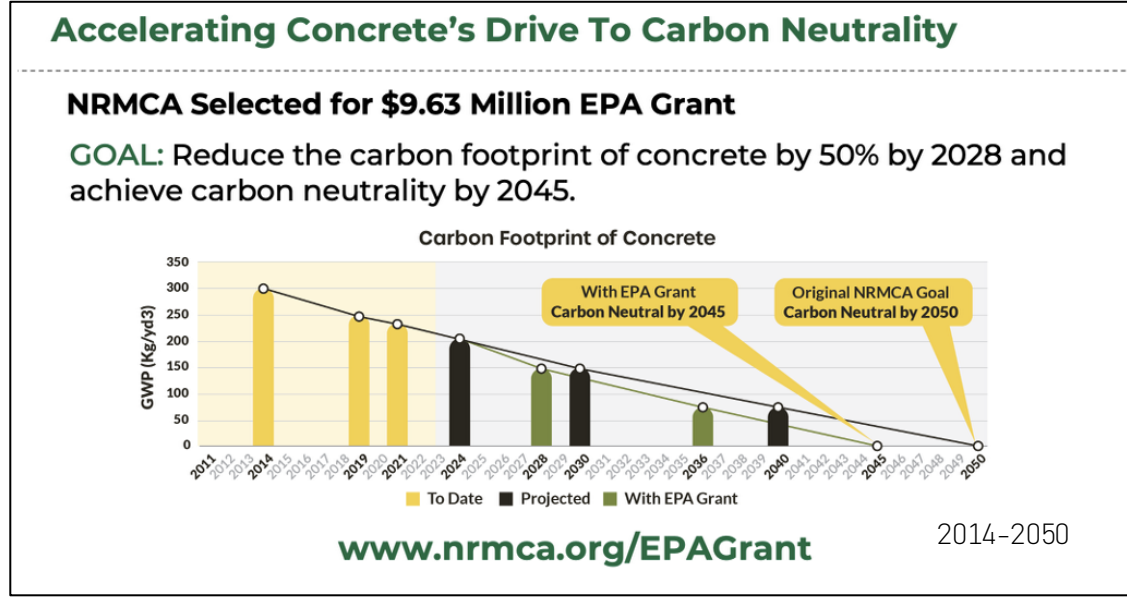
INCREASING RATE OF CHANGE



The singularity is also the point at which machines' intelligence and humans would merge; Kurzweil predicts this date as 2045.



The 2016 McKinsey report on the construction industry. Key findings showed large projects typically **80% over budget and 20% behind schedule, calling for increased technology adoption.**



World Economic Forum, Davos

2026

“By the end of 2026: AI will likely be smarter than any single human (often referred to as AGI.)”

“By 2030 or 2031: AI will be smarter than all of humanity collectively”
Elon Musk

Toward a New Practice

“Design not to impress the present — but to answer the future.”

If we accept that buildings are becoming intelligent systems— where AI operates in real time and materials operate across decades— then the question is no longer:

“What is the strongest material?”

or

“What is the lowest carbon material?”

The question is:

Which material can operate across time, scale, and systems simultaneously?

Concrete already does this.

- It scales from structure to infrastructure
- It is resilient across time
- It can act as a supercapacitor
- It stores energy, carbon, and thermal performance
- It persists long enough to matter

It is not just a material choice. It is a **systems decision**.

And in the emerging era of regenerative design & agentic architecture concrete is not just relevant. It is foundational.



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