Using BOxCrete to Optimize Concrete Mixtures with AI:

From Open-Source Models to Data-Center Deployment

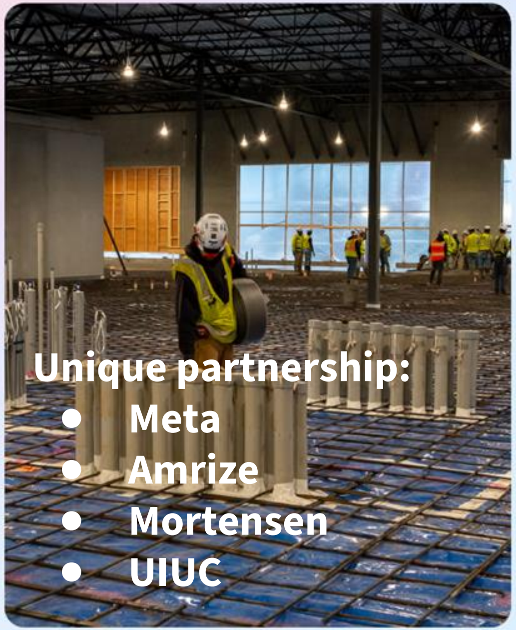
American Concrete Institute Spring Convention 2026 (Chicago, IL)

See: Using AI to make lower-carbon, faster-curing concrete

Presented by:
Julius Kusuma Meta Platforms, Inc
Nishant Garg University of Illinois Urbana-Champaign
Mark Bintzler Amrize

We demonstrated the end-to-end application of AI in a slab section of Meta's data center

Critical slab-on-grade application



Unique partnership:

- Meta
- Amrize
- Mortensen
- UIUC

Building a greener future.

Met all critical use-case requirements

- Faster: 43%
- Stronger: 37%
- Lower carbon: 40% below regional benchmark (v3.2)
- Similar cost
- Standard materials

Outline

- Why this partnership
  - Data centers and concrete
  - AI opportunities
- AI development
  - Foundational data
  - Lab tests
  - AI performance
- At-scale deployment
- Scaling the use of AI

Nishant Garg

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

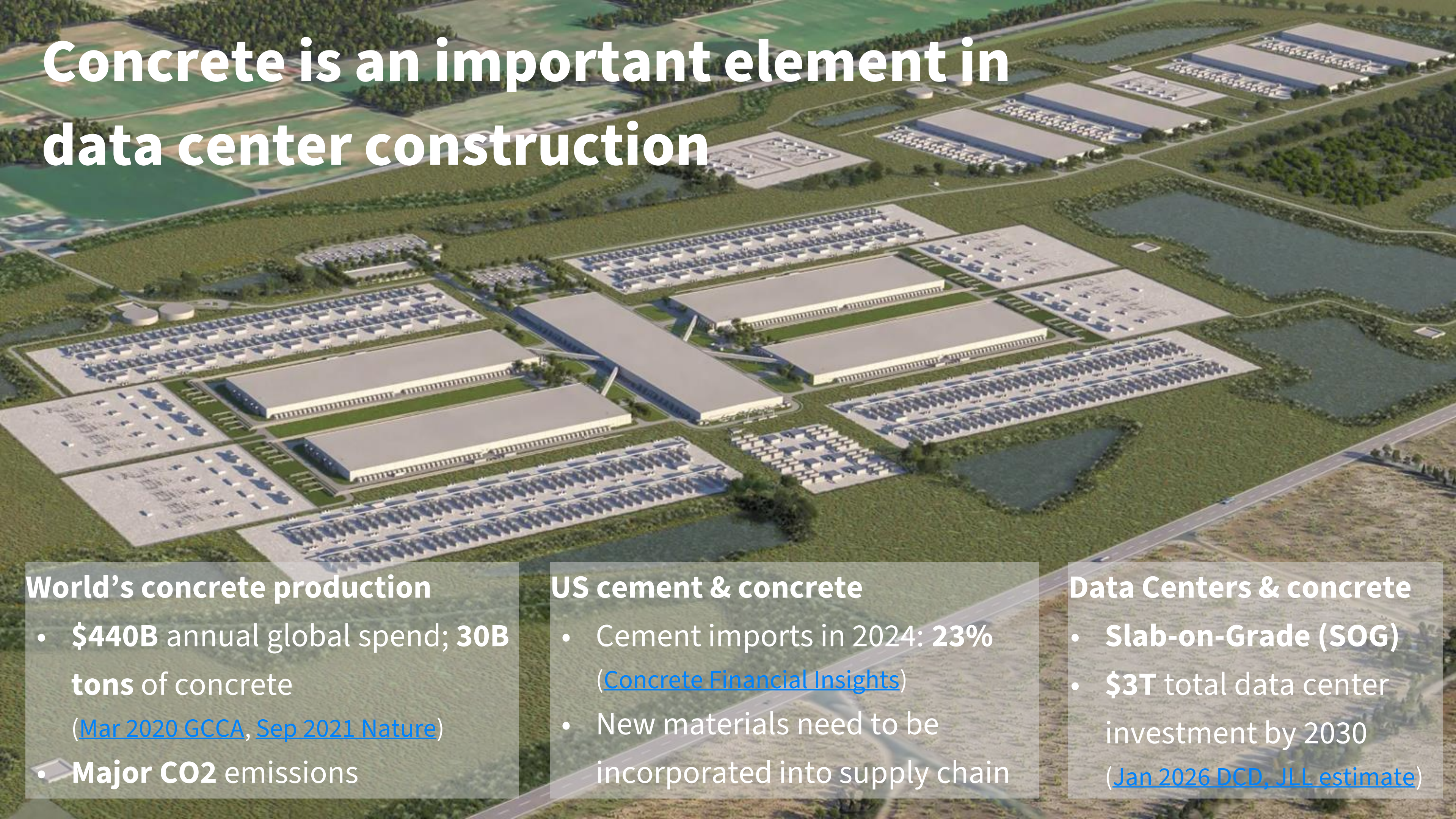
Julius Kusuma

Meta

Mark Bintzler

AMRIZE

Data centers and concrete



Concrete is an important element in data center construction

World's concrete production

- **$440B** annual global spend; **30B tons** of concrete
  ([Mar 2020 GCCA](), [Sep 2021 Nature]())
- **Major CO2 emissions**

US cement & concrete

- Cement imports in 2024: **23%**
  ([Concrete Financial Insights]())
- New materials need to be incorporated into supply chain

Data Centers & concrete

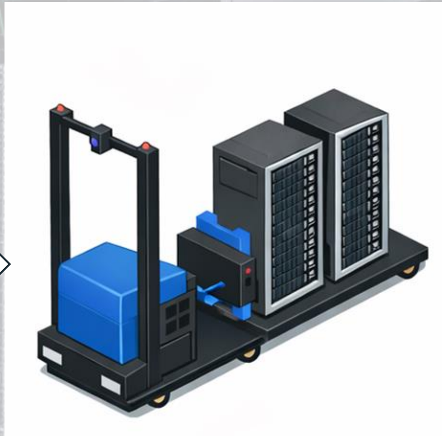
- **Slab-on-Grade (SOG)**
- **$3T** total data center investment by 2030
  ([Jan 2026 DCD, JLL estimate]())


20.b
21.b
22.b
23.b

Manual

Max Concrete point load

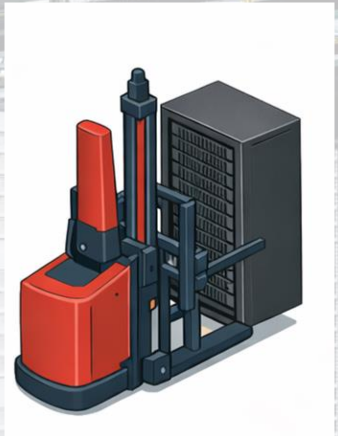
7.2 MPa (1038 PSI)



Auto Delivery

Max Concrete point load

8.1MPa (1170 PSI)



Auto Pick/Deliver/Drop

Max Concrete point load

7.9 MPa (1146 PSI)

Bigger Rack Automation

Max Concrete point load

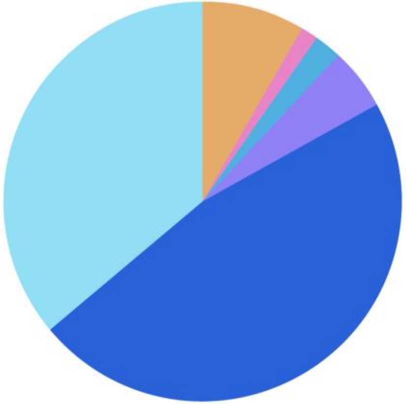
10.38 MPa (1506 PSI)

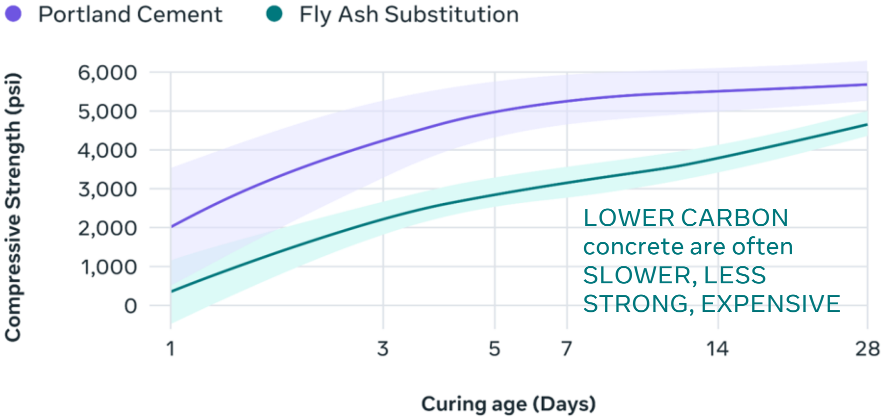
We need Faster, Stronger, Greener concrete that meet critical Data Center use-case requirements – and AI is a key enabler

Low-carbon concrete

Relative proportion of ingredients by weight

- Cement 8.4%
- Fly Ash 1.5%
- Slag 1.97%
- Water 5.22%
- Fine Agg. 35.9%
- Coarse Agg. 46.9%





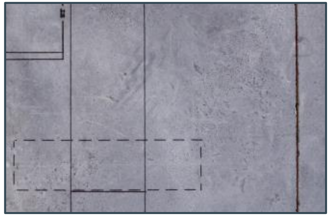
STRENGTH

COST

SPEED

SUSTAINABILITY

QUALITY

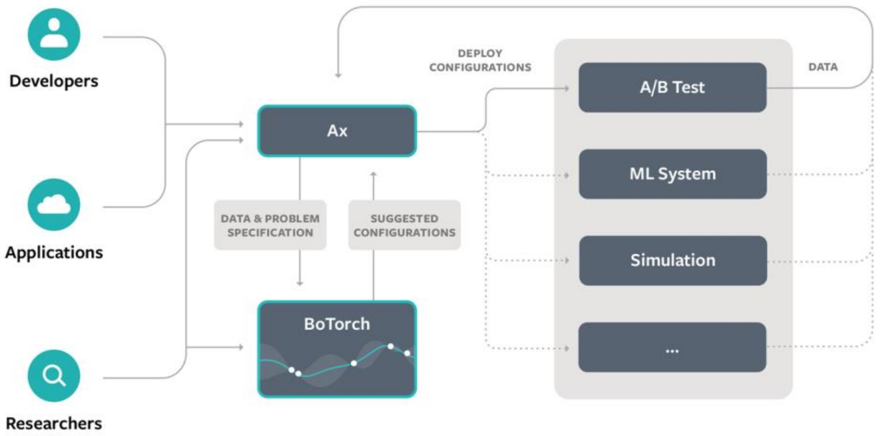


AI development

Adaptive Experimentation

- Meta develops central tools and methods for efficient optimization of ML models, online experiments, and hardware
- Meta's Adaptive Experimentation team maintains two open-source software (OSS) projects
  - Ax: platform for running adaptive experiments
  - BoTorch: framework for Bayesian optimization research
- Team engages with academic research community via publications, OSS, and workshops.

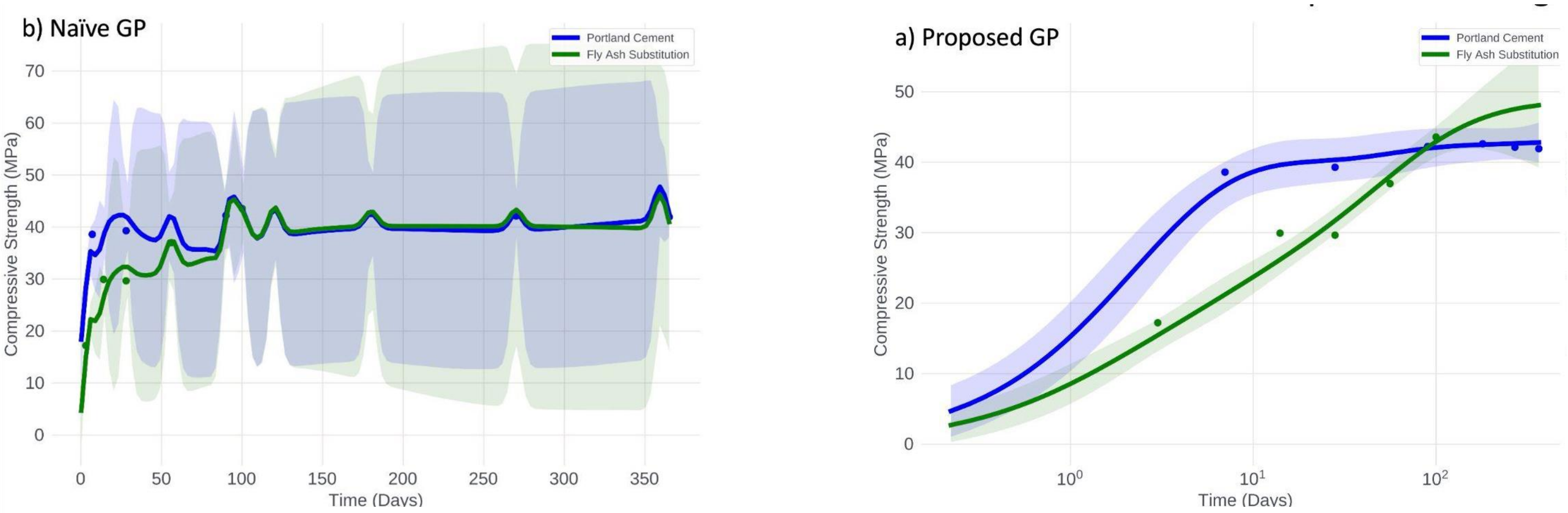
ax.dev



botorch.org

Ax and BoTorch can efficiently learn & solve high-dimensional design problems, and concrete mix design seems promising – what else is needed?

Modeling Compressive Strength Curve



$$k((\mathbf{x}, t), (\mathbf{x}', t')) = \alpha k_{\text{time}}(\log t, \log t') + \beta k_{\text{joint}}((\mathbf{x}, \log t), (\mathbf{x}', \log t'))$$

A problem:

A naïve application of a Gaussian Process (GP) is **inaccurate**,
and worse,
yields **non-physical**
predictions.

The path to a solution:

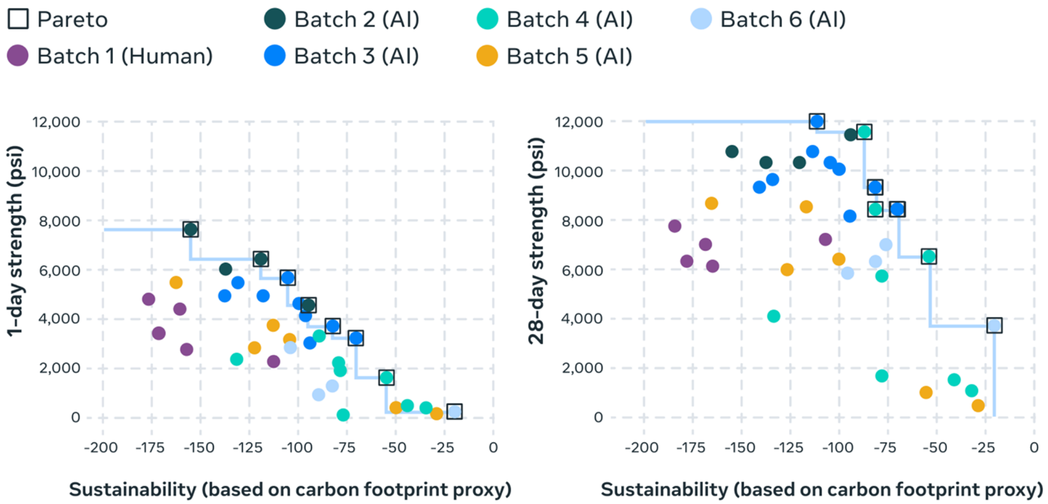
Incorporate physics-inspired features
1) conditioned to have zero strength at day zero zero,
2) based on log-transformed time,
3) includes an additive time-dependent, composition independent component that learn a representative strength curve, from which we can model composition-dependent deviations.

Sustainable Concrete via Bayesian Optimization, *NeurIPS 2023 Workshop on Adaptive Experimental Design and Active Learning in the Real World*

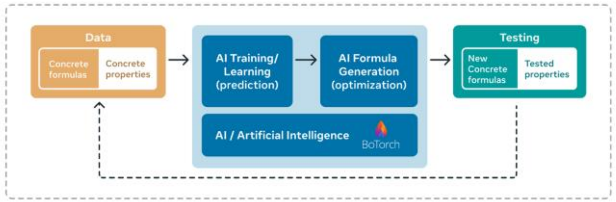
AI has arrived

AI can learn, predict, and optimize basic concrete performance with modest training & standard materials

Pareto Frontier of concrete strength and sustainability



Adaptive experimentation using AI



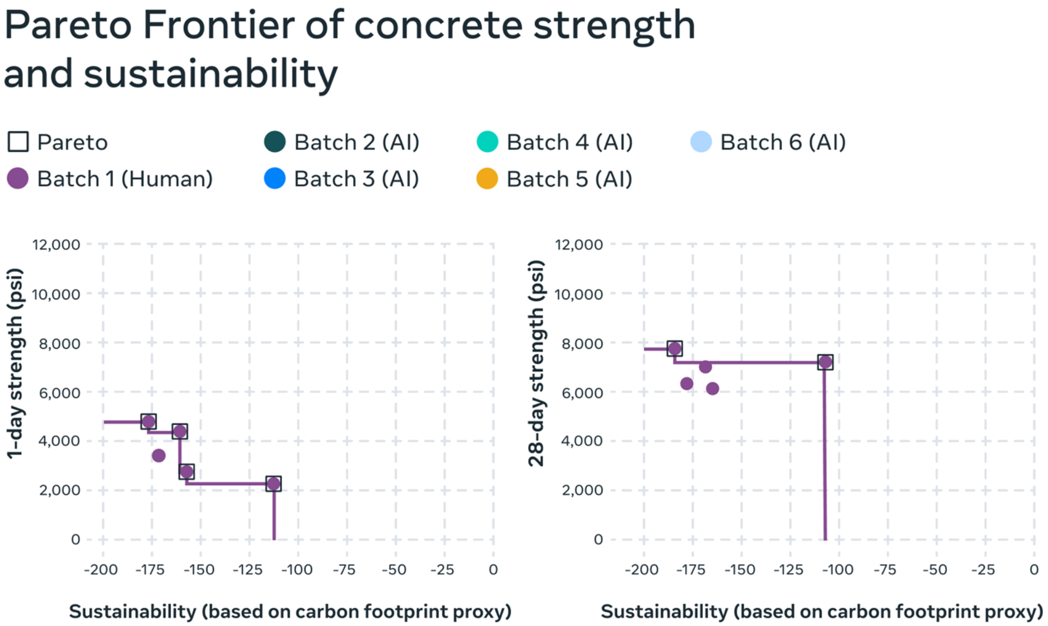
Meta's AI: [open-sourced in GitHub]

- Bayesian optimization for strength, speed, CO2
- Iterative testing with research & industry partners

[Meta's Adaptive eXperimentation (Ax) AI toolbox] optimizes between learning & optimization

AI features available today

https://github.com/facebookresearch/SustainableConcrete/



Prediction

- Compressive strength curve
- GWP
- Slump

Optimization & constraints

- x-day strength
- GWP
- Slump
- Other linear functions eg cost
- Constraints:
    - Volumes
    - w/b

Pareto front

See: our 2023 NeurIPS workshop paper

Foundational data: lab tests

With Bayezid Baten (PhD Candidate) and Ayyan Iqbal (MS Candidate)

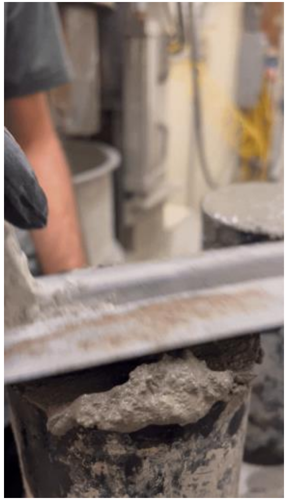
News story: Recipe for Success (U of Illinois, October 2025)

AI for sustainable concrete

Developing new mixes with AI

Bayesian Optimization

Initial data → AI training ⇄ Iterative testing *(cylinder testing)* → Means & Methods, *(Workability, Finish quality)* → Further testing → In-field pilots → At-scale applications

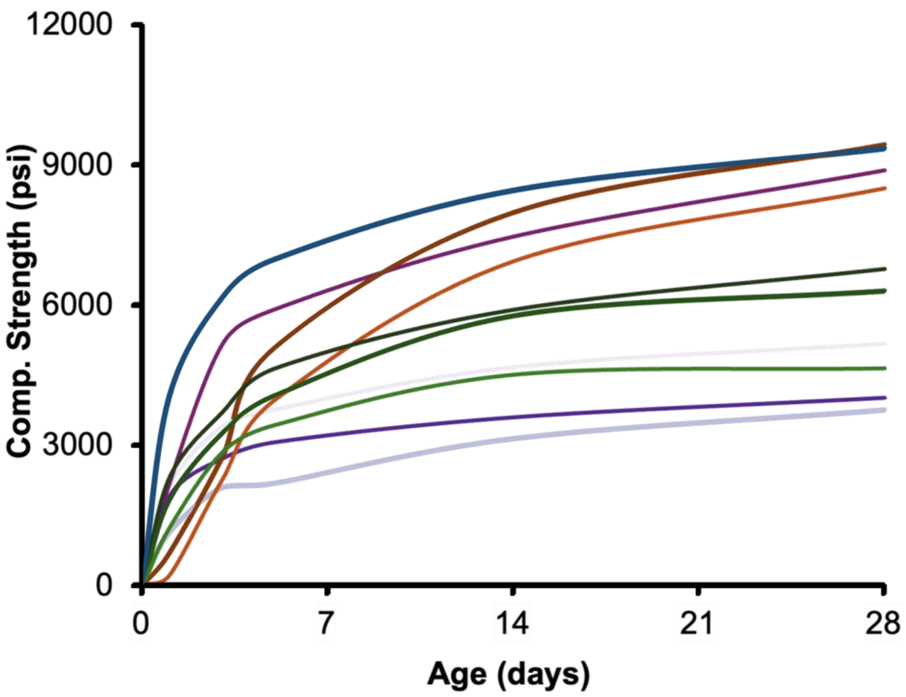


Phase-Wise Mix Development

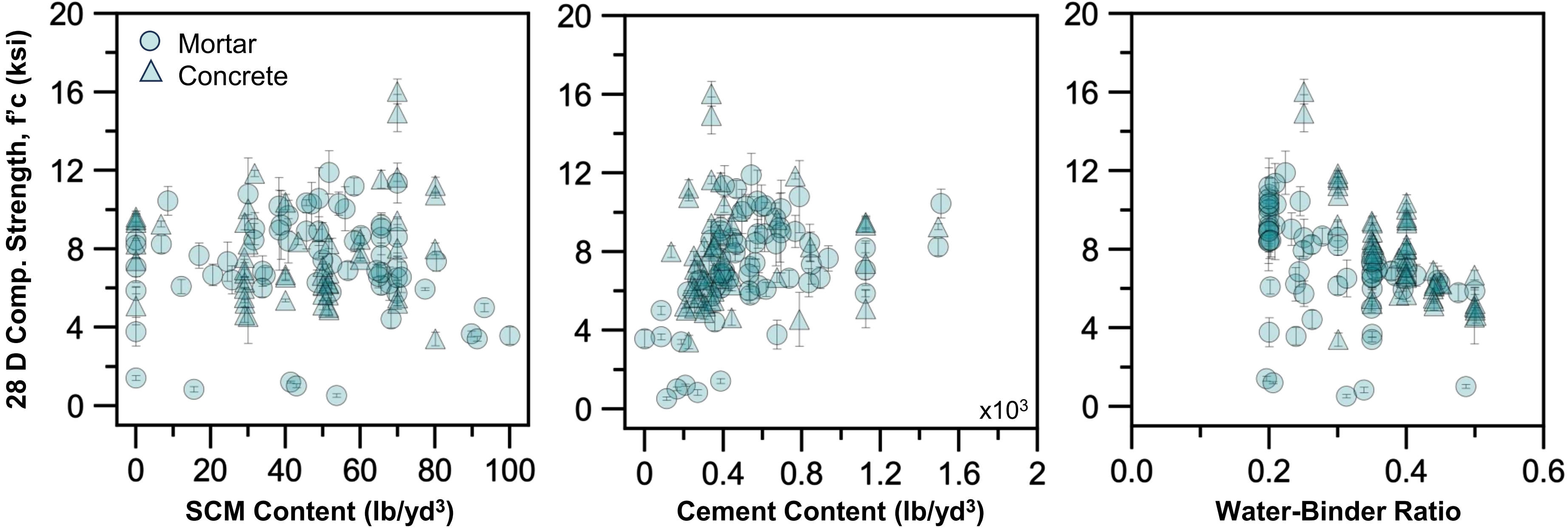
Phase ID	Number of Mixes	Mix Type	Parameters Modified
P I			
P II			
P III			
P IV			
P V			
P VI			

In summary, 500+ diverse strength measurements from a total 123 unique mixes at a single lab (69 mortar + 54 concrete mixes) across five ages (1, 3, 5, 14, and 28 days)

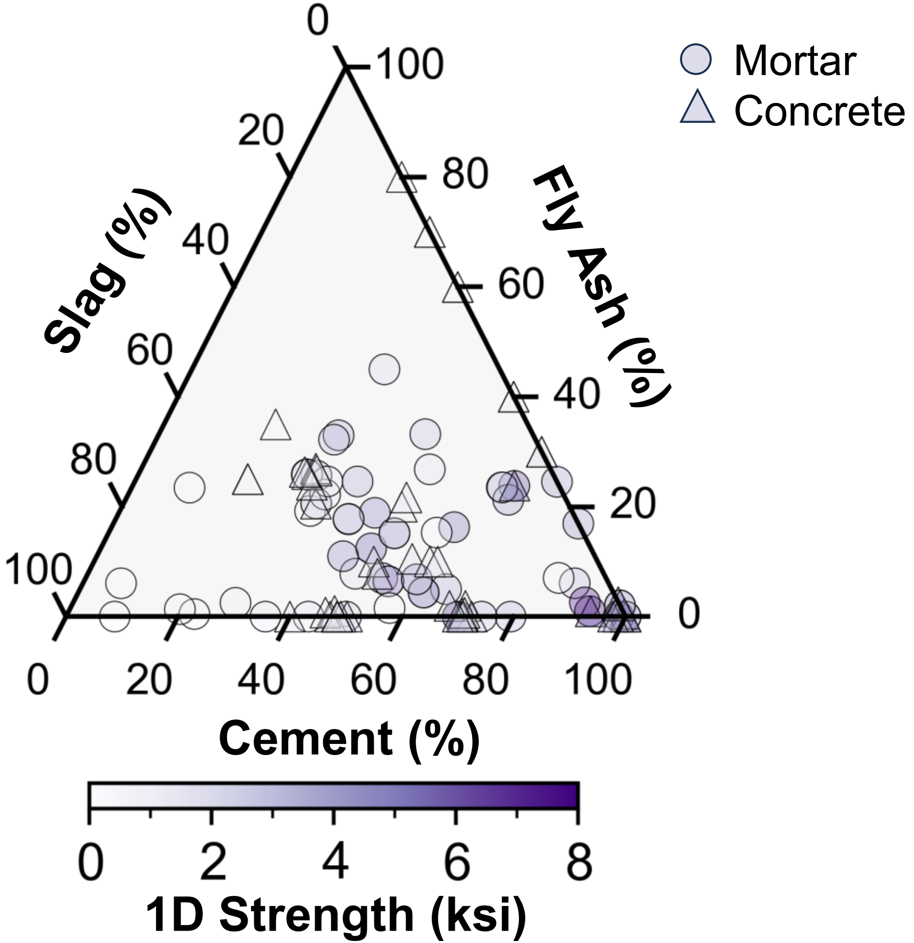
The Perplexity of Strength Prediction

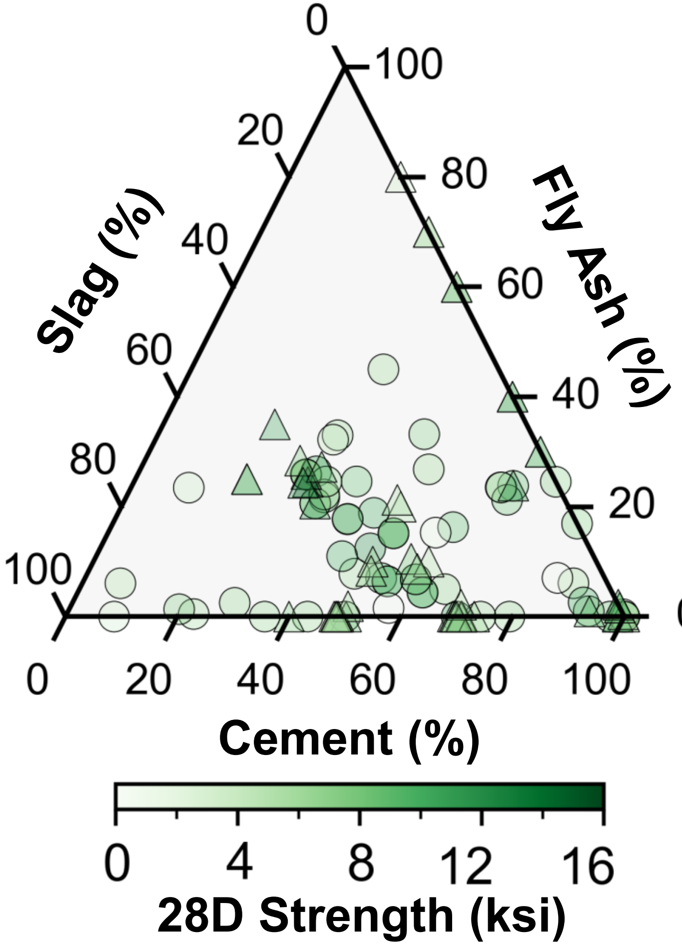


Role of Mix Components on Compressive Strength

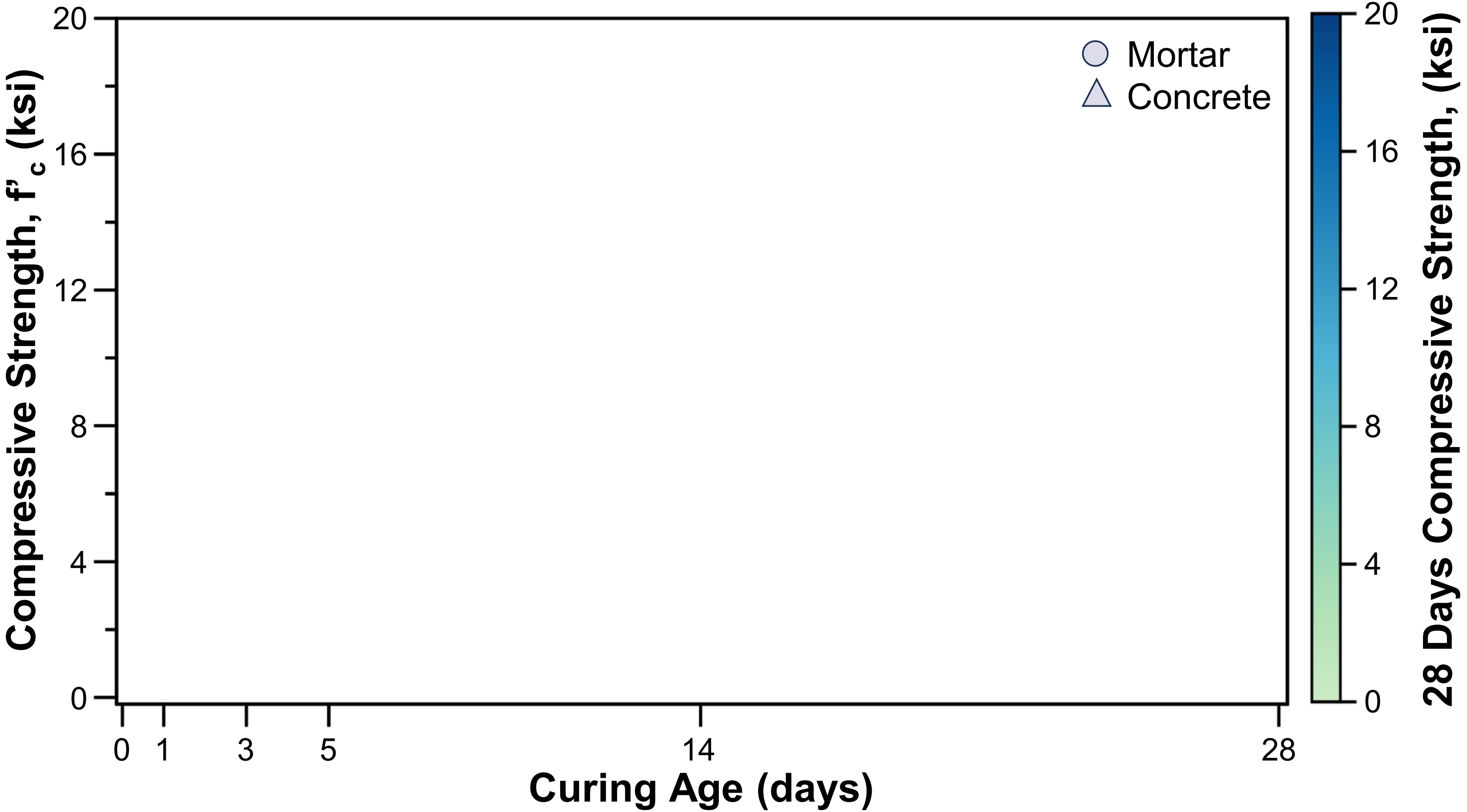


The Mix-Design Space



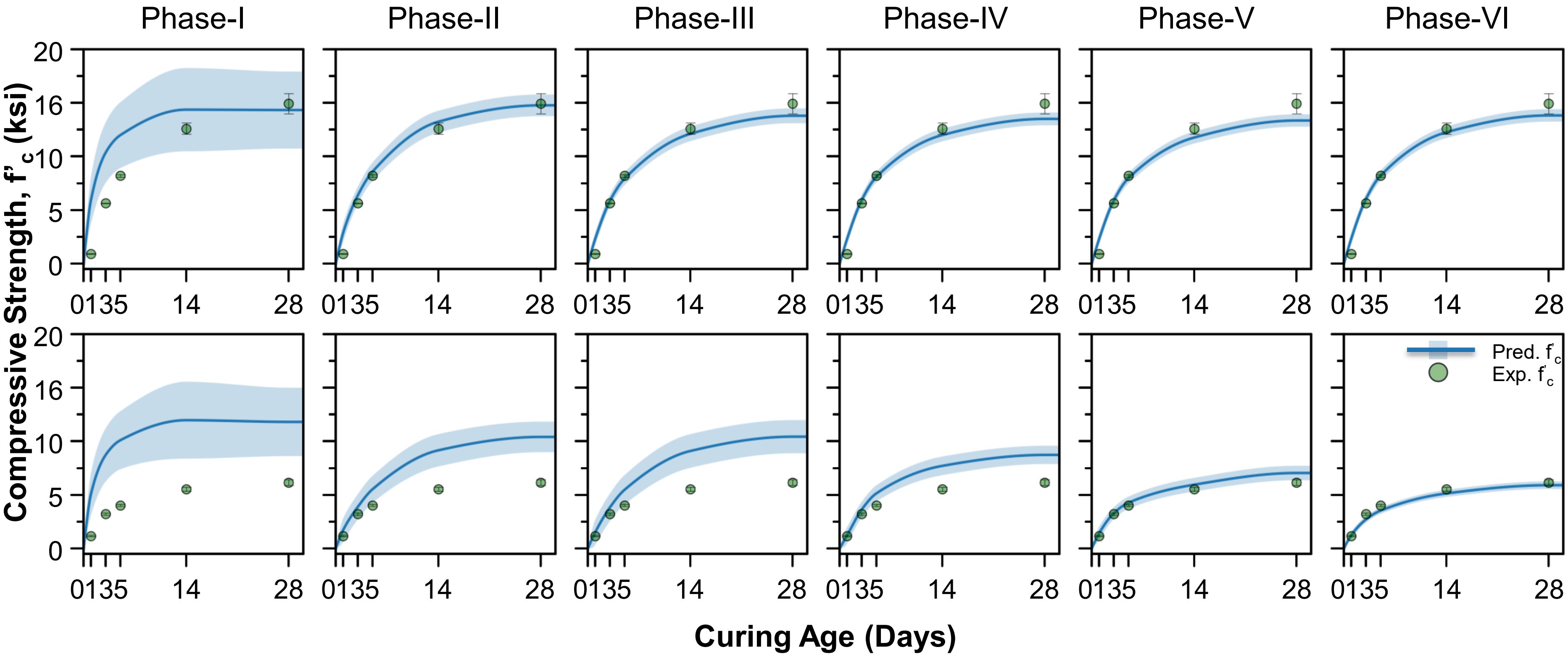


Interplay between Strength and Sustainability

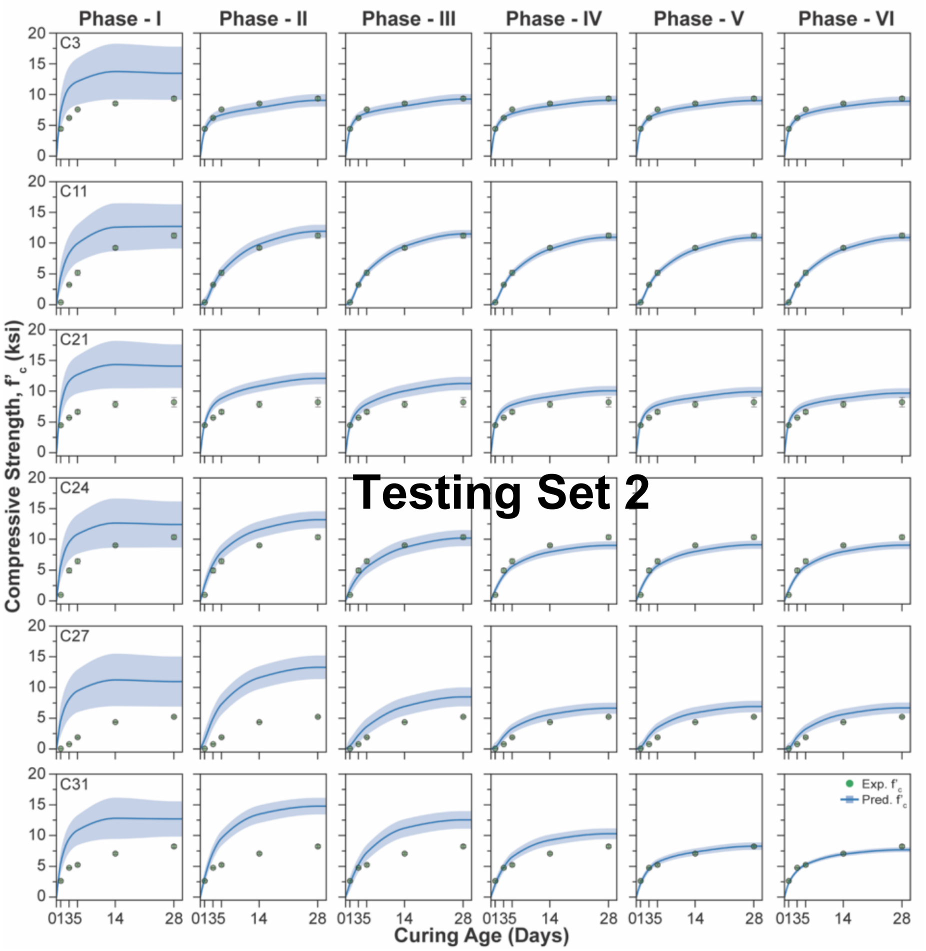


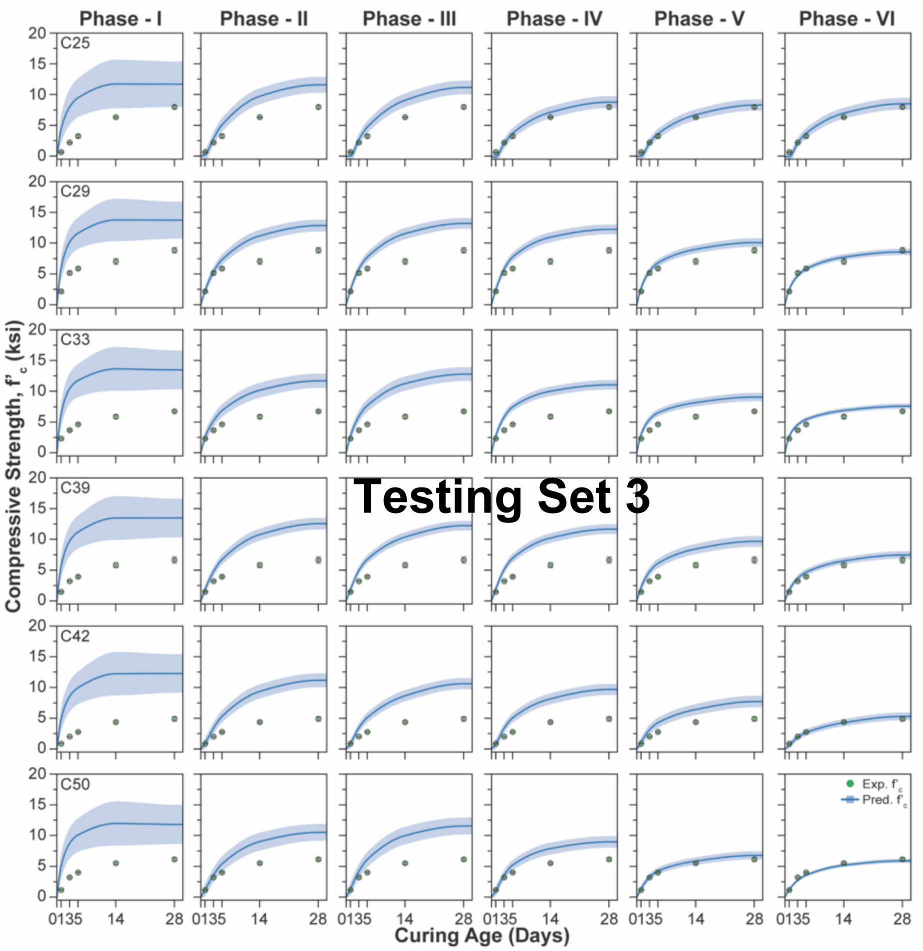
AI performance

Strength Prediction over Phases

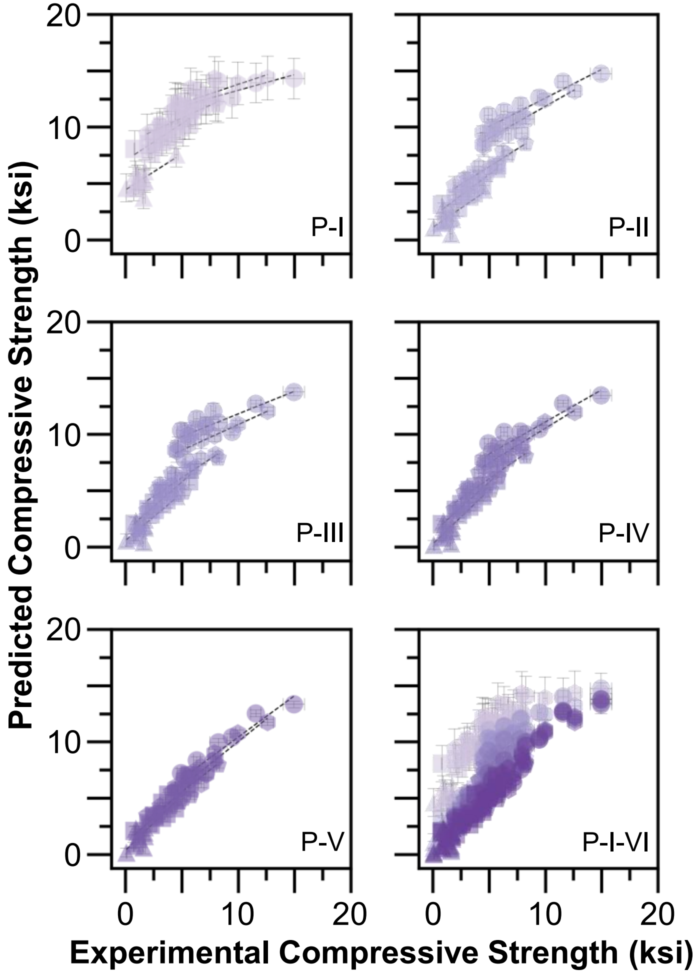


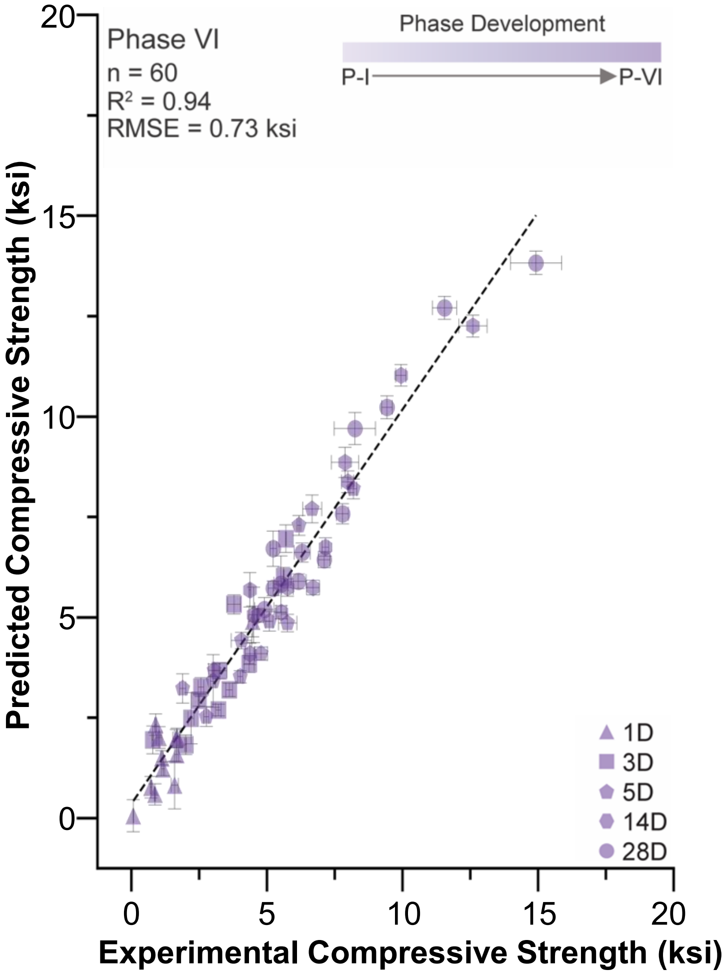
Strength Prediction over Phases



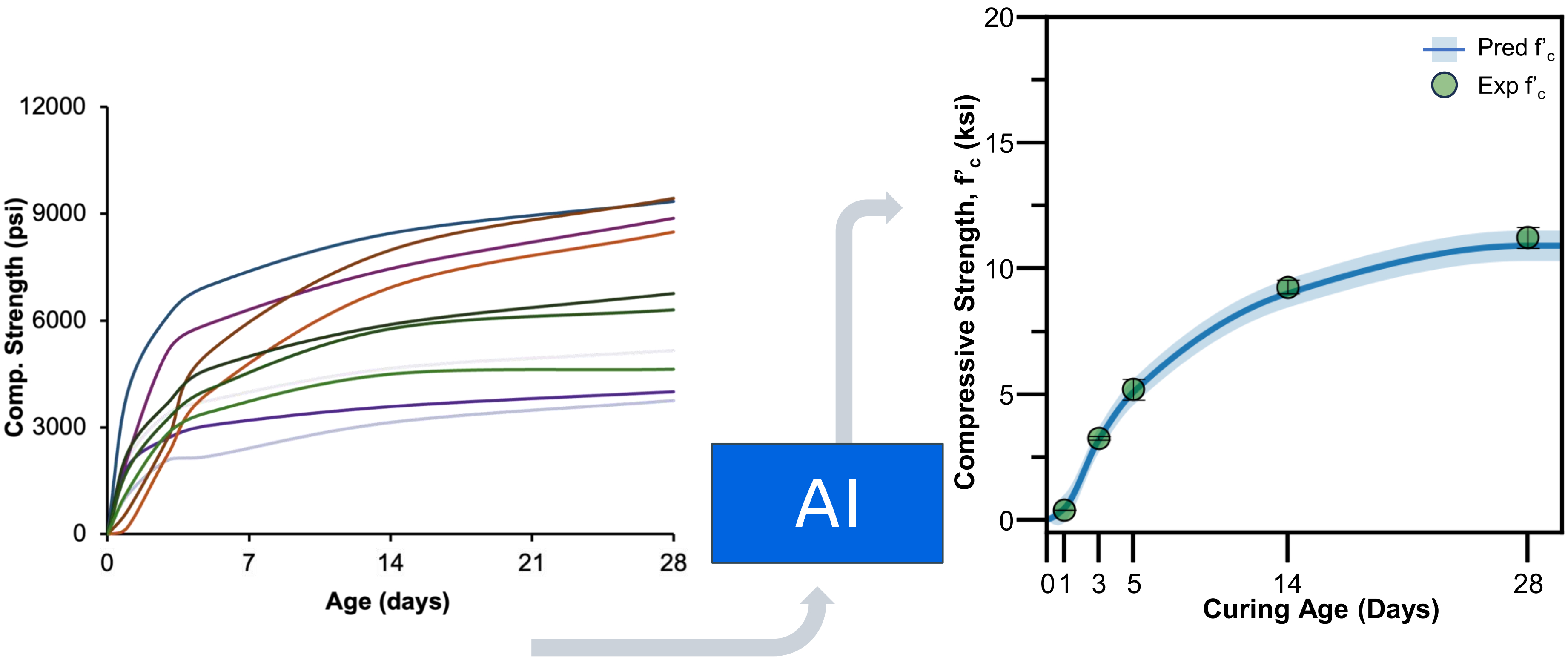


Strength Prediction over Phases





The Perplexity of Strength Prediction – Solved?

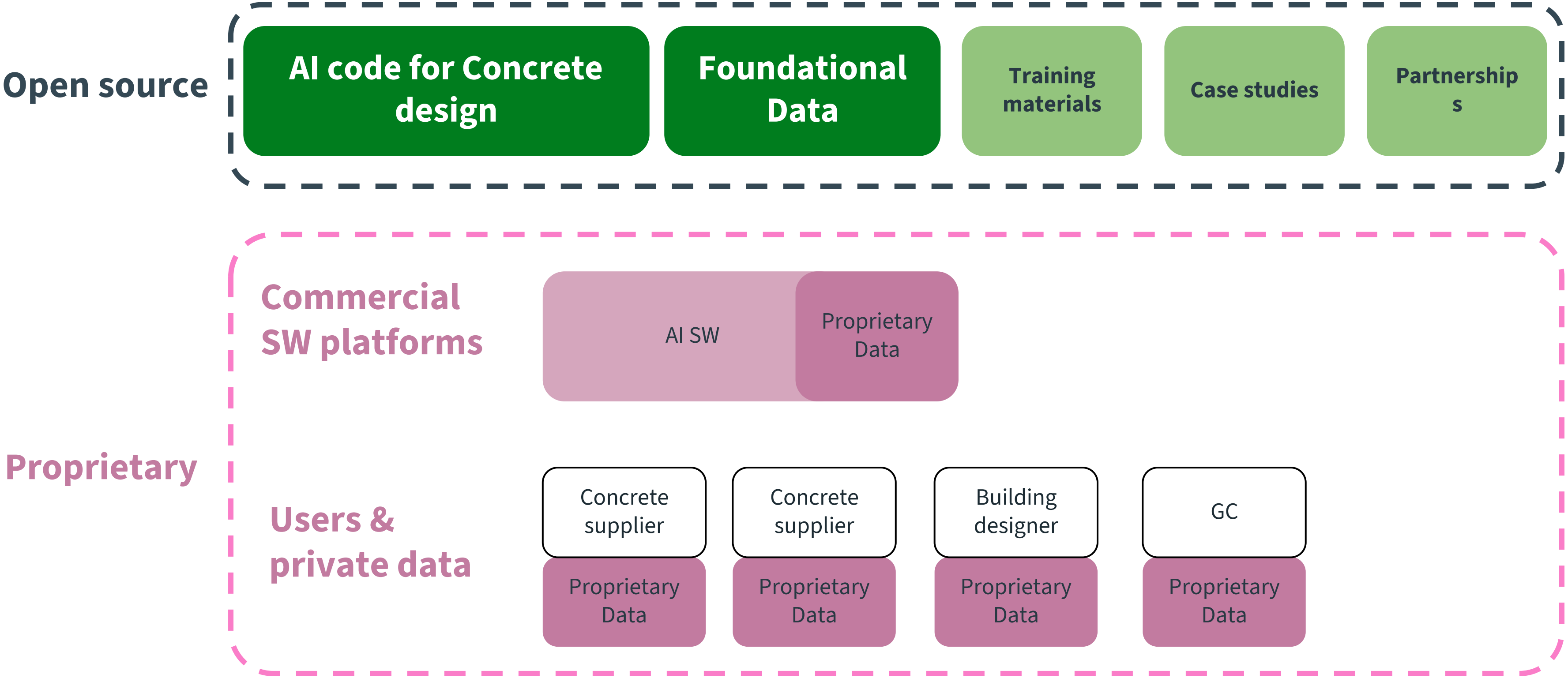


Baten, Iqbal, Ament, Kusuma, and Garg, 2026
(Paper under review, available on [arXiv] currently)

Deployment in a Meta data center

Scaling AI for concrete

This is what success looks like



Meta's open-sourced AI model ([GitHub]) is provided under MIT license: allows for commercial use with minimum restrictions while benefiting from open-source AI advances and investments

This is what success looks like

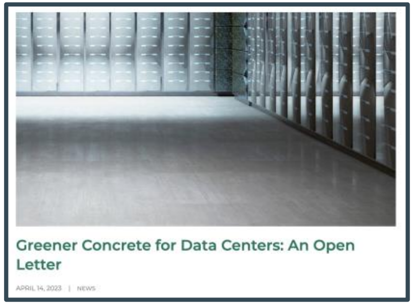
Open source

- **AI code for Concrete design**
- **Foundational Data**
- **Training materials**
- **Case studies**
- **Partnership s**

A hyperscalers coalition has started to build elements of this open source ecosystem:

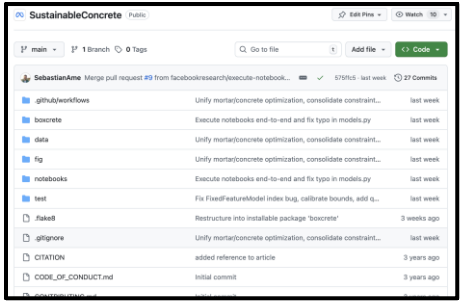
Meta, Google, aws, Microsoft

The iMasons Climate Accord™



https://climateaccord.org/news/greener-concrete-for-data-centers-an-open-letter/

GitHub



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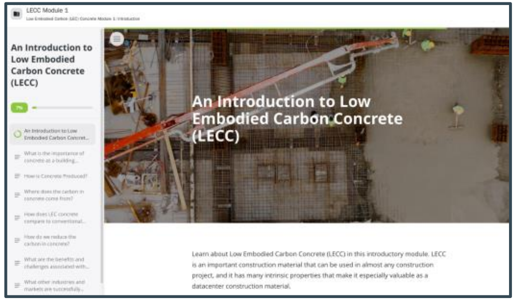
OPEN Compute Project®



https://academy.opencompute.org/learn/courses/12/low-embodied-carbon-lec-concrete-module-1-introduction/lessons/95:50/lecc-module-1

AI use-cases

AI can learn, predict, and optimize basic concrete performance with modest training & standard materials BUT each use-case has its own requirements including AI features, data, pipelines.

Optimize mixes

- Strength
- Speed
- Sustainability
- Cost
- Workability
- Performance limits

Predict field performance

- Placement
- Means & methods
- Performance
- Temperature

Incorporate novel materials

Other use cases

AI models, pipelines, data

Closing comments

AI has arrived

- Use-cases
- Real-world at-scale examples
- Strong open-source ecosystem in “traditional domains”
- Coalitions of partners
- Opportunities to solve impactful problems

Let’s work together

- Scale AI
- Scale foundational data
- Develop the right features and use-cases
- Leverage lessons learned & features built in other domains
- BOxCrete