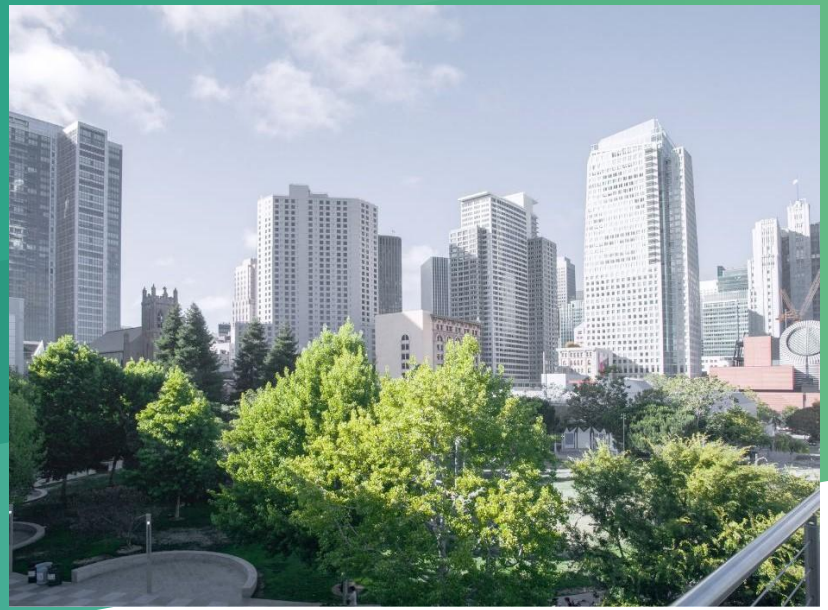
Low-Carbon Concrete: Technologies, Policy, and the Pathway to Model Code Language



Matthew P. Adams, Ph.D., FACI
New Jersey Institute of Technology

September 21, 2023

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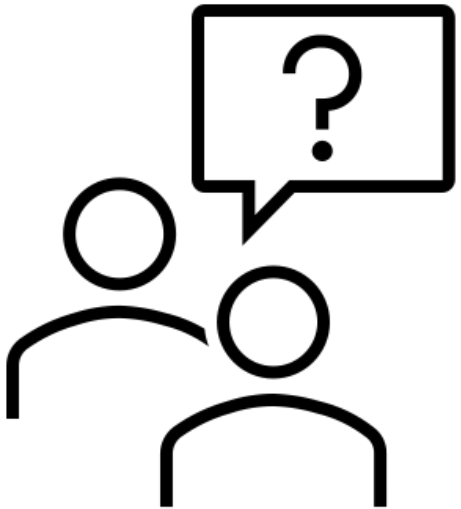
Presentation Notes

- Find presentation slides and post event recording at:
  - https://www.neuconcrete.org/events-and-education
- Attendees are in listen only mode.
- Ask questions via email at info@neuconcrete.org



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Disclaimer

As with all concrete mixtures, trial batches should be performed to verify concrete properties. Results may vary due to a variety of circumstances, including temperature and mixture components, among other things.

You should consult your materials, cement, and concrete professionals for design assistance. Nothing contained herein shall be considered or construed as a warranty or guarantee, either expressed or implied, including any warranty of fitness for a particular purpose.

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Today's Speaker

Matthew P. Adams, Ph.D., FACI

Dr. Matthew Adams is an associate professor and co-director of the materials and structures (MatSLab) at the New Jersey Institute of Technology in Newark, NJ. His research focuses on the sustainability, resiliency, and long-term durability of innovative cement-based materials. He also studies how governmental policies both support and hinder the adoption of sustainable practices in construction. He is a fellow of the American Concrete Institute, where he is currently chairman of ACI 323 Low Carbon Concrete Code Committee and member of several other committees; he is also a member of ASTM, International where he chairs the Subcommittee on Testing for Strength of Concrete. Dr. Adams has received research funding from the Port Authority of New York and New Jersey, New Jersey Department of Transportation, the American Concrete Institute Foundation, and the U.S. Department of Transportation. He received his undergraduate degree from the University of New Hampshire in 2006, and his Master of Science and Ph.D. degrees from Oregon State University in 2012 and 2015, respectively.

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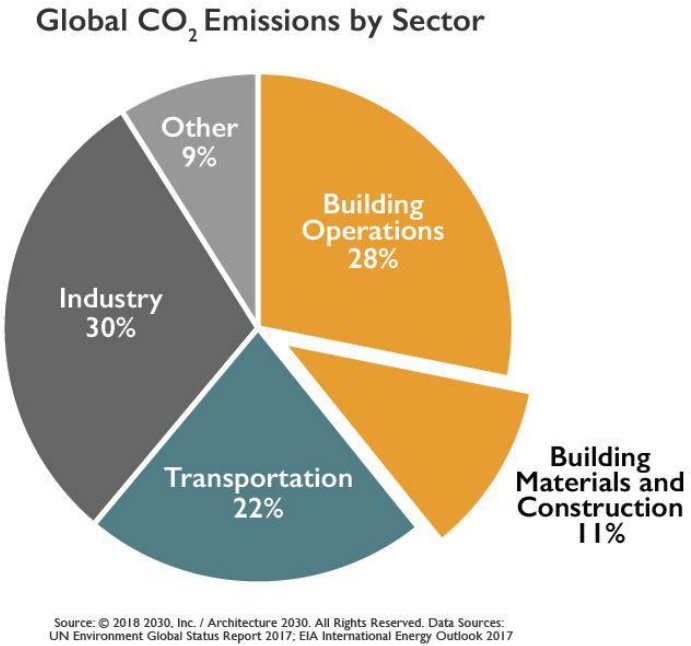
Presentation Overview

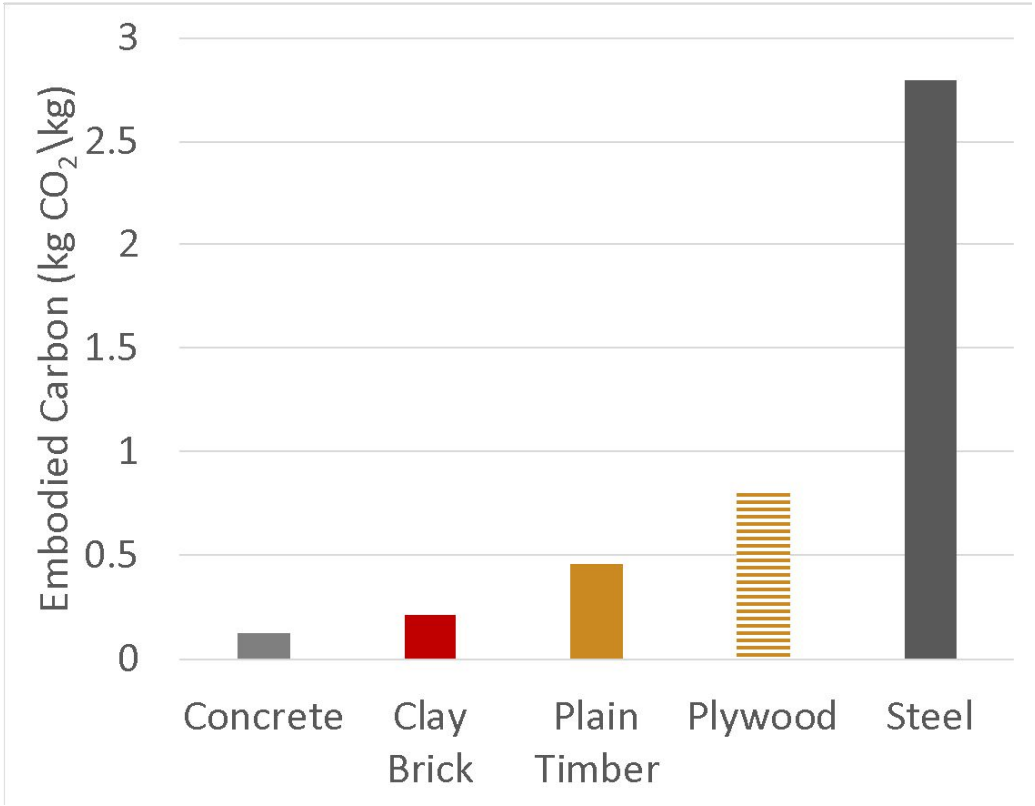
1. Introduction
2. Low-Carbon Concrete Technologies
3. Barriers to Implementation
4. Existing Policy Solutions
5. Effectiveness of Solutions
6. Developing Model Code Language
7. Summary

Carbon Production Worldwide

- Building materials and construction account for 11% of global CO_2 emissions
- Concrete is responsible for 8% of global CO_2 emissions
- Majority of emissions come from cement production and scale of use



Embodied Carbon of Building Materials



Data from: Scrivener et al. 2014 and Hammond and Jones 2008

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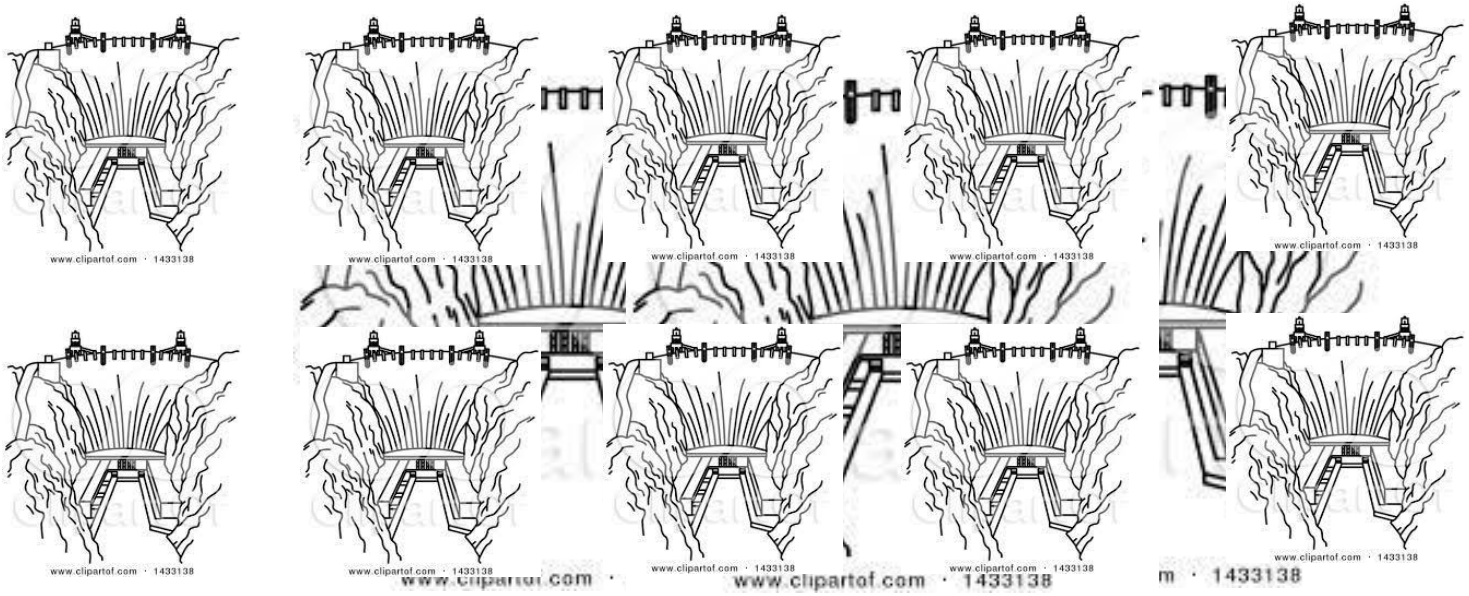
What is the source of all that CO_2?

Data source: NRMCA
Image: clipartof.com

- Concrete is produced at a massive scale
- US: 404,000,000 yd^3



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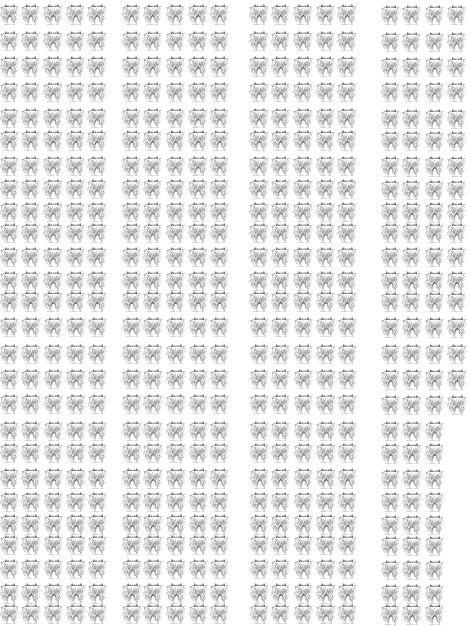
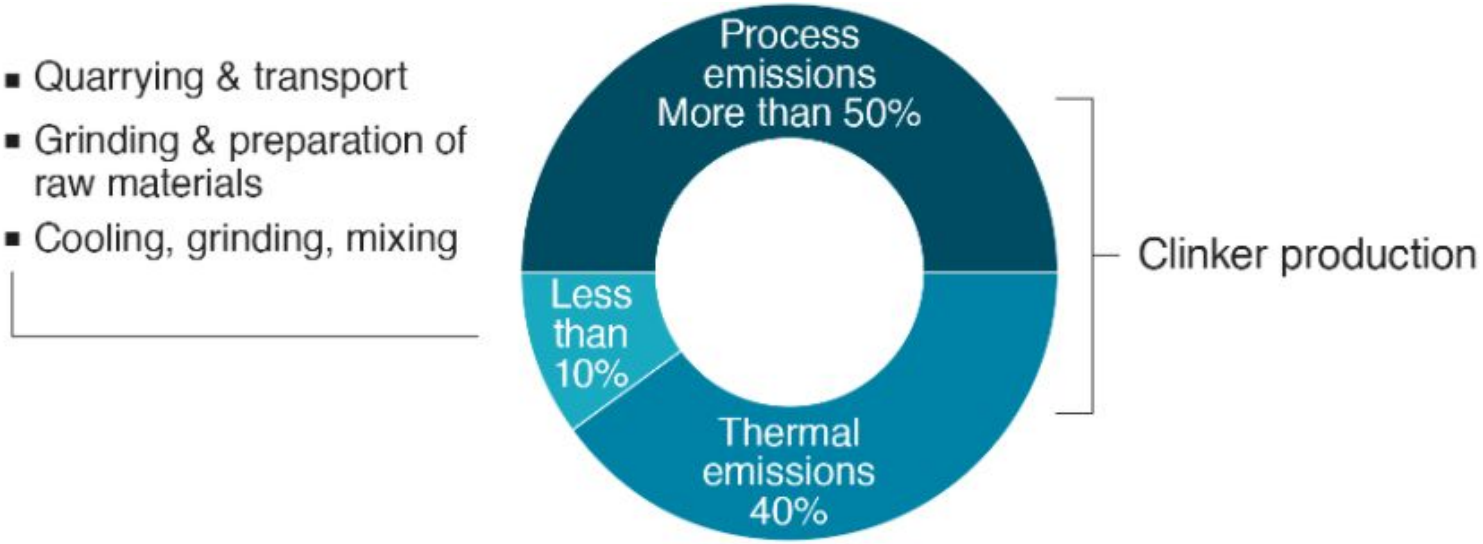


615 Hoover Dams Produced Each Year in the US Alone!

What is the source of all that CO_2?

- >90% embodied CO_2 in a portland cement mixture is from cement production



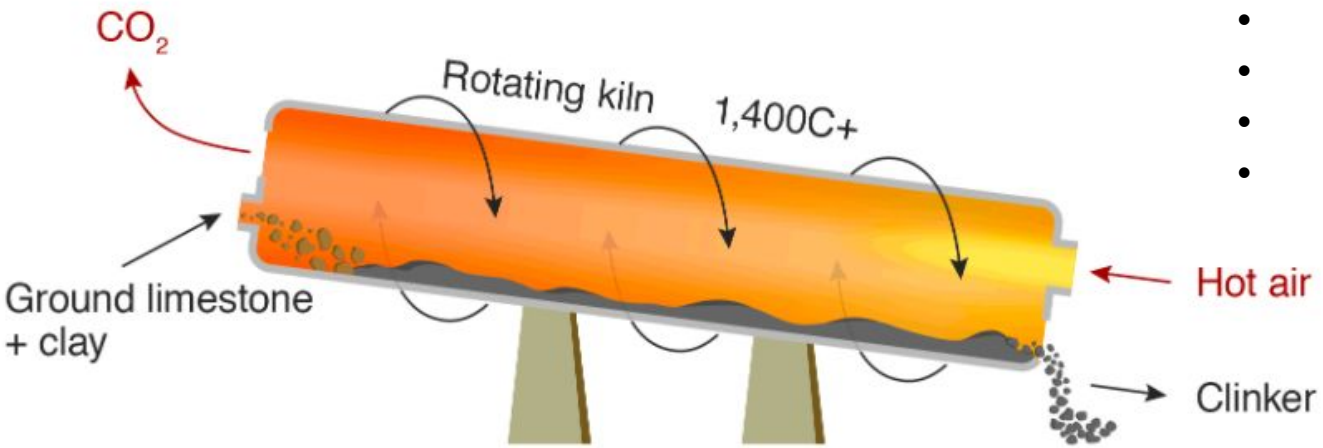
Embodied CO_2 Allocation by Cement Production Process

Image courtesy: Chatham House

What is the source of all that CO_2?

Calcination of Limestone

$CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2$



Fuel Source

- Coal
- Oil
- Gas
- Tire Rubber
- Biomass
- Wood

Cement Production Results in Significant CO_2 Production

Technologies for Reducing CO_2

- Sequester CO_2

CARBON CURE™

- Reduce Cement Content
- Reduce or CaptureCO_2 Production At the Source
- Minimize CO_2 in non-cementitious materials

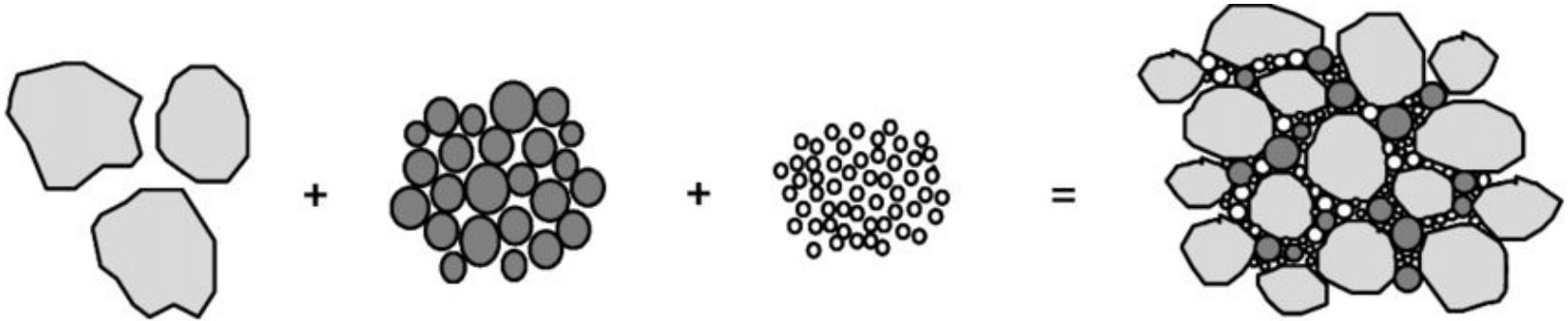
Reducing Cement Content

7 - 15 % ~~Hydraulic~~ Cementitious ~~Cement~~ Materials

- Ground limestone
- Common Supplementary Cementitious Materials (SCMs)
  - Fly Ash, Slag, Silica Fume
- Newer SCMs
  - Ground glass pozzolan, calcined clay

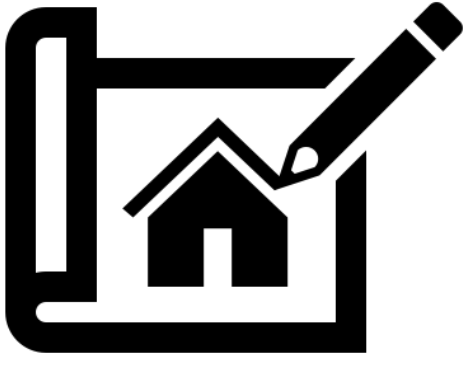
Reducing Cement Content

- Improved aggregate gradation
  - Improve particle packing
  - Reduce cement content



Reducing Cement Content

DO NOT OVER DESIGN



Reducing or Capture CO_2 at Source

- Modern cement plants are very efficient
- New capture technologies in development
- Retrofitting is costly

Image: AZoCleantech.com

Minimize CO_2 in aggregate component

- Minimal impact on overall CO_2

Recycling

Carbon Sequestered Aggregates

Minimize CO_2 in aggregate component

- Minimal impact on overall CO_2

Recycling

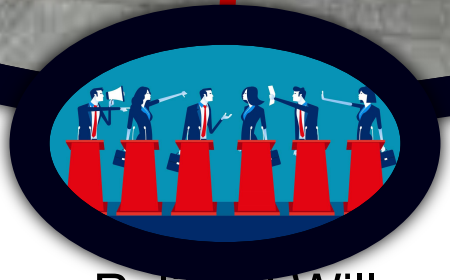
Carbon Sequestered Aggregates

Barriers to Implementation

Fear of Cost

Space and Capital

Knowledge Transfer

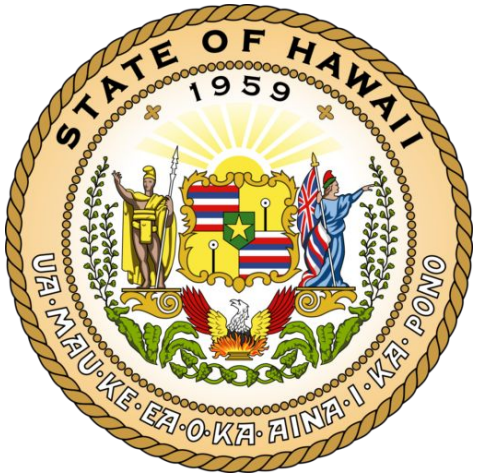


Political Will

Liability

Good Policy Can Save the World!

- Policy work began at the local/state level
- Many non-mandatory resolutions



Resolutions promoting the use of concrete carbon storage technologies.
Mainly pushed by private companies

Successful Resolutions

Why was this successful:

- Technology agnostic
- Engaged community stakeholders
- Had leadership involved in both policy development and implementation
- Community involvement working with contractors to transfer knowledge
- Willing to absorb risk

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GWP Declaration Policies

CALGreen®

- Require contractors to declare global warming potential of mixtures
- No limits (yet?)

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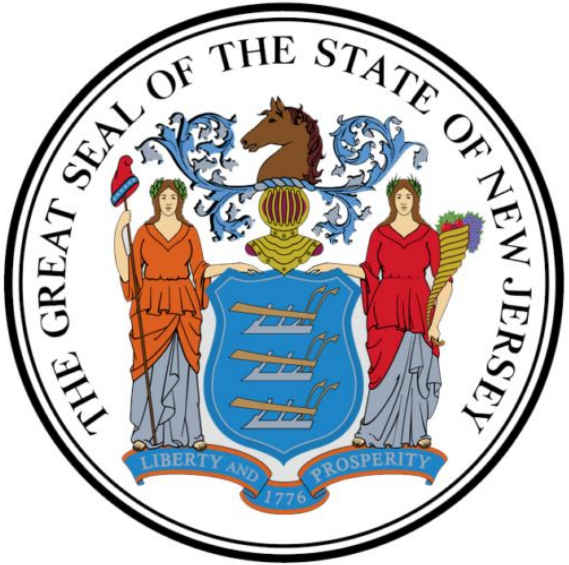
Tax Incentives to Contractors



- Contractors that use low GWP mixtures get tax incentives – (8% of total cost of contract)

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GWP and Cement Limits

PORT AUTHORITY NY NJ
AIR LAND RAIL SEA

- Limits on total cement content and/or GWP based on concrete strength
- Limits based on internal studies of GWP

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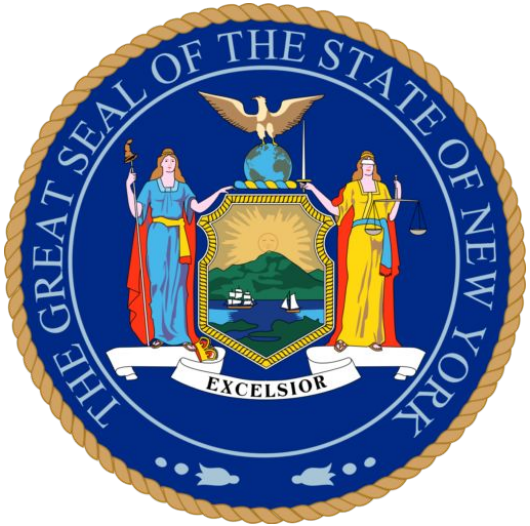
GWP and Cement Limits



- Limits on total GWP based on concrete strength
- Limit set to 150% of NRMCA Regional Average Concrete GWP for Northeast

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Federal Programs

- Requirements for “low-carbon” building materials.
- Multiple avenues for calculations

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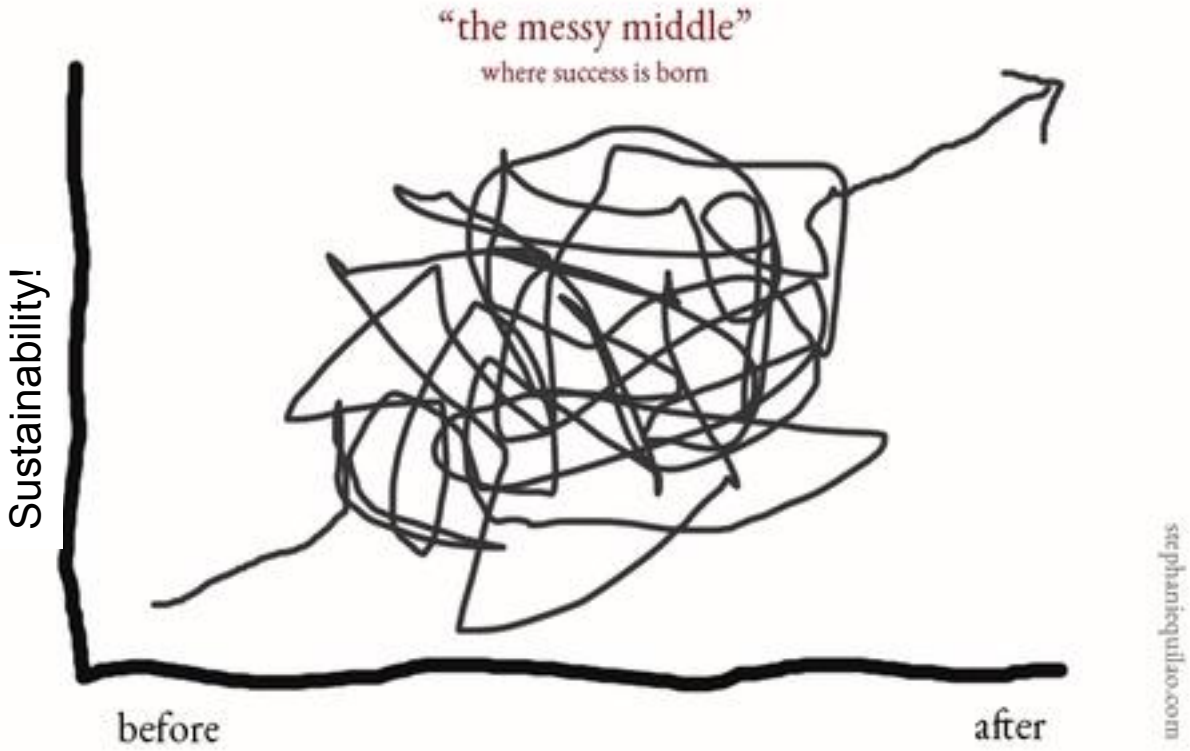
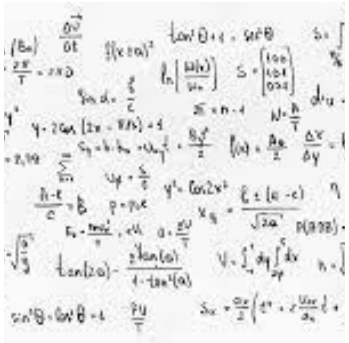
Progress is MESSY!



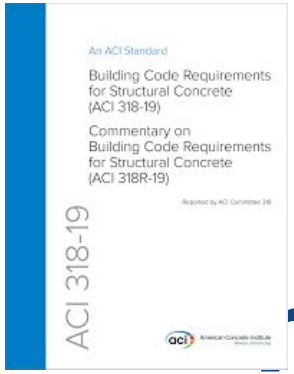
National Level Model Code Guidance is Needed

- How to determine the GWP?



- What limits to set?

- How do GWP limits interact with life-safety codes?



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ACI Code Committee 323

- Here we come to save the day!

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ACI Code Committee 323

- First met April 2023
- Strong cross section of experts
- Expect new code release in mid-2024

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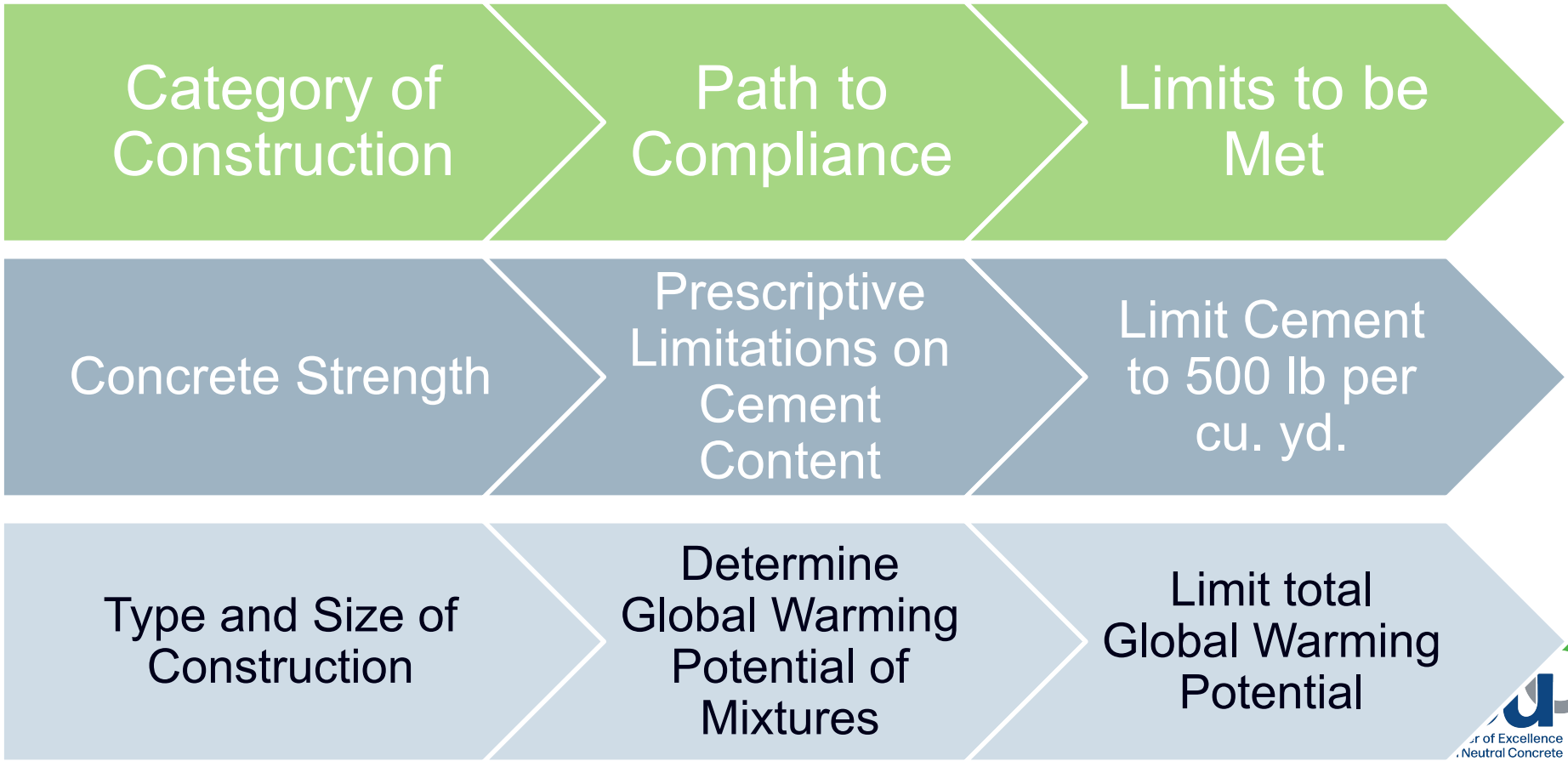
Code Development



Code Development – Likely System

Category of Construction

- Type of construction: Bridges, Pavements, Buildings, etc.
- Size of construction (total square footage or volume)

Code Development – Likely System

Path to Compliance

- Determine GWP for each mixture
  - Environmental Product Declaration (EPD)
- Determine weighted GWP for all concrete on project (weighted by volume)

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Code Development – Likely System

Limits to be Met

- Limit will be based on NRMCA Regional GWP Benchmarks
- Jurisdictions can also use localized data to set their own limits and benchmarks

Learning Objectives Revisited

- Describe the state of low-carbon concrete policy in the United States
- Discuss the need for model building code language for sustainable concrete
- Describe the current state of technology for low-carbon concrete and the barriers to implentation

Acknowledgements

- MatSLab Research Group
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- ACI and NEU Staff

THE PORT AUTHORITY OF NY & NJ

aci Foundation

DEPARTMENT OF TRANSPORTATION THE STATE OF NEW JERSEY

DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA

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Thank you!

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