The Top 10 Ways to Reduce Concrete's Carbon Footprint

Lionel Lemay, NRMCA
Brandon Wray, NRMCA

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Learning Objectives

- Understand the basics of embodied carbon of concrete.
- Evaluate the immediate steps that can be taken to reduce carbon footprint when specifying concrete.
- Prioritize design strategies to get the greatest reductions in carbon footprint using current technologies and design tools.
- Explore how innovative technologies will result in zero carbon concrete in the future.

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Continuing Education Credit

- NRMCA will e-mail a link to the slides and quiz
- Or visit: https://www.flexiquiz.com/SC/N/Top10
- Complete the quiz
- 10 attempts to achieve 70% passing grade
- Certificate of completion will be available for download and e-mailed to you

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UN Environment Global Status Report

- 2.5 Trillion sq ft of new construction by 2060
- Double existing building stock
- Design disaster resilient buildings
- Design zero-energy buildings
- Reduce embodied impacts

The Top 10 List

1. Communicate Carbon Reduction Goals
2. Ensure Good Quality Control and Assurance
3. Optimize Concrete Design
4. Specify Innovative Cements
5. Specify Supplementary Cementitious Materials
6. Specify Admixtures
7. Don't Limit Ingredients
8. Set Targets for Carbon Footprint
9. Sequester Carbon Dioxide in Concrete
10. Encourage Innovation

No. 1:

Communicate Carbon Reduction Goals

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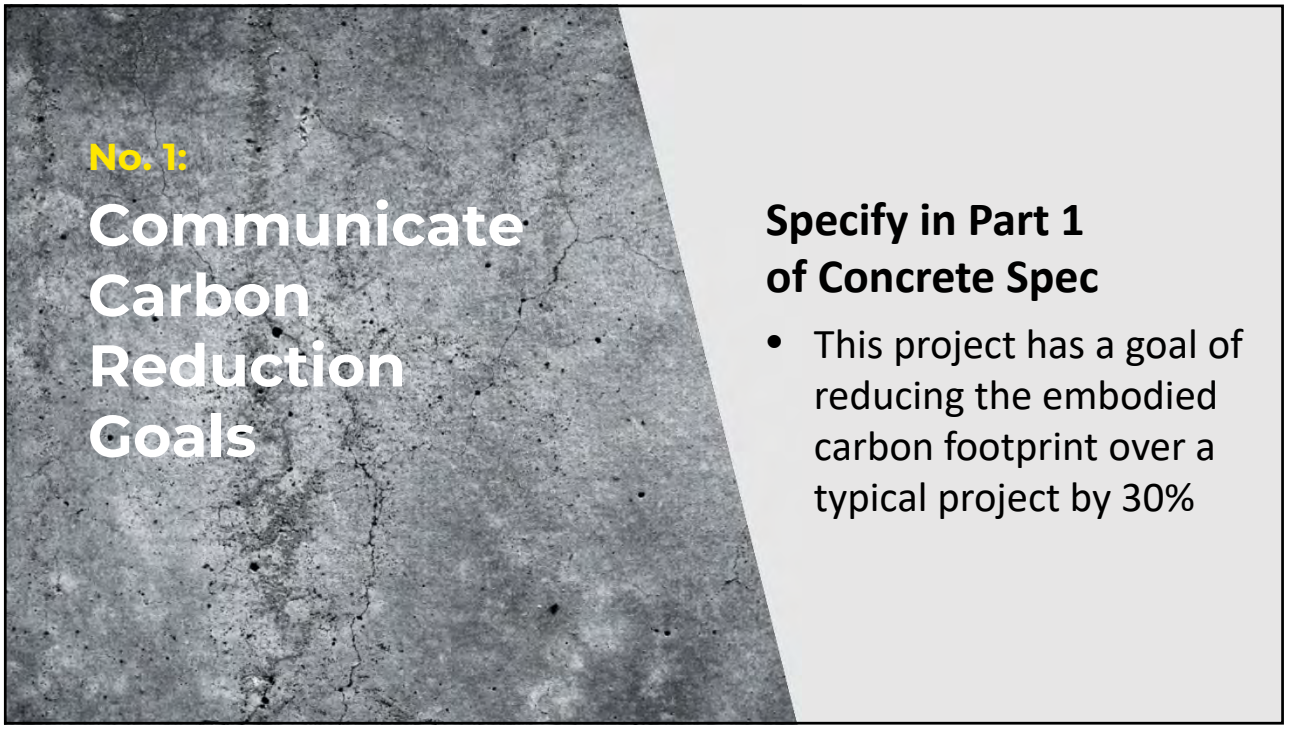
Communicate Carbon Reduction Goals

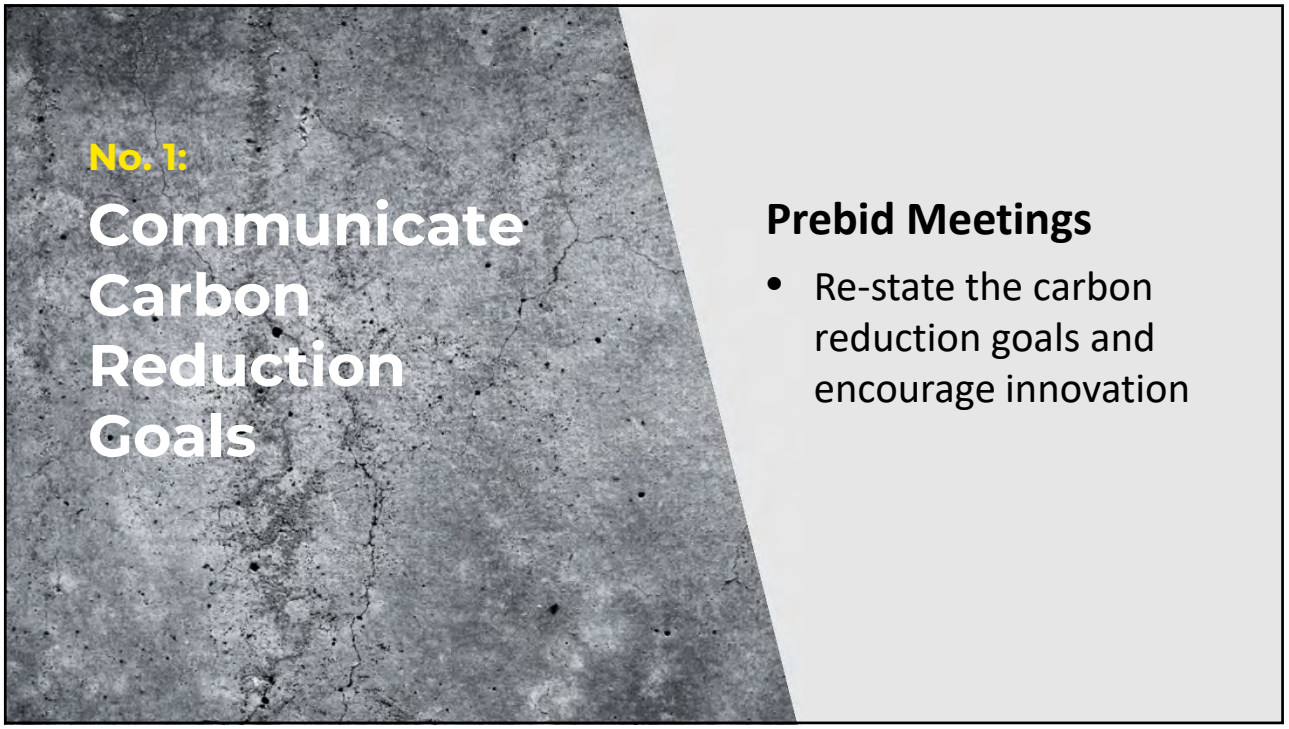
Collaborate during design process

- Meetings and charettes



Specify in Part 1 of Concrete Spec

- This project has a goal of reducing the embodied carbon footprint over a typical project by 30%



Prebid Meetings

- Re-state the carbon reduction goals and encourage innovation

Manufacturer Qualifications:

- NRMCA Certified Concrete Production Facility
- NRMCA Concrete Technologist Level 2

No. 2:
Ensure Good Quality Control and Assurance

Installer Qualifications:

- ACI Flatwork Finisher

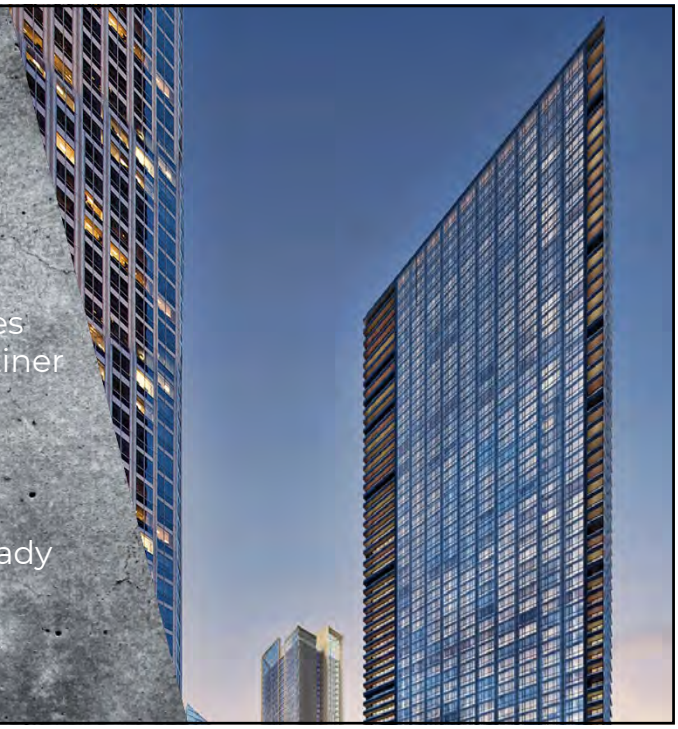
Testing Agency Qualifications:

- Meets ASTM C1077
- ACI Concrete Field Testing Technician Grade I
- ACI Concrete Laboratory Testing Technician Level I
- Results certified by a registered design professional

Case Study: 960 W. 7th, Los Angeles

- 64-story tower
- 780 residential units
- 807,000 square feet

- Developer: Brookfield Properties
- Design Architect: Marmol Radziner
- Executive Architect: Large Architecture
- Structural Engineer: MKA
- Contractor: Webcor
- Concrete Supplier: National Ready Mixed Concrete Company
- Photos: Brookfield Properties



Challenges

- Balancing cost, long term value, energy efficiency, occupant comfort and sustainability
- The design team, developer, contractor and product suppliers have the same goals
- Reducing environmental impact, including carbon footprint.

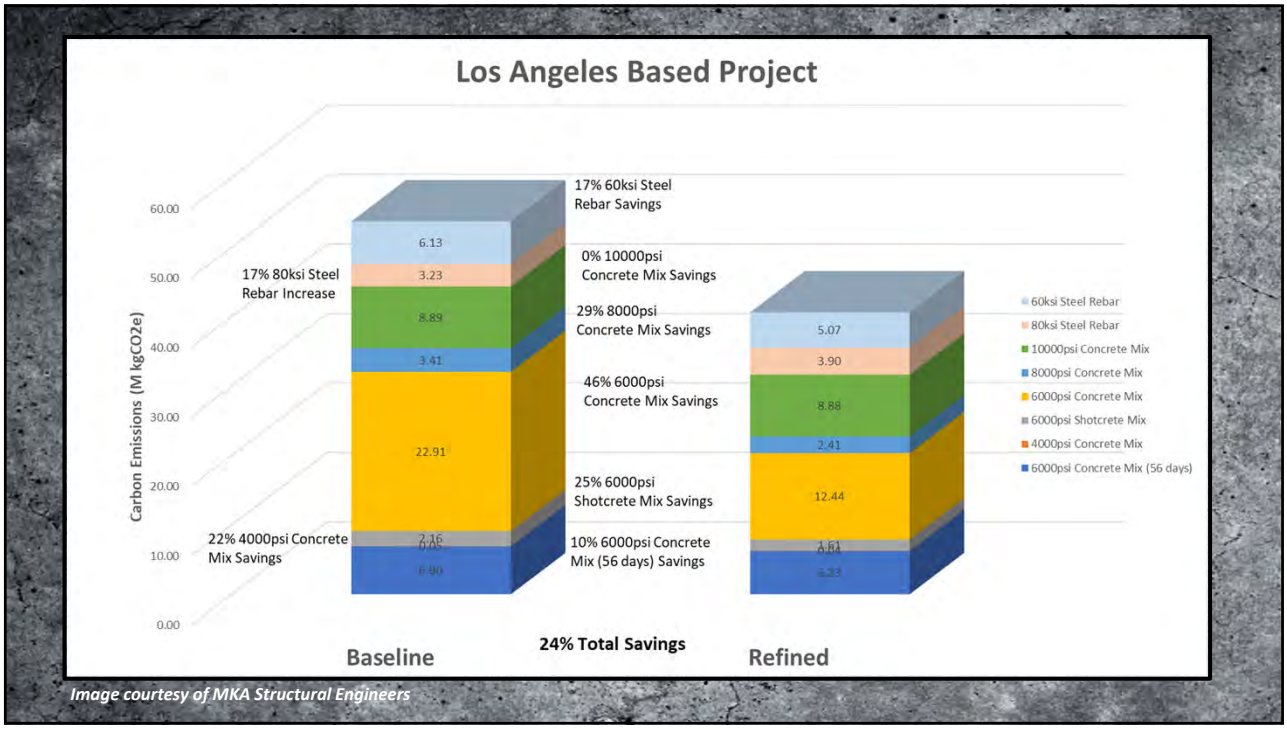
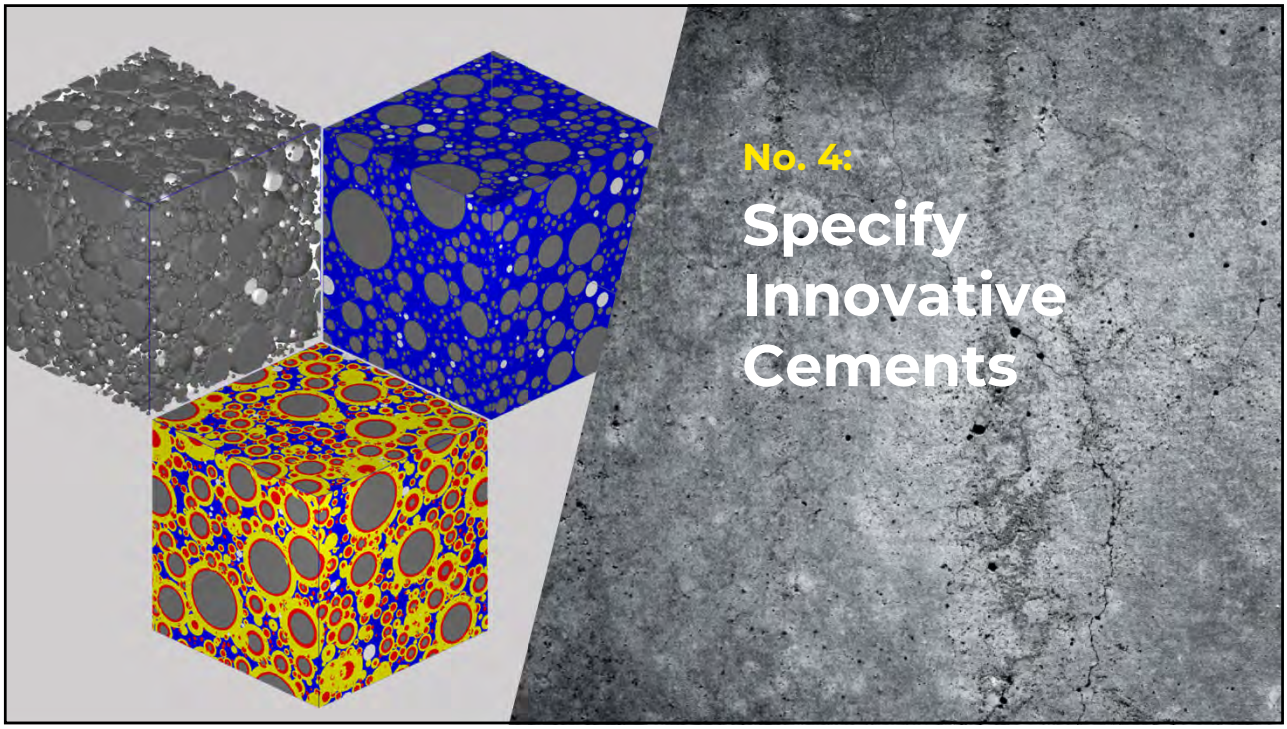


Image courtesy of MKA Structural Engineers



No. 4:

Specify Innovative Cements

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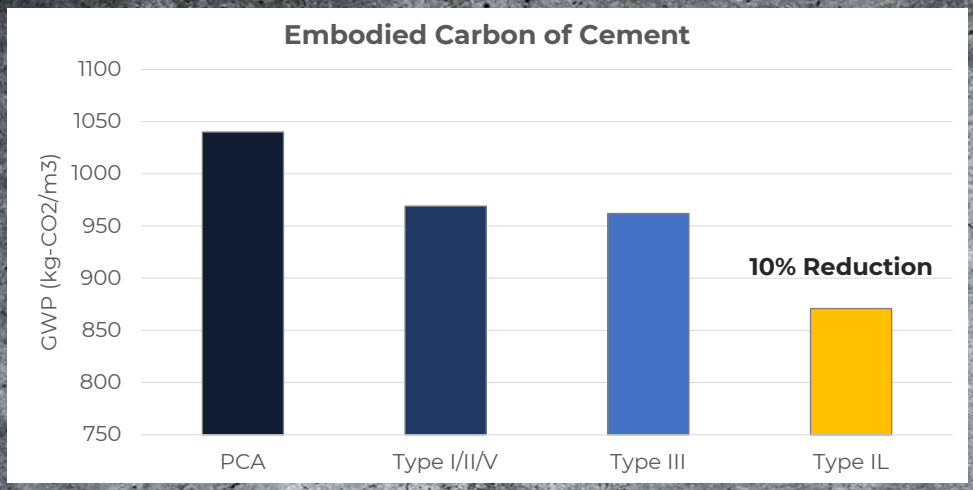
Specify Innovative Cements

ASTM C595		
Type	**Description**	**Notes**
Type IL (X)	Portland-Limestone Cement	Where X can be between 5 and 15% limestone
Type IS (X)	Portland-Slag Cement	Where X can be up to 70% slag cement
Type IP (X)	Portland-Pozzolan Cement	Where X can be up to 40% pozzolan (fly ash is the most common)
Type IT (AX)(BX)	Ternary Blended Cement	Where X can be up to 70% of pozzolan + limestone + slag, with pozzolan being no more than 40% and limestone no more than 15%

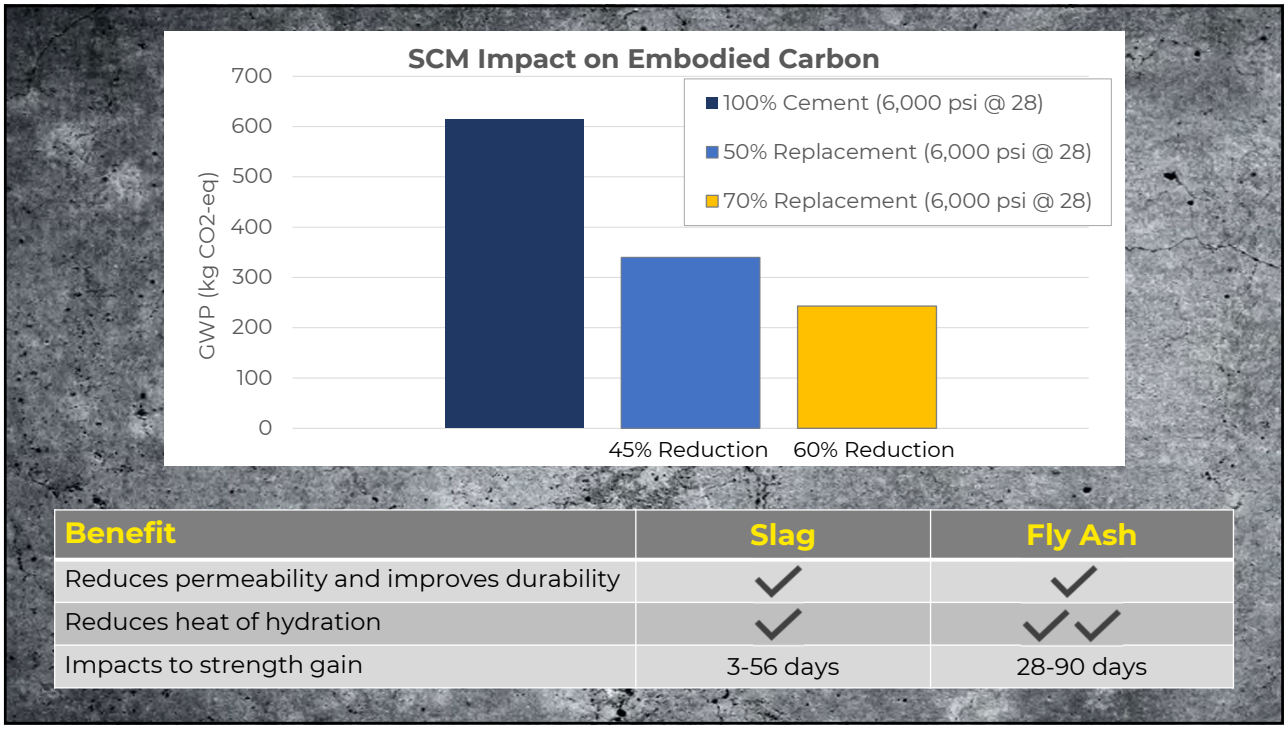


Specifications:

Concrete Materials

- **Hydraulic Cement: ASTM C150, ASTM C595, or ASTM C1157**


No. 5:
Specify Supplementary Cementitious Materials



Benefit	Slag	Fly Ash
Reduces permeability and improves durability	✓	✓
Reduces heat of hydration	✓	✓✓
Impacts to strength gain	3-56 days	28-90 days

No. 5:

Specify Supplementary Cementitious Materials

Concrete Materials:

A. Cementitious Materials: use materials meeting the following requirements:

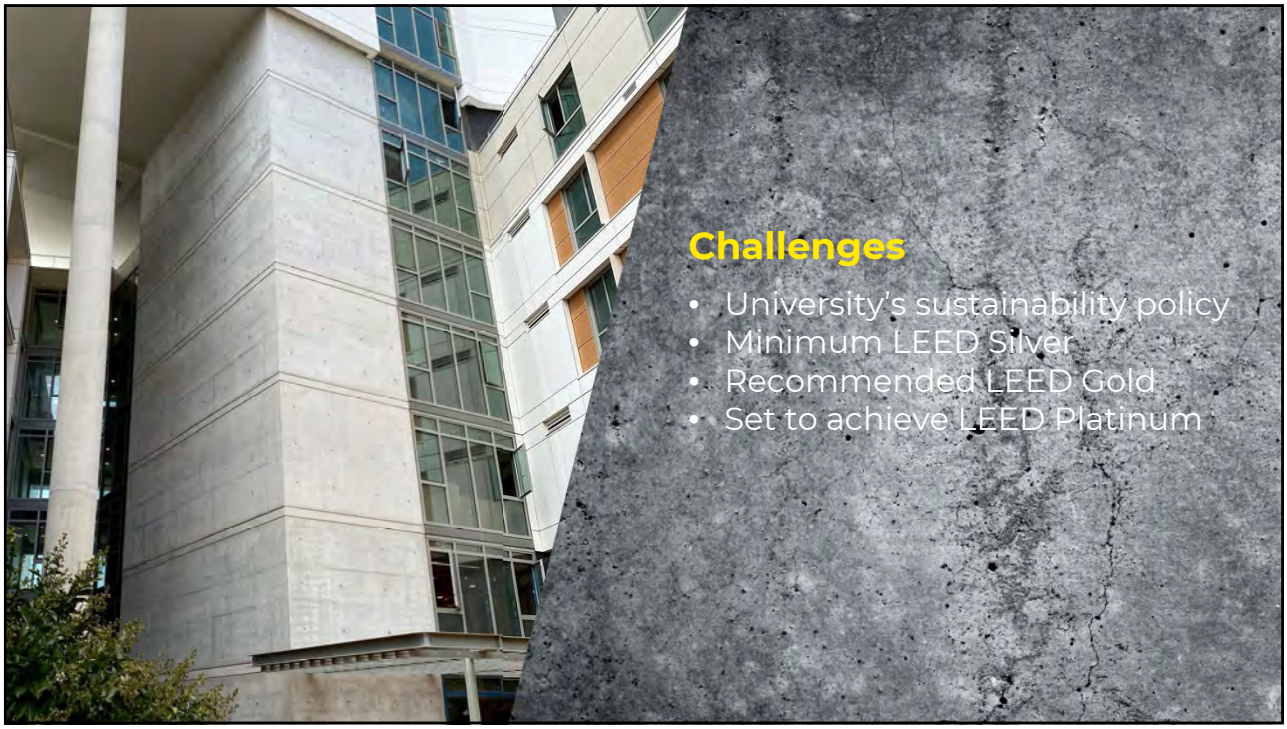
1. Hydraulic Cement: ASTM C150, ASTM C595, or ASTM C1157
2. **Fly Ash or Natural Pozzolan: ASTM C618**
3. **Slag Cement: ASTM C989**
4. **Silica Fume: ASTM C1240**
5. **Glass Pozzolan: ASTM C1866**

Case Study: UC San Diego, North Torrey Pines Living and Learning Neighborhood

- 10 acres of academic, residential and commercial buildings
- Housing for 2,000 students

- Contractor: Clark Construction
- Architects: HKS in association with Safdie Rabines Architects
- Concrete Specialists: CalPortland

Photo: Courtesy of Walter Kanzler



Challenges

- University's sustainability policy
- Minimum LEED Silver
- Recommended LEED Gold
- Set to achieve LEED Platinum

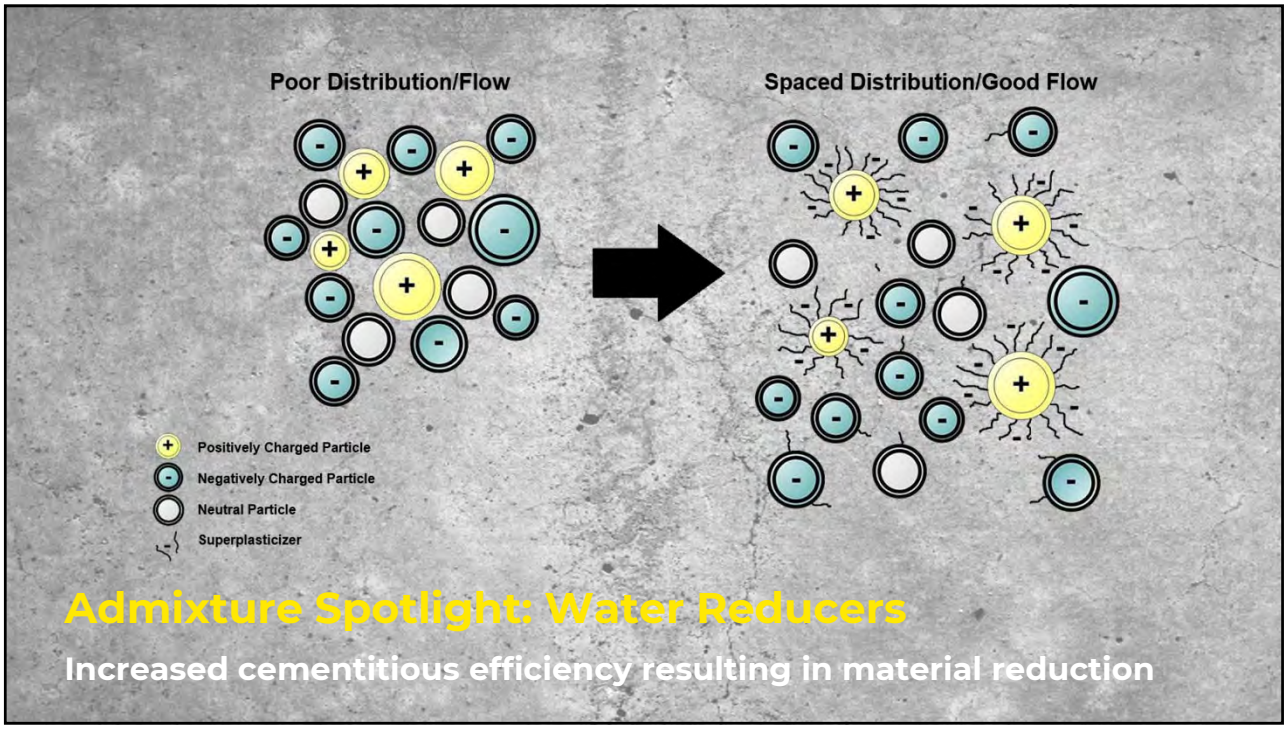
Cement Type	Global Warming Potential
Portland Limestone Cement Type IL (13)	**871 kg CO_2eq**
Portland Cement Type I/II/V	**969 kg CO_2eq**

Sustainable Solutions

- Life Cycle Analyses (LCAs)
- Demonstrate sustainable design and outcomes
- Used Type IL blended portland-limestone cement
- Save 3,055 metric tonnes of CO_2

Sustainable Solutions

- Exposed concrete aesthetic
- Structural benefits
- Environmental benefits
- Reduce embodied carbon
- Maintain a high-quality appearance with PLC



Concrete Materials:

Chemical Admixtures:

1. Air-Entraining Admixture: ASTM C 260/C 260M
2. Water-Reducing Admixture ASTM C 494/C 494M Type A
3. High-Range Water-Reducing Admixture: ASTM C 494/C 494M Type F or G
4. Accelerating Admixture: ASTM C 494/C 494M Type C or E
5. Retarding Admixture: ASTM C 494/C 494M Type B or D
6. Hydration Control Admixture: ASTM C 494/C 494M Type B or D
7. Specialty Admixtures: ASTM C 494/C 494M Type S

No. 6:

Specify Admixtures

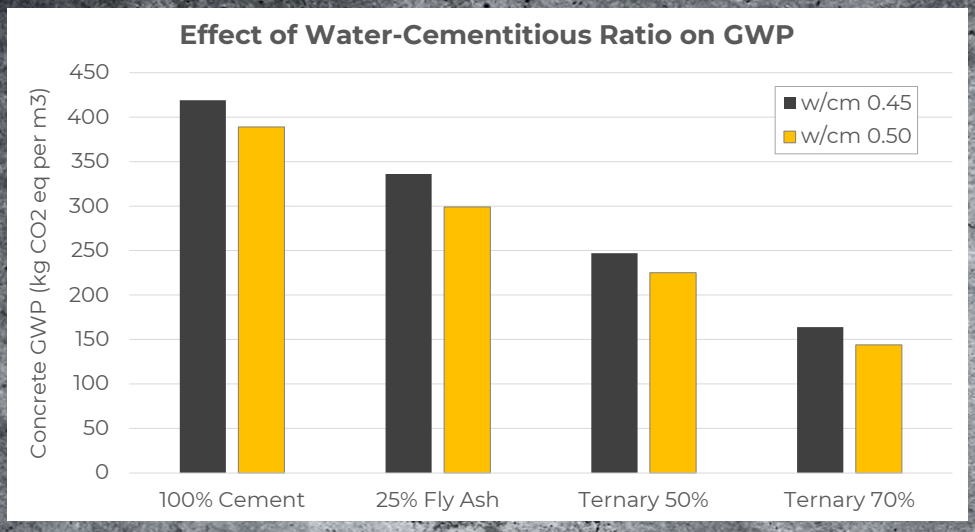
No. 7:

Don't Limit Ingredients

No. 7:

Don't Limit Ingredients

- ~~Maximum w/cm ratio~~
- ~~Air content of 6% for all concrete~~
- ~~Maximum cement content~~
- ~~Minimum cement content~~
- ~~Maximum fly ash content~~
- ~~Minimum fly ash content~~
- ~~Water: Potable~~



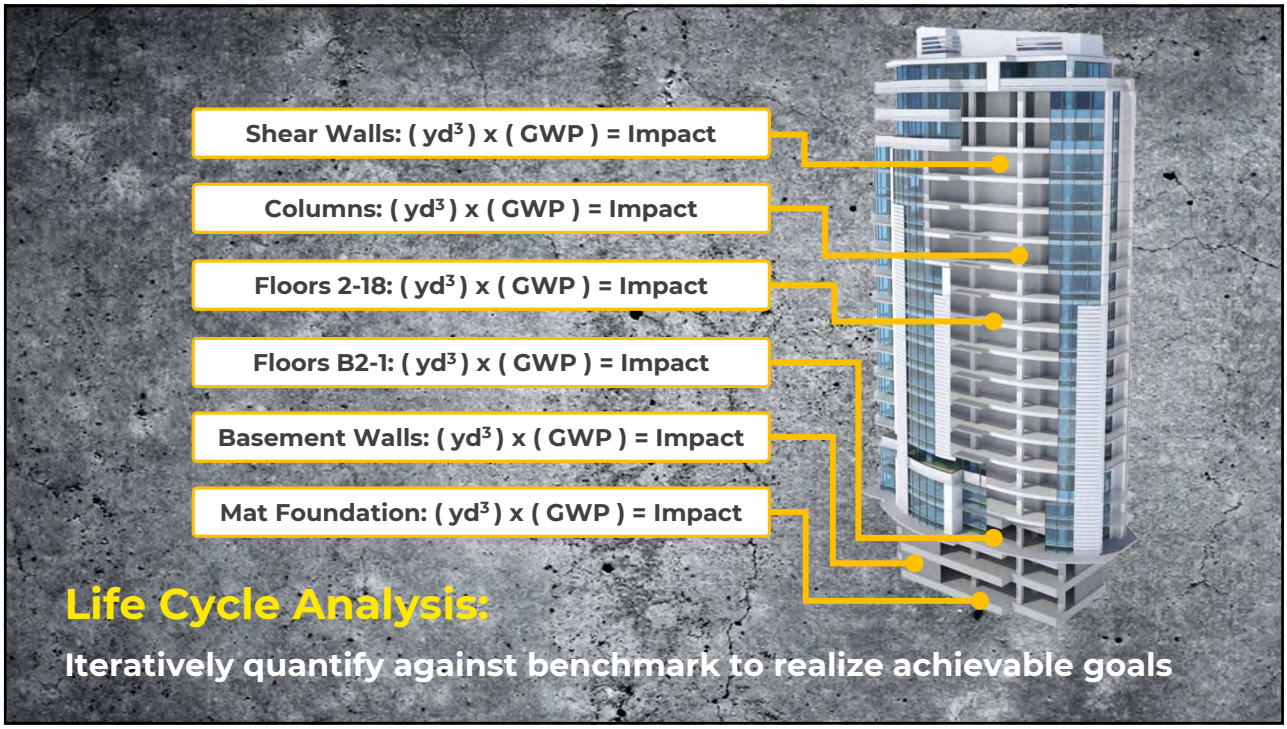
Impacts to sustainability:

For similar mixes, 7-12% reduction in GWP

No. 7:
Don't Limit Ingredients

Class	Location	Nominal Max. Aggregate Size	Exposure Class	F'c, Psi @ Age
1	Mat Foundation	3"	F0, S1, W0, C0	6,000 at 90 days
2	Basement Walls	1-1/2"	F0, S1, W0, C0	4,000 at 56 days
3	Shear Walls	3/4"	F0, S0, W0, C0	6,000 at 56 days
4	Columns Level B2-L6	3/4"	F0, S0, W0, C0	6,000 at 28 days
5	Columns Level L7-L12	3/4"	F0, S0, W0, C0	4,000 at 28 days
6	Slabs	3/4"	F0, S0, W0, C0	5,000 at 28 days
7	Exterior Pavements	3/4"	F3, S1, W0, C0	4,000 at 28 days

No. 8:
Set Targets for Carbon Footprint



Concrete Materials:

B. Supply concrete mixtures such that the total Global Warming Potential (GWP) of all concrete on the project is less than or equal to 4,298,000 kg of CO2 equivalents.

No. 8:

Set Targets for Carbon Footprint

Case Study: Oracle Waterfront Campus, Austin, TX

- 550,750 ft² office building
- 147,000 ft² ground level parking
  646,800 ft² parking garage

- Owner: Oracle
- Architect: STG Design
- Structural Engineer: Walter P Moore
- General Contractor: Ryan Companies
- Concrete Contactor: Keystone Concrete
- Concrete Producer: Centex Materials
- Photos: Casey Dunn

Challenges

- Create an active campus
- blur the lines between public and private spaces
- Pedestrian friendly community
- LEED Certification
- Austin Energy Green Building (AEGB) standards

Sustainable Solutions

- Optimized concrete elements
- Structural engineers worked closely with design-build team
- Over-sized floor plates
- Expansive balconies and terraces
- Floating stair and bridge

Sustainable Solutions

- Conducted LCA using software
- Studied impacts of all materials
- Focused on improving concrete
- LEED Whole Building Life Cycle Assessment credits (WBLCA)
- Created two computer models
- Compare proposed building to baseline building
- Maintained functional equivalence of the two buildings
- Varied the mix design

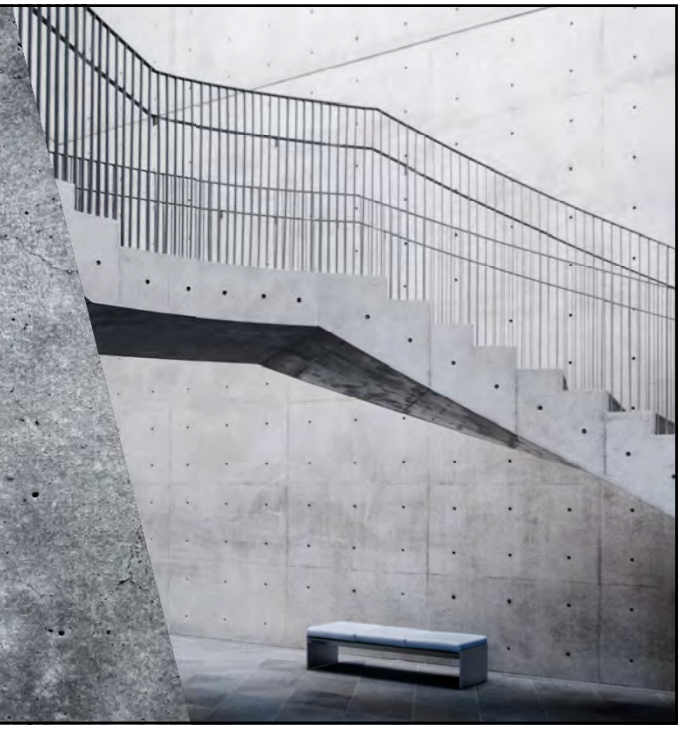
Impact Measure	Units	Estimated % Reduction from Baseline to Proposed
Acidification Potential	kg SO_2eq	-13%
Eutrophication Potential	kg Neq	-3%
Global Warming Potential	kg CO_2eq	-12%
Ozone Depletion Potential	CFC-11eq	-11%
Smog Formation Potential	kg O_3eq	-12%
Non-Renewable Energy	MJ	-6%

Sustainable Solutions

- Optimized mix designs
- High volume of SCMs
- Test age for drilled piers at 56 days
- Met LEED WBLCA requirement
- At least 10% reduction of GWP (12% in this case)
- At least 10% reduction in at least two other categories

No. 9:

Sequester Carbon Dioxide



Carbon Uptake:

CO_2

+

Ca (+O)

=

$CaCO_3$

Atmospheric Carbon Dioxide

Calcium Byproducts in Hardened Concrete

Recombines into Limestone

No. 9:

Sequester Carbon Dioxide

Concrete Materials:

A. Normal-weight Aggregate: ASTM C33
B. Lightweight Aggregate: ASTM C330
C. Recycled concrete aggregate (crushed concrete) meeting the requirements of ASTM C33 or ASTM C330 may be used in structural concrete up to 10% of the total aggregate. Crushed concrete shall have been crushed and exposed to air at least 1 year before use in concrete (to maximize CO2 sequestration).

No. 9:

Sequester Carbon Dioxide

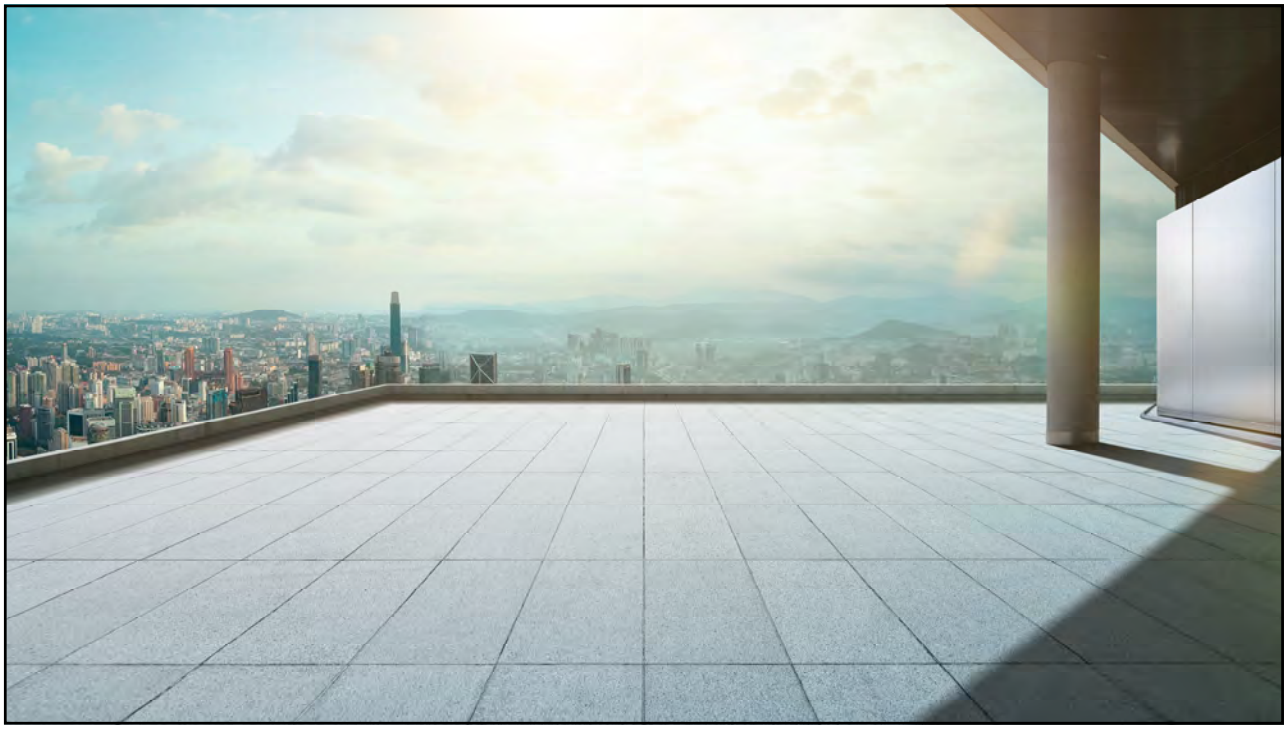
Concrete Materials:

D. Carbon mineralization by injecting CO2 into concrete during manufacturing or curing in CO2 atmosphere shall be permitted.

E. Artificial limestone aggregate meeting the requirements of ASTM C33 or ASTM C330 is permitted.

No. 10:

Encourage Innovation



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