The Top 10 Ways to Reduce Concrete's Carbon Footprint

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National Ready Mixed Concrete Association

NRMCA

minnesota concrete council
Dedicated to Cast-in-Place Concrete

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AIA Continuing Education – 1 LU/HSW

Learning Objectives

- Understand the basics of embodied carbon in 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.

CONTINUING EDUCATION AIA

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Concrete is Unique

Formulation Influenced by:
- Application
- Design professionals
- Contractors
- Specifications

Can be made:
- Stronger
- Weaker
- Lighter
- More flowable
- Stiffer
- Less Permeable

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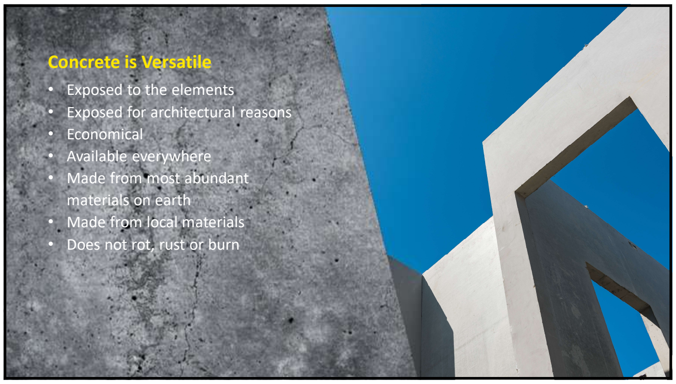
Concrete is Versatile
• Exposed to the elements
• Exposed for architectural reasons
• Economical
• Available everywhere
• Made from most abundant materials on earth
• Made from local materials
• Does not rot, rust or burn

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Used Everywhere
• Tallest buildings
• Longest bridges
• Largest buildings
• Busiest airports
• Most efficient rapid transit
• Roadways
• Theaters
• Stadiums
• Schools
• Apartment buildings
• Homes
• Water supply and treatment

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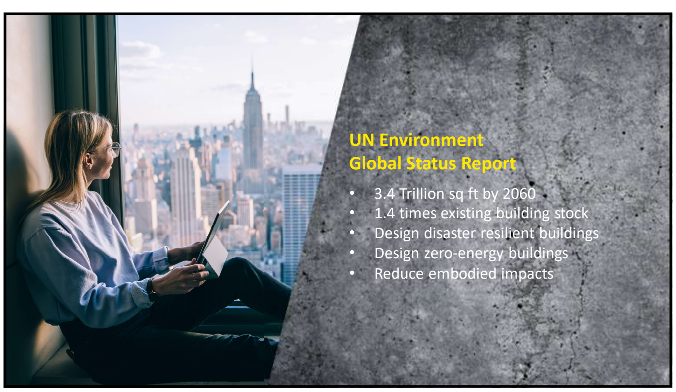
UN Environment
Global Status Report
• 3.4 Trillion sq ft by 2060
• 1.4 times existing building stock
• Design disaster resilient buildings
• Design zero-energy buildings
• Reduce embodied impacts

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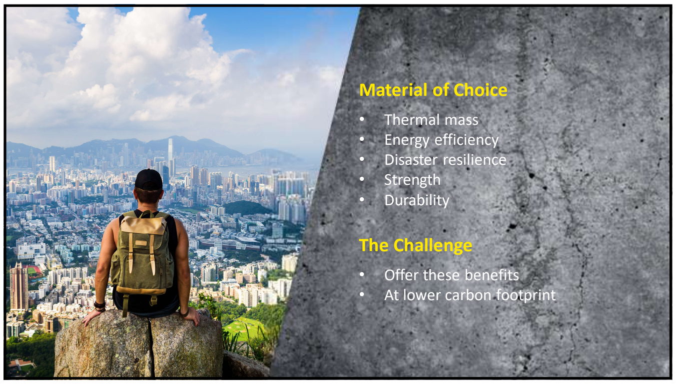
Material of Choice
• Thermal mass
• Energy efficiency
• Disaster resilience
• Strength
• Durability
The Challenge
• Offer these benefits
• At lower carbon footprint

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

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No. 1:
Communicate Carbon Reduction Goals
CO2
MIN

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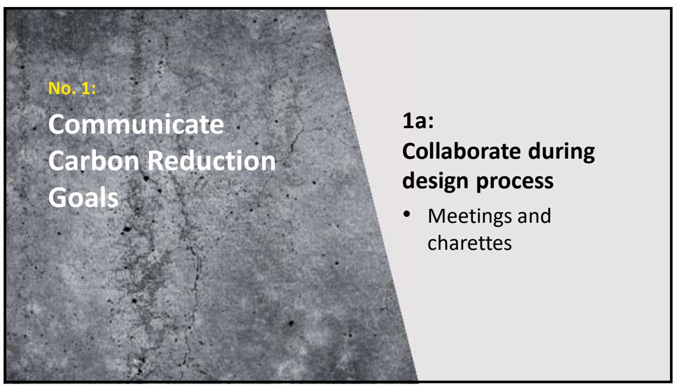
No. 1:
Communicate Carbon Reduction Goals
1a:
Collaborate during design process
• Meetings and charettes

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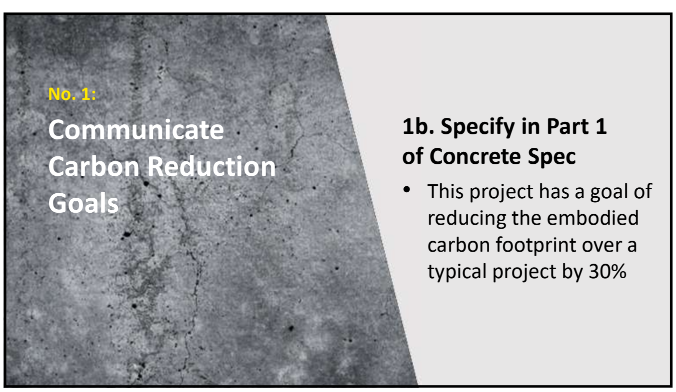
No. 1:
Communicate Carbon Reduction Goals
1b. Specify in Part 1 of Concrete Spec
• This project has a goal of reducing the embodied carbon footprint over a typical project by 30%

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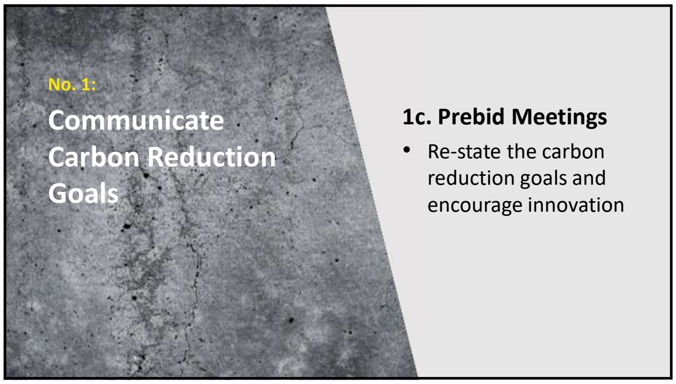
No. 1:
Communicate Carbon Reduction Goals
1c. Prebid Meetings
• Re-state the carbon reduction goals and encourage innovation

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No. 2:
Ensure Good Quality Control and Assurance

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No. 2:
Ensure Good Quality Control and Assurance

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No. 2:
Ensure Good Quality
Control and Assurance

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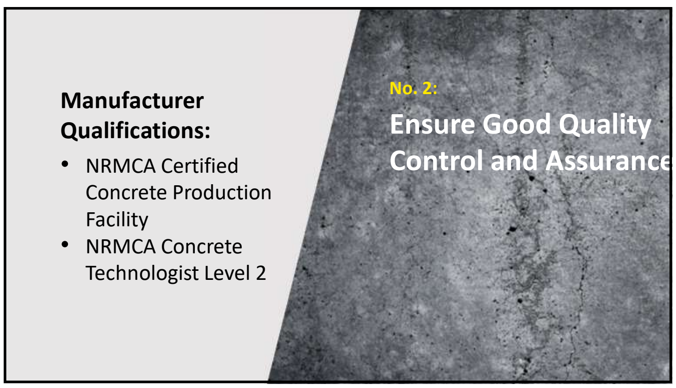
Manufacturer
Qualifications:
• NRMCA Certified Concrete Production Facility
• NRMCA Concrete Technologist Level 2
No. 2:
Ensure Good Quality
Control and Assurance

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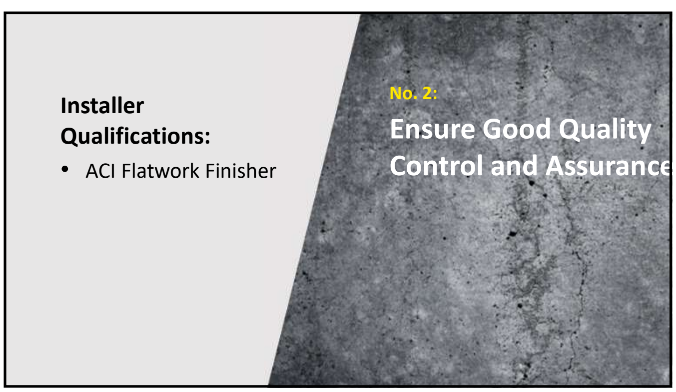
Installer
Qualifications:
• ACI Flatwork Finisher
No. 2:
Ensure Good Quality
Control and Assurance

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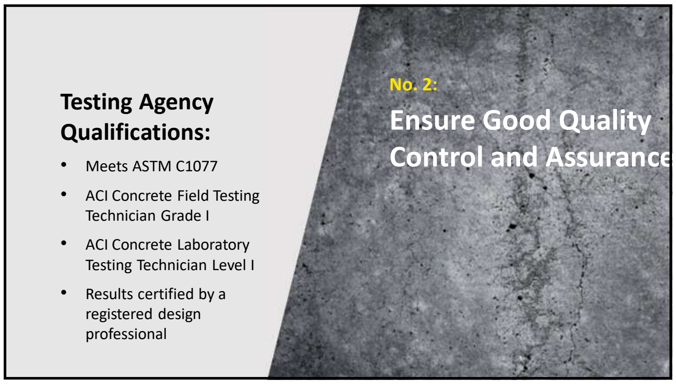
Testing Agency Qualifications:
Meets ASTM C1077
ACI Concrete Field Testing Technician Grade I
ACI Concrete Laboratory Testing Technician Level I
Results certified by a registered design professional
No. 2:
Ensure Good Quality Control and Assurance

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No. 3:
Optimize Concrete Volume

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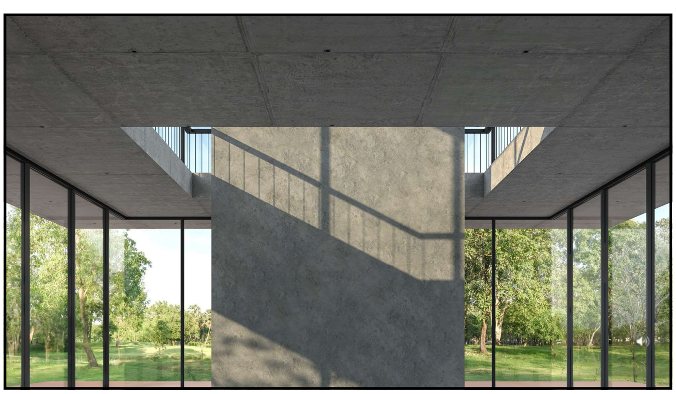

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Case Study: 960 W. 7th, Los Angeles
• 64-story tower
• 780 residential units
• 807,000 square feet
• Developer: Brookfield Properties
• Design Architect: Marmol Radziner
• Executive Architect: Large Architecture
• Structural Engineer: MKA
• Contractor: Webcor
• Concrete Supplier: National Ready Mixed Concrete Company
• Photos: Brookfield Properties

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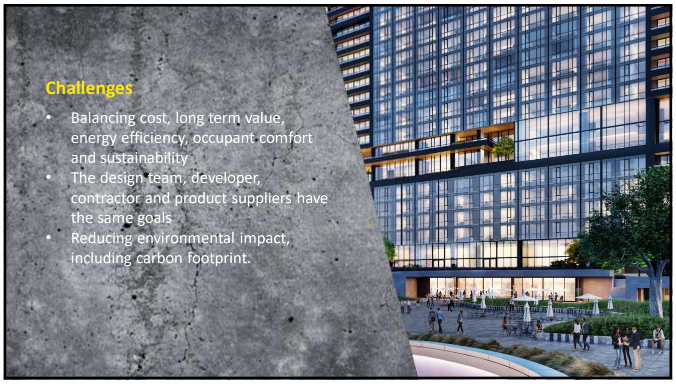
Challenges
• Balancing cost, long term value, energy efficiency, occupant comfort and sustainability
• The design team, developer, contractor and product suppliers have the same goals
• Reducing environmental impact, including carbon footprint.

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Sustainable Solutions
• Efficient structural system
• Post-tensioned slabs
• Centralized buttressed core
• Optimized floor to floor heights
• Eliminated transfers
• Unobstructed views Performance Based Design
• 80 ksi rebar

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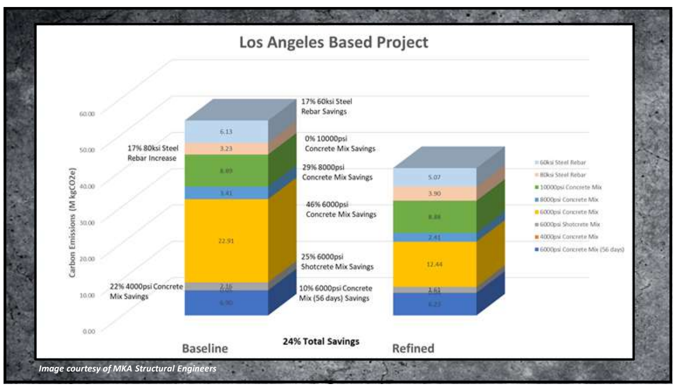

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ASTM C595

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 (X)(X)	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%

No. 4:

Use Alternative Cements

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ASTM C595		
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No. 4:

Use Alternative Cements

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No. 4:

Use Alternative Cements

Concrete Materials:

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

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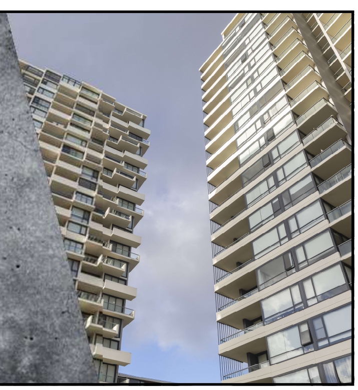
No. 5:

Use Supplementary Cementitious Materials



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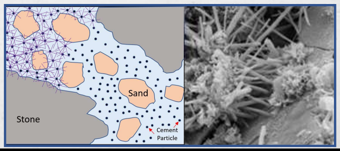
Hydration and SCMs

Portland Cement + Water ⟶ C-S-H + CH **Hydraulic**

Pozzolan (Fly Ash/Silica Fume) + CH ⟶ C-S-H **Pozzolanic**

Slag + Water $\xrightarrow[\text{(cement)}]{\text{Alkali/lime Activator}}$ C-S-H (no CH) **Hydraulic**

Slag + CH ⟶ C-S-H **Pozzolanic**



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No. 5:

Use 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**

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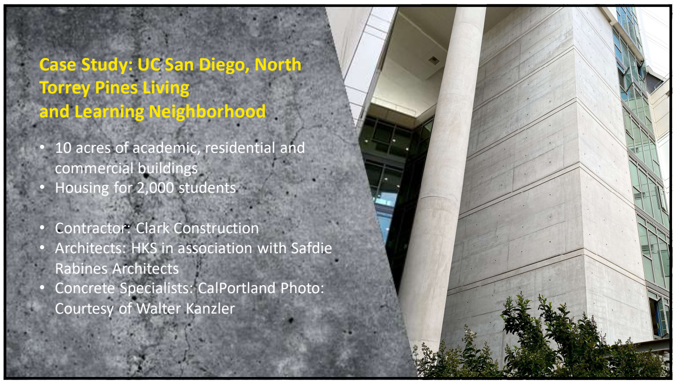

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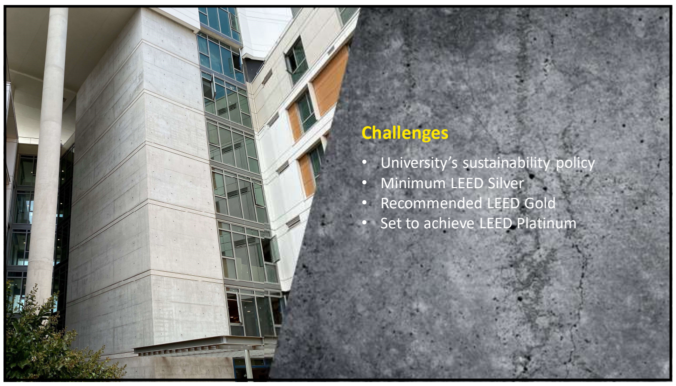

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Cement Type	Global Warming Potential
Portland Limestone Cement Type IL (13)	871 kg CO_2eq
Portland Cement Type I/II/V	969 kg CO_2eq

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

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

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No. 6:
Use Admixtures

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No. 6:
Use Admixtures

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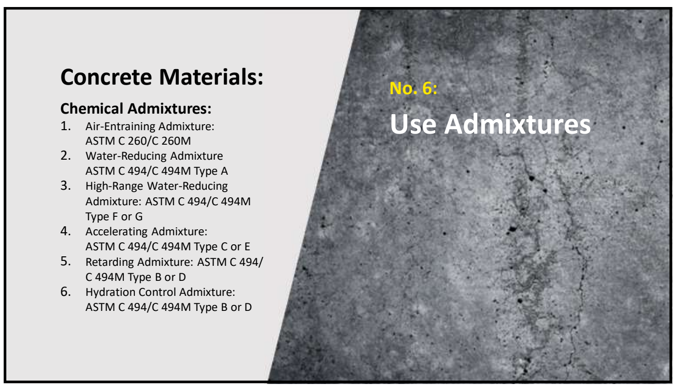
Concrete Materials:
Chemical Admixtures:
1. Air-Entraining Admixture: ASTM C 260/C 260M
2. Water-Reducing Admixture ASTM C 494/C 494M Type A
3. High-Range Water-Reducing Admixture: ASTM C 494/C 494M Type F or G
4. Accelerating Admixture: ASTM C 494/C 494M Type C or E
5. Retarding Admixture: ASTM C 494/ C 494M Type B or D
6. Hydration Control Admixture: ASTM C 494/C 494M Type B or D
No. 6:
Use Admixtures

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No. 7:
Don’t Limit
Ingredients

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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~~

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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~~

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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

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No. 8:
Set Targets for Carbon Footprint

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No. 8:
Set Targets for Carbon Footprint

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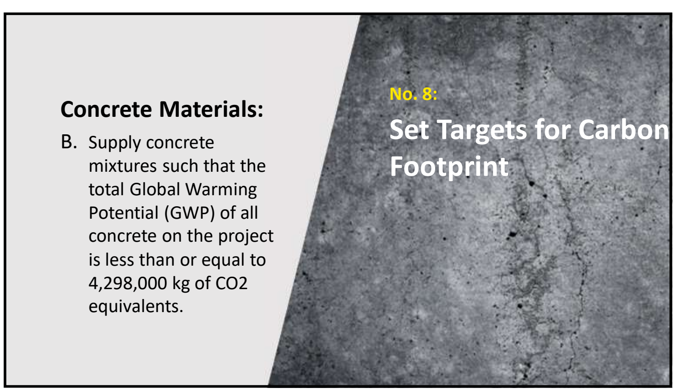
Concrete Materials:
B. Supply concrete mixtures such that the total Global Warming Potential (GWP) of all concrete on the project is less than or equal to 4,298,000 kg of CO2 equivalents.
No. 8:
Set Targets for Carbon Footprint

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Case Study:
Oracle Waterfront Campus, Austin, TX
• 550,750 ft^2 office building
• 147,000 ft^2 ground level parking 646,800 ft^2 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

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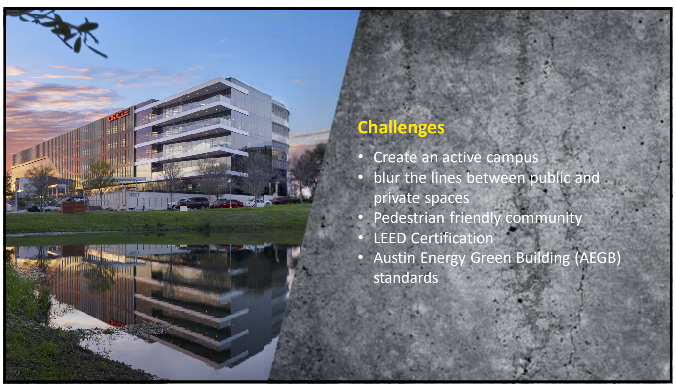
Challenges
• Create an active campus
• blur the lines between public and private spaces
• Pedestrian friendly community
• LEED Certification
• Austin Energy Green Building (AEGB) standards

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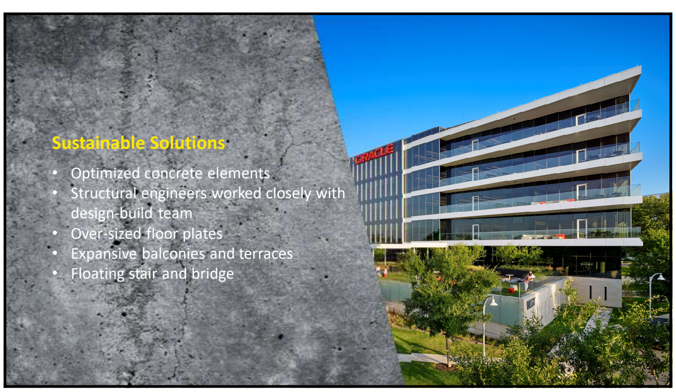
Sustainable Solutions
• Optimized concrete elements
• Structural engineers worked closely with design-build team
• Over-sized floor plates
• Expansive balconies and terraces
• Floating stair and bridge

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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

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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

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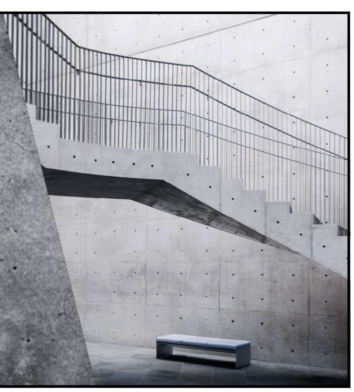
No. 9:

Sequester Carbon Dioxide



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No. 9:
Sequester Carbon Dioxide

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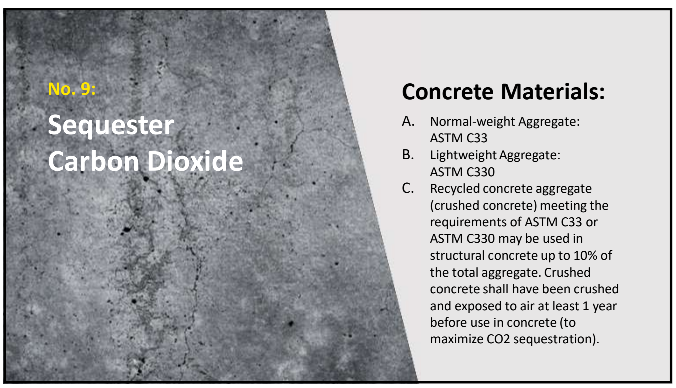
No. 9:
Sequester Carbon Dioxide
Concrete Materials:
A. Normal-weight Aggregate: ASTM C33
B. Lightweight Aggregate: ASTM C330
C. Recycled concrete aggregate (crushed concrete) meeting the requirements of ASTM C33 or ASTM C330 may be used in structural concrete up to 10% of the total aggregate. Crushed concrete shall have been crushed and exposed to air at least 1 year before use in concrete (to maximize CO2 sequestration).

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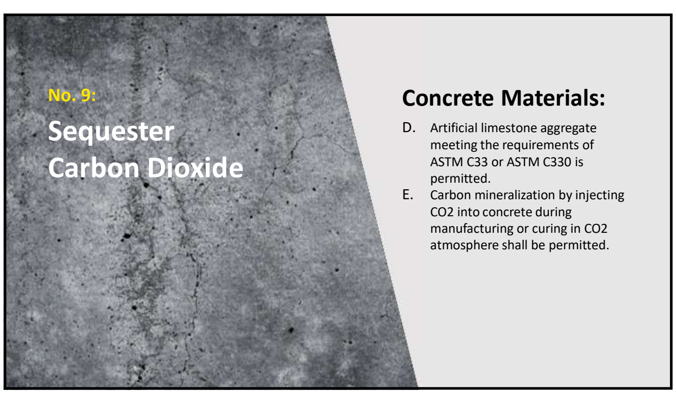
No. 9:
Sequester Carbon Dioxide
Concrete Materials:
D. Artificial limestone aggregate meeting the requirements of ASTM C33 or ASTM C330 is permitted.
E. Carbon mineralization by injecting CO2 into concrete during manufacturing or curing in CO2 atmosphere shall be permitted.

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No. 10:
Encourage Innovation

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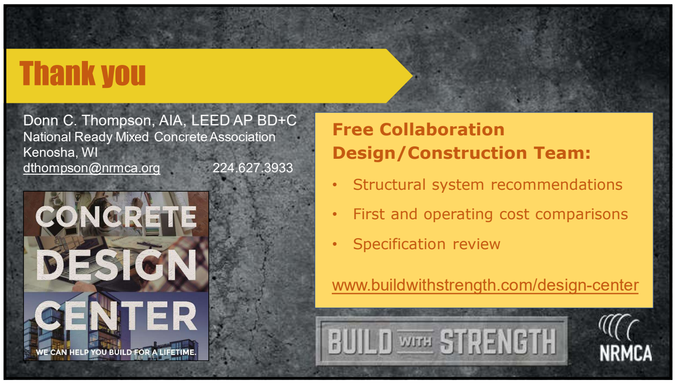
Thank you
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The Top 10 Ways
to Reduce Concrete's Carbon
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