The Future is Now
Environmentally Sustainable Concrete
Higher Performing Low Carbon Mixes

Supplementary Cementitious Materials (SCM’s)
Fly Ash, Slag, Natural Pozzolans

High Volume Fly Ash (HVFA)

Ternary Blends: 50% replacement, 28 day strength; 70% replacement, later age strengths
Higher Performing
Low Carbon Mixes

Example Case Study:
Approximately 80,000 cubic yards of lower carbon concrete were supplied for the auger piles and the overall Stadium structure. The mixes selected reduced the overall footprint by 23 million pounds of CO$_2$. 
Higher Performing
Low Carbon Mixes

1700 Webster
Oakland

• Used for nearly all applications on a daily basis
• Increase strength
• Reduce Global Warming Potential (GWP)
Carbon Sequestration Example: CarbonCure

Recycled waste carbon dioxide makes a greener, stronger concrete.

$\text{CEMENT} + \text{H}_2\text{O} \rightarrow \text{Ca} (\text{calcium})$

$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CO}_3^{\text{2-}}$

$\text{Ca} + \text{CO}_3^{\text{2-}} \rightarrow \text{CaCO}_3$ (solid limestone)
Carbon Sequestration Example: Blue Planet

Blue Planet has developed a process to coat aggregate with calcium carbonate from CO₂.

Field trial at SFO: Batched and delivered concrete containing lightweight aggregate coated by Blue Planet.

Provides carbon footprint reduction of the concrete mix.
Recycled Concrete Aggregate

San Francisco has an ordinance that requires maximum reuse and recycling of material and debris generated during construction and demolition projects.

Solution: Crushed concrete used as aggregate in concrete >> No landfill, less draw on raw materials, less energy
Returned Fresh Concrete

Reusing Fresh Concrete: A Win-Win For Everyone

ASTM C1798 recognizes unused concrete in a fresh state as an ingredient for a new concrete batch – in other words, it can be treated as a raw material, just like water, aggregates & cement.

Reduced Waste. Improved Productivity. Proven Performance.

Reduced C1798 AB 2355 Saves
Waste Meets ASTM Standard Compliant Natural Elements

Decreased or Zero Trips to Landfills

- Reduced trucks on road
- Reduced air pollution
- Saves landfill space
2–8% of concrete produced in California is returned.

CalEPA has estimated that unused concrete results in 2.2 million lbs. of excess carbon emissions/yr.
Returned Fresh Concrete

DID YOU KNOW?

Caltrans *green lighted* the use of returned, fresh concrete at 15%
Environmental Product Declarations (EPDs)

Summary of Environmental Product Declaration

**Central Concrete**

**Mix** 340PG9Q1
San Jose Service Area
EF V2 Gen Use P4000 3rd Line 50% SCM

| Performance Metrics | 28-day compressive strength | 4,000 psi | Slump | 4.0 in |

Environmental Impacts

<table>
<thead>
<tr>
<th>Impact name</th>
<th>Unit</th>
<th>Impact per m3</th>
<th>Impact per cyd</th>
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<tr>
<td>Total primary energy consumption</td>
<td>MJ</td>
<td>2,491</td>
<td>1,906</td>
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<tr>
<td>Concrete water use (batch)</td>
<td>m3</td>
<td>6.66E-2</td>
<td>5.10E-2</td>
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<tr>
<td>Concrete water use (wash)</td>
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<td>8.56E-3</td>
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<td>Global warming potential</td>
<td>kg CO2-eq</td>
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<td>207</td>
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<tr>
<td>Ozone depletion</td>
<td>kg CFC-11-eq</td>
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<td>4.14E-6</td>
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<td>Acidification</td>
<td>kg SO2-eq</td>
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<td>Eutrophication</td>
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<tr>
<td>Photochemical ozone creation</td>
<td>kg O3-eq</td>
<td>46.6</td>
<td>35.7</td>
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</table>
High Performance Concrete

1640 Broadway
Oakland
Increased construction of high-rise buildings is driving the need for high strength mixes.

High Rise = High Performance

Tall Buildings = Pumping Challenges
High Strength Mixes

Benefits of high strength concrete

- Superior compressive strength
- Low shrinkage
- Low permeability
- High modulus of elasticity (MOE)

San Francisco Skyline
“…to make high-performance concrete, the materials matter. Use lower-quality sand and gravel and you’ll need to add a larger amount of cement”, said Todd Lamberty, a project manager for construction firm Webcor Builders.

Excerpt: Los Angeles Times. Project; Oceanwide Plaza, mixed-use development across from the Staples Center. Orca aggregate from Polaris.
High Early Strength Concrete

... Rapid Strength Concrete

Evolution of High Early Strength Concrete

LAX Airport
>> One of first locations to use High Early Strength Concrete for overnight runway repairs

Highways
>> High Early Strength Concrete quickly moved to highway repairs across the country
High Early Strength Concrete

PT Decks
>> Now: High Early Strength Concrete = faster construction = reduced costs
Site: 1400 Mission, SF

>> High Early Strength Concrete moved to bridge decks, including the closure strips for the SF-Oakland Bay Bridge
Rapid Drying Concrete

Eliminates moisture issues: takes moisture totally out of play before the floor is installed.

ARIDUS® Rapid Drying Concrete

Prevents Floor Covering Failures

Consumes excess water >> preventing moisture problems from the very beginning by accelerating the concrete drying time
Rapid Drying Concrete

Impact of Excess Moisture in Concrete Slabs

Construction Delays – Environmental Hazards – Cost Overruns

Liability Issues – Moisture Mitigation – Damaged Reputation

Community Aquatics Center, Dublin, CA
Improving Productivity
Flowable Mixes

Properties of Flowable Mixes:

- In-place costs – less labor and equipment
- Worker safety – workers can place w/o entering excavation site.
- Easy to place because it is “self-leveling”
- Ideal for congested, reinforcement & difficult to reach sites
- Specified for projects needing highest levels of aesthetic results

- 8” – 10” slump: High Slump
- 22” – 28” spread: Self-Consolidating Concrete (SCC)
Flowable Mixes

SFO Airport
Real-time Communications
High Performance Testing
Problem: Inaccurate results from “field-cured” cylinders can create schedule delays and cost overruns. Test probes enable contractors to monitor strength of early-age, in-place concrete in real-time = confidence + time-savings + reduces overdesign.
Maturity Testing

Monitor concrete temperature and strength in real time.

More efficient by offering:
• Wireless connectivity
• Mobile-based data collection
• Labor cost reduction
• Quick decision making
Collaboration Case Study

San Francisco Public Utilities Commission
Case Study: SFPUC

2014: Greenest office building in US

LEED Platinum

Immediate Occupancy after the *Big One*

Structural VE Redesign from Steel to Concrete

$7.4M savings in structure

High-replacement concrete on large scale
Case Study: SFPUC

By bringing the supplier in early:

- Allowed design team to have a better understanding of current concrete advances
- Clearly defined structural and environmental goals
- Time to develop and test mixes
- Allowed discussion on potential environmental impact of local material requirements of LEED
Case Study: SFPUC

Collaboration included:

Address constructability issues - scale and speed

Provide simple and reliable design info and construction specifications

Redefine concrete specification - limit cement content, specify target replacement with SCM

Proportion slag and fly ash to optimize cost, workability, performance

Mix design basis, batch testing vs. ACI methods
Case Study: SFPUC

Collaboration at the front end, based on a PERFORMANCE approach vs. a PRESCRIPTIVE approach, along with mutually agreed upon sustainability and testing requirements yielded multiple advantages.

Trimmed Construction Schedule

Resulted in $12M in Savings

Reduced

12 Inches

Floor thickness

13th Floor

Due to concrete’s reduced floor-to-floor height

Achieved

3 Day

High, early-strength requirement of 4500 PSI

Concrete Structure

Increased natural lighting

Concrete Reflectivity

Allowed for reduced lighting requirements

Improved

Matt Slab

70%

Cement replacement

Mats Slab

70%

Cement replacement

Elevated P.T. Slabs

56%

Cement replacement

Saved 7.4M lbs.

In CO₂ emissions

Thermal mass Cement replacement Cement replacement Cement replacement
Every technology you have learned about today is HERE, NOW.