Opportunities to lower the environmental impacts of cement and concrete

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Concrete is a mixture that can be designed to meet many performance requirements.

Concrete Constituents

- Coarse aggregates
- Fine aggregates
- Binder
- Water
- Admixtures

Performance Requirements

- Early strength
- Late strength
- Stiffness
- Density
- Constructability
- Durability
Many binders can be used in concrete
Composition, performance, and availability vary significantly

Portland Cement  Natural Pozzolans  Calcined Clay
Fly Ash  Granulated Slag  Post-Consumer Glass
Cement drives concrete’s environmental impact

3000 psi mixture with no SCMs
Cement manufacture at a glance

Cement is a man-made powder that, when mixed with water and aggregates, produces concrete. The cement-making process can be divided into two basic steps:

1. Clinker is made in the kiln at temperatures of 1,450°C
2. Clinker is then ground with other minerals to produce the powder we know as cement

Carbon Emissions Reduction Levers
1. Thermal and electric efficiency
2. Alternative fuels
3. Clinker substitution
4. Carbon capture and storage

Source: WBCSD-IEA Cement Technology Roadmap, 2009
Numerous solutions are available today for lowering cement and concrete’s environmental impact

**Cement**
- Alternative fuels
- Energy efficiency
- Clinker replacement
- Cement formulation
- Carbon capture at cement plant
- Cement production using captured carbon

**Concrete**
- Low-carbon binders
- Mixture optimization through performance-based specifications
- Concrete production using captured carbon
- Aggregate production using captured carbon

**Barriers to adoption: risk aversion and cost**
Captured carbon in cement and concrete can be used to create net zero or carbon negative materials.

Alkaline reactant:
- Cement
- Brine solution
- Industrial waste

Construction product:
- Binder
- Aggregate
- Concrete

Carbon sequestration in concrete is permanent.
Significant potential for concrete and aggregates to use CO₂

Source: Center for Climate and Energy Solutions (C2ES), 2019
Many strategies can contribute to carbon negative concrete

**Concrete Constituents**

- **Coarse aggregates**
  - Use captured carbon in concrete mixture
  - Synthetic limestone aggregates from captured carbon
- **Fine aggregates**
  - Blended cements
  - Supplementary cementitious materials
  - Alternative cement formulation
  - Binder from captured carbon
  - Cement produced with carbon capture
- **Binder**
  - Improve concrete performance for unique mixtures
- **Water**
- **Admixtures**

Lowest carbon mixtures will use multiple strategies
Performance-based specifications are the best way to spur innovation in low-impact concrete.

Optimize concrete mixtures to meet performance specifications for cost and environmental impact targets.

Coarse aggregates
Fine aggregates
Binder
Water
Admixtures

Performance

Environmental impacts

Cost

Need measurement & reporting
Recommendations for reducing embodied impacts

Address barriers of risk and cost

• Implement:
  – Product environmental footprint requests
  – Performance-based specifications for concrete to spur innovation in low-carbon cement and concrete mixtures

• Support development and deployment:
  – Carbon capture at cement plants and other industrial sources
  – Low-carbon technologies for cement, concrete, and aggregate production that use captured carbon
Thank you

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