

Arizona Chamber of Commerce and Industry and the Arizona Manufacturers Council Environmental Summit

September 10, 2009



CalPortland Company



Cement is an ingredient of concrete

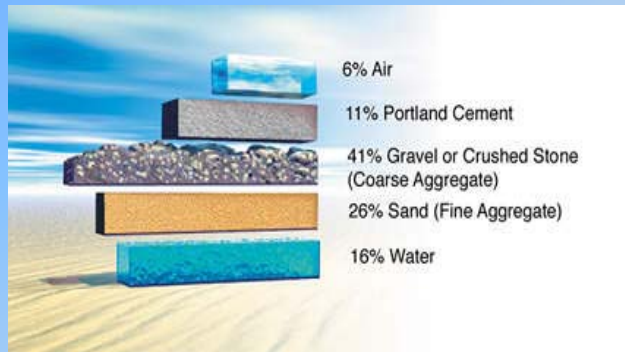


Cement & Concrete

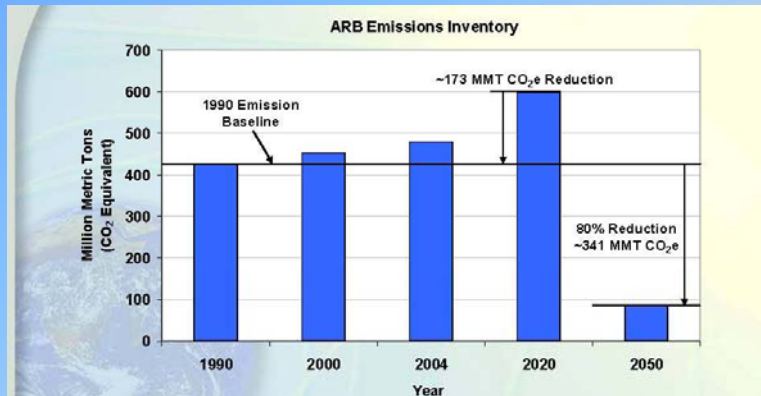
Cement



Concrete

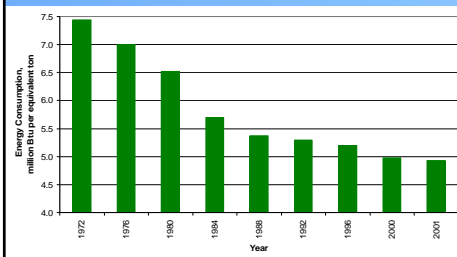


California Law AB 32: Reduce green house gas emissions to 80% below 1990 levels by 2050



Reduction of Energy Consumption

30% reduction of energy use in
the last 35 years



Use of alternate energy:

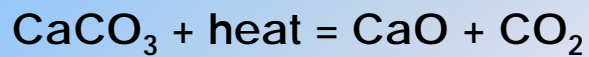
Mojave, CA generates 60 million
kwh/year of the cement plant's power



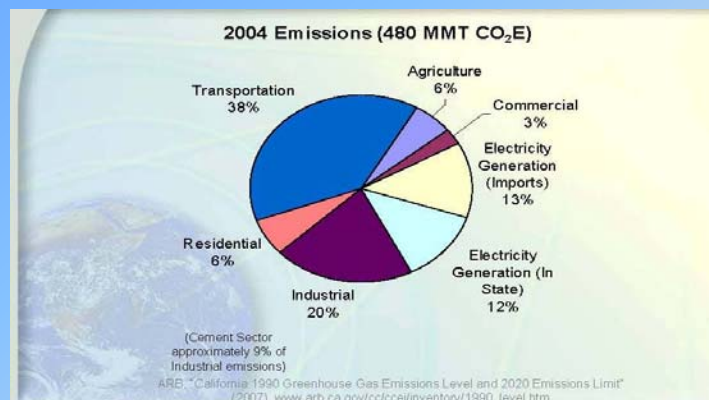
Unique Impact of Cement



- Cement Production Produces CO₂ in 2 ways:
- Energy and Process Emissions
- 35% = Fuel consumption
- 10% = Electrical (indirect) power consumption
- 55% = product of limestone calcination under intense heat



- Cement Production Contributes 1.8% of California's CO₂ Emissions and 3.7 - 5% of World-wide GHG Emissions



BUT

Cement and Concrete can also be a significant part of the solution.....



Site Design Opportunities

- Projections show that two-thirds of development that will be in place by 2050 has not yet been built. – *Urban Land Institute*
- *32 new square miles of parking for San Diego County by 2030*



Site Design Opportunities

Concrete can significantly reduce GHG emissions through:

- Life Cycle GHG Analyses
- Urban Heat Island Reduction
- Stormwater Runoff Reduction
- Highway Fuel Efficiency Improvements



Life Cycle GHG Analyses

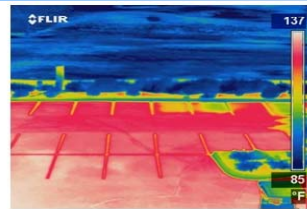
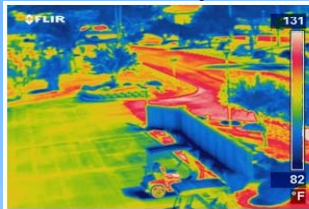
The embodied energy of the construction products is approximately equal to 4 years of operational energy use. Stated another way, the operational energy use and associated emissions to air during the life of the building is 85 to 95% of the total energy and emissions.



Urban Heat Island Reduction

Up to 5°F site impact with trees and cool roofs and cool pavement

Pavement Type	Albedo (solar reflectance)
Asphalt	0.05-0.10 (new) 0.10-0.15 (weathered)
Gray Portland Cement Concrete	0.35-0.40 (new) 0.20-0.30 (weathered)
White Portland Cement Concrete	0.70-0.80 (new) 0.40-0.60 (weathered)



Stormwater Runoff Reduction

Recharging groundwater with pervious concrete



Highway Fuel Efficiency Improvements

Vehicles traveling on rigid pavements can achieve significantly better fuel efficiency than on asphalt highways.



News Item:

2002: “The Mountain Pass Mine, unable to compete with cheap Chinese imports of rare earth minerals, announced it will shut down operations”

2009: “China, supplier of 97% of the world’s rare earth minerals, announced today that it will significantly reduce exports”



Leakage is our Biggest Concern

- Leakage occurs when an industry relocates operations to a less regulated (costly) location.
- Loss of jobs.
- Loss of tax revenue.
- Increase in global emissions due to increased transport distances.



Cement is a Globally Traded Commodity

- 2006 production in tons: Worldwide: 2.5 billion
 - China: 1.1 billion (44%)
 - India: 155 million (6%)
 - US: 101 million (4%)
 - California: 11.4 million (0.45%)



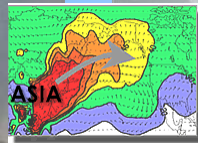
Unforeseen Impacts of Leakage

- **Trans-pacific vessel burns fuel oil that adds about 0.3 tons GHG/ton of cement**
- Ancillary emissions increase due to reduced environmental regulations.



Unforeseen Impacts of Leakage

- Ancillary emissions increase due to reduced environmental regulations.
- Higher mercury and fine particulate emissions travel to the US anyway.



Survival Strategies for Trade-Exposed, High-Energy Use Industries

"Walk the Talk"

Reduce our GHG Footprint:

- Supplementary Cementitious Materials
- Reduced energy consumption
- Recycled raw materials
- Alternate Fuels
- Use of Recycled Materials in Concrete



Survival Strategies for Trade-Exposed, High-Energy Use Industries

"You're either at the table or you're on the menu"

Stay engaged:

- Educate your Environmental Regulatory Agencies
- Educate your State and Local Elected Officials
- Educate your Federal Elected Officials



Survival Strategies for Trade-Exposed, High-Energy Use Industries

" That sounds expensive and time-consuming, and it is "

- Retain experienced consultants and lobbyists
- Educate your own people and get them actively engaged at all levels.
- Participate in industry associations



Survival Strategies for Trade-Exposed, High-Energy Use Industries

Cement has significant barriers to entry

- Extremely long permitting times
- Very high capital cost
- Limited to locations with supply of raw materials and access to rail and roads



Further Reduce the Carbon Footprint through the Use of Supplementary Cementitious Materials for Cement and Concrete



Others include natural pozzolans, rice hull ash, and ultra fine fly ash



Questions?

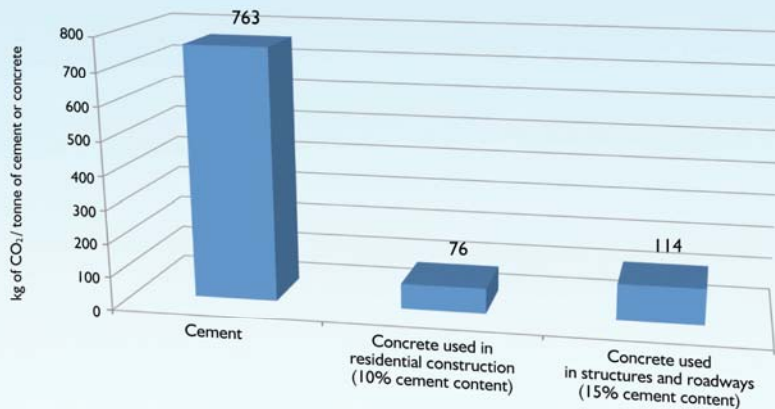
Life Cycle: are we selecting energy-efficient materials that stand the test of time, water, fire, insects & rust?

Pantheon in Rome (AD 126) and it's concrete dome roof



LO1: impact of cement & concrete

GHG EMISSIONS INTENSITY OF CEMENT VS. CONCRETE



Source: Data based on WBCSD CO₂ Protocol (2006) and Cement Association of Canada Design and Control of Concrete Mixtures, 7th edition.



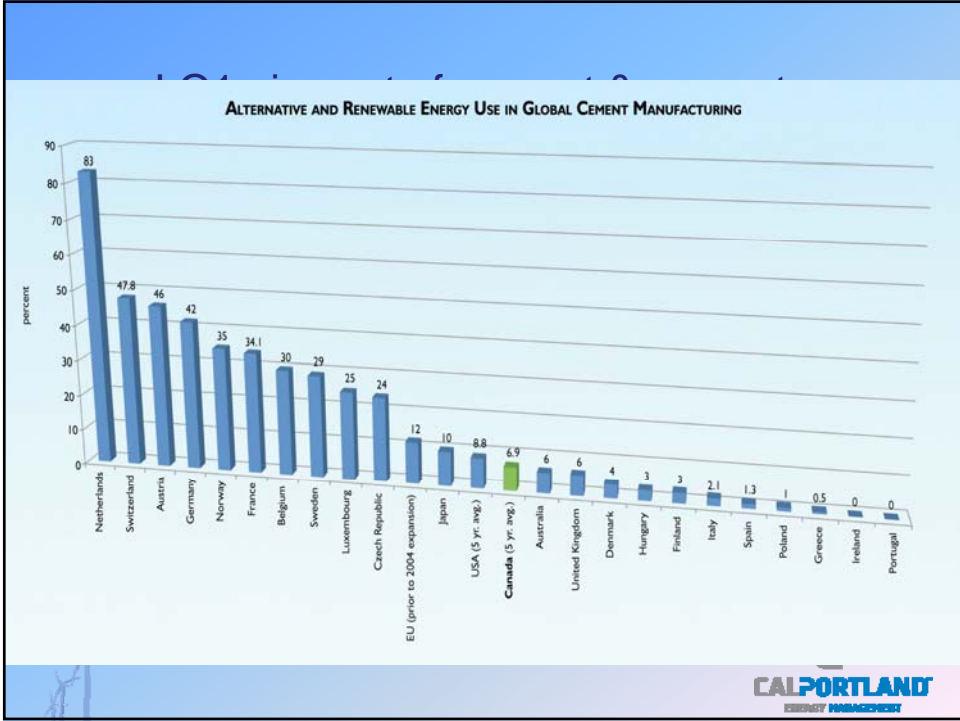
LO1: impact of cement & concrete

- Alternative Fuels – sample California cement plant:



- Used tires (replace iron & sulfur)
- Blast furnace scale (recycled from steel industry-replaces iron)
- Lime sludge (recycled paper waste-replaces limestone)
- Paint residue (raw grinding aid)
- Foundry sand (replaces silica)
- Waste soap (air entraining)



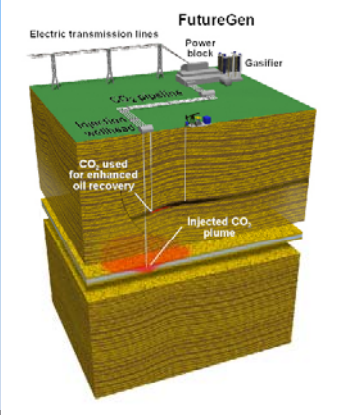


LO1: impact of cement & concrete



Product Reformulation – limestone in cement, blended cements

Putting CO₂ to use
For enhanced oil recovery



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LO1: impact of cement & concrete
California's Global
Warming Act: AB
32

Potential Directions:

Cap & Trade
Intensity Targets

Largest cement concern:

Leakage to other states
and nations



**Address climate change through material
specifications for concrete**

Learning Objective 2



LO2: reducing concrete's CO₂ impact

- Recycled Content in Concrete



LO2: reducing concrete's CO₂ impact

- Concrete is a huge consumer of industrial by-products
 - Fly ash (from coal fired power plants)
 - Slag cement (from iron smelting of ore)
 - Others, ternary mixtures, and blended cements
- Opportunities for mixture optimization that:
 - Lowers cement intensity
 - Reduces disposal
 - Can improve performance and longevity



LO2: reducing concrete's CO₂ impact

- Replacement rates for cement:

- Blended Cements: ASTM C 595
 ASTM C 1157
- Coal fly ash: 0 to 50% ASTM C 618
- GGBF slag: 0 to 70% ASTM C 989
- Silica fume: 5 to 30% ASTM C 1240



LO2: reducing concrete's CO₂ impact



Mass concrete
Mats, footings
Piles, pile caps
Grade beams
Walls, Columns
Beams
Slab on metal deck
Slabs
Thin slabs, thin soq
Lightweight concrete
Post-tensioning

Easier

Harder

Use of supplementary cementitious materials by building element



LO2: reducing concrete's CO₂ impact

Spherical Shape and Improved Packing Leads to:

- Lower water demand
- Improved pumping
- Improve cohesion
- Reduced bleeding and segregation

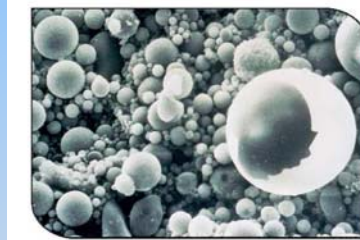


Figure 3. Micrograph showing spherical fly ash particles



LO2: reducing concrete's CO₂ impact

Know the impacts of fly ash and other substitutes

Effects of SCMs on Fresh Concrete

	Fly Ash		Slag	Silica Fume	Natural Pozzolans		
	Class F	Class C			Calced Shale	Calced Clay	Metakaolin
Water Demand	↓	↓	↓	↑	↔	↔	↑
Workability	↑	↑	↑	↓	↑	↑	↓
Bleeding	↓	↓	↔	↓	↔	↔	↓
Setting Time	↑	↔	↑	↔	↑	↑	↔
Air Content (dosage rate)	↑	↑	↔	↑	↔	↔	↑
Heat of Hydration	↓	↔	↓	↔	↓	↓	↓

Effects of SCMs on Hardened Concrete

	Fly Ash		Slag	Silica Fume	Natural Pozzolans		
	Class F	Class C			Calced Shale	Calced Clay	Metakaolin
Early Age Strength Gain	↓	↔	↓	↑	↓	↓	↑
Long Term Strength Gain	↑	↑	↑	↑	↑	↑	↑
Permeability	↓	↓	↓	↓	↓	↓	↓
Chloride Ingress	↓	↓	↓	↓	↓	↓	↓
ASR	↓	↓	↓	↓	↓	↓	↓
Sulfate Resistance	↑	↑	↑	↑	↑	↑	↑
Freezing & Thawing	↔	↔	↔	↔	↔	↔	↔



LO2: reducing concrete's CO₂ impact

- Recycled Concrete as Aggregate

ASTM C 33 ASTM C 125



Effects of Recycled Aggregates on Concrete Properties

Water Demand	↑	Compressive Strength	↔
Paste Content	↑	Tensile Strength	↔
Workability	↓	Modulus of Elasticity	↓
Slump Loss	↑	Drying Shrinkage	↑
Density	↓	Creep	↑
		Permeability	↔
		Freeze-Thaw Resistance	↔
		Depth of Carbonation	↔



LO2: building design opportunities

A Hidden Bonus:

Carbon sequestering:

- 60% of the CO₂ emitted during cement production is due to calcination
- Once cement has hydrated the reaction can start occurring in reverse: carbonation



- Recycling and crushing accelerates this dramatically - can allow the recapture CO₂ evolved during calcination (RMRC '05)



Consider site design opportunities to mitigate global warming

Learning Objective 3



CO₂ site design opportunities



- 20' X 20' driveway
- 4" slab w/15% fly ash
- 5 cu yards=20,000 lbs
- 392 lbs CO₂/ cu yd = 2000 lbs of CO₂



LO3: site design opportunities



- Typical sedan at 15,000 miles / year and 25 mpg =
- 600 gallons of gas = 11,760 lbs of CO₂/yr

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LO3: site design opportunities



Car =
11,760 lbs
CO₂/yr

Driveway =
67 lbs
CO₂/yr

CO₂ Impact over 30 years

2000 lbs / 30 years = 67 lbs CO₂/ yr

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LO3: site design opportunities

Life Cycle:
sustainable pavements
require minimal
maintenance and use of
natural resources over time

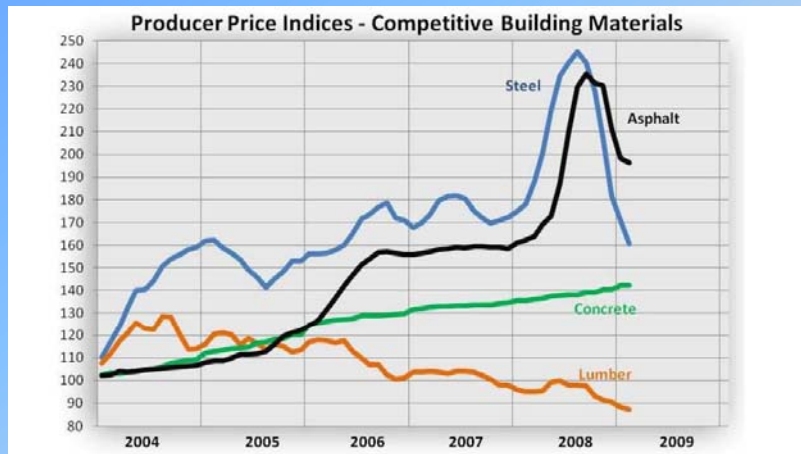


maintenance every 5-7 years

no maintenance for generations



LO3: site design opportunities environmental and cost life cycle impact



Base Year: 2002 = 100
Source: Bureau of Labor Statistics



LO3: site design opportunities



Lawrence Berkeley Lab:

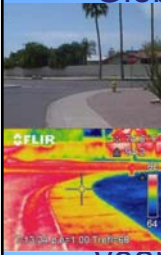
Changing reflectivity of pavement and adding trees in LA = 1 degree cooler per year, saving \$15 million per year in energy and reduces smog by 2.5% valued at \$75 million per year



LO3: site design opportunities

Urban Heat Island Mitigation

- Globally, roofs account for 25% of the surface of cities, and pavement accounts for about 10%. If all were switched to reflective material in major urban areas, it would offset 44 metric tons of greenhouse gases, That is more than all the countries on Earth emit in a single year. LA Times /Lawrence Berkeley National Lab



LO3: site design opportunities

- Impact of Solar Reflectance
- Study of reflectance of 150 parking lots:
 - 250 watt bulbs for concrete
 - 400 watt bulbs for asphalt
 - Example: 14 light standards can be used instead of 22. Saving 5844 kw/hr per year or 57%



*Adrian/Jobamputra PCA R&D Serial Number 2458



LO3: site design opportunities

Stormwater runoff – it takes energy to transport water that can be captured

- Provision of water & wastewater = 19% of state's total electricity demand (IEUA)



LO3: site design opportunities



LO4: building design opportunities

- Life Cycle
- Thermal Mass in Walls
- Reducing other materials / VOC's
- Green Roofs



LO4: building design opportunities

- Buildings in the U.S. consume more than 30% of our total energy and 60% of electricity- *USGBC*

- Construction materials are not the most significant impact.

the production phase comprises only a small portion of the total energy consumption over the life of a building



LO4: building design opportunities

- *The embodied energy of the construction products is approximately equal to 4 years of operational energy use. Stated another way, the operational energy use and associated emissions to air during the life of the building is 85 to 95% of the total energy and emissions.*
- Commercial buildings run around 85 to 95% operational impact – the nature of the building and location will cause this to vary. Uses like a restaurant and labs will have the higher percentage due to fresh air requirements and vent hoods, while offices tend to be lower



LO4: building design opportunities Life Cycle



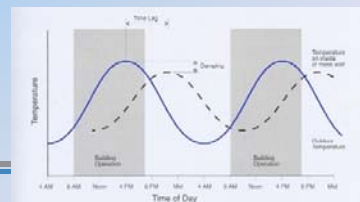
-477 to -438 BC

-2750 to -1500 BC



LO4: building design opportunities Thermal Mass

...a property that enables building materials to absorb, store, and later release significant amounts of heat. Buildings constructed of concrete and masonry have energy-saving advantage because of their inherent thermal mass. These materials absorb energy slowly and hold it for much longer periods of time than do less massive materials.



LO4: building design opportunities

Thermal mass

- Fewer spikes in heating and cooling requirements as mass slows the response time and moderates indoor temperature fluctuations.
- A massive building uses less energy than a similar low mass building due to the reduced heat transfer.
- Thermal mass can shift energy demand to off-peak time periods when utility rates are lower.



6 story ICF dorm at
Azusa Pacific



LO4: building design opportunities

- Fundamentals of Architectural Concrete
 - Formwork Selection & Preparation
 - Form alignment – prevent leakage
 - Uniform concrete mixes and color, job-site test panels
 - Continuous placement
 - Proper placing and curing procedures
 - Careful formwork removal



Summary



Learning Objective 1
Recognize the environmental impacts of cement and concrete production.



Learning Objective 2
Address climate change through material specifications for concrete



Summary



Learning Objective 3
Consider site design opportunities to mitigate global warming



Learning Objective 4
Consider building design opportunities to mitigate global warming

