



American Concrete Institute®
Advancing concrete knowledge

Innovations in Chemical Admixture Technology as Related to Sustainability

ACI Spring 2012 Convention
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ACI
WEB SESSIONS




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Using Chemical Admixtures and Advanced Methodologies to Produce and Quantify Sustainable Concrete

Innovations in Chemical Admixture Technology
As Related to Sustainability, Part 1
March 20, 2012
Dallas, Texas
Mark A. Bury and David Green



Presentation Overview




Most of the focus of our industry today is on the **economy and sustainability**.

These issues will continue to challenge and shape our industry.

Two main concrete goals:

- Optimize mix economics and performance
- Lower the overall environmental impact

The Old Way




Recipe:	
Cement	550 lb
Sand	1,450 lb
Stone	1,700 lb
Water	300 lb
Admixtures (Type A)	40 fl oz.


- Mix 5 minutes
- Deliver to job site
- Place

4,000 lb (1 yd³)

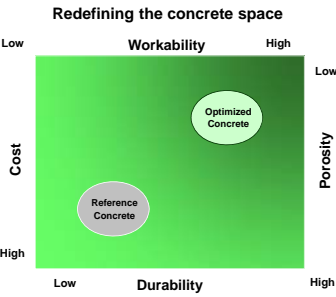
Cash and carbon costs are heavy



Advanced Concrete Technology



Redefining the concrete space

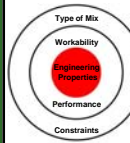


Proportioning Expertise + Recycled Materials + Special PCE Admixtures + Workability Retention

Advanced Mix Optimization: The New Way!



Start with an existing reference mix



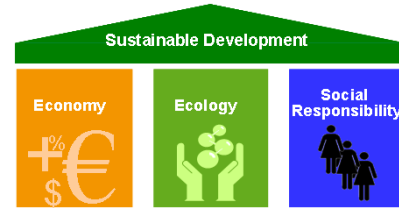
Advanced Level of Mix Optimization

Region	Chemistry	Recipe
Available Materials Reactivity Levels Regional Admixtures	Novel Chemistry Custom Molecules Rheology Slump Retention	Characterization Gradations Custom Software Proportioning Expertise

Cash and carbon costs are minimized!

Customized Specific Optimized
Concrete Mix Design

Integration of the Three Pillars of Sustainability



Sustainability means combining economic success with environmental protection and social responsibility.

Buzz Words

Lower CO₂ Emissions
Lower Your Carbon Footprint



Goal: Make a more fuel-efficient car.

How?

- ❖ Lighter
- ❖ Aerodynamic
- ❖ Lower rolling resistance
- ❖ Battery assistance
- ❖ Lower AC requirement

Material/Process

- ✓ Plastic
- ✓ New alloy/design
- ✓ Innovative rubber
- ✓ Supplement engine
- ✓ Reflective paint

Potential Net Effect

- ⊗ More oil
- ⊗ Higher energy/cost
- ⊗ Land usage
- ⊗ Heavy metal disposal
- ⊗ Toxic

25% Reduction!



Are these options sustainable?

Concrete Sustainability



Recurring Conference Themes

- Reduce cement content
- Use more supplementary cementitious materials
- Use recycled concrete

Which Mix is More Sustainable?

Mix A	Mix B
Material (lb/yd ³) Cement 517	Material (lb/yd ³) Cement 564

- Cement from Mix A comes from China – larger CO₂ footprint

Myth Busters

Mix A	Mix B
Material (lb/yd ³) Cement 564	Material (lb/yd ³) Cement 479 Fly Ash 85

- California project – no fly ash
- Fly ash comes from east of Mississippi
- Fly Ash has a carbon footprint

Mix A	Mix B
Material (%) Recycled Concrete 0	Material (%) Recycled Concrete 20

- Depends on recycler efficiency and distance

So how does one know which mix is more sustainable???

Measuring Sustainability



Challenge: many sustainability activities are actually "Greenwashing"

Green-wash (gren'wosh', -wōsh') – verb: the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service.

Solution: the ability to measure and compare the environmental impacts of a product or service differentiates one from another.

Eco-Efficiency Analysis is a credible methodology that achieves that goal.

Eco-Efficiency Analysis

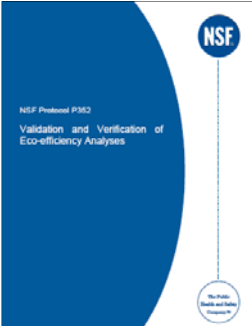


Eco-Efficiency Analysis is a strategic life cycle methodology for comparing the relative ecological and economic efficiencies of alternative

- ❖ **Products** (like baby diapers or concrete)
- ❖ **Processes** (curing compounds or steam curing)
- ❖ **Technologies** (automobiles or motorcycles)

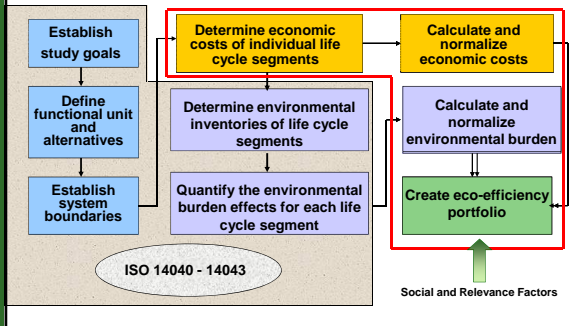


NSF Protocol P352



- Considers EEA methodologies developed for evaluation at the product category level.
- Relies on concepts outlined in LCA standards developed by ISO.
- Protocol divided into two parts:
 - Validation of an EEA methodology
 - Verification of EEA studies

Developing EEA using NSF Protocol P352

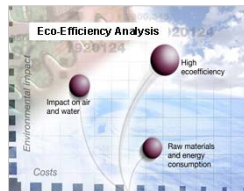


A Tool for Concrete

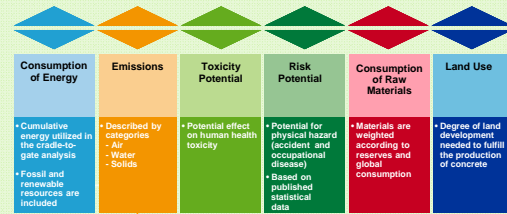


Eco-Efficiency Analysis quantifies the economical and ecological impact of concrete mixes

1. Customized Interactive Program specifically for concrete mix designs
 - Data gathered from vendors, Industry Associations, Government Databases, Contract Consultants
2. Evaluates environmental and economical impact of concrete ingredients based on input
3. Quantifies environmental and economical impact for each mix
4. Compares up to five different concrete mix designs for six environmental impact areas

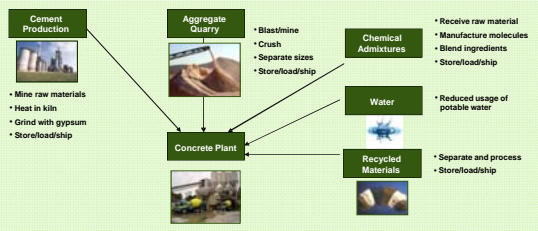


Environmental Impact Categories



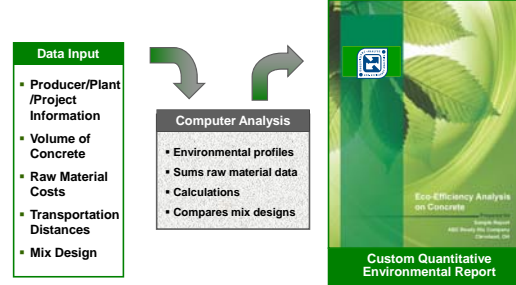
Global Warming Potential
Ozone Depletion Potential
Photochemical Ozone Creation Potential
Acidification Potential

Eco-Efficiency Analysis for Concrete Cradle-to-Gate

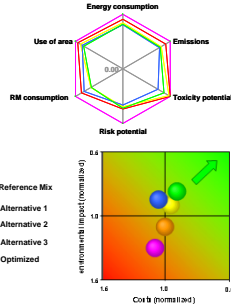


EEA concrete analyses can be conducted on ready mixed, precast, manufactured concrete products, highway paving, self-consolidating and pervious concrete.

Conducting an Eco-Efficiency Analysis



Eco-Efficiency Analysis (EEA) Program Results



Ecological Fingerprint
The four concrete alternatives are progressively more environmentally preferable.

EEA Profile
Optimized concrete has the lowest overall environmental burden and is the most economical to produce.

One World Trade Center, New York (Freedom Tower)



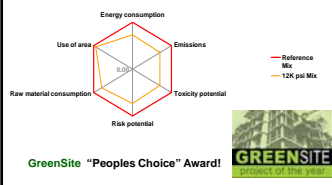
- Optimized mixes used in columns
 - 12,000 and 14,000 psi column designs
 - SCC high strength mixes
 - 38,000 yd³ thru 40 floors
- Eco-Efficiency Analysis performed



Photo Credit: Joe Woolhead

Parameter	Reference Mix	14K psi Mix	Savings (%)	Reference Mix	12K psi Mix	Savings (%)
Energy (kWh/yd ³)	833	619	26%	806	588	27%
Res. Consumption (lb/yd ³)	102	82	20%	100	79	23%
Fossil Fuel Consumption (lb/yd ³)	36	28	22%	36	27	25%
GWP (lbCO ₂ e/yd ³)	785	459	42%	760	440	44%
POCP (lb ethene eq/yd ³)	0.150	0.140	7%	0.15	0.140	7%
AP (lbSO ₂ e/yd ³)	5.0	3.0	40%	5	3.0	40%
Water emissions (gal/yd ³)	349	297	15%	351	286	18%
Solid Waste (lb/yd ³)	95	80	16%	90	80	16%
Land Use (ft ² /yd ³)	252	242	4%	254	240	5%

One World Trade Center, New York (Freedom Tower)



Category	Environmental Parameter	14K psi Mix	12K psi Mix	Total	Practical Equivalent Savings	14K psi Mix	12K psi Mix	Total
Energy	Energy (kWh)	1,285,900	6,973,754	8,259,654	Homes (homes/year)	111	603	714
Carbon Footprint	Air Emissions (lb CO ₂ equiv.)	1,955,536	10,237,787	12,193,323	Forest (acres/project)	1,111	5,817	6,928
Acidification Potential	Air Emissions (lb SO ₂ equiv.)	12,426	65,523	77,949	Air Conditioners (number/year)	828	4,368	5,196
Solid Waste Generation	Solid Emissions (lb)	92,786	332,221	424,977	Solid Waste (personals/yr)	18,651	86,444	84,995
Fossil Fuel Consumption	Fossil Fuel (lb)	111,352	637,723	749,075	Barrels of Oil Saved on Project	1,463	8,163	9,626

Benefits of Eco-Efficiency Analysis

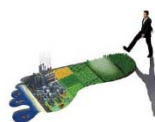


- Demonstrate the economic and ecological benefits of optimized mixes
 - ❖ Increase attractiveness to stakeholders
 - ❖ Support sustainability initiatives
- Quantify the ecological impact of optimized concrete mixes
 - ❖ Community/social sustainability acceptance
 - ❖ Market acceptance of green concrete
 - ❖ Position industry as leaders in sustainable construction
 - ❖ Specification changes to more sustainable mixes
 - ❖ Project acquisition where sustainability is required/desired

Eco-Efficiency Analysis for Concrete



- Is so much more than a CO₂ footprint.....
- Is so much more than LEED points.....
- Eco-Efficiency Analysis
 - ❖ measures multiple environmental categories
 - ❖ addresses economics
 - ❖ includes social relevance
 - ❖ provides comprehensive environmental impact data to make good decisions on sustainability based on facts!



Thank You!

