

# Concrete and the Environment





## The Nobel Peace Prize 2007

"for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change"



**Intergovernmental  
Panel on Climate  
Change (IPCC)**



Photo: Scanpix/Tom Hevezi

**Albert Arnold (Al)  
Gore Jr.**



## Concrete and the Environment

There is increasing concern now that the choice of construction materials must also be governed by ecological considerations.



## Population Growth

- At the **beginning of the 20th Century**, the world population was **1.5 billion**; by the **end of the 20th Century** it had risen to **6 billion**.
- Considering that it took **10,000 years** after of the last ice age for the population to rise to the **1.5 billion mark**, the rate of growth from 1.5 to 6 billion people is remarkable



## Urbanization

- At the **beginning of the 20 th Century**, approximately **ten percent** of the people lived in cities; in the year **2001** nearly **three of the six billion** inhabitants live in and around the cities.



## Technology Choices

- Unfortunately, our technology choices have turned out to be wasteful because decisions are based on short term and narrow goals of the enterprise rather than a holistic view of the full range of consequences from the use of a technology.



## Waste

- **Only 6%** of the total global flow of materials, some **500 billion tons a year**, actually ends up in **consumer products** whereas much of the virgin materials are being returned to the environment in the form of harmful solid, liquid, and gaseous wastes



## Environmental Impact of Technology Choices

- The greatest environmental challenge today is that of the human-made climate change due to global warming caused by steadily rising concentration of green-house gases in the earth's atmosphere during the past 100 years





## A new vision

- In a **nature-centered capitalism**, the environment will no longer be treated as a minor factor of production but rather an envelope containing, provisioning, and sustaining the entire economy.



## Future Demand for Concrete

- Ordinary concrete, typically, contains about 12 percent cement, 8 percent mixing water, and 80 percent aggregate by mass.
- This means that, in addition to 1.5 billion tonnes of cement, the concrete industry is consuming annually 9 billion tonnes of sand and rock together with one billion tonne of mixing water.

# TWO MAJOR CHALLENGES

## Challenge I: Environmental Impact

World demand/year

- 11.5 billion ton of concrete
- 1.5 billion ton of cement
- 1 billion ton of water
- 9 billion ton of aggregate

## Consequences (1)

1.5 billion ton of cement

- Generates 1.5 billion ton of CO<sub>2</sub>
- Responsible for 5% CO<sub>2</sub> production in the world

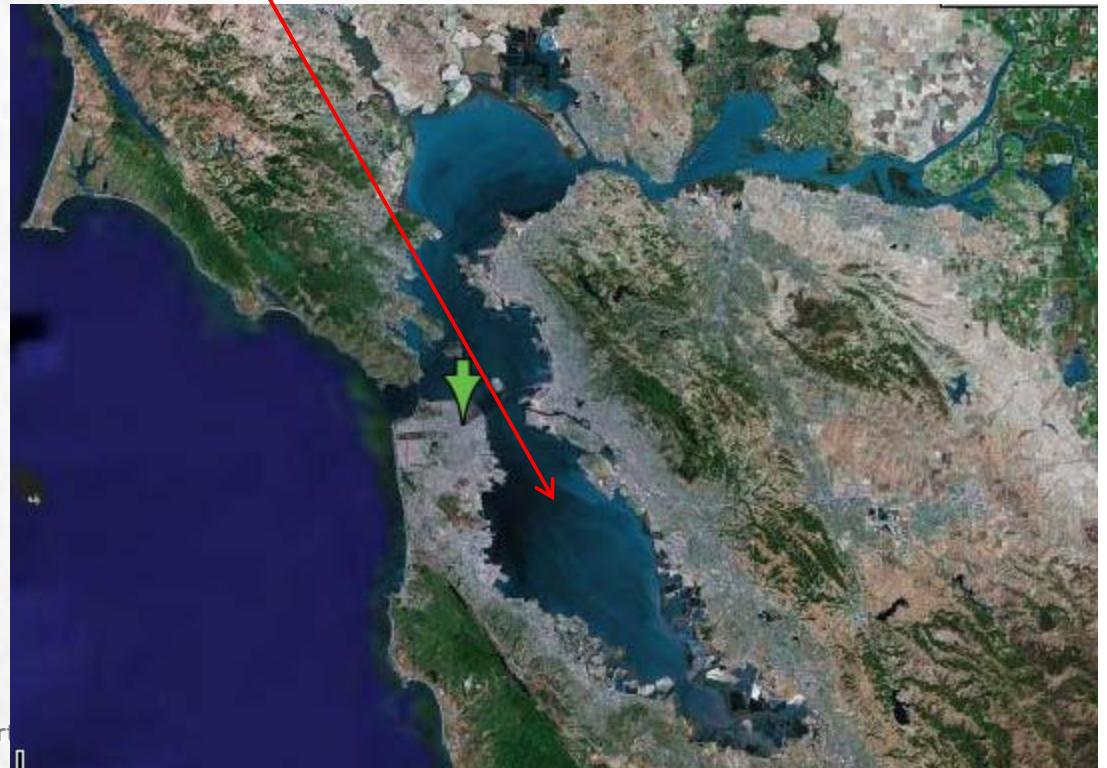


**Problem!**



Consequences (2)

- 1 billion ton of water  
110,000 times the amount of water in  
the SF Bay





Consequences (3)

9 billion ton/y of aggregate

Depletion of natural resources

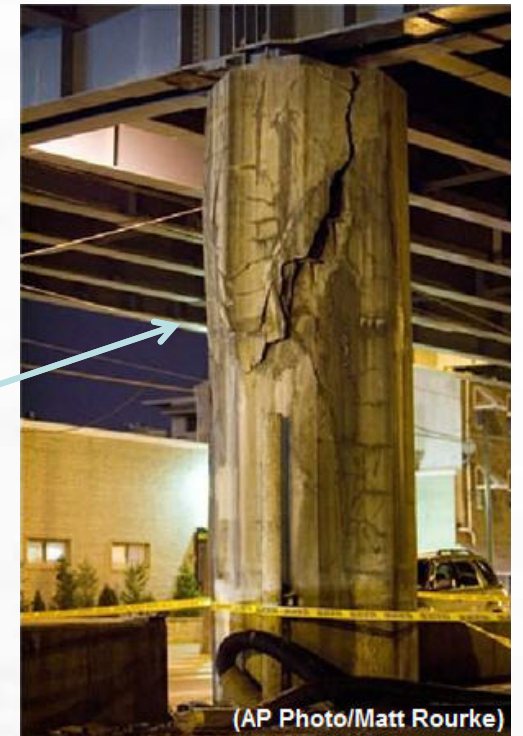


## Challenges

- Challenge II: Long-term durability
- Civil Infrastructure quickly deteriorating

*Of the 597,340 bridges in this country, 73,784, or about 12.4 percent, are structurally deficient.*

March 17,  
2008,  
I-95 in  
Philadelphia





## Major deterioration

- Corrosion of reinforced concrete
- Sulfate attack
- Alkali silica reaction
- Hot weather



# Concrete and The Environment



## Durability (lack of): Sixth Street Viaduct

**SIXTH STREET VIADUCT**

The Sixth Street Viaduct was aligned to provide a smooth transition from Whittier Boulevard to East Sixth Street. Monumental piers on the approach announce the beginning of the bridge to the driver. The nearly mile-long bridge spans the Los Angeles River, multiple railroad tracks, and many streets.

River Span Elevation

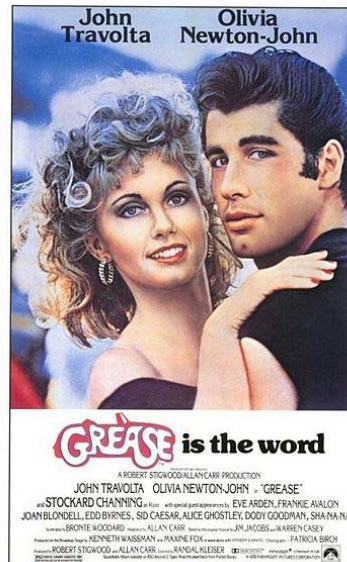
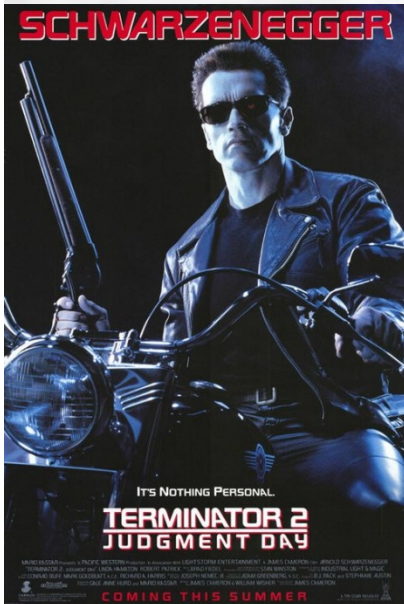
Restoration

VIADUCT  
32  
BUTLER  
ST  
AND  
6TH  
ST  
DETROIT

# Concrete and The Environment

## Facts

- National Historic Structure
- Daily Traffic: 11,000 Vehicles





## Big Durability Problem

- Every 10 Years –
- City Must Apply Epoxy
- Injection and Patching
- Now facing replacement





### Future Demand for Concrete

- The 11.5 billion tonnes-a-year concrete industry is thus the largest user of natural resources in the world.
- The demand for concrete is expected to grow to approximately 18 billion tons (16 billion tonnes) a year by 2050.
- The mining, processing, and transport of huge quantities of aggregate, in addition to billions of tons of raw materials needed for the cement manufacture, consume considerable energy and adversely affects the ecology of virgin lands



## Future Demand for Concrete

- Both in developed and developing countries, gigantic construction projects are underway in the metropolitan areas not only for new construction but also for rehabilitation or replacement of existing structures.



## Reducing the Environmental Impact of Concrete

- Portland cement is a product of an industry that is not only energy-intensive but also responsible for large emissions of CO<sub>2</sub> -- a major green-house gas.
- The manufacture of one ton of portland-cement clinker releases a ton of CO<sub>2</sub> into the atmosphere.
- The world's yearly cement output of 1.5 billion tonnes of mostly portland cement, accounts for nearly 7 percent of the global CO<sub>2</sub> emissions.



## Industrial ecology

- The waste product of one industry is recycled as a substitute for virgin raw material of another industry, thereby reducing the environmental impact of both.



## Opportunities

- Over a billion tons of construction and demolition wastes are being disposed of in road-bases and landfills every year, in spite the fact that cost-effective technologies are available to recycle most of it as a partial replacement for coarse aggregate in concrete mixtures.





## Opportunities

- Most waste-waters and undrinkable natural waters can be substituted for municipal water for mixing concrete unless proven harmful by testing.



## Opportunities

- Blended portland cements containing fly ash from coal-fired power plants and granulated slag from the blast-furnace iron industry provide excellent examples of industrial ecology because they offer a holistic solution to reduce the environmental impact of several industries.

Concrete and The Environment



# Technology for Sustainable Development





## Technology for Green Concrete

- The high-volume fly ash provides a promising of how we can build concrete structures in the future that would be far more durable and resource-efficient than those made of conventional portland-cement concrete.
- Whether as a component of blended cements or as a mineral admixture added to concrete during mixing, the fly ash content of HVFA concrete mixtures is typically between 50 to 60 percent by mass of the total cementitious material.



## A Better Concrete in the Future

- Although as a structural material concrete generally has a history of satisfactory performance, it is expected that even a better product will be available in the future owing to overall improvements in elastic modulus, flexural strength, tensile strength, impact strength, and permeability.



## Better concrete

- A reduction of the water content in a concrete mixture decreases the porosity of both the matrix and the interfacial transition zone and thus has a strengthening effect.
- Again, the presence of a pozzolan in a hydrating cement paste can lead to the processes of pore-size and grain-size refinement



## Improved concrete (1)

- A better control of the bleeding tendency in concrete mixtures will be sought through proper aggregate grading, and the use of water-reducing and mineral admixtures (e.g., fly ash or finely ground natural pozzolans or slags).



## Improved concrete (2)

- Fiber reinforcement of concrete that is subject to cyclic or impact loads will be commonly practiced. For developing countries, the use of natural organic fibers (such as sisal fiber and rice straw) presents interesting possibilities.





## Improved concrete (2)

- The use of centralized and high-speed concrete mixers instead of truck mixing will help in the production of more homogeneous concrete than is generally available today.