SUSTAINABILITY OF THE CEMENT AND CONCRETE INDUSTRIES

By

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Reduce, reuse, and recycle for sustainable developments.
Minimize use of manufactured materials.
Maximize environmental benefits: clean air, clean water, and resource conservation.
Basic Approach

WASTE is wasted if you waste it, otherwise it is a resource. Resource is wasted if you ignore it and do not conserve it with holistic best practices and reduce societal costs. Resource is for the transformation of people and society.

Focus on turning brown fields into green fields of the 21st Century.
Basic Approach

Recycle. Recycle as is.

Recycle without additional processing, (i.e., without adding any cost to it).
According to the World Commission on Environment and Development, Brundtland Report 1987, sustainability means “Meeting the needs of the present without compromising the ability of the future generations to meet their own needs.”

My definition: would the current resources last 200+ plus years? If yes, then the resource is sustainable. If not, we are leaving our challenges for someone else.
• **Sustainability** is an idea for the concern of the well-being of our planet with continued growth and human development.

• For example, if we **run out of limestone (calcite not dolomite)**, as it is predicted to happen in some places, then we cannot produce portland cement and, therefore, we cannot produce concrete; and, all the employers associated with the **concrete industry** goes out-of-business, along with their employees.
Sustainable Cement and Concrete

Entire geographical regions are running out of limestone resource to produce cement.

Major metropolitan areas are running out of sources of aggregates for making concrete.
A sustainable concrete structure is one that is constructed so that the total societal impact during its entire life cycle, including during its use, is minimum.

Designing for sustainability means accounting in the design the full short-term and long-term consequences of the societal impact. Therefore, DURABILITY is the key issue.

New generation of admixtures/additives are needed to improve durability.
Infrastructures are Dependent on Durable Concrete
AKITA TUNNEL

Traffic tunnel being built in Akita, Japan (2001 – 2007) is expected to cost about 625 million USD (about 70 billion Yens). If it is not constructed as a durable infrastructure, with a minimum life-cycle cost, then say 45 years from now, in 2050 it would cost 700 billion Yen (?).

2004 cost is 5 USD (550 Yens) per person in Japan (Population: 127.6 million, in May 2004; down 50,000 from a year ago, The Japan Times, Oct. 21, 2004). If the population of Japan, as expected in 2050 is 100 million, then it would cost 7,000 Yen per person to re-build this tunnel. Would it be re-built?
Environmental Issues

The production of one ton of portland cement releases approximately one ton of CO$_2$ and other greenhouse gases (GHGs) into the atmosphere.
In the last 2 yrs. CO2 has increased at a higher rate than expected (The Japan Times, Oct. 21, 2004).

Nitrous Oxide Emissions

For each ton of portland cement clinker, 3 to 20 lbs. of NOx are released into the atmosphere. Assuming 10 lbs of NOx per ton of clinker, this equals 8 million tons of NOx due to 1.6 billion tons of clinker.

Yomiuri Shimbun reported from Kobe, Japan that: “The Hyogo prefecture government on (Oct. 1, 2004) banned automobiles with emissions of nitrogen oxide (NOx) and particulate matter that exceed levels set in a law concerning these emissions from traveling in certain parts of the prefecture.”
TOO HOT!!

Hindustan Times, New Delhi, India, November 15, 2004.

• GHGs (not the sun) “melt most of the ice covering the earth, from the Himalayas to the polar caps.” Although (other) environmental threats (e. g., effects on rain forests) are dangerous, “the global glacier melt is the most dangerous.”

• “When the Greenland icecap goes, sea levels rise 24 feet; when the Antarctica melts, it will be another 370 feet.” New York and Mumbai are on the edge of the sea.

One deg. C temperature rise reduces rice yield by 10% (Milwaukee Journal Sentinel, June 29, 2004).
Concrete is environmentally very friendly material.

As good engineers, we must use more of it in construction.
Portland Cement is not environmentally very friendly material.

As good engineers, we must reduce its use in concrete; and, we must use more of other cementitious materials.
As good engineers, we must reduce the use of water; and, we must use more organic, liquid or powder admixtures.
Environment, Energy, and Economy Related Issues in the Production of Portland Cement
Sources of CO$_2$ Emissions in the Manufacturing of Portland Cement Clinker

- From calcinations of limestone $= \pm 50 - 55\%$

- From fuel combustion $= \pm 40 - 50\%$

- From use of Electric Power $= \pm 0 - 10\%$
After aluminium and steel, the manufacturing of portland cement is the most energy-intensive process.

The manufacturing of portland cement requires about six million BTU of energy per ton (equivalent to about $\frac{1}{2}$ ton of coal).
Economic Issue

The cost of a new portland cement plant is in the order of 250+ million dollars per one million ton of installed capacity.
Resource Conservation

The production of one ton of portland cement requires 1.6 tons of raw materials. These materials are primarily good quality limestone/calcite and clay.

Therefore, for 1.6 billion tons of cement annually we need about 2.5 billion tons of raw materials.
SOLUTION

As good engineers, we must use more environmentally friendly other cementitious materials in concrete.

Use fly ash, granulated b. f. slag, silica fume, natural pozzolans, rice-husk ash, wood ash, and agricultural products ash.

Use more application specific high-quality, durable aggregates, and organic admixtures.

Use less water.
Extinct Homo Sapiens
2500 BC - 2100 AD ?

Cause of death :

Friendly fire; by excessive GHG emissions and excessive use of natural resources, including water and cement.
Hannover Principles

Hannover Principles by William McDonough (1992):

• Insist on rights of humanity and nature to co-exit.
• Recognize interdependence.
• Respect relationships between spirit and matter.
• Accept responsibility for consequences of design.
Hannover Principles (Cont’d)

• Create safe objects of long-term value.
• Eliminate the concept of waste.
• Rely on natural energy flows.
• Understand the limitations of design.
• Seek constant improvement by the sharing of knowledge.
“We (over) extract from earth what the planet can replace by an estimated 20%, meaning it takes 14.4 months to replenish what we use in 12. Sustainable developments works to reduce that.”

• In USA, concrete construction provided 2,000,000 jobs in 2002.

• The concrete industry provides employment to many skilled employees, including batch plant operators, truck drivers, ironworkers, laborers, carpenters, finishers, equipment operators, and testing technicians, as well as professional engineers, architects, surveyors, and inspectors.

• “When the well’s dry, we know the worth of water.” Benjamin Franklin said over 200 years ago in Poor Richard’s Almanac.
“The issue is not environment vs. development or ecology vs. economy; the two can be (and must be) integrated.”

“We have the human and material resources needed to achieve sustainable developments, not as an abstract concept but as concrete reality”.

Kofi Annan, U. N. Secretary-General, Johannesburg, South Africa, August 2002.
Conclusions

Recycling not only helps in reducing disposal costs, but also helps to conserve natural resources, providing technical and economic benefits. This is sustainability.
• Eliminate waste and take life-cycle responsibility/ownership.

• Think Ecology, equity, and economy.

• Acknowledge and balance the Triple-Es.
• Use less portland cement.

• Use blended cements with pozzolanic additives.

• Use less water.

• Use applications specific high-quality, durable aggregates.

• Use organic chemical admixtures.
La Bella Terra

Center for By-Products Utilization
Thank you very much for your interest.
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