# Sustainability and Concrete Technology

by

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# Sustainability as defined in Brundtland Report 1987

"Development that meets the needs of the present without compromising the ability of the future generations to meet their own needs"

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# Report by Environmental Protection Agency (EPA) of the U.S.A.

- In a climate change progress report to the United Nations, the EPA found that:
- Greenhouse gases are accumulating in the earth's atmosphere as a result of human activities, causing global mean surface temperatures and sub surface ocean temperatures to rise.
- It reported that the U.S. greenhouse gas emissions increased 12 per cent over the course of the 1990's, and that average U.S. temperature can be expected to rise three to five degrees Celsius over the course of the next hundred years.

Globe and Mail, June 4, 2002

# 1997 Kyoto Protocol

**Main Thrust :**

**The developed countries agree to stabilize the GHG emissions to about 6% below the 1990 level by the year 2012.**

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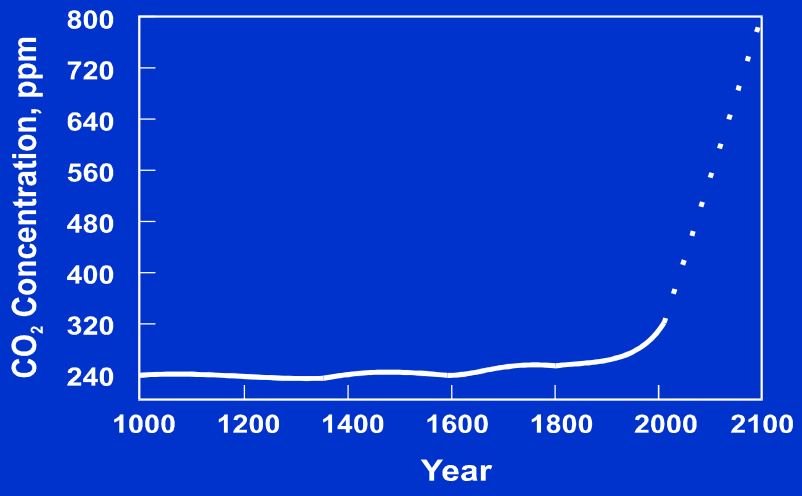
## Historical and Projected $CO_2$ Levels




## Nitrous Oxide Emissions

**For each tonne of portland cement clinker, 1.5 to 9.5 kg of NOx are released into the atmosphere. Proposed limit in Canada is 2.3 kg of NOx per tonne.**

**In 2000, the worldwide cement clinker production was approximately 1.6 billion tonnes. This results in a release of 3.7 million tonnes of NOx . This is equivalent to 1/5 th of the NOx released in all of Asia in a year.**

## $CO_2$ Emissions by Industrialized Countries in 2002

| Country | % |
|---|---|
| U.S.A. | 25 |
| E.U. | 20 |
| Russia | 17 |
| Japan | 8 |
| China | > 15 |
| India | > 10 |

Total $CO_2$ emissions worldwide ~ 21 billion tonnes

## Global Temperature Rise

The Inter-governmental Panel on Climate Change (IPCC) meeting in Geneva recently warned that the average temperature is expected to rise between 1.4 and 5.8 °C over the next 100 years. Only five years ago, the panel had predicted a maximum temperature rise of 3.5 °C over the same period.

The average global temperature has risen only 0.6 °C over the past 100 years.

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**Concrete**
**is environmentally very friendly material.**

**As good engineers, we must use more of it in construction.**

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**Portland Cement**
**is environmentally very unfriendly material.**

**As good engineers, we must reduce its use in concrete.**

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# Environment, Energy and Cost Related Issues in the Production of Portland Cement

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## Environmental Issues

The production of one tonne of portland cement releases approximately one tonne of $CO_2$ into the atmosphere.

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## Sources of $CO_2$ Emissions in the Manufacturing of Portland Cement Clinker

- From calcination of limestone = ± 50 - 55%
- From fuel combustion = ± 40 - 50%
- From use of Electric Power = ± 0 - 10%

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## Energy Related Issues

- After aluminium and steel, the manufacturing of portland cement is the most energy-intensive process.
- The manufacturing of portland cement requires about 4 GJ of energy per tonne of the finished product.

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## Cost Related Issues

The cost of a new portland cement plant is in the order of 175 million dollars per one million tonnes of installed capacity.

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## World Cement Production to Year 2010

| Year | World total (million tonnes) |
|---|---|
| 1995 | 1,396 |
| 2000 | 1,662 |
| 2005 | 1,839 |
| 2010 | 1,946 |

## World-wide Cement Production and $CO_2$ Emissions

| Year | Cement Production, billion tonnes | Total $CO_2$ Emissions, billion tonnes | $CO_2$ Contribution by cement Industry, % |
|---|---|---|---|
| 1995 | 1.4 | 21.6 | 7 |
| 2010 | 1.9 | 28 - 30 | 7 |

## Resource Conservation

The production of one tonne of portland cement requires 1.55 to 1.60 tonnes of raw materials. These materials are primarily good quality limestone and clay.

Therefore, for 1.6 billion tonnes of cement annually we need 2.5 to 2.6 billion tonnes of raw materials.

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## So what is the solution ?

As good engineers, we must use more environmentally friendly Supplementary Cementing Materials in concrete. These materials are :

- Fly Ash
- Granulated B.F. Slag
- Silica Fume
- Rice-husk Ash
- Natural Pozzolans

## Reduction of $CO_2$ Emissions by Increased use of Fly Ash

- Replacing 15% of cement worldwide by SCM will reduce $CO_2$ emissions by 227 million tonnes.
- Replacing 50% of cement worldwide by SCM will reduce $CO_2$ emissions by 750 million tonnes. This is equal to removing 1/4 of all automobiles in the world.

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## Some Coal Facts

Those who thought coal use was a thing of the past will be surprised by the following statistics :

- Rather than declining, coal demand grew by more than one billion tonnes from 1980 to 1995. About half the global coal production is destined for the electricity market, with steel and cement manufacturing the other two prominent uses.
- Coal is a major part of world energy reserves supplying over 25% of the total global primary energy demand.

Source: The World Coal Institute and the Coal Association of Canada

## Some Coal Facts (cont'd)

- North America has about 25%of all the world's coal, and uses about 24%. Conversely, North America has about 6% of the world's reserves of gas, and uses about 33%.
- Canada's coal industry generates, directly and indirectly, employment for 73,000 Canadians.
- Canada's coal industry annually generates $ 5.8 billion.

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## Some Coal Facts (cont'd)

- Currently, about 36% of the electricity generated world-wide is produced by coal. However, some countries use more coal than others. The U.S. share (in usage) is about 57%, India's is about 75%, China sits a 80%, and South Africa is more than 90% dependent on coal for its electricity. In Alberta, 81% of electricity is coal-fired, the highest percentage for any Canadian province.

- Coal has extensive reserves, and is mined in over 50 countries.

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## Fly Ash Availability and Portland Cement Production in India in 2002/2010

Fly ash availability:

Estimated availability: 80 to 100 million tonnes

Estimated availability in year 2010: 180 to 200 million tonnes

Portland cement production:

Estimated availability in 2002: 80 million tonnes

Estimated availability in 2010: 120 million tonnes

## Fly Ash in India
## What to do with it ?

You cannot feed it to the holy cows (even though they are undernourished) because cows do not like it.

You cannot dump it in the oceans because fish do not eat it.

You cannot dump it on the ground because environmentalists will not allow it.

So what is the solution ?

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## The Solution to the Fly Ash Problem in India

Use it in very large volumes to replace portland cement in concrete, i.e. use HVFA concrete developed at CANMET in Canada in the 1980's.

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## Primary uses of HVFA concrete in India

- Interstate highway system (both for the pavement and the base course)
- Secondary roads using roller-compacted concrete
- Low-cost subsidized housing
- Structural concrete for buildings
- Development of added value products by beneficiating fly ash to replace imported silica fume

## Why Fly Ash is Ideal for the Interstate Highway System and Secondary Roads ?

HVFA is more durable than asphaltic concrete and needs almost no maintenance.

The design of a highway pavement is based on flexural strength and HVFA concrete keeps gaining strength with age (a built in safety factor).

There is no reinforcing steel in pavement concrete and roller compacted concrete. Thus the corrosion of steel is a non issue (a point always raised, though erroneously, by Indian engineers).

It increases fuel efficiency of transport trucks by 11%, resulting in cost savings and lower exhaust emissions..

HVFA concrete is competitive with asphaltic concrete even on first-cost basis.

# New Technologies in the use of Fly Ash in Concrete

A. Development of high-performance high-volume fly ash concrete by CANMET in 1985

B. High-volume fly ash blended cements

Typical Characteristics :

1. 60% of Portland cement is replaced by fly ash in concrete
2. Long-term strength and durability of high performance high-volume fly ash concrete is equal to or superior to control Portland cement concrete

# Extinct Homo Sapiens 2500 BC - 2100 AD ?

Cause of death :

Self inflicted by excessive GHG emissions and excessive use of natural resources, including water and cement.

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