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ENVIRONMENTAL ANALYSIS PROGRA

"Those who contemplate the beauty of the earth find reserves of strength that will er

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A Survey of the Environmental Impacts of the Cement Industry

by Nick Hawkins, '04

Introduction

Cement is ubiquitous in the United States and throughout the developed world. The moc modern city could not exist without it. Cement is the key ingredient in many key parts of and canals. Nearly all construction involves cement in some way. The volume of worldwide than 1.7 billion tons of cement is produced annually; per capita, that works out to be abc (Pearce, 2002).

The environmental impacts of the cement industry are significant on both a global and a loc these impacts. It will also present some methods by which the environmental impacts of cem

A few definitions are necessary for clarity. Cement is an inorganic substance with binding pr materials like concrete (Martin and others, 1999). The product technically referred to a cement with calcium silicates as its primary is a hydraulic cement with calcium silicates as it majority of all cement produced worldwide. Throughout this article, unless stated otherwis of portland cement.

The Cement Industry and Global Warming

The cement industry is an important contributor to global warming, with estimates of to (Philipson and others, 1999). Given the difficulty of assessing the contribution of a single ir uncertainty implied by this range should be expected. However, it is universally acknowl energy intensive process that releases large amounts of carbon into the atmosphere, what contributes.

A brief outline of the cement manufacturing process at a typical American cement plant is r global warming. Cement kilns, where cement is manufactured, are usually located near a lin calcium-rich mineral. Limestone, chalk, and other calcite ($CaCO_3$) bearing rock are crushed crushed rock is combined with clay and is burned in a furnace to achieve calcination. Cal calcium carbonate goes to calcium oxide (lime), and carbon dioxide is liberated ($CaCO_3$ C the clay breaks down to aluminum oxide and iron oxide. The minimum temperature need gulping 1640 degrees farenheit.

After calcination, the lime is then combined with an iron ore and silica sand. The mix chemically with the iron ore and silica. The minimum temperature needed for this process i of this process is called clinker. Clinker is combined with several additives and ground t product - portland cement.

The bulk of the carbon emitted in the cement manufacturing process comes from the C02
and the carbon emitted by burning of fossil fuels to bake the clinker. According to a repor
Association, in the average American cement kiln manufacturing one ton of cement re
equivalent to about 400 pounds of coal (Richardson, 2002). According to other analyststhe
GJ per ton, which converts to 5.3 million Btu/ton (Martin and others, 1999). Coal is the
industry; this has important implications for more local air pollution, which will be discu
released per unit energy produced by coal than is released by other fossil fuels.

Worldwide Trends in Cement Production and Global Warming

The cement industry is a core industry in developed countries. Cement is a staple of r
inconceiveable. This fact is important because given current trends we can expect cement
forms of industrialization in poorer nations over the next few decades. In fact since cemen
that uses raw materials that are quite abundant, it is reasonable to expect cement productio
be more closely correlated with population growth than GNP or any other measure of econ

China is now, by far, the world's largest producer of cement. Annual cement production vo
annual production in Japan or the U.S. - the second and third place nations. As poorer co
and more adequate housing for their citizens, cement production will surely increase. F
poorer nations will also drive an increase in cement production (Philipson and others, 1999).

Cement production trends in several developing countries offer insight into what can be ex
countries. The growth rate of China's cement industry over the period from 1970 to 1995 is
out to 12%. Growth rates of the industry in Brazil and Mexico, two countries with a
development average to 4.5% over the period. The average rate in India was 6.6% (Philipson

Cement production in China is therefore the most influential on worldwide carbon
Unfortunately, fairly inefficient cement manufacturing processes predominate in China. Small
kilns produce much of the cement in China, and these kilns are generally inefficient when
(Philipson and others, 1999).

The United States also relies heavily on inefficient cement production processes. Remarl
found that the United States' cement industry is less energy efficient than the cement ind
cement production, where the crushed, raw ingredients of cement are fed into the kiln a
cement produced in the U.S. in 1995 (Philipson and others, 1999). This process is extremel
is wasted evaporating water from the slurry. It should be noted that this process has been
States to attempt to rein in carbon emissions, targeting the cement industry would be an ob

Opportunities for Carbon Reductions in the US Cement Production

Martin, Worrel and Price of the Lawrence Berkley lab wrote a report (1999) discussing opp
in the U.S. cement industry. Much of the information in the folllowing sections relates
efficiency has improved over time in the U.S., and carbon emissions have dropped. In 1970,
was 7.9 GJ per ton of cement (which converts to 7.5 Btu/ton), and total carbon dioxide emi
per ton of cement, were 0.29 ton per carbon per ton. By 1997 energy intensity had droppec
carbon emissions had dropped 17% to 0.24 carbon per ton per cement.

Current Best Practices

In general, cement is produced with greatest energy efficiency and the least emission of
multistage process of baking the cement. Waste heat is utilized to preheat the powdere
process. Additionally, waste heat may be used to generate electrical power. A multi-stage,
machinery like rock crushers and conveyer belts is what constitutes the best current industr

In addition, current industry practices include the production of blended cements, which ha
per ton of cement. The production of blended cement is increasing. Currently blended ce
parts of Asia, but they make up a miniscule share of the American cement market (Marti

made by mixing materials like fly ash (a byproduct of coal combustion), blast furnace sla natural volcanic ash with finished clinker. The resulting product has similar properties to n used for most of the same purposes. However, by supplementing the cement with fly ash o needed per ton of cement. This significantly improves energy efficiency and lowers carbor process is the most energy intensive process and where most of the carbon is emitte Association of data from 1996 showed that it would have been possible to produce 36% of the U.S. that year as blended cement. Potential production was determined by analyzing the furnace slag easily available and the feasible marketability of the finished product (Martin a blended cements is a feasible way to significantly lower carbon emissions.

In addition to potential improvements in the cement industry through the adoption of cu many advanced technological solutions that are highly promising. These are all, however, still before they are widely available, if ever.

Advanced Technological Solutions
There are several promising developments which could increase energy efficiency and de cement industry. Cement kilns using fluidized bed technology could potentially lead to emissions and air pollution. According to the U.S. (http://www.fe.doew.gov/coal_power/fluidizedbed/index.shtml): fluidized beds suspend solid the combustion process. The result is a turbulent mixing of gas and solids. The tumbling ac more effective chemical reactions and heat transfer.

Energy savings using the process of cement production promise to be significant, as do pollution emissions. This process, however, is still years away from being comercially viable (

In addition, several portland cement alternatives exist in the research stage that are comp cement. These all have the promise of requiring less energy to produce and releasing less C are one possible replacement for portland cement. Mineral polymers can be made from ino and others, 1999) and have essentially the same properties and strength as concrete. T polymers would be that it requires lower temperatures to produce them compared wit development in these products is needed.

According to the magazine New Scientists, work is currently being done to develop a carbonate. It is claimed that production of this cement would be less energy intensive and le the course of its lifespan it would actually absorb more carbon than was emitted during pr potentially promising development.

Finally, it is important to consider the potential of renewable energies (wind and solar) industry. Though information regarding the potentials of hydrogen and renewable energy find, one would expect renewable energies to make the cement industry much more energy/hydrogen economy eventually develops, as theorists like Jeremy Rifkin predict, the c industry - would be revolutionized. However, the idea appears to be considered pie in generally unmentioned in analyses of the cement industry.

Opportunities for Carbon Reductions in Cement Production of Developing Natio
Philipson and others (1999) detail opportunities for decreasing cement-associated emiss technological techniques and industrial improvements to reduce CO2 emissions in the dev discussed above. It was found that China was the furthest from the best available industr associated with cement production are 37% higher than the amount of carbon that wo practices. India, Mexico, and Brazil's total cement-associated emissions exceeded the sa respectively.

Discussing methods to induce poorer nations to reduce their emissions is beyond the scope like international emissions trading to be set up to encourage carbon emissions reductions, emissions can readily be gotten in the cement industry. Similarly, were the U.S. to sign emissions on its own, the U.S. cement industry is ripe for modernization and improvement.

Localized Enivornmental Impacts
The good news about cement kilns is that they are usually located near a quarry, and are t news is that cement kilns are exceedingly bad neighbors for the people and the organism effect (localized compared to the global effects of CO2 emissions) is air pollution. Besi pollution is associated with cement kilns. As mentioned previously, coal and coke are the p (Martin and others, 1999). With these fossil fuels, especially coal, one sees the usual a deposition from sulfur dioxide and nitrogen oxides emissions, fine particulate matter emiss specific to cement plants is the emission of cement kiln dust (CKD). So called fugitive powdered material in the cement kilns can release large amounts of CKD, which is compo can be suspended in the air. Such small particulate matter is a suspected carcinogen, a Windborne dust from piles of CKD can cause much light-colored, silver-gray air pollution. and water contamination (Missouri Coalition for the Environment, 1999).

Due to a gap in EPA enforcement, since the 1970's cement kilns have been allowed to bu subject to less stringent emissions standards than toxics incinerators (Shipley, 2002). This lo industrial solvents, used motor oil, and other materials of fuel classified as hazardous waste (by observers vary. While burining the waste to produce cement does utilize energy assoc otherwise be wasted, the emissions from the burning of these materials can be quite nasty leads to elevated emissions of heavy metals like lead and cadmium and toxic organic chemica

This year the EPA instituted new regulations which essentially close the loophole. Starti hazardous waste will have to meet emissions standards equivalent to those for toxic inciner environmentalists be vigilant in monitoring how enforcement of the new regulations progres

It is possible to hope that the new regulations will in themselves indirectly reduce the ca Many of the cement kilns burning hazardous waste are older, less efficient kilns (Richards they are provided a free source of fuel and are paid to burn it. This subsidizes the u production processes. With new regulations, the cost of having hazardous waste incinerated of having it destroyed in a commercial toxic incinerator. It is reasonable to expect that this cement kiln, and this in a roundabout way might incite owners of less efficient cement plants

Long-range Concerns
There are many potential improvements that would lessen the environmental impacts of the can view the environmental impacts of cement production as being merely symptomatic overdevelopment. It is well within our grasp to significantly pare down the environmental in it is important to consider the basic question of how much of what is being produced is r cement and how much of that is necessary? Change at the most basic level is needed. We lessened ecological footprint. Analyzing the cement industry suggests that the best way to g begin more sustainable patterns of growth. Cement industry emissions are a problem in cement, because our houses are too big, because we have too many roads, because we da canals, and so on. No environmentally benign alternative to cement will have any positive used to build roads for cars that get 15 miles to the gallon. Detailed, industry-by-industry ar but in the end we should be mindful of the root cause of environmental problems: Our shortsighted consumption and overdevelopment.

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