Concrete and Cement Production in Beloit

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The journey of dolomite and limestone begins with the rock being blasted out of the ground, then mixed with water, and heated and dried. Dolomite is used to make cement and concrete, and each process has interesting environmental effects. Since cement production involves the oxidation of limestone to create lime, it is more hazardous than the manufacturing of concrete because more gases are released in the process. The concrete production process does not require a large number of inputs; it is simply water, cement, and rock mixed together to make a stronger stone product, concrete. Although it seems a basic process, there are serious environmental effects to consider, such as the release of dust and particles that contribute to smog and respiratory illness (Seeley).

Local Geology

Limestone is rock made up of carbonate sediments, such as shells of organisms that contain the mineral calcite, and fossils. Dolomite is a carbonate rock that is created when water-borne magnesium replaces calcium in limestone through gradual recrystallization (Schultz 6). The underlying bedrock of greater Beloit and northern Illinois is mainly Galena dolomite from the Ordovician period, 425 to 475 million years ago (Steidtmann 79). During this period in time there was a warm, shallow sea that covered the Midwest and parts of the South, where shelled organisms and coral lived. When these animals died, their shells and skeletons provided the carbonate sediments from which limestone and dolomite were created. The dolomite beds are covered with glacial drift and outwash that was left by the glaciers of the Pleistocene Ice Age,
two to three million years ago, which is the most recent ice age. Glacial drift can be material of any size, from fine-grained sand to boulders, and is sometimes mixed and other times sorted (Schultz 13-14, 21-23).

_Cement and Concrete Definitions_

Aggregate is used in the production of both cement and concrete, but it is important to note that these are two different mixtures. According to the Portland Cement Association, cement is a chemical combination of calcium, silicon, aluminum, iron, and gypsum, a mineral used to regulate the setting time of concrete. Lime and silica are ingredients that make up about 85 percent of cement. Concrete is defined as a mix of about 10 to 15 percent cement, 60 to 75 percent aggregate, and 15 to 20 percent water (Portland Cement Assoc. “Basics”).

_Cement Production: Excavation_

The first step in cement production is excavation. Dolomite is quarried from dolomite beds that are blasted and mined in open pits (Seeley). The crushed stone, sand, and gravel, called aggregate, is used for the production of cement and concrete, and the construction of most buildings, roads, bridges, dams, airports, tunnels, and water and sewer systems. The quarrying process does not require the use of much water, but water is used to control the release of dust (Kutz). Dust is considered a pollutant because when it is stirred up and released into the air, it affects respiratory function, weather patterns, and visibility (Manahan). Spraying water or chemical dust suppressants periodically on the aggregate storage piles and plant roadways can help to control dust. Because such a minimal amount of water is used, run-off is not an issue that the EPA is currently concerned with (Ohio Environmental Protection Agency).

After a quarry has been thoroughly mined, it is in the best interest of the industry to reclaim the land so that others will want to purchase the land (Pit & Quarry). Quarries are
usually transformed into parks, recreation areas, industrial and commercial properties, office
parks, and golf courses. Although using the property for commercial land might turn a profit, the
most environmentally friendly and cheapest option is for the quarry to be used as a park, where
native plants are reseeded and animals are sometimes reintroduced to the lake.

*Cement Production*

As stated by the EPA, cement manufacturing is more hazardous than concrete
manufacturing because of the involvement of lime and kilns. When cement is produced, the
limestone, clay, and sand must first be crushed into a powder. The powder is then heated in kilns
to about 2,700 degrees Fahrenheit in order for the limestone (calcium carbonate) to oxidize into
lime (calcium oxide) (Portland Cement Assoc. “Virtual Tour”). Kilns are usually about twelve
feet in diameter and longer than the height of a forty story building (Portland Cement Assoc.
“Basics”). Kiln dust is the largest waste product during this process. The dust is usually
collected in baghouses that are installed in the grinders. Baghouses are filtration systems that
take the dust out of the air and store it so it is not released. Kiln dust is made up of alumina,
silica, metallic oxides, and clay, and may also contain organic chemicals like dioxins, and heavy
metals, such as cadmium, lead, and selenium (US EPA 37). The kilns also generate gaseous
emissions that contain nitrogen oxides, sulfur oxides, carbon monoxides, and hydrocarbons, all
of which are gasses that contribute to smog and respiratory complications in animals. The
wastewater from cement manufacturing contains dissolved solids, such as chlorides, sulfates, and
potassium and sodium hydroxide, and calcium carbonate as a suspended solid (US EPA 37).
This water is often recycled and reused in the product after it has been through the settling pond
where the concentration of solids is reduced. Similarly to the quarry site, water sprays can be
used to contain dust, as well as having enclosed conveyors, elevators, and dumping and loading
areas (US EPA 37). Although cement kiln dust is one of the largest pollutants from cement production, it can be reused. The dust can be returned to the kiln, or sold for sewage sludge solidification and other absorbent uses (US EPA 63-68).

*Rockford Sand & Gravel*

Rockford Sand & Gravel in Rockford, Illinois (Figure 1), is a local producer of aggregate. It has an Environmental Protection Agency permit that must be followed for air pollution. This permit is necessary because of the amount of dust that is stirred up from blasting rock and having large piles of aggregate on site. Spraying the aggregate with water helps to prevent dust from being released into the air (Kutz).
Concrete Production

Concrete production is as simple as mixing aggregate, water, and cement (Seeley). This mixture can be made into precast, which is concrete building material that has been formed with molds, such as freestanding walls, concrete pipes, and traffic barriers (National Precast Concrete Association), or it can be used as ready-mixed concrete at construction sites. According to the EPA, concrete production has a number of harmful byproducts. The traffic of heavy machinery usually stirs up dust that negatively affects the air quality, while cement, sand, and gravel dust can be released into the air during production. Some concrete products require a finish to be applied, which produces paint waste from the spray guns, but there are two alternatives to using paint, water-based coatings and powder coatings, both of which are easy to reuse and have almost no emissions or waste (US EPA 63-68). The equipment requires maintenance, and so there is some amount of waste oil at the plant. If the calcium compound lime is produced, then there are several pollutants that are byproducts, such as nitrogen oxides, carbon monoxide, and sulfur dioxide, which cause smog and respiratory problems (US EPA 36).

Table 1. Summary of Process Material Input/Pollutant Output (US EPA 38).

<table>
<thead>
<tr>
<th>Process</th>
<th>Material Input</th>
<th>Air Emissions</th>
<th>Process Wastes</th>
<th>Other Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Product</td>
<td>Cement, sand, gravel, limestone, aggregate</td>
<td>Cement dust, sand and gravel dust, constituents</td>
<td>Total dissolved solids (potassium and sodium hydroxide), total suspended solids</td>
<td>Equipment and</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>material</td>
<td>from burning of fuel</td>
<td>(calcium carbonate), pH, waste heat</td>
<td>repair waste, paint wastes</td>
</tr>
<tr>
<td>Cement</td>
<td>Lime, silica sand, alumina, iron, gypsum,</td>
<td>Cement kiln dust, constituents from burning of</td>
<td>Total dissolved solids (potassium and sodium hydroxide), total suspended solids</td>
<td>Cement kiln dust, waste oil, laboratory</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>byproducts (fly ash, metal)</td>
<td>fuel, particulate matter, sulfur</td>
<td></td>
<td>wastes, waste oil</td>
</tr>
</tbody>
</table>

Figure 1. Aerial image of Rockford Sand & Gravel, Loves Park, IL (MapQuest).
| smelting slags, mill scale | dioxide, trace metals, organic compounds | (calcium carbonate), pH, waste heat |

**Health Effects**

A major health issue for concrete plant workers is silicosis, an occupational lung disease caused by the inhalation of silica (Seeley). When the concrete is cut into the desired dimensions, dust is released that contains crystalline silica (silicon dioxide or quartz), which causes inflammation of the lungs when inhaled. According to WebMD, inflammation leads to scar tissue formation, which prevents oxygen from getting to the cardiovascular system. There are three types of silicosis: simple chronic silicosis, accelerated silicosis, and acute silicosis. Simple chronic silicosis arises from long-term (over twenty years) exposure to low amounts of silica dust, and results in swelling of the lungs and chest lymph nodes. Accelerated silicosis develops after five to fifteen years of exposure to larger amounts of silica and has the same symptoms as simple silicosis, except that they occur faster. Acute silicosis occurs from short-term exposure to high amounts of silica. Because of the higher concentration of exposure, very inflamed lungs that fill with fluid cause severe shortness of breath and low blood oxygen levels (WebMD).

**Mid-States Concrete Industries**

Mid-States Concrete Industries in South Beloit, Illinois is a local plant where precast concrete is produced (Seeley). The beams, columns, wall panels, and floor and ceiling pieces (See Figure 2) produced at Mid-States Concrete are shipped to building sites in Chicago, southern Illinois, Iowa, and Wisconsin and used to assemble buildings, garages, and high-end houses. If we examine this plant as an (eco)system, the inputs would be cement from St. Mary’s
Cement, a cement producer in Dixon, IL, aggregate (dolomite) from Rockford, IL and water from the City of Beloit, as well as recycled water (they use 10% recycled water and 90% city water in their product). The outputs would be concrete, little water from evaporation and in the product, and some dust. This company recycles all of the water that it possibly can, which is why there is so little output. Mid-States Concrete does not apply paint to their products, nor do they produce cement, so there is no paint waste, nor pollutants from lime. They also do not release enough pollution to need EPA pollution permits (Seeley).

Figure 2. Image of one type of precast produced at Mid-States Concrete for floors and roofs (Answers.com).

As for employee health, David Seeley, the Director of Human Resources at Mid-States Concrete, stated that the incidence of silicosis at Mid-States is not high, and all of their employees are trained to take the necessary precautions to prevent getting silicosis and are tested at least once a year to check the condition of their respiratory health.
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