

## Lafarge North America Products

Lafarge North America, part of the Lafarge Group, is a large, diversified supplier of cement, aggregates and concrete as well as other materials for residential, commercial, institutional, and public works construction in the United States and Canada. Four Lafarge products are included in BEES:

- Silica Fume Cement (SFC). A mixture of portland cement (90 %) and silica fume (10 %).
- NewCem Slag Cement. Ground granulated blast furnace slag used as a partial replacement for portland cement.
- BlockSet. A blend of cement kiln dust, fly ash, and cement used to make concrete blocks for basement walls.
- Portland Type I Cement.

BEES data for SFC and BlockSet products come from the Lafarge plant in Paulding, Ohio, with an annual production of 436 810 metric tons (481 500 short tons) of SFC, Type I cement, and masonry cement.<sup>1</sup> The Lafarge South Chicago location manufactures a total of 816 466 metric tons (900 000 short tons) of slag products. Data for the Portland Type I Cement product come from the Lafarge plant in Alpena, Michigan, with an annual production of 2 059 310 metric tons (2 270 000 short tons). The portland cement manufactured in Alpena is shipped by lake vessels to terminals around the Great Lakes. These cementitious products are incorporated in different concrete products in BEES as shown in the Table below.

*Table 1: Lafarge North America Concrete Products*

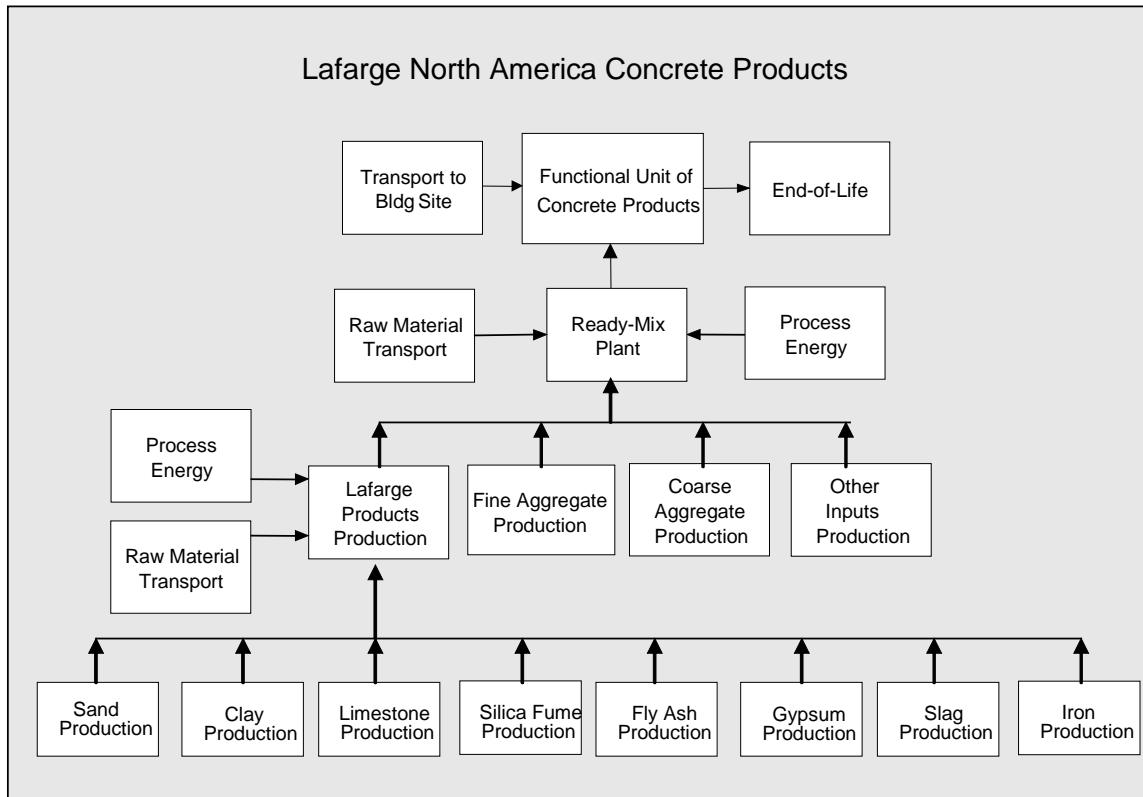
| <i>BEES Building Element</i>                          | <i>Lafarge Product</i>   | <i>Specifications</i>  |
|---|--------------------------|--|
| Concrete for Slabs, Basement Walls, Beams and Columns | Silica Fume Cement (SFC) | 1 kg (2.2 lb) of SFC is equivalent to 1 kg (2.2 lb) of generic portland cement. Fully 100 % of the portland cement is replaced by SFC.   |
|   | Slag Cement              | 1 kg (2.2 lb) of slag cement is equivalent to 1 kg (2.2 lb) of generic portland cement. The following substitution ratios of slag cement for portland cement are used: 20 %, 35 %, and 50 %. |
|   | Alpena Portland Type I   | 1 kg (2.2 lb) of Alpena Portland Type I cement is equivalent to 1 kg (2.2 lb) of generic portland cement   |
| Concrete for Basement Walls                           | BlockSet                 | 1 kg (2.2 lb) of BlockSet is equivalent to 1 kg (2.2 lb) of generic portland cement. Forty percent (40 %) of the portland cement is replaced by BlockSet.                                    |
| Parking Lot Paving                                    | Alpena Portland Type I   | 1 kg (2.2 lb) of Alpena Portland Type I cement is equivalent to 1 kg (2.2 lb) of generic portland cement used in the concrete layer of paving.   |

### Flow Diagram

The flow diagram below shows the major elements of the production of this product as it is currently modeled

<sup>1</sup> Annual production data is based largely on 2001 production. Other Lafarge plant data ranges in time from the late 1990s to 2001.

for BEES.



*Figure 1: Lafarge North America Concrete Products System Boundaries*

### Raw Materials

The Lafarge products are comprised of the raw materials given in the Table below.

**Table 2: Lafarge North America Cement Constituents**

| <i>Constituent</i> | <i>Silica Fume<br/>Cement</i> | <i>Slag<br/>Cement</i> | <i>BlockSet</i> | <i>Alpena Portland<br/>Type I</i> |
|--------------------|-------------------------------|------------------------|-----------------|-----------------------------------|
| Limestone          | 72 %                          | --                     | 76 %            | 91 %                              |
| Clay               | 16 %                          | --                     | 16 %            | --                                |
| Silica Fume        | 5 %                           | --                     | --              | --                                |
| Sand               | 3 %                           | --                     | 3 %             | 3 %                               |
| Gypsum             | 3 %                           | --                     | 3 %             | --                                |
| Slag               | --                            | 100 %                  | --              | --                                |
| Fly Ash            | <0.01 %                       | --                     | <0.01 %         | 5 %                               |
| Iron source/scrap  | 1 %                           | --                     | 1 %             | 1 %                               |

**Clay and limestone.** Energy consumption and air emissions data for clay and limestone production were provided by Construction Technology Laboratories, Inc. as part of the overall cement plant data collected for Lafarge’s Alpena site, and take into account fuel combustion, quarry operations, and haul roads.

**Silica fume.** Silica fume is a by-product of the metallurgical processes used in the production of silicon metals. It is called "fume" because it is an extremely fine smoke-like particulate material. Because it is both pozzolanic and extremely fine (about 100 times finer than cement particles), silica fume may be used to considerable advantage as a supplementary cementitious material in portland cement concrete. Silica fume has been used in the North American cement and concrete industry for over 25 years and can be used in concretes to withstand aggressive exposure conditions. Transportation of the silica fume to the electric furnace is accounted for in the model.

**Sand and gypsum.** Sand production takes into account energy combustion, waste production, and air emissions from fuel combustion and quarry operations. Gypsum production takes into account electricity and diesel fuel consumption used in surface mining and processing, as well as air emissions and waste production. Data for both of these materials are based on the SimaPro database.

**Slag.** Slag is a waste material from the blast furnace during the production of pig iron. Blast furnaces, which produce iron from iron ore in the presence of limestone or dolomite fluxes, produce a molten slag. This slag is tapped off the furnace separately from the iron.

**Fly ash.** Fly ash comes from coal-fired, electricity-generating power plants. These power plants grind coal to a fine powder before it is burned. Fly ash – the mineral residue produced by burning coal – is captured from the power plant's exhaust gases and collected for use. Fly ash particles are nearly spherical in shape, allowing them to flow and blend freely in mixtures, one of the properties making fly ash a desirable admixture for concrete. In LCA terms, this waste byproduct from coal combustion is assumed to be an environmentally “free” input material. However, transport of the fly ash from the production site is included.

**Iron.** The iron source for the Paulding site is mill scale, a by-product from hot rolling steel. It is treated as scrap iron with no upstream burdens since it is a byproduct, but transportation of the material is accounted for.

## **Manufacturing**

**Energy requirements and emissions.** The Paulding site uses electricity, petroleum coke, diesel oil, and fuel-quality waste (primarily solvents) as energy sources to produce silica fume cement, BlockSet, and cement dust. Fuel-quality waste is the largest source of energy for the plant. Its upstream production is modeled as being “free,” but its combustion emissions are accounted for (using the U.S. LCI Database’s fuel oil combustion data). The Alpena site uses electricity, coke, coal, diesel oil, fuel oil, and gasoline as energy sources to produce Portland Type I cement.

To prepare the slag for use in concrete, slag is quenched with water and is ground. Since the water evaporates, there is no effluent run off. Water, electricity, and natural gas consumption associated with this process are taken into account. All energy and electricity data are based on the U.S. LCI Database.

**Transportation.** Transportation distances for the raw materials to the manufacturing site were provided by Lafarge. Clay and limestone are hauled 1.61 km (1 mi) to the Paulding cement plant and 3.22 km (2 mi) to the Alpena site. Silica fume is transported to the Paulding plant 241 km (150 mi). Sand is transported to the Paulding and Alpena plants 80 km (50 mi) and 16 km (10 mi), respectively. Gypsum is transported to the Paulding plant 97 km (60 mi). Slag and iron are transported 32 km (20 mi). Fly ash is transported by rail 322 km (200 mi). With the exception of fly ash, materials are transported by diesel truck. Both diesel truck and rail transport are modeled based on the U.S. LCI Database.

## **Transportation**

Transportation of finished products to the building site is evaluated based on the same parameters given for the generic counterparts to Lafarge products. All products are shipped by diesel truck as modeled in the U.S. LCI Database. Emissions from transportation allocated to each product depend on the overall weight of the product.

## **Installation and Use**

Installing each of the BEES concrete applications requires plywood forms and steel reinforcement. Refer to the documentation on generic portland cement concrete products for a full description of the modeling of these installation materials.

## **End of Life**

Beams, columns, basement walls, and slabs are all assumed to have 100-year lifetimes. Concrete parking lot paving is assumed to last 30 years. Since the BEES model for parking lot paving accounts for a 50-year use period, two concrete installations are made.

## **References**

### **Life Cycle Data**

National Renewable Energy Laboratory (NREL): *U.S. Life-Cycle Inventory Database*. 2005. Golden, CO.

Found at: <http://www.nrel.gov/lci/database>.

PRÉ Consultants, *SimaPro 6.0 LCA Software*. 2005. The Netherlands.

## **Industry Reference**

Oscar Tavares, Lafarge North America (2002)