Generic Brick & Mortar

Product Selection and Description

Brick is a masonry unit of clay or shale, formed into a rectangular shape while plastic, cored, and then burned or fired in a kiln. Mortar is used to bond the bricks into a single unit. Facing brick is used on exterior walls.

The BEES model for brick in mortar evaluates fired clay facing brick. The brick is cored prior to being fired, which removes about 25 % to 30 % of the clay material. The actual dimensions of the brick are 9.2 cm x 5.7 cm x 19.4 cm (3.6 in x 2.2 in x 7.62 in). A cored and fired brick of this size weighs 1.86 kg (4.10 lb). The nominal dimensions of the brick including the mortar joint are 9.2 cm x 6.8 cm x 20 cm (3.6 in x $2^2/_3$ in x 8 in). The brick is assumed to be installed with Type N mortar, which has a density of 1840 kg/m^3 (115 lb/ft^3), with an air content of at least 20 %. Masonry is typically measured on the basis of wall area (m^2 or ft^2). A brick wall is assumed to be 80 % brick and 20 % mortar by surface area.

Flow Diagram

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

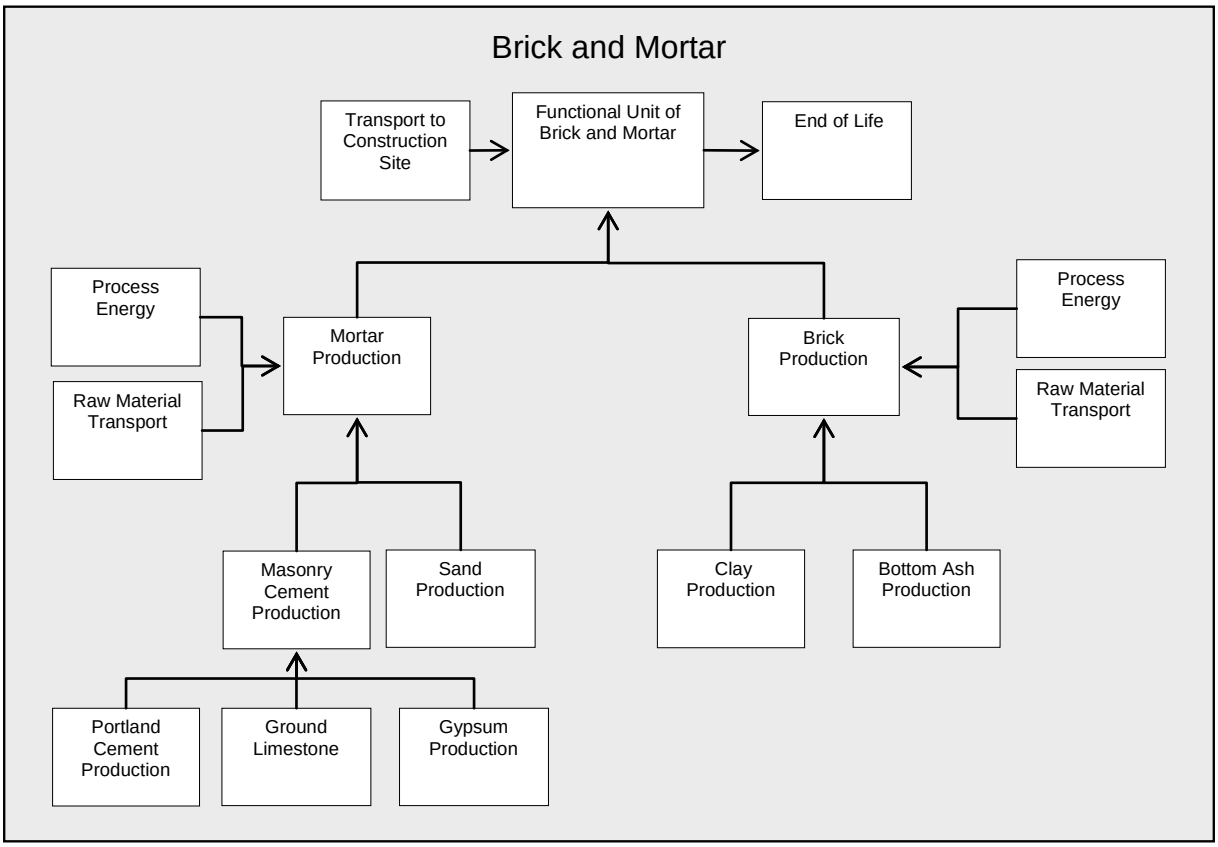

Figure 1: Brick and Mortar System Boundaries

Raw Materials

Brick uses virtually 100 % mined clay or shale. Bottom ash, a post-industrial recycled material, is the most widely used recycled material that is added to the clay during brick production. Typical replacement of clay or shale inputs is 0.8 % bottom ash by mass.

Table 1: Fired Brick Constituents

Constituent	*Mass Fraction (%)*
Clay	99.2
Bottom Ash	0.8

All material removed in the manufacturing process is returned to the manufacturing stream. Fired product that is scrapped is used as grog[1] in brick manufacturing or for other uses such as landscape chips and roadbed.

Type N mortar consists of 1 part masonry cement (by volume fraction), 3 parts sand,[2] and 6.3 L (1.7 gal) of water. The raw material use for masonry cement is based on Type N masonry cement, and its constituents are shown below.

Table 2: Masonry Cement Constituents

Constituent	*Mass Fraction (%)*
Portland Cement Clinker	50.0
Limestone	47.5
Gypsum	2.5

The flow diagram for brick and mortar shows only the solid components of mortar. Some water in mortar is chemically bound, so there is some net consumption of water—based on 25 % by weight for hydration, approximately 230 kg/m^3 (14 lb/ft^3) of water is used. Production of the raw materials for brick and mortar are based on the SimaPro LCA database and the U.S. LCI Database.

Manufacturing

Energy Requirements and Emissions. The energy requirements for brick production are listed in the Table below. These figures include the drying and firing production steps only, based on the latest Brick Industry Association survey stating that these are the most important steps in terms of energy use. Environmental flows resulting from the production of the different types of fuel are based on the U.S. LCI Database.

Table 3: Energy Requirements for Brick Manufacturing

Energy Carrier	*Quantity per Lb*
Natural Gas	0.028 m^3 (0.987 ft^3)
Grid Electricity	0.0810 MJ (0.0225 kWh)

[1] Grog is previously-fired ceramic material, typically from ground brick. It is included in the brick body to reduce drying shrinkage or provide a more open texture to the fired brick.

[2] Based on ASTM Specification C270-96.

Brick production is distributed across U.S. Census Regions as given below.

Table 4: U.S. Brick Production by Census Region

Census Region	*Brick Production*
Pacific	2.8 %
Mountain	3.5 %
West South Central	17.8 %
East South Central	17.9 %
South Atlantic	39.6 %
West North Central	4.1 %
East North Central	8.1 %
Middle Atlantic	5.4 %
New England	0.8 %

A blend of grid electricity sources are used to represent this distribution of manufacturing facilities.

Emissions for brick firing and drying are based on AP-42 data for emissions from brick manufacturing for each manufacturing technology and type of fuel burned.[3,4]

Water Consumption. Water is used in the manufacturing process to impart plasticity to the raw materials, which allows the brick to be formed. On average, approximately 20.5 % water by weight is used and returned to the atmosphere in drying.

Transportation. Brick raw materials are typically transported less than 80 km (50 mi) by truck to the brick plant.[5]

Waste. The manufacturing process generates no waste materials as all materials are reused in the plant.

Transportation

Transportation of brick to the building site is modeled as a variable of the BEES system. Bricks are assumed to be transported by truck and rail (84.7 % and 15.3 %, respectively) to the building site.[6]

Installation

Installation of brick and mortar primarily consists of manual labor; no energy use is modeled for the installation phase. Losses during the installation phase are estimated to be 5 % of total materials per ft^2. Waste from the installation process is typically landfilled.

While sheathing, weather resistive barriers, and other ancillary materials may be required to complete the

[3] United States Environmental Protection Agency, "Brick and Structural Clay Product Manufacturing," Volume I: Section 11.3, AP-42: Compilation of Air Pollutant Emission Factors(Washington, DC: US Environmental Protection Agency, August 1997). Found at: http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s03.pdf.

[4] According to the Brick Industry Association (BIA), AP-42 emissions data are likely to be overstated, as at least 30 brick plants have added emission control devices in the past five years, and all new plants (including at least 5 new plants completed in the past 5 years) include these emission control devices. However, no alternate emissions data were made available by BIA.

[5] An additional note regarding the production of bricks: according to BIA, brick companies have been cited for their reclamation of spent clay pits. Examples include golf courses, wetlands, and land fills.

[6] United States Environmental Protection Agency, "Brick and Structural Clay Product Manufacturing," Volume I: Section 11.3, AP-42: Compilation of Air Pollutant Emission Factors(Washington, DC: US Environmental Protection Agency, August 1997). Found at: http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s03.pdf.

exterior wall system, these materials are not included in the system boundaries for BEES exterior wall finishes.

Use

Brick walls are often in service for more than 100 years. Older buildings are adapted to new uses, with the existing brick walls included as a design feature. A useful life of 200 years is assumed. Most brick walls have little maintenance. Repointing of mortar joints on portions of the wall may be required after 25 years, but this minor maintenance step was not included within the system boundary of the model.

While buildings with brick and mortar finishes require insulation, the finish does provide a thermal resistance value of about R-2. Thermal performance differences among exterior wall finish alternatives are not accounted for.

End of Life

Demolition of brick walls at end of life typically is not done very carefully. The walls are knocked down using equipment such as a wrecking ball or explosives, resulting in some loss of brick. It is estimated that 75 % of the brick is recovered in usable form. The mortar is removed by hand labor using chisels and hammers, typically at the demolition site. The cleaned brick is sold for new construction, and the mortar and broken brick are taken to landfills.

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.

United States Environmental Protection Agency, "Brick and Structural Clay Product Manufacturing," Volume I: Section 11.3, *AP-42: Compilation of Air Pollutant Emission Factors,* (Washington, DC: U.S. Environmental Protection Agency, August 1997). Found at: http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s03.pdf.

ASTM International, *C270-06 Standard Specification for Mortar for Unit Masonry*, (West Conshohocken, PA, 2005).

Industry Contacts

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