

# Generic Clay Roofing Tile

## Product Selection and Description

Clay tiles are manufactured from clay, shale, or similar naturally-occurring earthy substances and subjected to heat treatment at elevated temperatures (known as firing). The most commonly used clay tiles are the one-piece “S” mission tile and the two-piece mission tile. One-piece “S” tile accounts for about 60 % of the clay roof tile market. Red-colored tiles are still quite popular, although there is now a wide range of colors and blends available.

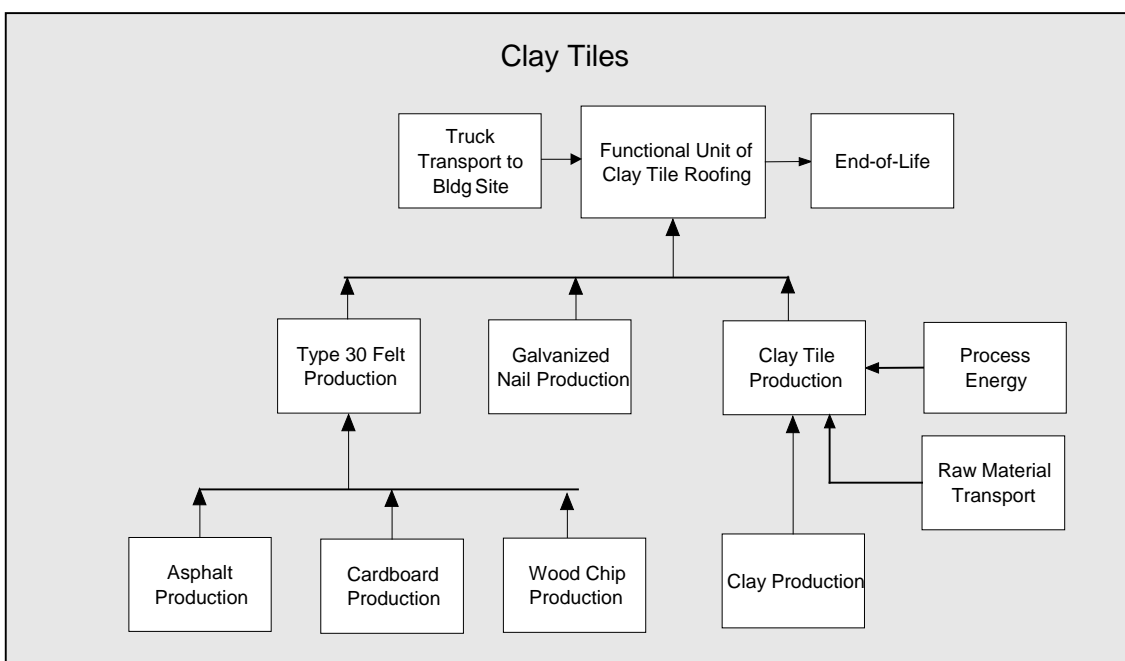
Roof coverings such as clay tile are evaluated in BEES on the basis of a functional unit of roof area covered: 1 square (9.29 m<sup>2</sup>, or 100 ft<sup>2</sup>). The weight of the one-piece “S” tile is 357 kg to 381 kg (788 lb to 840 lb) per square, with 75 to 100 pieces of tile per square. The two-piece mission tile weighs approximately 476 kg (1 050 lb) per square, with 150 pieces of tile (75 tops and 75 pans) per square.

Clay tiles are installed over a deck of wood sheathing, typically oriented strand board covered with underlayment, which is generally asphalt-impregnated organic felt. For roof pitches from 4:12 to 10:12, two layers of Type-30 felt are used, while roof pitches of greater than 10:12 use one layer of Type-30 felt.<sup>1</sup> The weight of the clay tile studied is 381 kg (840 lb) per square, with 75 to 100 pieces of tile per square. The tiles are assumed to be installed using one nail per tile.

For the BEES system, a roof covering of red Spanish one-piece “S” clay tiles is evaluated two ways: with an underlayment of one layer of D226 Type II No. 30 roofing felt and an underlayment of polypropylene weave with modified polyolefin coatings (ECP Nova-Seal II) The felt underlayment is described in this product summary while the Nova-Seal II underlayment is described in its own summary.

## 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: Clay Roof Tile System Boundaries**

<sup>1</sup> Crowe, J. P. “Steep-slope roof systems require different underlayment installations.” Professional Roofing (May 2005).

## Raw Materials

The clay tile is composed of fired clay. Raw material sources are typically located relatively close to tile plants, so an 80 km (50 mi) transport distance is assumed in the model. For the underlayment, Type II No. 30 roofing felt is used, which consists of asphalt and organic felt in the quantities given in the Table below. The organic felt is assumed to consist of 50 % recycled cardboard and 50 % wood chips. The production of clay and felt materials is based on the SimaPro LCA database and U.S. LCI Database.

**Table 1: Type-30 Roofing Felt Constituents**

<b>Constituent</b>	<b>Kg/m<sup>2</sup> (lb/square)*</b>	<b>Mass Fraction</b>
Asphalt	0.57 (12)	45 %
Organic Felt	0.51 (10)	10 %
Limestone	0.13 (2.6)	5 %
Sand	0.06 (1.3)	40 %
<b>Total</b>	<b>1.27 (25.9)</b>	<b>100 %</b>

\* One square is equivalent to 9.29 m<sup>2</sup> (100 ft<sup>2</sup>)

## Manufacturing

**Energy Requirements and Emissions.** In the United States, the top three (by market share) clay roofing tile manufacturers are located in Southern California, Northern California, and Ohio. All clay tile manufacturers use 100 % natural gas to fire the kilns; most plants, however, are at least partially automated and use the latest technology, which requires electricity. Natural gas and electricity use reported by one tile producer were 8.7 therms (873 390 Btu) of natural gas and 110 MJ (30.5 kWh) of electricity per 381 kg (840 lb) square of tile. No other production data was available; these values were taken as representative.

**Table 2: Energy Requirements for Clay Tile Manufacturing**

<b>Energy Carrier</b>	<b>MJ/kg (Btu/lb)</b>
Natural Gas	2.42(1040)
Electricity	0.29 (120)
<b>Total</b>	<b>2.7 (1160)</b>

Data on electricity generation and production and on combustion of natural gas are from the U.S. LCI Database.

No manufacturing data for felt underlayment were available, so its contribution to the life cycle may be underestimated.

**Transportation.** The clay raw material is assumed to be transported 80 km (50 mi) to the manufacturing plant, and to be evenly split between train and truck modes of transport. All components of roofing felt are assumed to be transported 402 km (250 mi). Asphalt is assumed to be transported by truck, train, and pipeline in equal proportions, while the cardboard and wood chips are assumed to be transported by truck.

**Waste.** Clay tile scrap or rejects that occur before the firing process are recycled back into the manufacturing process. After firing, any scrap or rejects are recycled by crushing for use on tennis courts, baseball fields, and other applications.

## Transportation

Transportation of clay tile by heavy-duty truck to the building site is modeled as a variable of the BEES system.

Roofing underlayment and nails are assumed to be transported 161 km (100 mi) by truck to the building site.

### **Installation**

Rollers, conveyors, or cherry pickers are used to move the tile up to the roof; however, no data quantifying the associated energy use were available. Nailing of clay tiles is done by hand; nail guns are not used. Galvanized steel or copper nails can be used for installation; galvanized nails are cheaper and are more commonly used, so are assumed for the BEES analysis. For installation, one nail per tile is used for a roof pitch less than 7:12.<sup>2</sup> For roofs with a pitch greater than 7:12, two nails are required per tile, or 150 to 200 nails per square. In BEES, the tiles are assumed to be installed using one nail per tile.

Clay tile roofing requires at least one layer of Type II No. 30 felt, and one layer is assumed for the model. The underlayment uses 30 to 40 “roofing top” nails per square. Each galvanized steel nail is assumed to weigh 0.002 kg (0.004 lb). Installation waste from scrap is estimated at 2 % to 5 % of the installed weight.

### **Use**

Clay roof tile has a long service life. Many clay roofs have been in existence for more than one hundred years. Clay tile generally does not need to be replaced; however, the underlayment may need replacement after 10 years to 15 years. When the underlayment is replaced, the roof tiles are typically reused. The tiles themselves are replaced after 70 years.

### **End of Life**

At end of life, clay tiles are recovered and re-used. Usually, clay tile removed for underlayment replacement is saved on a pallet for re-use on the same building. If the tile is not to be replaced on the building, the roofer will use it on another building that specifies the same tile type and color. The trend today is that old clay tiles are in demand and are often considered more valuable than the newly produced clay tile. Recovered clay roofing tiles are offered by wholesalers to the public worldwide via the Internet, local advertising, and trade magazines. Regardless of condition, used clay tile is not thrown away. All clay tile can be 100 % re-used, re-sold, or crushed for use on tennis courts, baseball fields, and other applications.

### **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.

Crowe, J. P. “Steep-slope roof systems require different underlayment installations.” *Professional Roofing* (May 2005).

### **Industry Contacts**

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<sup>2</sup> 7:12 pitch = 7 in rise per 12 in run.