Generic Composite Marble Tile

Product Selection and Description

Composite marble tile is a type of composition flooring. It is a mixture of polyester resin and matrix filler, colored for a marble effect, that is poured into a mold to form tiles. The mold is then vibrated to release air and level the matrix. After curing and shrinkage the tile is removed from the mold, trimmed, and polished if necessary.

For the BEES system, a 30 cm x 30 cm x 0.95 cm (12 in x 12 in x 3/8 in) tile, installed using a latex-cement mortar, is studied.

Flow Diagram

The following flow diagram shows the major elements of the production of composite marble tile, as currently modeled in BEES.

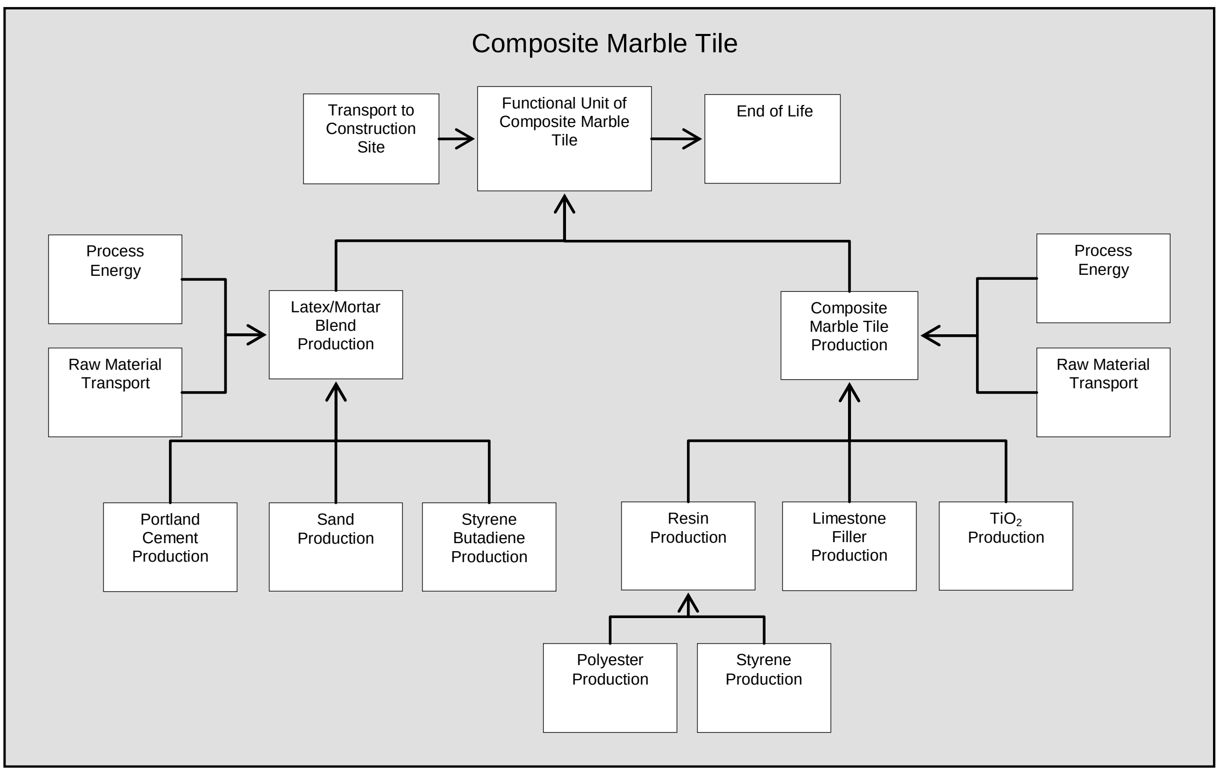

Figure 1: Composite Marble Tile System Boundaries

Raw Materials

The Table below gives the constituents included in the marble matrix and their proportions. It is assumed that 3 % of the material is lost at manufacture from the trimming process.

Table 1: Composite Marble Tile Constituents

Constituent	*Mass Fraction (%)*
Filler	78.25
Resin	20.01
Pigment (TiO_2)	1.50
Catalyst (MEKP)	0.24

The resin percentage given above is a weighted average, based on data from four sources ranging from 19 % to 26 % resin content. The remainder of the matrix is composed of filler, pigment, and catalyst. Since calcium carbonate is the typical filler used for U.S. composite marble tile production, it is the assumed filler material in the BEES model. The filler is composed of coarse and fine particles in a combination of two parts coarse to one part fine. Filler production involves the mining and grinding of calcium carbonate, and these data are based on the U.S. LCI Database. The resin used in the matrix is an unsaturated polyester resin cross-linked with styrene monomer, with the styrene content ranging from 35 % to 55 %. An average value of 45 % styrene is used for the model. Data for both polyester resin and styrene come from the Plastics Division of the American Chemistry Council.[1]

The main catalyst used in the United States for the marble matrix is methyl ethyl ketone peroxide (MEKP). This catalyst is used as a solvent in the mixture of resin and filler, so is consumed in the process; however, approximately 1 % of the MEKP catalyst is composed of unreacted MEK, which is assumed to be released during the reaction. The amount of catalyst is assumed to be about 1 % of the resin content, or 0.24 % of the total marble matrix. No publicly-available data were available for MEKP, but data for MEK – a small fraction of MEKP – were included and are based on the EcoInvent data set for MEK.

A colorant may be used if necessary. The quantity depends on the color required. The colorant is usually added to the mixture before all the filler has been mixed. For the BEES study, titanium dioxide at 1.5 % is assumed, and this is based on EcoInvent.

Composite marble tiles are installed using a latex/mortar blend. The constituents of the latex/mortar blend are provided in the Table below.

Table 2: Latex/Mortar Blend Constituents

Constituent	*Mass Fraction (%)*
Portland Cement	38

[1] Franklin Associates, a Division of ERG, for the Plastics Division of the American Chemistry Council: *Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors* (Prairie Village, KS, 2010).

Sand	22
Styrene-Butadiene Latex	40

Manufacturing

Energy Requirements and Emissions. Electricity is the only energy source involved in producing and casting the resin-filler mixture for composite marble tile. The tile is cured at room temperature. The Table below shows electricity use for composite marble tile manufacturing.

Table 3: Energy Requirements for Composite Marble Tile Manufacturing

Energy Carrier	***MJ/kg (Btu/lb)***
Electricity	0.047 (20.3)

The chief emissions from composite marble tile manufacturing are fugitive styrene and MEK air emissions. The styrene emissions come from the resin constituent and are assumed to be 2 % of the resin input. The MEK emissions come from the 1 % un-reacted MEK in the catalyst blend. Emissions of styrene from the matrix are assumed to be 0.129 kg/m^2 (0.026 lb/ft^2), and MEK emissions 0.00086 kg/ m^2 (0.00018 lb/ft^2).

Transportation. All product raw materials are assumed to be transported 402 km (250 mi) by truck. For the mortar raw materials, the portland cement and sand are assumed to be transported 48 km (30 mi) by truck to the packaging plant, and the latex raw materials are assumed to be transported 161 km (100 mi) to the production facilities.

Transportation

Shipping the cement, sand, and latex to the end user is assumed to cover 322 km (200 mi) via diesel truck. Transportation of tiles by diesel truck to the building site is modeled as a variable of the BEES system.

Installation

Installing composite marble tile requires a sub-floor of a compatible type, such as concrete. A layer of latex/mortar approximately 1.3 cm (½ in) thick is used, which is equivalent to 17.96 kg/m^2 (3.563 lb/ft^2). Installation of tile and mortar is assumed to be primarily a manual process, so there are no emissions or energy inputs. About 5 % of the installation materials are assumed to go to waste, all of which is disposed of in a landfill.

Use

With general maintenance, properly installed composite marble tile will have a useful life of 75 years. Maintenance – such as cleaning and sealing of the tile - is not included within the boundaries of the BEES model.

End of Life

At end of life, it is assumed that the composite marble tile and the latex/mortar used for installation are disposed of in a landfill.

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.

EcoInvent Centre: *EcoInvent data v2.0* (Dübendorf: Swiss Centre for Life Cycle Inventories, 2007). Found at: www.ecoinvent.org.

Franklin Associates, a Division of ERG, for the Plastics Division of the American Chemistry Council: *Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors* (Prairie Village, KS, 2010).

Industry Contacts

No industry contacts were found that were able to provide industry data.