Generic Asphalt Shingles

Product Selection and Description

Asphalt shingles, available in a wide range of colors and styles, are suitable for use on roofs with pitches from 2:12 to 21:12.[1,2] Asphalt shingles are commonly made from fiberglass mats impregnated and coated with a mixture of asphalt and mineral filler for both a decorative finish and a wearing layer. The shingles are nailed over roofing underlayment installed over a deck of sheathing, typically oriented strand board.

The market for asphalt shingles has changed significantly in the past 10 years, from primarily 3-tab shingles to now over 56 % of the market consisting of laminated/multi-layered products. Laminate asphalt shingles typically are available in dimensions of 30 cm by 91 cm (12 in by 36 in). Roof coverings such as asphalt shingles are evaluated in BEES on the basis of a functional unit of roof area covered: 1 square (9.29 m^2, or 100 ft^2). Allowing for the recommended overlap, a typical number of shingles required to cover one square is about 80 standard shingles or 65 metric shingles, with an average weight of about 14 kg/m^2 (280 lb/square).[3]

The type of underlayment used has typically been asphalt-impregnated organic felt, although self-adhering polymer modified bituminous sheet materials have been experiencing 20 % to 30 % growth in use over the past several years. For roof pitches from 3:12 to 4:12, two layers of Type-15 felt underlayment are used, while roof pitches greater than 4:12 shed water more quickly and thus require only one layer of Type-15 felt.[4]

Three options are modeled with asphalt laminated shingles: the first with one layer of Type-15 felt underlayment, the second with two layers of Type-15 felt underlayment, and the third with 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.

[1] Pitch ratio expressed as rise in in: run in in.

[2] Asphalt Roofing Manufacturers Association (ARMA), *Asphalt Roofing Manufacturers Association (ARMA) Residential Asphalt Roofing Manual* (Calverton, MD: Asphalt Roofing Manufacturers Association, 1997) pp. 17.

[3] Shingle dimensions and weight per square based on survey of product information available in ICC reports on laminated asphalt shingles produced by various manufacturers (http://www.icc-es.org/reports/index.cfm?search=search). Number of shingles per square from survey of laminated asphalt shingle products on ebuild.com.

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

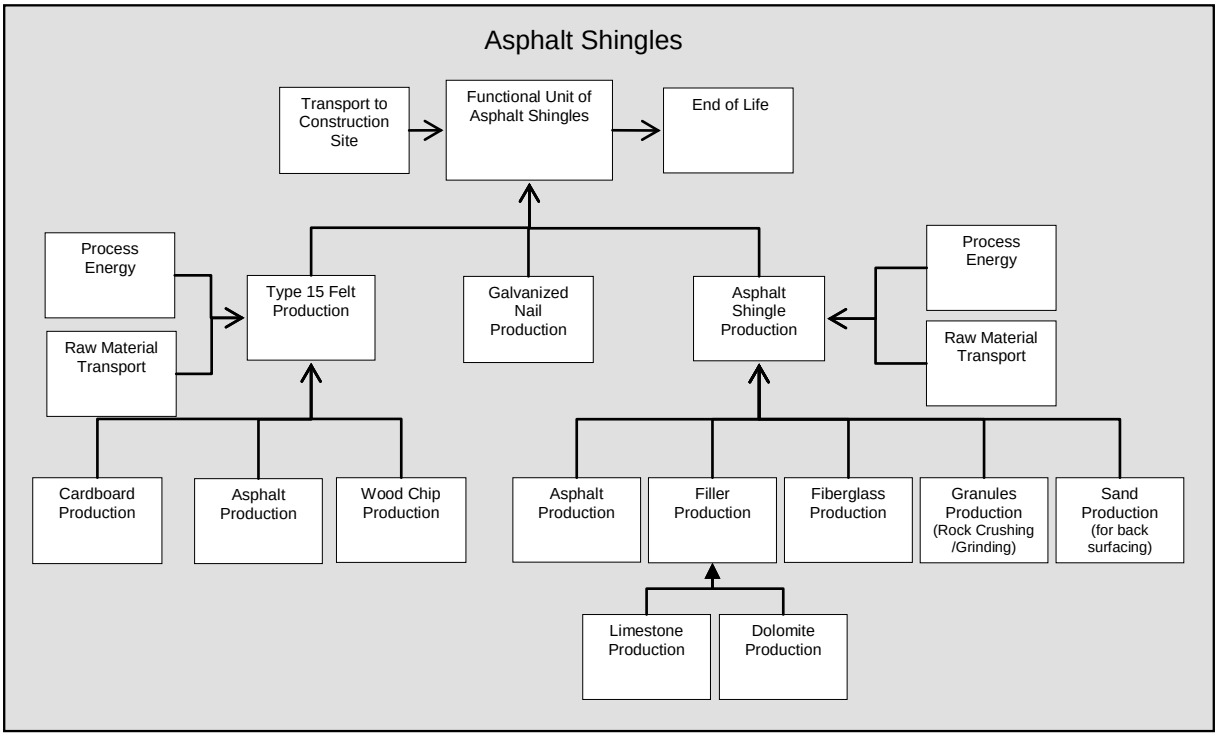

Figure 1: Asphalt Shingles System Boundaries

Raw Materials

The composition of asphalt shingles is shown in the Table below. Granules production is modeled as rock mining and grinding.

Table 1: Asphalt Shingle Constituents

Constituent	***Kg/m^2 (lb/square)****	***Mass Fraction***
Asphalt	2.7 (56)	20 %
Filler	5.9 (120)	43 %
Fiberglass Mat	0.7 (14)	5 %
Granules	3.4 (70)	25 %
Back surfacing (sand and talc)	1.0 (19.6)	7 %
Total	14 (280)	100 %

*One square is equivalent to 9.29 m^2 (100 ft^2)

Type-15 felt consists of asphalt and organic felt. The composition is shown in the following Table. The organic felt is assumed to consist of 50 % recycled cardboard and 50 % wood chips.

Table 2: Type 15 Felt Underlayment Constituents

Constituent	*Kg/m^2 (lb/square)*[*]	*Mass Fraction*
Asphalt	0.3 (5.4)	45 %
Organic Felt	0.2 (4.8)	40 %
Limestone	0.06 (1.2)	10 %
Sand	0.03 (0.6)	5 %
Total	0.6 (12)	100 %

[*] One square is equivalent to 9.29 m^2 (100 ft^2)

Data for the production of underlayment materials and asphalt shingle constituents are from the SimaPro LCA database and U.S. LCI Database.

Manufacturing

Energy Requirements and Emissions. According to the Asphalt Roofing Manufacturers Association (ARMA), asphalt shingles are produced by nine manufacturers in about 22 states. Data on production and combustion of fuels for shingle manufacture is from the U.S. LCI Database.

Table 3: Energy Requirements for Asphalt Shingle Manufacturing

Energy Carrier	*MJ/m^2 (Btu/ft^2)*
Natural Gas	2.3 (202)
Electricity	0.89 (78)
Total	**3.19 (280)**

Emissions pertaining to manufacturing asphalt shingle roofing materials follow.[5]

Table 4: Asphalt Shingle Production Emissions

Air Emission	*Emission factor g/kg (lb/ton) asphalt*
Particulates (unspecified)	0.04 (0.08)
Sulfur oxides	0.45 (0.9)
Carbon monoxide	0.35 (0.7)
Nitrogen oxide	0.03 (0.06)
Total organic compounds	0.02 (0.04)

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

Transportation. Asphalt is assumed to be transported 402 km (250 mi) by truck, rail, and pipeline in equal proportions. Limestone, sand, talc, and granules are assumed to be transported by truck and rail, also over the same distance and in equal proportions. Fiberglass materials are assumed to be transported the same distance by truck.

[5] Trumbore, D. et al. "Emission Factors for Asphalt-Related Emissions in Roofing Manufacturing." Environmental Progress 24:3 (2005): 268-278.

Roofing underlayment raw materials are also 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. Solid wastes generated during the manufacturing process that are not internally recycled within the process are sent off site to either be landfilled or incorporated into other products.

Transportation

Transportation of asphalt shingles 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

In areas with normal wind conditions, four nails should be used to fasten each shingle, while six nails per shingle are recommended in high wind regions. Galvanized roofing nails should be used, with a minimum nominal shank diameter of 12 gauge, 0.267 cm (0.105 in), and a minimum head diameter of 0.953 cm (3/8 in).[6] At four nails per shingle, 320 nails per square are required to secure standard shingles (80 shingles/square), and 260 nails per square are required for metric shingles (65 shingles/square). Installation of one layer of Type-15 felt underlayment is assumed to require an additional 120 nails per square. The weight of 440 nails (for 80 standard shingles with underlayment) is 2.2 kg (4.9 lb) and the weight of nails for 65 metric shingles including underlayment is 1.9 kg (4.2 lb).

Installation of asphalt shingles is assumed to be done primarily by manual labor, so the installation phase in BEES is free of environmental burdens; however, equipment such as conveyors may be used to move the roofing materials from ground level to rooftop, and compressors may be used to operate nail guns used to install roofing materials. There were not enough data to quantify this aspect.

Installation waste from scrap is estimated at approximately 10 % of the installed weight. Installation scrap is generally landfilled, although some manufacturers offer an incentive for contractors to return scrap for recycling into shingles. Data were not available to quantify installation scrap recycling.

Use

At 20 years, new shingles are installed over the existing shingles. No additional underlayment is generally required, since the original roof covering left in place serves the same purpose as the underlayment.[7] At 40 years, the two layers of shingles and the original underlayment are removed before installing replacement shingles with underlayment.

End of Life

When the two layers of shingles and underlayment are removed after 40 years, all materials (shingles, underlayment, and nails) are assumed to be disposed of in a landfill, and are modeled as such. However, there is a growing trend to recycle shingles into pavement products.

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.

Trumbore, D. et al. “Emission Factors for Asphalt-Related Emissions in Roofing Manufacturing”.

[6] Asphalt Roofing Manufacturers Association (ARMA), *Asphalt Roofing Manufacturers Association (ARMA) Residential Asphalt Roofing Manual*, pages 20-23.

[7] Ibid, p. 71.

Environmental Progress 24:3 (2005): 268-278.
Asphalt Roofing Manufacturers Association (ARMA), *Asphalt Roofing Manufacturers Association (ARMA) Residential Asphalt Roofing Manual* (Calverton, MD: Asphalt Roofing Manufacturers Association, 1997) pp. 17.
Crowe, J. P. "Steep-slope roof systems require different underlayment installations." *Professional Roofing* (May 2005) Found at http://www.professionalroofing.net/article.aspx?A_ID=640.

Industry Contacts

Russ Snyder, Vice President, Asphalt Roofing Manufacturers Association, December 2005 – February 2006