Generic Plywood Sheathing

Product Selection and Description

Plywood sheathing is a structural building material used for residential and commercial construction. The panels must be grade-stamped to meet building code. Each panel has a third party certification, a grade stamp that provides such information as the grading agency, the manufacturer, the product type (in this case, sheathing), wood species, adhesive type, the allowable roof and floor spans, and panel thickness.

Plywood sheathing is made from lower density softwoods. Phenol formaldehyde (PF) is used as an adhesive in the manufacturing process. The flow diagram below shows the major elements of plywood sheathing production.

For residential construction, the building code requirement typically is for a rated sheathing panel of either OSB or plywood of 0.95 cm (3/8 in) thickness when sheathing is required, as for shear wall sections; however, the common practice is to use sheathing thicknesses greater than code, which is referred to as "code plus." The most common sheathing thicknesses are 1.2 cm (15/32 in) for plywood and 1.1 cm (7/16 in) for OSB.

For the BEES system, 0.09 m^2 (1 ft^2) of 1.2 cm (15/32 in) thick plywood panel is studied. BEES performance data are provided for both roof and wall sheathing. Life-cycle costs and environmental performance data are essentially the same for both products.

Flow Diagram

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

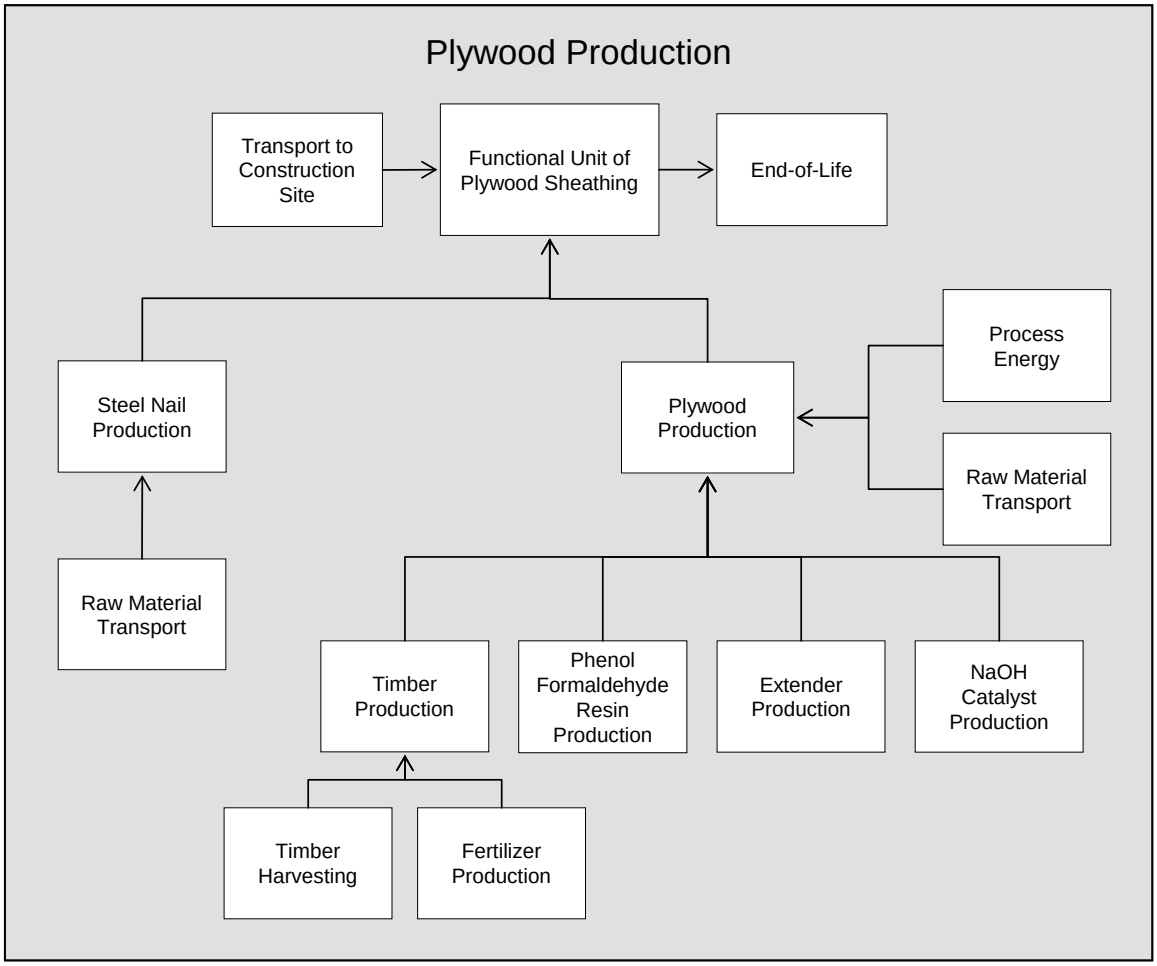

Figure 1: Plywood Sheathing System Boundaries

Raw Materials

The plywood data for BEES are based on two CORRIM resources.[1,2] The dry weight of plywood is assumed to be 521 kg/m^3 (32.5 lb/ft^3). The Table below shows the constituents of 0.09 m^2 (1 ft^2) of 1.2 cm (15/32 in) thick plywood in terms of their final product percentages.

[1] Bowyer, J., et al., Phase I Final Report: Life Cycle Environmental Performance of Renewable Building Materials in the Context of Residential Construction. (Seattle, WA: Consortium for Research on Renewable Industrial Materials--CORRIM, Inc./University of Washington, 2004). Found at: http://www.corrim.org/reports; data also submitted to US LCI Database.

[2] www.corrim.org

Table 1: Plywood Sheathing Constituents

Constituent	*Mass* $kg/m^2 (lb/ft^2)$	*Mass Fraction (%)*
Wood	5.96 (1.22)	97
PF Resin	0.108 (0.022)	1.8
Extender	0.065 (0.013)	1.1
Catalyst (NaOH)	0.014 (0.003)	0.1
Total	6.15 (1.23)	100

Softwood plywood sheathing is primarily produced in the Pacific Northwest and the Southeastern United States. For the Pacific Northwest the species of wood used are Douglas Fir and Western Hemlock, while for the Southeast the wood species is Southern Yellow Pine, which is actually a group of six different softwood species.

The data for growing and harvesting softwood logs for a composite forest management scenario of the Pacific Northwest (PNW) and Southeastern United States (SE) is found in the CORRIM studies. The growing and harvesting of wood is comprised of a mix of low-, medium-, and high-intensity managed timber. Energy use for wood production includes electricity for greenhouses to grow seedlings, gasoline for chain saws, diesel fuel for harvesting mechanical equipment, and a small amount of fertilizer. Emissions associated with production and combustion of gasoline and diesel fuel and those for the production and delivery of electricity are based on the U.S. LCI Database. Fertilizer production data is adapted from European data in the U.S. LCI Database. Electricity use for greenhouse operation is based on the grids for the regions where the seedlings are grown, while the U.S. average electricity grid is used for fertilizer production. CORRIM equally weights production in PNW and SE

BEES modeling accounts for the absorption of carbon dioxide by trees as they grow; the carbon becomes part of the wood, and the oxygen is released to the atmosphere. The “uptake” of carbon dioxide from the atmosphere during the growth of timber is about 1.84 kg (4.06 lb) of carbon dioxide per kilogram of harvested wood (oven-dry weight).

The glue used in bonding plywood consists of PF resin in liquid form combined with extender (which can be a dry agrifiber such as walnut shells or corn husks) and an alkaline catalyst. Data for the production of PF resin comes from the U.S. LCI Database. Weights of resin, extender and catalyst are given on a 100 % solids basis (moisture content not considered).

Manufacturing

Energy Requirements. Manufacturing to produce oven-dry plywood includes several process steps including debarking, log conditioning, production of green veneer, production of dry veneer, pressing and lay-up, and trimming and sawing.

The energy for the plywood manufacturing process is generated from burning wood waste and a small amount of natural gas, and from purchased electricity. Electricity production emissions are based on an average of regional electricity grids for PNW and SE. A small amount of fuel is used for log haulers and forklifts at the plywood mill, and consists of liquid petroleum gas (propane) and diesel. The allocated site energy and electricity use are broken down in the following Table for SE and PNW plywood production. The BEES model uses an equally-weighted average for the final product--1.2 cm (15/32 in) thick plywood:

Table 2: Plywood Production Energy

Energy Carrier	*Units*	*Plywood from SE*	*Plywood from PNW*
Electricity - Regional Grid	MJ/m^2 (kWh/ft^2)	4.26 (0.11)	4.26 (0.11)
Natural Gas	MJ/m^2 (ft^3/ft^2)	3.04 (0.26)	1.64 (0.14)
Diesel Fuel	L/m^2 (gal/ft^2)	0.041 (0.001)	0.041 (0.001)
LPG	L/m^2 (gal/ft^2)	0.015 (0.0004)	0.011 (0.0003)
Hogfuel/Biomass (oven-dry)	kg/m^2 (lb/ft^2)	1.41 (0.29)	0.88 (0.18)

Emissions. The allocated air emissions from the plywood manufacturing process are based on the CORRIM study and reported in the Table below. Allocation is based on mass and a multi-unit process analysis to correctly assign burdens. The VOC emissions are from the drying of wood veneer.

Table 3: Plywood Production Emissions

Air Emission	*Plywood from SE kg/MJ (lb/ft^2)*	*Plywood from PNW kg/MJ (lb/ft^2)*
Particulates (unspecified)	3.12E-03 (6.40E-04)	2.00E-03 (4.10E-04)
VOC (unspecified)	1.32E-03 (2.70E-04)	3.95E-03 (8.10E-04)
Acetaldehyde	2.39E-05 (4.90E-06)	6.83E-05 (1.40E-05)
Acrolein	--	2.78E-03 (5.70E-04)
Methanol	7.32E-04 (1.50E-04)	8.30E-04 (1.70E-04)
Phenol	8.78E-06 (1.80E-06)	1.85E-05 (3.80E-06)
Formaldehyde	1.17E-05 (2.40E-06)	1.37E-04 (2.80E-05)
Acetone	3.42E-05 (7.00E-06)	3.03E-05 (6.20E-06)
Alpha-pinene	4.88E-04 (1.00E-04)	4.54E-04 (9.30E-05)
Beta-pinene	1.95E-04 (4.00E-05)	1.76E-04 (3.60E-05)
Limonene	5.37E-05 (1.10E-05)	4.88E-05 (1.00E-05)
Methyl-ethyl ketone	3.46E-06 (7.10E-07)	7.32E-06 (1.50E-06)

Transportation. For transportation of raw materials to the plywood manufacturing plant, CORRIM surveys report truck transportation of 126 km (78 mi) for harvested wood and truck transportation of 177 km (110 mi) for the resin. The weights of materials shipped to the plywood mill reflect the actual moisture content rather than the oven-dry weight in the plywood product.

Both the logs and the PF resin are shipped with 50 % moisture content on a wet basis (50 % water). The delivery distances are one-way with an empty backhaul.

Waste. There is no solid waste from the plywood manufacturing process. The PF resin is assumed to go into the final product and all the wood is assumed to go into plywood or co-products. Co-products include materials such as peeler core, veneer clippings, panel trim, and sawdust, as well as wood fuels in the form of bark and wood waste that are burned on site.

Transportation

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

Installation

During installation, 1.5 % of the mass of the product is assumed to be lost as waste which is sent to the landfill – although wood construction materials are increasingly being recycled into other products. For walls and roofs, plywood is installed using nails. Approximately 0.0024 kg (0.0053 lb) of steel nails are used per ft^2 of plywood. Steel h-clips are used in addition to nails for roof sheathing, although only a small number of clips are required per panel. H-clip production is not included within the boundary of the model.

Use

Based on U.S. Census data, the mid-service life of plywood sheathing in the United States is over 85 years. As a conservative estimate, CORRIM uses a product life of 75 years.

There is no routine maintenance required for sheathing over its lifetime. Roofing material and siding over the sheathing should be replaced as needed. Sheathing would only be replaced when the framing is replaced; no replacement is assumed.

End of Life

All of the plywood is assumed to be disposed of in a landfill at end of life.

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.

Bowyer, J., et. al., *Phase I Final Report: Life Cycle Environmental Performance of Renewable Building Materials in the Context of Residential Construction*. (Seattle, WA: Consortium for Research on Renewable Industrial Materials. (CORRIM, Inc.)/University of Washington, 2004). Found at: http://www.corrim.org/reports.

Industry Contacts

Jim Wilson, Oregon State University/CORRIM, Inc. (August 2005-Jan 2006)