DOVETAIL PARTNERS, INC.
528 Hennepin Ave, Suite 202
Minneapolis, MN 55403
Phone: 612-333-0430
Fax: 612-333-0432
Website: http://www.dovetailinc.org

Carbon in Wood Products – The Basics

Trees and the products made from them store carbon - and lots of it. Where does the carbon come from? How much carbon is stored, and how is the quantity of carbon determined? These and other questions are addressed in this fact sheet.

Carbon Storage in Trees

Trees absorb carbon dioxide (CO_2) from the atmosphere. The absorbed carbon dioxide is converted to sugars through the process of photosynthesis, with the carbon-containing sugars becoming cellulose, hemicellulose, and lignin, the building blocks used to create new cells and new compounds that collectively make up wood; one-half the dry weight of wood is carbon. The 'waste' product of photosynthesis is life-giving oxygen. Net annual growth in the forests of North America substantially exceeds the volume of wood removed annually. In the U.S., for example, forests have had positive net annual growth for more than 75 years (1, 2, 3). There is also a long history of positive net annual growth in Canada's forests, with the exception of occasional years in which forest fires and insect infestation have combined to slightly reduce net growth (4, 5). As a result, inventories of standing timber have been increasing in the US and Canada for over 50 years (1, 2, 5).

Because of the high net growth in forests relative to removals and the associated increases in timber inventories, the volume of carbon stored in U.S. forests is increasing as well. Above-ground biomass carbon is increasing in the form of both living and dead trees, as is the volume of carbon stored in litter, roots, and soils (1, 2, 3, 5). Moreover, subsequent to harvest, much of the carbon within the trees becomes part of long-lived forest products, increasing carbon stocks in the built environment.

Carbon Storage within Wood

<u>Large Quantities of Carbon</u>

Climate issues are increasing interest in the carbon implications of building design and building materials selection. Consequently, attention to carbon storage within forest products and wood structures is increasing as well.

When wood is used for building materials, there is an extended opportunity for carbon storage. In effect, a new "carbon pool" is created. For example, a carbon pool is created by framing a home with wood where carbon will be stored for as long as that home lasts. An average new single family home contains about 15,800 board feet of lumber and 10,900 square feet of wood panels, a quantity of wood that incorporates about 9.3 tons of carbon (4). The carbon dioxide equivalent is over 34 tons. A massive quantity of carbon is stored within over 72 million such homes in the United States and Canada, a similar number of townhouses and multiple occupant residences, and a growing number of non-residential structures.

Estimation of the quantity of carbon within wood is seemingly straightforward since carbon makes up about one-half the dry weight of wood. However, care is needed in making estimates since several factors significantly influence accuracy. Among these are wood moisture content and the critical difference between carbon (C) and carbon dioxide (CO_2).

<u>Estimating Carbon within Wood</u>

Adjusting for Moisture Content

It is important to recognize that carbon comprises about one-half of the *dry weight* of wood. Wood in use is never completely dry. Kiln-dried lumber, for example, typically has a moisture content of about 15%, meaning that the weight is 15% greater than if the wood were completely dry. Green lumber (S-GRN) may have a moisture content of 30% or higher, while the moisture content of freshly harvested logs may be in excess of

100% (6), meaning that the weight of water in logs may equal or exceed the weight of the wood itself. To determine the dry weight it is necessary to divide the weight of a given volume of wood by 1 + moisture content, where the moisture content is expressed as a decimal. In the example above, the weight of kiln-dried wood would need to be divided by 1.15 to calculate the dry weight. Nearly all of the wood used in construction is kiln-dried.

Proper Consideration of Wood Volume

Calculation of carbon content based on wood density (weight per volume) can be tricky. The volume of wood remains constant as it dries until it reaches 30% moisture content. Further moisture loss results in shrinkage. Wood has a higher volume when in the green condition than when kiln-dry, and a greater volume kiln-dry than when moisture free (i.e. at zero percent moisture content). Thus, accurate calculation requires that wood density be matched to moisture content.

Carbon and Carbon Dioxide – the Difference

Discussions about climate issues commonly focus on CO_2 emissions, or more precisely CO_2 equivalent emissions. Perhaps as a result, carbon content is sometimes confused with the CO_2 equivalent of a given quantity of carbon.

The molecular mass (sometimes referred to as molecular weight) of carbon is 12, and of oxygen 16; that of carbon dioxide (CO_2) is 44. Therefore, the carbon dioxide equivalent of 1.0 or tonne of carbon is 44/12 x 1 or tonne = 3.67 tonnes. It is quite important to be certain in estimating carbon content that carbon content is not confused with the carbon dioxide equivalent; doing so can greatly overstate the quantity of carbon.

Units of Measure

In the table below, wood densities at a kiln-dry moisture content (15%) are given, as are the carbon contents of various quantities of wood. Wood density and carbon content are expressed as pounds per cubic foot (ft^3) and kilograms (2.2046 pounds) per cubic meter (35.31 ft^3). One cubic meter is roughly equivalent to that of an average-sized telephone pole.

While the values given herein can be helpful in making a quick determination of the carbon content of bulk-piled wood, obtaining estimates of carbon contained in an entire structure can be laborious. For more information on estimating carbon content from a bill of materials, there is a new web-based tool that greatly simplifies this task (5).

The simplest way to estimate carbon content is on a mass basis. Kiln-dried wood contains 0.435 tons (or tonnes) of carbon per ton (or per tonne) of wood.

Wood Density and Carbon Content of Commonly Used Wood Species

	Standard Units			Metric Units		
	Density * of Wood 6/	Estimated Carbon Contained within Wood **	Estimated CO_2 equivalent Contained within Wood **	Density * of Wood 6/	Estimated Carbon Contained within Wood**	Estimated CO_2 equivalent Contained within Wood **
	Pounds per ft^3 for kiln-dried wood (15% MC)			Kilograms per m^3 for kiln-dried wood (15% MC)		
Cedar, western red	24.6	10.7	39.2	394	171	627
Douglas-fir/Larch	34.5	15.0	55.0	553	240	880
Hem/Fir	30.7	13.3	48.8	492	214	785
Spruce/Pine/Fir	27.8	12.1	44.4	445	193	708
Pine, southern yellow	36.3	15.8	57.9	582	253	928
Redwood	24.0	10.4	38.1	385	167	612
Red oak	44.5	19.3	70.9	713	309	1136

* To determine the dry (moisture-free) weight, divide density numbers shown above (columns one and four) by 1.15.
** The carbon content per unit volume is less in green wood (S-GRN). For approximate carbon content of a given volume of green wood, multiply carbon content values above by 0.95.

References

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