

A Word From the Watershed

Carbon Trade-offs in Construction: Wood, Steel, and Concrete

By Jim Crawford

A lot of people are talking now about the emission of carbon dioxide and other greenhouse gases. For this article I thought I would look into how carbon emissions can change depending on the materials sourced for construction. According to the Environmental Protection Agency (EPA), the construction sector accounts for about 48% of all greenhouse gas emissions in the United States. Meaning, a reduction in emissions in the construction field could have a major impact on total U.S. emissions.

Most buildings whether residential, commercial, or industrial are constructed from either wood, steel, concrete, or a combination of the above. Wood is the dominant material in residential housing, whereas steel and concrete are typically more dominant in commercial and industrial spaces.

Multiple models have been developed to assist in the effort of quantifying emissions from each of these construction materials. One of these models, developed by the nonprofit Athena Sustainable Materials Institute, was used by researchers (professors in Renewable Materials and Engineering) from Oregon State University to assess how a change in construction materials could change total emissions associated with the project. Looking at six different commercial buildings and using this life cycle emissions model, they found that using wood as the primary construction material could reduce greenhouse gas emissions by a factor of 3.1 compared to concrete buildings and 2.2 for steel buildings.

Let's look into why wood emits fewer greenhouse gases than steel and concrete. First, concrete's raw materials are mined from the earth, then crushed into a more manageable product and transported to a production plant. At the plant, these mined minerals are

fed into a kiln for further processing and then ground into a powder. A series of additives is then incorporated, the exact type and quantity of which determines the final type of cement that is produced. According to the EPA, over 90% of total greenhouse gas emissions from concrete occur during the kiln firing phase, and the lion's share (71%) of the emissions come from the use of coal required to achieve the extremely high temperatures in the kilns – about 2700° F.

Steel has a similarly complicated production process. First, iron is mined from the earth and transported to a steel plant. In a furnace the iron is then mixed with lime and "coke," which is essentially a processed and highly refined coal. Next, oxygen is forced through the furnace to remove carbon and other impurities from the mixture. Depending on the exact type of steel being made, different additives will become a part of the mixture. For example, the addition of aluminum creates drawing quality steel, while the addition of chromium and nickel creates stainless steel. The steel is then cast into molds, allowed to cool, and cut into transportable pieces. To achieve the final shape and quality, the steel is cast into rough shapes, processed to further remove impurities, and then formed into the final product. According to the World Steel Association, an industry group, the steel industry accounts for up to 9% of global emissions from fossil fuels, emitting 1.85 tons of carbon dioxide for each ton of steel produced.

The production of building materials from wood makes an interesting comparison to that of concrete and steel. Trees grow and sequester carbon, are harvested, processed into logs, and transported to a production facility that is very rarely more than 100 miles away. The area is then replanted with more trees for future carbon sequestration and harvest. At

the production facility they are either cut into lumber for construction or peeled into sheets of veneer and then "glued" into plywood. These products continue to sequester carbon until the end of their lifespan. According to the EPA, since 1990 land use and forestry/lumber activities in the U.S. have resulted in more removal of carbon dioxide from the atmosphere than has been emitted. In addition, these activities have removed nearly 12% of all U.S. greenhouse gas emissions from the atmosphere. The EPA also states that the opposite is true in many other parts of the world in which forestland is cleared for agriculture and human settlement.

Of course, steel and concrete also offer characteristics that traditional wood does not, such as high tensile strength from steel and extreme compressive strength from concrete. However, the new technology of cross laminated timber, which is essentially gluing together pieces of lumber for additional strength, is beginning to compete with the strength characteristics of these products. For example, the 18 story Brock Commons at the University of British Columbia was constructed with cross laminated timber instead of the usual steel.

It seems clear that wood products provide a construction material that offers tremendous greenhouse gas benefits rather than the costs associated with other modern materials, particularly when produced locally within the U.S. The local nature of wood construction materials also provides stark contrast to the carbon cost associated with transporting steel and concrete, a further win for these materials.

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