Comparative assessment of carbon uptake and release of wooden and concrete building materials

Franz Dolezal[1], Philipp Boogman[1]

[1] Alserbachstr. 5/9, 1090 Vienna, Austria, IBO – Austrian Institute for Building and Ecology GmbH; e-mails: franz.dolezal@ibo.at; philipp.boogman@ibo.at

Keywords: carbon uptake, carbon release, carbon sequestration, carbonisation, biogenic carbon

The building industry plays a major role in climate change issues. Especially production of concrete, as the most important building material, contributes 5% to global carbon dioxide emissions (Xi *et al.* 2016). On the first glance it seems to be obvious to replace concrete by renewable materials if procurable. But taking the whole life cycle of the building products into account, results may change. Comparative assessments usually are not satisfying since outcomes mainly depend on the chosen methodology. However, climate change mitigation is the major issue nowadays and building materials with the ability to sequester atmospheric carbon dioxide are the ones that have to be chosen. Therefore, two different, important building materials with ability of carbon sequestration, but with completely different performance are analyzed. This survey aims to clarify methodological differences, but also amounts of stored carbon dioxide in common building elements in order to get a clearer picture.

Storage of biogenic carbon in wooden building products

Among the major building materials, wood is the only one with the ability to store a significant amount of biogenic carbon dioxide. Starting with the germination of the seed, carbon dioxide assessment of a wooden product is not only time dependent, it requires an accurate tracking through the whole life cycle until its release into the atmosphere through combustion or decay (Kuittinen *et al.* 2013). The important life cycle phases (Fig. 1) for the carbon stock of wooden building products according to EN 15804 are A1 (the growth of the tree), when carbon is stored by photosynthesis, and C3, where the carbon stock is released, usually by combustion of the timber.

Storage of carbon in concrete building products – (re)carbonation

Concrete stores carbon as well, but in a completely different way than wood. When limestone is burned during cement production, calcium carbonate $CaCO_3$ is transformed to calcium oxide CaO by releasing carbon dioxide CO_2. So on one hand cement production needs a lot of energy which is covered to a significant amount by fossil fuels with related CO_2 emissions, on the other hand, the process itself emits around 90% of global GHG emissions from industrial production (Xi, *et al.* 2016). These latter emissions are partly reversible in a process called recarbonation or simply carbonation. In this physiochemical process, CO_2 diffuses into cement based materials throughout their entire life cycle and is reabsorbed to an amount of nearly 50% of the one that has been released during production process (without fuel emissions). Hence, important phases for CO_2 storage and release (Fig. 1) for concrete are phase A3 (production) where large amounts of CO_2 are emitted, B1 (use phase, with contact to the atmosphere) and C4, when exposed concrete surfaces have the opportunity to absorb CO_2 after having reached waste status. Calculation is carried out according to FprEN 16757 on the basis of a variety of different studies e.g. Lagerblad 2005 and Andersson *et al.* 2013.

Carbon uptake and release in the life cycle of wooden and concrete building products

Fig. 1 shows the significant differences in CO_2 storage and release of wooden and concrete building products. Uptake and release takes place in different life cycle phases with subsequent methodological impacts. Relevant quantities are indicated by the size of the arrows.

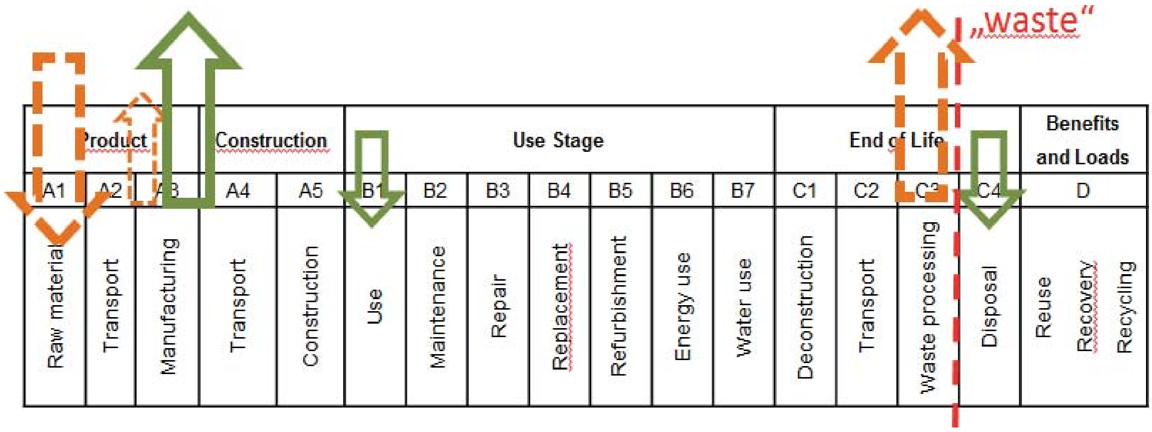

Figure 2: CO_2 uptake and release in different life cycle phases - wood (dashed) and concrete (solid line)

Conclusions

Calculation of CO_2 storage of wood is based on simply considering carbon share in the product, and described in detail in EN 16449. Methodology of assessment of carbonation is already normalized in FprEN 16757, but is not based on natural law and contains a lot of controversial assumptions and scenarios which need to be discussed. Especially carbonation scenarios during use phase, when concrete is covered with different materials and end of life phase, when used as a secondary material or landfilled in deep layers, still need further investigations.

References

Andersson R. *et al.* 2013. Calculating CO2 Uptake for Existing Concrete Structures during and after Service Life. Environmental Science and Technology, 47 (20), pp 11625–11633. DOI: 10.1021/es401775w

Kuittinen M. *et al.* 2013. Wood in Carbon Efficient Construction – Tools methods and applications. CEI-Bois. Brussels. ISBN: 978-9-0820-9080-2

Lagerblad B. 2005. Carbon dioxide uptake during concrete life cycle – State of the art. Swedish Cement and Concrete Research Institute. CBI Report 2:2005. ISBN 91-976070-0-2

Xi F. *et al.* 2016. Substantial global carbon uptake by cement carbonation. Letters, nature geoscience. DOI: 10.1038/NGEO2840