CONCRETE

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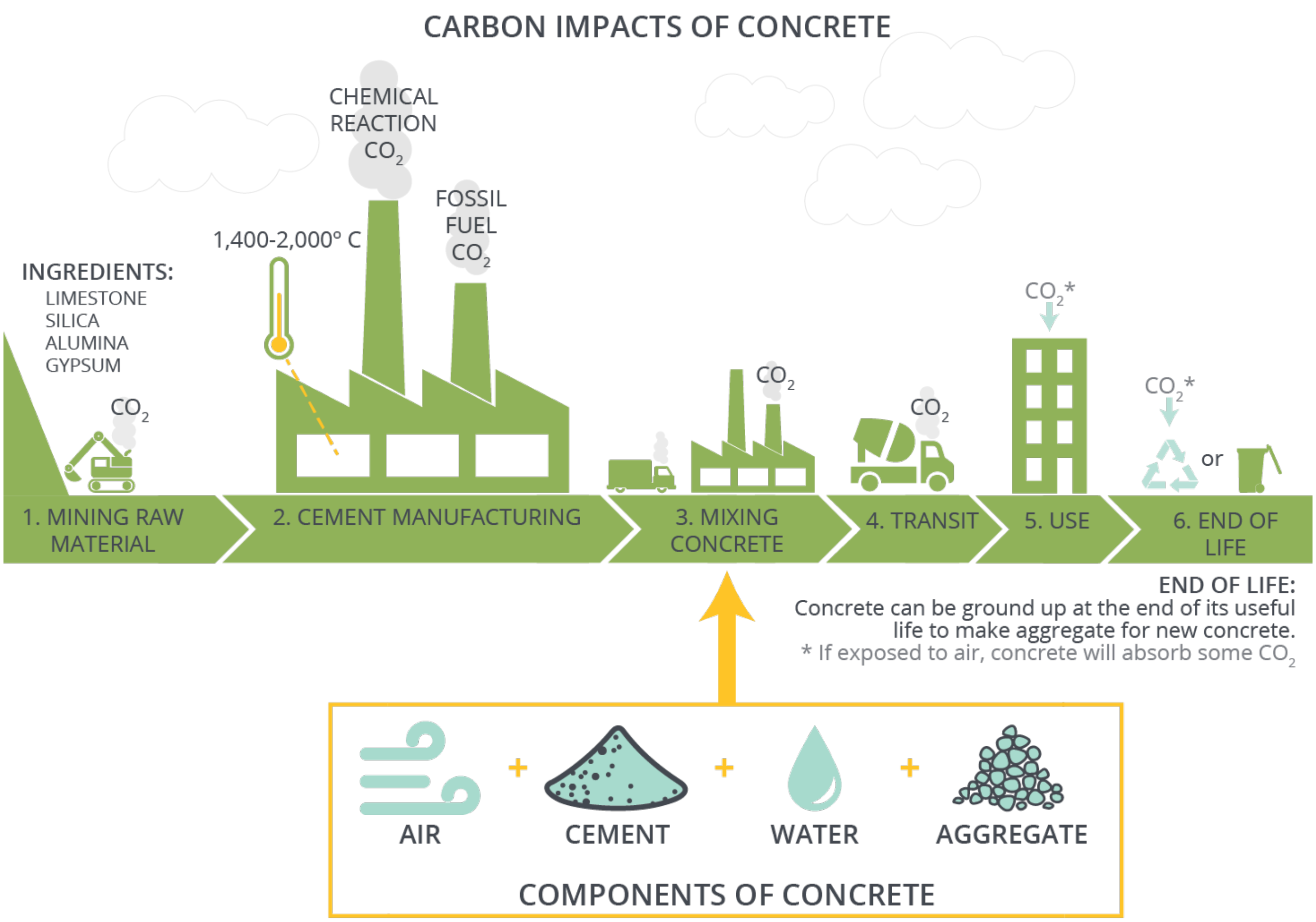

Carbon Smart Attributes

Less cement = less carbon

After reducing the carbon impact of cement production, additional carbon reductions can be made by reducing the amount of cement used per unit volume of concrete. Substitute cement with supplementary cementitious materials (SCMs) from non-fossil fuel based sources (see **Use non-fossil fuel based SCMs**), and/or use larger sized aggregate (e.g. 1" vs ¾" coarse aggregate) where appropriate. Typical practice is to define a minimum amount of cement required and/or a maximum allowable amount of SCMs, both of which can result in the inclusion of more cement than necessary. Instead, specify the required compressive strength at a specific age[1].

Get to know what options are available to suppliers local to the project

Not all the options below are available to all concrete suppliers, as materials in concrete vary significantly depending on local supplies. Aggregate, the largest and heaviest portion of concrete, should ideally come from nearby sources, but this can dictate the amount of cementitious materials needed for strength. SCMs also vary in quality, consistency, and availability (transport distance), so it is important to know which ones local suppliers can utilize dependably and economically. Lastly, admixtures can make low-cement concrete that would normally be unworkable much easier to handle and finish in the field but require well-trained teams at the batch plant and the construction site, which not all suppliers and subcontractors can guarantee. Understand the options available to local suppliers and work with them to reach the most optimal specifications while also pushing them towards and creating demand for carbon reduction strategies.

Select different mixes for different uses and plan ahead

Concretes with high supplementary cementitious materials to reach the required strength often require longer cure times than conventional concrete. Identify building components that don't need high early strength and plan ahead to allow for these components to have longer cure times. For example, footings and mat slabs, as well as shear walls and columns at lower levels of high-rise structures, are good targets for low cement mixes even when relatively high strengths are required.

Consider 56 or later day strength on parts of the project

Strength conformity at 56, 90, 120, or more days, rather than the conventional 28, could enable an increase in the amount of SCMs replacing cement. Specify design compressive strengths greater than 28 days whenever possible to allow the maximum use of SCMs.

Kiln types matter for cement

The different kiln types used for cement production, listed in increasing order of energy intensity, are: dry with preheater and precalciner, dry with preheater, long dry, and wet. Dry with preheater and precalciner kilns use on average 85% less energy than wet kilns[2]. Understand what type of kiln your concrete suppliers use for cement production, and request cement that comes from the least energy intensive kiln that is locally available.

Consider the mixing method

Some methods for mixing concrete can create high-strength concrete with a lower volume of cement. For example, the scattering-filling aggregate process adds an additional "10-30% (by the volume of the finished concrete) of coarse aggregate while the concrete is being poured, paved or placed, then vibrating the mixture to form a consolidated concrete"[3]. This method results in 10-30% less cement than conventional concretes, reducing carbon emissions while increasing the compressive strength of the mix. This method is often referred to as 'controlled particle size distribution' and is common practice in certain regions (e.g. North America).

Utilize carbon sequestration (CO_2 injection)

New technology captures the carbon naturally emitted during the cement manufacturing process and injects it back into the concrete mix during mixing. Encourage concrete suppliers to use carbon sequestration/CO_2 injection methods.

Specify hard, clean, and strong aggregates

Weak and/or lightweight aggregates often require the addition of more cement to achieve the necessary mix strength. Soft, porous aggregates can also result in weak concrete with low wear resistance, reducing the life-span of the material. Whenever possible and locally available, use strong aggregates to reduce the required cement quantity and create concrete with a high resistance to abrasion and a longer life-span[4].

Specify Portland Limestone Cement (PLC) instead of Portland cement

PLC, or type IL cement, is a slightly modified version of Portland cement that can result in reduced embodied carbon by using higher percentages of limestone (5-15% in PLC, compared to the 5% typically used in Portland cement)[5]. This results in a smaller portion of cement in the mix. Where locally available, specify PLC over typical Portland cement.

Use non-fossil fuel-based SCMs

Specify non-fossil fuel-based SCMs or cement replacements whenever locally available, including but not limited to the following:

Glass Pozzolan*

Glass Pozzolan is recycled, post-consumer glass that is ground up and used as an SCM, reducing the amount of cement in a concrete mix. Glass pozzolan has been shown to contribute to effective, consistent strength gain and workability.

Rice Husk Ash Concrete

Rice husks (the hard protective coverings of rice grains) are agricultural byproducts (waste material from rice mill processes), and are made up of approximately 85-90% amorphous silica plus about 5% alumina, making the ash highly pozzolanic*[6].

*Pozzolans are a broad class of siliceous or siliceous and aluminous materials which, in themselves, possess little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties[7].

Design & Construction Guidance

Design for material optimization and efficiency

There are many pathways for optimizing material efficiency to reduce concrete use and embodied carbon emissions. A careful analysis should be done to ensure carbon emissions will be reduced overall.

Using shorter bay sizes can allow for thinner slabs. However, more columns may be needed to make up for shorter bay sizes which could result in more overall concrete use. A careful analysis should be done to ensure concrete volume will be reduced overall.

Using longer bay sizes can create more usable floor area and reduce foundation loads from structural components. High-strength concrete (HSC) can be used in conjunction with longer bay sizes to achieve smaller columns and thinner slabs. However, HSC often requires more cement, which can increase embodied carbon emissions. Preliminary calculations should be run to balance strength (which at some point rapidly decreases with slenderness) versus weight and total cement volume needed. This strategy is eventually limited by the minimum size reinforcement cages can be made, and the cover needed to protect the reinforcement.

Consider the trade-offs when using prestressed and precast concrete

Post-tensioned slabs and beams generally require more cement in order to reach their desired early strength. While prestressed and precast slabs and walls often enable thinner sections, the total cement content should be compared to the total cement content of a mildly reinforced cast-in-place system to determine which has lower embodied carbon overall.

Lighten the weight of slabs

Reducing the weight of slabs helps reduce the loads on the columns and foundations, thereby reducing their size and embodied carbon. There are two approaches for reducing the weight of the slab: 1) use structural lightweight concrete (which incorporates lighter aggregates but can still be high strength), or 2) incorporate voids (such as proprietary air-filled recycled plastic spheres) to reduce the amount of concrete needed. The use of some proprietary void systems has been shown to yield slabs that use an average of 35% less concrete than traditional slabs, while performing like solid reinforced concrete. Preliminary calculations should be run to balance weight versus strength and stiffness in slab systems.

Use reinforcement only when needed

As long as alternate crack control measures are taken, many slabs on grade can be cast without reinforcement. The embodied carbon of metal or polymer fibers used in standard quantities to control cracking in slabs on grade is typically small compared to the reinforcement removed, but the embodied carbon balance between the two should be evaluated.

If using reinforcement, consider high-strength

High-strength reinforcement often has the same embodied carbon as conventional reinforcement, since the strength is achieved using small quantities of micro-alloys with negligible embodied carbon. When the higher strength results in lower steel quantities, the embodied carbon of the concrete structure is reduced.

If using structural concrete, also use it as a finish material

Use structural concrete as a finish material to eliminate the embodied carbon emissions of additional architectural finishes. Additionally, if exposed to air, concrete has the ability to absorb some CO2 during its life[8]. However, ensure that the amount of cement in the mix is **not** increased in order to create a consistent appearance.

Crush and spread concrete at the end of life

After its useful life, concrete is normally crushed and used as secondary product (for roads or base courses, or as fill material). If exposed to air, concrete has the ability to absorb some CO_2[8], though the amount of carbon absorbed depends on a variety of factors. Therefore, grind or crush and spread concrete to maximize surface area at its end of life. A careful analysis should be done to compare the amount of CO_2 absorbed if concrete is crushed and spread at the end of its useful life to the cement savings if reused as a secondary product.