Green Newton: Building Standards Committee
Embodied Carbon Reduction Recommendations for Buildings over 20,000 sq. ft.
11 December 2023

Green Newton encourages all developers to reduce the embodied carbon[1] of their projects.

Green Newton will only support new multifamily projects over 20,000 sq. ft. that report back to Green Newton their embodied carbon reduction plans for their projects. Projects over 50,000 sf should meet the LEED Material and Resources Building Life-Cycle Impact Reduction credit category and demonstrate a minimum of a 10% reduction relative to a reference building representing standard design and construction practices described in LEED. Projects between 20,000 and 50,000 sf should estimate the embodied carbon of the structure only using Environmental Product Declarations (EPDs) or other methodology listed in the SE 2050 Database User Guide (https://se2050.org/).

Green Newton also asks developers to commit to requesting Environmental Product Declarations of all products and specifying concrete with reduced Global Warming Potential targeting the 25th percentile where feasible (see 4 and Appendix for more detail).

Project teams may consider using the following additional practices to achieve embodied carbon reductions.

1. Include the structural engineer, architect, and general contractor in early discussions that emphasize it is a high priority to use lower embodied carbon materials and design when feasible.

2. Renovate existing construction where feasible.

3. Optimize Concrete Design and Specification with the Structural Engineer.
   - Specify concrete with reduced GWP. The tables in the Appendix 1 provide GWP and cement thresholds for concrete meeting various performance criteria. For public and private construction in Newton we recommend targeting the 25% percentile where feasible and in no case exceeding the 75th percentile.
   - Use Performance Based Concrete Specifications with performance requirements for embodied carbon.
   - Replace cement with other cementitious materials, such as slag or glass pozzolans such as Pozzotive. 30% cement replacement with slag, for instance, does not slow strength gain appreciably, improves many concrete properties, and will likely be cost competitive. Higher replacement percentages are possible in many applications, especially where rate of

[1] Embodied carbon is the sum of greenhouse gas emissions associated with the building materials. Embodied carbon always includes emissions due to raw material extraction, manufacturing, and transportation for materials production and often includes the emissions associated with the construction, maintenance, renovation, and end-of-life of buildings and infrastructure. Greenhouse gas emissions are calculated relative to the impact of one molecule of carbon dioxide and reported as carbon dioxide equivalent (CO_2e) with units of mass. In Life Cycle Assessment reports and Environmental Product Declarations (EPDs), embodied carbon is equivalent to Global Warming Potential (GWP).

strength gain is not critical. Also consider products like CarbonCure, Solidia, Blue Planet Aggregate, ground limestone, and calcined clay where available.
- Consider beam size and spacing to reduce the amount of concrete needed. Joist construction, for instance, generally uses less concrete than flat slab or flat plate construction.
- Consider reducing or eliminating below-grade interior space and using frost-protected shallow footings to reduce concrete consumption.
- Use well-graded aggregates with maximum aggregate sizes as large as project requirements and availability permits.
- Consider specifying strength at 56 days instead of 28 days to allow more time for strength gain. This can be for some components and not others.

4. Steel Reinforcement:
   - Use rebar with low GWP, such as rebar produced with renewable energy. Request EPDs to confirm performance and to compare GWP values of supplied rebar to industry-average values.
   - Use High strength rebar if it can reduce rebar tonnage by at least 10% compared to 60 ksi rebar.

5. Structural Steel:
   - Use Structural Hot Rolled Steel (if used) that is created with Electric Arc Furnaces with 90% recycled content steel (usually North American specified) or specify GWP limits 25% above American average for each type of member as demonstrated by product-specific EPDs. American average GWP values may be sourced from industry-average EPDs.
   - Optimize Structural Steel Design with Structural Engineer (if structural steel is used).
     - Consider Higher Strength Steel
     - Consider Composite Design
     - Consider Camber
     - Consider Geometry Design Changes such as smaller bays to reduce steel requirements
   - Use HSS structural steel tubes from Electric Arc Furnaces.

6. Timber:
   - Consider MassTimber construction techniques to minimize steel and concrete use.
   - Use certified wood (SFI or FSC) for as many wood products as possible.

7. CMU:
   - If CMU is used in construction, use specified compressive stress method instead of prescriptive method to proportion grout mix.

8. Insulation:
   - Do not use closed cell spray foam with blowing agents with high global warming potential.
   - Avoid XPS with traditional blowing agents (XPS manufactured with low GHG blowing agents are readily available).

- Use Foam glass gravel when possible instead of XPS in subsurface foundation/basement insulation.
- Use Hempcrete or other biobased insulation types for wall or floor insulation.
- Use wood fiberboard (properly managed forest or rapid growth) or other biogenic sequestering insulation for exterior continuous insulation and other rigid fiberboard applications when feasible.

9. Finishes:
   - Consider interior finishes with low embodied carbon (avoid carpet where possible) or eliminating finishes altogether where feasible.
   - Specify low-carbon gypsum wall board.

10. Cladding:
    - Evaluate embodied carbon of cladding options and use lower GHG options (see study of Washington St. cladding types) Fiber Cement Board in several studies seems to be attractive option.
    - Consider low-embodied-carbon brick alternatives if using brick.
        - Recycled brick
        - BioMASON
        - Thinbrick attached to substructure

11. Design MEP system to minimize embodied carbon and/or use next gen refrigerants.

12. Incorporate salvaged building materials.

Resources:

- Beyond Fly Ash: How to Optimize Your Concrete Structure to Reduce Embodied Impacts, Tally Webinar Feb. 13, 2020 https://choosetally.com/webinars/. Minute 26- Use LCA-Tool from ZGF for requests for substitution to know how they will change embodied carbon impact. Minute 28- things to avoid in specifications. Minute 34- List of questions to ask structural engineer and builder.
- Impact Conference, "The Elephant in the Room: Tackling Embodied Carbon in Practice" available in USGBC continuing education webinars. Most relevant for concrete: Minute 13- Erika Winters-Downey, McCownGordon Construction, minute 14-30; Most relevant for steel: Minute 30, Trevor Acorn, Walter P Moore, Cement section.
- BSA Embodied Carbon 101: Structure; https://www.architects.org/embodied-carbon-101-video-archive.
- Re-framing Steel: How to Optimize Your Steel Structure to Reduce Embodied Impacts, Tally webinar April 2, 2020 https://choosetally.com/webinars/; Michael Gryniuk; compares Basic Oxygen Furnace (BOF) and Electric Arc Furnace (EAF) minute 26 (describes specification with CO2 limits) Michael Gryniuk; increase steel strength minute 28; Be Careful with lightweight lightweight concrete.

- One example of low embodied carbon gypsum board is USG EcoSmart. See Cultivate, Solara Apartments LCA.
- Nucor's $250 million micromill in Sedalia, Missouri, is the first U.S. steel plant to run on wind energy. A recycled steel plant run by EVRAZ in Colorado is transitioning from coal to solar in a partnership with Xcel Energy and a solar developer half owned by BP.
- Use Payette Kaleidoscope wall assembly tool to compare cladding and wall assembly options.
- The CPG members who are making CarbonX CMU are in the process of preparing EPDs to demonstrate the lowered GWP from use of CarbonX, so designers will have new options to meet their targets, such as the Architecture 2030 Challenge and the SE 2050 Challenge. CarbonBuilt also has developed a technology for low-embodied-carbon CMU and are working to make it available in our region.
- BSA Embodied Carbon 101: MEP; See "Key Questions to ask your MEP Engineer" at minute 47; Julie Janiski. Listen to early Q and A at end.

APPENDIX 1: RECOMMENDATIONS FOR SETTING EMBODIED CARBON TARGETS FOR CONCRETE PRODUCED IN NEW ENGLAND

Concrete industry stakeholders, including specifiers, policy-makers, owners, and suppliers, point to the need for more uniformity around specifying concrete for building and other projects. The following guidelines are a step in that direction. Policy-makers, owners, and specifiers can decide how aggressively they wish to reduce the embodied carbon of the concrete used for their projects. Policy-makers may choose to be less aggressive, say by filtering out the most carbon-intensive 10, 20 or 25% of the available mixes, while owners with strong sustainability objectives may wish to specify concrete that is better-than-average. These guidelines offer the means to implement any of these options.

Selecting the threshold for a project or policy requires some knowledge of the availability and cost of low-carbon concrete. These factors are in constant flux, making it more difficult to set the threshold. Regulatory requirements should be less demanding to account for this uncertainty, whereas project-specific thresholds can be more aggressive, particularly if the specifiers have access to contractors and suppliers who can provide guidance based on current market conditions. We recommend that specifiers check with local producers that might be supplying mixes when specifying low-carbon concrete to confirm availability and pricing.

When EPDs are available, we recommend specifying low-carbon concrete using GWP as the performance metric. Using this metric will provide a more accurate measure of climate performance compared to setting cement limits. For example, the carbon emissions of cement itself varies with source. This variation will likely be accounted for in mix-specific EPDs. The number of EPDs available in Massachusetts is increasing. The MassCEC has initiated a program offering financial incentives for ready-mix companies wishing to produce EPDs for their mixes, which should accelerate this trend.

We recommend setting targets for low-carbon concrete using a Percentile-Based approach. The Percentile-Based approach allows the specifier to exclude the use of a selected percentage of available mixes, with the 50th percentile representing typical practice.

The following tables provide the recommended GWP and cement limits for Massachusetts (and the northeastern United States) using the Percentile-Based approach. The figures are rounded to the nearest multiple of 5 so as not to imply an unwarranted level of precision. GWP limits are given per cubic meter, corresponding to the units reported in most EPDs. Cement limits are per cubic yard, the units ready-mix producers normally use. The derivation of these tables is described in detail below.

	Concrete 28-Day Strength (psi)								
Percentile	**2500**	**3000**	**4000**	**5000**	**6000**	**8000**	**3000 LW**	**4000 LW**	**5000 LW**
90%	400	355	420	495	530	605			
80%	345	325	385	455	485	560			
75%	325	310	370	440	470	540			
50%	240	265	315	380	400	470			
25%	155	215	260	315	330	400			
20%	135	205	245	300	315	385			

Table 1: Recommended GWP Limits for Reduced-Carbon Concrete Using Percentile-Based Approach (kg CO2e/m3)

	Concrete 28-Day Strength (psi)								
Percentile	**2500**	**3000**	**4000**	**5000**	**6000**	**8000**	**3000 LW**	**4000 LW**	**5000 LW**
90%	575	520	635	770	820	955			
80%	495	475	580	705	750	880			
75%	465	460	560	680	725	855			
50%	345	385	475	585	620	745			
25%	225	315	390	490	515	635			
20%	195	300	370	465	490	610			

Table 2: Recommended Portland Cement Limits for Reduced-Carbon Concrete Using Percentile-Based Approach (lb/cy)

Adjustments

Adjustments may be made for special conditions.

High-Early-Strength Concrete: Concrete that requires high early strength may require more portland cement and therefore have higher carbon emissions. If aggressive carbon reduction thresholds are specified for a project, these thresholds may need to be relaxed if high early strength is required. We do not expect high-early strength allowances will be required for concrete in the 90th percentile. Marin County low carbon concrete provisions include a 30%

high-early-strength allowance for concrete otherwise specified as 10% to 30% below the NRMCA benchmark.[2]

Cold Weather: The lower heat of hydration associated with low-carbon concrete can make it challenging to keep the concrete warm enough during curing in cold weather conditions (typically below freezing) to avoid damage. Specifiers may wish to offer an allowance such as that for high-early-strength concrete for cold weather conditions.

Flatwork: Finishing slabs with high cement replacement can be challenging, especially for installers who are not familiar with working with these mixes. Longer drying times may affect installation of finishes. Some designers choose to be more cautious about specifying embodied carbon reductions for slabs. Experienced finishers report that they can finish slabs with 30% slag replacement without difficulty.

Durability: For concrete exposed to certain corrosive environments, the code caps the quantity of SCMs in the mix. Designers need to be aware of these provisions when specifying cement and GWP limits on their mixes.

[2] MarinLCCCProcessSummary2021.pdf (stopwaste.org)