DUBLIN
CALIFORNIA

FACT SHEET

LOW CARBON CONCRETE

EXAMPLE CALCULATIONS

LOW CARBON CONCRETE BUILDING CODE COMPLIANCE PATHWAYS

In support of Climate Action Plan 2030 and Beyond, the City of Dublin adopted a low carbon concrete building code which is effective as of January 1, 2025. All projects requiring a building permit and that use ready-mix concrete are subject to the code. The two compliance pathways to meet the building code are explained in this document.

CEMENT LIMIT AND EMBODIED CARBON LIMIT COMPLIANCE PATHWAYS

The two low carbon concrete compliance pathways are the cement limit and the embodied carbon limit. The calculations provided in this document demonstrate how to use these pathways to meet the low carbon concrete building code. Compliance requirements for each pathway are based on the minimum specified compressive strength of the concrete used in the project. The examples provided here are for illustrative purposes only. Applicants are encouraged to use the low carbon concrete compliance spreadsheet which does the calculations for you rather than completing hand calculations.

Table 4.420.3 shows the limits included in Dublin Municipal Code Chapter 7.94 (Green Building), Section7.94.085 (Low Carbon Concrete).

Table 4.420.3 Cement and Embodied Carbon Limit Pathways

	Cement Limits	Embodied Carbon Limits*
Minimum specified compressive strength f'c, psi	Maximum ordinary Portland Cement content, lbs/yd^3	Maximum embodied carbon $kgCO_2e/m^3$, per EPD
Up to 2500	362	260
2501-3000	410	289
3001-4000	456	313
4001-5000	503	338
5001-6000	531	356
6001-7000	594	394
Greater than 7000	657	433
Up to 3000 light weight	512	578
Up to 4000 light weight	571	626
4001-5000 light weight	629	675

*Limits for use with any compliance method 4.420.3.2 through 4.420.3.5

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CEMENT LIMIT CALCULATION

For the cement limit pathway, the sum of all cement content for each mixture used in a project [$\Sigma((Cem_n)(v_n))$] must be less than or equal to the sum of maximum limit of cement content for each mixture as shown in table 4.420.3 [$\Sigma((Cem_{lim})(v_n))$].

$$\Sigma((Cem_n)(v_n)) \leq \Sigma((Cem_{lim})(v_n))$$

Where,
n = the total number of concrete mixtures for the project
Cem_n = the cement content for mixture n, pounds (lb)/yard $(yd)^3$
Cem_{lim} = the maximum cement content for mixture n per Table 4.420.3, lb/yd^3
v_n = the volume of mixture n concrete to be placed, yd^3 or m^3

Calculations may use yd^3 or m^3, but must keep the same units throughout.

EMBODIED CARBON LIMIT CALCULATION

For the embodied carbon limit pathway, the sum of embodied carbon in all concrete mixtures [$\Sigma((EC_n)(v_n))$] must be less than or equal to the sum of maximum embodied carbon content for each mix as shown in table 4.420.3 [$\Sigma((EC_{lim})(v_n))$]. The embodied carbon content in a mix can be found in the environmental product declaration (EPD) for the mix. An EPD reports objective, comparable and third-party verified data about the lifecycle environmental performance of a product or service. EPDs are provided by the concrete mix supplier. An example EPD is provided in the low carbon concrete fact sheet available on the City's website (dublin.ca.gov/2531/Development-Permits-Climate-Action-Plan).

$$\Sigma((EC_n)(v_n)) \leq \Sigma((EC_{lim})(v_n))$$

Where,
n = the total number of concrete mixtures for the project
EC_n = the embodied carbon content for mixture n, per mixture EPD, $kgCO_2e/m^3$
EC_{lim} = the maximum embodied carbon content for mixture n per Table 4.420.3, $kgCO_2e/m^3$
v_n = the volume of mixture n concrete to be placed, m^3 or yd^3

Calculations may use yd^3 or m^3, but must keep the same units throughout.

See next page for example project scenarios.

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EXAMPLE PROJECT SCENARIOS

To demonstrate how to use the two pathways, three project scenarios are provided. Each scenario is based on the example construction project described below.

Construction project: A new 1,500 square foot home requires a 5-inch thick slab and a retaining wall that needs a total of 23 cubic yards (yd) of concrete.

Standard Concrete Scenario

This scenario demonstrates the embodied carbon in a project using standard Portland Cement concrete. This scenario assumes a single mix concrete with a compressive strength of up to 3,000 pounds per square inch (PSI) is needed.

Per Submitted EPD for the concrete mix:

- Portland Cement concrete content = 564 lbs/yd^3
- Embodied carbon content = 400 kg CO_2/m^3

For 3000psi limits are:

- Portland Cement content = 410 lbs/yd^3
- Embodied carbon content = 289 kg CO_2/m^3

Cement Limit Check

Project Cement Content: $\frac{564\ lbs\ cement}{yd^3} \times 23\ yd^3 = 12{,}972\ lbs\ cement$

Project Cement Limit: $\frac{410\ lbs}{yd^3} \times 23\ yd^3 = 9{,}430\ lbs\ cement\ maximum$

12,972 lbs cement in mix > 9,430 lbs cement maximum

Mix does not comply with cement limits.*

Embodied Carbon Check

Mix Embodied Carbon Content: $\frac{400\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 23\ yd^3 = 7{,}038\ kg\ CO_2$

Mix Embodied Carbon Limit: $\frac{289\ lbs}{yd^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 23\ yd^3 = 5{,}085\ kg\ CO_2\ maximum$

7,038 kg CO_2 in mix > 5,085 kg CO_2 maximum

Mix does not comply with embodied carbon limits.*

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Single-Mix Calculation Scenario

This scenario demonstrates how using low carbon concrete impacts the cement limit and embodied carbon calculations.

Per Submitted EPD:

- Portland Cement content = 400 lbs/yd^3
- Embodied carbon content = 230 kg CO_2/m^3

For 3000psi limits are:

- Portland Cement content = 410 lbs/yd^3
- Embodied carbon content = 289 kg CO_2/m^3

Cement Limit Check

$$\textit{Mix Cement Content: } \frac{400\ lbs\ cement}{yd^3} \times 23\ yd^3 = 9{,}200\ lbs\ cement$$

$$\textit{Mix Cement Limit: } \frac{410\ lbs}{yd^3} \times 23\ yd^3 = 9{,}430\ lbs\ cement\ maximum$$

9,200 lbs cement in mix < 9,430 lbs cement maximum

Mix complies with cement limits

Embodied Carbon Check

$$\textit{Mix Embodied Carbon Content: } \frac{230\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 23\ yd^3 = 4{,}047\ kg\ CO_2$$

$$\textit{Mix Embodied Carbon Limit: } \frac{289\ lbs}{yd^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 23\ yd^3 = 5{,}085\ kg\ CO_2\ maximum$$

4,047 kg CO_2 in mix < 5,085 kg CO_2 maximum

Mix complies with embodied carbon limits

Multiple Mix Calculation Scenario

This scenario demonstrates how to perform the calculations and determine compliance for the example project if it uses multiple concrete mixes with compressive strengths up to 2,500 psi, 3,000 psi, and 4,000 psi.

Per Submitted EPDs:

- Mix #1 (2,500 compressive strength). 6 cubic yards to be poured
  - Portland Cement content = 100 lbs/yd^3
  - Embodied carbon content = 230 kg CO_2/m^3
- Mix #2 (3,000 compressive strength). 8 cubic yards to be poured
  - Portland Cement content = 400 lbs/yd^3
  - Embodied carbon content = 255 kg CO_2/m^3
- Mix #3 (4,000 compressive strength). 9 cubic yards to be poured
  - Portland Cement content = 480 lbs/yd^3
  - Embodied carbon content = 320 kg CO_2/m^3

For 2500psi limits are:

- Portland Cement content = 362 lbs/yd^3
- Embodied carbon content = 260 kg CO_2/m^3

For 3000psi limits are:

- Portland Cement content = 410 lbs/yd^3
- Embodied carbon content = 289 kg CO_2/m^3

For 4000psi limits are:

- Portland Cement content = 456 lbs/yd^3
- Embodied carbon content = 313 kg CO_2/m^3

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Project Cement Limit Check

Project Cement Content: $\left(\frac{100\ lbs\ cement}{yd^3} \times 6\ yd^3\right) + \left(\frac{400\ lbs\ cement}{yd^3} \times 8\ yd^3\right) + \left(\frac{480\ lbs\ cement}{yd^3} \times 9\ yd^3\right) = 8{,}120\ lbs\ cement$

Project Cement Limit: $\left(\frac{362\ lbs\ cement}{yd^3} \times 6\ yd^3\right) + \left(\frac{410\ lbs\ cement}{yd^3} \times 8\ yd^3\right) + \left(\frac{456\ lbs\ cement}{yd^3} \times 9\ yd^3\right) = 9{,}556\ lbs\ cement$

8,120 lbs cement in project < 9,556 lbs cement maximum

Even though mix 3 cement content (480 > 456) exceeds cement limits, the total cement content in the project complies with the limits.

Project complies with low carbon concrete requirements.

Project Embodied Carbon Check

Embodied Carbon in Project: $\left(\frac{230\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 6\ yd^3\right) + \left(\frac{255\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 8\ yd^3\right) + \left(\frac{320\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 9\ yd^3\right) = 4{,}820\ kg\ CO_2\ in\ project$

Project Embodied Cement Limit: $\left(\frac{260\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 6\ yd^3\right) + \left(\frac{289\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 8\ yd^3\right) + \left(\frac{313\ kg\ CO_2}{m^3} \times \frac{0.765\ m^3}{1\ yd^3} \times 9\ yd^3\right) = 5{,}117\ kg\ CO_2\ limit\ for\ project$

4,820 kg CO_2 in mix < 5,117 kg CO_2 maximum

Even though mix 3 embodied carbon content (320 > 313) exceeds embodied carbon limits, the total embodied carbon in the project complies with the limits.

Project is compliant with low carbon concrete requirements.

NON-COMPLIANT MIXES

If mixes do not comply with the requirements, the City reserves the right to issue a penalty fee. The maximum penalty fee is based on the social cost of carbon as established by the United States Environmental Protection Agency, plus the City's administrative costs to process the fee. Currently, the social cost of carbon is $190 per metric ton of carbon dioxide. The following equation applies to this penalty:

$$Pm = (EC_x)(\$190) + A$$

Where,
P_m = the maximum penalty ($)
EC_x = the total excess embodied carbon content in the project, in metric tons, determined from Equation 4.420.3.5.
$190 = current penalty per metric ton of excess embodied carbon ($/metric ton)
A = Building and Safety Division Administrative Fee ($), refer to the City's Master Fee Schedule

As an example of the maximum penalty fee that may be assessed for a non-compliant project, the standard concrete scenario described above results in 1.95 metric tons of excess CO_2. Following the equation above and using an estimated two hours of staff time to process the penalty fee billed at $290/hour, the maximum penalty fee would be $950.50 as shown below.

Maximum Penatly: $1.95\ metric\ tons\ CO_2 \times \frac{\$190}{1\ metric\ ton\ Co_2} + \$580 = \$950.5$

QUESTIONS?

For more information, visit the City's website or contact the Environmental & Sustainability Division.

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