ENVIRONMENTAL REPORT

Low-carbon concrete, enabled by Trident

An 80% slag concrete that qualifies for a **5,000 psi** structural specification, at **42%** less binder CO_2e than an untreated 50/50 slag mix and **67%** less than an all-cement mix. Without Trident, the same 80% slag mix qualifies only for a 2,000 psi specification and gains strength more slowly than a 50/50 mix. With Trident, it is stronger than the untreated 50/50 mix at 3, 7 and 28 days, using the cement, slag, plants and equipment producers already have.

CO₂E VS 50/50 SLAG MIX
−42%
20/80 slag with Trident, full binder as tested, Trident's footprint included

CO₂E VS ALL-CEMENT MIX
−67%
Same mix against 100% portland cement at the same binder content

SPECIFICATION QUALIFIED
5,000 psi
6,701 psi at 28 days with Trident; 3,000 psi spec without it (5,134 psi)

SCHEDULE
7 days
To pass the untreated 80% slag mix's 28-day strength (5,178 vs 5,134 psi)

WHERE THE CARBON IS

Where does the carbon in a mix come from?

Almost all of it comes from the cement. The less cement a concrete carries, the lower its carbon.

Cement production accounts for roughly 5–8% of global CO_2 emissions, about **1.6 Gt** in 2022, and clinker is 80–90% of that[1]. In the EPD factors used here, portland cement carries **922 kg** CO_2e per tonne, slag **147 kg** and fly ash about **10 kg**[2–4]. A 100% portland cement mix at **380 kg/m³** of binder comes to about **350 kg** CO_2e/m³; a 50/50 slag mix, **203 kg**.

Producers have replaced part of the cement with slag and fly ash for decades, so why not replace more? The limit is strength, early and late. Untreated, an 80% slag mix reached **3,597 psi** at 7 days, against **4,061 psi** for a 50/50 mix[5]. Form stripping, post-tensioning and the pour schedule all run on those early breaks, and the producer carries the risk of a slow or low one, so most stop near 40–50% replacement.

QUALIFICATION

Does an 80% slag mix qualify without Trident?

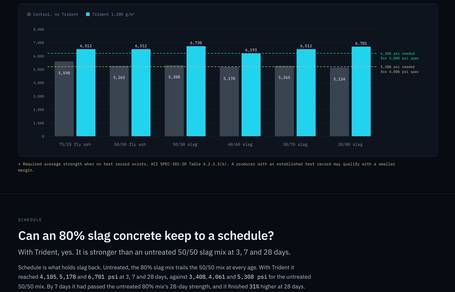
No. Untreated, it falls short of the strength a producer must design for. With Trident, it clears a 5,000 psi specification.

A mix does not qualify by reaching the specified strength. When a producer has no test record for a new mix, ACI 301 requires it to average **1,200 psi** above the specified strength for specifications from 3,000 to 5,000 psi[6]. A 4,000 psi specification needs **5,200 psi**; a 5,000 psi specification needs **6,200 psi**.

The untreated 80% slag mix reached **5,134 psi** at 28 days, just short of the 4,000 psi threshold. With Trident it reached **6,701 psi**, enough for a 5,000 psi specification, which the untreated 50/50 slag mix (**5,308 psi**) does not reach.

The lab designed these mixes to M30 under IS 10262, which sets a target mean of **38.25 MPa (5,548 psi)**[7,8]. The same result holds: untreated, the 80% slag mix reached **35.4 MPa** and fell short; with Trident it reached **46.2 MPa**.

FIG. 1 — 28-DAY STRENGTH, PSI · SIX BLENDS · CONTROL VS TRIDENT 1.200 G/M³ · AGAINST ACI 301 REQUIRED AVERAGES



* Required average strength when no test record exists, ACI 301-20 Table 4.2.3.1(b). A producer with an established test record may qualify with a smaller margin.

SCHEDULE

Can an 80% slag concrete keep to a schedule?

With Trident, yes. It is stronger than an untreated 50/50 slag mix at 3, 7 and 28 days.

Schedule is what holds slag back. Untreated, the 80% slag mix trails the 50/50 mix at every age. With Trident it reached **4,105**, **5,178** and **6,701 psi** at 3, 7 and 28 days, against **3,408**, **4,061** and **5,308 psi** for the untreated 50/50 mix. By 7 days it had passed the untreated 80% mix's 28-day strength, and it finished **31%** higher at 28 days. The early gain is not borrowed from later strength, the way an accelerator's often is: Trident adds strength at every age.

Trident is a liquid admixture dosed into the mix a producer already runs. Six blends, from 25% fly ash to 80% slag, were tested at four doses against an untreated control by a third-party government-accredited laboratory[9].

FIG. 2 — COMPRESSIVE STRENGTH, PSI · 3, 7 AND 28 DAYS

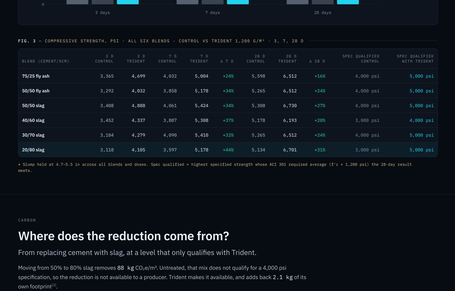


FIG. 3 — COMPRESSIVE STRENGTH, PSI · ALL SIX BLENDS · CONTROL VS TRIDENT 1.200 G/M³ · 3, 7, 28 D

BLEND (CEMENT/SCM)	3 D CONTROL	3 D TRIDENT	7 D CONTROL	7 D TRIDENT	Δ 7 D	28 D CONTROL	28 D TRIDENT	Δ 28 D	SPEC QUALIFIED CONTROL	SPEC QUALIFIED WITH TRIDENT
75/25 fly ash	3,365	4,699	4,032	5,094	+24%	5,590	6,512	+16%	4,000 psi	**5,000 psi**
50/50 fly ash	3,292	4,032	3,858	5,178	+34%	5,265	6,512	+24%	4,000 psi	**5,000 psi**
50/50 slag	3,408	4,688	4,061	5,424	+34%	5,308	6,730	+27%	4,000 psi	**5,000 psi**
40/60 slag	3,452	4,337	3,887	5,308	+37%	5,178	6,193	+20%	3,000 psi	**4,000 psi**
30/70 slag	3,104	4,279	4,090	5,410	+32%	5,265	6,512	+24%	4,000 psi	**5,000 psi**
20/80 slag	3,118	4,105	3,597	5,178	+44%	5,134	6,701	+31%	3,000 psi	**5,000 psi**

* Slump held at 4.7–5.5 in across all blends and doses. Spec qualified = highest specified strength whose ACI 301 required average (f'c + 1,200 psi) the 28-day result meets.

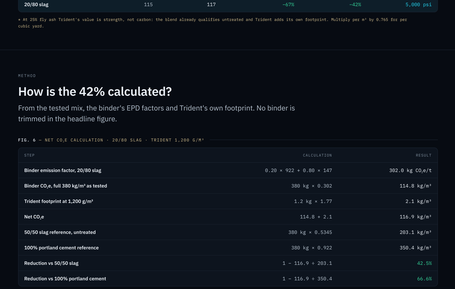
CARBON

Where does the reduction come from?

From replacing cement with slag, at a level that only qualifies with Trident.

Moving from 50% to 80% slag removes **88 kg** CO_2e/m³. Untreated, that mix does not qualify for a 4,000 psi specification, so the reduction is not available to a producer. Trident makes it available, and adds back **2.1 kg** of its own footprint[10].

FIG. 4 — BINDER CO₂E, KG/M³ · 100% PORTLAND CEMENT → 50/50 SLAG → 20/80 SLAG WITH TRIDENT



* 380 kg/m³ binder, full binder as tested. Binder and Trident only; aggregates, transport and batching excluded.

FIG. 5 — NET CO_2E PER M³ · TRIDENT 1,200 G/M³: FULL BINDER

BLEND (CEMENT/SCM)	CONTROL KG CO_2E/M³	WITH TRIDENT KG CO_2E/M³	VS 100% PORTLAND CEMENT	VS 50/50 SLAG UNTREATED	SPEC QUALIFIED WITH TRIDENT
75/25 fly ash	264	266	−24%	+31%	**5,000 psi**
50/50 fly ash	177	179	−49%	−12%	**5,000 psi**
50/50 slag	203	205	−41%	+1%	**5,000 psi**
40/60 slag	174	176	−50%	−13%	**4,000 psi**
30/70 slag	144	146	−58%	−28%	**5,000 psi**
20/80 slag	115	117	−67%	−42%	**5,000 psi**

* At 20% fly ash Trident's value is strength, not carbon: the blend already qualifies untreated and Trident adds its own footprint. Multiply per m³ by 0.765 for per cubic yard.

METHOD

How is the 42% calculated?

From the tested mix, the binder's EPD factors and Trident's own footprint. No binder is trimmed in the headline figure.

FIG. 6 — NET CO_2E CALCULATION · 20/80 SLAG · TRIDENT 1,200 G/M³

STEP	CALCULATION	RESULT
Binder emission factor, 20/80 slag	0.20 × 922 + 0.80 × 147	**302.8 kg CO_2e/t**
Binder CO_2e, full 380 kg/m³ as tested	380 kg × 0.302	**114.8 kg/m³**
Trident footprint at 1,200 g/m³	1.2 kg × 1.77	**2.1 kg/m³**
Net CO_2e	114.8 + 2.1	**116.9 kg/m³**
50/50 slag reference, untreated	380 kg × 0.5345	**203.1 kg/m³**
100% portland cement reference	380 kg × 0.922	**350.4 kg/m³**
Reduction vs 50/50 slag	1 − 116.9 ÷ 203.1	**42.5%**
Reduction vs 100% portland cement	1 − 116.9 ÷ 350.4	**66.6%**

* EPD factors: portland cement 922, slag 147 kg CO_2e/t[2,3]. Trident footprint 1.77 kg CO_2e per kg of Trident, Pipedream estimate; third-party LCA in progress[10].

Further potential: trimming binder

Trident's extra strength could also let a producer use less binder. Holding water constant and staying within a water/binder ratio of 0.45, Bolomey's relation puts the 80% slag mix at about **355 kg/m³** of binder, still above the 5,200 psi needed for a 4,000 psi specification. This is a model estimate and needs trial batches to confirm.

20/80 SLAG + TRIDENT 1,200 G/M³	BINDER KG/M³	W/B	28 D PSI	BASIS	KG CO_2E/M³	VS 50/50 SLAG	VS 100% PORTLAND
Full binder, as tested	380	0.42	6,701	Tested	117	−42%	−67%
Binder trimmed to w/b 0.45	355	0.45	≈ 6,140	Modeled	109	−46%	−69%

* Deeper trims raise the water/binder ratio above the 0.45–0.50 limits ACI 318 sets for on-exist exposure classes, so full below the 320 kg/m³ minimum binder zone specifications require.

CONTEXT

How significant is this?

The industry has been working to cut concrete's carbon for more than 25 years. In 1999, ten of the largest cement companies began the work that became the WBCSD Cement Sustainability Initiative[11]. In 2009 that group and the IEA published a technology roadmap to 2050 that named cutting the clinker in cement as a main lever, and updated it in 2018[12]. Even so, the CO_2 intensity of cement has risen by nearly 10% since 2015, the IEA says the sector is not on track for net zero, and clinker still makes up about 71% of a tonne of cement worldwide[13,14].

Much of the plan depends on capacity that does not exist yet: the IEA counts 22 Mt of announced near-zero cement capacity for 2030, against roughly 350 Mt needed[13]. This concrete cuts binder CO_2e by 67% against an all-cement mix with the cement and slag producers already buy, in the plants they already run, with Trident dosed like any admixture.

SUPPLY

Does it need new plants?

No. Trident is dosed into the mix a producer already runs, with the materials and equipment already on site.

Trident goes in through a standard admixture dispenser and ships in totes and drums. Batching, mixing, placement and curing stay the same. The cement and slag are bought the way they are today, and producers' EPDs already cover them.

REFERENCES

1. Third-party government-accredited laboratory, Trident test series: six blends at a 30 MPa (M30) design, control and four doses, 3/7/28-day strength and slump. October 2026. Tested using international test methods; absolute values may differ from ASTM C39 results. Strengths converted from MPa at 1 MPa = 145.038 psi.
2. Pipedream Industries, CO_2 model: producer EPD factors (portland cement 922, slag 147, fly ash about 10 kg CO_2e/t). 380 kg/m³ binder at w/b 0.42. Internal, October 2026.
3. Pipedream Industries, Trident cradle-to-gate estimate: 1.77 kg CO_2e per kg of Trident. Internal; third-party LCA and EPD in progress.
4. Columbia Business School, CKI, Cement (2024).
5. WBCSD, Cement Sustainability Initiative (CSI).
6. IEA and WBCSD CSI, Technology Roadmap: Low-Carbon Transition in the Cement Industry (2018), updating the Cement Technology Roadmap 2009.
7. IEA, Breakthrough Agenda Report 2023: Cement.
8. IEA, Cement, tracking report.
9. ACI CPEC 301-20, Specifications for Concrete Construction, Table 4.2.3.1(b): required average compressive strength when data are not available.
10. Bureau of Indian Standards, IS 10262:2019, Concrete Mix Proportioning — Guidelines: M30 target mean strength 30 + 1.65 × 5 = 38.25 MPa.