CONCERA®

Novel Superplasticizers for Reducing the Embodied Carbon of Concrete

David C. Darwin, PhD, LEED AP & Riccardo Stoppa | **May 4th, 2022**

CO2ST Reducers

CONCRETE INNOVATIONS

Outline

- Introduction: the global CO_2 issue
- Concrete admixtures to reduce CO_2
- CONCERA®
- Case studies

GCP Admixtures

A history of Innovation and Change

1931-1935
Dewey & Almy
Invented cement and concrete admixtures
1932 NSFC (US patent 2,141,569)
1934 TEA (US patent 2,091,621)
1935 Lignin (US patent 2,141,570)

1936
TDA®
Water Reducing and Accelerating Admixtures

1967
HEA2®
Grinding Aids

1985
DARACEM®
Superplasticizers

2001
STRUX®
Synthetic Macro Fibers

2008
VERIFI®
In-transit Concrete Management Technology

2022
CONCERA®
All-in-one Admixtures

1954
Grace acquired Dewey & Almy

1945
DAREX AEA®
Air Entraining Agents

1979
DCI®
Corrosion Inhibitors

1996
ADVA®
PCE-based Superplasticizers

2016
GCP Applied Technologies spin-off from Grace

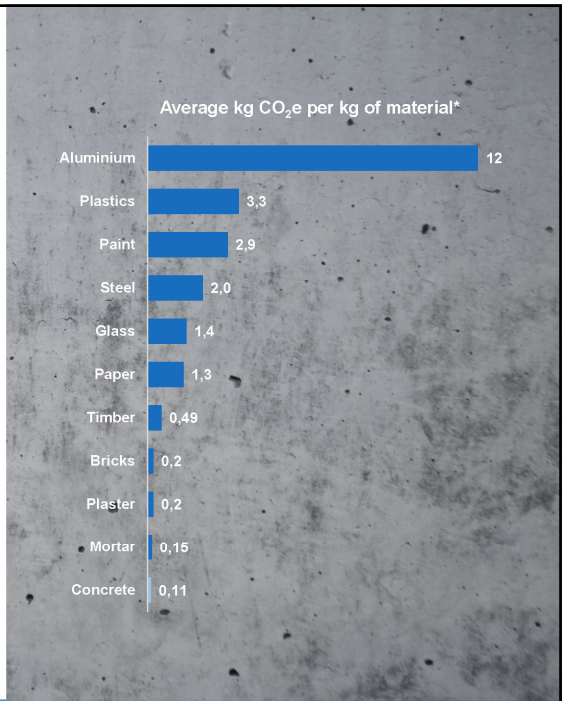
2013-2019
CLARENA®
Admixtures for Aggregates and Returned Concrete

 3

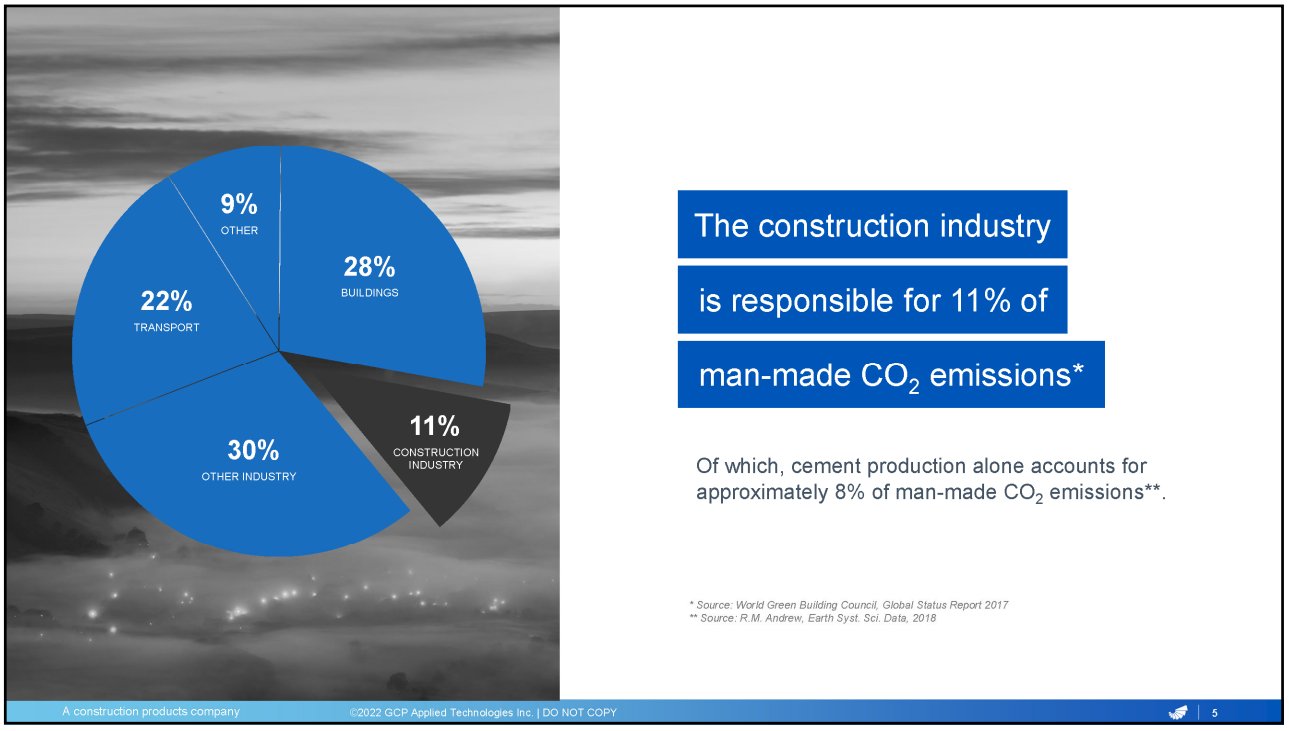
Concrete is perhaps the most eco-friendly, versatile, low-cost and durable construction material.

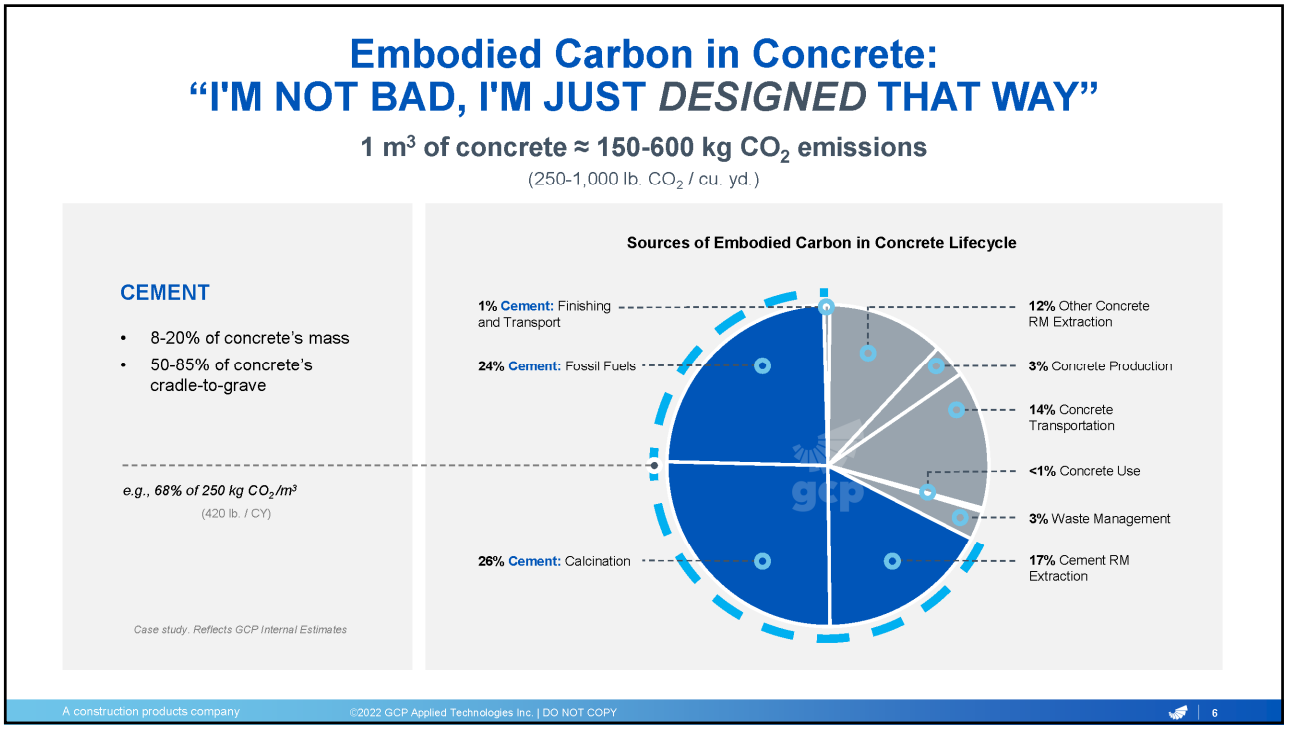
- Its embodied carbon is 10-20 times lower than that of Glass and Steel*.
- But because of the huge (14.0 billion m^3 **) *and growing* global demand…

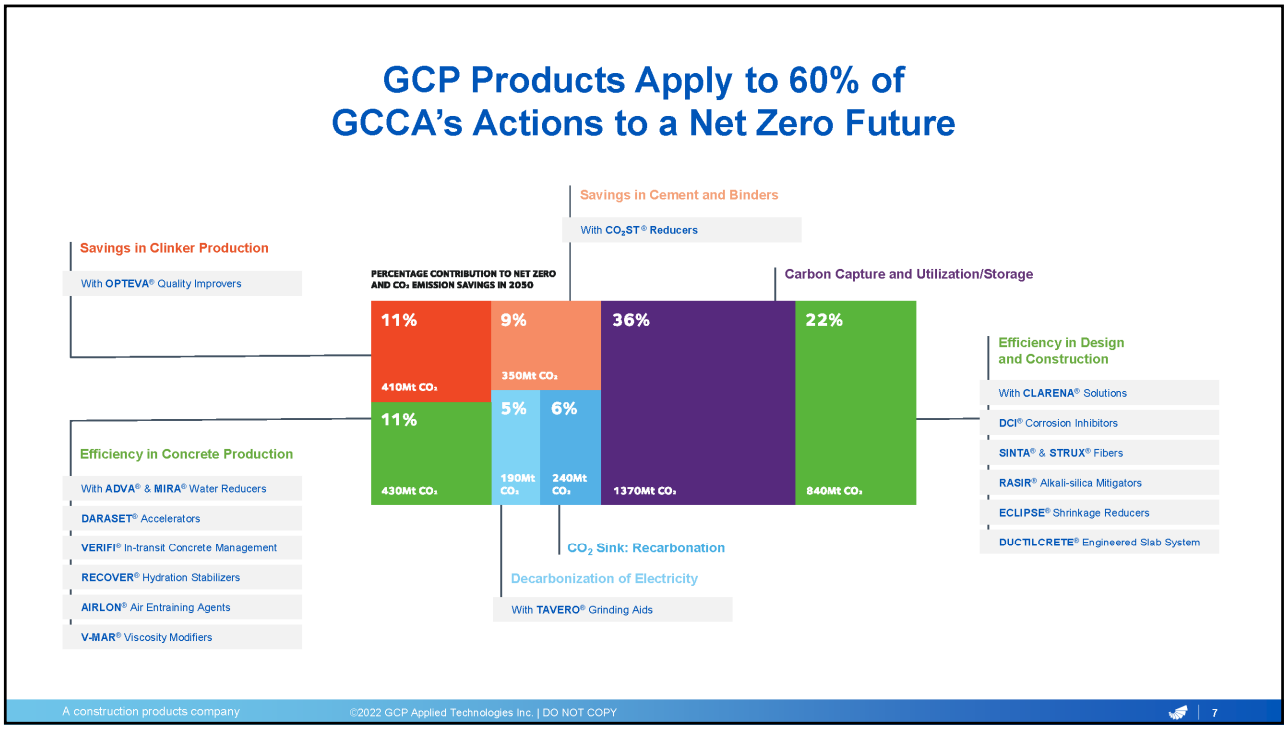
** Source: ICE database 2019 and internal estimates*
*** Source: GCCA's "Concrete Future" roadmap 2021*

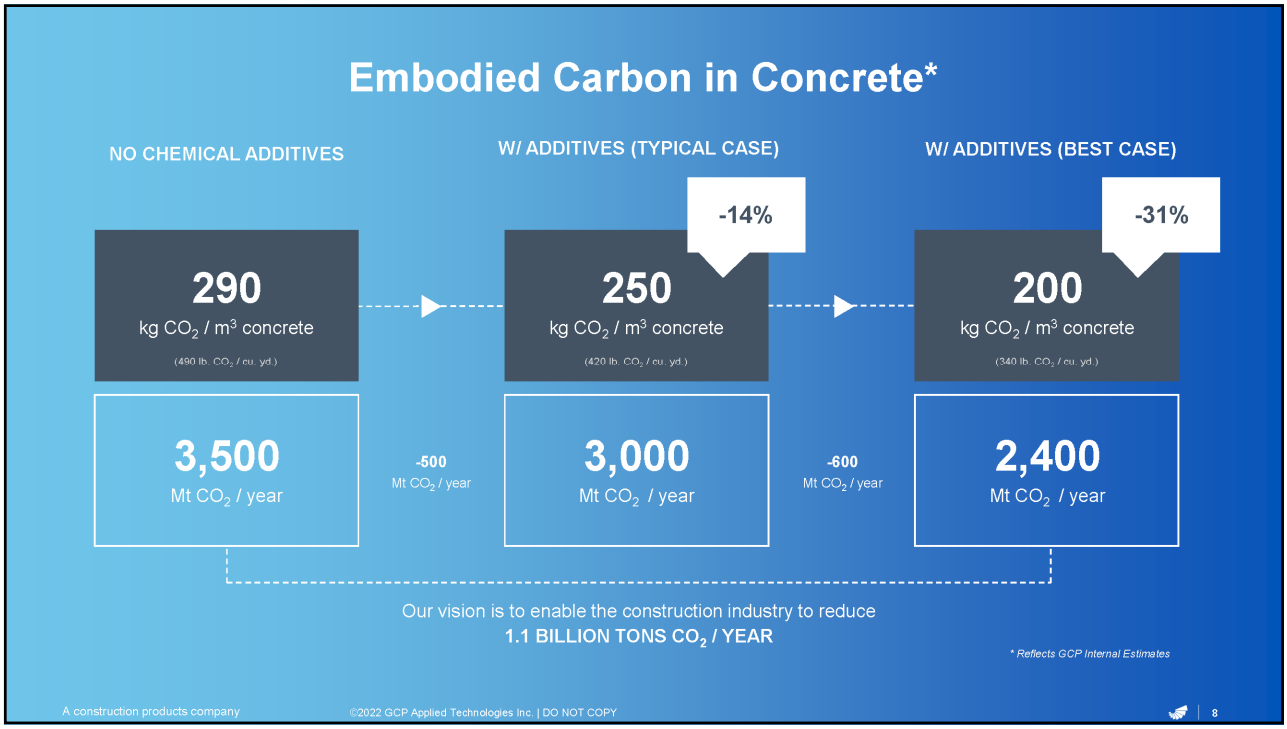


 4


9%
OTHER
28%
BUILDINGS
22%
TRANSPORT
11%
CONSTRUCTION INDUSTRY
30%
OTHER INDUSTRY
The construction industry
is responsible for 11% of
man-made CO_2 emissions*
Of which, cement production alone accounts for approximately 8% of man-made CO_2 emissions**.
* Source: World Green Building Council, Global Status Report 2017
** Source: R.M. Andrew, Earth Syst. Sci. Data, 2018
A construction products company
©2022 GCP Applied Technologies Inc. | DO NOT COPY
5


Embodied Carbon in Concrete:
"I'M NOT BAD, I'M JUST DESIGNED THAT WAY"
1 m^3 of concrete ≈ 150-600 kg CO_2 emissions
(250-1,000 lb. CO_2 / cu. yd.)
CEMENT
8-20% of concrete's mass
50-85% of concrete's cradle-to-grave
e.g., 68% of 250 kg CO_2/m^3
(420 lb. / CY)
Case study. Reflects GCP Internal Estimates
Sources of Embodied Carbon in Concrete Lifecycle
1% Cement: Finishing and Transport
24% Cement: Fossil Fuels
26% Cement: Calcination
12% Other Concrete RM Extraction
3% Concrete Production
14% Concrete Transportation
<1% Concrete Use
3% Waste Management
17% Cement RM Extraction
A construction products company
©2022 GCP Applied Technologies Inc. | DO NOT COPY
6


GCP Products Apply to 60% of GCCA's Actions to a Net Zero Future
Savings in Clinker Production
With OPTEVA® Quality Improvers
Savings in Cement and Binders
With CO2ST® Reducers
PERCENTAGE CONTRIBUTION TO NET ZERO AND CO2 EMISSION SAVINGS IN 2050
Carbon Capture and Utilization/Storage
11%
410Mt CO2
9%
350Mt CO2
36%
1370Mt CO2
22%
840Mt CO2
11%
430Mt CO2
5%
190Mt CO2
6%
240Mt CO2
Efficiency in Design and Construction
With CLARENA® Solutions
DCI® Corrosion Inhibitors
SINTA® & STRUX® Fibers
RASIR® Alkali-silica Mitigators
ECLIPSE® Shrinkage Reducers
DUCTILCRETE® Engineered Slab System
Efficiency in Concrete Production
With ADVA® & MIRA® Water Reducers
DARASET® Accelerators
VERIFI® In-transit Concrete Management
RECOVER® Hydration Stabilizers
AIRLON® Air Entraining Agents
V-MAR® Viscosity Modifiers
CO2 Sink: Recarbonation
Decarbonization of Electricity
With TAVERO® Grinding Aids
A construction products company
©2022 GCP Applied Technologies Inc. | DO NOT COPY
7


Embodied Carbon in Concrete*
NO CHEMICAL ADDITIVES
W/ ADDITIVES (TYPICAL CASE)
W/ ADDITIVES (BEST CASE)
-14%
-31%
290
kg CO2 / m3 concrete
(490 lb. CO2 / cu. yd.)
250
kg CO2 / m3 concrete
(420 lb. CO2 / cu. yd.)
200
kg CO2 / m3 concrete
(340 lb. CO2 / cu. yd.)
3,500
Mt CO2 / year
-500
Mt CO2 / year
3,000
Mt CO2 / year
-600
Mt CO2 / year
2,400
Mt CO2 / year
Our vision is to enable the construction industry to reduce
1.1 BILLION TONS CO2 / YEAR
* Reflects GCP Internal Estimates
A construction products company
©2022 GCP Applied Technologies Inc. | DO NOT COPY
8

Fundamentals of CO_2 Reduction by Water Reducing Admixtures

Abrams' Law (Duff Abrams, 1918):

"For a mixture of workable consistency, the strength of concrete provided by the mixture is determined by the ratio of the amount of water to the amount of cement."

Water Reducing Admixtures – cut the water demand in cementitious systems. Maintain flow (slump, rheology)

ASTM C 494 Type A:	ASTM C 494 Type F:
Minimum 5% water cut (LRWR)	Minimum 12% water cut (LRWR)

This will enable an optimization in our concrete mix design that reduces the cement factor. With the CO_2 burden from portland cement being the dominant CO_2 factor in today's concrete mix designs, reduction of the cement factor leads to a reduction in CO_2 burden.

 9

Concrete Admixtures Innovation Demands

Everyone's using water reducing admixtures and taking cement cut	We want more! We want more!	What have you done for me lately?

 10

All-in-One Admixture CO_2 Reduction – US Southwest

Target concrete and mix design: 3000 psi; basic slab mix; non-air entrained; CO_2 reduced

{pounds/cy or oz/cwt.}	Base Mix	CO_2 Reduced	Delta Δ	Notes
Type I/II Cement (lbs.)	318	303	-15 (-4.7%)	This cement cut gives the CO_2 reduction.
Class C Fly Ash (lbs.)	105	101	-4 (3.8%)	The fly ask cut represents material reduction.
Manufactured Sand (lbs.)	1478	1478		CONCERA® empowers manufactured sand.
Coarse Aggregate (lbs.)	1766	1766		
Water (lbs.)	268	260	-8 (-3.0%)	The water cut is a resource savings.
Type A LRWR (oz/cwt)	3	3		
Type F HRWR (oz/cwt)	2.3			
All-in-one Admix. (oz/cwt)		11.3		

 11

All-in-One Admixture CO_2 Reduction – US Southwest

Theoretical concrete expected values for success

Expected Property	Base Mix	CO_2 Reduced	Desired Property Notes
w/c	0.84	0.86	
w/cm	0.63	0.64	
Air (% by volume)	1.15% measured	1.55% measured	We took materials out, must replace with volume. Air is good, if not too much.
Flow Rheology	measured	measured	No reduction in flow.
Compressive Strength	measured	measured	No reduction in strength.

 12

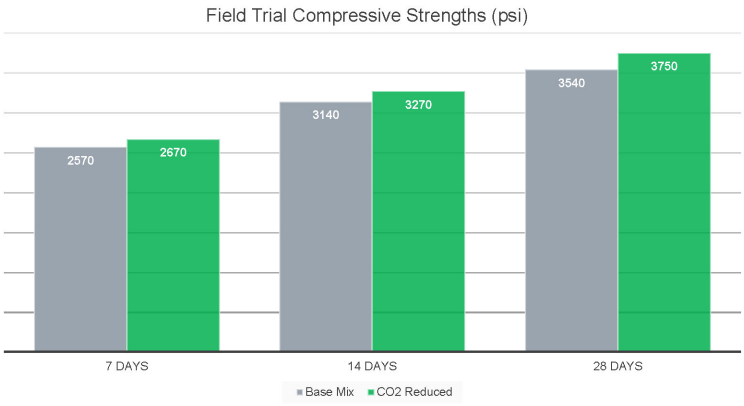
All-in-One Admixture CO_2 Reduction – US Southwest

Field test results – plastic concrete properties

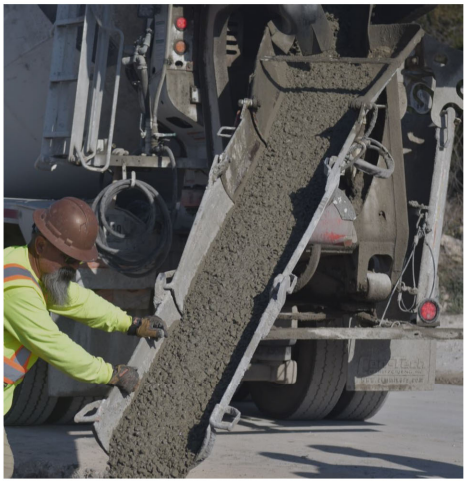
Measured Property	Base Mix	CO_2 Reduced	Measured Property Notes
Air – unit weight (% by volume)	1.0%	1.2%	✓
Air – meter (% by volume)	1.1%	1.2%	✓
Slump (in.)	9.5	7.0	Need more all-in-one in CO2 reduced or less HRWR in base.

All-in-One Admixture CO_2 Reduction – US Southwest

Compressive strength development



All-in-One Admixture CO_2 Reduction – US Southwest



All-in-One Admixture CO_2 Reduction – US Southwest

All-in-One Admixture CO_2 Reduction – US East

Target concrete and mix design: 6000 psi; high-strength mix → SCC mix; 6% air entrained; CO_2 reduced

{pounds/cy or oz/cmwt.}	Base Mix	CO_2 Reduced	Delta Δ	Notes
Type I Cement (lbs.)	495	435	-60 (-12.1%)	This cement cut gives the CO2 reduction.
Slag Cement (lbs.)	165	145	-20 (-12.1%)	This slag cut represents material reduction.
Sand (lbs.)	1233	1407	+174	Here we fill volume with sand.
Coarse Aggregate (lbs.)	1900	1800	-100	Cut coarse to aid SCC.
Water (lbs.)	267	263	-4 (-1.5%)	This water cut is a resource savings.
AEA (oz/cmwt)	0.5	0.8		
Retarder (oz/cmwt)	2			
Type F HRWR (oz/cmwt)	3.0			
All-in-one Admix (oz/cmwt)		12.0		

All-in-One Admixture CO_2 Reduction – US East

Theoretical concrete expected values for success

Expected Property	Base Mix	CO_2 Reduced	Desired Property Notes
w/c	0.54	0.60	
w/cm	0.40	0.45	
Air (% by volume)	6% measured	6% measured	We took materials out, must replace with volume. Here, keep air neutral.
Flow Rheology	High slump measured	SCC slump flow measured	
Compressive Strength	measured	measured	No reduction in strength.

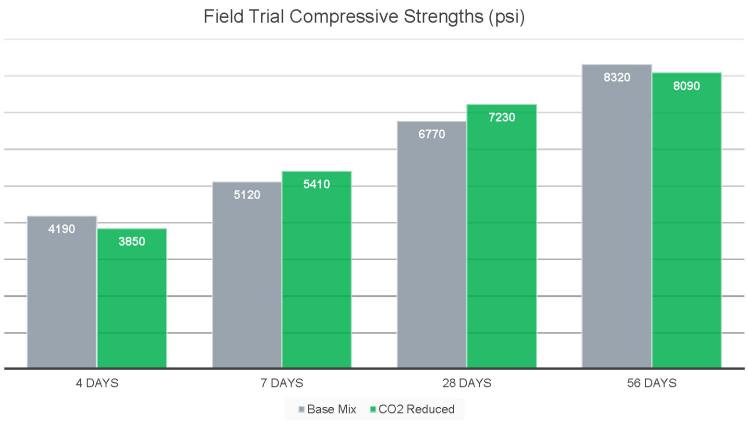
All-in-One Admixture CO_2 Reduction – US East

Field test results – plastic concrete properties

Measured Property	Base Mix	CO_2 Reduced	Measured Property Notes
Air – unit weight (% by volume)	3.86%	3.99%	✓
Air – meter (% by volume)	4.9%	5.5%	✓
Slump /Slump Flow (in.)	7.5	21.6	Conversion to SCC worked. ✓

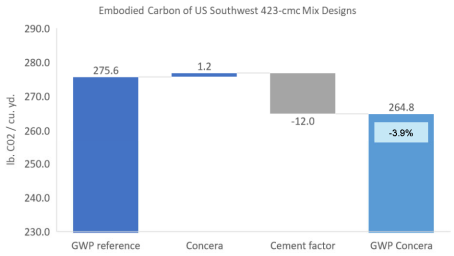
All-in-One Admixture CO_2 Reduction – US East

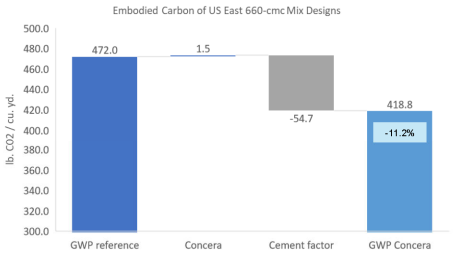
Compressive strength development



All-in-One Admixture Summary CO_2 Reduction Accounting

- **Through usage of CONCERA® All-in-one Admixture:**
  - US Southwest Customer reduced CO_2 burden by 10.8 pounds CO_2/cy → -3.9% GWP Reduction
  - US East Customer reduced CO_2 burden by 53.2 pounds CO_2/cy → -11.2% GWP Reduction
- **This CO_2 burden reduction is:**
  - Over and above the CO_2 burden reduction provided by standard admixtures applied to non-admixed concretes
  - Obtained with neutral or performance enhancements over standard admixture treated concretes





Conclusion

When designing concretes considering sustainability, consider using advanced admixture approaches

Commitment to Sustainability

Building with the world in mind

- GCP believes that protecting people and the planet is good for business.
- Together, GCP and its customers already reduce 23M tons of CO_2 every year.
- Together, we can reduce cement's and concrete's CO_2 by up to 30%!

For enquires

david.c.darwin@gcpat.com
riccardo.stoppa@gcpat.com