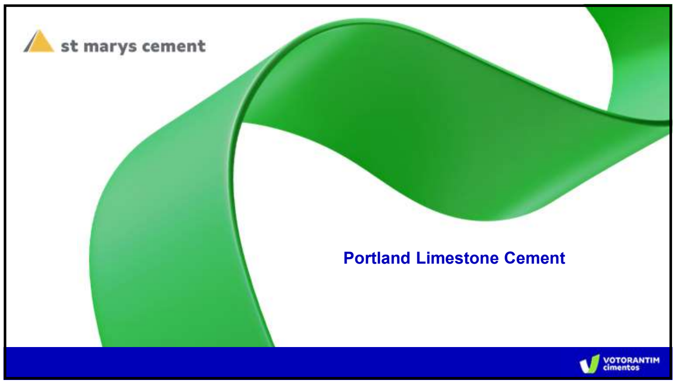

st marys cement
Portland Limestone Cement
VOTORANTIM cimentos

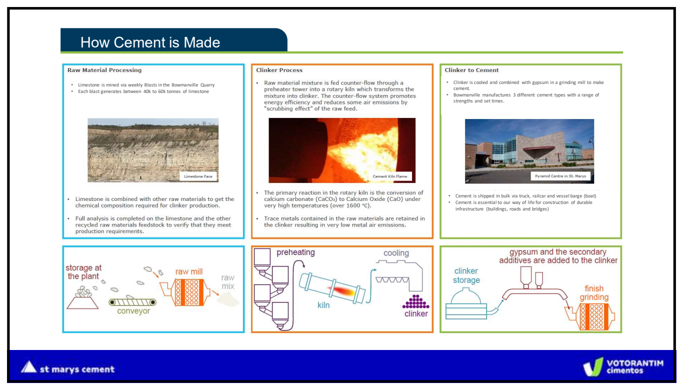
1


VOTORANTIM cimentos
CO2- The Elephant in the Room
We can't ignore…
CO2 footprint of cement production
US – ~ 1.5%
Worldwide – 5% to 8%
Increased pressure to reduce our environmental impact from many groups: designers, regulators, even the public
Concrete is so essential to the way we live, that our industry must do its part to address climate issues
CALIFORNIA'S CEMENT INDUSTRY
FAILING THE CLIMATE CHALLENGE
Guardian concrete week
Concrete: the most destructive material on Earth

2


VOTORANTIM cimentos
A Global Commitment
Ambition and Sco
• Carbon neutral concrete by 205
• Across built environment val chain
• Circular econom
• Whole life
nue to drive operations ver society by 2050. environment iration in context.
BREEDON
ARGOS
CEMENTOS MOLINS
cementos PROGRESO
Pacasmayo
CEMEX
CIMSA
CRH
DANGOTE
Dalmia
GCC
HOLCIM
HEIDELBERGCEMENT
JKcement
ORIENT CEMENT
SCG
SECIL
TCC
TITAN
UltraTech
UNACEM
VASSILIKO
VICAT
Votorantim

3


How Cement is Made
Raw Material Processing
Clinker Process
Clinker to Cement
storage at the plant
raw mill
raw mix
conveyor
preheating
cooling
kiln
clinker
clinker storage
gypsum and the secondary additives are added to the clinker
finish grinding
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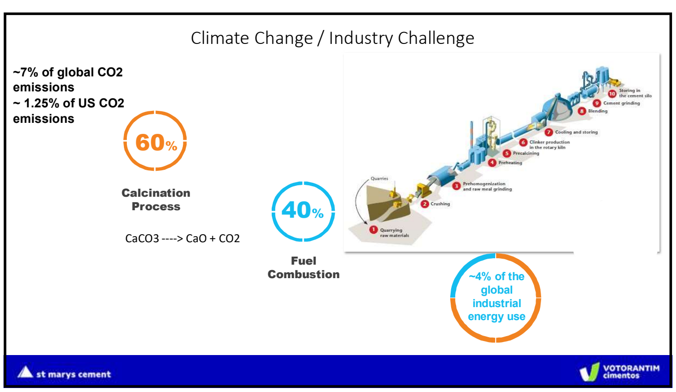
4


Climate Change / Industry Challenge
~7% of global CO2 emissions
~ 1.25% of US CO2 emissions
60%
Calcination Process
CaCO3 ----> CaO + CO2
40%
Fuel Combustion
~4% of the global industrial energy use
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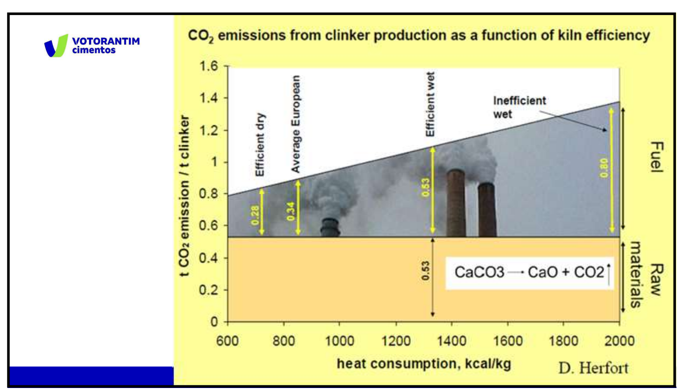
5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CO2 emissions from clinker production as a function of kiln efficiency
t CO2 emission / t clinker
heat consumption, kcal/kg
Efficient dry
Average European
Efficient wet
Inefficient wet
Fuel
Raw materials
CaCO3 → CaO + CO2
0.28
0.34
0.53
0.80
0.53
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
600
800
1000
1200
1400
1600
1800
2000
D. Herfort

6

The Five 'C's of the Value Chain

The value chain

CLINKER – Key chemically reactive ingredient | CEMENT – The binder | CONCRETE – Critically useful material to society | CONSTRUCTION – Service life / use phase impacts | CARBONATION – Concrete is a CO_2 sink

- Clinker
  - AFR/Green Energy and Precalcined materials
- Cement
  - Reduced clinker factor- PLC
- Concrete
  - Increased SCM use
  - Decreased CM content
- Construction
  - Less Concrete
  - Less Overdesign
- Re-Carbonation
  - IVL, EPA broadly 23%
  - CCUS- Leaving approximately 45%

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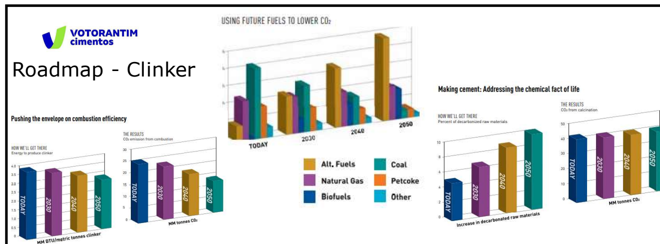
Roadmap - Clinker



	1972	1990	2019	2030	2040	2050
CO2 MT/MT Clinker Produced Combustion Emissions	0.525	0.439	0.320	0.273	0.217	0.170
Process Emissions (Calcination)	0.528	0.528	0.528	0.518	0.509	0.500
Total Emissions / MT Clinker	1.053	0.967	0.848	0.791	0.726	0.670

8

Bowmanville

Phase 1 – Wood Burning Phase 2018
- Permanent full-time permit to burn wood waste at a maximum rate of 96 tpd

Phase 2 – Plastic Burning Phase 2021
- Permit for burning 400 tonnes per day of biomass and plastics - March 2021

Next Steps
- Increase use of ALCF
- Installation of new storage and feeding system
- Hydrogen Fuel potential

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Charlevoix

Permanent full-time permit in place to burn plastics, cellulose fibers, asphalt flakes and biomass

Obtained new permit on March 5, 2021 for:
- ✓ Installation of new feeding system
- ✓ New shredder
- ✓ New Storage area
- ✓ Include biomass, wood chips, paper, cardboard, non-tire derived rubber as Alternative Fuels

Installation of new feeding system and storage area

Next Steps
CCUS?

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Great Lakes Tissue
- Milk Cartons to Toilet Paper
- >130,000 Tons of Polyfill

CHEBOYGANNEWS.COM
Great Lakes Tissue invests in circular economy, Michigan recycling

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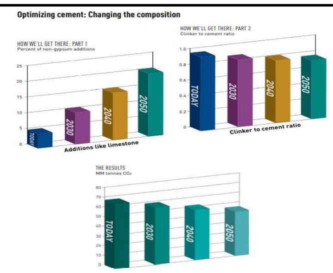
Roadmap - Cement



Clinker Factor in Cement	2019	2030	2040	2050
Future non-gypsum addition (limestone & IPAs)	4%	10%	15%	20%
Future clinker to cement ratio	0.91	0.85	0.80	0.75
CO2 Cement & Clinker / Tonne Cement	0.772	0.666	0.559	0.461

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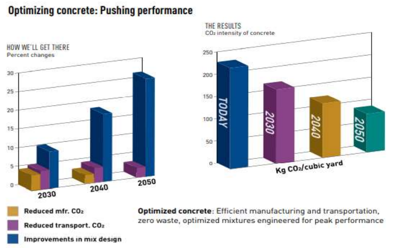
Roadmap – Concrete



Concrete Reductions	2019	2030	2040	2050
Total Cementitious	570	530	513	485
% Cementitious Reduction		7%	10%	15%
SCM % Replacement	20%	24%	27%	30%
Kg CO2 / CY of Concrete (Future EPD)	229	164	123	89

plc portland-limestone cement

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Roadmap – Construction

Construction	2019	2030	2040	2050
Future % waste concrete	5%	4%	3%	3%
Optimization in design, construction, & use phases		10%	20%	30%
kg CO2 /CY Concrete in Place	229	113	78	49

Roadmap – Carbonation

- Reduction of 20 percent of calcination emissions (use phase) (metric ton)
- Reduction of 2 percent of calcination emissions (end-of-life phase)
- Reduction of 1 percent of calcination emissions (demolished concrete reused as aggregate)

Roadmap – Carbon Capture Use Storage (CCUS)

Amount for CCUS (MT)	80,236,558	62,668,586	53,742,557	45,434,556
Total MT CO2 reduced through the value chain		17,567,972	26,494,001	34,802,002
% CCUS		22%	33%	43%

plc portland-limestone cement

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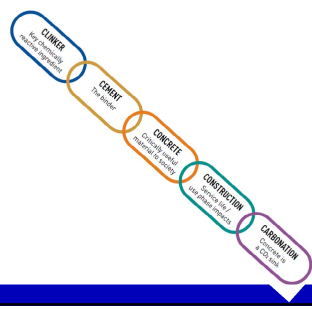
2050 Roadmap and the 5 C's

Votorantim Cimentos Life is made to last

- Clinker
  - AFR/Green Energy and Precalcined materials
- Cement
  - Reduced clinker factor- PLC
- Concrete
  - Increased SCM use
  - Decreased CM content
- Construction
  - Less Concrete
  - Less Overdesign
- Re-Carbonation
  - IVL, EPA broadly 23%
- CCUS- Leaving approximately 45%



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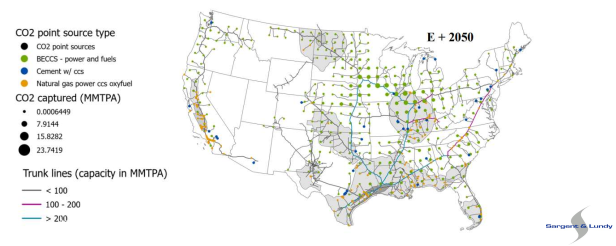
US: Future Sequestration/Pipeline Development



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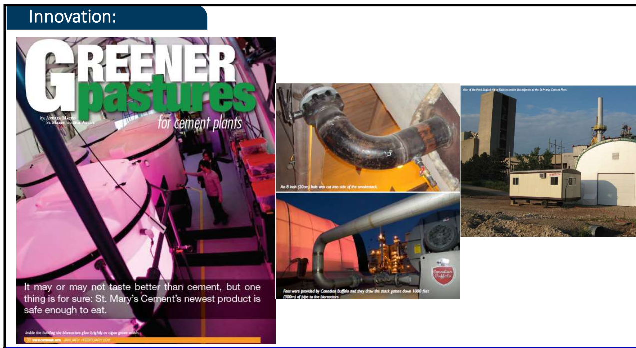
Innovation:



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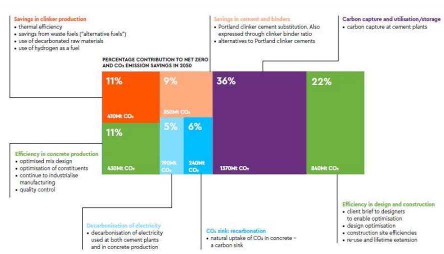
Actions to a Net Zero Future



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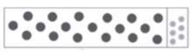
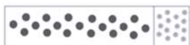
What is Portland Limestone Cement.

- Type I Portland Cement (ASTM C 150)



- Type IL Portland Limestone Cement (ASTM C 595)



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What is Portland Limestone Cement.

Cement Type	ASTM C150	ASTM C595	CSA A3000
General Use	I	IL	GUL, GULb
Moderate Sulfate Resistance	II, II(MS)	IL(MS)	MSL
Moderate Heat of Hydration	II(MH)	IL(MH)	-
High Sulfate Resistance	V	IL(HS)	HSL
Low Heat of Hydration	IV	IL(LH)	-
High-Early Strength	III	IL(HE)	HEL, HELb

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What is Portland Limestone Cement.


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Portland Cement Type I

Production Period : 12/1/2021 To 12/31/2021

STANDARD REQUIREMENTS

Chemical Data

Item	Spec. Limit	Results
SiO_2 (%)		18.4
Al_2O_3 (%)		4.5
Fe_2O_3 (%)		2.7
CaO (%)		59.2
MgO (%)	6.0 max	3.1
SO_3 (%)*		3.7
Loss of ignition (%)	3.5 max	1.7
Na_2O (%)		0.08
K_2O (%)		0.83
Insoluble residue (%)	1.5 max	0.38
CO_2 (%)		1.4
Limestone (%)	5.0 max	3.5
$CaCO_3$ in limestone (%)	70 min	95
Inorganic process addition(%)	5.0 max	0.0

Physical Data

Item	Spec. Limit	Results
Air Content of mortar (volume %)	12 max	[illegible]
Blaine fineness (m^2/kg)	260 min	386
Autoclave expansion (%)	0.80 max	0.14
Compressive strength (MPa/psi)		
1 day		17.2 [2490]
3 days	12.0[1740] min	28.6 [4150]
7 days	19.0[2760] min	35.5 [5140]
28 days (previous month)	28.0[4060] min	43.8 [6500]
Time of setting (minutes)		
(Vicat) Initial	45 - 375	114
(Vicat) Final		205
Mortar Bar Expansion (ASTM C1038) (%)*	0.02 max	0.010

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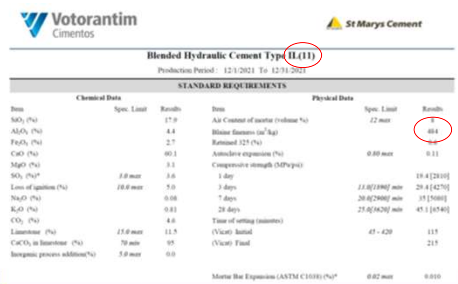
What is Portland Limestone Cement.


Votorantim Cimentos | St Marys Cement

Blended Hydraulic Cement Type IL(11)

Production Period : 12/1/2021 To 12/31/2021

STANDARD REQUIREMENTS

Chemical Data

Item	Spec. Limit	Results
SiO_2 (%)		17.9
Al_2O_3 (%)		4.4
Fe_2O_3 (%)		2.7
CaO (%)		60.1
MgO (%)		3.1
SO_3 (%)*	3.0 max	3.6
Loss of ignition (%)	10.0 max	5.0
Na_2O (%)		0.08
K_2O (%)		0.81
CO_2 (%)		4.6
Limestone (%)	15.0 max	11.5
$CaCO_3$ in limestone (%)	70 min	95
Inorganic process addition(%)	5.0 max	0.0

Physical Data

Item	Spec. Limit	Results
Air Content of mortar (volume %)	12 max	[illegible]
Blaine fineness (m^2/kg)		484
Retained 325 (%)		[illegible]
Autoclave expansion (%)	0.80 max	0.11
Compressive strength (MPa/psi)		
1 day		19.4 [2810]
3 days	13.0[1890] min	29.4 [4270]
7 days	20.0[2900] min	35 [5080]
28 days	25.0[3620] min	45.1 [6540]
Time of setting (minutes)		
(Vicat) Initial	45 - 420	115
(Vicat) Final		215
Mortar Bar Expansion (ASTM C1038) (%)*	0.02 max	0.010

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DOT Acceptance

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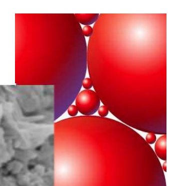
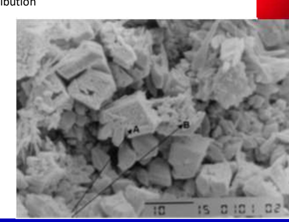
How Limestone Works in Cement

- **Particle Packing**
  - Improved Particle Size Distribution
- **Nucleation**
  - Surface for precipitation





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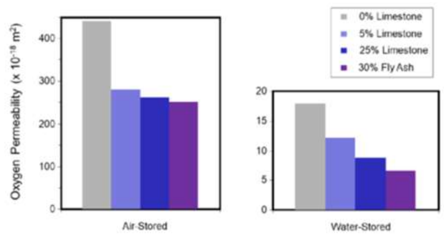
Particle Size Distribution Improvements



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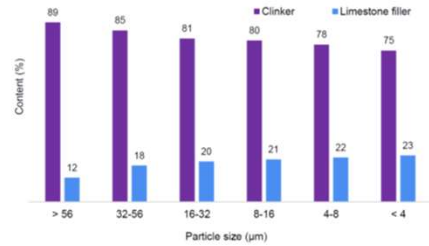
Particle Size Distribution



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Three Point Curve with PLC & Type I

		PLC / Slag					
	Slump	**Air %**	**Unit Weight**	**Yield**	**Water**	**W/C**	**oz/cwt**
4.5 Sack	5.25	6.4	143.8	26.6	267	0.63	0.7
5.5 Sack	5.75	5.9	144.6	26.5	287	0.55	1
6.5 Sack	5.75	6.2	142.6	27	300	0.49	1.25
		Type I / Slag					
	Slump	**Air %**	**Unit Weight**	**Yield**	**Water**	**W/C**	**oz/cwt**
4.5 Sack	5.25	6.8	143	26.7	262	0.62	0.7
5.5 Sack	5	7.2	141.7	27	282	0.55	1
6.5 Sack	5	7	141.9	27.1	296	0.48	1.4
		Type I					
	Slump	**Air %**	**Unit Weight**	**Yield**	**Water**	**W/C**	**oz/cwt**
4.5 Sack	5.25	7	143.9	26.5	249	0.59	0.56
5.5 Sack	5	7.3	143.4	26.6	256	0.5	0.68
6.5 Sack	4.75	7.2	143.1	26.9	273	0.45	0.8

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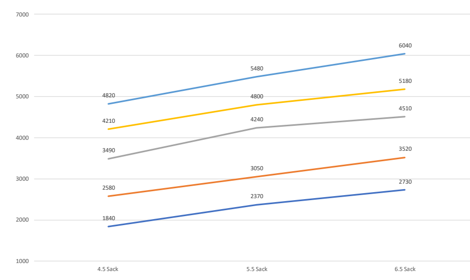
PLC & 40% Slag Cement



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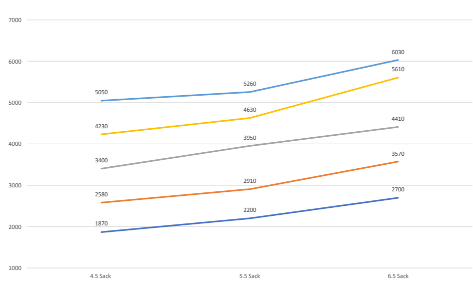
Type I & 40% Slag Cement



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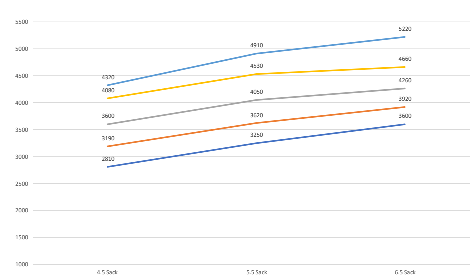
Type I



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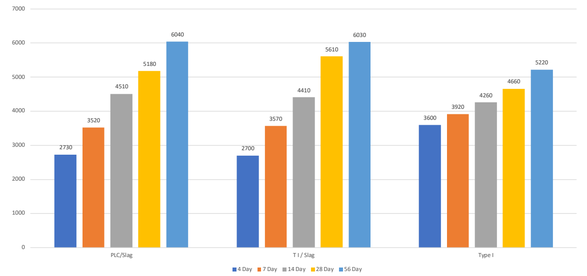
6 ½ Sack Comparisons



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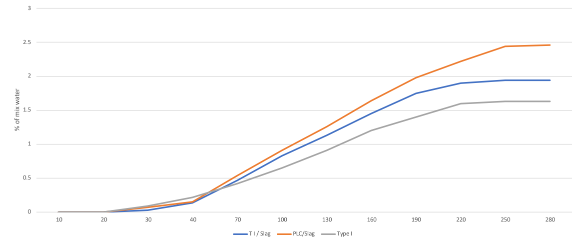
Bleed Rate



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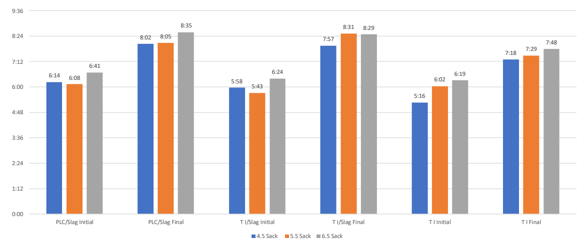
Time of Set



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Sulphate Resistance

Table 6.1.4.1b—Requirements to protect against damage to concrete by sulfate attack from external sources of sulfate

Severity of potential exposure	*w/cm* by mass, maximum	Prescriptive cementitious material requirements			Performance cementitious material requirements		
		Cement types[*]			Maximum expansion when tested using ASTM C1012/C1012M		
		ASTM C150/C150M	ASTM C595/C595M	ASTM C1157/C1157M	At 6 months	At 12 months	At 18 months
S0	No *w/cm* restriction	No type restriction	No type restriction	No type restriction	—	—	—
S1	0.50[‡]	Type II[§‖]	IP (MS), IS (<70) (MS), IT (P<S<70) (MS), or IT (P≥S) (MS)	MS	0.10%	—	—
S2	0.45[†]	Type V[#]	IP (HS), IS (<70) (HS), IT (P<S<70) (HS), or IT (P≥S) (HS)	HS	0.05%	0.10%[‖]	—
S3	0.40[†]	Type V plus pozzolan or slag cement[**]	IP (HS), IS (<70) (HS), IT (P<S<70) (HS), or IT (P≥S) (HS)	HS[††]	—	—	0.10%

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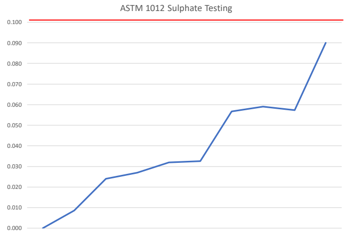
Sulphate Resistance (Type II)



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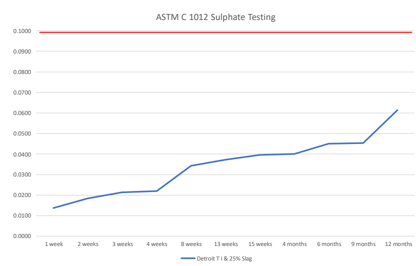
Sulphate Resistance (Type V)



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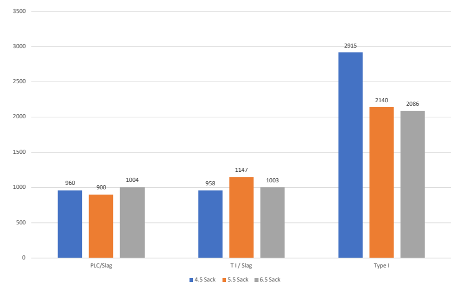
Rapid Chloride Permeability Testing



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Life Cycle Assessment of 6 ½ Sack Mixes

Mix ID	PLC Slag	TI Slag	Type I
Climate Change (kg CO2-eq)	202.49	218.82	318.81
Ozone depletion (kg CFC-11-eq)	6.57E-06	6.97E-06	7.99E-06
Acidification (kg SO2-eq)	0.91	0.96	1.02
Eutrophication (kg N-eq)	0.26	0.28	0.38
Photochemical Ozone Creation/Smog (kg O3-eq)	17.34	18.20	21.05
Total primary energy consumption (MJ)	1,577.51	1,669.88	2,041.70
Depletion of non-renewable energy resources (MJ)	1,545.61	1,636.02	2,002.18
Use of renewable primary energy (MJ)	31.90	33.86	39.52
Depletion of non-renewable material resources (kg)	1,601.48	1,623.38	1,789.69
Use of renewable material resources (kg)	1.66	1.77	2.34
Concrete batching water consumption (m3)	0.14	0.13	0.12
Concrete washing water consumption (m3)	0.13	0.13	0.13
Total water consumption (m3)	0.27	0.26	0.25
Concrete hazardous waste (kg)	0.32	0.32	0.33
Concrete non-hazardous waste (kg)	3.43	3.57	4.53

PLC/Slag mix has 37% less CO2 than Type I and about 7% less than Type I/Slag mix.

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Life Cycle Assessment of PLC & Slag Cement

Mix ID	4.5 Sack	5.5 Sack	6.5 Sack
Climate Change (kg CO2-eq)	148.68	175.82	202.49
Ozone depletion (kg CFC-11-eq)	4.80E-06	5.69E-06	6.57E-06
Acidification (kg SO2-eq)	0.72	0.82	0.91
Eutrophication (kg N-eq)	0.19	0.23	0.26
Photochemical Ozone Creation/Smog (kg O3-eq)	13.97	15.67	17.34
Total primary energy consumption (MJ)	1,222.05	1,401.14	1,577.51
Depletion of non-renewable energy resources (MJ)	1,198.56	1,373.41	1,545.61
Use of renewable primary energy (MJ)	23.49	27.72	31.90
Depletion of non-renewable material resources (kg)	1,625.34	1,613.73	1,601.48
Use of renewable material resources (kg)	1.22	1.44	1.66
Concrete batching water consumption (m3)	0.12	0.13	0.14
Concrete washing water consumption (m3)	0.13	0.13	0.13
Total water consumption (m3)	0.25	0.26	0.27
Concrete hazardous waste (kg)	0.32	0.32	0.32
Concrete non-hazardous waste (kg)	3.00	3.22	3.43

4.5 sack mix has 27% less CO2 than 6.5 sack mix.

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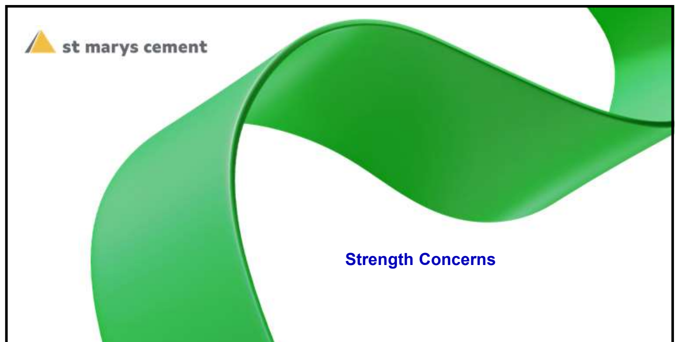
st marys cement



Strength Concerns

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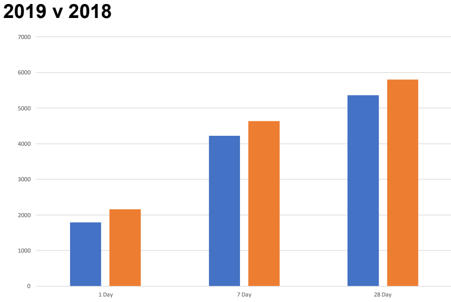
Type I - 2019 v 2018



8% difference in Type I between 2018 v 2019

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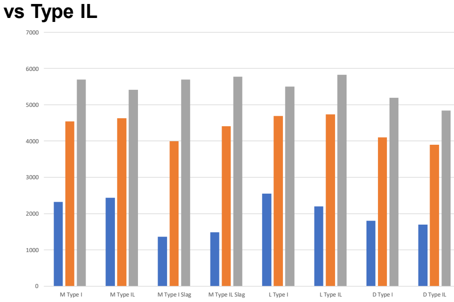
Type I vs Type IL



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"They Don't Make Cement Like They Used Too!"

Year	Blaine sq cm/g	Vicat Initial min	Vicat Final min	1 Day psi	3 Day psi	7 Day psi	28 Day psi
1953	3500	214	395	960	2150	3250	5060
1999	4240	109	227	2470	3920	4790	6240

st marys cement

VOTORANTIM cimentos

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