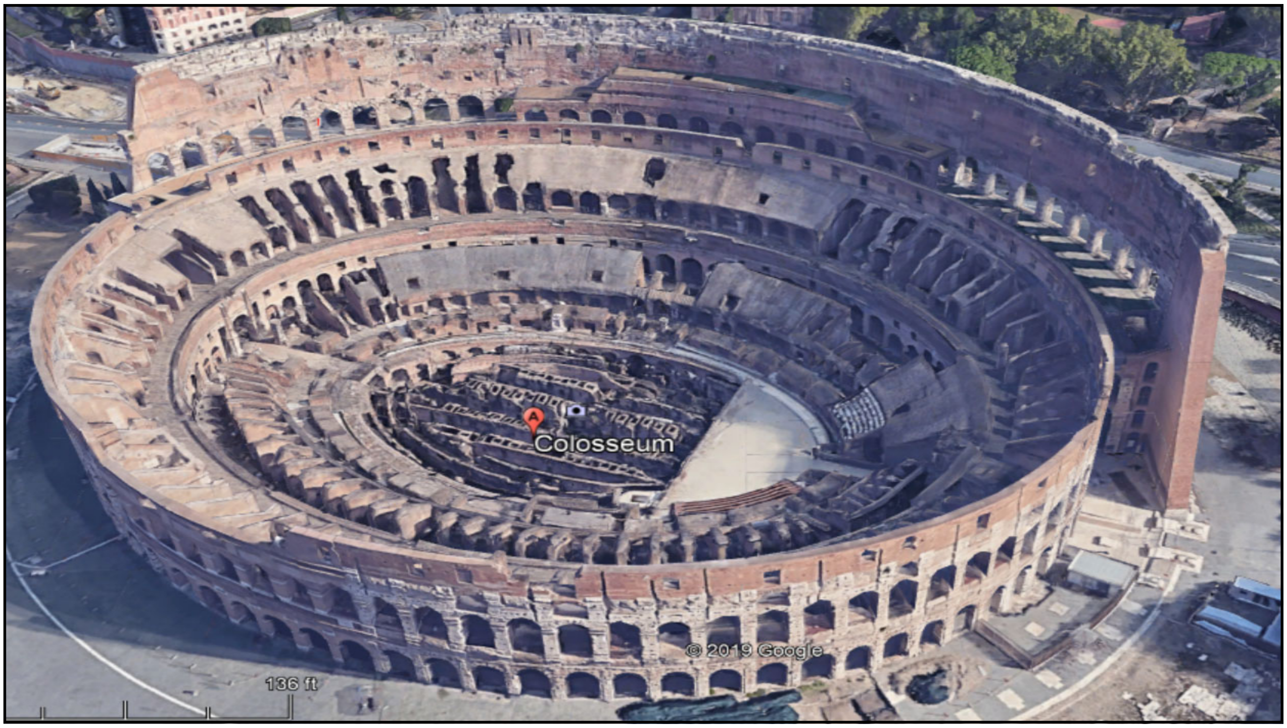
NATURAL POZZOLAN ASSOCIATION

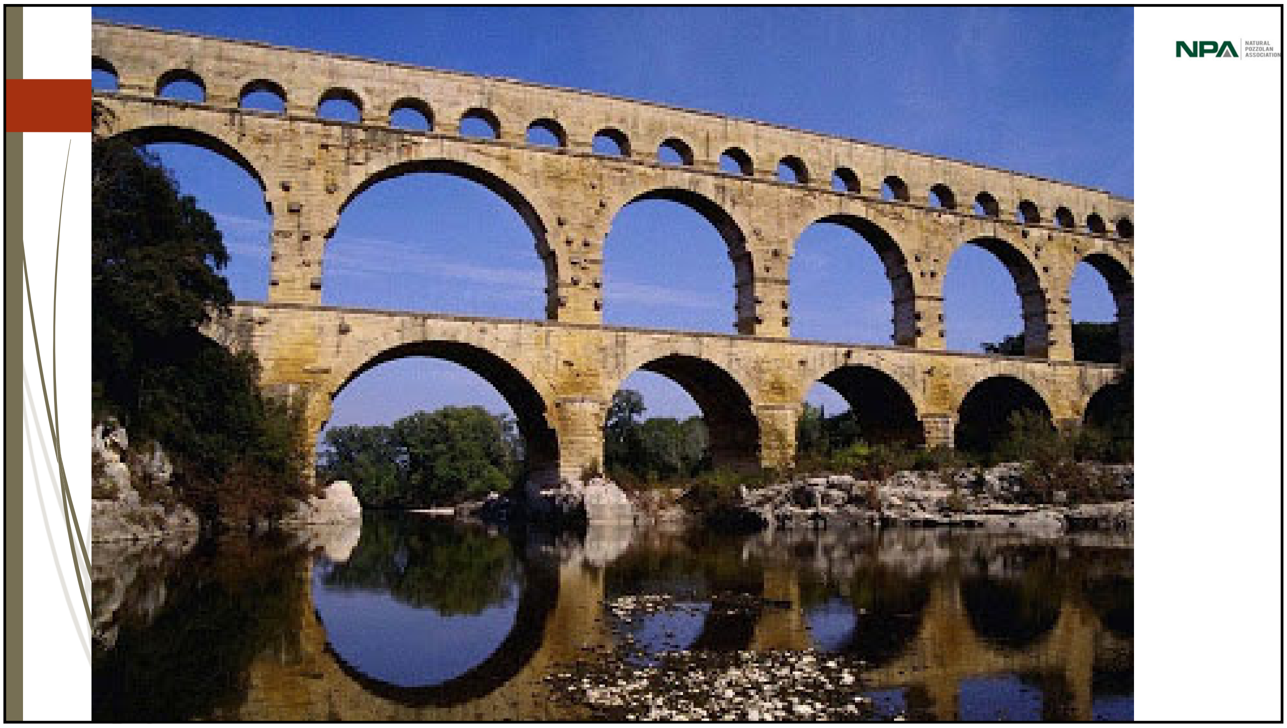
Established - March 2017

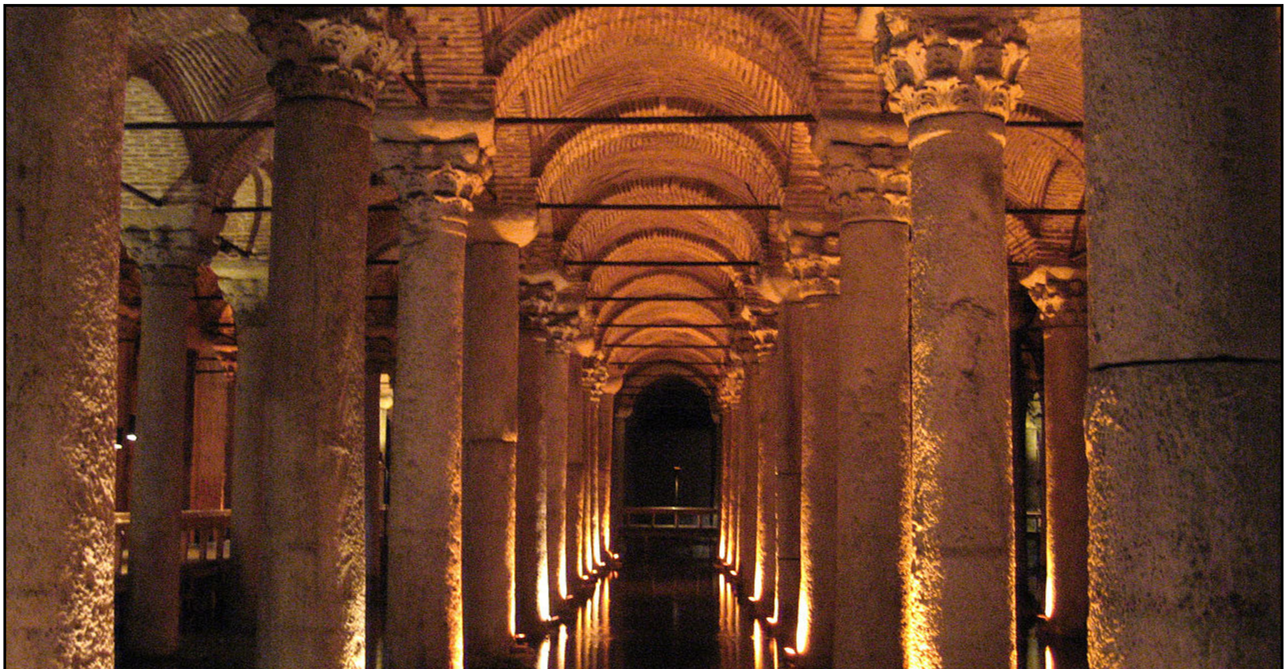
Website: Pozzolan.org

A Renaissance: What is old, is new again!


Pantheon


Colosseum
© 2019 Google
136 ft





By Gun Powder Ma - Own work, Public Domain,
https://commons.wikimedia.org/w/index.php?curid=3405702

Vitruvius – Roman Engineer

General recipe for Roman Concrete:

1 part - Lime
3 parts - Pozzolana
Sand/Aggregates (aggregates were generally lightweight materials such as pumice, scoria, & terracotta)

There are 2 types of Natural Pozzolans (NP):

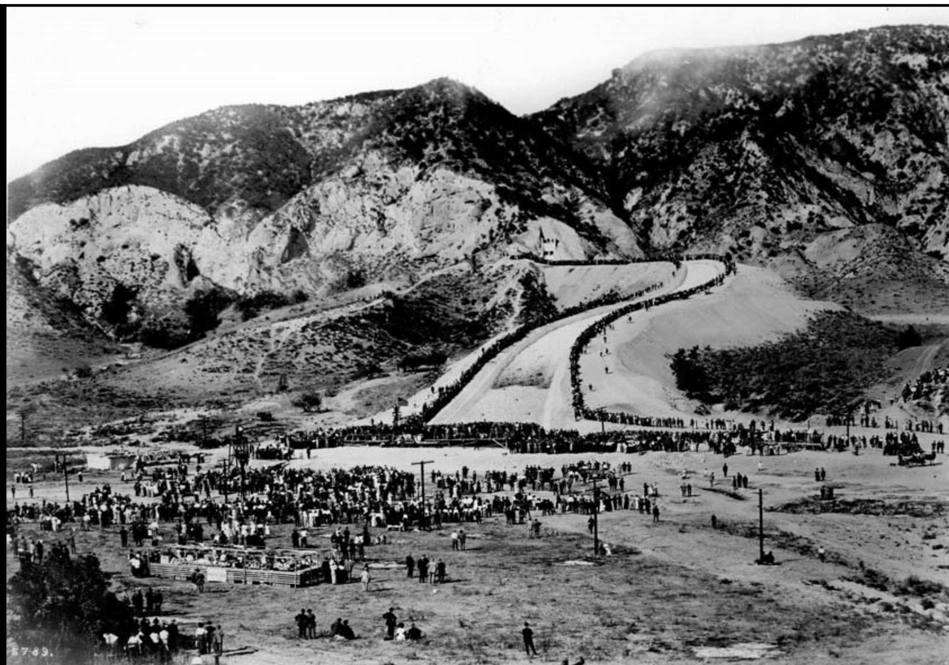
1. **Raw NP** (Volcanic ejecta-based materials – pumice, pumicite, volcanic ash, etc. Pre-calcined by Mother Nature)

2. **Calcined NP** (such as MetaKaolin)

Roman Concrete: "It's the most durable building material in human history, and I say that as an engineer not prone to hyperbole," Roman Concrete expert Phillip Brune told the Washington Post. July 4, 2017, Washington Post

NP in modern concrete infrastructure: Pre-Fly Ash Era

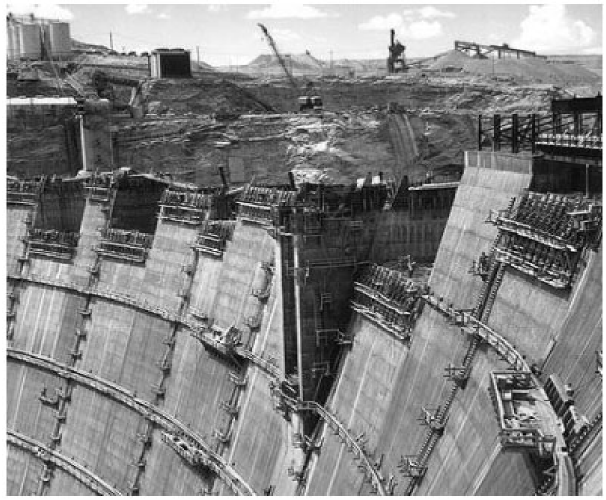
First renaissance of Natural Pozzolan: 1900~1970



Los Angeles Times File Photo

Hoover Dam, and hundreds of other infrastructure, projects used natural pozzolan. Picture/USBR

Glen Canyon dam used several hundred thousand tons of natural pozzolan in its construction.



File photo: Construction of Glen Canyon Dam, Page, Arizona, circa 1960

Fly Ash Era

Natural Pozzolans are back: Diminishing-Fly Ash Era

2nd Renaissance


DEERE
624J

Pumice Producing Facilities

Some cement companies are producing a NP and/or a Type IP cement

First US-based NP production facility dedicated solely to producing natural pozzolan (2018). There are more to follow - 3 more by the end of 2022.

NPA NATURAL POZZOLAN ASSOCIATION

New 500K+ TPY NP plant going up in AZ

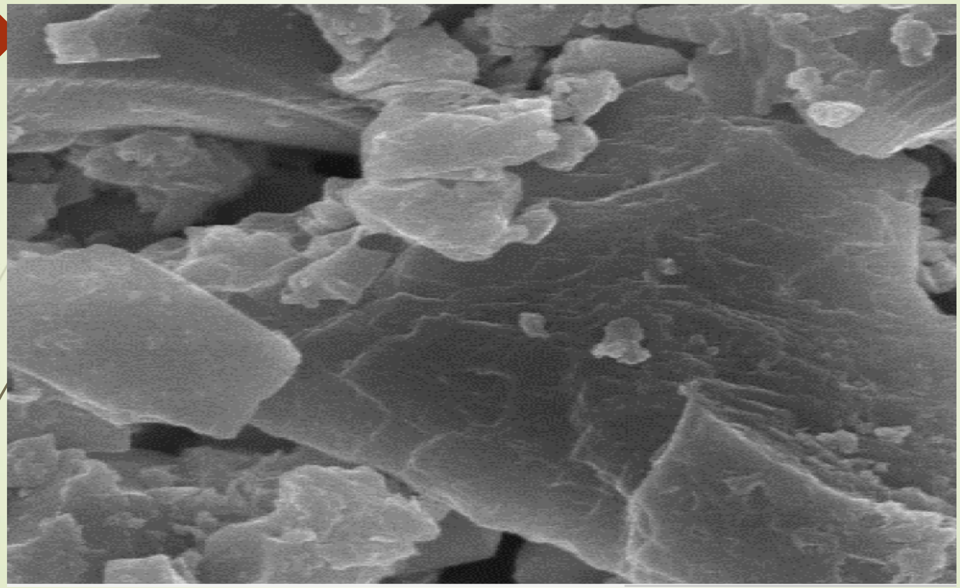
Metakaolin Processing Plant

There are approximately 10 NP production facilities in North America, and about 10 more deposits in various phases of development (that we know of….).

Currently there is a total production capacity of an estimated 1.5m tons - and much more to follow.

- Operational or Permitted
- Proposed

Physical and Chemical properties of Natural Pozzolan



Sample Date: 8/9 - 8/11/15 **MTRF ID:**

Sample ID:

Chemical Analysis			**ASTM / AASHTO Limits Class F**	**Class C**	**ASTM Test Method**
Silicon Dioxide (SiO2)	59.73	%			
Aluminum Oxide (Al2O3)	23.01	%			
Iron Oxide (Fe2O3)	4.47	%			
Sum of Constituents	87.21	%	70.0% min	50.0% min	D4326
Sulfur Trioxide (SO3)	0.37	%	5.0% max	5.0% max	D4326
Calcium Oxide (CaO)	4.84	%			D4326
Moisture	0.05	%	3.0% max	3.0% max	C311
Loss on Ignition	0.85	%	6.0% max 5.0% max	6.0% max 5.0% max	C311 AASHTO M295
Available Alkalies, as Na2Oe **When required by purchaser**	1.36	%	not required 1.5% max	 1.5% max	C311 AASHTO M295
Physical Analysis					
Fineness, % retained on #325	17.13	%	34% max	34% max	C311, C430
Strength Activity Index - 7 or 28 day requirement 7 day, % of control	 84	 %	 75% min	 75% min	C311, C109
28 day, % of control	84	%	75% min	75% min	
Water Requirement, % control	95	%	105% max	105% max	
Autoclave Soundness	0.00	%	0.8% max	0.8% max	C311, C151
Density	2.25				C604

Typical Class F – Fly Ash

ASTM C618-19 - Chemical and Physical Analyses - Fly Ash/Pozzolans

CTL Ticket: 21102	Plant of Origin:) NP	Sample Date Range: 06/08/2021
CTL Project: CT16959	Sample ID: ne Comp #1	to:
Report Date: 07/29/2021	Supplier:	Date Received: 06/10/2021

Chemical Composition (%)
(by Wyoming Analytical Laboratories, Inc.)

	Result	ASTM C618-19 Class N	Class F	Class C
Silicon Dioxide:	73.4			
Aluminum Oxide:	12.4			
Iron Oxide:	1.3			
Total Silica, Aluminum, Iron:	87.1	≥70.0%	≥50.0%	≥50.0%
Sulfur Trioxide:	0.0	≤4.0%	≤5.0%	≤5.0%
Calcium Oxide:	0.9	N/A	≤18.0%	>18.0%

Product Class: Class N   Conforms to Class: Yes

Volatile Composition (Mass%)

	Result	Class N	Class F	Class C
Moisture Content:	0.9	≤3.0%	≤3.0%	≤3.0%
Loss on Ignition:	3.8	≤10.0%	≤6.0%	≤6.0%

Physical Test Results

	Result	Class N	Class F	Class C
Fineness, Retained on #325 Sieve (%):	3.2	≤34%	≤34%	≤34%
Strength Activity Index (%) *		* No 7-day limit if 28-day meets		
Percent of Control @ 7 Days:	85	≥75%	≥75%	≥75%
Percent of Control @ 28 Days:	100	≥75%	≥75%	≥75%
Water Requirement, % of Control:	103	≤115%	≤105%	≤105%
Soundness, Autoclave Expansion (%):	-0.01	≤0.8%	≤0.8%	≤0.8%
Density (g/cm3) :	2.33	N/A	N/A	N/A

Meets AASHTO M321 HR Pozz

Uniformity Established from 10 previous tests

			Class N	Class F	Class C
Average Fineness:	3.4	Difference 0.3(%)	±5(%)	±5(%)	±5(%)
Average Density:	2.35	Difference -0.85%	±5%	±5%	±5%

Supplementary Requirements

Available Alkalis, as Na_2O 1.29%

CTL Ticket: *19081*	Source: *Metakaolin*	Sample Date Range:
CTL Project: *16638*	Sample ID:	to:
Report Date: *08/23/2019*	Docket:	Date Received: *06/03/2019*

Chemical Composition (%)
(by Wyoming Analytical Laboratories, Inc.)

	Result		ASTM C618-15 Class N
Total Silica, Aluminum, Iron:	*96.0*		70.0 Min
Silicon Dioxide:		*53.4*	
Aluminum Oxide:		*42.0*	
Iron Oxide:		*0.6*	
Sulfur Trioxide:	*0.1*		4.0 Max
Calcium Oxide:	*0.1*		
Moisture Content:	*0.2*		3.0 Max
Loss on Ignition:	*0.5*		10.0 Max
			AASHTO M295-11 Specifications
Available Alkalies (as Na_2O):	*0.0*		1.5 Max
Sodium Oxide:		*0.03*	
Potassium Oxide:		*0.00*	

Physical Test Results

	Result	ASTM C618-15 Class N
Fineness, Retained on #325 Sieve (%):	*2.5*	34 Max
Strength Activity Index (%)		
Ratio to Control @ 7 Days:	*109.8*	
Ratio to Control @ 28 Days:	*122.0*	75 Min
Water Requirement, % of Control:	*111.6*	115 Max
Soundness, Autoclave Expansion (%):	*-0.07*	0.8 Max
Drying Shrinkage, Increase @ 28 Days (%):	*0.00*	0.03 Max
Density Mg/m^3:	*2.52*	

Class-N Pozzolan

Comments: *Meets ASTM C618-17 Class N and AASHTO M295-11 Spec.*

CTL | Thompson Materials Engineers, Inc.

COLORADO REGISTERED PROFESSIONAL ENGINEER 14540 *8/23/2019*

Does higher water demand for NP mean more permeability, less density, or diminished durability?

NO!

Compressive Strength	NP Class N @ 0.45 w/cm	Class F @ 0.45 w/cm	NP Class N @ 0.50 w/cm	Class F @ 0.50 w/cm	NP Class N @ 0.55 w/cm	Class F @ 0.55 w/cm	
1 Day 10/12/22	2760	2290	2210	1520	1770	1230	
7 Day 10/18/22	6000	5900	5320	4880	4600	4070	
28 Day 11/8/22	7460	7200	6640	5750	5760	4950	
28 day psi per pound of CM	*13.23*	*12.77*	*11.77*	*10.20*	*10.21*	*8.78*	
56 Day 12/6/22	8530	7980	7440	6240	6280	5400	
AASHTO T-358 Surface Resistivity	NP Class N @ 0.45 w/cm In KΩ-cm	Class F @ 0.45 w/cm In KΩ-cm	NP Class N @ 0.50 w/cm In KΩ-cm	Class F @ 0.50 w/cm In KΩ-cm	NP Class N @ 0.55 w/cm In KΩ-cm	Class F @ 0.55 w/cm In KΩ-cm	AASHTO T-358 Classification 28 day reading is the standard maturity in Ohms Resistance for CDOT specifications, CDOT performance requirment > 12 Ohms Resistance
3 Day 10/14/22	5.4	6.0	4.4	4.5	3.8	4.5	Chloride Ion Penetrability Scale
7 Day 10/18/22	7.3	7.4	5.9	5.7	5.5	5.6	<12 High
14 Day 10/25/22	11.5	8.6	9.5	6.4	8.6	6.4	12-21 Moderate
21 Day 11/1/22	15.6	10.2	13.2	7.7	12.1	7.5	21-37 Low
28 Day 11/8/22	20.1 Moderate	12.8 Moderate	16.9 Moderate	9.5 High	16.2 Moderate	8.71 High	37-254 Very Low
56 Day 12/6/22	41.6 Very Low	25.1 Low	35.4 Low	17.2 Moderate	34.2 Low	16.1 Moderate	>254 Negligible
90 Day 1/9/23	60.2 Very Low	36.0 Low	51.2 Very Low	24.3 Low	48.4 Very Low	24.0 Low	
AASHTO T-277, ASTM C1202 RCP Test	927 Very Low	1019 Low	1327 Low	2435 Moderate	1545 Low	3547 Moderate	
56 Day 12/6/22 CDOT requires <2500 at 56 days							

Rapid Chloride Ion Permeability
ASTM C 1202

Mix ID	Age (days)	Test Date	Chloride Ion Penetrability (Coulombs)
NP at 0.50 w/c #1	56	12/6/22	1206
NP at 0.50 w/c #2	56	12/6/22	1448
Average			1327

Classification Table

Charge Passed (Coulombs)	Chloride Ion Penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very Low
<100	Negligible

Based on these results, the NP at 0.50 w/c mix has a "Low" chloride ion penetrability. If you have any questions regarding this report, please feel free to contact us.

Rapid Chloride Ion Permeability
ASTM C 1202

Mix ID	Age (days)	Test Date	Chloride Ion Penetrability (Coulombs)
CF at 0.50 w/c #1	56	12/6/22	2668
CF at 0.50 w/c #2	56	12/6/22	2201
Average			2435

Classification Table

Charge Passed (Coulombs)	Chloride Ion Penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very Low
<100	Negligible

Based on these results, the CF at 0.50 w/c mix has a "Moderate" chloride ion penetrability. If you have any questions regarding this report, please feel free to contact us.

Mitigates ASR to 0 expansion in the Std 14d test, and .01% at 28d (For FAA job in KS)

SUMMARY TABLE

Figure ID	Mix Constituents				14-Day Expansion	28-Day Expansion	ASTM C 1567 Classification (14-Days)
	Aggregates		Cementitious Materials				
	Coarse	Fine	Cement	NP			
Control Sand	0%	100%	100%	0%	0.29%	0.42%	Potentially Deleterious
A-1	0%	100%	75%	25%	-0.01%	0.01%	Acceptable

The ASTM C 1567 test method defines the potential of an aggregate for deleterious expansion as follows, based on the 14-Day expansion:

Test Expansion (14-Days)	Classification	Potential for Deleterious ASR
< 0.1%	Acceptable	Low
> 0.1%	Potentially Deleterious	High

Based on our test results and ASTM standards for performance, the use of 25% a NP mitigates the reactive rock to a "Low" potential for deleterious ASR. The 28-day performance can be compared to other project specific requirements, if applicable.

Credit: FHWA

Wind Turbine - Kansas


20
30

Cement & SCM changes and Performance Specifications
The game is changing quickly

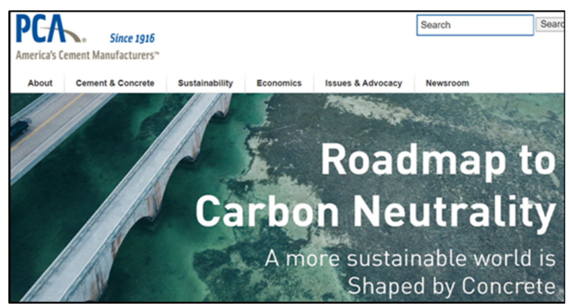
Dave Figurski, PE
Holcim

Colorado Concrete Conference
September 28th, 2022

ROCKY MOUNTAIN CHAPTER

Global Cement Industry's Reaction to Pressure

- Quickly cover what the GCCA has committed to:
  - 25% CO_2 reduction by 2030 (from 2020)
  - Net Zero emissions by 2050
- New Terminology:
  - EPD's…Environmental Product Declarations
    - Environmental "Nutrition Label"
  - **GWP**…Global Warming Potential (CO_2 equiv.)
- Low hanging fruit:
  - Reduce clinker contents within cements
  - Minimize cement content within concrete
  - "Buy Clean Colorado Act" already here
- Future focus:
  - Renewable Energy additions to cement plants
  - Alternative Fuels
  - More efficient plants
  - Large scale carbon capture



Metric	Cradle-to-gate total per metric tonne of production	Unit
Environmental impact		
Global warming potential (100 years)	1040	kg CO2-eq.
Acidification potential	2.45	kg SO2-eq.
Eutrophication potential	1.22	kg N-eq.
Formation potential of tropospheric ozone	48.8	kg O3-eq
Ozone depletion potential	2.61E-05	kg CFC 11-eq.

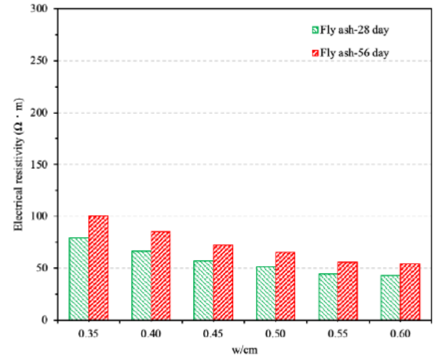
PCA Portland Cement Industry Average EPD

ROCKY MOUNTAIN CHAPTER

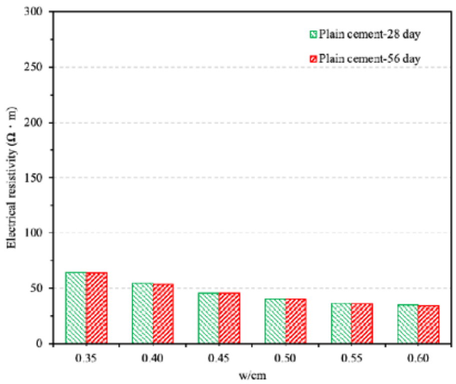
SCM's & Durability

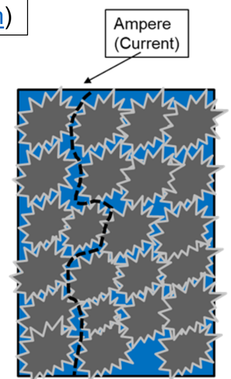
Bulk Resistivity Results on 2" x 4" mortar cylinders

- Asses the ability of concrete to resist electrical current
- Current moves thru pore continuity…so do sulfates/chlorides

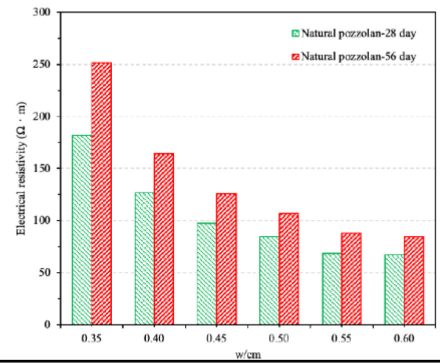


Work performed by DRP (Boulder, CO)
- Now, DRP, Twining Concrete Insight (drpcinc.com)





Evaluating Concrete Quality w/Electrical Resistivity (Giatec)



Durability testing

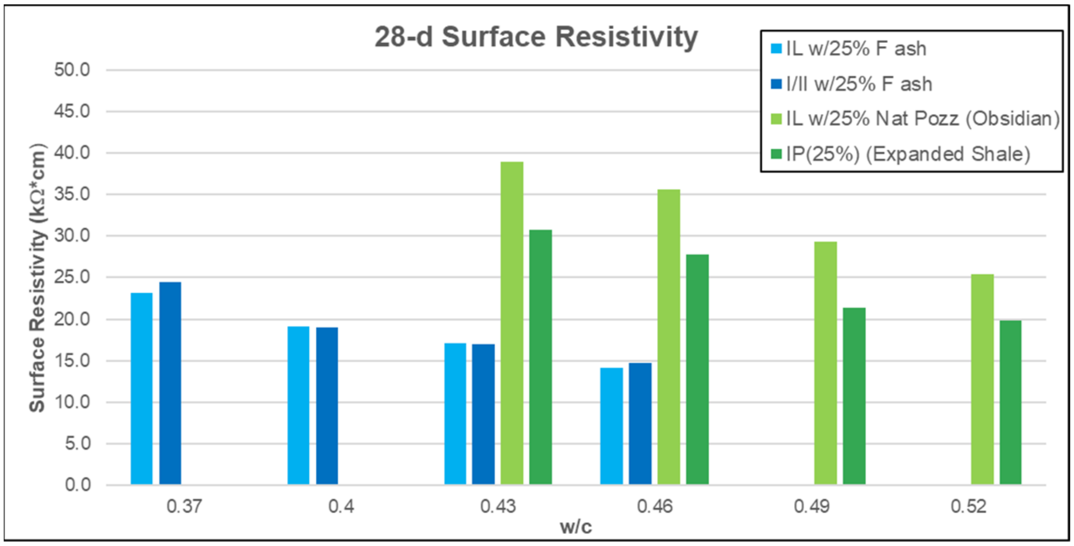
- For year's there's been no easy/quick test method for assessing a mix's durability performance
- Specs have relied on limiting the w/cm as a surrogate

- ASTM C1202 - Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
  - Measures amount of electrical current passing thru 2" core
  - Significant prep, time and handling of caustic solutions
  - Has been specified for years…lower coulomb values better

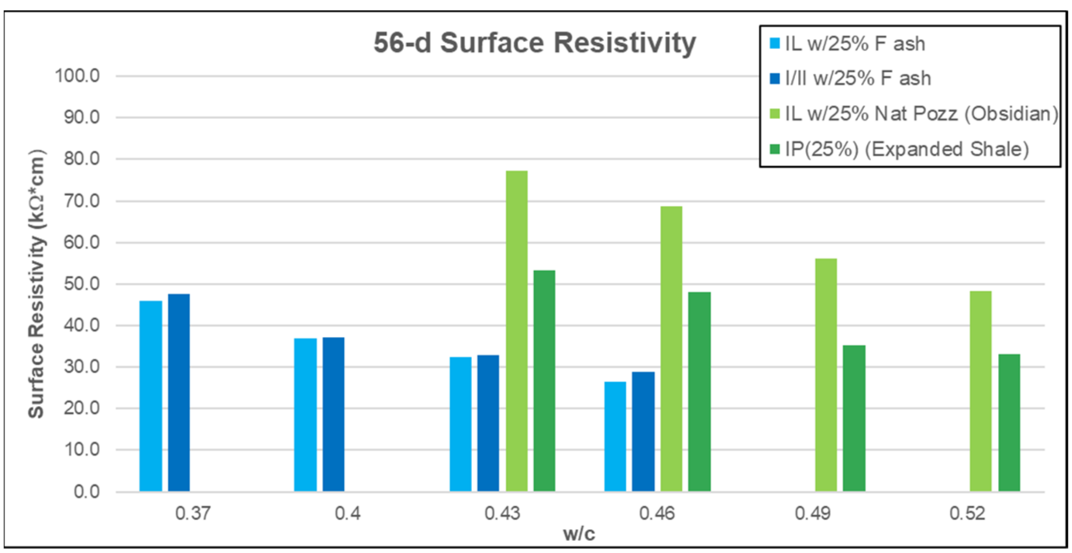
- AASTHO T358 - Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration (2015)
  - Newer and easier test to perform
  - Excellent correlation to C1202
  - Required for most CDOT approved mixes in 2021
  - Higher resistivity values better

(FHWA)

Surface Resistivity's (AASHTO T358)



Surface Resistivity's (AASHTO T358)



Basis for moving to performance specifications

Concrete mix design development is a balancing act!

a) Strength
b) Workability (and how long you have it)
c) Durability
d) Dimensional stability
e) Finishability
f) Repeatability
g) Economics
h) Sustainability

(ppic.org)

Prescriptive specifications limit the innovative potential of the concrete supplier

ROCKY MOUNTAIN CHAPTER

NRMCA Prescriptive to Performance Initiative

P2P INITIATIVE (NRMCA.org)

- History
  - P2P introduction of performance spec work initiated in 2002 via NRMCA.
    - Phase I report (2006) and Phase II report (2008)
  - Developed into ACI 329-14 Report on Performance-Based Requirements for Concrete

- Challenges
  - Historical inertia w/regard to specifications
  - Until recently, durability tests more labor intensive (w/c limits & strengths much easier)

- Fun Fact:
  - ACI 501-36T (4th "building code")…allowed for an alternative to the prescribed w/c, as long as mix strengths exceeded design requirements by 15-20%

AASHTO R101

ROCKY MOUNTAIN CHAPTER

ACI 318-19 ACI Building Code Requirements

- Specified mix criteria to ensure adequate durability, protecting against:
  - F - Freezing & Thawing
  - S - Sulfate
  - P/W - In contact w/water
  - C - Corrosion Protection of Reinforcement

What testing were these specifications based upon? Can we redo the foundational testing using Natural Pozzolans in order to establish new guidelines for a very different, yet very effective SCM?

(ACI 318-19)

Table 19.3.2.1—Requirements for concrete by exposure class

Exposure class		Maximum w/cm[1,2]	Minimum f'_c, psi	Additional requirements			Limits on cementitious materials
				Air content			
F0		N/A	2500	N/A			N/A
F1		0.55	3500	Table 19.3.3.1 for concrete or Table 19.3.3.3 for shotcrete			N/A
F2		0.45	4500	Table 19.3.3.1 for concrete or Table 19.3.3.3 for shotcrete			N/A
F3		0.40[3]	5000[3]	Table 19.3.3.1 for concrete or Table 19.3.3.3 for shotcrete			26.4.2.2(b)
[redacted]				Cementitious materials[4] — Types			Calcium chloride admixture
				ASTM C150	ASTM C595	ASTM C1157	
S0		N/A	2500	No type restriction	No type restriction	No type restriction	No restriction
S1		0.50	4000	II[5][6]	Types with (MS) designation	MS	No restriction
S2		0.45	4500	V[6]	Types with (HS) designation	HS	Not permitted
S3	Option 1	0.45	4500	V plus pozzolan or slag cement[7]	Types with (HS) designation plus pozzolan or slag cement[7]	HS plus pozzolan or slag cement[7]	Not permitted
	Option 2	0.40	5000	V[8]	Types with (HS) designation	HS	Not permitted
[redacted]							
W0		N/A	2500	None			
W1		N/A	2500	26.4.2.2(d)			
W2		0.50	4000	26.4.2.2(d)			
[redacted]				Maximum water-soluble chloride ion (Cl^-) content in concrete, percent by mass of cementitious materials[9,10]		Additional provisions	
				Nonprestressed concrete	Prestressed concrete		
C0		N/A	2500	1.00	0.06	None	
C1		N/A	2500	0.30	0.06		
C2		0.40	5000	0.15	0.06	Concrete cover[11]	

(Use authorized by ACI)

Industry Resources

- NRMCA P2P
  - Specifications in Practice documents
  - Selected Published Papers/Reports

P2P INITIATIVE

(NRMCA.org)

Summary….

- New cements, new SCM's, & new tests are here
- NPs don't behave like the materials our prescriptive specs are built around
- If the industry is going to make progress on the sustainability goals in front of us, producers will need to be able to innovate.

Start becoming familiar and permit performance specifications where you can!

Questions…feel free to email:
Dave Figurski
david.figurski@holcim.com

NP industry's request to the DOT's and other specifiers in the industry:

1. Give us optional performance standards that align with the prescribed w/c ratios.

2. Provide optional 56d specifications for strength and durability (resistivity or RCP) specifications – in order to reduce cementitious.

3. NPs are different materials which require different mix designs for proper optimization.

4. Remove LOI restrictions on NP. LOI in NP is not carbon but rather bound water which does not affect air entrainment.

5. We aren't looking for a pass, but rather a pathway. Allow for approval of NP mix designs based on performance rather than W/C ratio.

We can reduce clinker in cement now. We can reduce cement in concrete now. We can reduce concrete in construction now (optimized mix designs). We can make extremely durable, sustainable concrete now by learning lessons from the past. Why wait?

Learn More!

NPA Symposium: 16~18 May 23

Wickenburg, AZ

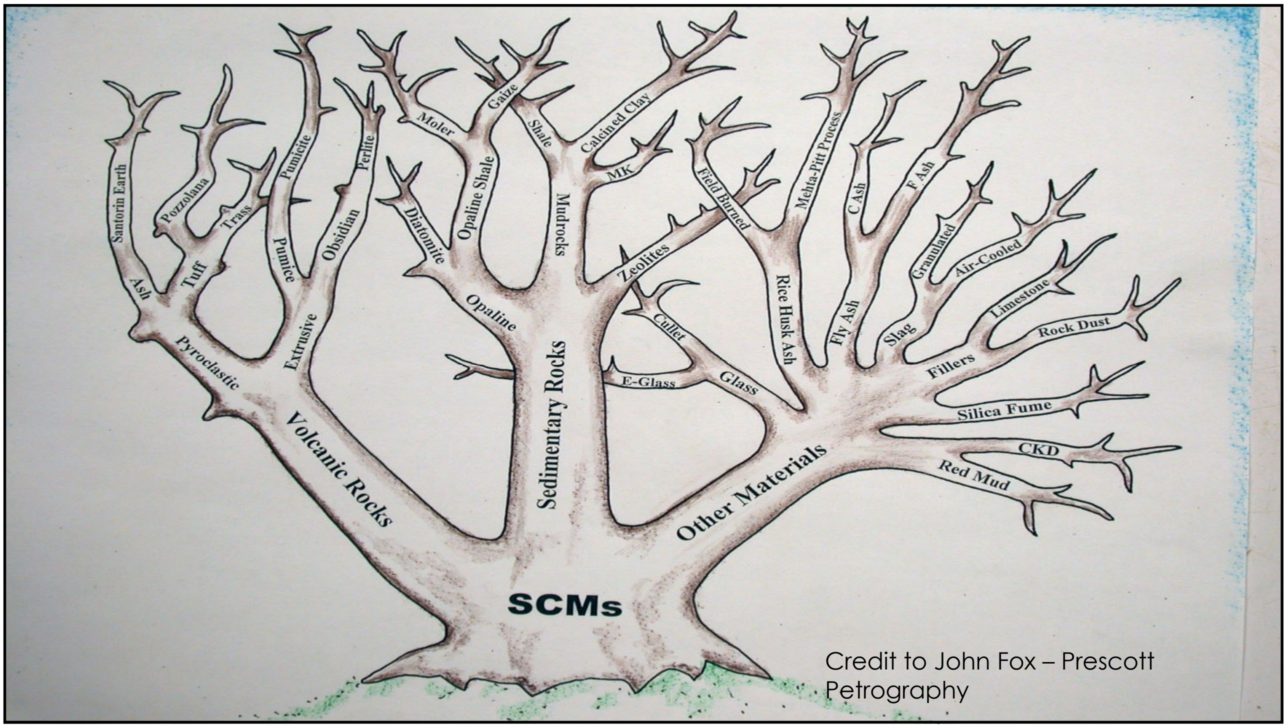
NATURAL POZZOLAN ASSOCIATION

Website: **Pozzolan.org**
Email: Info@pozzolan.org
Tel: 2082522808

Questions?

NATURAL POZZOLAN ASSOCIATION

ND volcanic ash near Badlands



Credit to John Fox – Prescott Petrography

Roman Concrete utilized a balanced cement paste – virtually all of the Calcium Hydroxide was consumed based on the recipe shared by Vitruvius.

Note: Calcium Hydroxide (Lime) in concrete, which is not converted to C-S-H, becomes a volatile, bad actor in concrete.

NATURAL POZZOLAN ASSOCIATION

So, how does Natural Pozzolan enhance and protect concrete?

Modern portland cements produce unreacted excess free lime. Standard TI/II cements can release up to 25% calcium hydroxide (a by-product of the hydraulic reaction) into the pore solution - unbound, & free to go about its deleterious work - **Ca(OH)2** is:

1. A key ingredient in ASR
2. A key ingredient in Sulfate Attack
3. A key ingredient in Efflorescence
4. A key ingredient in Chlorides induced expansion
5. A key contributor to porosity in concrete - (allowing ingress of chlorides, sulfates, etc)

Natural Pozzolan consumes the excess $Ca(OH)_2$ and converts it into additional C-S-H (and C-A-S-H), the binder in concrete, thereby densifying the concrete, which in turn increases the impermeability of the concrete and thus its resistance to ingress of damaging chemicals.

By converting the free-lime into additional C-S-H, a concrete using NP at a 20~25% replacement of cement will have greater ultimate compressive strength than a 100% cement mix design - up to 150% SAI of the straight cement index mix at 1 year.

Most of the free-lime will be converted to C-S-H, providing enhanced strength, reduced permeability, and fortifying the concrete against chemical attack, such as ASR and Sulfate attack.

The NP converts a bad actor into a good actor, and your concrete will be inoculated from common concrete diseases, giving your customer's concrete a very long service life….

Listed Benefits of Natural Pozzolan:

1. Consistency: Natural Pozzolans are extremely consistent – load to load, batch to batch. You do not have to retest NP every load to ensure your concrete has the right amount of AE admixture.

2. Reduced Carbon Footprint: Raw NPs were calcined by Mother Nature (Magma), and Calcined NPs are heated to less than 50% of the heat required to produce clinker. Calcined NPs do not emit carbon (carbonates) upon heating like limestone does when used to produce clinker. (Almost a lb for lb (approx. 93%) reduction of carbon with raw NP and 65~70%+ reduction for Calcined NP.)

Reduction of Carbon Footprint is significant:

Typical GWP of cement: .922 mt/1 ton of Cement produced*
GWP for raw NP: < .05~.08 mt/1 ton of Raw NP produced**

There is a massive reduction in carbon footprint when cement is replaced with NP. Currently some customers are replacing up to 40% of their cement with NP and still hitting their strength requirements, reducing embodied carbon, permeability, and heat of hydration while mitigating ASR and Sulfate attack. It is a win-win-win proposition.

** PCA EPD OPC 2021*
*** Each process is slightly different*

Benefits of Natural Pozzolan (Cont'd):

3. Permeability Reduction: When used at 25% replacement levels, C1202 data shows coulomb transmissivity rates reduced to less than 1000 (versus over 3000 for a typical cement mix).

4. Control Efflorescence: When used at a 20~25% replacement rate, NPs significantly reduce or eliminate efflorescence completely.

Benefits of Natural pozzolan (Cont'd):

5. ASR: ASR in aggregates shown to expand to nearly .7% in 16 days (C1260) were mitigated down to .03% expansion in 16 days, essentially flatlining the Alkali-Silica reaction (C1567). Long-term testing shows that ASR mitigation rates are steady (correlate) whether using the rapid C1567 test (2-week test) or the C1293 (2-year test).

6. Sulfate Attack: Using the C1012 18-month test method, expansion from sulfate attack is reduced to less than .05% versus above .1% for straight TI/II cement in 18 mo. test.

Benefits of Natural pozzolan (Cont'd):

7. Reduce Heat of Hydration: The heat of hydration can be reduced up to 40% by incorporating NPs into your mix design. This is especially helpful in mass pours and/or placing concrete in hot weather.

8. **LOI**: Loss on ignition testing on an NP provides data on the amount of bound water in the material. NPs do not have carbon content to burn off like fly ash, therefore, regardless of the LOI figure, NP does not interfere with Air Entrainment (AE) in concrete. Some DOTs are placing enhanced LOI limits on both Fly Ash and NP as a preventative measure to ensure their DOT projects have no AE problems. Such restrictions on NP are based on a lack of knowledge/understanding and needlessly prevents use of NPs.

Based on these factors, and the development of niche markets, raw NPs slowly broke back into the marketplace in the 2000s, despite having a higher price tag than fly ash.

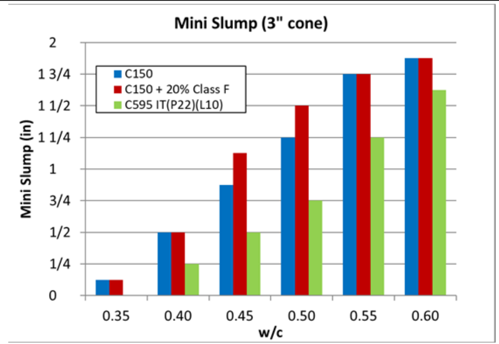
Now, with fly ash approaching the cost of cement in certain markets, NPs are competitive in price and more than competitive in performance. Thus, the conditions for a rapid increase in NP products has arrived.

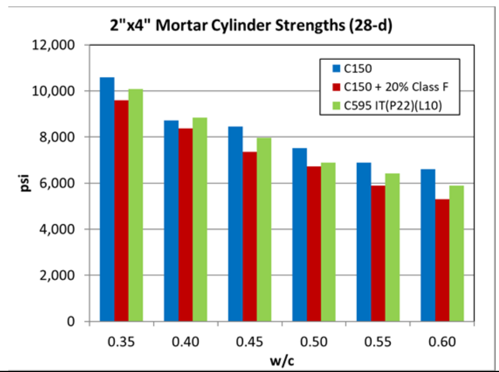
The DOTs (and Federal agencies such as FHWA, FAA, USBR, and USACE) work with cement & concrete innovators to develop and prove new technologies that are needed to meet increasingly stringent durability and sustainability requirements for the built environment.

Only after such efforts are implemented by the DOT's, etc, can ASTM/ACI modify (and codify) new standards and specifications for the new paradigm materials - NPs and other new SCMs.

These P2P innovations need to be based on science/data, rather than desperation. We believe the science is there, and now we need performance initiatives from the DOTs and others to allow square pegs to go into square holes. The data also shows this approach will only increase the performance and sustainability of concrete based public works. We stand ready to work with you to initiate this transition now, rather than in 5 years from now.

April 2020-Covid Garage mortar mixes





Lab mix plan to evaluate Natural Pozzolans and water demand

- (4) mixes per material combination w/varying w/cm ratios
  - 611 lbs of total cementitious per yard
  - Fixed 25% SCM replacement
  - Target a 4 - 5" slump with 5 - 6% total air content

	IL cement	IL cement	C595 Blended Nat. Pozzolan cement	I/II cement
	25% Class F ash	25% Nat. Pozzolan		25% Class F ash
0.37	High Range WR			High Range WR
0.40	Mid Range WR			Mid Range WR
0.43	Low Range WR	High Range WR	High Range WR	Low Range WR
0.46	No WR	Mid Range WR	Mid Range WR	No WR
0.49		Low Range WR	Low Range WR	
0.52		No WR	No WR	

Goals:
- Natural Pozzolans vs. Fly Ash (& smaller extent C150 vs. C595 IL)
- Understand the limitations of adding extra water to NP mixes
  - Can the water demand of NP's be met w/o adverse effects?
- NP's being used successfully today:
  - Can they be used more sustainably/cost effectively/etc.

Natural Pozzolan availability is expanding at an historic pace. These materials will help specifiers achieve all your desired strength and durability requirements.

If you will give us performance specifications to meet, the availability of high-performance natural pozzolans will continue to expand to fill the gaps in SCM supply, now and into the future. Please contact me for any questions or suggestions.

Joseph Thomas/info@pozzolan.org/2082522808