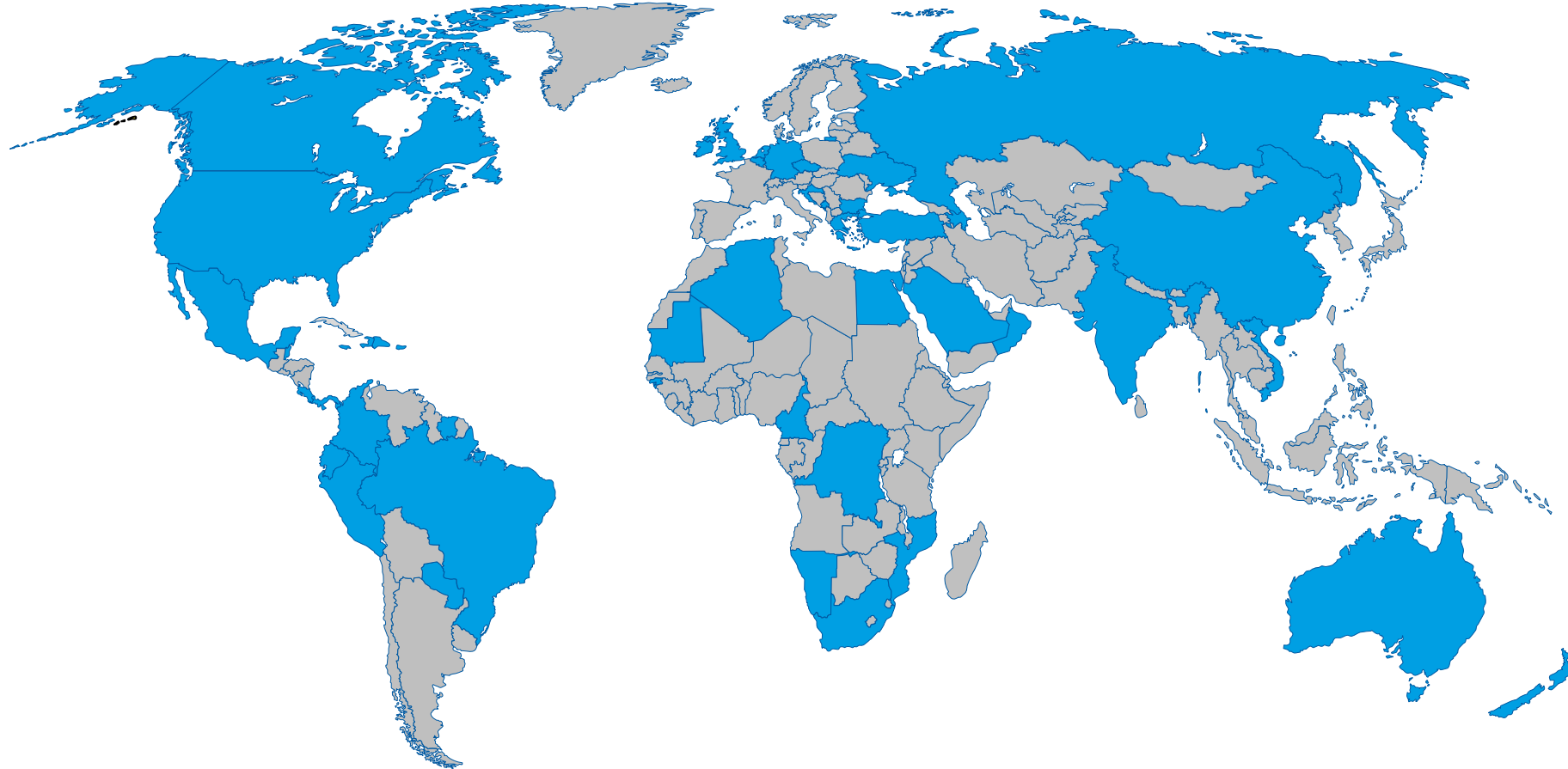


MINING REMEDIATION SOLUTIONS



POWERCEM WORLDWIDE

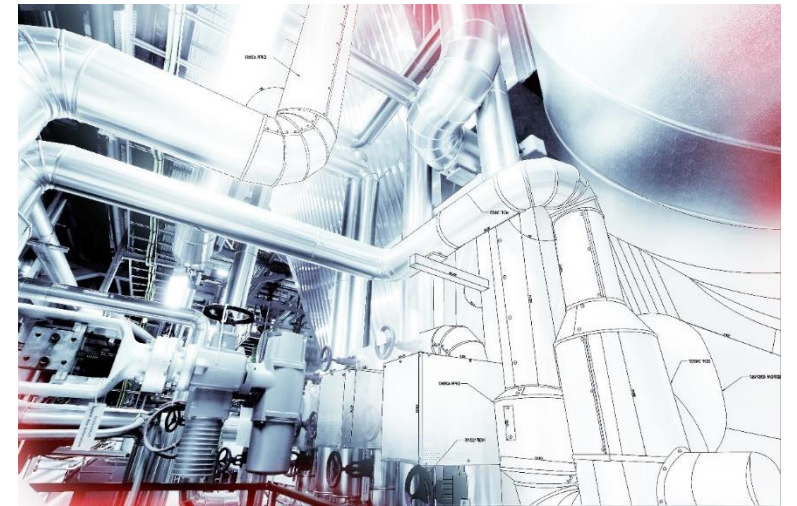
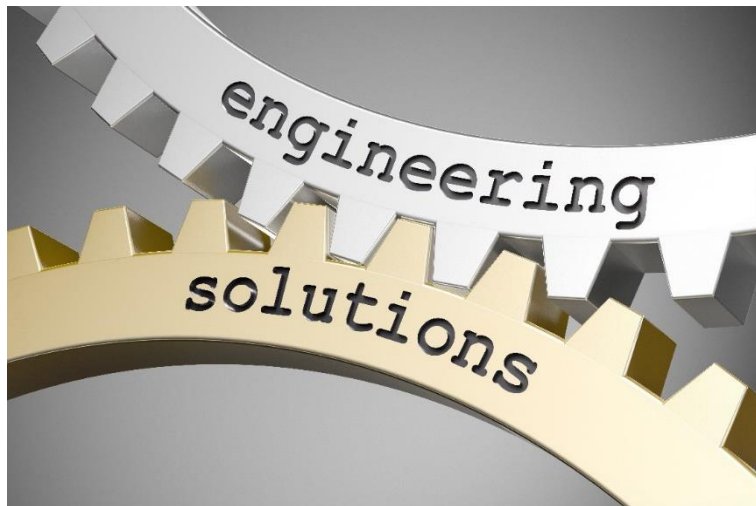


Established in The Netherlands - PowerCem has over 24 years of experience with environmental remediation projects around the world.

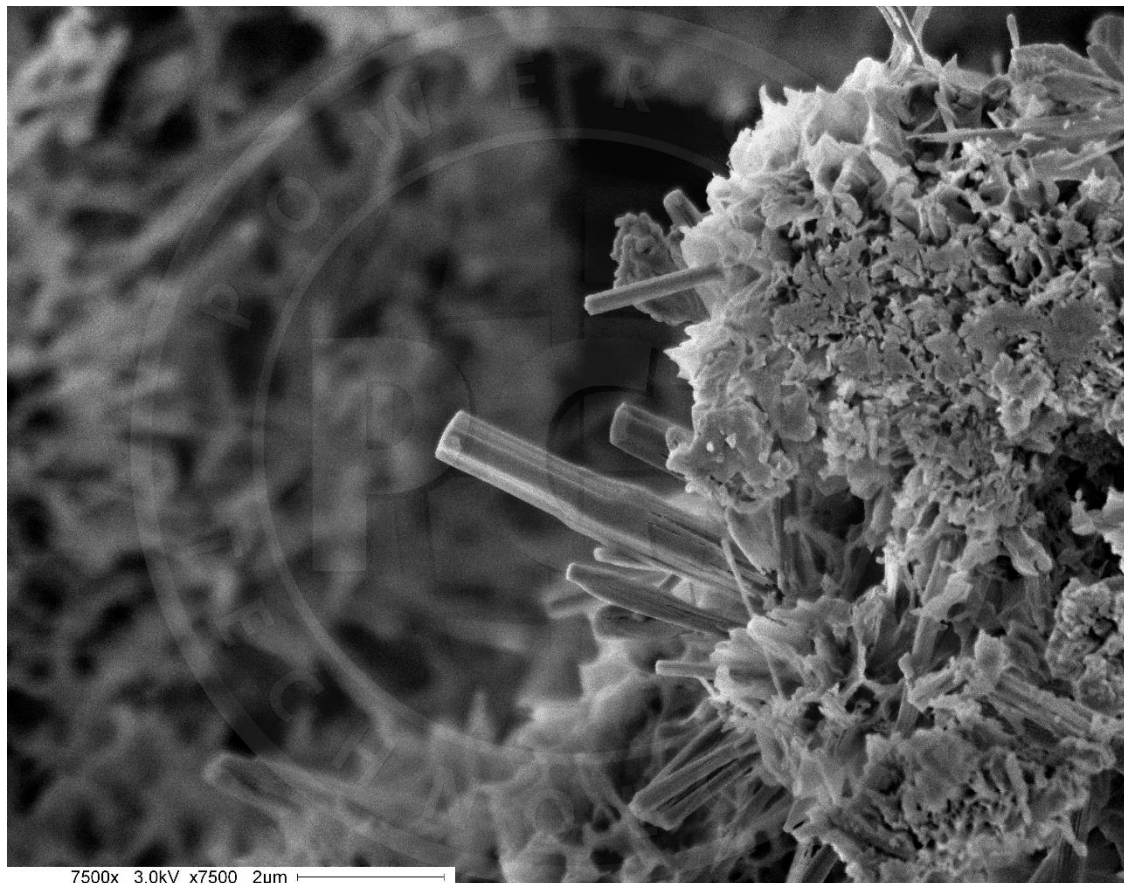
THE PRODUCT

ImmoCem®, a group of synthetic zeolites with alkali compounds and patented activators, for building complex structures and accomplish a good solidification / immobilization of the tailing and waste.

ImmoCem® contributes to the adjustment of the ion pattern in the water to a stable matrix, by building “hydrogen bridges” at the polar molecule level.



TECHNICAL SPECIFICATIONS



7500x 3.0kV x7500 2µm

TECHNICAL SPECIFICATIONS

Ratio Silice / Alumina	5.8 : 1 - 6.4 : 1
Ratio Silicio / Alumina	5.1 : 1 - 5.7 : 1
Specific Gravity	1 394 Kg / m3
Apparent Density	(817 - 961) Kg / m3
Hardness Mohs	5,1
Pore Diameter	4.0 x 4.6 Angstrom
Surface	43.8 m2 / gr
Alkaline Stability	7.0 -13.0 pH
Acid Stability	1.0 - 7.0 pH
Thermal Stability	700 °C
Shear Strength	176 kg / cm2

APPLICATIONS



ZEOLITIC TAILINGS



CEMENTED BACKFILL



BACKFILL PASTE



MORTAR



SHOTCRETE



HYDRAULIC BACKFILL

APPLICATIONS



**Metallurgy and
Manufacturing**

Oil Industry

**Contaminated
Soils**

**Chemical
Industry**

Mining Industry

USAGE

The process of using ImmoCem has four simple steps :

- Step 1:** Split the dangerous waste that you want to neutralize from the needed minerals.
- Step 2:** Add cement and ImmoCem. This mix is named Zeolite Concrete which immobilizes the dangerous waste inside the nanostructure.
- Step 3:** Perform mechanical resistance and leaching tests to determine that the compound is stable.
- Step 4:** Reuse the tailings as a safe construction material by forming a Zeolite Concrete that can have a compressive strength of 0.1 to 50 MPa.

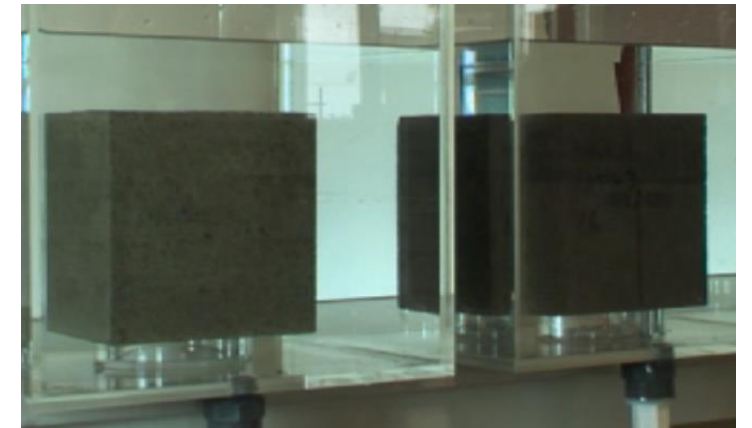
BENEFITS

- Reduce the use of construction materials - sand, stone, cement - and reuse 100% of tailings strengthened with ImmoCem®.
- Increase the capacity of tailings dams, by reusing this material for different construction applications, reducing the CAPEX of mining operations.
- Reduce acid water formation and waste generated by encapsulating and immobilizing pollutants.
- Increase the resistance of the tailings, reducing the risk of spills.



BENEFITS

1. Decontamination
2. High resistance to compression
3. Reuse of contaminated waste
4. Cost Saving





PowerCem Technologies BV
Mr. C. Egyed-
Plaza 24
4782 SK MOERDIJK


Subject:
PowerCem Technologies proven Green Technology

Dear Mr. Egyed,

PowerCem Technologies is a technology that makes it possible to create a more ecological economical and durable technology. In this certification the focus is on the greener solution for infrastructure works when using one of the nan based products of PowerCem Technologies.

PowerCem Technologies is used to make building materials of in-situ soils and or either contaminated soils. In Road Engineering normally a lot of primary and secondary materials need to be transported on a site, and in weak areas a lot of soil needs to be removed. By working with RoadCem a product of PowerCem Technologies it is possible to establish a hard, flexural bounded material with all types of material even peat and clay. In the appendix of this mail a project example is submitted. In that project the peat was bounded to an impermeable, pH neutral stabilization. Due to the fact that the pH is neutral, after the lifetime of the bounded material, what can be more than 100 years it can be left after it has been crushed in the environment.

Also contaminated soils can be transformed in a product were the contamination will not leach out anymore above maximum values that are acceptable. With the product ImmoCem a large number of contaminations sites were transformed from a hazardous location to a green area what is used for further development. With ImmoCem it is possible to immobilize all type of contaminations. In the appendix of this certificate, several projects are prescribed. **With contaminated materials treated with ImmoCem the contaminations will be kept permanently inside the material for more than 100 years.** The alternative was to excavate and remove the contaminated material to another site or burn the contamination. By using ImmoCem this product based on the PowerCem Technology prevents these environmental harmful measurements, with high CO2 amounts, in a sophisticated greener technology.

Kind regards,
ARCADIS Nederland BV

ing. E. Vlieland

Imagine the result

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The Netherlands
Tel +31 10 2532 222
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ENVIRONMENT DIVISION

's-Hertogenbosch,
21 September 2012

Contact:
ing. E. Vlieland

Direct line:
+31 650736841

E-mail:
cster.vlieland@arcadis.nl

Our ref.:
076629437:0.1

Project number:
B02013.000212.0100



Dutch Trade Register
9036504

CERTIFICATE

- ✓ Help the environment
- ✓ Duration of more than 100 years

METAL ANALYSIS IN TAILINGS IMMOCEM

TAILING SAMPLE ANALYSIS TREATMENT: WITH AND WITHOUT IMMOCEM				ECA: ENVIRONMENTAL QUALITY STANDARDS FOR SOILS		
TOTAL METAL PARAMETER	TAILING SAMPLE (mg/L)	WITH IMMOCEM 0.5 kg/m ³ (mg/L)	WITH IMMOCEM 0.7 Kg/m ³ (mg/L)	INDUSTRIAL, EXTRACTIVE COMMERCIAL SOIL (mg/L)	TESTING METHOD	
1	Arsenic (As)	380	<0.001	<0.001	140	EPA 3050 EPA 3051
2	Barium (Ba)	31.50	<0.19	<0.19	2,000	EPA 3050 EPA 3051
3	Cadmium (Cd)	4.69	0.016	0.005	22	EPA 3050 EPA 3051
4	Copper (Cu)	188.50	0.073	0.072	1,000	EPA 3050 EPA 3051
5	Chromium (Cr)	7.50	<0.011	<0.011	1.4	EPA 3060 / EPA 7199 o DIN EN 15192
6	Mercury (Hg)	0.31	0.0008	0.0005	24	EPA 6020 o 200.8
7	Lead (Pb)	871.4	0.854	0.346	800	EPA 3050 EPA 3051
8	Selenium (Se)	<0.02	0.012	0.009		
9	Zinc (Zn)	1403	0.859	0.726		

METAL ANALYSIS IN TAILINGS IMMOCEM

**TAILING SAMPLE ANALYSIS TREATMENT:
WITH AND WITHOUT IMMOCEM**

**ECA: ENVIRONMENTAL QUALITY
STANDARDS FOR SOILS**

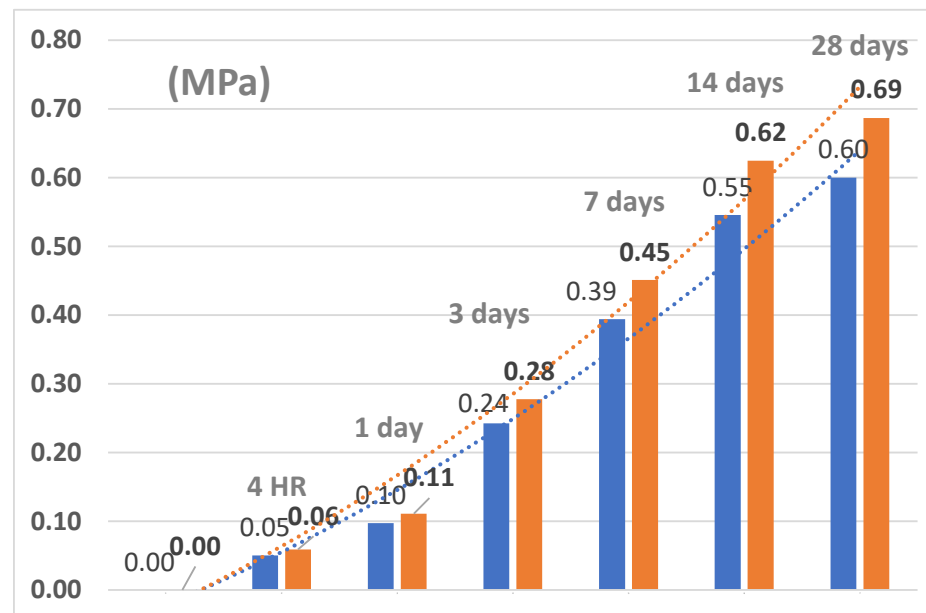
	TOTAL METAL PARAMETER	TAILING EXAMPLE (mg/L)	WITH IMMOCEM 0.7 kg/m ³ (mg/L)	INDUSTRIAL, EXTRACTIVE COMMERCIAL SOIL (mg/L)	TESTING METHOD
1	Arsenic (As)	217.69	113.51	140	EPA 3050 EPA 3051
2	Barium (Ba)	10.90	7.20	2,000	EPA 3050 EPA 3051
3	Cadmium (Cd)	8.18	5.18	22	EPA 3050 EPA 3051
4	Copper (Cu)	597.20	196.30	1,000	EPA 3050 EPA 3051
5	Chromium (Cr)	0.70	0.50	1.4	EPA 3060 / EPA 7199 o DIN EN 15192
6	Mercury (Hg)	0.19	0.12	24	EPA 6020 o 200.8
7	Lead (Pb)	365	78.40	800	EPA 3050 EPA 3051
8	Selenium (Se)	<0.02	<0.02		
9	Zinc (Zn)	1,356	348		

CEMENTED BACKFILL

	DESCRIPTION	UNID.	PATTERN	FIRST TEST	SECOND TEST	THIRD TEST
1	Water	Lt.	270	304.8	640.0	305.8
2	Tailing	Kg.	-	1,574.4	1,945.0	1,564.8
3	Sand	Kg.	570			
4	Stone 2", 3"	Kg.	1,300			
5	144 Cement type	Kg.	-		40.0	
6	Cement APU 36	Kg.	50	30.0		40.0
7	IMMOCEM	Kg.		0.5	0.5	0.5
8	Tailing Information					
9	Mest 200	%		92.3	92.3	92.3
10	Total water content	%		30.4		
11	Relations					
12	Water/Cement	Lt/Kg		10.2	16.0	7.6
13	Resistance Results					
14	Day 03	MPa		0.1	0.325	0.2
15	Day 07	MPa		0.3	0.674	0.4
16	Day 14	MPa		0.4		0.6
17	Day 28	MPa	0.6	0.6	0.7	0.7

COMPARATIVE OF CEMENTED BACKFILL (0.6-2.0) MPa

- **Standard Design**
- **Design with IMMOCEM**



OBSERVATIONS:

1. The tests were performed with 100% Tailings (91% M-200 - 61% solids).
2. It is reduced in cement by more than 25% (more than \$ 6.0 / m³). Cement can be further reduced according to customer requirement.
3. If the aggregate is replaced by 100% Tailings, the cost is reduced between 5.00 - 15.00 USD / m³.
4. If cyanide tailings are used, 100% encapsulation can be performed with IMMOCEM.

RESISTANT TESTS AT 106 DAYS

Compression Resistance	28 Days	106 Days	Method
40 kg/m ³ Cement 500 g/m ³ IMMOCEM 30-04-2019	0.67 MPa	0.76 MPa	ASTM C 109

Source: Quality Control Laboratory Union de Concreteras S.A, Lima Peru

IMMOCEM & CONCRECEM – SHOTCRETE APPLICATIONS



- ✓ ConcreCem modified shotcrete application by use of primary and secondary aggregates.
- ✓ ImmoCem to make a holistic circular shotcrete application possible by use of tailing residues replacing valuable aggregates and saving cement binder
- ✓ High economic advantage for mining companies/operations



SHOTCRETE 28 MPa

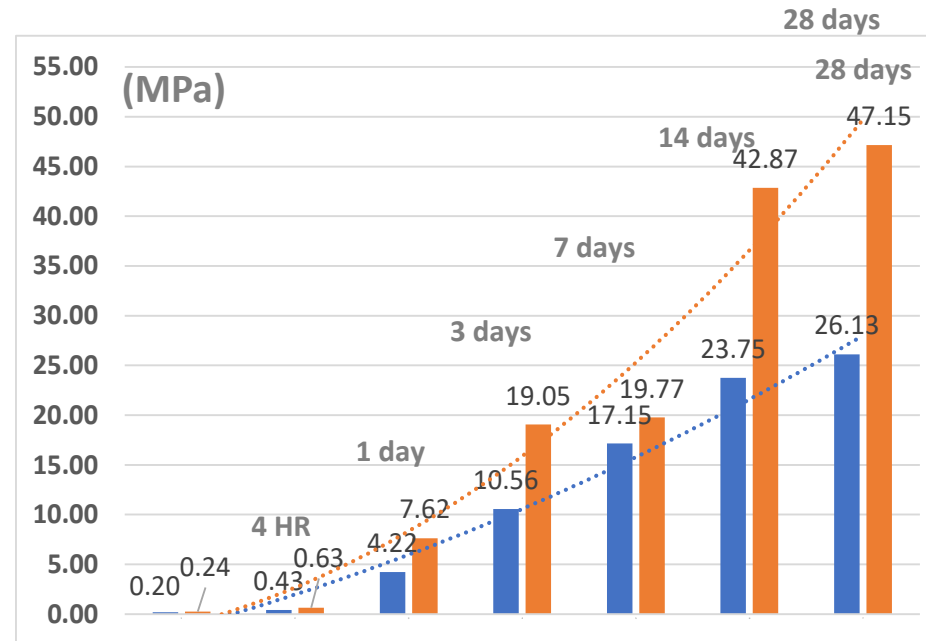
	DESCRIPTION	UNID	PATTERN	FIRST TEST	SECOND TEST
1	Water	Lt.	191	195	195
2	Tailing	kg.	-	-	
3	Sand	kg.	1,553	1,137	1,612
4	Pebble Stone	kg.	172	660	181
5	I 52.5 N Cement Type	kg.	425	320	320
6	CONCRECEM	kg.	-	1	1
7	Accelerator	kg.	18	16	16
8	Metallic fiber	kg.	20	20	20
9	Relations				
10	Water/Cement	Lt/Kg	0.45	0.61	0.61
11	Resistance Results				
12	4 hours	MPa	0.91	1.05	1.17
13	24 hours	MPa	9.05	9.16	10.87
14	7 days	MPa	23.11	26.83	24.08
15	28 days	MPa	28.90	32.90	28.20

SHOTCRETE 35 MPa

	Design Code	Pattern	M-1	M-2	M-3	M-4
1	Cement Type I (Kg)	410.0	320.0	320.0	340.0	350.0
2	Dry Water Design (Lt)	185.0	185.0	145.0	185.0	200.0
3	Granulation Sand 02 (Kg)	1500	1560	1610	1510	1005
4	Mining Tailing (Kg)					530
5	Hydration controller (Lt)	1.69	1.32	1.96	1.40	2.50
6	Super plasticizer (Lt)	5.64	4.40	6.00	4.68	7.26
7	Super Accelerator (Lt)	23.20	18.10	18.10	19.20	19.78
8	Synthetic fiber (Kg)	4.0	4.0	4.0	4.0	4.0
9	ConcreCem (Kg)		1.0	1.0	1.0	
10	ImmoCem (Kg)					1.0
11	Sand/Tailing Incidence	100%	100%	100%	100%	70% - 30%
12	R water/cement	0.451	0.578	0.453	0.544	0.571
13	Hardened state at plant					
14	Early Temperature Test Resistance (MPa) 1.5 Hrs.	1.05	0.34	1.07	0.95	0.95
15	Age	Resis.Average. MPa	Resis.Average. MPa	Resis.Average. MPa	Resis.Average. MPa	Resis.Average. MPa
16	1 Day	8.7	3.5	4.8	6.5	6.8
17	3 Days	30.7	27.2	19.6	28.7	22.5
18	7 Days	39.5	34.2	34.9	32.1	35.2
19	28 Days	42.0	37.7	40.4	46.7	41.6

COMPARATIVE OF SHOTCRETE (25-45) MPa

- Standard Design
- Design with IMMOCEM



OBSERVATIONS:

1. The use of IMMOCEM increases the resistance above the standard.
2. It is reduced in cement by more than 25% (more than \$ 6.0 / m³). Cement can be further reduced according to customer requirement.
3. With 50% of tailings than the original design, it reduces the cost between 2.50 - 12.50 USD / m³.
4. 100% of the materials from the tailings can be used.

MORTAR 21 MPa

	Test Place	PLANT			
	Design Code	Pattern	M-5		
1	Cement Type I (kg)	290.0		290.0	
2	Dry Water Design (lt)	205.0		215.0	
3	Granulation Sand 02 (kg)	1,550		1,065	
4	Mining Tailing (kg)			560	
5	Super plasticizer (lt)	2.32		4.93	
6	ImmoCem (kg)			1.0	
7	Sand/Tailing Incidence	100%		70% - 30%	
8	R water/cement	0.707		0.741	
9	Hardened state at plant				
10	Age	Resis.Average. Mpa	Resist. %	Resis.Average. Mpa	Resist. %
11	1 Day	5.5	26%	6.8	32%
12	3 Days	12.5	60%	22.8	109%
13	7 Days	17.8	85%	24.4	116%
14	28 Days	22.5	107%	31.4	150%

NEXA RESOURCES

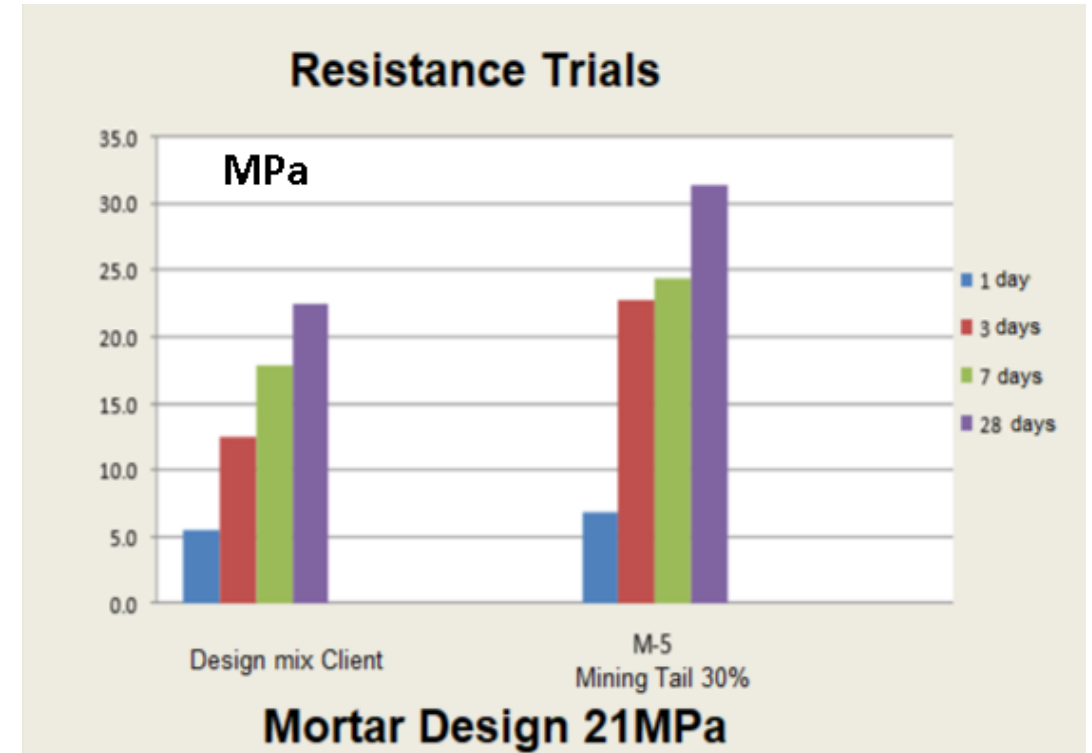
Tailing reuse:

The nanotechnology of PowerCem Technologies B.V., was used to make a laboratory tests with tailings.

The laboratory tests were carried out for Shotcrete, Backfill Paste and Mortar (For buildings, accesses, etc.)

ImmoCem encapsulate contaminated tailings.

We can achieve the UCS shear strength, necessary for customer requirements. In this case the molds used were 4'' x 8''



MINSUR MINE-RAURA

Tailing reuse:

Pilot field projects were carried out in the hydraulic backfill plant, by using ImmoCem. It was possible to increase the pumping of tailings from 55% solid to 65%, maintaining the flow and discharge pressure of the pump at normal conditions.

The use of ImmoCem reduces the viscosity of the tailings, improving the performance of the pumping system with a higher percentage of solids in the tailings.



CALCULATION OF INCREASE FLOW OF TAILINGS UNDERGROUND OF THE MINE(HYDRO PIT)

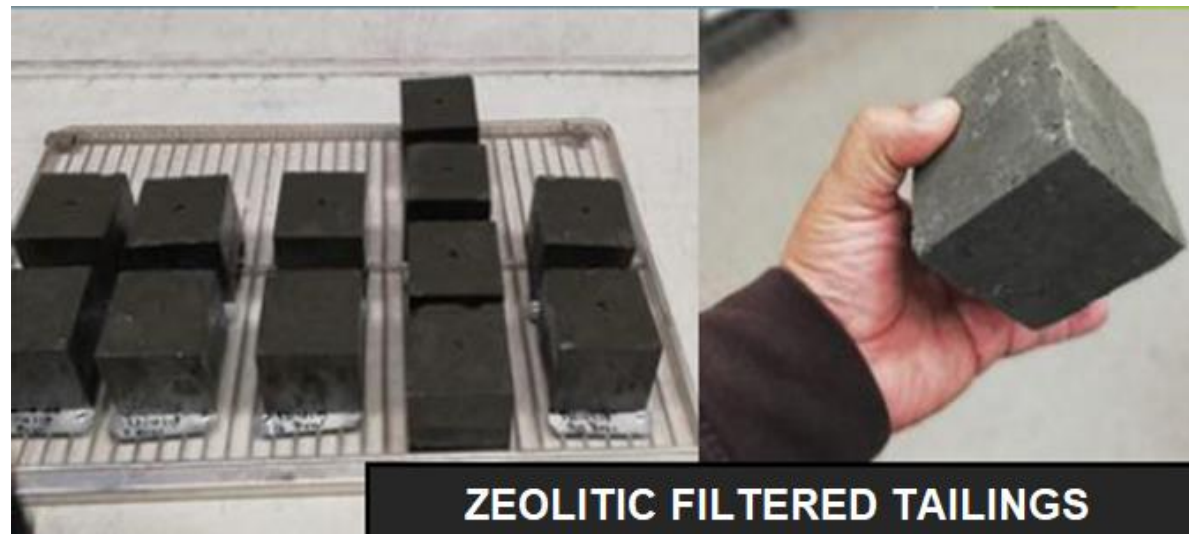
MARS PUMP (PUMP)			(U/F) CYCLONE TAILINGS			
CONDITION OPERATIONAL	FLOW (M3/HR)	PRESSURE (BAR)	DENSITY (GR/L)	SOLIDS (%)	TAILINGS (TMS/HR)	TAILING: (TMS/DIA)
ACTUAL	80.00	32.00	1 600.00	55.00	70.40	1 689.60
CON IMMOCEM	80.00	32.00	1 800.00	65.00	93.60	2 246.40
INCREASE OF MASS FLOW					23.20	556.80

ZEOLITIC FILTERED TAILINGS, RESISTANCE: 0.5 MPa

ALS Metallurgy-PERTH-Australia Laboratory

The disposal of filtered tailings (Dry Stacking) is a method of high-water recovery, reduced storage space, high slope and innovative, but it is limited by the high rainfall rates in the area of influence.

To eliminate the impact of possible tailings washing by precipitation, ImmoCem generates high resistance, impermeability, encapsulation and high solidification, guaranteeing safety and stability of the Dry Stacking.



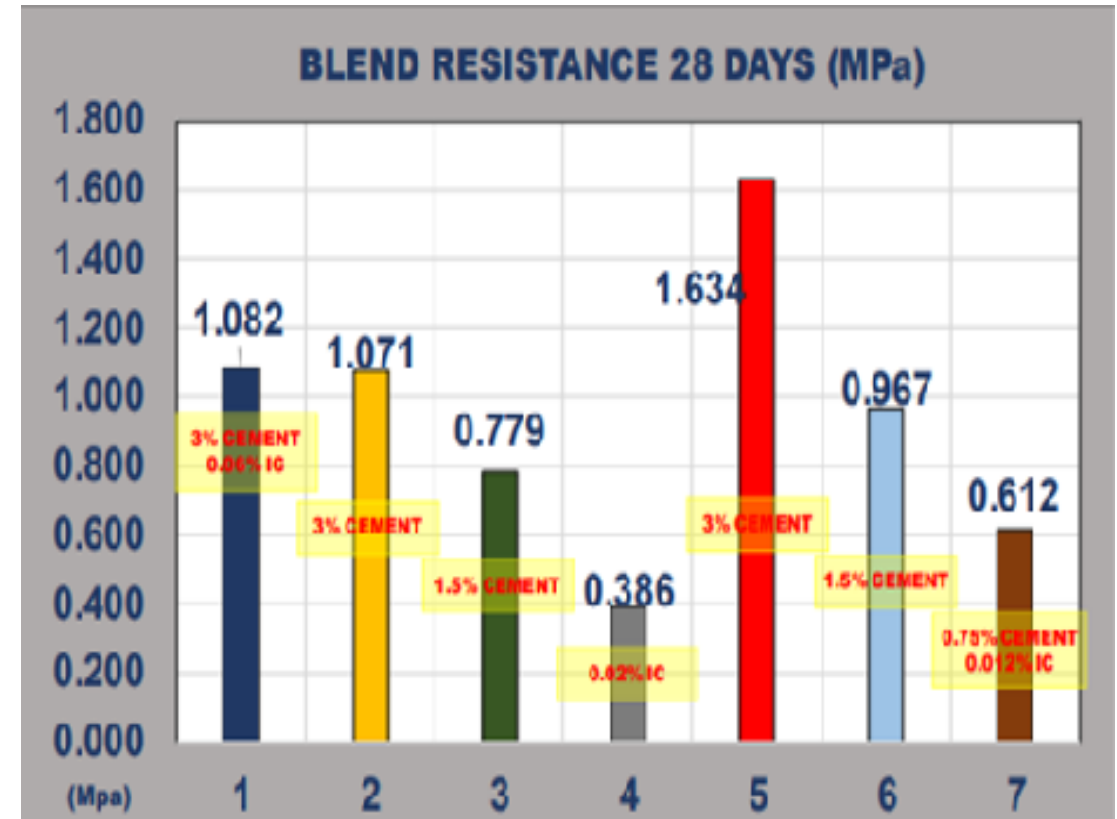
ZEOLITIC FILTERED TAILINGS, RESISTANCE: 0.5 MPa

TEST	MATERIALS USED			RESISTANCE MEASUREMENT (MPa)						
N°	TYPE OF TAILINGS	CEMENT (% W/W)	IMMOCEM (% W/W)	3 Days	7 Days	14 Days	28 Days (average)	SUCTION 28 DAYS (Mpa)	Water Content	
1	BULK COMPOSITE ROUGHER TAILS	3.00	0.06	0.809	0.994	1.380	1.082	0.365	13.200	
2		3.00	0.00	0.782	0.780	0.742	1.071	0.545	13.600	
3		1.50	0.00		0.606	0.731	0.779	0.820	9.500	
4				0.02		0.323	0.228	0.386	0.410	9.300
5		3.00	0.00			1.286		1.634	0.670	11.200
6		1.50	0.00			0.851		0.967	0.680	10.900
7		0.75	0.012		0.664	0.964	0.702	0.612	0.750	7.700

ZEOLITIC FILTERED TAILINGS, RESISTANCE: 0.5 MPa

Conclusion :

- Blend: Increase Cohesion (Kg/cm²) UCS resistance and suction at 28 days
- Design 4: 0.02% of ImmoCem (w/w), UCS equal to 0.386 MPa and suction of 0.410 MPa
- Design 7: 0.75% of Cement (w/w) and 0.012% of ImmoCem (w/w), UCS equal to 0.612 MPa and suction of 0.750 MPa
- ImmoCem acts as an absorbent, flocculant, catalyst, molecular sieve, neutralizer and ion exchanger, which makes them more versatile to use in tailings
- ImmoCem increases the cohesion of Blend tailings, obtaining better results when these tailings are compacted



ANNUAL REDUCTION OF CEMENT AND CO₂ EMISSIONS IN TWO MINES

			Gold Mine	Zinc Mine
1	Backfill Paste Production	m ³ /Year	460,800	1,382,400
2	Distance Origin to Mine	km	914	261
3	Driving to Mine	Hours	24	8
4	Altitude	masl	4,700	1,800
5	Cement Saving	TPY	37,960	113,880
6	Trucks Reduction	VPY	1,265	3,796
7	CO ₂ Emmision Reduction	TPY	42,858	101,804
8	Carbon Bonds	US\$/Year	847,207	2,012,423



- ✓ Less Trucks
- ✓ Less Community Issues
- ✓ Less Dust Emissions
- ✓ Safer Traffic
- ✓ Less Risk of Accidents
- ✓ Longer Infrastructure Life Time
- ✓ Less Road Maintenance

ESTIMATED CO₂ EMISSION IN PERUVIAN MINES

- 92 Active Big and Medium Mines
- 6.37 MM TPY of CO₂ Reductions
- 126 MM of US\$ a year for Carbon Bonds



Toxicity in humans

Brain and nervous system:

Lead, carbon monoxide, mercury, pesticides.

Eyes:

Ultraviolet light, noxious gases.

Oral Cavity:

Lead, mercury.

Heart and Circulatory system:

Carbon monoxide, nitrates (in infants), pesticides, nitrogen dioxide.

Liver:

Chlorinated hydrocarbons, selenium.

Digestive System:

Lead, arsenic, fluoride, pesticides.

Fetus:

Mercury, lead, radioactive materials, pesticides.



Longs and Respiratory System:

Cobalt, asbestos, sulphur oxides, ozone, nitrogen oxides, ammonia, carbon monoxide, cadmium, cigarette smoke, pesticides, animal and vegetal dusts.

Skin:

Arsenic, nickel, chromium, beryllium, pesticides.

Bones:

Lead, strontium 90, cadmium.

Cancer-causing substances:

Chlorinated hydrocarbons, mercury, polycyclic aromatic hydrocarbons, radioactive materials, pesticides.

Kidneys:

Mercury, cadmium, lead.

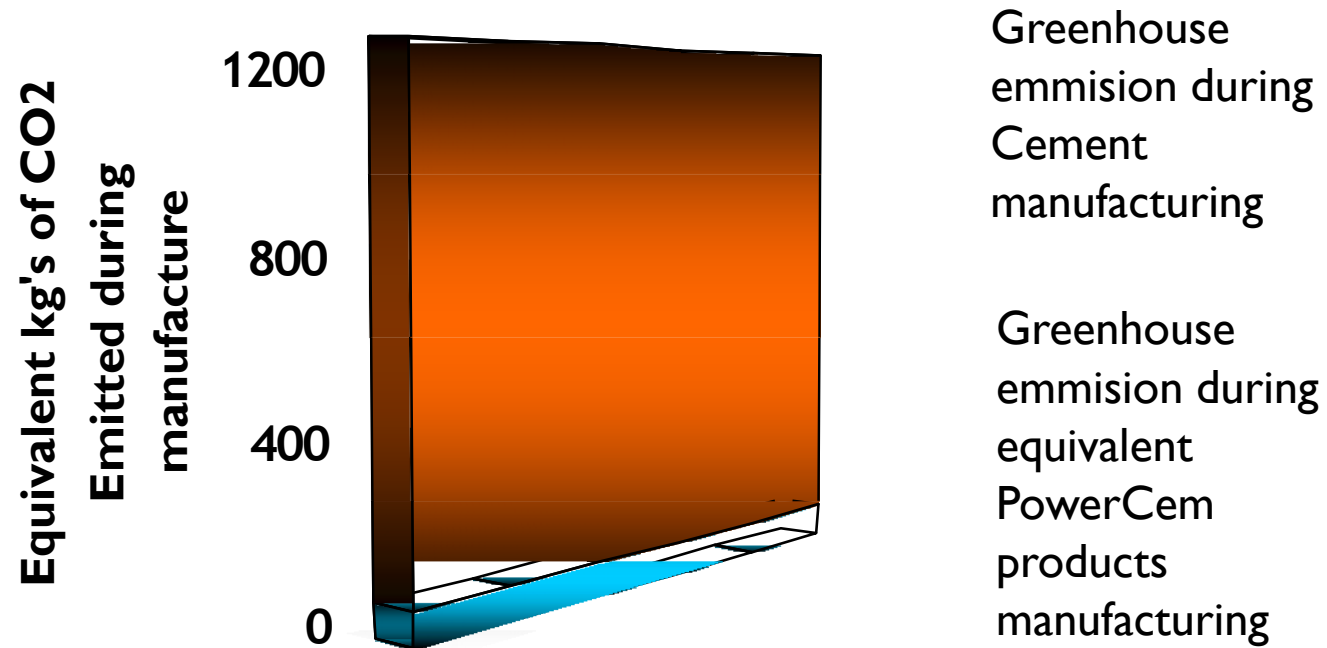
CARBON DIOXIDE EMISSION COMPARISON

Every ton of manufactured cement represents 5.1 Giga-Joules of energy consumed, equating to 1200kg of CO₂ pumped into the atmosphere.

The use of PowerCem products enables the reduction of CO₂ equivalent emissions in global cement.



CARBON DIOXIDE EMISSION COMPARISON



ZEOLITIC TAILINGS & SLOPE FORMATIONS WITH HIGH DISPLACEMENT RESISTANCE

DISPLACEMENT RESISTANCE			
No	Process	Yield Stress (kPa)	Comparative Cost
1	Zeolitic Tailing	(5 - 50)	Low OPEX & CAPEX
2	Filtered Tailing	(0.80 - 1.50)	High OPEX & CAPEX
3	Tailing Paste	(0.20 - 0.50)	High OPEX & CAPEX
4	Thickened Tailing	(0.05 - 0.20)	Standard Cost OPEX & CAPEX

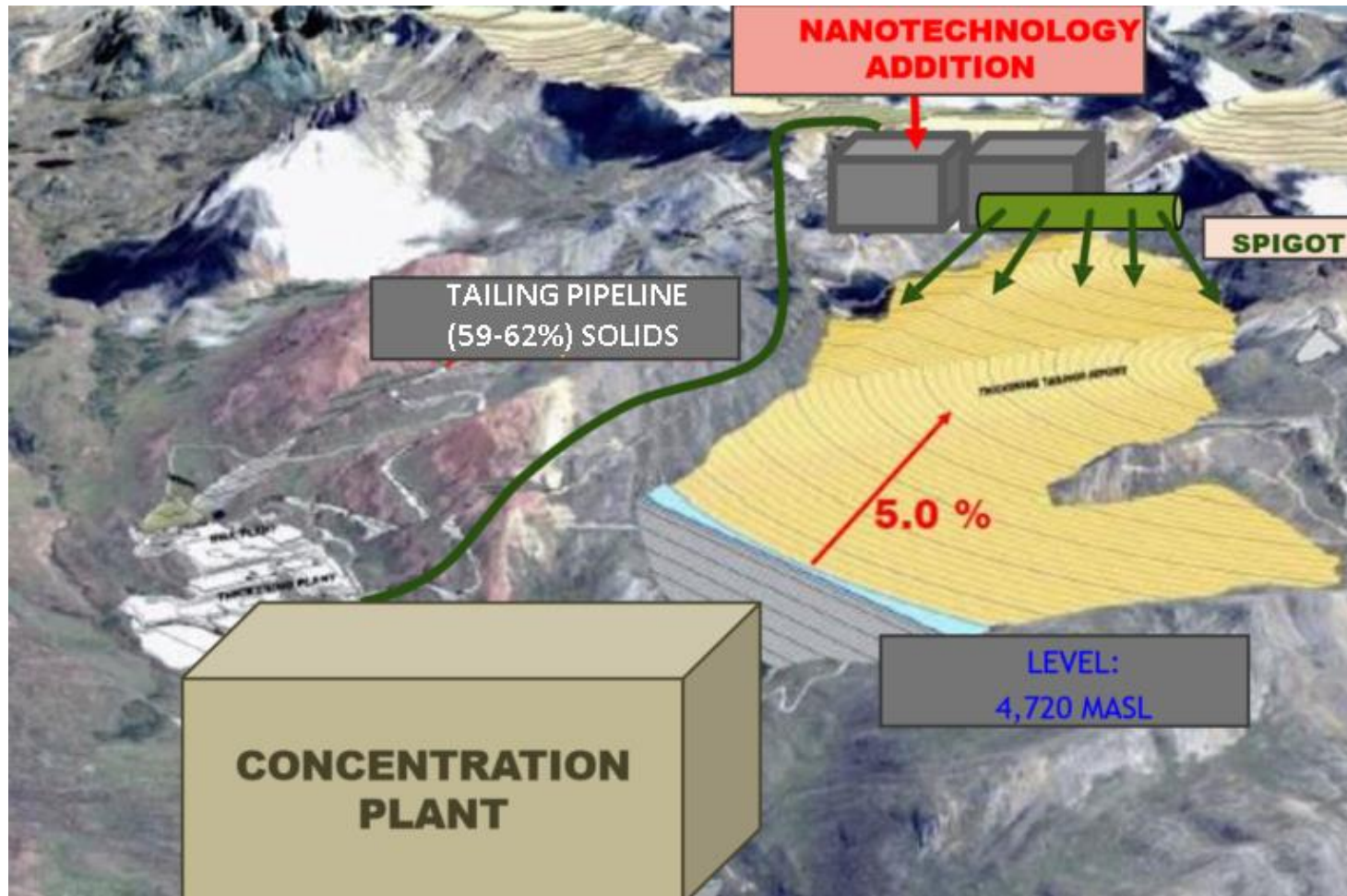


TAILING MANAGEMENT WITH IMMOCEM

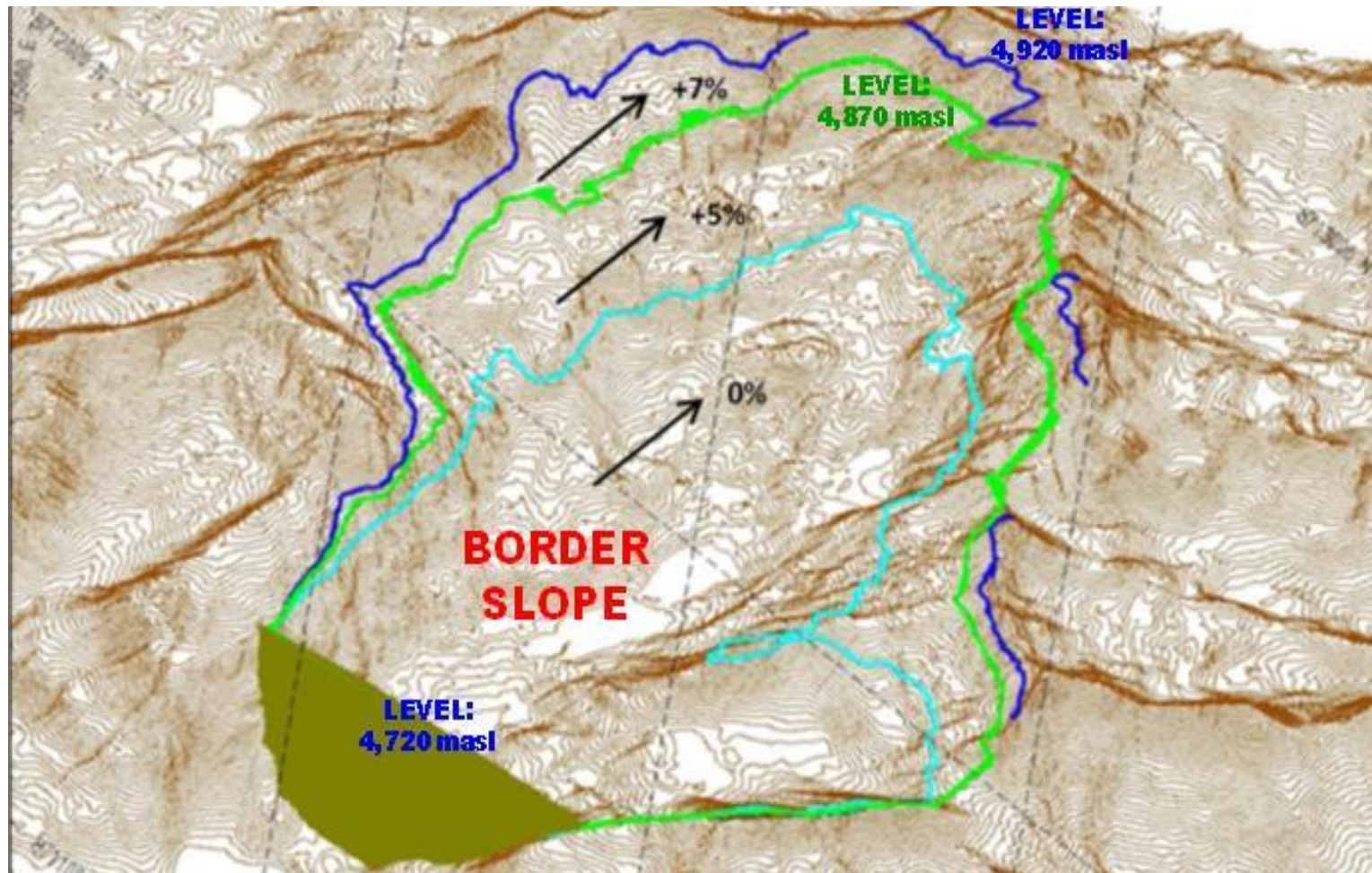
ON SITE :

- Increase the Yield Stress of the Tailing, using Nanotechnology.
- Reduce the mechanical energy of the tailing before disposal
- Tailings Disposal Design with Spigot System
- Slope formation of the Tailing in a laminar form, layer upon layer.
- Tailings Disposal Plan, forming a high Slope, maximizing the recovery of clarified water.
- Solidification, Immobilization and Encapsulation of the Tailings.

TAILING DISCHARGE PLAN WITH NANOTECHNOLOGY (SLOPE: 5%)



IMMOCEM: INCREASES THE CAPACITY OF THE TAILING DAMS BY THE SLOPE

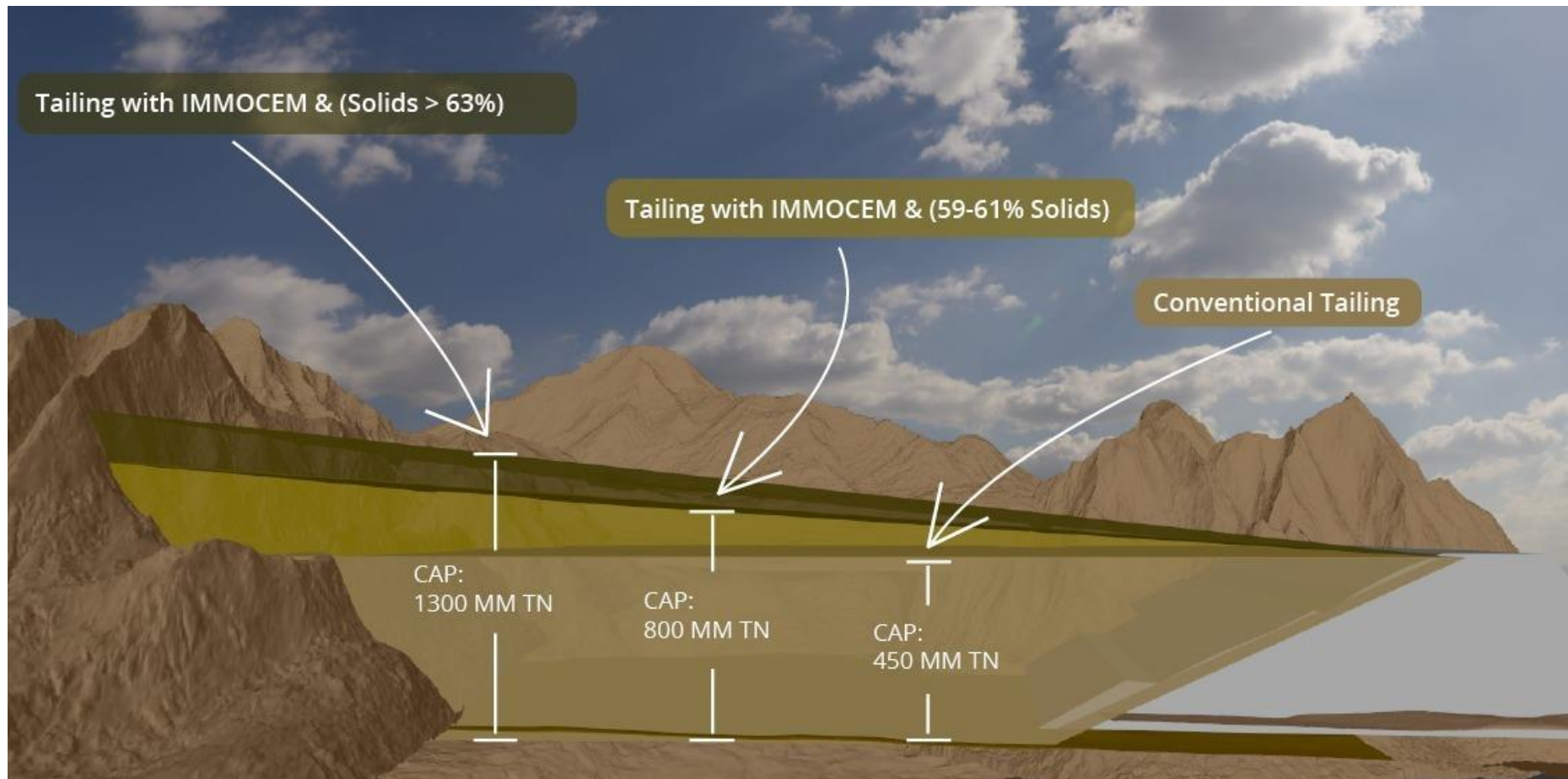


**Tailing with
IMMOCEM
(Solids > 63%)
CAP: 1,300 MM TN**

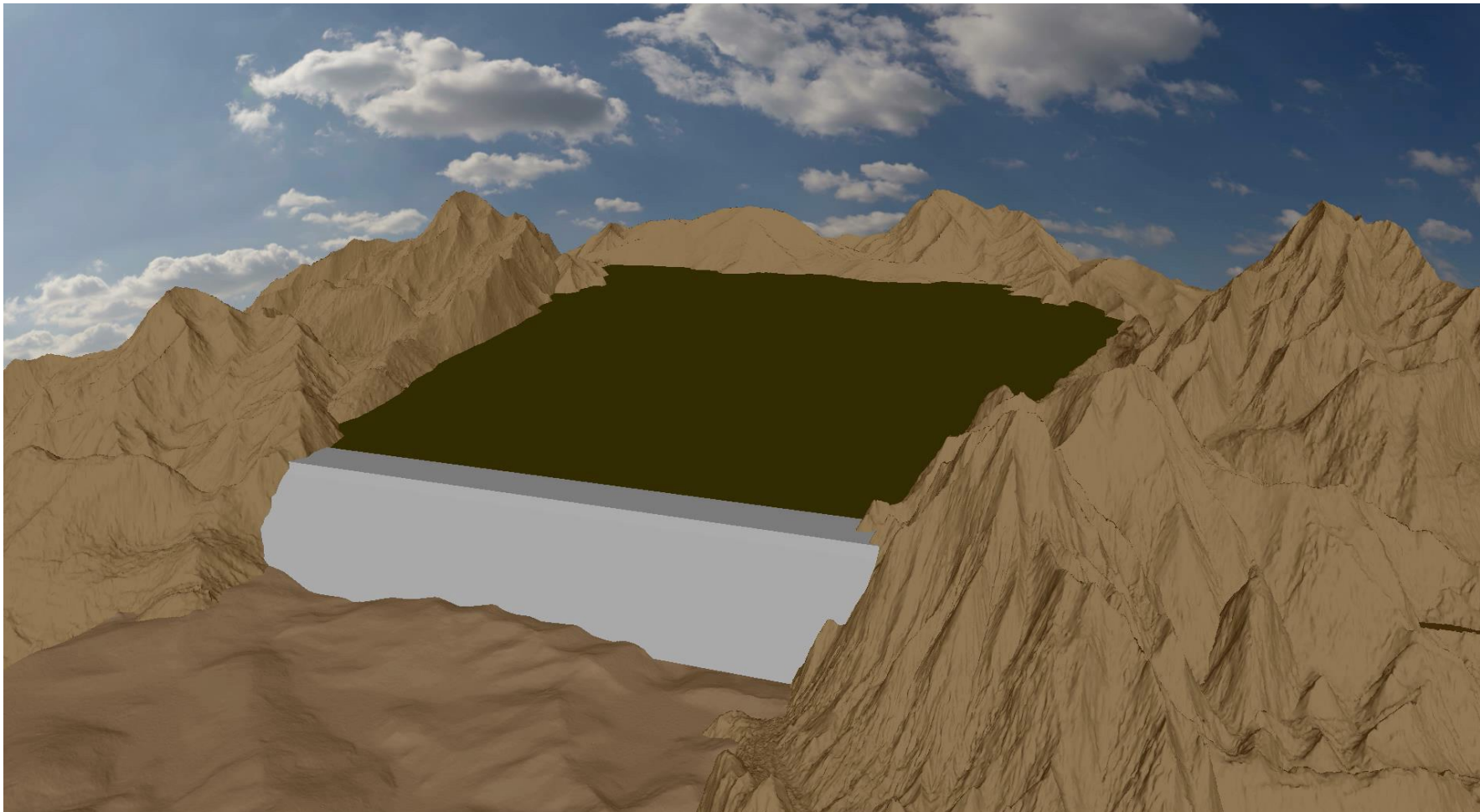
**Tailing with
IMMOCEM (59-61%
Solids)
CAP: 800 MM TN**

**Conventional
Tailing:
CAP: 450 MM TN**

IMMOCEM: INCREASES THE CAPACITY OF THE TAILING DAMS BY THE SLOPE



IMMOCEM: INCREASES THE CAPACITY OF THE TAILING DAMS BY THE SLOPE



DISASTER IN MINERA VALE-BRASIL TAILING DAM OF BRUMADINHO, COLLAPSE: 25/01/19 COMPACTED TAILING VS ZEOLITIC TAILING

Compacted Tailing (Conventional Procedures):

1. Tailings dam closed 3 years before the disaster.
2. Tailings treated with flocculants, coagulants and other rheology modifiers
3. Phyto stabilized and covered with farmland.
4. The saturation by rainwater and runoff was NOT considered.
5. Inspection in Jun-2018 and Sep-2018
6. 13 million m³ of Tailings discharged, Post Collapse.
7. 332 missing persons.
8. USD 7M allocated for damage repair

Zeolitic Tailings:

1. No pore saturation
2. High resistance of sedimentary tailings
3. Rains and runoff do not affect stability

THANK YOU FOR YOUR ATTENTION



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