MINING REMEDIATION SOLUTIONS

PowerCem Technologies
Innovations for better solutions!

POWERCEM PRODUCTS

OUR PARTNERS

Geochem
Cutting-Edge Geochemistry

Rijksdienst voor Ondernemend Nederland

Radboud Universiteit Nijmegen

TU Delft
Technische Universiteit Delft

UNESCO

KTH VETENSKAP OCH KONST
ROYAL INSTITUTE OF TECHNOLOGY

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ABOUT POWERCEM

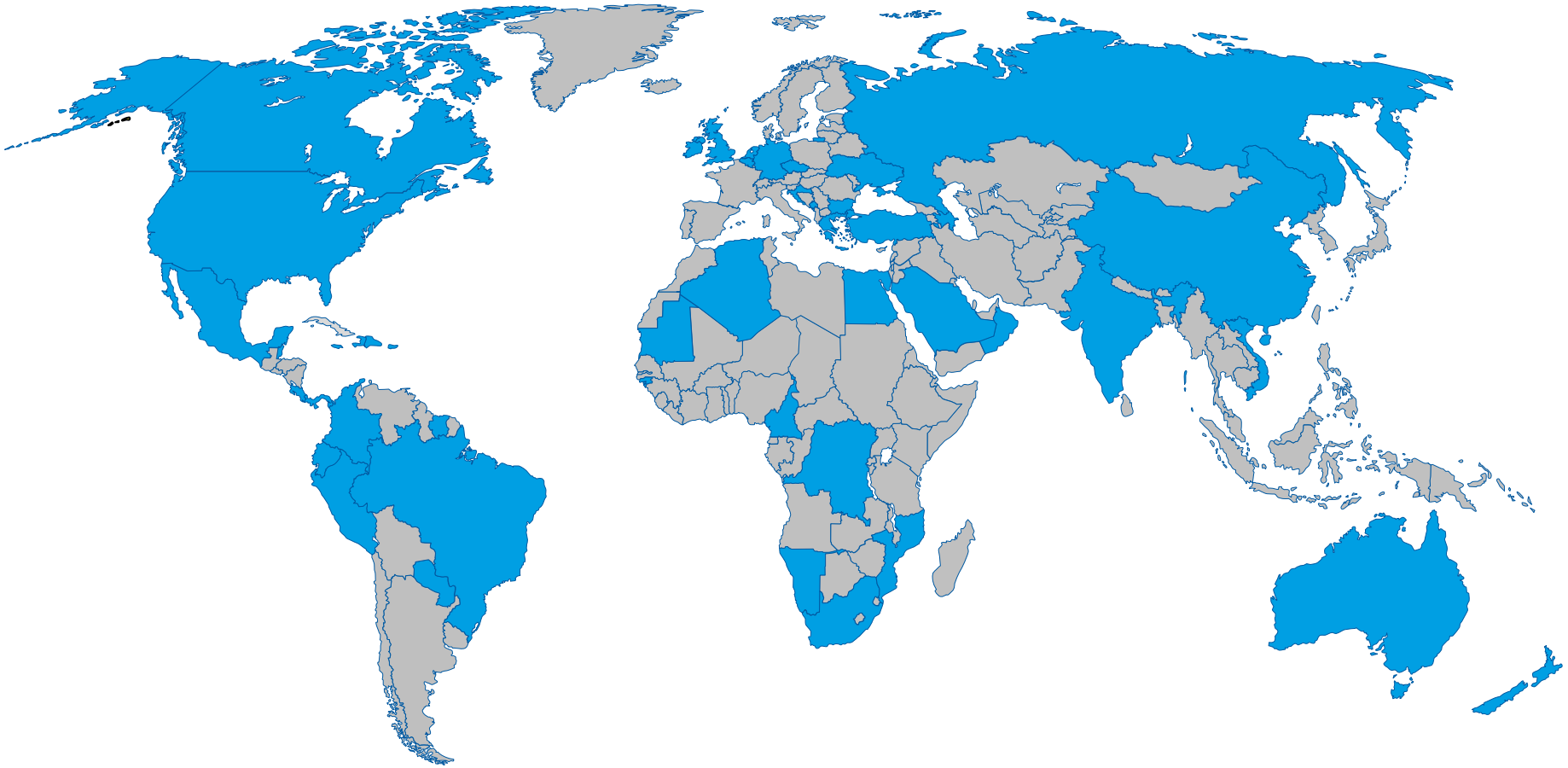
PowerCem Technologies

Dynamic company focused on sustainable development

- Product development and diversification
- Professional team focused on marketing and distribution
- Distributors all around the globe

Besides the head office in The Netherlands, distributors can be found all around the globe. Together, the technology and the product are passed on to local markets by the distributors. These distributors are carefully screened for competence and reliability.

POWERCEM WORLDWIDE



Established in The Netherlands - PowerCem has over 25 years of experience with environmental remediation projects around the world.

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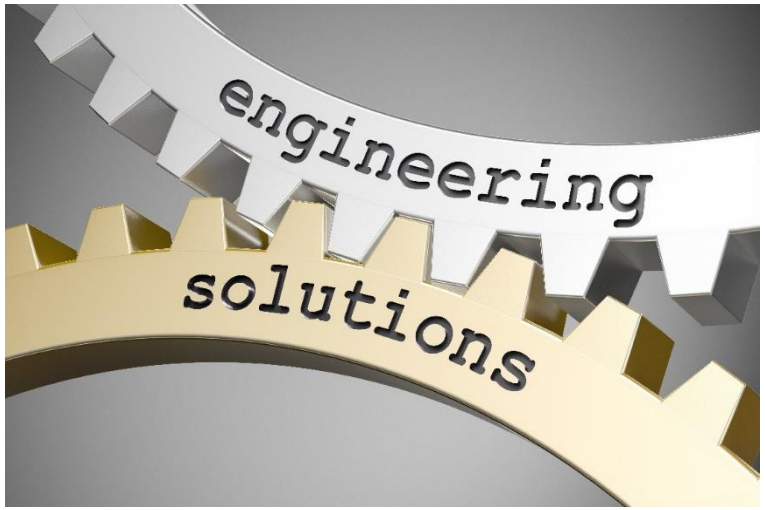
THE

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 industrial as well municipal waste.

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



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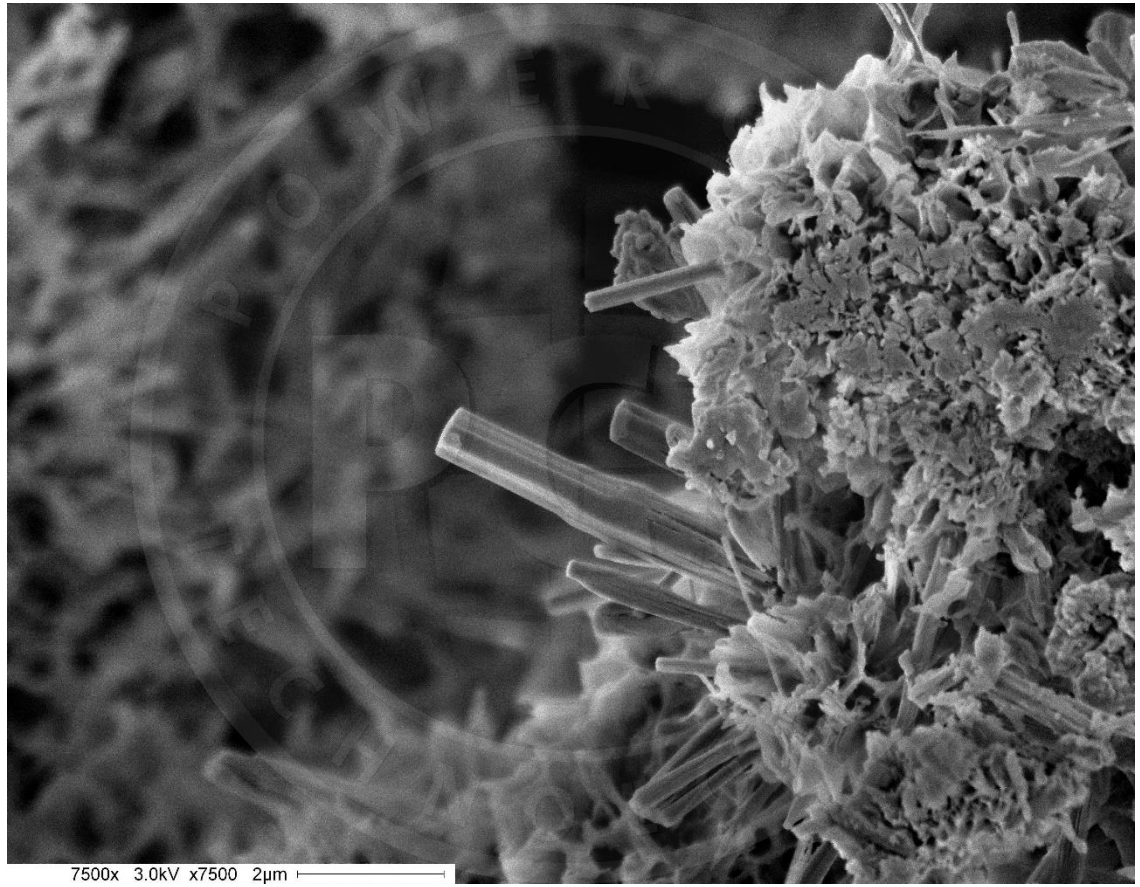
TECHNICAL SPECIFICATIONS



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

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APPLICATIONS

TAILINGS

CEMENTED BACKFILL

BACKFILL PASTE

MORTAR

SHOTCRETE

HYDRAULIC BACKFILL

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APPLICATIONS

Metallurgy and Manufacturing

Oil Industry

Contaminated Soils

Chemical Industry

Mining Industry

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PROJECTS IN GENERAL

1. Immobilization (IMOB) PAH / heavy metals funded EU Bakar Croatia / IMOB PAH/ heavy metals funded EU Sibenik Croatia
2. Immobilization (IMOB) Light radioactive pollutions/ PAH/ heavy metals/ Kosovo
3. Immobilization (IMOB) Tailings / heavy metals / PAH / mineral oil Ireland
4. Immobilization (IMOB) Tailings / Drilling invert cuttings / oil spill Shell and Conoco Philips Canada
5. Immobilization (IMOB) toxics Bulgaria
6. Immobilization (IMOB) Tar coal lagoons Poland
7. Immobilization (IMOB) Inorganically and organically polluted substances Czech Republic
8. Immobilization (IMOB) Industrial waste streams including PAH / VOC / Inorganic heavy metals Gàzprom Russia
9. Immobilization (IMOB) The Netherlands several projects in cooperation with Arcadis
10. Immobilization (IMOB) Germany polluted substances PAH / mineral oil / heavy metals
11. Immobilization (IMOB) China Industrial waste streams of all types
12. Immobilization (IMOB) United Kingdom industrial waste streams
13. Immobilization (IMOB) Highly polluted area's inorganic and organically South Africa
14. Etc etc.

HEAVY DUTY OIL RIKS ON TOP

HOC LA INMACULADA
HOC PALLANCATA
MINA TOROMOCHO
NEXA CERRO LINDO
VOLCAN ANDAYCHAGUA
CONDESTABLE
MINSUR
ATACAMA KOZAN CHILE
MINA PODEROSA
CEMENTOS PACASMAYO

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POWERCEM EN LA MINERIA PERUANA

PODEROSA MINING COMPANY
Poderosa Unit

MINSUR MINING COMPANY
Raura Mining Unit

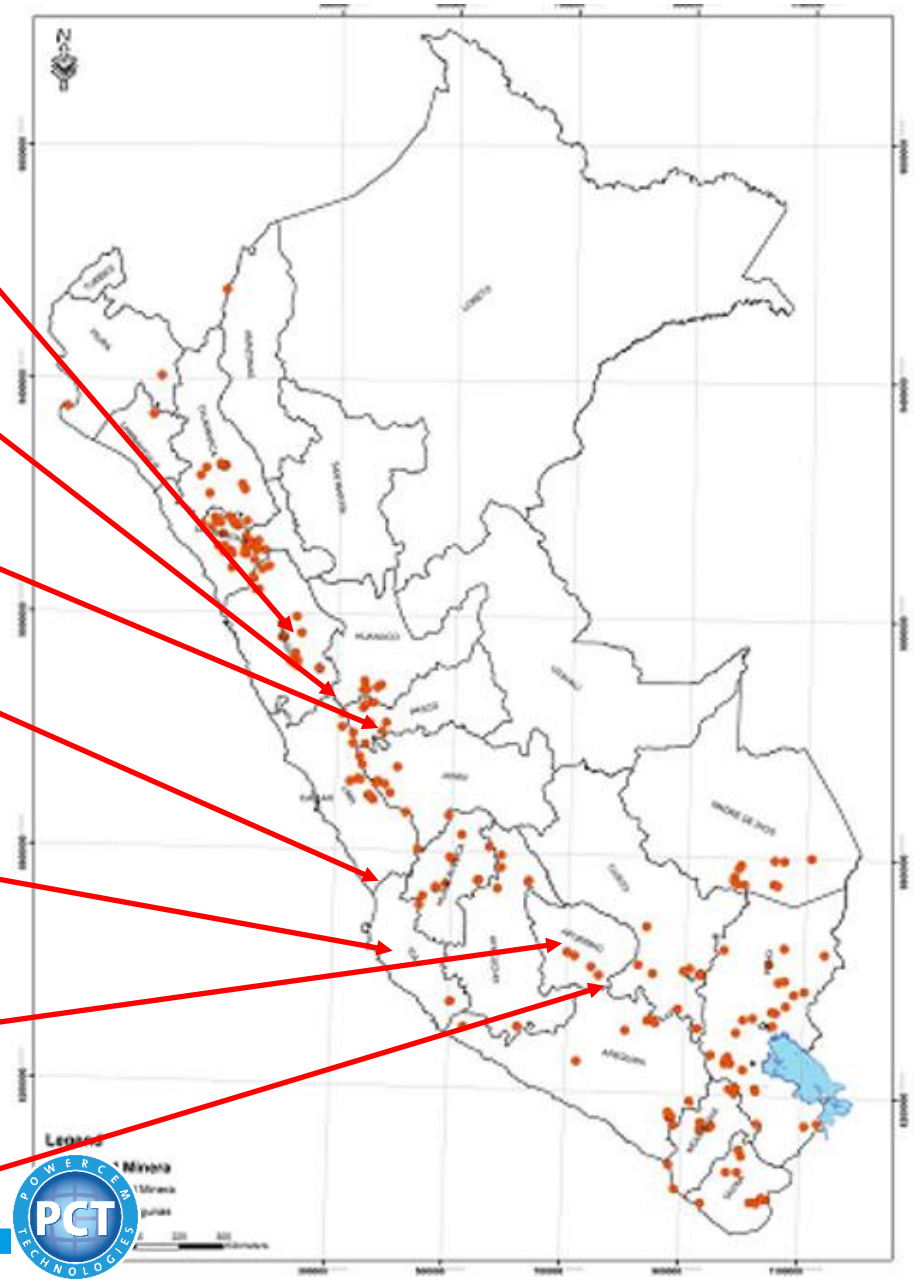
CHINALCO MINING COMPANY
Unidad de Toromocho

CONDESTABLE MINING COMPANY

NEXA CORPORATION
Cerro Lindo Mining Unit

HOCHSCHILD MINING
Pallancata Mining Unit

HOCHSCHILD MINING
Inmaculada Mining Unit



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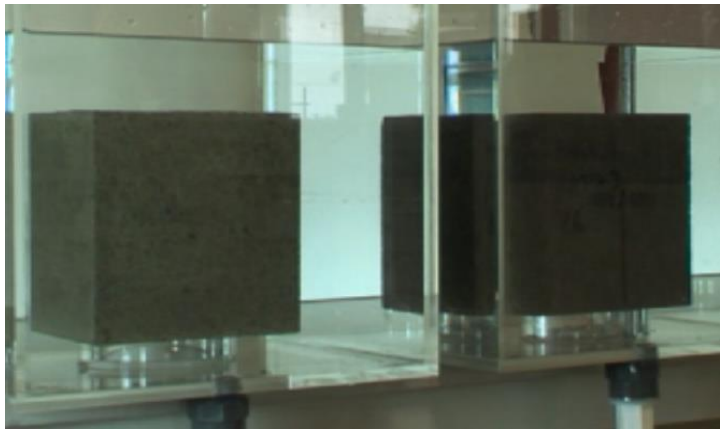
BENEFITS

- Reduction of construction materials - sand, stone, cement - and reuse 100% of tailings modified in addition of ImmoCem.
- Increase the capacity of tailings dams, by reusing mining residues, industrial residues 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



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CERTIFICATE

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

ARCADIS
Infrastructure · Water · Environment · Buildings

PowerCem Technologies BV
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The Netherlands
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Subject:
PowerCem Technologies proven Green Technology

ENVIRONMENT DIVISION

Dear Mr. Egyed,

's-Hertogenbosch,
21 September 2012

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 C02 amounts, in a sophisticated greener technology.

Kind regards,
ARCADIS Nederland BV

ing. E. Vlielander

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Our ref.:
076629437:0.1

Project number:
B02013.000212.0100

Environment Division holds certificates ISO 9001, ISO 14001, OHSAS 18001, SCC**, SIKB BRLs and the CO2-Performance ladder

Imagine the result

Dutch Trade Register
9036504

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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/m3 (mg/L)	WITH IMMOCEM 0.7 Kg/m3 (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		

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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/m3 (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		

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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

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SHOTCRETE 28 MPa

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

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**

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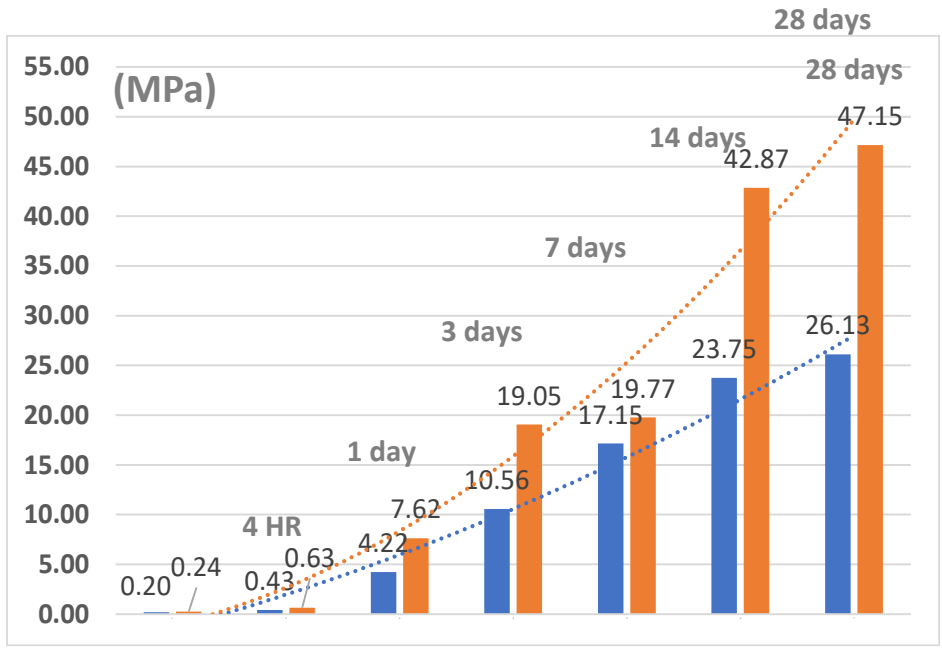
COMPARATIVE OF SHOTCRETE (25-45) MPa

- **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.

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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

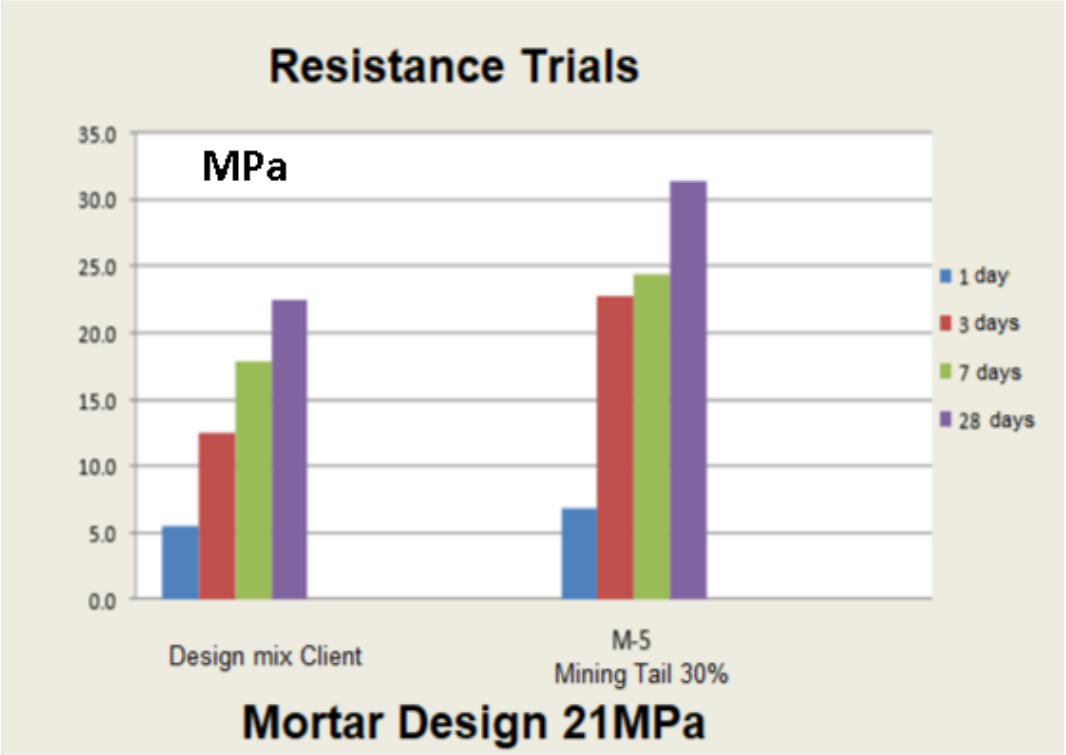
Tailing reuse:

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´´



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MINSUR MINE-RAURA

Tailing reuse:

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 OI
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

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ANNUAL REDUCTION OF CEMENT AND CO_2 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

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ESTIMATED CO_2 EMISSION IN PERUVIAN MINES

- 92 Active Big and Medium Mines
- 6.37 MM TPY of CO_2 Reductions
- 126 MM of US$ a year for Carbon Bonds

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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.

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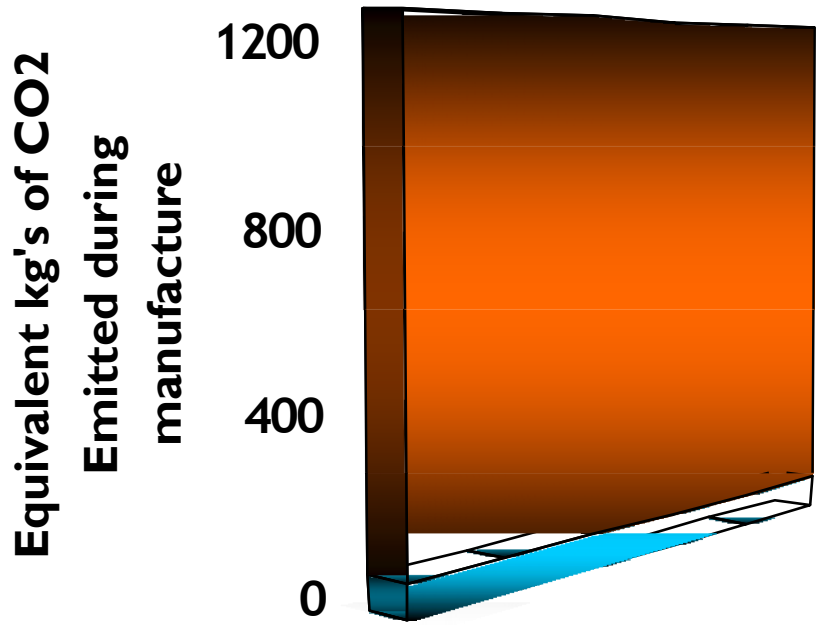
CARBON DIOXIDE EMISSION COMPARISON



Greenhouse emmision during Cement manufacturing

Greenhouse emmision during equivalent PowerCem products manufacturing

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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

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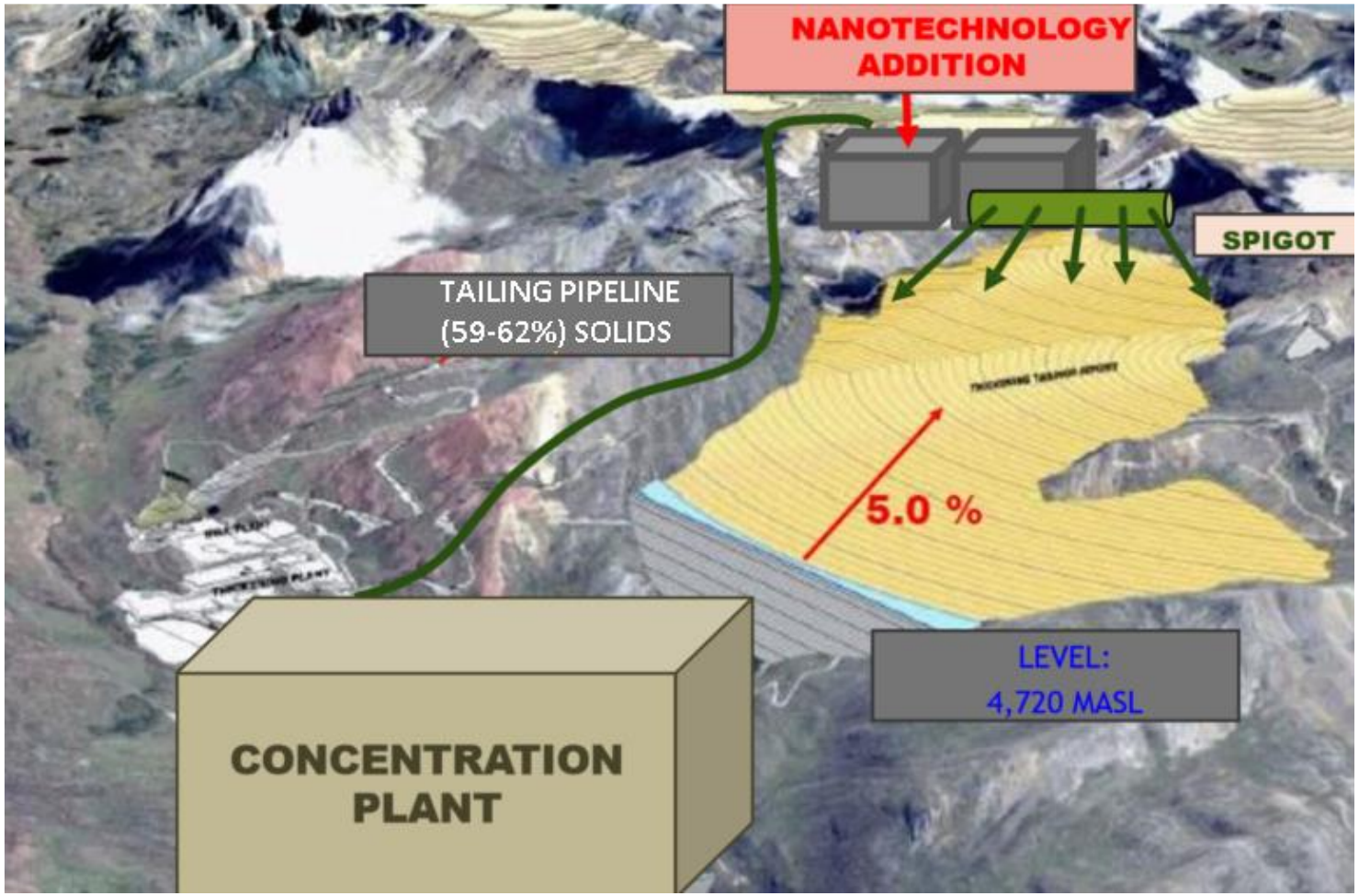
TAILING MANAGEMENT WITH IMMOCEM

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 Inertization of the Tailings.

TAILING DISCHARGE PLAN WITH NANOTECHNOLOGY (SLOPE: 5%)



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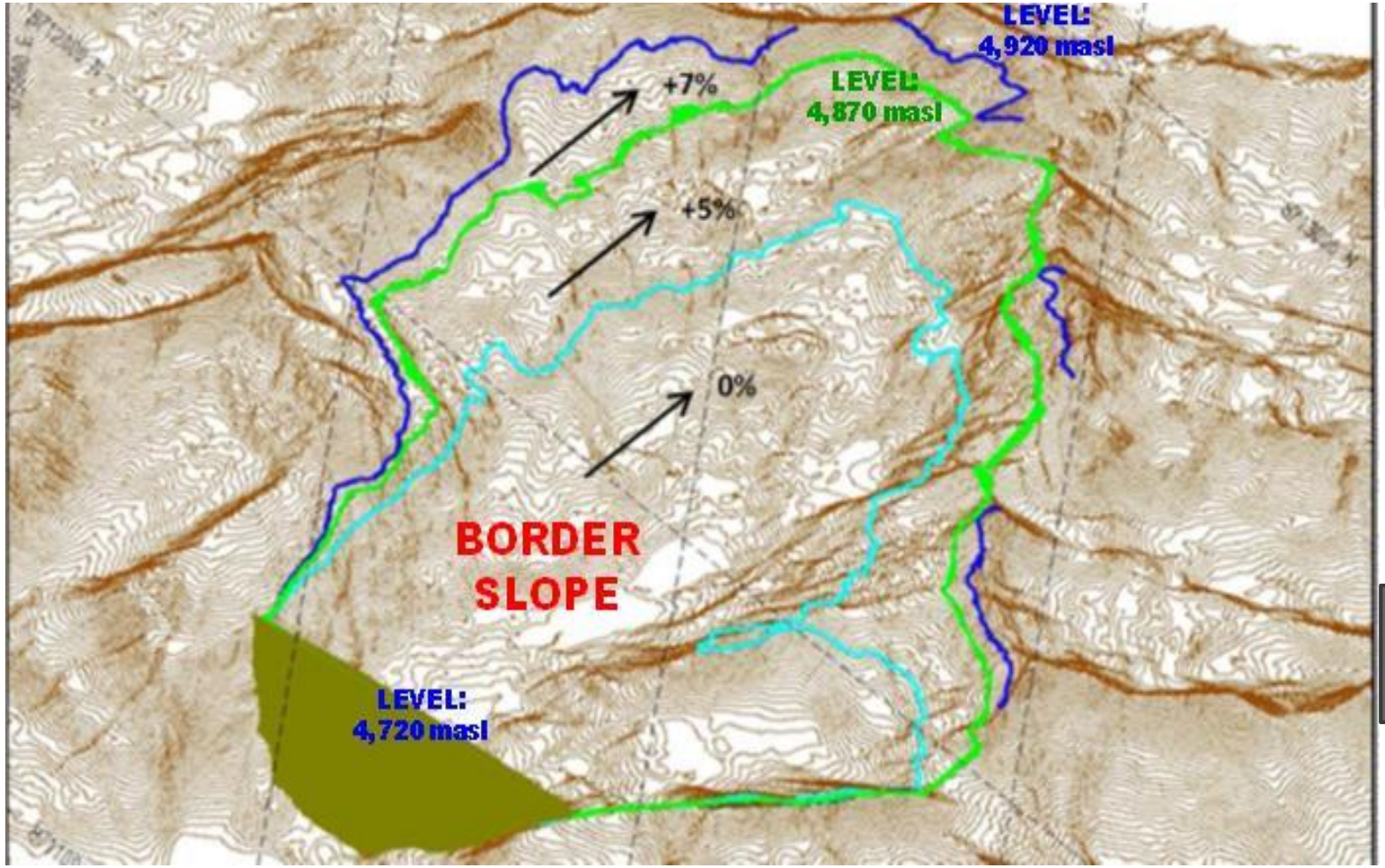
IMMOCEM:
INCREASES THE CAPACITY OF THE TAILING DAMS BY THE SLOPE



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

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

Convencional Tailing: CAP: 450 MM TN

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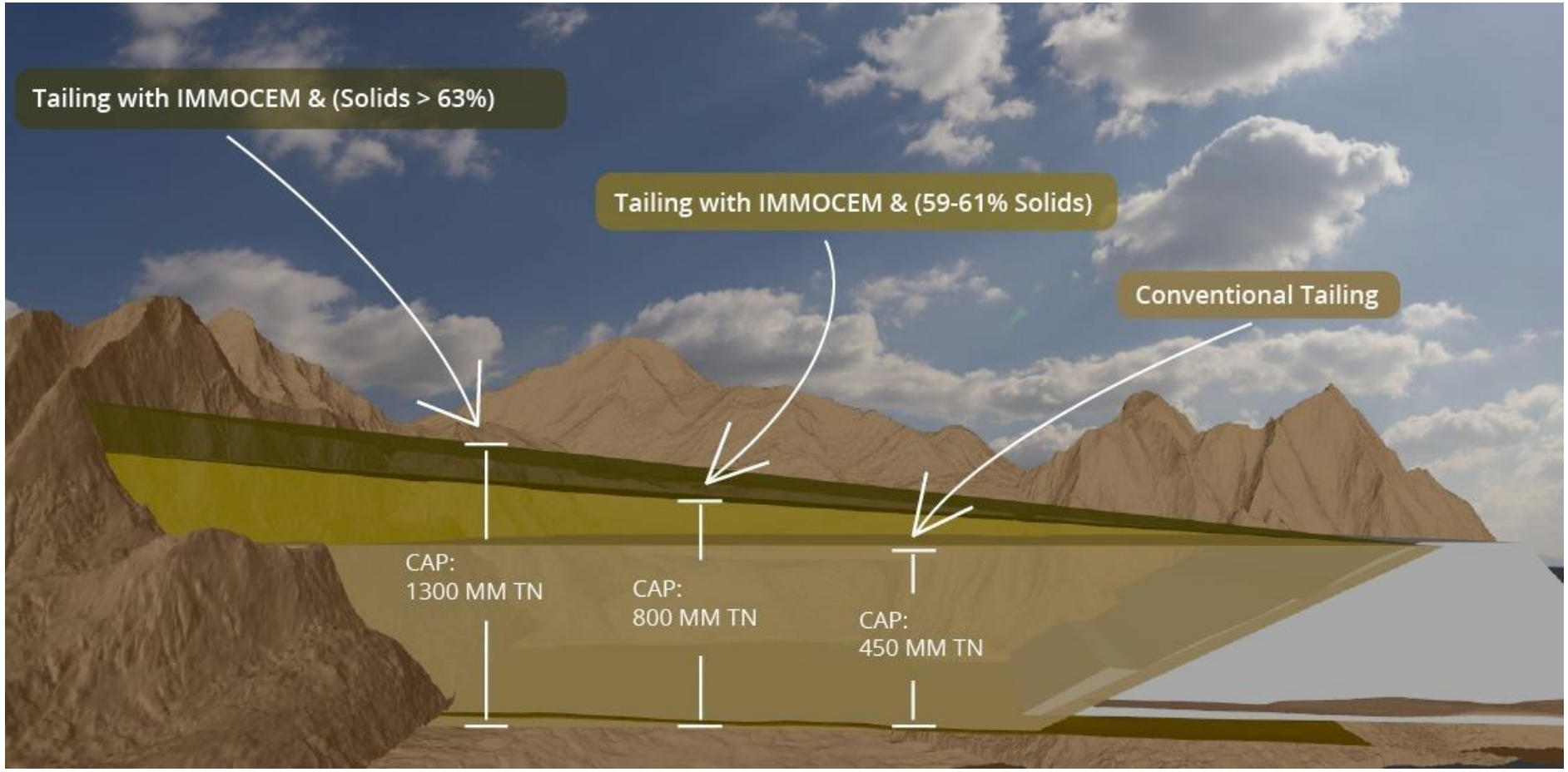
IMMOCEM:
INCREASES THE CAPACITY OF THE TAILING DAMS BY THE SLOPE



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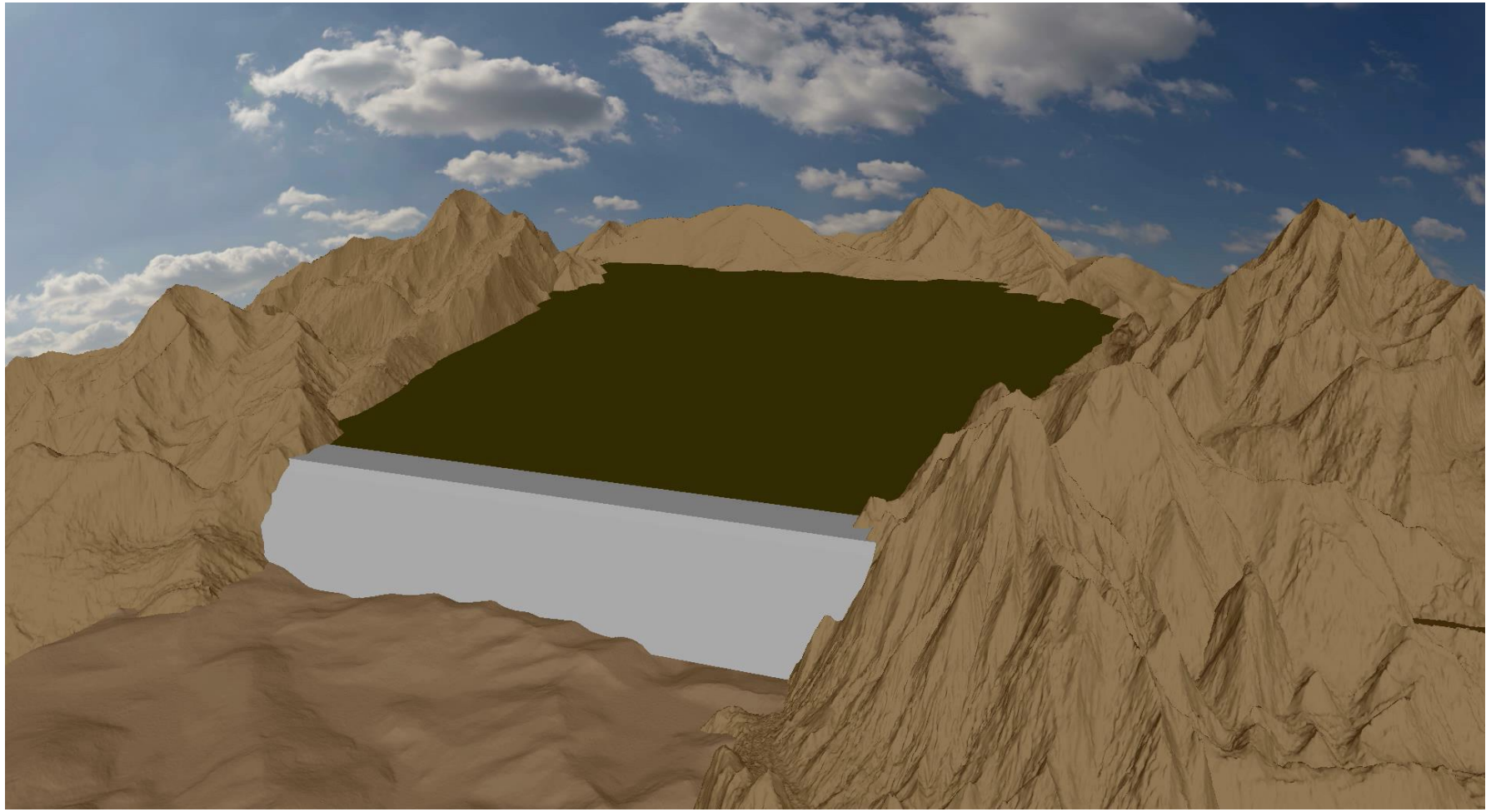
IMMOCEM:
INCREASES THE CAPACITY OF THE TAILING DAMS BY SLOPE ANGLE



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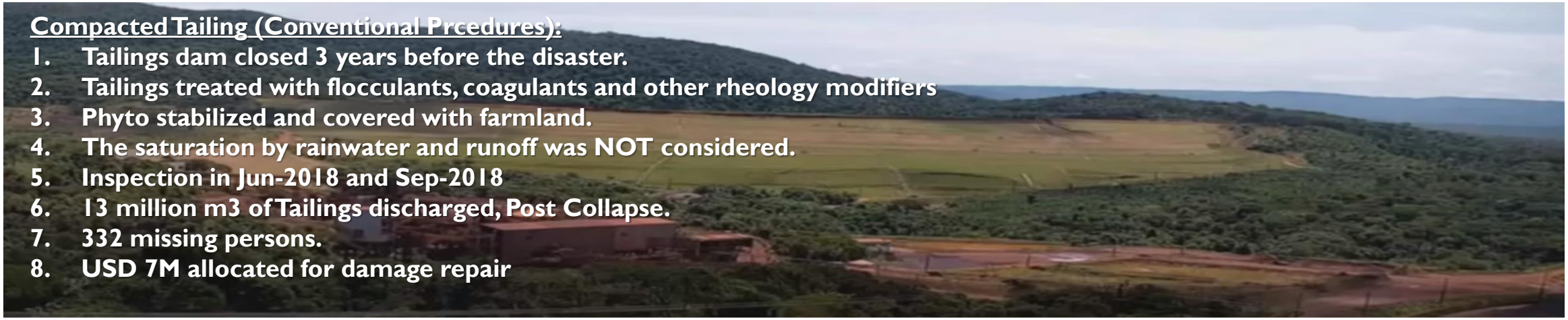
DISASTER IN MINERA VALE-BRASIL TAILING DAM OF BRUMADINHO, COLLAPSE: 25/01/19 COMPACTED TAILING VS ZEOLITIC TAILING



Compacted Tailing (Conventional Prcedures):

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

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POWERCEM
PCT
TECHNOLOGIES


Geochem
Cutting-Edge Geochemistry