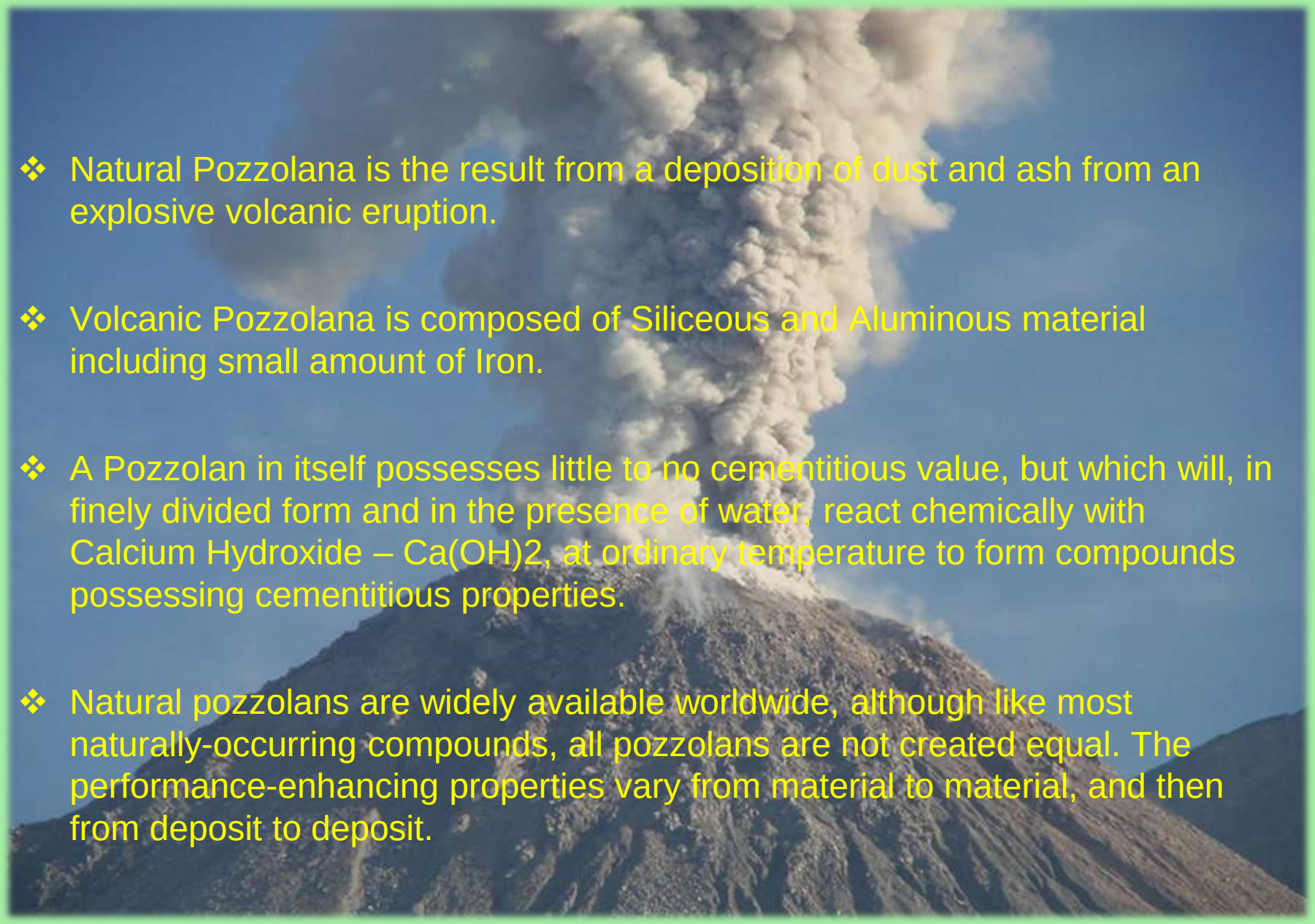
Natural Pozzolana Role in Green Cement and Concrete Industries

Peakward Enterprises

Peakward (Holdings) Ltd.

Introduction and Timeline

- The name Pozzolan comes from the town Pozzuoli, Italy.
- Ancient Romans (~100 B.C.) produced a hydraulic binder by mixing hydrated lime with soil (predominantly volcanic ash).
- The Colosseum and Pantheon in Italy which is approximately 2000 years old and still intact is based on Pozzolan Material.
- Most of the knowledge of modern-day cement comes from a person known as Vitruvius (Marcus Vitruvius Pollio). "1st Roman architect"
- The secret of enduring Roman concrete was lost to the world with the collapse of their empire.
- Beginning somewhere in the 14th century, the use of cement gradually returned.
- The Canal in Southern France (150 miles long) was built using concrete in 1670.
- Joseph Aspdin patented a method for producing what he named Portland cement in 1824.
- Early in the 20th century, engineers faced a dilemma—they needed to build massive concrete dams but were aware that OPC wasn't up for the job—including critical factors like strength and performance. They solved this problem by introducing natural pozzolans to their concrete formulations, replicating the success of the Romans.
- Natural Pozzolans had again found place in durable concrete construction.



- Natural Pozzolana is the result from a deposition of dust and ash from an explosive volcanic eruption.
- Volcanic Pozzolana is composed of Siliceous and Aluminous material including small amount of Iron.
- A Pozzolan in itself possesses little to no cementitious value, but which will, in finely divided form and in the presence of water, react chemically with Calcium Hydroxide – $Ca(OH)2$, at ordinary temperature to form compounds possessing cementitious properties.
- Natural pozzolans are widely available worldwide, although like most naturally-occurring compounds, all pozzolans are not created equal. The performance-enhancing properties vary from material to material, and then from deposit to deposit.

There are almost 120 volcanic mountains in Indonesia (some of them are underwater and dormant)

Pozzolana Testing Results

It meets the strict quality requirement of ASTM standard:

Test Result by USA Lab

Test Results by Singapore Laboratory

Test Results by Dubai Laboratory

Resource Materials Lab USA 2014

*Sample provided by Peakward Group

Resource Materials Testing, Inc.

"Specialists in Fly Ash Testing"

24 Fine Drive Murphy, NC 28906 828.506.7636

REPORT OF NATURAL POZZOLAN ANALYSIS

PROJECT NO. RMT-531
SAMPLE NO. 20295
DATE REC.: 07-05-14
DATE REP.: 08-12-14

SAMPLE ID: Natural Pozzolan Indonesia

CHEMICAL ANALYSIS:	RESULTS:	ASTM C 618 Spec N
Silicon Dioxide, SiO_2, %	68.86	----
Aluminum Oxide, Al_2O_3, %	16.37	----
Iron Oxide, Fe_2O_3, %	3.90	----
Sum of SiO_2, Al_2O_3 & Fe_2O_3, %	89.13	70 Min
Calcium Oxide, CaO, %	3.72	----
Magnesium Oxide, MgO, %	1.04	----
Sodium Oxide, Na_2O, %	3.20	----
Potassium Oxide, K_2O, %	1.94	----
Sulfur Trioxide, SO_3, %	0.09	4.0 Max
Moisture Content, %	2.99	3.0 Max
Loss on Ignition, %	3.60	10.0 Max

PHYSICAL ANALYSIS:	RESULTS:	ASTM C 618 Spec N
Amount Retained on No. 325 Sieve, %	5.2	34 Max
Sieve Uniformity, % Points from Ave		5 Max
Specific Surface by Air Permeability, m^2/g	790	
Strength Activity Index		
Portland Cement @ 7 days, % of Control	89	75 Min
Portland Cement @ 28 days, % of Control	97	75 Min
Water Requirement, % of Control	98	115 Max
Autoclave Expansion, %	-0.03	0.8 Max
Density	2.62	----
Density Uniformity, % from Ave		5 Max
Increase of Drying Shrinkage, %*		0.03 Max
Reactivity with Cement Alkalis, %*		
Reduction of Mortar Expansion, %	----	----
Mortar Expansion, % of LA Cement Control		100 Max
Air Entrainment of Mortar, %		----
Air Entrainment Uniformity, % from Ave		20 Max

*Optional Requirements applicable only when requested by purchaser. This material meets the requirements of ASTM C 618 and AASHTO M 295 for the parameters tested.

By Robert J. Smith

Admaterials Tech. Lab Singapore 2015

*Sample provided by Peakward Group

ADMATERIALS TECHNOLOGIES PTE LTD

JOB REF: ADM/13/6572
Page 2 of 2

TEST RESULTS:

Chemical Analysis of Natural Pozzolan

Table 1. Chemical and Elemental Analysis

Our Sample Ref	ADM/13/6572	
Property	**Test Method**	**Result % (m/m)**
Loss on Ignition	BS EN196-2: 2005	3.50
Sulfate as SO_3	BS EN196-2: 2005	0.19
Total Silica as SiO_2	BS EN196-2: 2005	70.28
Iron (III) Oxide as Fe_2O_3	BS EN196-2: 2005	1.04
Aluminium Oxide as Al_2O_3	BS EN196-2: 2005	8.85
Calcium Oxide as CaO	BS EN196-2: 2005	0.63
Magnesium Oxide as MgO	BS EN196-2: 2005	0.48
**Reactive Silicon Dioxide (Residue Insoluble in HCL and KOH)	BS EN 196-2 & BS EN 197-1,3.2	26.60
Sodium Oxide as Na_2O	BS EN196-2: 2005	0.04
Potassium Oxide as K_2O	BS EN196-2: 2005	0.06
Total Alkalinity as $Na_2O + 0.658\ K_2O$	BS EN196-2: 2005	0.07
Moisture Content	SS EN15167-1 Annex A	14.67

Property	Test Method	Result (mg/l)
Cadmium	EPA 3051/6010C	<0.1
Chromium	EPA 3051/6010C	0.39
Lead	EPA 3051/6010C	4.31
Mercury	EPA 3051/6010C	<0.1

Note : ** Not Singlas Accredited

PREPARED BY:

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Chemist

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Company No. : 200201480C

ANALYSIS REPORT

To: Julifin Ad Materials	Report No.: QSG13120578 Date: 20 December 2013
1. ANALYSIS OBJECTIVE XRD analysis of glass and Zeolite content.	2. EQUIPMENTS AND OPERATING CONDITIONS X-ray "Zeolite" diffraction (XRD)

3. SAMPLE INFORMATION

Glass content and zaolite content sample was received for XRD analysis.

4. TEST METHOD AND PROCEDURE

Determination of sample by X-ray diffraction (XRD)

5. RESULTS SUMMARY

Amorphous(Glass)	3427.85	Crystalline (Zeolite)	58.28
Amorphous / Total	98.3%		1.7%

6. REMARKS: NA

Analyzed by: Leila L. Lapina FA Engineer	Reviewed by: Qi SuiYi Asst Lab Manager

Elements Lab Singapore 2020

TEST CERTIFICATE OF NATURAL POZZOLANA

Client	Peakward Enterprises (Holdings) Ltd. Hong Kong	**Lab Reference**	WR20- 16527 (Page 1 of 3)
		Sample No.	D20-05299/1
Job No	J0136M-DB20	**Request No.**	D20-05299
Sampling Location **Sampled by**	Peakward Quarry, SGS	**Client's ref. (Seal #)**	SGS AP 012462, SGS AP 0129463
Sample description **Sample preparation date**	Natural Pozzolana, 21.07.2020	**Date Received**	08.08.2020
Sampling date	08.07.2020	**Date Reported**	18.10.2020
Date tested	18.09.2020-14.10.2020	**Tested by**	Element group laboratory-Singapore

TEST RESULTS:

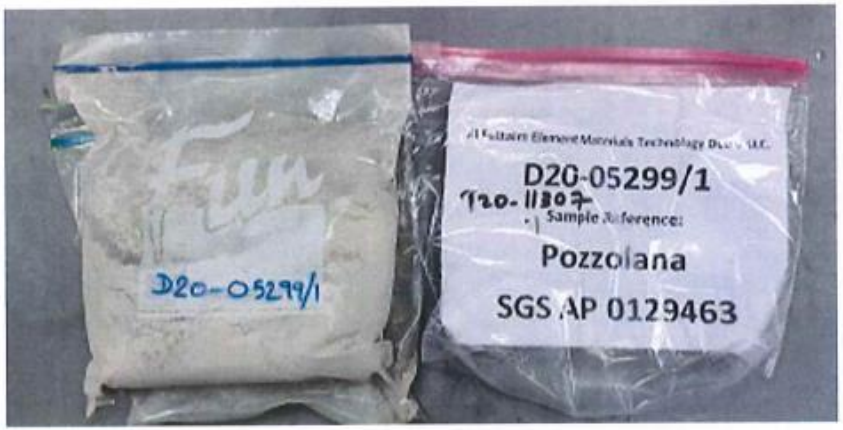
Chemical Analysis of Natural Pozzolana (Volcanic Ash)

Sample Ref			T20-11307	
Client Sample Ref			D20-05299/1 (REF 88496/1)	
Property	**Unit**	**Test Method**	**Result**	**BS EN 450-1:2012 Requirement % (m/m)**
Free Calcium Oxide	(%, m/m)	BS EN 451-1: 2017	<0.1	≤ 1.5
Reactive Silicon Dioxide	(%, m/m)	SS EN 197-1:2014	34.86	≥ 25
Reactive Calcium Oxide[1]	(%, m/m)	BS EN 197-1: 2011	<0.1	≤ 10.0

Remarks:

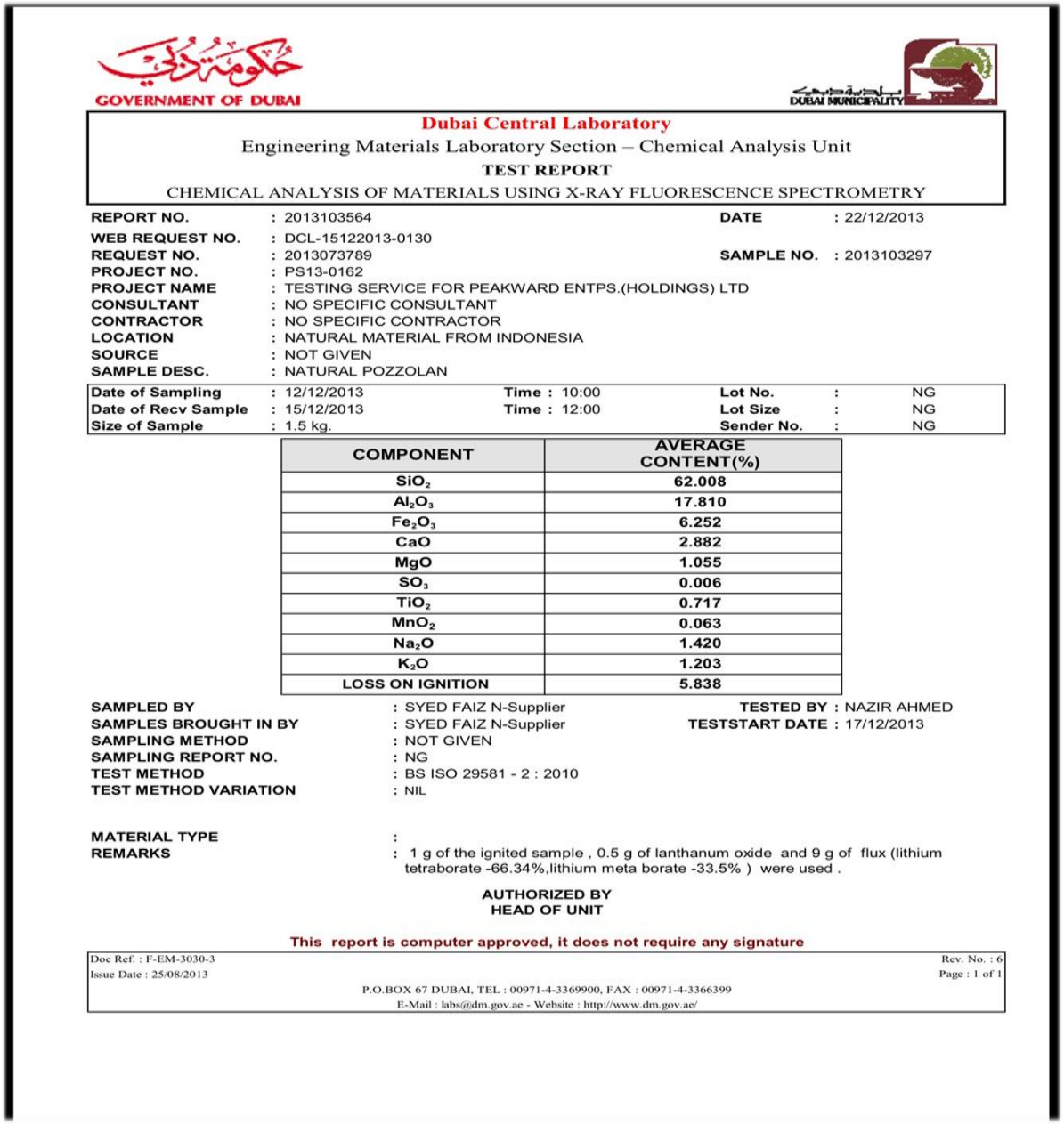
[1] Reactive calcium oxide test was conducted by TUV SUD PSB Pte. Ltd. (Report Ref. No. 7191244623-CHM20-LHS).

*Sample provided by Peakward Group



Dubai Central Lab 2013

*Sample provided by Peakward Group



GOVERNMENT OF DUBAI

DUBAI MUNICIPALITY

Dubai Central Laboratory

Engineering Materials Laboratory Section – Chemical Analysis Unit

TEST REPORT

CHEMICAL ANALYSIS OF MATERIALS USING X-RAY FLUORESCENCE SPECTROMETRY

REPORT NO.	: 2013103564	**DATE**	: 22/12/2013
WEB REQUEST NO.	: DCL-15122013-0130		
REQUEST NO.	: 2013073789	**SAMPLE NO.**	: 2013103297
PROJECT NO.	: PS13-0162		
PROJECT NAME	: TESTING SERVICE FOR PEAKWARD ENTPS.(HOLDINGS) LTD		
CONSULTANT	: NO SPECIFIC CONSULTANT		
CONTRACTOR	: NO SPECIFIC CONTRACTOR		
LOCATION	: NATURAL MATERIAL FROM INDONESIA		
SOURCE	: NOT GIVEN		
SAMPLE DESC.	: NATURAL POZZOLAN		

Date of Sampling	: 12/12/2013	**Time :** 10:00	**Lot No.**	:	NG
Date of Recv Sample	: 15/12/2013	**Time :** 12:00	**Lot Size**	:	NG
Size of Sample	: 1.5 kg.		**Sender No.**	:	NG

COMPONENT	AVERAGE CONTENT(%)
SiO_2	62.008
Al_2O_3	17.810
Fe_2O_3	6.252
CaO	2.882
MgO	1.055
SO_3	0.006
TiO_2	0.717
MnO_2	0.063
Na_2O	1.420
K_2O	1.203
LOSS ON IGNITION	5.838

SAMPLED BY	: SYED FAIZ N-Supplier	**TESTED BY**	: NAZIR AHMED
SAMPLES BROUGHT IN BY	: SYED FAIZ N-Supplier	**TESTSTART DATE**	: 17/12/2013
SAMPLING METHOD	: NOT GIVEN		
SAMPLING REPORT NO.	: NG		
TEST METHOD	: BS ISO 29581 - 2 : 2010		
TEST METHOD VARIATION	: NIL		

MATERIAL TYPE :

REMARKS : 1 g of the ignited sample , 0.5 g of lanthanum oxide and 9 g of flux (lithium tetraborate -66.34%,lithium meta borate -33.5%) were used .

AUTHORIZED BY
HEAD OF UNIT

This report is computer approved, it does not require any signature

Doc Ref. : F-EM-3030-3 Rev. No. : 6
Issue Date : 25/08/2013 Page : 1 of 1

P.O.BOX 67 DUBAI, TEL : 00971-4-3369900, FAX : 00971-4-3366399
E-Mail : labs@dm.gov.ae - Website : http://www.dm.gov.ae/

Elements Lab Dubai 2020

*Sample provided by Peakward Group

TEST CERTIFICATE OF NATURAL POZZOLANA

Client	Peakward Enterprises (Holdings) Ltd. Hong Kong	**Lab Reference**	WR20- 15052 (Rev.01)
		Sample No.	D20-05299/1
Job No	J0136M-DB20	**Request No.**	D20-05299
Sampling Location	Peakward Quarry,	**Client's ref. (Seal #)**	SGS AP 012462, SGS AP 0129463
Sampled by	SGS		
Sample description	Natural Pozzolana,	**Date Received**	08.08.2020
Sample preparation date	21.07.2020		
Sampling date	08.07.2020	**Date Reported**	26.11.2020
Date tested	25.08.2020-23.11.2020	**Tested by**	JRE/SSK/GPA

S. No.	Constituent			BS-EN 450 Part I : 2012 Sp. Limits	Results
	CHEMICAL COMPOSITION				
1	Loss on ignition	%	LOI	Max. 7.0 (Category B)	6.31
2	Silicon Dioxide	%	SiO_2	-	67.0
3	Aluminum oxide	%	Al_2O_3	-	13.8
4	Iron oxide	%	Fe_2O_3	-	3.19
5	Calcium oxide	%	CaO	Max 10.0	2.60
6	Magnesium oxide	%	MgO	Max. 4.0	0.66
7	Sulphate	%	SO_3	Max. 3.0	0.12
8	Chloride	%	Cl	Max. 0.10	0.011
9	Sodium oxide	%	Na_2O	-	0.16
10	Potassium oxide	%	K_2O	-	2.53
11	Titanium oxide	%	TiO_2	-	0.28
12	Manganese oxide	%	Mn_2O_3	-	0.10
13	Total alkalis	%	Na_2O equivalent	Max. 5.0	0.18
14	Soluble Phosphate	mg/kg	P_2O_5	Max. 100	1.1
15	Silicon dioxide + Aluminum Oxide + Iron Oxide			Min. 70	84
PHYSICAL PROPERTIES					
1	Fineness (Retained on 45 microns)		%	Max. 40 (Category N)	6
2	Moisture content		%	Max. 0.5	< 0.01
3	Particle Density		kg/m^3	Declared value ±200	2358
4	Water requirements		%	-	93
5	Soundness		mm	Max 10	0.5
6	Setting time (Vicat method) (Test sample) ** Initial (Minutes) Final (Minutes)			Max. Twice the value of control	 160 240
7	Setting time (Vicat method) (Control sample) * Initial (Minutes) Final (Minutes)		-	-	 140 210
8	Compressive Strength (Test sample) ** (a) 28 days (b) 90 days		N/mm^2	-	 41.0 60.4
9	Compressive Strength (Control sample)* (a) 28 days (b) 90 days		N/mm^2	-	 51.9 58.0
10	Strength Activity Index (a) 28 days (b) 90 days		%	 Min. 75 Min.85	 79 104

Test Method: BS EN 450-1:2012 / BS EN 451-2:2017 / BS EN 196-2: 2013 / BS EN 196-1: 2016 / BS EN 196-3: 2015 / BS EN 196-6:2018

*Test was carried out using OPC cement / ** Test was carried out using 25% Volcanic Ash Natural Pozzolana & 75 % OPC

Elements Lab Dubai (2020/2021)

Strength - Activity Index

180 & 360 days

*Sample provided by Peakward Group

الفطيم Al-Futtaim اليمنت element

TEST CERTIFICATE OF NATURAL POZZOLANA

Client	Peakward Enterprises (Holdings) Ltd. Room 2901, Pacific Plaza, 410 Des Voeux, Road West, Hong Kong	Lab Reference	WR21- 04839
		Sample No.	D20-07350/1
Job No	DQ31624, dated 01.10.2020	Request No.	D20-07350
Sampling Location Sampled by	N.G N.G	Client's ref.	Requestion dated 01.10.2020
Sample description Sample preparation date	Natural Pozzolana (Volcanic Ash) 21.11.2020	Date Received	22.11.2020
Sampling date	N.G	Date Reported	24.11.2021
Date tested	21.11.2020-17.11.2021	Tested by	SSK

S. No.	Constituent		BS-EN 450 Part I : 2012 Sp. Limits	Results
PHYSICAL PROPERTIES				
1	Compressive Strength (Test sample) **	N/mm^2	-	
	(a) 180 days			61.7
	(b) 360 days			68.5
2	Compressive Strength (Control sample)*	N/mm^2	-	
	(a) 180 days			64.6
	(b) 360 days			66.6
3	Strength Activity Index	%		
	(a) 180 days		-	96
	(b) 360 days		-	103

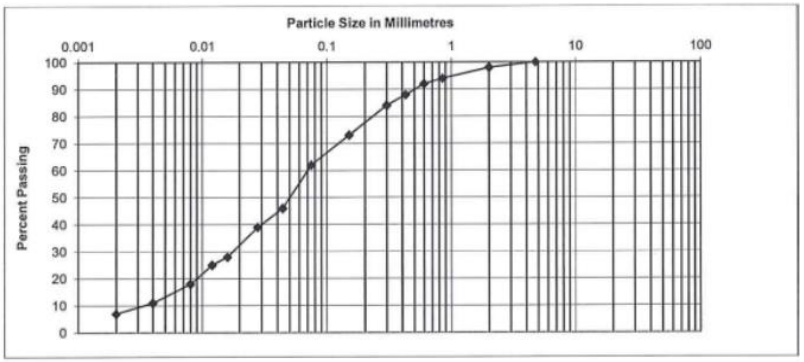
Test Method: BS EN 450-1:2012 / BS EN 196-1: 20168

*Test was carried out using OPC cement / ** Test was carried out using 25% Natural Pozzolana (Volcanic Ash) & 75 % OPC

Particle Size Distribution Chart

PARTICLE SIZE ANALYSIS

Client	Peakward Enterprises (Holdings) Ltd., Hong Kong	Lab Report No.	WR21-00850
Client's Reference	Request Dated 19.01.2021	Sample No.	D21-00289
Project Name	N.G	Request No.	D21-00289
Sample Reference	N.G	Date Received	19.01.2021
Source/ Supplier	N.G	Date Tested	19.01.2021
Sample Description	Volcanic Ash Natural Pozzolana	Date Reported	25.01.2021
Lab Description	Volcanic Ash Natural Pozzolana	Tested by	AFE
Sample Preparation	ASTM D421: 85(2007)	Size of sample	Approximately 50g
Test Method	ASTM D422: 63(2007)	Sampled by	AFE



Particle Diameter mm	Passing %
4.750	100
2.000	98
0.850	94
0.600	92
0.425	88
0.300	84
0.150	73
0.075	62
0.044	46
0.028	39
0.016	28
0.012	25
0.008	18
0.004	11
0.002	7

III. According to ASTM (618-07) Pozzolana should comply with Req:

- $SiO_2 + Al_2O_3 + Fe_2O_3$, Min 70%.
- So_3, Max 4.0 %.
- H_2O Max 3.0 %.
- LOI (Loss Of Ignition), Max 10%.
- Compressive Strength for 28 days with PC, Min Percent of Control, 75% (Pozzolanic Activity Index).

III. According to ASTM (618-07) Pozzolana should comply:

- **According to USA lab test report, Pozzolana Activity Index for 28 Days = 97%. This shows that Pozzolana strength development is almost equal with OPC Cement.**

- **It is indicated that our Natural Pozzolana is very reactive in Strength Development of Cement.**

- Pozzolan activity of Natural Pozzolan of Volcanic origin depend on:

  ✓ Chemical composition ($SiO_2 + Al_2O_3 + Fe_2O_3 \geq 70\%$)

  ✓ Mineralogies:

  - Glass Content from Silica Rich Glass
  - Content Of Zeolitic Mineral that gained with good result from Zeolit Material such as:
    - Chabazite : $Ca\ (Al_2Si_4O_{12}).\ 6H_2O$
    - Heulandites : $(Ca.Na_2)\ (Al_2Si_7O_{18}).6H_2O$
    - Natrolite : $Na_2\ (Al_2Si_3O_{10})\ 2H_2O$
    - Stilbite : $(Ca,\ Na_2,\ K_2)\ (Al_2Si_7O_{18})\ 7H_2O$
    - Wairakite : $Ca_8(Al_{16}Si_{32}O_{96})*16H_2O$

There are Four (4) Categories of Pozzolan:

- Category I : Fully Crystallized With Zeolite
- Category II : Glassy with Quartz
- Category III : Glassy, Quartz-free
- Category IV : Glassy + Zeolite (Best Quality)

✓ Our Pozzolana Based on Chemical Composition and Mineralogical Composition Could be Categorized as the Best Quality

Pozzolana Deposit

Deposit: 50 (Fifty) Million M^3

Peakward Enterprises (Holdings) Ltd.
Natural Pozzolana Shipment

V. How To Utilize Pozzolana In Cement Manufacturing and Concrete Batching Plants

A) **In Cement Making**: Intergrinding certain proportion between Clinker (1st Material), Gypsum (2nd Material), 3rd Materials (Pozzolana, etc).

Type Of Cements:

- **OPC** (95% Clinker + 5% Gypsum).
- **Blended Cement** (65% Clinker + 30% 3rd Materials + 5% Gypsum).
- **PCC/ Portland Composite Cement** (65% Clinker + 30% 3rd Materials + 5% Gypsum = "Cocktail Cement"

CEMENT MILL

CLINKER
+ Gypsum

CLINKER
+ Gypsum
+ LIMESTONE

CLINKER
+ Gypsum
+ POZZOLAN

CLINKER
+ Gypsum
+ POZZOLAN
+ LIMESTONE
+ FLY ASH
+ SLAG, EAF
+ DLL.

OPC
(TYPE I)

SMC

PPC (Portland Pozzolan Cement, Blended Cement)

PCC
(Cocktail Cement)

B) In Batching Plant:

Table Shown: The Requirement of Pozzolana Used in Concrete Making (C618 – ASTM).

Pozzolana and Slag as Applicable	Applicable Test Method	Req.
Fineness: Amount retained when wet-sieved on 45 Micron (No.325) Sieve, Max %	C430	20 %
Alkali Reactivity of Pozzolan use in Types IP(<15);IT(P<15) and IP(<15)-A; IT(P<15)-A Cements, Six Tes t Mortar Bar Expansion at 91 Days, Max %	C227	0.05
Activity Index with Portland Cement at 28 Days min % ***(Our Testing Result)**		75/ **97***

How to Use Pozzolana in Concrete Batching Plant?

Pozzolana is ground and dried separately in a grinding mill. At the mixer, partial replacement of Portland Cement (Up to 30% replacement as 3rd Material) is used.

VII. Concrete Issues

- High Performance Concrete will emit a High Temperature during hydration process which will causing crack on Concrete Surface.
- Harmful effect on Concrete Long Terms Performance due to Calcium Hydroxide (CH) remaining in hydration process which is not fully converted as Calcium Silicate Hydrate (CHS).

VIII.Natural Pozzolana Role in Eliminating Concrete Issue

- Adding High Quality Natural Pozzolana can Reduce Temperature in Concrete Hydration Process up to 20° C.

- Natural Pozzolana can lower Calcium Hydroxide in concrete to almost Zero Percent by converting the remaining CH to CHS resulting a Solid and Impermeable concrete

IX. Pozzolana Concrete Test Result

- **A. Test Result By Unibeton Ready Mix - UAE**

LAB TRIAL FOR POZZOLAN - By UNIBETON

	L.T.M. NO		L.T.M.759	L.T.M.760	L.T.M.767	L.T.M.768	L.T.M.769	L.T.M.770
	Class of Concrete & Source of Cement Usage		C40/20 (OPC)	C4020 (OPC + 10% POZZZOLAN)	C40/20 (OPC + 20% POZZOLAN)	C40/20 (OPC + 30% POZZOLAN)	C40/20 (OPC+40% POZZOLAN)	C40/20 (OPC + 50% POZZOLAN)
MIX PROPORTION	Cement	Kg	340	306	272	238	204	170
	POZZOLAN	Kg	0	34	68	102	136	170
	Water	Kg	140	140	140	140	140	140
	20mm Crushed	Kg	582	580	580	577	572	570
	10mm Crushed	Kg	425	425	425	425	425	425
	5mm Crushed	Kg	620	620	620	620	620	620
	Dune Sand Natural	Kg	345	345	340	340	340	340
	W 415	Kg	4.5	4.6	4.8	4.9	5.2	5.3
	Admixture 1	Kg	0	0	0	0	0	0
	Admixture 2	Kg	0	0	0	0	0	0
	Density of Mix	Kg/m3	2457	2455	2450	2447	2442	2440
FRESH CONCRETE TEST	DATE		7-Jul-15	7-Jul-15	20-Jul-15	21-Jul-15	21-Jul-15	22-Jul-15
	Initial after 5 Mini	mm	225	230	230	220	230	235
	30 Mini	mm	210	220	210	215	220	220
	60 Mini	mm	200	175	190	180	180	195
	90 Mini	mm	185	160	180	160	160	160
	120 Mini	mm	170	100	160	140	140	130
COMP STRENGTH	24 Hrs	N/mm²	20	15	13.5	14	10.5	8
	72 Hrs (3 Days)	N/mm²	39	35.5	34	32.5	29	28.5
	7 Days	N/mm²	47.5	45.5	44	41.5	38.5	35.5
	28 Days	N/mm²	58	52.5	53	49.5	47	46.5
	REMARKS							

B. Test Result By Union Cement - UAE

شركة اسمنت الاتحاد (ش.م.ع)
UNION CEMENT COMPANY (P.S.C.)

Dated: 09-08-15

Subject: Pozzolona Analysis Report

02 Samples received from M/s Peakward Enterprises (Holding) Ltd. Chemical analysis and sieve analyses are as under

Chemical parameters (%)	Grounded Pozzolona	Ungrounded Pozzolona
SiO2	66.65	54.37
Al2O3	13.34	12.97
Fe2O3	2.02	1.63
CaO	9.91	20.20
MgO	0.82	2.50
K2O	3.52	2.28
Na2O	0.88	0.90
SO3	0.33	0.26
TiO2	0.21	0.31
LOI	3.37	3.96
Moisture	0.24	0.25
Sieve Analysis		
>2mm	Nil	3.32
>1mm	Nil	7.94
>90micron	0.25	30.25
>45 micron	5.98	31.54
<45 micron	93.77	3.32

CASE: 01: Trial with Grounded Pozzolona

Pozzolona cement produced by using different proportions of OPC and pozzolona material is as under. For this purpose, we used OP cement and mix with grounded pozzolna and grind in laboratory ball mill with following proportions to reduce the size of material. Following are the proportions;

Reference Cement Sample: 90.5% Clinker+4.5% Gypsum+5.0% Limestone

Trial #A: 90%Reference sample +10 % Grounded Pozzolona

Trial #B: 80% Reference sample +20% Grounded Pozzolona

Trial #C: 70% Reference sample + 30% Grounded Pozzolona

CHEMICAL ANALYSIS

Chemical parameters (%)	Reference Cement	Trial #A	Trial #B	Trial #C
SiO2	18.68	22.49	26.32	28.52
Al2O3	4.58	5.62	6.58	7.36
Fe2O3	3.48	3.27	3.31	3.27
CaO	63.68	58.95	57.47	54.64
MgO	1.40	1.24	1.23	1.18
K2O	0.69	0.83	0.94	0.99
Na2O	0.15	0.25	0.31	0.39
SO3	2.63	2.07	1.93	1.66
LOI	3.54	3.56	3.68	3.66
Free Lime	1.24	1.30	1.21	1.20
Alkali equivalent	0.60	0.80	0.93	1.04
Physical Analysis				
Blaine(Cm2/gm)	3461	4265	5080	5150
Residue 45µ	7.5	6.20	7.40	5.7
Residue 90 µ	0.50	1.80	1.50	1.1
Consistency (%)	26.2	26	27	28.4
Expansion(mm)	0.90	0.75	0.85	1.0
Initial Setting time (Minutes)	140	130	150	160

Final Setting time(Minutes)	245	250	250	240
Compressive Strength(MPa)				
2 Days	23.7	25.1	23.7	19.96
7Days	36.5	37.2	36.0	31.20
28 Days	49.10	47.40	46.80	43.10
POZZOLANIC ACTIVITY (is determined as Strength Activity Index (SAI) ASTM C 618)				
7Days (SAI)	93.22			
28 Days(SAI)	91.96			

CASE: 02: **Trial with Ungrounded Pozzolona**

Pozzolona cement produced by using different proportions of Clinker, gypsum and pozzolona material grinding in laboratory Ball Mill to reduce the size of the materials. Following are the proportions;

Trial #D: 85%Clinker+ 5.0% Gypsum +10 % Grounded Pozzolona

Trial #E: 80% Clinker+5.0% Gypsum +20% Grounded Pozzolona

Trial #F: 70% Clinker+5.0%gypsum+ + 30% Grounded Pozzolona

CHEMICAL ANALYSIS

Chemical parameters (%)	Trial #D	Trial #E	Trial #F
SiO2	22.73	24.86	27.34
Al2O3	6.04	6.56	7.32
Fe2O3	3.71	3.57	3.44
CaO	59.48	56.55	53.33
MgO	1.75	1.84	1.88
K2O	0.96	1.09	1.27
Na2O	0.11	0.11	0.11
SO3	2.91	2.72	2.44
LOI	1.25	1.54	1.81
Free Lime	1.20	1.10	1.14
Alkali equivalent	0.74	0.83	0.94
Physical Analysis			
Blaine(Cm2/gm)	5500	5740	6040
Residue 45µ	9.5	7.4	6.7
Residue 90 µ	3.40	2.0	1.10
Consistency (%)	27.8	28.0	28.8
Expansion(mm)	0.80	0.75	0.85
Initial Setting time (Minutes)	125	120	155
Final Setting time(Minutes)	240	230	230
Compressive Strength(MPa)			
2 Days	33.8	31.1	28.7
7Days	45.2	41.70	40.90
28 Days	53.60	52.4	51.80

RAFIQUE ARSHAD
Chief Quality Control

Cc: GM Technical Advisor
Production Manager
Marketing Manager
Quality Assurance Manager

X.Conclusion on Pozzolana Concrete Test Result

A. Compressive Strength Result By Unibeton shown that Concrete With Pozzolana (20-30 %) gained low result but still meet the standard for Concrete.

- This happen due to the phenomena of Pozzolanic slow reaction (Below 28 days, Hydration Process still running and $Ca(OH)_2$ content were not fully optimized).
- After 28 Days, it will surpass the reference OPC and CHS will fully formed and fill the concrete pores (filler effect).
- At 90 days it will achieve a Peak of Compressive Strength and will support a long-term strength and durability of concrete.

B. Test Result By Union Cement

- Chemical Composition meet the req.

- It is shown that the finer the cement, the quicker the compressive strength development for mortar as well as for concrete.

- Sieve residue of slag on 45 micron = 3% on the other hand sieve residue on 45 micron for pozzolan = 12 %. The different in sieve residue on 45 micron will affect the rate of strength development significantly, since we can also said that either mortar or concrete are composite material

- Theoretically, the particle of cement between 30 micron – 5 micron play important role for the quality and physical properties of cement

- The Strength development of concrete mix with GGBS slag has quicker/ higher strength development compare with concrete mix with Pozzolana. In 90 Days, Pozzolana Compressive Strenght will increase significantly.

- The blaine value check by Union Cement, for every product development trials, the higher the percentage of pozzolan as 3rd materials the higher the blaine value

XI.Sieve Residue as Quality Target

- When we grind materials (clinker, gypsum, pozzolan) with different grindability, the blaine value is sometime misleading (not correct value), especially, since pozzolan is lot easier to grind than clinker and gypsum
- Controlling the quality of blended cement (process control), the sieve residue is the process quality target instead of blaine value (finesse).
- Therefore in concrete trial test, we also have to grind pozzolana as fine as slag (sieve residue of 45 micron = 3%)

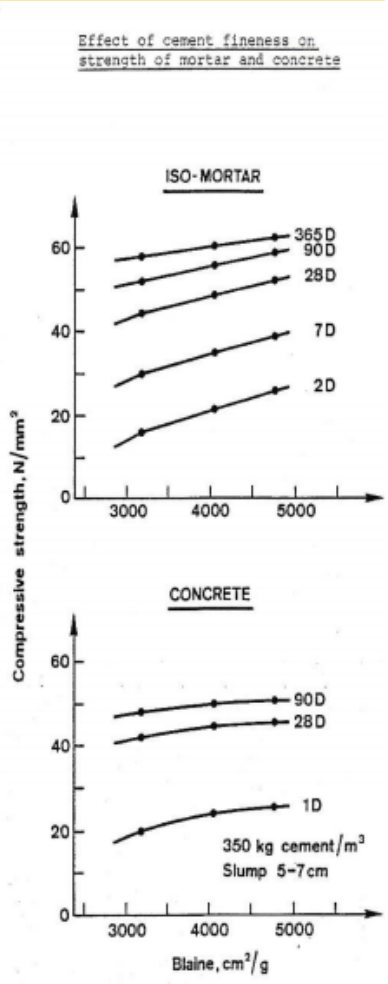
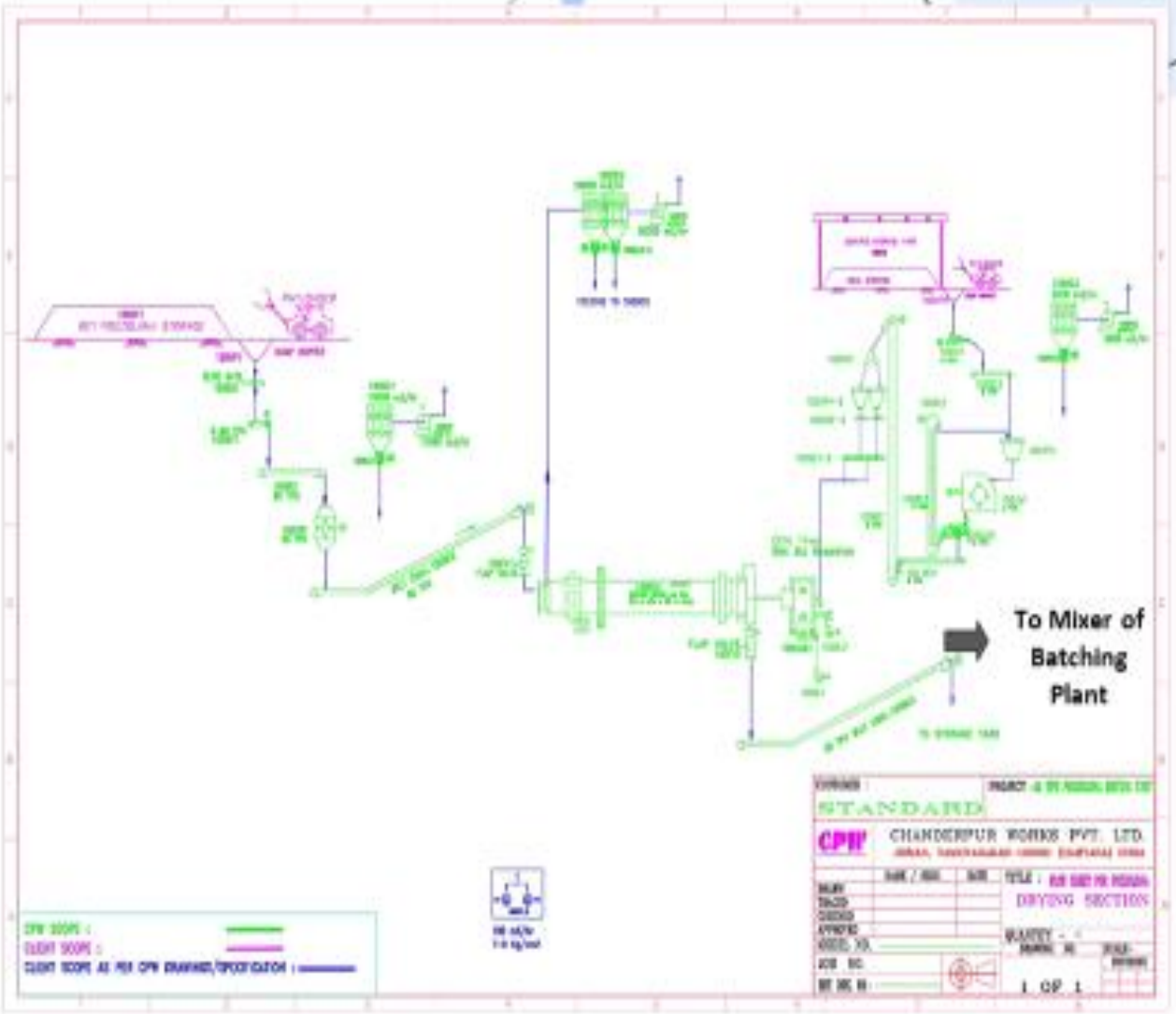
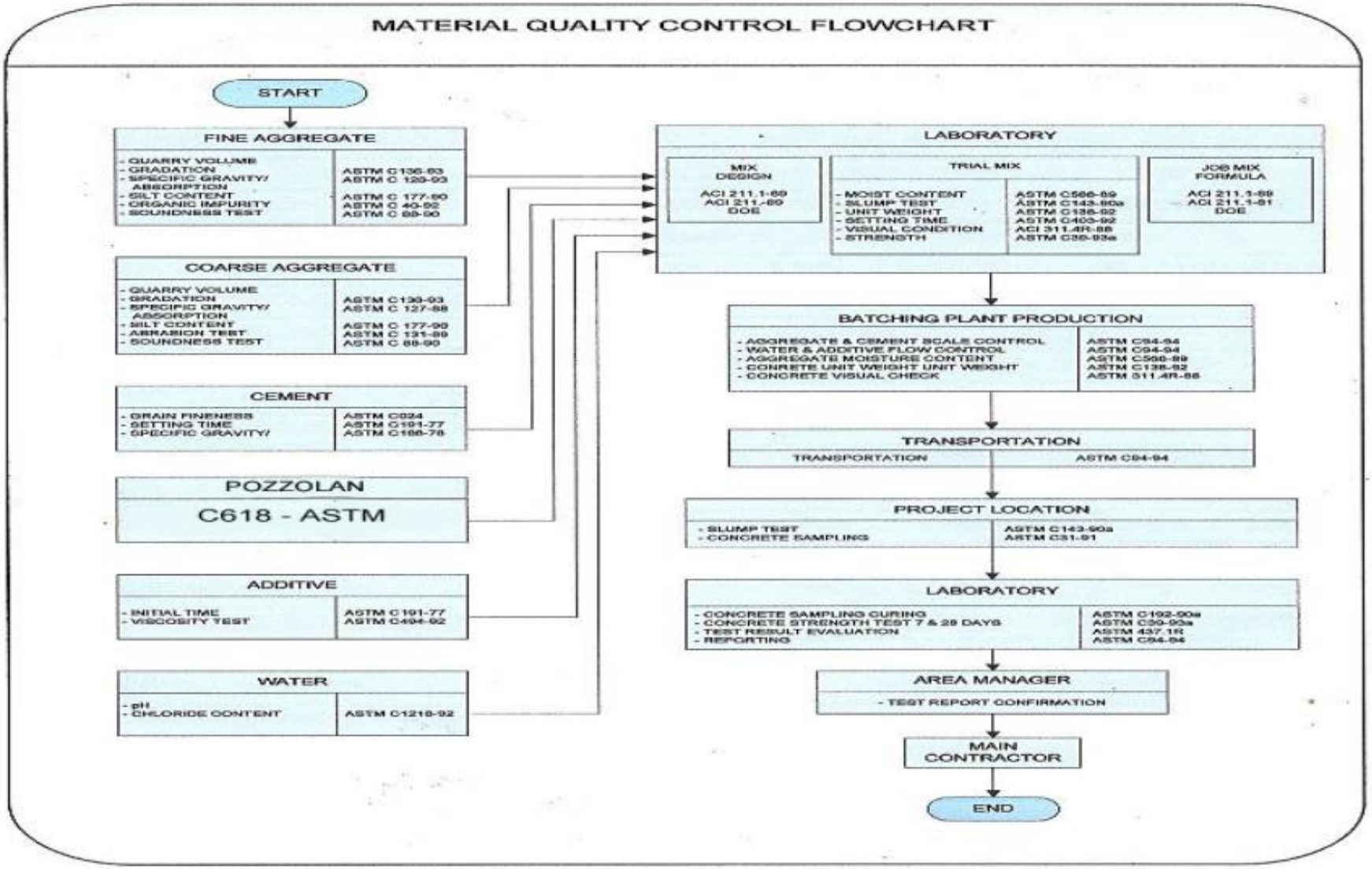
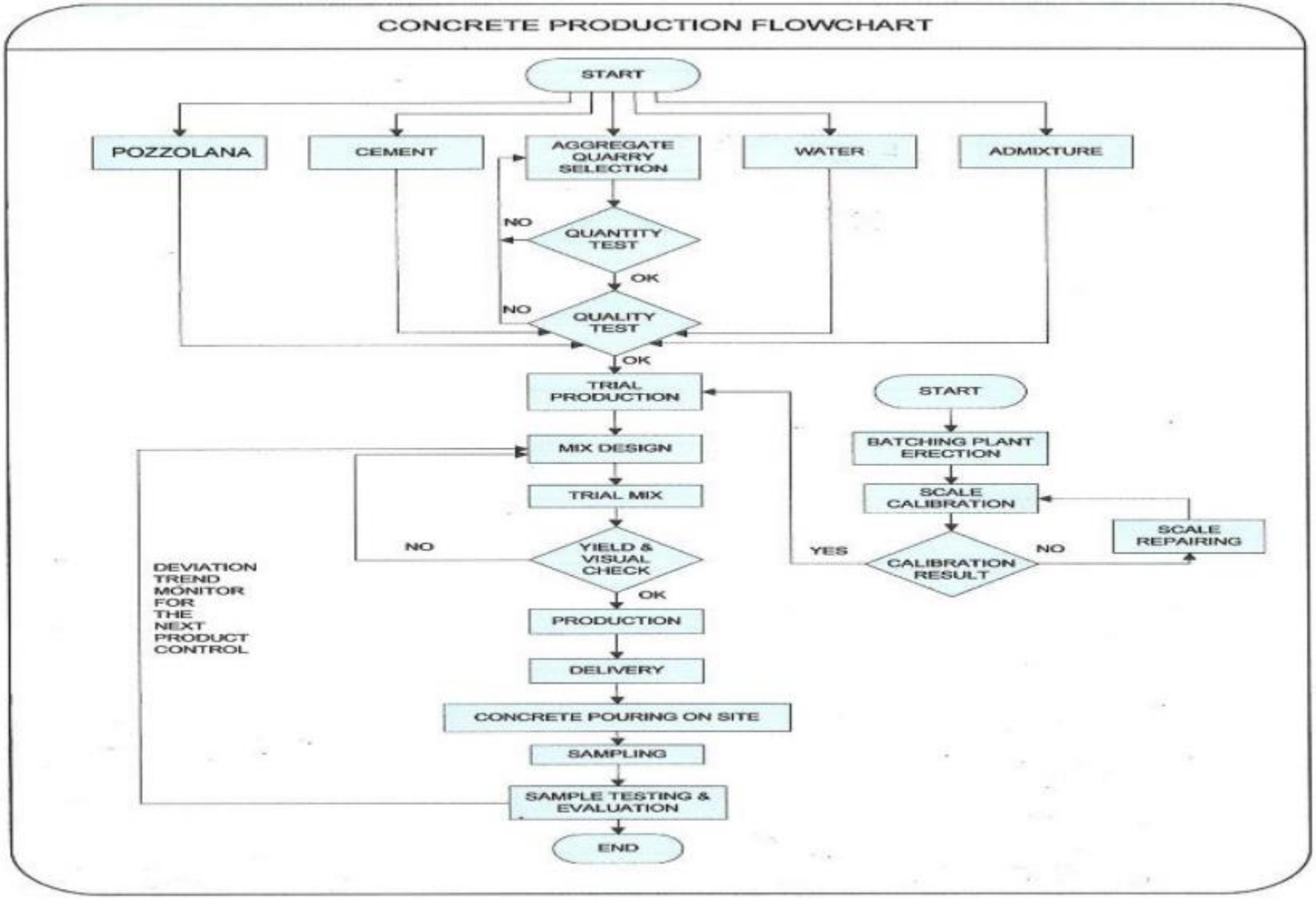


Diagram of Pozzolan Grinding and Drying Mill




MATERIAL QUALITY CONTROL FLOWCHART
START
FINE AGGREGATE
- QUARRY VOLUME
- GRADATION
- SPECIFIC GRAVITY/ ABSORPTION
- SILT CONTENT
- ORGANIC IMPURITY
- SOUNDNESS TEST
ASTM C136-93
ASTM C 128-93
ASTM C 177-90
ASTM C 40-92
ASTM C 88-90
COARSE AGGREGATE
- QUARRY VOLUME
- GRADATION
- SPECIFIC GRAVITY/ ABSORPTION
- SILT CONTENT
- ABRASION TEST
- SOUNDNESS TEST
ASTM C136-93
ASTM C 127-88
ASTM C 177-90
ASTM C 131-89
ASTM C 88-90
CEMENT
- GRAIN FINENESS
- SETTING TIME
- SPECIFIC GRAVITY/
ASTM C024
ASTM C191-77
ASTM C188-78
POZZOLAN
C618 - ASTM
ADDITIVE
- INITIAL TIME
- VISCOSITY TEST
ASTM C 191-77
ASTM C494-92
WATER
- pH
- CHLORIDE CONTENT
ASTM C1218-92
LABORATORY
MIX DESIGN
ACI 211.1-89
ACI 211.-89
DOE
TRIAL MIX
- MOIST CONTENT
- SLUMP TEST
- UNIT WEIGHT
- SETTING TIME
- VISUAL CONDITION
- STRENGTH
ASTM C566-89
ASTM C143-90a
ASTM C138-92
ASTM C403-92
ACI 311.4R-88
ASTM C39-93a
JOB MIX FORMULA
ACI 211.1-89
ACI 211.1-91
DOE
BATCHING PLANT PRODUCTION
- AGGREGATE & CEMENT SCALE CONTROL
- WATER & ADDITIVE FLOW CONTROL
- AGGREGATE MOISTURE CONTENT
- CONRETE UNIT WEIGHT UNIT WEIGHT
- CONCRETE VISUAL CHECK
ASTM C94-94
ASTM C94-94
ASTM C566-89
ASTM C138-92
ASTM 311.4R-88
TRANSPORTATION
TRANSPORTATION
ASTM C94-94
PROJECT LOCATION
- SLUMP TEST
- CONCRETE SAMPLING
ASTM C143-90a
ASTM C31-91
LABORATORY
- CONCRETE SAMPLING CURING
- CONCRETE STRENGTH TEST 7 & 28 DAYS
- TEST RESULT EVALUATION
- REPORTING
ASTM C192-90a
ASTM C39-93a
ASTM 437.1R
ASTM C94-94
AREA MANAGER
- TEST REPORT CONFIRMATION
MAIN CONTRACTOR
END


CONCRETE PRODUCTION FLOWCHART
START
POZZOLANA
CEMENT
AGGREGATE QUARRY SELECTION
WATER
ADMIXTURE
NO
QUANTITY TEST
OK
NO
QUALITY TEST
OK
TRIAL PRODUCTION
MIX DESIGN
TRIAL MIX
NO
YIELD & VISUAL CHECK
OK
PRODUCTION
DELIVERY
CONCRETE POURING ON SITE
SAMPLING
SAMPLE TESTING & EVALUATION
END
DEVIATION TREND MONITOR FOR THE NEXT PRODUCT CONTROL
START
BATCHING PLANT ERECTION
SCALE CALIBRATION
SCALE REPAIRING
NO
YES
CALIBRATION RESULT

VI. Types of 3rd Materials

I. Natural Products:

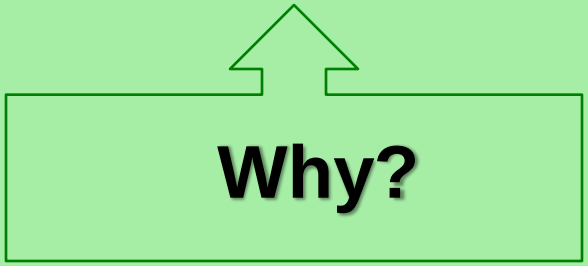
- Natural Pozzolana

II. Industrial By-Products:

- Slag
- Fly Ash

III. Other Products:

Natural Pozzolana is the best choice amongst Materials.



VII. Advantages of Using Pozzolan in Cement and Concrete Making

A. Replacing of Portland Cement Type I, (in making of Concrete, Mortar, Concrete Unit).

B. Green Material For Green Cement/Green Concrete:

- **The use of Pozzolana leads to creating Green Environment (Zero man made, CO_2 emission).**
- **Natural Pozzolana reduces Carbon Footprint of Construction Projects.**

C. Pozzolana is cost effective compared to the other materials.

D. Free from poisonous heavy elements (Cd, Hg, Pb).

E. Super Product:

- Suitable for seaside and swampy area construction.
- Medium heat of hydration that is suitable for hot climate.
- Suitable for making concrete unit (hollow brick, paving block, etc).
- Resist Acid Attack (Medium Sulphate Resistance). It is recommended practice to grind type II Clinker together with Pozzolana to increase Type II cement. Medium Sulphate Resistant becomes high Sulphate Resistant. Grinding OPC clinker together with Pozzolan obtains medium Sulphate Resistant.

F. Better Workability.

G. Prevent Alkali Silicate Reaction.

H. Reduce Creep and Shrinkage.

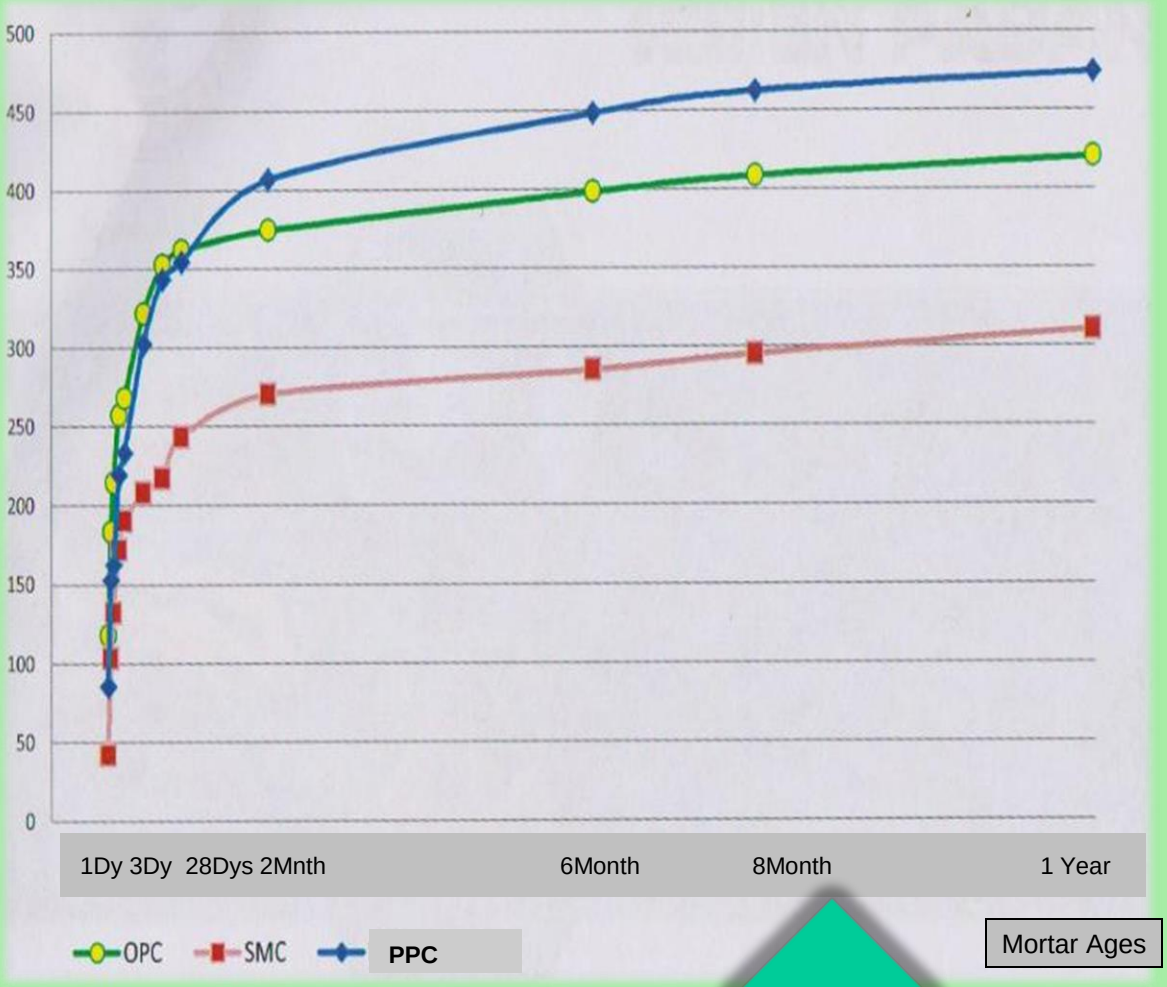
I. Less Power Consumption and Prolonged Grinding

Equipment life due to the low grind ability and small particle size of the material.

VIII. Disadvantages of Pozzolana

There are almost no drawbacks in utilizing Pozzolana in the Cement Industry, but there are some notifications:

1. Pozzolana Cement takes longer to get to full strength, however the Pozzolanic reaction keeps active until no Calcium Hydroxide is left. The compressive strength will Surpass the reference OPC by 30-40%.
2. Requires a thoroughness in mixing Pozzolana. Less of it will decrease the quality but more of it will gain nothing.



Compressive Strength Comparison

Compressive Strenght Kg/ Cm²

Age (Days)	Ordinary Portland Cement (OPC)	Pozzolan Portland Cement (PPC)
1	117	85
2	183	152
3	214	162
5	257	219
7	268	233
14	321	302
21	352	343
28	361	354
60	374	406
180	398	448
240	408	462
365	420	474

The Graph and Table above shows that the Compressive Strength of Portland Pozzolana Cement will surpass OPC after 28 Days. Pozzolana Cement takes longer to get to full strength, however the Pozzolanic reaction keeps active until no Calcium Hydroxide is left. The compressive strength will Surpass the reference OPC by 30-40%.

Concrete Compressive Strength Comparation Between Type I (OPC) and Portland Pozzolan Cement (Cement + Aggregate + Sand + Water)

	Description	Unit	Type I/ OPC	PCC	Type I / OPC	PCC
			K - 225		K - 350	
I.	**Komposisi (m3)**					
	- Cement	kg	**320**	**320**	**400**	**400**
	- Water	liter	**185**	**185**	**185**	**185**
	- Sand	kg	**680**	**680**	**675**	**675**
	- Split 2/3	kg	**1040**	**1040**	**1040**	**1040**
	- W/C		**0,58**	**0,58**	**0,48**	**0,48**
II	**Result :**					
	- Slump	cm	**10,0**	**10,0**	**10,2**	**8,0**
III.	**Compressive Strenght :**					
	- 7 Days (Cylinder)	kg/cm2	**151**	**153**	**242**	**251**
	- 28 Days (Cylinder)	kg/cm2	**216**	**219**	**346**	**359**
	- 28 Days (Conversion to cube)	kg/cm2	**260**	**264**	**417**	**433**

PPC = 70% clinker+25% Pozzolan + 5 % Gypsum
OPC = 95% clinker+5% gypsum

High Compressive Strength Concrete Using Pozzolan Portland Cement (Various Design)

Composition 1 m^3	Unit	I	II	III	IV	V	VI
1. Cement	kg	515	530	513	528	529	523
2. Water	liter	129	205	189	234	190	238
3. Sand	kg	572	598	437	745	589	597
4. Split 5/10 mm	kg	261	248	494	198	651	450
5. Split 10/20 mm	kg	853	718	553	546	279	476
6. Additive (Sikament LN)	liter	9,30	9,54	7,85	7,91	5,29	7,53
Additive Percentage	%	1,81	1,80	1,50	1,50	1,00	1,50
Water Cement Ratio (W/C)		0,25	0,39	0,52	0,45	0,36	0,50
Slump	cm	9,2	9,2	10,4	10,5	9,5	12,0
Test Result							
Compressive Strenght Using Cylinder Concrete (28 Days)	**kg/cm^2**	**644**	**609**	**596**	**564**	**561**	**549**
(K)	**kg/cm^2**	**776**	**734**	**718**	**679**	**676**	**662**

Various Result Indicated PPC Could Produce Highly Strength Concrete

IX. Pozzolana use for Sustainable Development

Sources of CO2 Emission from Cement Plant:

- **Calcination Process in Kiln :**

  $CaCO_3$ □ $CaO + CO_2$

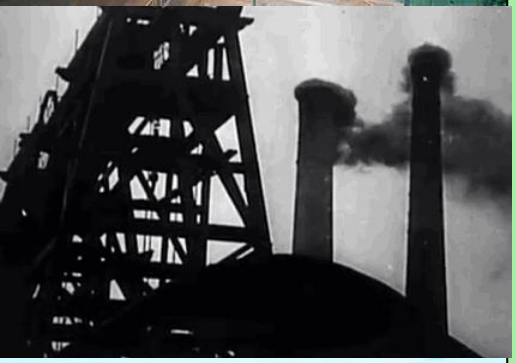
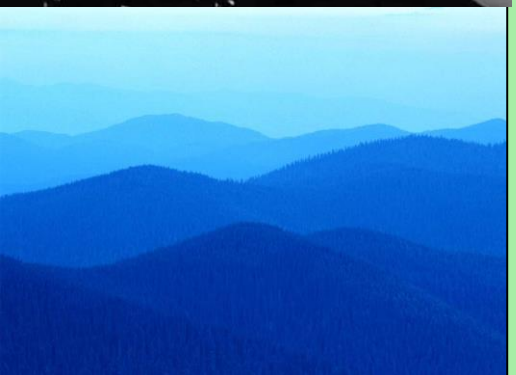
- **Oxidation Process of (Coal Burning) in Kiln □ Heat:**

  $C + O_2 \rightarrow CO_2$

- **CO2 Produced by Electrical Energy Consumption.**

- ✓ By replacing 30 - 40% of clinker with natural pozzolana. CO_2 emission can be reduced significantly (Up to 30 %).
- ✓ Abu Dhabi Urban Planning Council Centre has initiated "The Pearls Design System", as a guide of designing sustainable buildings using natural pozzolona.
- ✓ Dubai Municipality have initiated to include natural pozzolona into the calculator for concrete mix design.



Issue

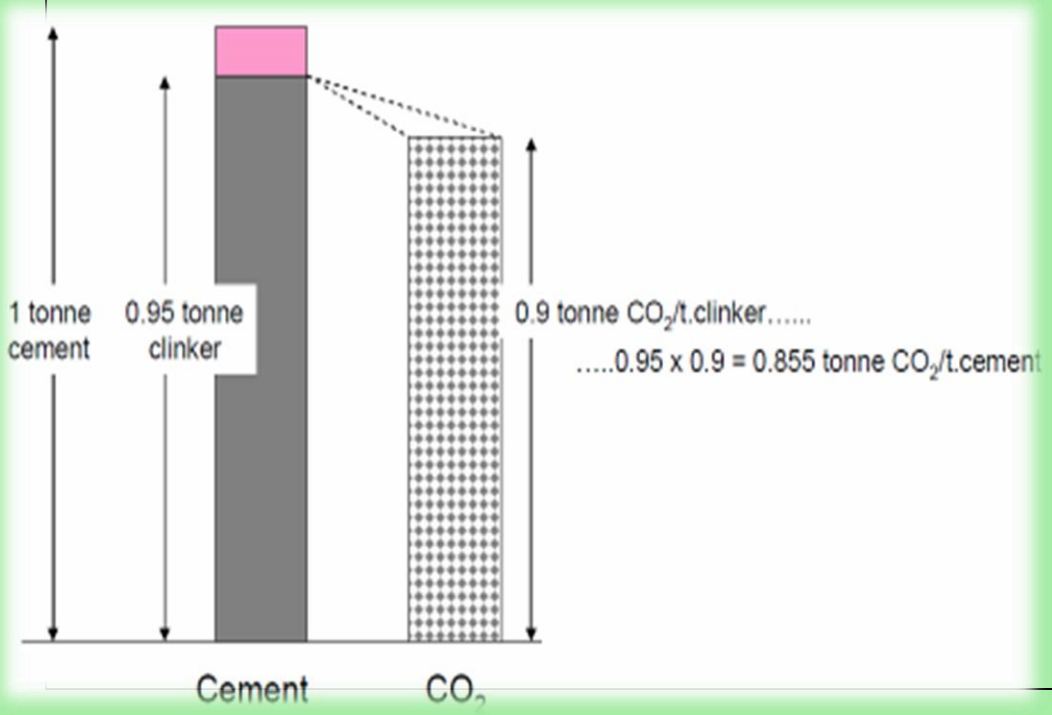
CO_2

- CO_2 has been a main cause of Greenhouse Effect. The cement industry is one of the primary producers of Carbon Dioxide.

- CO_2 emissions to the air tend to increase from time to time.

In Producing 1 Ton Portland Cement, (95% Clinker + 5% Gypsum)

→ 0.9 Ton CO_2 will be emitted into the air.



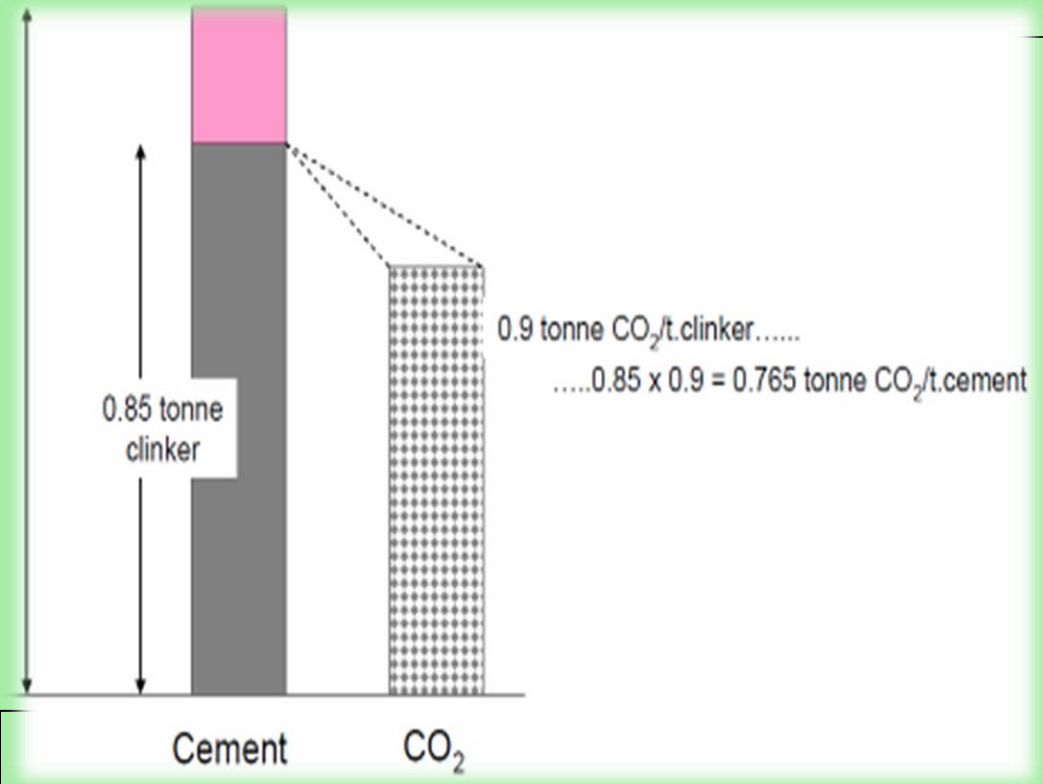
Source of CO_2 From Cement:

A. From Burning of Material of Clinker ($CaCO_3$ = CaO + CO_2)

B. Coal Burning / Liquid Burning / Gas → CO_2

C. Combustion Reaction (CHO + O_2 → H_2O + CO_2 + Heat)

D. Grinding Process, Electrical Energy Converted → CO_2



If we reduce clinker by 10%, CO_2 emission will be reduced:

0.865 Ton – 0.765 Ton = 0.10 / Ton Clinker - CO_2

Replacing 10% of Clinker with Pozzolana. CO_2 Emissions will be reduced by 10%.

THANK YOU

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