



INTRODUCING FLY ASH INTO READY MIXED CONCRETE



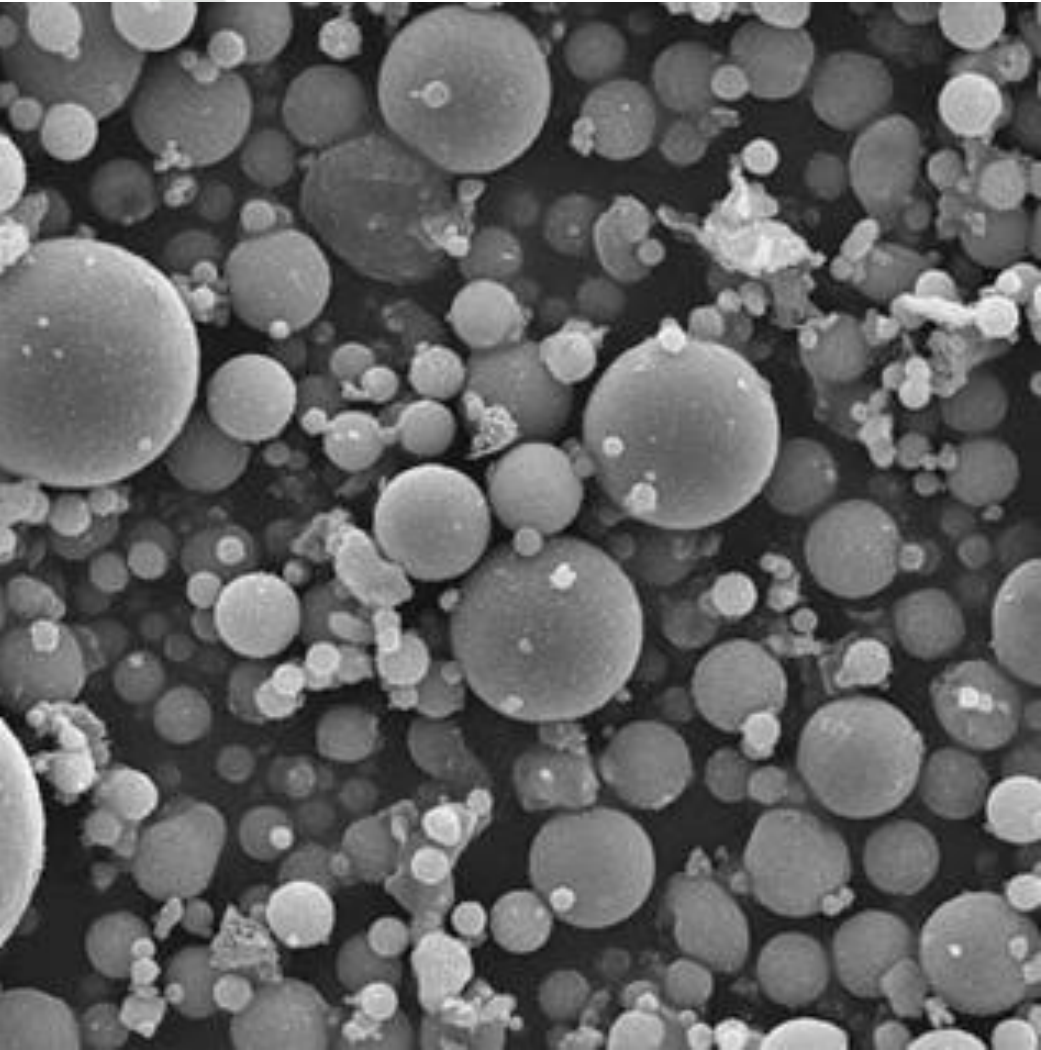
READYMIX



CONTENTS

- ❑ Introduction
- ❑ Nature of Fly Ash
- ❑ Production
- ❑ Fly Ash Classification
- ❑ Benefits of Fly Ash on Concrete
 - Fresh Concrete Properties
 - Hardened Concrete Properties
 - Durability of Concrete
- ❑ Environmental Impact
- ❑ Readymix Concrete experience
- ❑ Project references
- ❑ Summary

What Is 'Fly Ash'?



Fly ash is a by-product of burning pulverized coal in an electrical generating station. Specifically, it is the unburned residue that is carried away from the burning zone in the boiler by the flue gases and then collected by either mechanical or electrostatic precipitators.

Quality Is Our Strength

What Is 'Fly Ash'?



Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. A supplementary cementitious material when used in conjunction with portland cement contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity or both.

Quality Is Our Strength

Physical Aspect



The fly ash from the boilers where mechanical collectors are used is coarser than fly ash from electrostatic precipitators

The color varies from light to dark grey depending upon its carbon contents

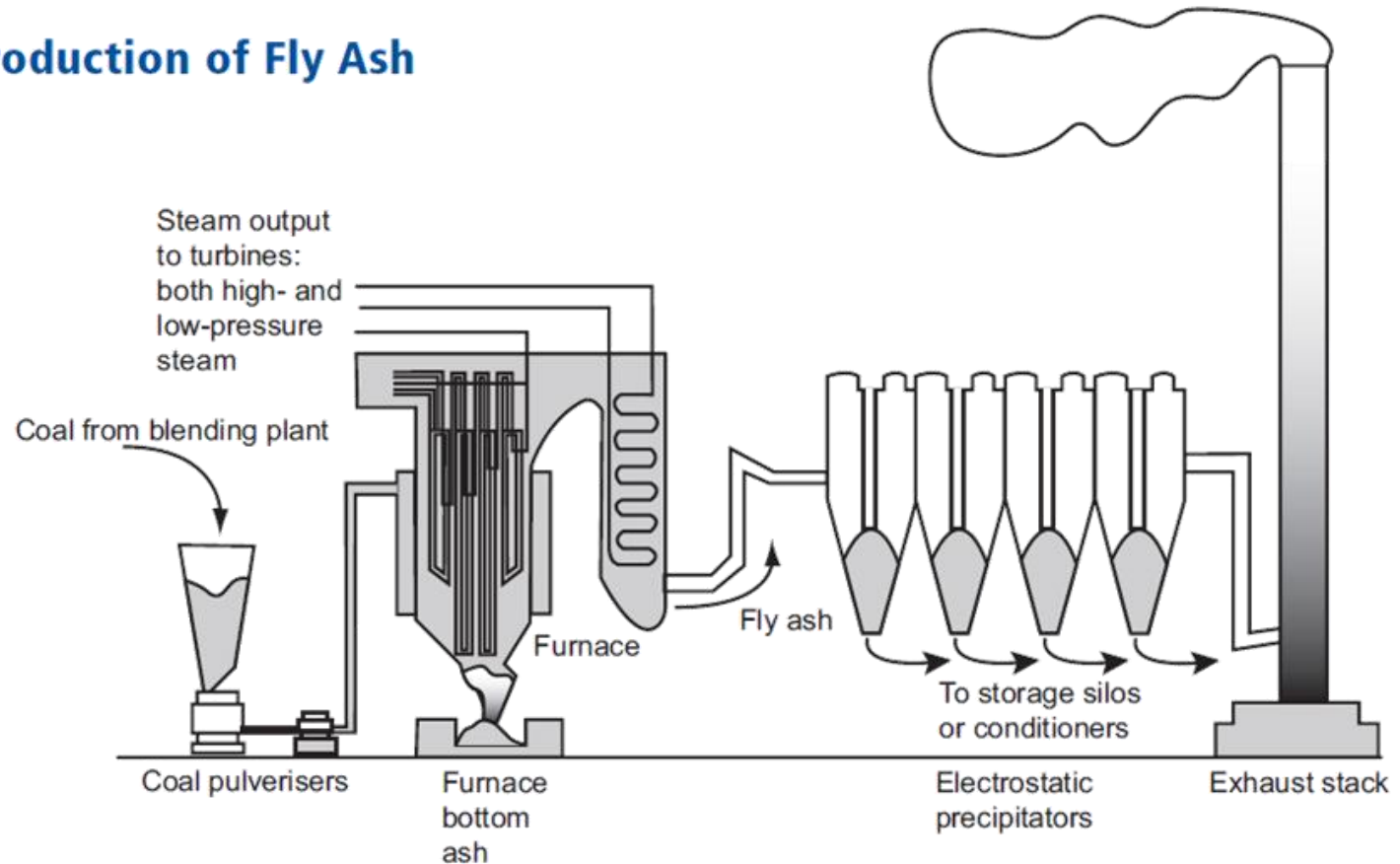
The quality of fly ash varies from source to source

Fly ash particles are small, they effectively fill voids

How does Fly Ash produced?



Production of Fly Ash



Quality Is Our Strength

Why Fly Ash?



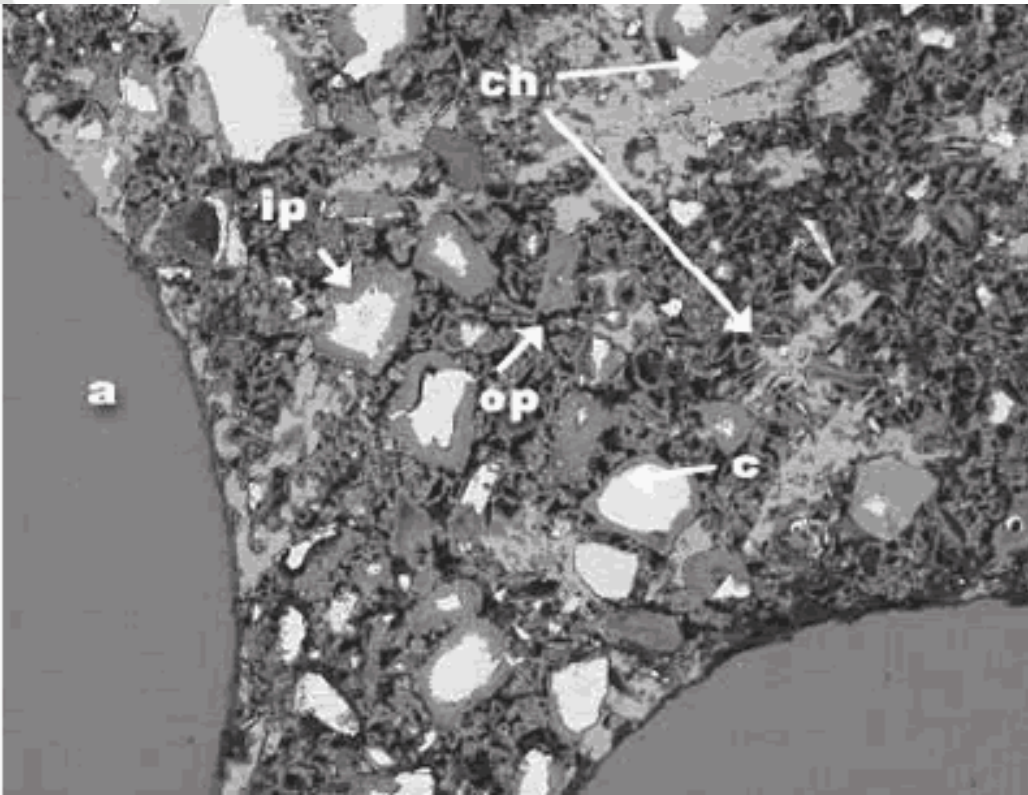
Fly ash has a high amount of silica and alumina in a reactive form. These reactive elements complement hydration chemistry of cement.

When cement reacts with water, we say that hydration of cement has began and produces C-S-H (Calcium-Silicate-Hydrate) Gel.

C-S-H Gel binds the aggregates together and strengthens concrete.

Quality Is Our Strength

Why Fly Ash?



However, one more compound is produced on hydration that is so different in behaviour. It is non other than the Calcium Hydroxide Ca(OH)_2 .

In construction industry, it is generally referred to as **Free Lime**.

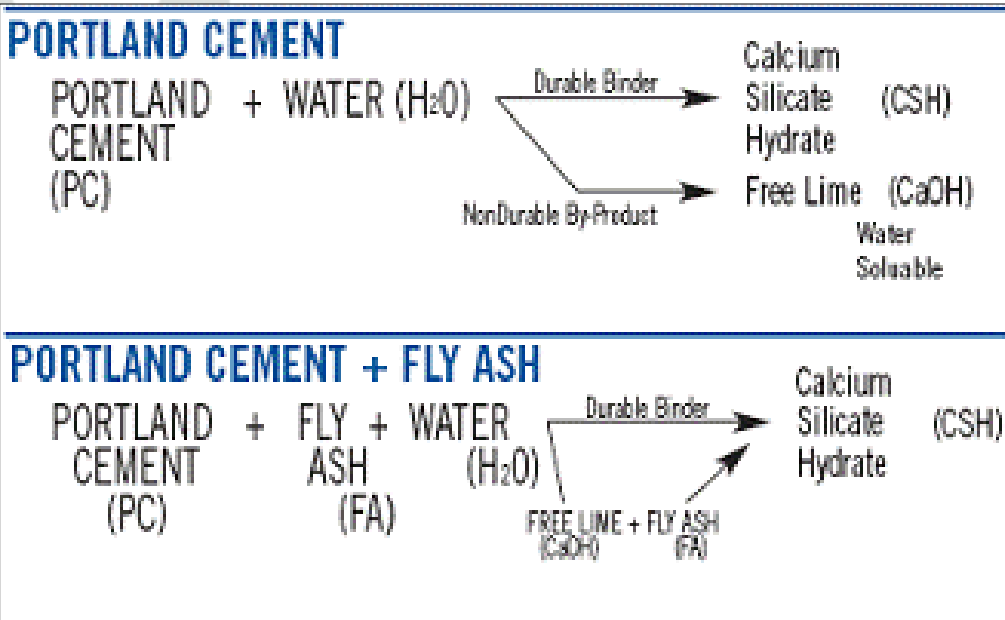
Why Fly Ash?



Aggressive environmental agents like water, sulphates, CO_2 attack this free lime leading to deterioration of the concrete.

Quality Is Our Strength

Why Fly Ash?



Fly ash, on itself, can not react with water. It needs *free lime*, produced on hydration of Portland cement, to trigger off its Pozzolanic effect.

Once it is triggered, it can go on and on!

Definition: A pozzolan is defined as a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value, but that will, in finely divided form and in the presence of moisture, **chemically react with calcium hydroxide** at ordinary temperatures to form compounds having cementitious properties

Why Fly Ash?



In simple words, all this means a much longer life for our concrete structure.

Quality Is Our Strength

Concrete Performance



Specific benchmarks have been set up to evaluate the performance of concrete with respect to durability—mainly Strength and Permeability. This means to produce a durable and long lasting concrete, it must possess: -

**High strength
And
Low permeability**

Quality Is Our Strength

Concrete Performance



Fly ash makes concrete denser, and hence less permeable, mainly by :-

- ☐ Reducing water demand in concrete
- ☐ Improving microstructure of concrete

At the same time, fly ash improves long term strength of concrete due to the **continued** Pozzolanic reaction as discussed earlier.

Quality Is Our Strength

Classification of Fly Ash

- ❑ ASTM C618 defines two (2) classes of Fly Ash:
 - ✓ Class C
 - ✓ Class F
- ❑ Primary difference between Class C and Class F fly ash are the amount of calcium, silica, alumina & iron content.

Table 2. ASTM Specification for Fly Ash

| Class | Description in ASTM C 618 | Chemical Requirements |
|-------|---|--|
| F | Fly ash normally produced from burning anthracite or bituminous coal that meets the applicable requirements for this class as given herein. This class of fly ash has pozzolanic properties. | $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 \geq 70\%$ |
| C | Fly ash normally produced from lignite or sub-bituminous coal that meets the applicable requirements for this class as given herein. This class of fly ash, in addition to having pozzolanic properties, also has some cementitious properties. Note: Some Class C fly ashes may contain lime contents higher than 10%. | $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 \geq 50\%$ |

Classification of Fly Ash



Class F

- ☐ Produced from burning harder, older anthracite and bituminous coal.
- ☐ Contains less than 15% lime.
- ☐ Requires cementing agent like PC, quick lime, hydrated lime.
- ☐ Used in high sulfate exposure conditions
- ☐ Use for structural concrete, high performance concrete, high sulfate exposure concrete.
- ☐ Useful in high fly ash content concrete mixes.

Classification of Fly Ash



Class C

- ☐ Produced from burning lignite and sub-bituminous coal.
- ☐ Higher concentration of alkali and sulfate.
- ☐ Contains more than 15% lime.
- ☐ Self-cementing properties.
- ☐ Not to be used in high sulfate conditions.
- ☐ Primarily residential construction.
- ☐ Limited to low fly ash content concrete mixes.

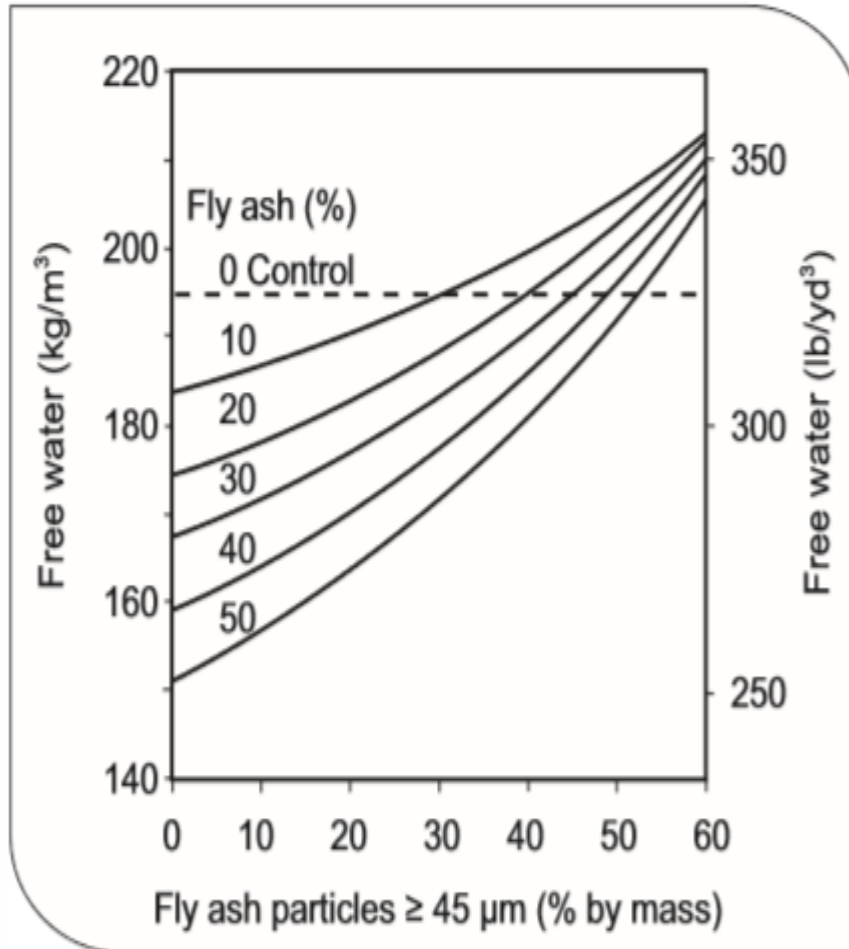
Comparison between different classes of Fly Ash & OPC



| CHEMICAL COMPOUND | POZZOLAN TYPE | | | CEMENT |
|--------------------------------------|---------------|---------|---------|--------|
| | CLASS F | CLASS C | CLASS N | |
| SiO ₂ | 54.90 | 39.90 | 58.20 | 22.60 |
| Al ₂ O ₃ | 25.80 | 16.70 | 18.40 | 4.30 |
| Fe ₂ O ₃ | 6.90 | 5.80 | 9.30 | 2.40 |
| CaO | 8.70 | 24.30 | 3.30 | 64.40 |
| MgO | 1.80 | 4.60 | 3.90 | 2.10 |
| SO ₃ | 0.60 | 3.30 | 1.10 | 2.30 |
| Na ₂ O & K ₂ O | 0.60 | 1.30 | 1.10 | 0.60 |

Quality Is Our Strength

Effects of Fly Ash in Fresh Concrete



Workability

The use of good quality fly ash with high fineness and low carbon content reduces the water demand of concrete and consequently, the use of fly ash should permit the concrete to be produced at a lower water content when compared to a portland cement concrete of the same workability.

Effects of Fly Ash in Fresh Concrete



Bleeding

Generally fly ash will reduce the rate and amount of bleeding primarily due to the reduced water demand.

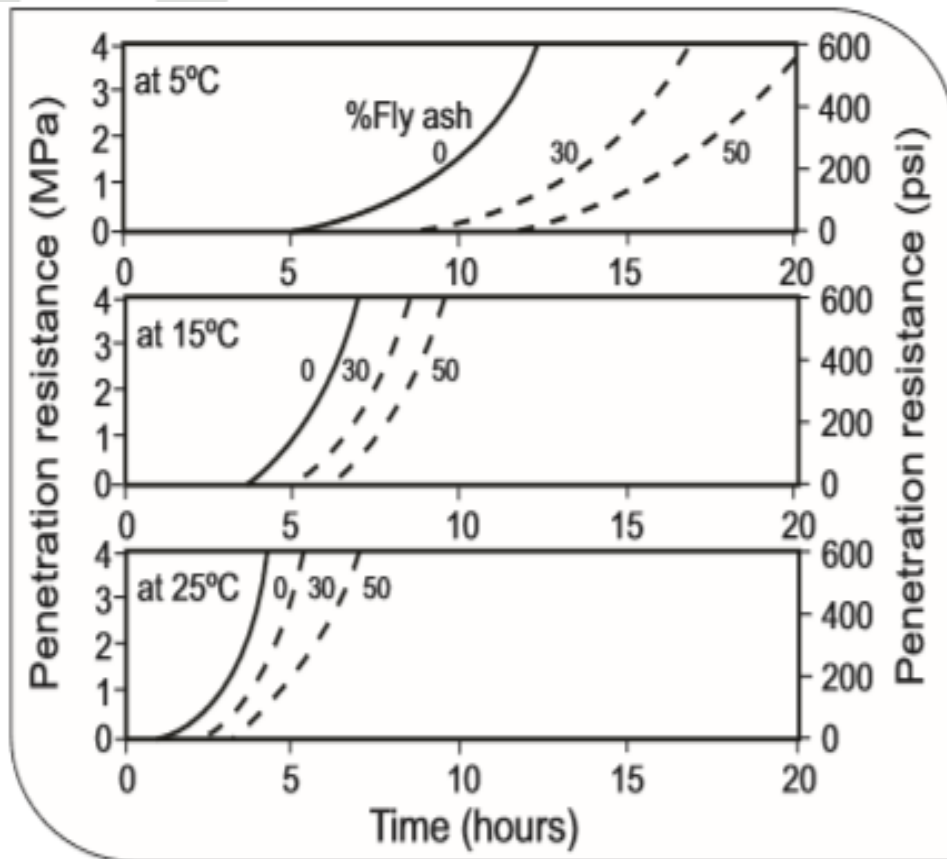
Quality Is Our Strength

Effects of Fly Ash in Fresh Concrete



Setting Time

The impact of fly ash on the setting behaviour of concrete is dependent not only on the composition and quantity of fly ash used, but also on the type and amount of cement, the water-to-cementitious materials ratio (w/cm), the type and amount of chemical admixtures, and the concrete temperature. However, it is fairly well-established that low-calcium fly ashes extend both the initial and final set of concrete.



Quality Is Our Strength

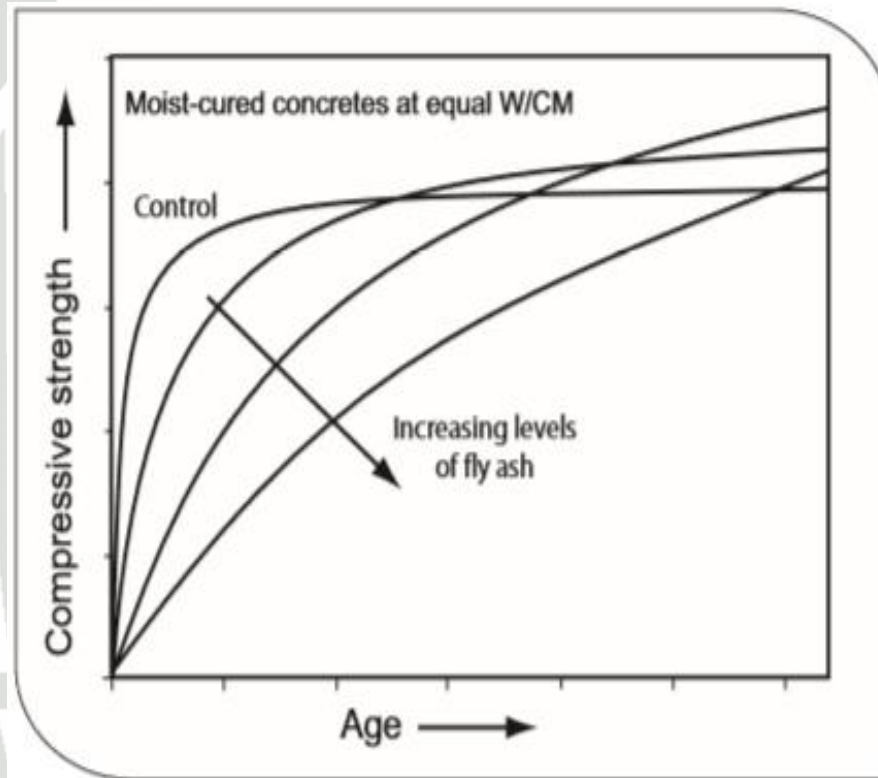
Effects of Fly Ash in Fresh Concrete



Heat of Hydration

The reduction in the rate of the heat produced and the internal temperature rise of the concrete has long been an incentive for using fly ash in mass concrete construction.

Effects of Fly Ash in Hardened Concrete



Strength Development

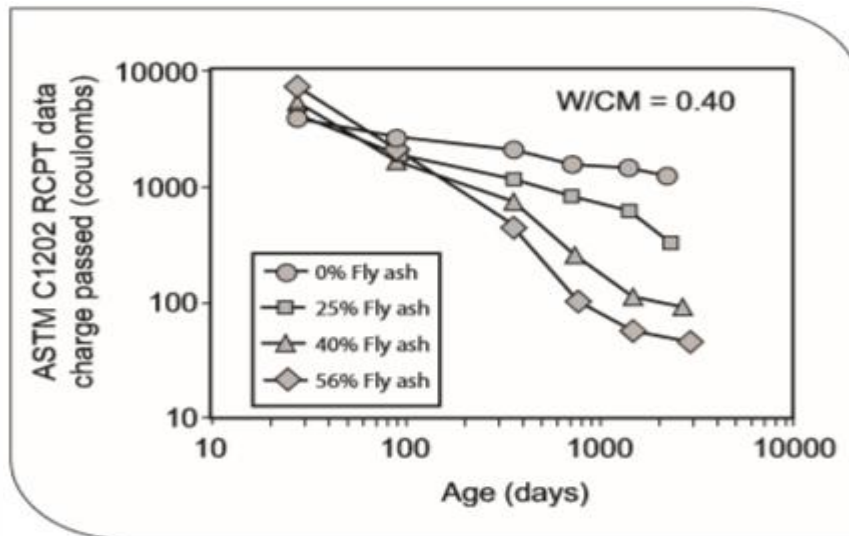
By replacing a certain amount of portland cement with the same amount of fly ash and maintaining a constant w/c. As the level of replacement increases the early-age strength decreases. However, long-term strength development is improved when fly ash is used as against portland cement concrete.

Durability of Concrete



Resistance to the Penetration of Chlorides

Fly ash reduces the permeability of concrete to water and gas provided the concrete is adequately cured (*Thomas 2002*).



This has been attributed to a refinement in the pore structure.

Durability of Concrete



Sulphate Resistance

Studies have demonstrated that the use of sufficient quantities of low-calcium Class F fly ash can increase the resistance of concrete to chemical attack when the concrete is exposed to sulphate-bearing soils or groundwater.

Quality Is Our Strength

Durability of Concrete



Alkali-Silica Reaction

It is well established that low-calcium (Class F) fly ash is capable of controlling damaging alkali-silica reaction (ASR) in concrete at moderate levels of replacement (20% to 30%) and the effect has been ascribed to the reduced concentration of alkali hydroxides in the pore solution when fly ash is present.

Quality Is Our Strength

Importance of Curing



Important for development of strength & durability properties

Prevention of moisture loss is important : (a) when W/C ratio is low (b) when cement has a high rate of strength development & (c) when concrete contains mineral admixtures

Moisture loss from concrete surface specially for thin elements, relatively high in hot & dry climate



Quality Is Our Strength

Fly Ash Is **GREEN**, Not Gray



Quote by:
Nicholas Edward,
Ready Mix USA,
19 February 2010

Quality Is Our Strength

Green Energy



Growth of cement usage leads to greater production of CO_2 which is one of the major cause of global warming

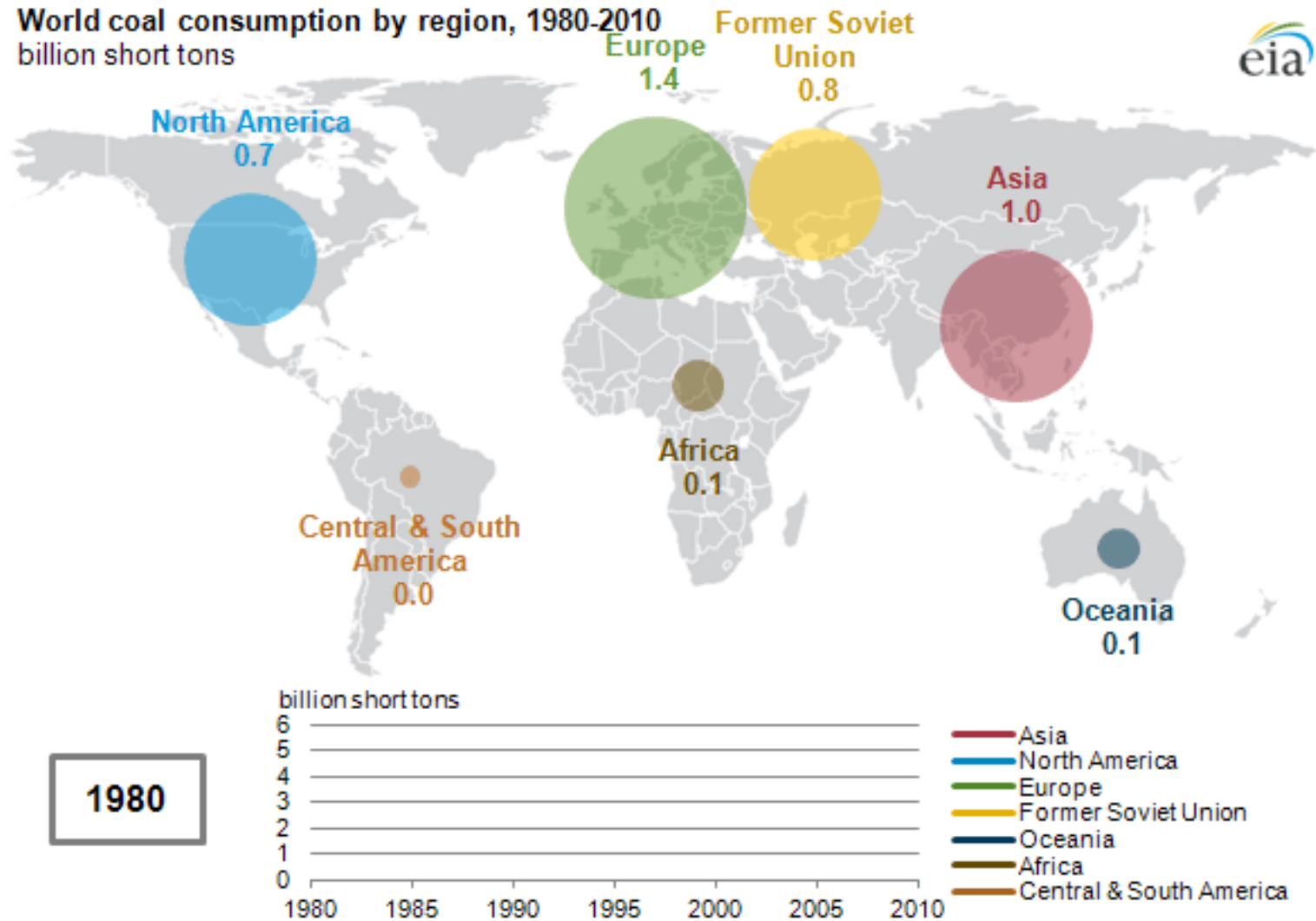
Cement industry contributes 5% of total anthropogenic CO_2 emission globally

Quality Is Our Strength

Global Coal Consumption



World coal consumption by region, 1980-2010
billion short tons



<http://www.eia.gov/>

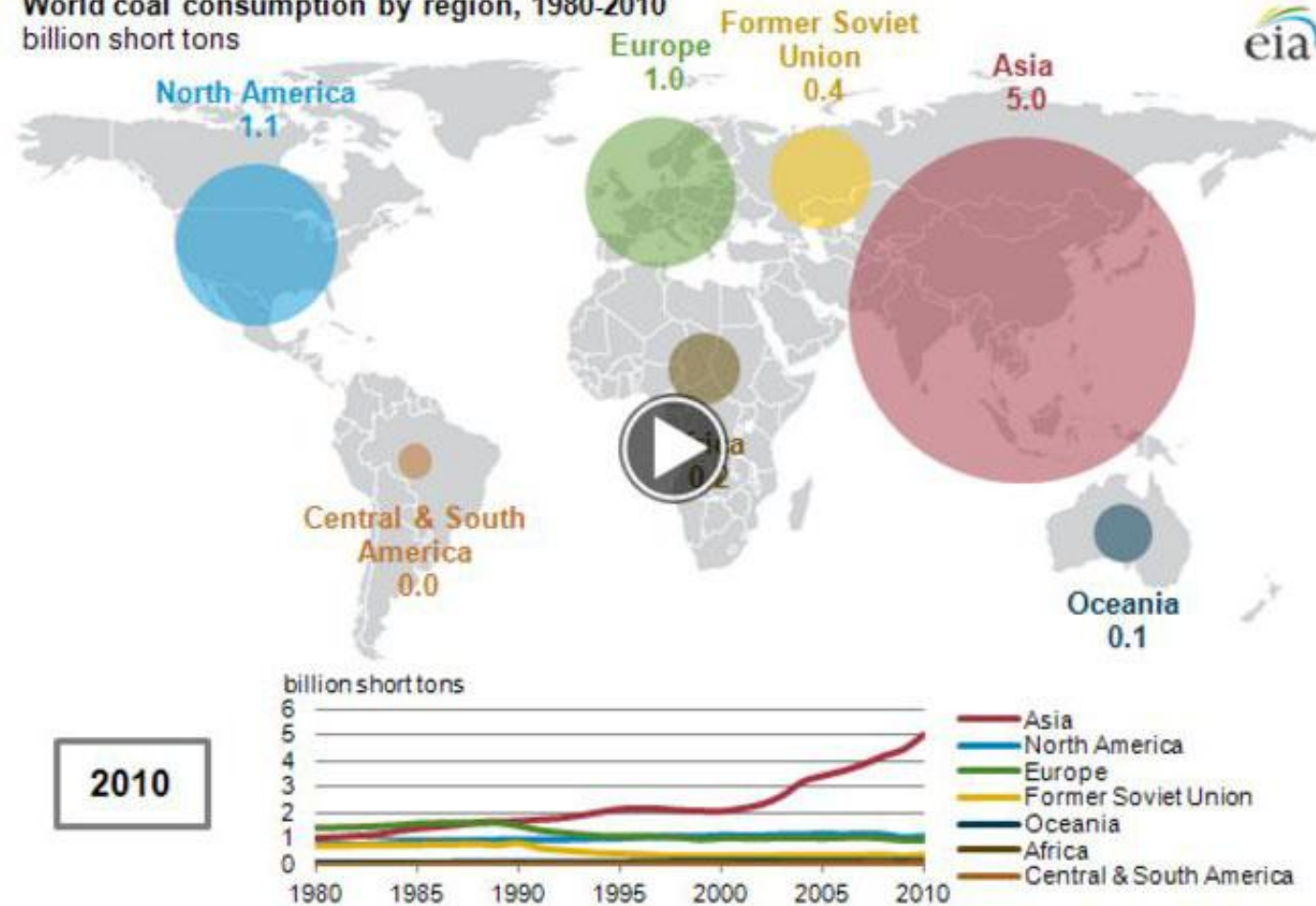
Quality Is Our Strength

Global Coal Consumption



World coal consumption by region, 1980-2010 (click to animate)

World coal consumption by region, 1980-2010
billion short tons



<http://www.eia.gov/>

Quality Is Our Strength

READYMIX EXPERIENCE



Approved Fly Ash Importer

Tuan,

PER : PERMOHONAN BAGI KEBENARAN MEMASUKKAN "FLY ASH"

Dengan hormatnya sukacita merujuk permohonan Tuan yang bertarikh 19hb Ogos, 2014 mengenai dengan perkara yang tersebut diatas.


Sehubungan dengan ini, sukacita dimaklumkan bahawa Jabatan ini tidak ada halangan bagi Syarikat Tuan untuk memasukkan "Fly Ash" bagi tujuan dalam proses pembuatan konkrit.

Sekian disampaikan untuk perhatian dan apa jua tindakan dari pihak Tuan selanjutnya.

"HIDUP BERDIKARI, KEHIDUPAN TERJAMIN"

BINA

Tel: 2444000
Faks: 2422000
Email: info@bina.gov.bn
Pusat Latihan & Pengajian



يادن كما جوان ايندوستري بروني
Badan Kemajuan Industri Brunei
Brunei Industrial Development Authority
Km. 8, Jalan Gadong, BEH18
Kementerian Perindustrian dan Sumber-Sumber Utama
NEGARA BRUNEI DARUSSALAM

04 Zulhijjah 1435
29th September, 2014

BINA/PDN/KASTAM

Yang Mulia
Ahmad Zaki bin Abdul Rahman
Pengurus Pencari Bahan Mentah
Readymix Concrete (B) Sdn Bhd
No 3B, First Floor, Bangunan Sri Nor,
Spj 158, Jln Pg Babu Raja, Kg. Kiarong BE 1318
Negara Brunei Darussalam

Tuan,

PER : PERMOHONAN BAGI KEBENARAN MEMASUKKAN "FLY ASH"


Dengan hormatnya sukacita merujuk permohonan Tuan yang bertarikh 19hb Ogos, 2014 mengenai dengan perkara yang tersebut diatas.

Sehubungan dengan ini, sukacita dimaklumkan bahawa Jabatan ini tidak ada halangan bagi Syarikat Tuan untuk memasukkan "Fly Ash" bagi tujuan dalam proses pembuatan konkrit.

Sekian disampaikan untuk perhatian dan apa jua tindakan dari pihak Tuan selanjutnya.

"HIDUP BERDIKARI, KEHIDUPAN TERJAMIN"

Dengan hormat,



(DY HAJAH MASNI BINTI HAJI MOHSIN)
b/p Pengarah,
Badan Kemajuan Industri Brunei (BINA)
Kementerian Perindustrian dan Sumber-Sumber Utama
Negara Brunei Darussalam

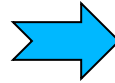
S.K. Jabatan Kastam dan Eksais Diraja

Quality Is Our Strength

READYMIX EXPERIENCE



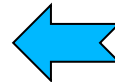
Arrived in bulk bags



Stored at warehouse



Pumped into silo



Loaded into Readymix tanker

Quality Is Our Strength

READYMIX EXPERIENCE



| Plants | Batching Capacity | Batching Software |
|--------------------------|-------------------------|---------------------------|
| P4 – Anduki Plant | 60 m ³ /hour | MHW Industrial Automation |
| P7 – Telisai Plant | 60 m ³ /hour | MHW Industrial Automation |
| P5 – Hj. Halus Plant | 60 m ³ /hour | MHW Industrial Automation |
| P23 – Sg. Akar Plant | 75 m ³ /hour | MHW Industrial Automation |
| P26 – Lugu On-Site Plant | 60 m ³ /hour | MHW Industrial Automation |



Quality Is Our Strength

READYMIX EXPERIENCE



Client: Indramas Sdn Bhd

Project: UBD Sport Complex Phase 2

Quantities: 470 m³

Date: 21 April 2015

Start: 4:45pm, 21 April 2015

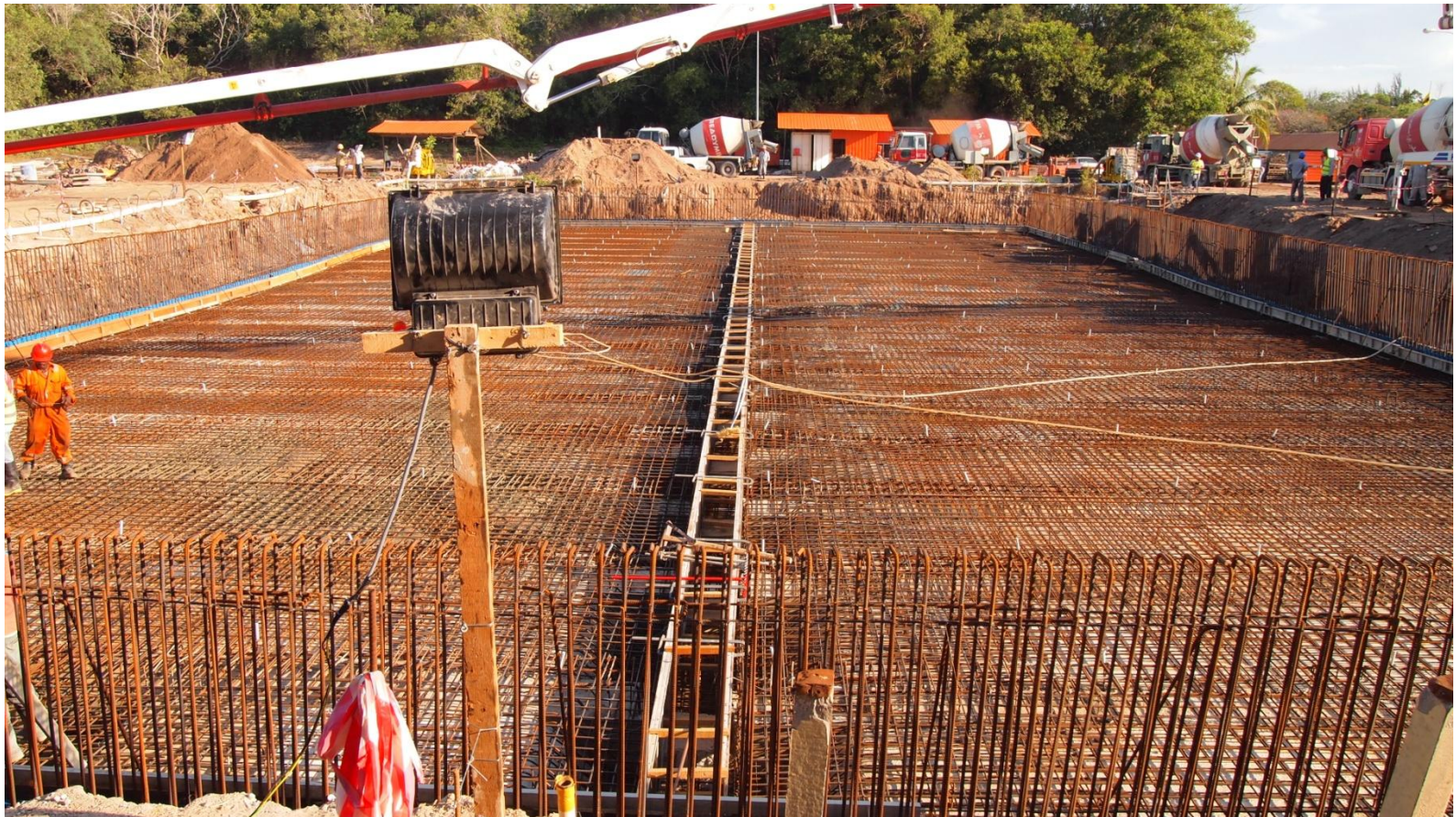
End: 00:45am, 22 April 2015

Quality Is Our Strength

READYMIX EXPERIENCE



All ready with RCB Team at site by 4:30 pm



Quality Is Our Strength

READYMIX EXPERIENCE



First discharge: 4:45pm



Quality Is Our Strength

READYMIX EXPERIENCE



As at: 7:35pm



Quality Is Our Strength

READYMIX EXPERIENCE



As at: 11:58pm



Quality Is Our Strength

READYMIX EXPERIENCE



Continuous monitoring by RCB Technical Manager



Quality Is Our Strength

READYMIX EXPERIENCE



<https://www.youtube.com/watch?v=5ldLwFSLMgM>

Quality Is Our Strength

READYMIX EXPERIENCE



24 hours



Quality Is Our Strength

READYMIX EXPERIENCE



7 days



Quality Is Our Strength

READYMIX EXPERIENCE



7 days



Quality Is Our Strength

READYMIX EXPERIENCE



7 days



Quality Is Our Strength

READYMIX EXPERIENCE



Readymix PFA Workshop 7 May 2015



Quality Is Our Strength

READYMIX EXPERIENCE



Readymix PFA Sharing with PICE 1 Nov 2015



Quality Is Our Strength

READYMIX EXPERIENCE



Test Results (100% OPC) Grade 30

| (N/mm ²) |
|----------------------|
| 84 |
| 25.37 |
| 32.12 |
| 40.92 |



Construction Material Research and Testing Section
Department of Technical Services
Public Works Department
Ministry of Development
Negara Brunei Darussalam

JKR/BKS-UBB/BR01

CONCRETE CUBE / CYLINDER TEST

A. TO BE COMPLETED BY APPLICANTS

| | | | |
|---------------------------|---------------------------------|-------------------------|-------------------|
| Project | PRODUCT DEMO | | |
| Part of Structure | TRIAL MIX | Casting Date | 07 MAY 2015 |
| Concrete Mix Grade | C30 OPC | Slump Test | 130 mm |
| Cement Type | OPC | Admixture Type | P3002 + G.A. 8588 |
| Coarse Agg. Size & Source | 20mm - D/ORITE | Fine Agg. Type & Source | SG. BAKU SAND |
| Department or Section | | Consultant | |
| Project Engineer | | Contact no: | |
| Contractor | READYMIX CONCRETE (B) SDN. BHD. | | |
| Site Supervisor | | Contact no: | 7182633 |

| Date | Cube Age (days) | Submitted by | | Signature | Quantity |
|----------|-----------------|-------------------|------------------|-----------|----------|
| | | Name | Company/Supplier | | |
| 11.05.15 | 4 | HOMEL D. CALICHAN | RCB | | 3 |
| 14.05.15 | 7 | GUERRERO ILASIN | RCB | | 3 |
| 04.06.15 | 28 | GUERRERO ILASIN | RCB | | 3 |

B. TO BE COMPLETED BY LABORATORY

| Testing Date | Cube Age (days) | Cube no. | Weight (Kg) | Density (Kg/m ³) | Dial Gauge Reading | Comp. Strength (N/mm ²) | Average Comp. Strength (N/mm ²) |
|--------------|-----------------|----------|-------------|------------------------------|--------------------|-------------------------------------|---|
| 11.05.15 | 4 | 1 | 7.940 | 2370 | 581.4 | 581.4 | 25.37 |
| | | 2 | 8.0 | 2370 | 585.0 | 26.17 | |
| | | 3 | 7.94 | 2370 | 542.5 | 24.11 | |
| 14.05.15 | 7 | 4 | 7.82 | 2310 | 720.2 | 32.01 | 32.12 |
| | | 5 | 7.96 | 2370 | 722.8 | 32.13 | |
| | | 6 | 8.04 | 2370 | 725.3 | 32.23 | |
| 04.06.15 | 28 | 10 | 7.94 | 2340 | 924.9 | 41.11 | 40.92 |
| | | 11 | 7.90 | 2340 | 901.8 | 40.09 | |
| | | 12 | 7.97 | 2370 | 935.4 | 41.57 | |

Quality Is Our Strength

READYMIX EXPERIENCE



Test Results (75% OPC + 25% PFA)

Grade 30

| (N/mm ²) |
|----------------------|
| 84 |
| 25.37 |
| 32.12 |
| 40.92 |

| |
|-------|
| 17.41 |
| 23.57 |
| 42.61 |



Construction Material Research and Testing Section
Department of Technical Services
Public Works Department
Ministry of Development
Negara Brunei Darussalam

JKR/BKS-UBB/BR01

CONCRETE CUBE / CYLINDER TEST

A. TO BE COMPLETED BY APPLICANTS

| | | | |
|---------------------------|---------------------------------|-------------------------|-------------------|
| Project | PRODUCT DEMO | | |
| Part of Structure | TRIAL MIX | Casting Date | 07 MAY 2015 |
| Concrete Mix Grade | C30 75% OPC + 25% PFA | Slump Test | 130 MM |
| Cement Type | 75% OPC + 25% PFA | Admixture Type | basol + G.A. 8538 |
| Coarse Agg. Size & Source | 20 mm DUKKE | Fine Agg. Type & Source | SG. PAU SAND |
| Department or Section | - | Consultant | - |
| Project Engineer | - | Contact no: | - |
| Contractor | READYMIX CONCRETE (S) SDN. BHD. | | |
| Site Supervisor | - | Contact no: | 782633 |

| Date | Cube Age (days) | Submitted by | | Signature | Quantity |
|----------|-----------------|-----------------|------------------|-----------|----------|
| | | Name | Company/Supplier | | |
| 11.05.15 | 4 | ARNOLD OMELIA | RCB | | 5 |
| 14.05.15 | 7 | GUERRERO ILASIN | RCB | | 3 |
| 04.06.15 | 28 | GUERRERO ILASIN | RCB | | 3 |

B. TO BE COMPLETED BY LABORATORY

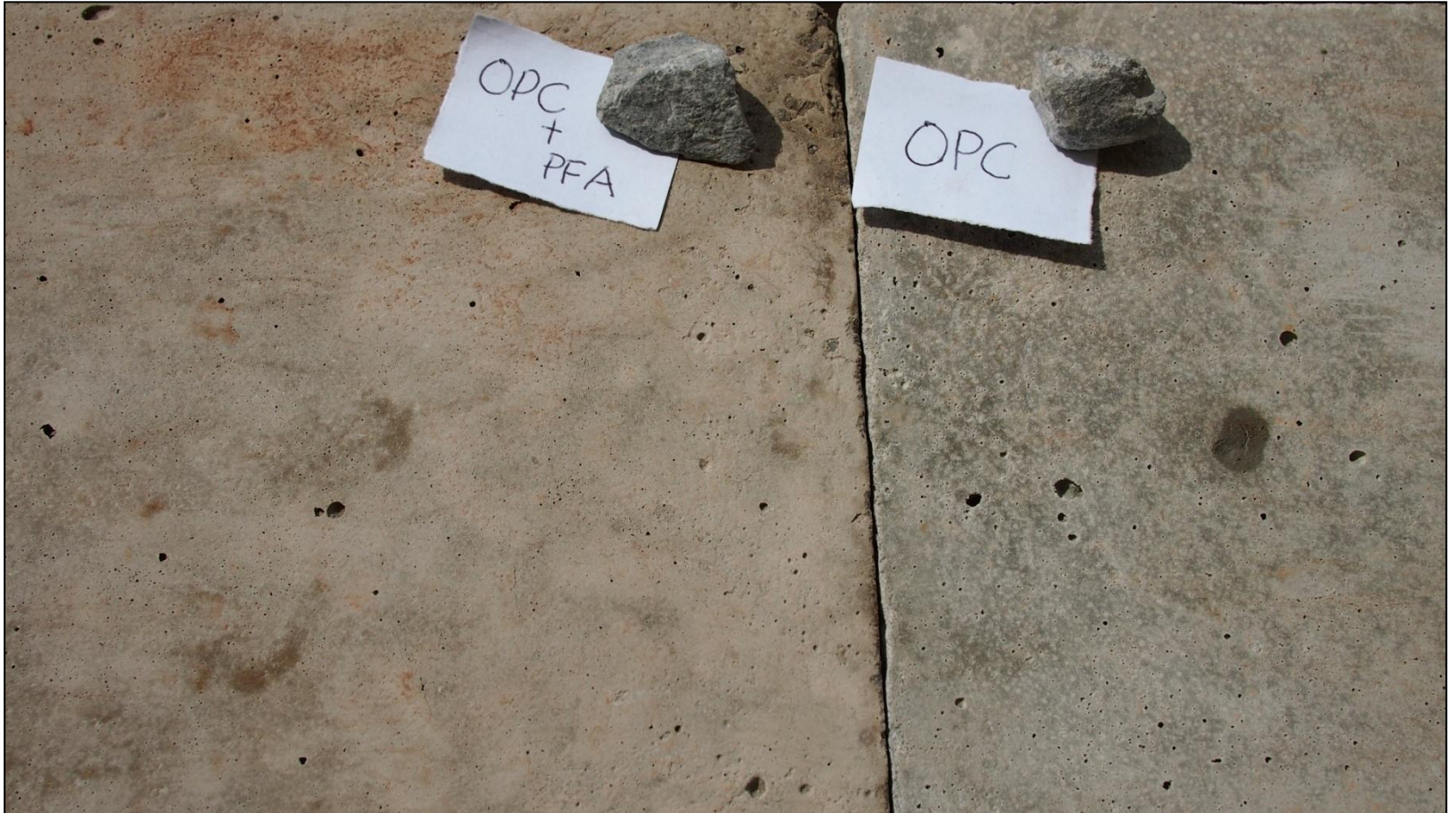
| Testing Date | Cube Age (days) | Cube no. | Weight (Kg) | Density (Kg/m ³) | Dial Gauge Reading | Comp. Strength (N/mm ²) | Average Comp. Strength (N/mm ²) |
|--------------|-----------------|----------|-------------|------------------------------|--------------------|-------------------------------------|---|
| 11.05.15 | 4 | 1 | 7.99 | 2370 | 387.1 | 17.20 | 17.41 |
| | | 2 | 7.87 | 2340 | 396.4 | 17.62 | |
| | | 3 | 8.02 | 2370 | 391.8 | 17.41 | |
| 14.05.15 | 7 | 4 | 8.07 | 2370 | 535.8 | 23.81 | 23.57 |
| | | 5 | 7.97 | 2370 | 530.3 | 23.57 | |
| | | 6 | 8.12 | 2399 | 524.8 | 23.32 | |
| 04.06.15 | 28 | 7 | 8.12 | 2399 | 976.3 | 43.39 | 42.61 |
| | | 8 | 8.15 | 2429 | 940.3 | 41.79 | |
| | | 9 | 8.16 | 2429 | 959.9 | 42.66 | |

Quality Is Our Strength

READYMIX EXPERIENCE



Physical Appearance



Quality Is Our Strength

READYMIX EXPERIENCE



Physical Appearance



Quality Is Our Strength

READYMIX EXPERIENCE



More local testing @ BHC



Quality Is Our Strength

READYMIX EXPERIENCE



First Commercial Delivery : 1 April 2016



Quality Is Our Strength

Around the world



It started more than 2,000 years ago...

The ash generated from Volcanoes was used extensively in the construction of Roman structures.

Colosseum is a classic example of durability achieved by using volcanic ash.

This is a building constructed 2,000 years ago and still standing today!

Quality Is Our Strength

Around the world



Ghatghar Dam



But the Ghatghar Roller Compacted Concrete Dam was a unique project in all respects. For the upper dam, 65% fly ash was used with 35% Portland cement. The result was much better than expected.

So Fly Ash was increased to 70% with only 30% of Portland cement!! Of course, this was possible due to the roller compacting technology employed and definitely not be advised for other regular structures. Though, it is amazing to see how the younger one turns into the Big Brother and carries the elder one in his arms!!

Quality Is Our Strength

Around the world



Burg-Al-Khalifa, Dubai



Concrete used

15

- High performance concrete (HPC)
- Low permeability
- High durability
- C80-C60 cube strength concrete was used
- It includes fly ash, Portland cement
- Two largest concrete pumping machines in the world were used for this purpose
- For reducing cracks due to high temperature concreting was done only at night
- So that air is cooler and humidity is higher with ice added to the mix

<http://www.slideshare.net/jojikulangara/burj-khalifamode-of-construction>

Quality Is Our Strength



SUMMARY – WHY FLY ASH

- ✓ It delays the heat of hydration and hence reduces the thermal cracks in concrete
- ✓ It improves the workability of concrete
- ✓ It makes the mix homogeneous and hence reduces segregation and bleeding
- ✓ The concrete finish is improved due to perfectly spherical fly ash particles
- ✓ The concrete permeability is substantially reduced which enhances the life of the structure
- ✓ Fly ash contributes to the long term strength in concrete

Engineers urged to rebuild mindset to face challenges

From Page One

the 'specifications' that have been agreed upon.

He said that the ministry often encounters 'over specs' leading to wastage and decline in the capacity or durability of the project.

He said, "The ministry welcomes every improvement in the skills of its officers and employees as it will not only add value to the organisation but also equip them with knowledge which is relevant to their respective career or work responsibilities".

The minister emphasised on improving

the design, technology and building materials to overcome the challenges posed by on-site accidents and natural disasters.

"The construction industry is a very complex field not because of its major role in science and technology, but as an industry which prioritises Health, Safety and Environment (HSE).

"It is essential for young engineers to strive for enhancing their technical skills so that they can produce high quality work and manage and supervise construction projects efficiently," he added.

SALES ENQUIRIES



SALES MANAGER

James Wong

Mobile: +673.729 5733

Email: james.wong@readymix.com.bn

Quality Is Our Strength