Institute Of Refractories Engineers

Unshaped Materials - Monolithics

Refractories Training Day
25th September 2008

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Institute Of Refractories Engineers

10:55 - 11:30 (35 mins)	Unshaped Materials Definition of castable, self flow, gunning, shotcrete etc Storage/Shelf Life Effect of water on properties Application temp/setting behaviour Anchoring Fibres – steel and plastic Dry-out Pre-cast

Unshaped Materials - Monolithics

What is a monolithic and why is it used ?

Definition monolith : *a single block of stone / a person or thing like a monolith*
In being massive, immovable or solidly uniform - monolithic

In refractory terms its really:

A refractory aggregate	different aggregates /different fractions
A refractory binder, additives	which can be simple or relatively complex
Packaging for transport to site	25KgBOP / 200 -100Kg Bulk Bags
Mixing medium	such as water

A form or space in which to place it
As necessary, some method of ensuring its retention –anchorage
Method of placing
Curing
Heating
….and into service

General types of Monolithics

- Refractory monolithics can be
- Castables
  - Standard
  - Conventional
  - Low Cement Vibrocast / Freeflow / Pumpable
  - No Cement
  - Insulating
- Gunning grades
  - Conventional
  - Advanced Low Cement
  - Insulating
- Shotcretes
  - Full Wet Low Cement

Rammings
  - Plastic
  - Granular
- Cements –(mortars)

Monolithics

What is a monolithic and why is it used ?

Can give exceptional performance in difficult to install areas

Advantages of monolithic

High strength
Tailored to meet specific requirements –eg chemical, strength, light weight, etc
Dry / minimal joints
Easy to repair
Large high quality and relatively fast installations with such as shotcrete
Special requirements eg Precast shapes, blasters , shrouds etc

Disadvantages

Difficult to
Setup / install
Dry
Demolish

Monolithics

What is a monolithic and why is it used ?

Monolithic

Example – Castable

Planning /Preparation
Anchoring
Shuttering
Homogenisation
Dosing
Mixing
Transport
Pouring
Vibration
Setting /Hardening
Curing
Drying
Heating-Up

Monolithics Manufacture

Different Ingredients

Different Products

Additions of Fibres or Needles to Monolithics

Fine Organic fibres such as polypropolene can be added to monolithics to help form a micrporous network in the installed material to aid in moisture removal on Heating up

Additions of Fibres or Needles to Monolithics

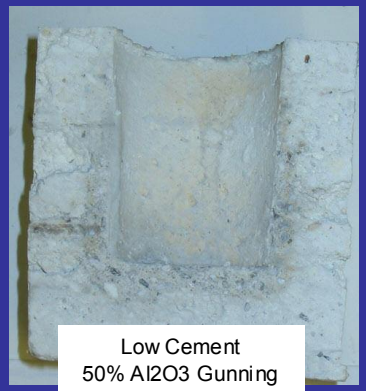
Metallic needles can be added to monolithics for distribution through the finished panels to help “knit” the structure together, limiting crack formation and break-up These metallics are of different qualities with some having better in-service characteristics than others eg thermal cycling, chemical and ultimate temperature resistance.

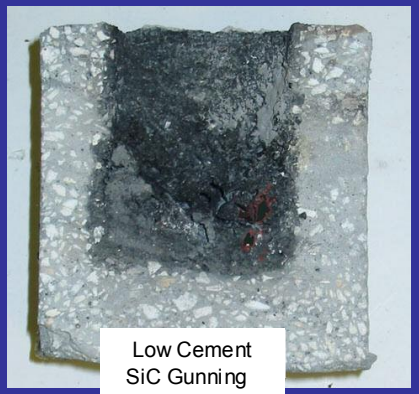
Room Temperature

After Heating To 1200C

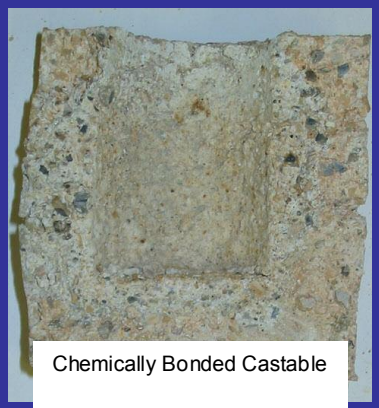
Monolithics Manufacture

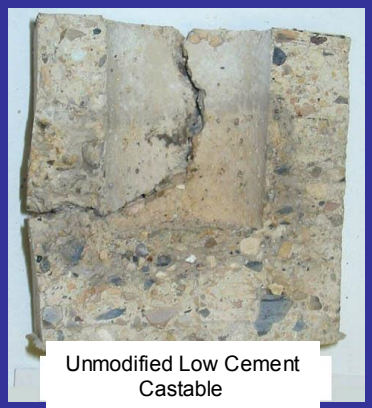
What is a monolithic and why is it used ?
..Products can be evolved for specific applications


Low Cement
50% Al2O3 Gunning


Low Cement
SiC Gunning


Standard
50% Al2O3 Gunning


Chemically Bonded Castable


Unmodified Low Cement
Castable


Modified Low Cement
Castable

Alkali pot tests- to check reactions and potentially modify products to perform better

Common Types of Monolithics

Technical Evolution

Castables

Standard Grade
mixed,placed / rodded

Standard Coarse Grade
mixed, placed under vibration behind shutters

Low Cement
mixed - critical water control, placed under vibration behind shutters

Free Flow & Cement Free mixed - critical water control, placement by pouring / pumping behind shutters (no vibration –free flow)

Sprayed Castables

Shotcrete
mixed - critical water control, special LC castable pumped to nozzle (already mixed), combined with accelerator, applied with airstream, sprayed onto area and quickly sets

Gunmixes

Standard gunmixes
mixed with water at nozzle, applied with airstream

Low Cement gunmix's
tighter water control, longer mixing at nozzle, applied with airstream

Common Types of Castable Monolithics & Their Characteristics

Standard Grade relatively high cement content	Easy to mix / place	Moderate properties	Requires curing	High cem content necessary in abrasive environments where <150 C achieved, no ceram bond, ie back end of chain zones
Conventional Coarse Grade preferably vibro cast	Easy to mix / place	Better properties	Requires curing	Difficult to vibration-cast thin sections effectively on site
Low Cement must be vibro cast behind shutters, water addn critical	Must use "Hi-Shear" mixer for best water distribution	Best properties	Setting - longer in winter.	Offers high strength through the temperature range Properties very dependant on water addn, how well mixed and placed
Free Flow Low Cement must not vibrate. Placement by pouring / pumping. Water critical	As above + tightness and support of shutters critical	Best properties	Setting - longer in winter.	As above + Big volumes can be pumped. Good option for thin sections. Shutters- accurate and secure. SS needles impede flow. Extremely sensitive to setting in winter (due to fine additions) - keep area warm.
Shotcrete pumpable LC castable, applied thru shotcrete method by expert team	Specialised equipment and dedicated team required	Best properties	Fast to install, fast setting time	High strength LC castable that can be pumped and sprayed quickly in big volumes (max 8t). Fast controlled setting (use of accelerator) No complex formwork, very clean working environment. SS needles can be incorporated

Monolithics
Manufacture and Installation

- Refractory monolithics can be
- Castables- Examples

Large Precast Units

Roofs /Sidewalls

Smaller Precast Pieces

Monolithics
Manufacture and Installation

•Technical Castables such as Low Cement, Freeflow Pumpable etc

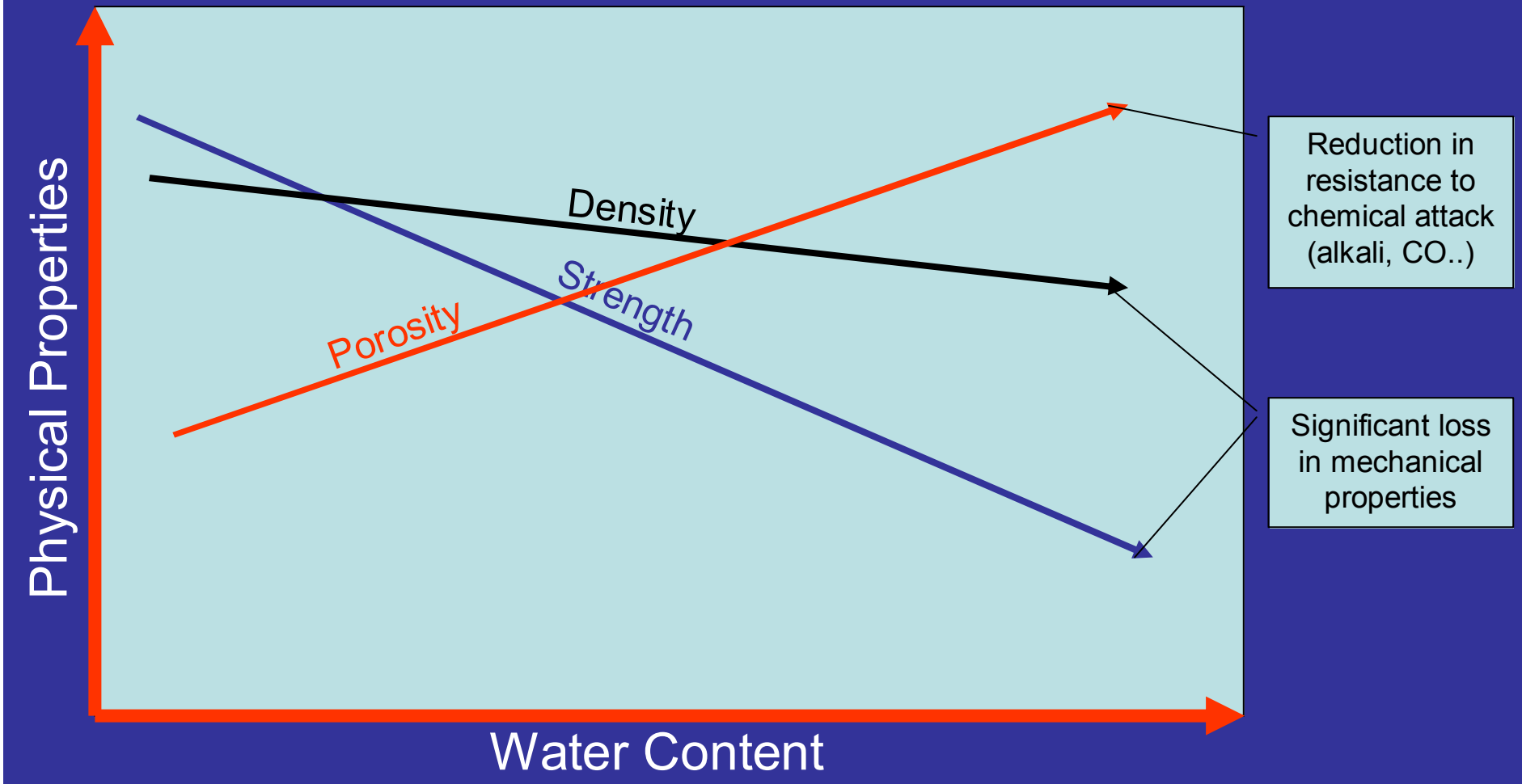
These type of products are quite complex and have several fine additive Additions which are crucial to the optimal performance
Increased water additions have a dramatic effect by decreasing strength

On –site installation is therefore very important to get the best properties and Performance in services.

Mixing must be with the use of a high shear mixer with a positive mixing action
Mixing time with this kind of equipment is generally
4 -6 minutes per batch
At the recommended water content (usually 5-7% for LC types)

Large High Shear Mixer
with measured water being added

Castable Properties



Common Types of Projected Monolithics
Gunnings and Shotcrete

Projection type	**Characteristics**		**Specific Benefits / Drawbacks**
Standard Grade Gunning relatively high cement content with clay addition	Water / aggregate mix at nozzle	Moderate properties	High cem content necessary in abrasive environments where <150C achieved, no ceram bond, ie back end of chain zones
Low Cement Gunning Low Cement technology for improved properties	Water / aggregate longer mix in elongated nozzle	Better properties	Offers high strength through the temperature range (>150C). Properties very dependent on water addn, and how well mixed and placed.
Full Wet Shotcrete pumpable LC castable, applied through shotcrete method by expert team	Specialised equipment and dedicated team required	Best properties	High strength LC castable that can be pumped and sprayed quickly in big volumes (max 8t). Fast controlled curing (use of accelerator) No complex formwork, very clean working environment. SS needles can be incorporated

NB Shotcrete appears in both categories as it has the properties of an LC castable combined with the versatility of a gunning installation (but cleaner). In general, when both types are available, LC gunning would be used for the smaller application eg <8t and Shotcreting for larger installations and faster setting.

Monolithics
Manufacture and Installation

What is a monolithic and why is it used ?

- Refractory monolithics can be
- Gunning grades

Monolithics
Manufacture and Installation

What is a monolithic and why is it used ?

- Refractory monolithics can be
- Shotcretes

Site Set Up

Loading mixer /
Pump unit with
Bulk LC pumpable
Spray castable

Applying inside a vessel

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Mouldables and Rammings

These are manufactured incorporating a binder and supplied to site in pre-formed slabs for installation by pneumatic ramming techniques.

Rammings supplied granular in bags. No additional water is required on site, installation by pneumatic methods

The binder is usually of a chemical type which initially starts to cure on exposure to the atmosphere and as such, plastics are usually termed to be “air setting”.

The aggregate / binder mixes (and type of bond developed) determine the product type and its characteristics

Phosphate bonded plastics tend to exhibit higher strength and abrasion resistance than conventional grades.

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Mouldable type	Characteristics		Specific Benefits / Drawbacks
Conventional Mouldables	Supplied ready to use	Moderate properties	Factory prepared ,ready to use on site / air setting, good thermal shock. Long time to install large quants- tend to shrink if left unfired. Less sensitive to firing in- no chemically combined water to remove Shorter shelf life. Useful for patch repairs and for thin sections
High Grade Mouldables	Supplied ready to use	Best properties	As above + yield superior properties

Generally, Mouldables tend to exhibit reasonable strength and good thermal shock resistance. The High Grade materials exhibit further improved strength and good abrasion resistance.

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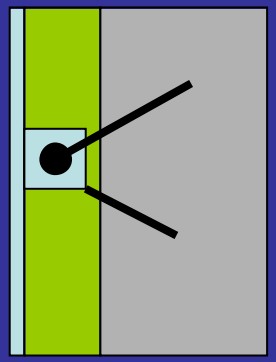
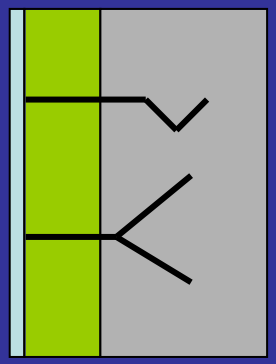
Lining Configuration, Anchorage, Panelisation and Expansion Allowance



Perceived typical
But can vary by application

Lining configuration
Determined by
Local conditions such as :
Heat Retention
Chemical and Abrasion Resistance

Anchorage and panelisation/ expansion
Determined on case by case basis
Taking into consideration, environment, history, and safety



IC9 Med Wt
Safety &Security

Metallic and Ceramic anchors

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Lining Configuration, Anchorage, Panelisation and Expansion Allowance

Roof being cast in sections and one year later on inspection

Monolithics
Manufacture and Installation

Lining Configuration, Anchorage, Panelisation and Expansion Allowance

Monolithics
Manufacture and Installation

Setting, Curing and Preheating

Setting is determined by the type of product and the ambient temperatures

At a **typical 20C** an initial set would be expected in 4-6 hours

In **hotter climates** setting time can be dramatically reduced due to the heat accelerating the bond. This can have consequences for the installation and retarders should be considered to be added at the suppliers factory with a minimal fine tune on site or wholly on-site under careful supervision

Conversely in **colder climes** the opposite is true.
The more technical low cement products can exhibit very long set times, even 1 -2 shifts
Which can have serious consequences for the installation programme
In these circumstances, retarder at the factory should be cut back and consideration should be given to the supply of accelerants for site addition

With extremes of temperature, site materials should be kept in controlled temperature Warehouses and site water temperatue controlled

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Manufacture and Installation

Setting, Curing and Preheating

Curing should be at least 12 hours and air drying similar
Theoretically castables should not be allowed to prematurely dry out in the first 12 hours and the surafce should be kept moist.
See manufacturers data sheets

This is best practice but with the exception of floors, it rarely happens on site

Thicker section jobs should be planned early in repair to allow maximum curing /air drying time

Where and when practicable, shells should be drilled and monolithic vented during installation. Organic fibres are added which also aid moisture removal.

Very dense monolithics give good performance but are the most difficult to dry out (Low porosity / permeability)

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Manufacture and Installation

Preheating

No Preheating curve is given as generally this follows custom and practice
Or is discussed and agreed on a case by case basis

Different schools of thought exist for drying out and Preheating monolithics

1 **Traditional**
Where possible, preheating should be done to an agreed regime and allowing good air movement across the face
Preheating regimes will vary but should consist of slow ramping- 20-25C/hr and holds at 110 and 350 visibly monitoring for high steam pressure and if so hold until it subsides

2 **Modern**
Ramping at a constant temperature from ambient, theoretically building heat up slowly at the hot face and driving moisture back through at a constant rate with no holds

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Manufacture and Installation

Preheating

In either Preheating situation it is extremely important to visually monitor the application and if excessive steaming or plumes are noted then the regime should be held until it subsides and then progressed with caution

Installations can be long and costly affairs taking place over long periods of time and consequently heating up should not be rushed.

Specialised companies are available for preheating on site for small or large project applications

Generally, > 80% of moisture is removed by 400C equilibrium.

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Storage

See manufacturers instructions

Generally supplied products should be kept under cover in a clean, dry
Well ventilated storage area

Manufacturers can modify the packaging spec liasing with the customer, especially for international destinations, however normally, such as 25Kg valve packed bags of monolithic stored in the above, can have a life of 6-12 months duration dependant on type

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And Finally……

Thank You for your time
And consideration