# 2022 Engineering Conference

MALAWI BUREAU OF STANDARDS
*Promoting Standardization and Quality Assurance in Malawi*

Limestone Calcined Clay Cement LC3

# Limestone Calcined Clay Cement (LC3 ) Initiatives in Malawi

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By
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# The Sad Reality – Every Engineers concern

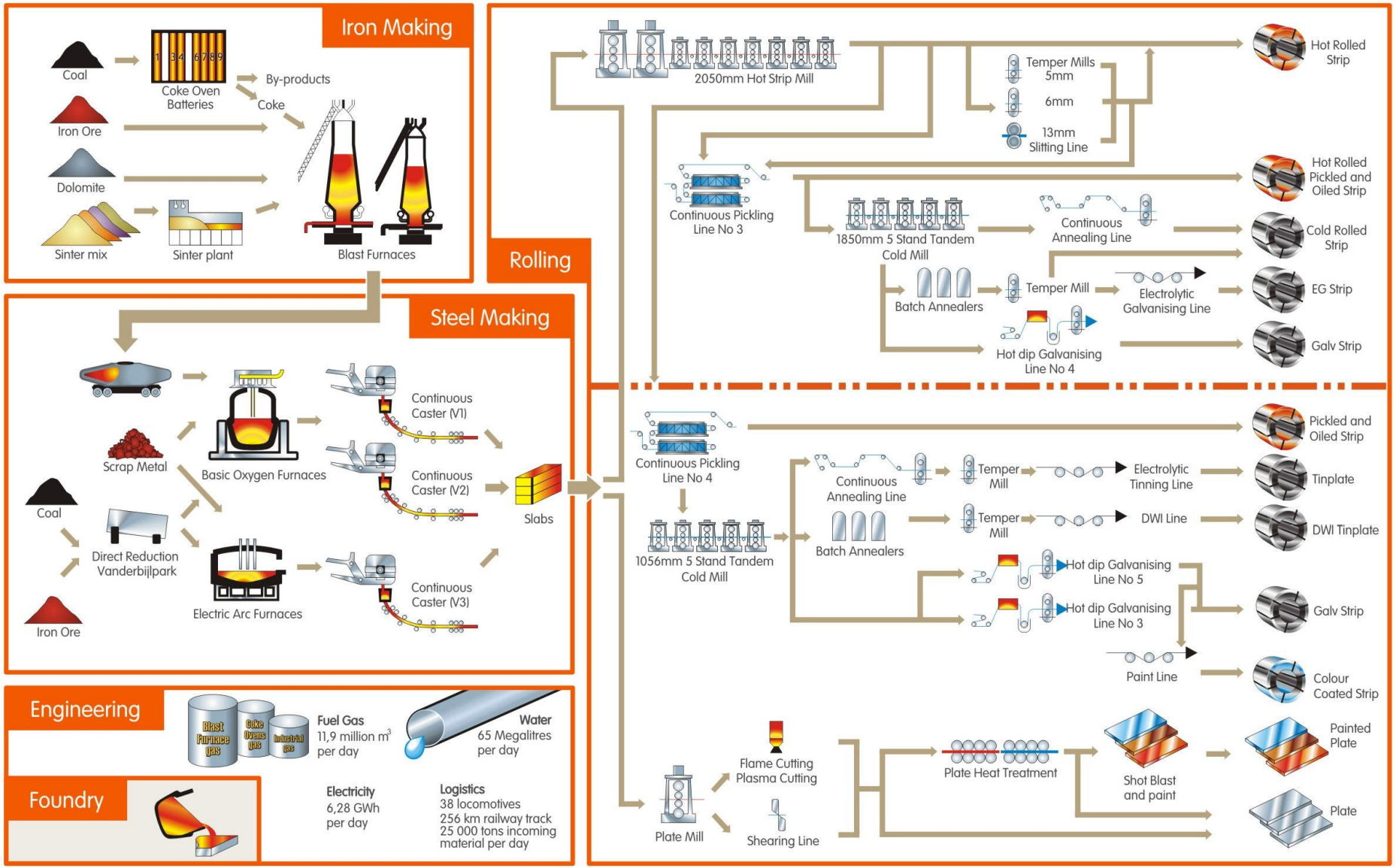
- Malawi: 11 Stations; 441.55 MW – Installed capacity; and 256.60 MW – Available capacity (Pop. 19.13 million)
- Zambia: 5 Stations; 2,800 MW – Installed capacity; and 1,990 MW – Available capacity (Pop. 18.38 million)
- Mozambique: 6 Stations; 2,375 MW – Installed capacity (Pop. 31.26 million)
- Tanzania: 6 Stations and Gas turbines; 1606 MW – Installed capacity; and 1,602 MW – Available capacity (Pop. 59.73 million)

- *Power requirement of a mine or steel processing plant (Vanderbijlpark RSA) – 260 MW*

ArcelorMittal South Africa

# Vanderbijlpark Works: Process Configuration

ArcelorMittal



# Presentation outline

- Status of cement production in Malawi
- Benefits of LC3
- Composition and testing of LC3
- Available Kaolinite clays in Malawi
- Where you can find us and our contacts

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# Status of cement production in Malawi

- Three (3) major cement companies (Huaxin, CPL and Shayona)
- Around 800,000 tons of cement produced annually
- Mainly 32.5 grade (CEM II) – around 85%
- 42.5 grade (CEM II) also introduced
- Import of cement from neighboring countries
- Import of clinker, local production started
- High transportation cost

# The business environment

- Malawi market served by 3 companies (Huaxin, Shayona and CPL ) and imports from neighboring countries namely Zambia (Dangote & Sinoma), Zimbabwe (PPC), Mozambique (CM) and Tanzania (LHT)
- Its more competitive to produce own clinker rather than import
- Therefore, clinker cost reduction, differentiation and innovation (new products) will be key in gaining competitive advantage against imports
- One area of clinker cost (volume) reduction is partial substitution with calcined clay to produce Limestone Calcined Clay Cement (LC3 )

# Challenges in cement production

- Current natural resources to meet the increased demand
- Mitigate environmental emission impact
- Make cement more affordable without reducing quality

# $CO_2$ emissions in Cement production

$$CaCO_3 \rightarrow CaO + CO_2$$

- Construction sector is the largest contributor to $CO_2$ emissions
- Cement sector contributes to 7% of the global $CO_2$ emissions -
- 1 tonne of cement leads to an emission of 650 – 900 kg $CO_2$

# Realistic solution

- Potential raw material available in viable quantities is calcined clay
- Blend containing combination of calcined clay and limestone are highly feasible

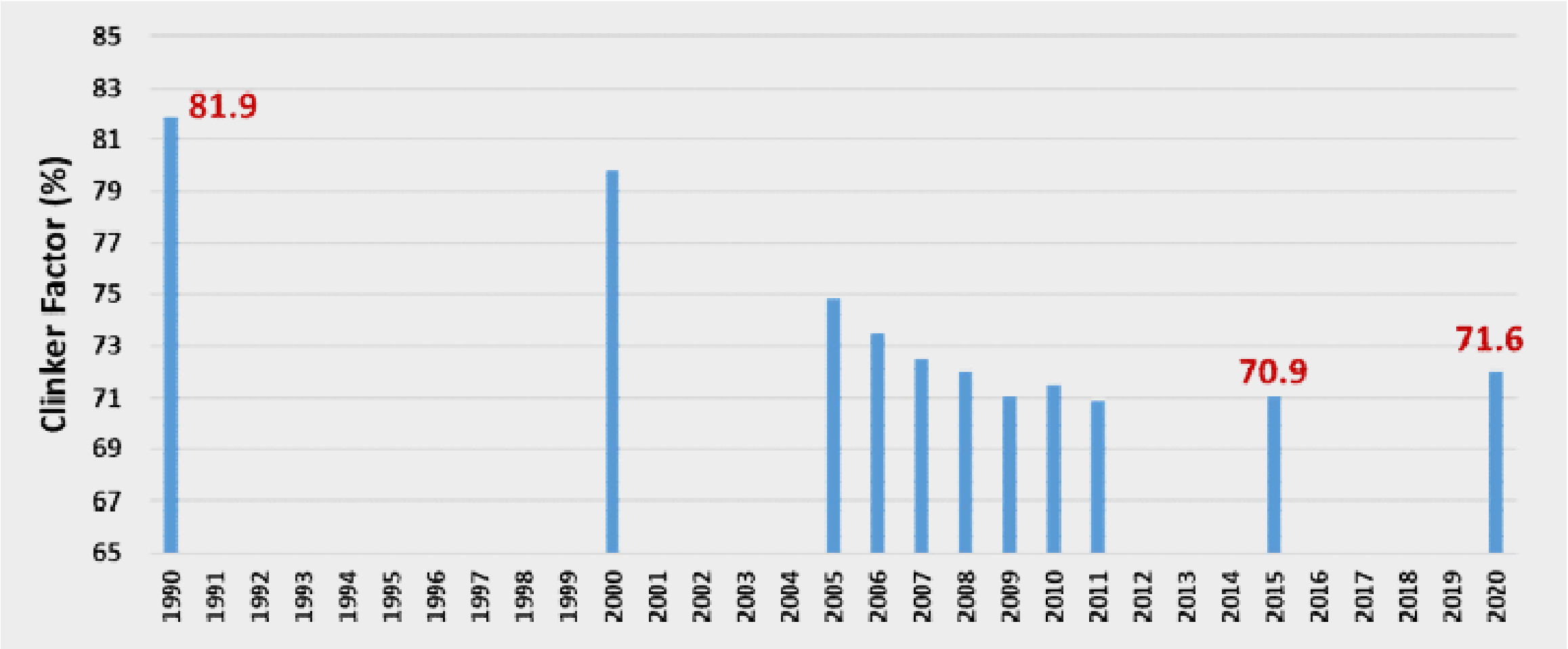
# Benefits of clinker reduction technologies i.e. LC3 Cement production

- Make cement affordable in line with SDGs and MW2063
  - *Decent housing for all*,
  - *Controlled & regulated infrastructure development* and
  - *Creation of secondary cities*
- Develop and support the inclusive wealth creation agenda through industrialized mining of raw materials for construction (MW2063)
- Potential to reduce GHG emissions by 0.55 MioT

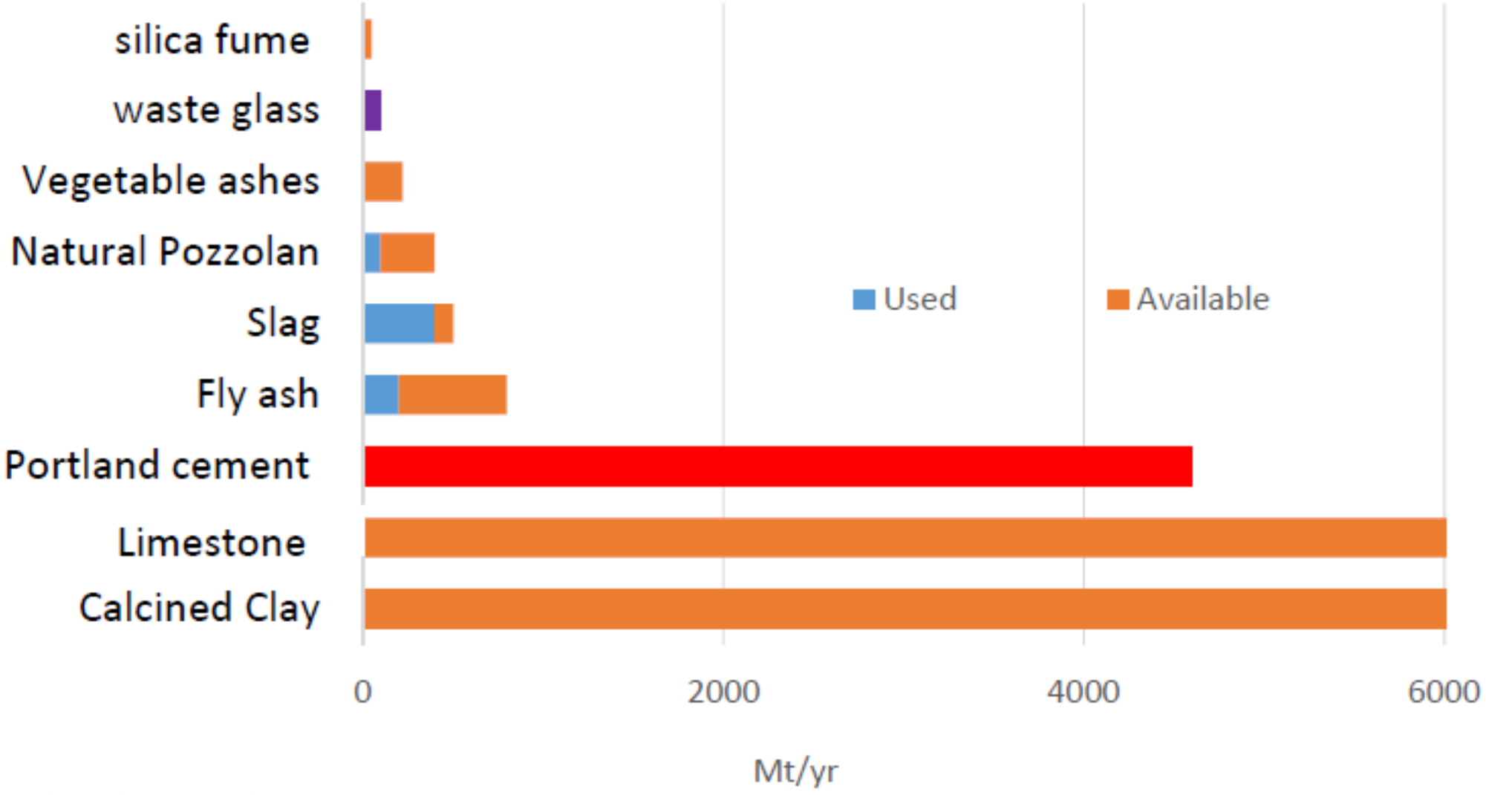
# Benefits of clinker reduction technologies i.e. LC3 Cement production

- Opportunity to earn carbon credits for companies
- Sustainable use of secondary raw materials
- Use of local raw materials – import substitution
- Save foreign exchange of Malawi
- Create local jobs and enterprises
- Export of cement to neighboring countries

# Evolution of clinker substitution

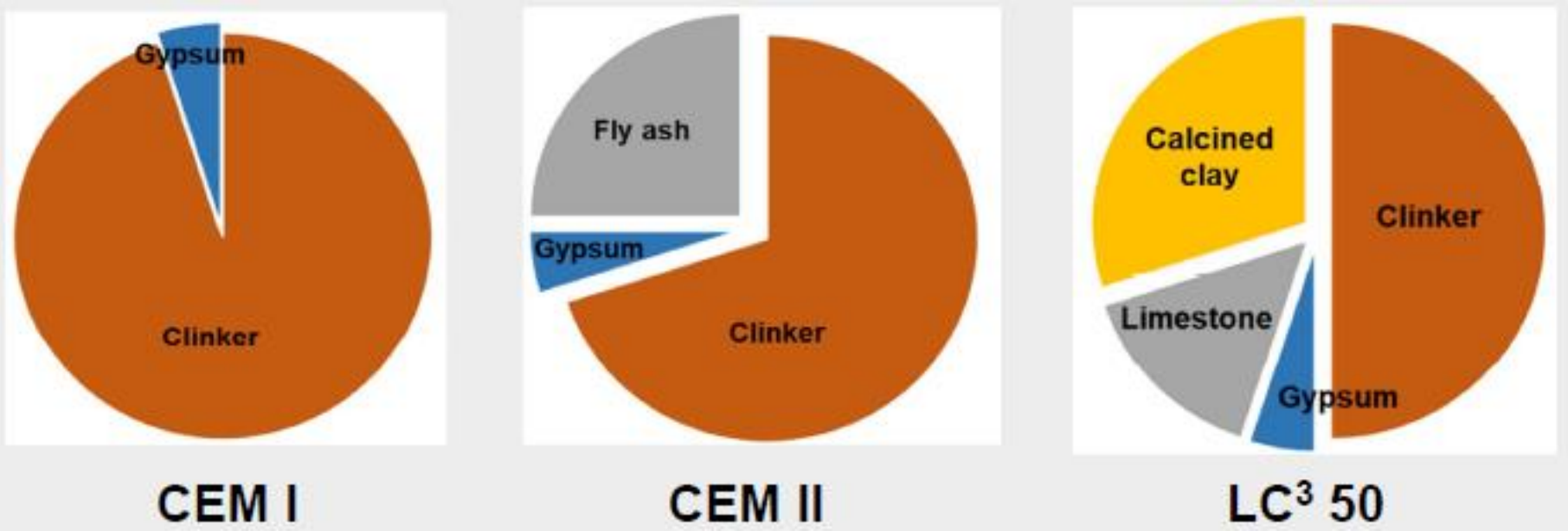


# Alternate materials availability



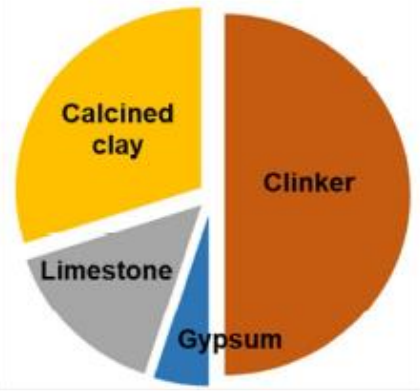
# Clinker reduction in $LC^3$

- Clinker factor reduced to 50%
- Use of moderate quality clays and low grade limestone resources
- Low temperature calcination of kaolinitic clays (800°C)
- Saving of up to 40% $CO_2$ emissions compared to CEM I



# Composition of $LC^3$

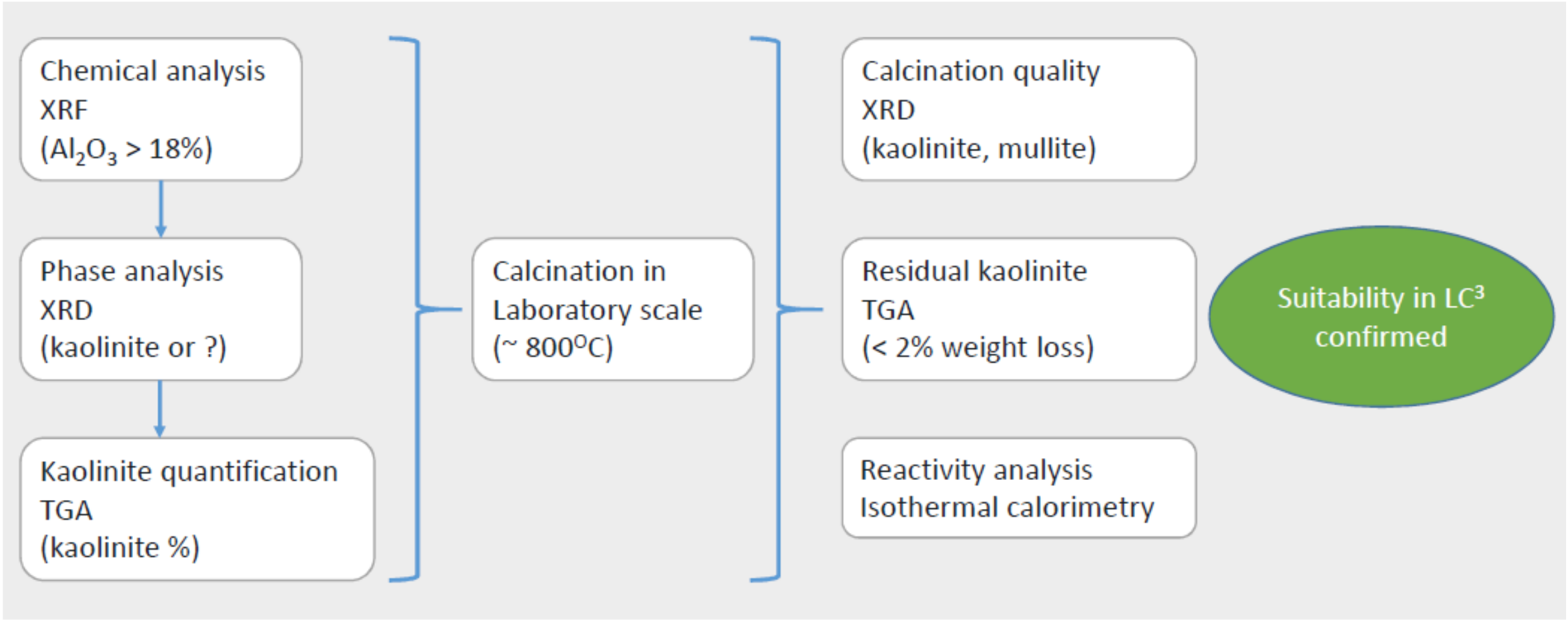
- **Only material really potentially available in viable quantities is calcined clay**
- Blend containing combination of calcined clay and limestone are of particular interest
- Ideal kaolinite content 40-60%
- Higher contents, possible to use more limestone
- *Even better economics and ecology*
- Lower contents can be enriched by separation *separated fine quartz, can be sold as separate product*



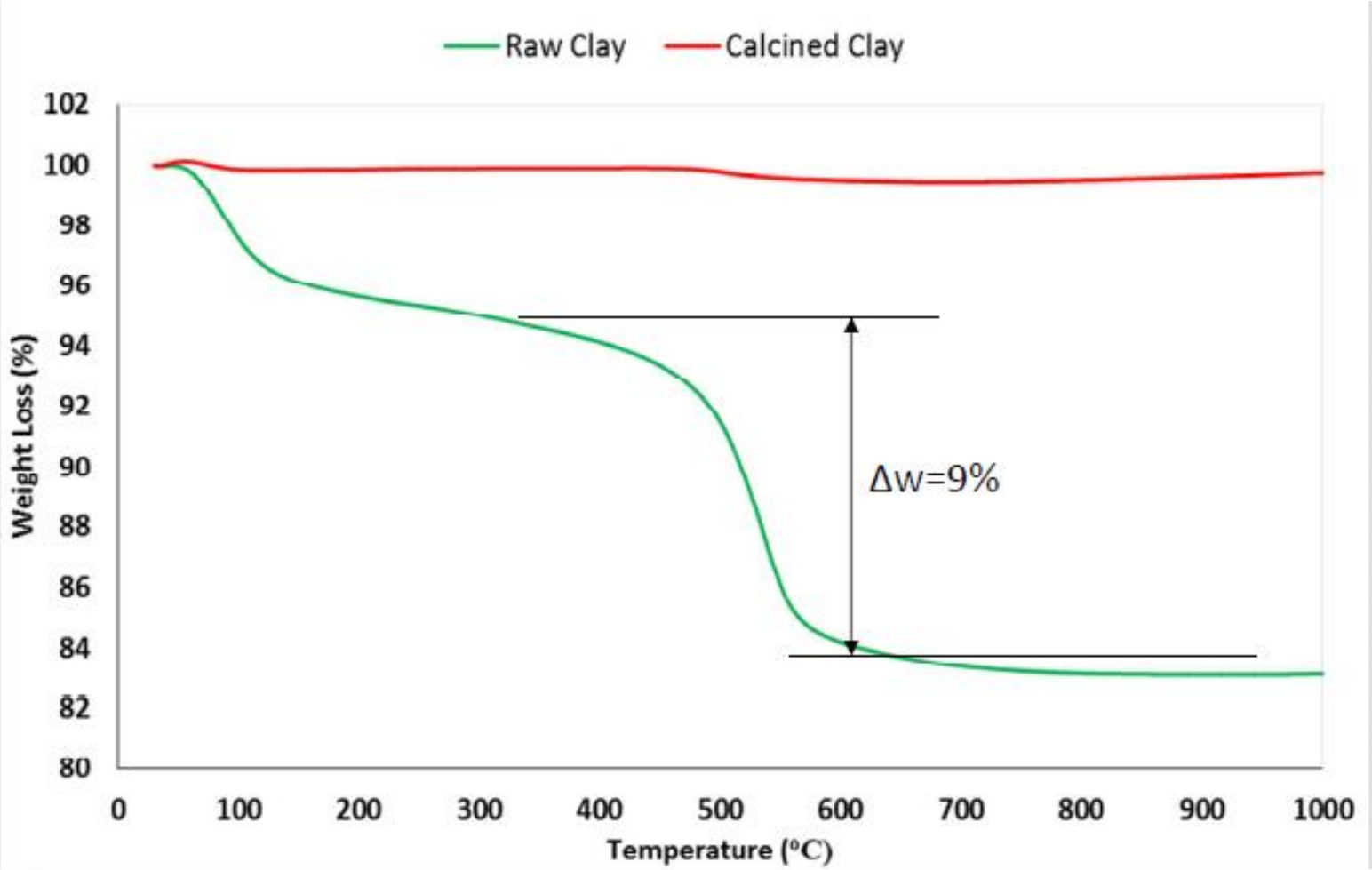
# Composition of $LC^3$

- **Kaolinitic clays are** composed principally of the hydrated aluminosilicate clay mineral **kaolinite**
- They consist of quartz, smectite, chlorite, muscovite, hematite, goethite, gibbsite, pyrite, calcite among others
- They have been known in literature with many terms such as – fire clays, ball clays, brick clays etc.

# Clay suitability test



# Clay suitability test – TGA analysis Linthipe clay




- Complete calcination – 800°C
- Kaolinite content – 65%

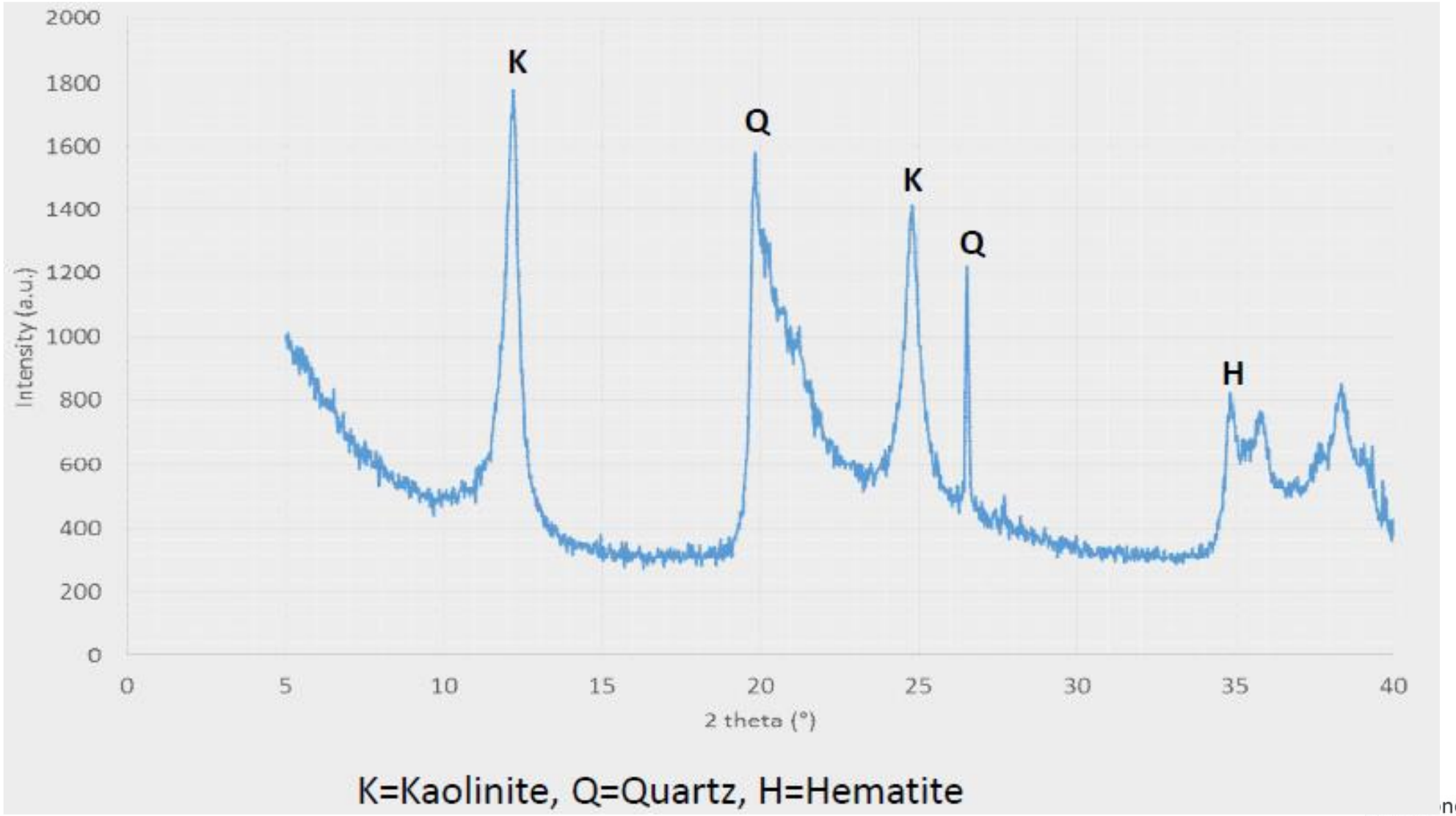
# Clay suitability test – XRF analysis Linthipe clay

| Compounds | % Composition |
|---|---|
| $SiO_2$ | 48.09 |
| $Al_2O_3$ | 33.40 |
| $Fe_2O_3$ | 3.84 |
| CaO | 0.94 |
| MgO | 1.43 |
| $SO_3$ | 0.78 |
| $Na_2O$ | 0.16 |
| $K_2O$ | 0.33 |
| $TiO_2$ | 0.42 |
| $V_2O_5$ | 0.04 |
| $Mn_2O_3$ | 0.06 |
| LOI | 10.50 |

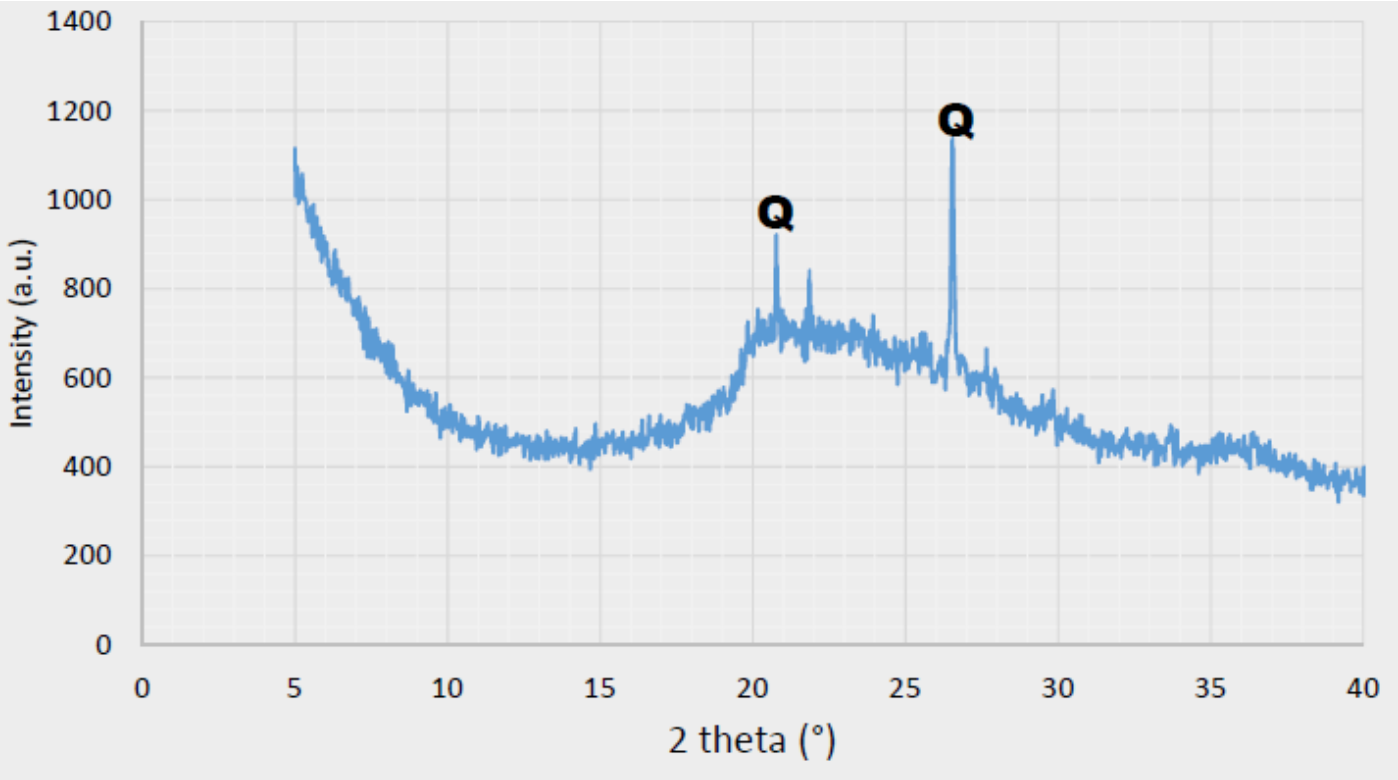
< 1%

- Major oxides – $SiO_2$ and $Al_2O_3$
- Moderate amount of $Fe_2O_3$

# Clay suitability test – XRD analysis Linthipe clay



# Clay suitability test – XRD pattern of Calcined Linthipe clay



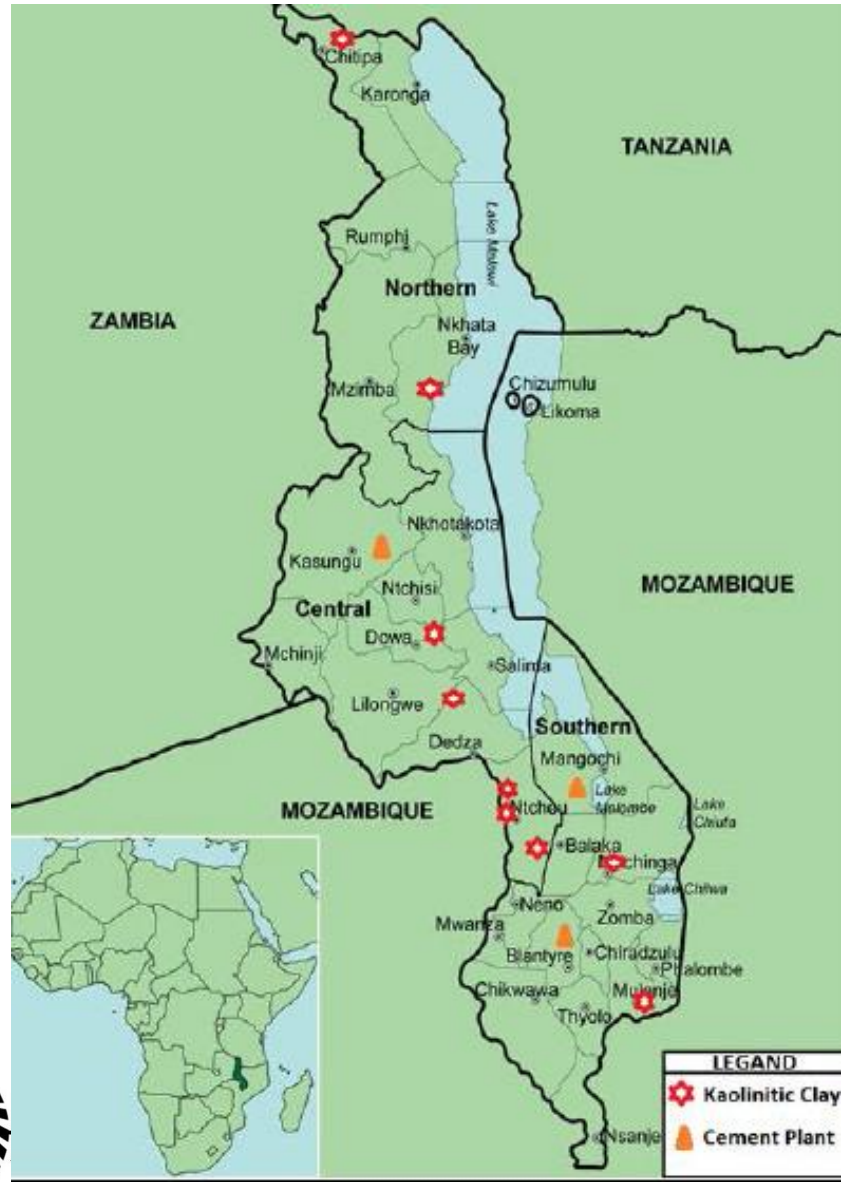

- Optimally calcined at 800°C
- No peak of kaolinite and mullite

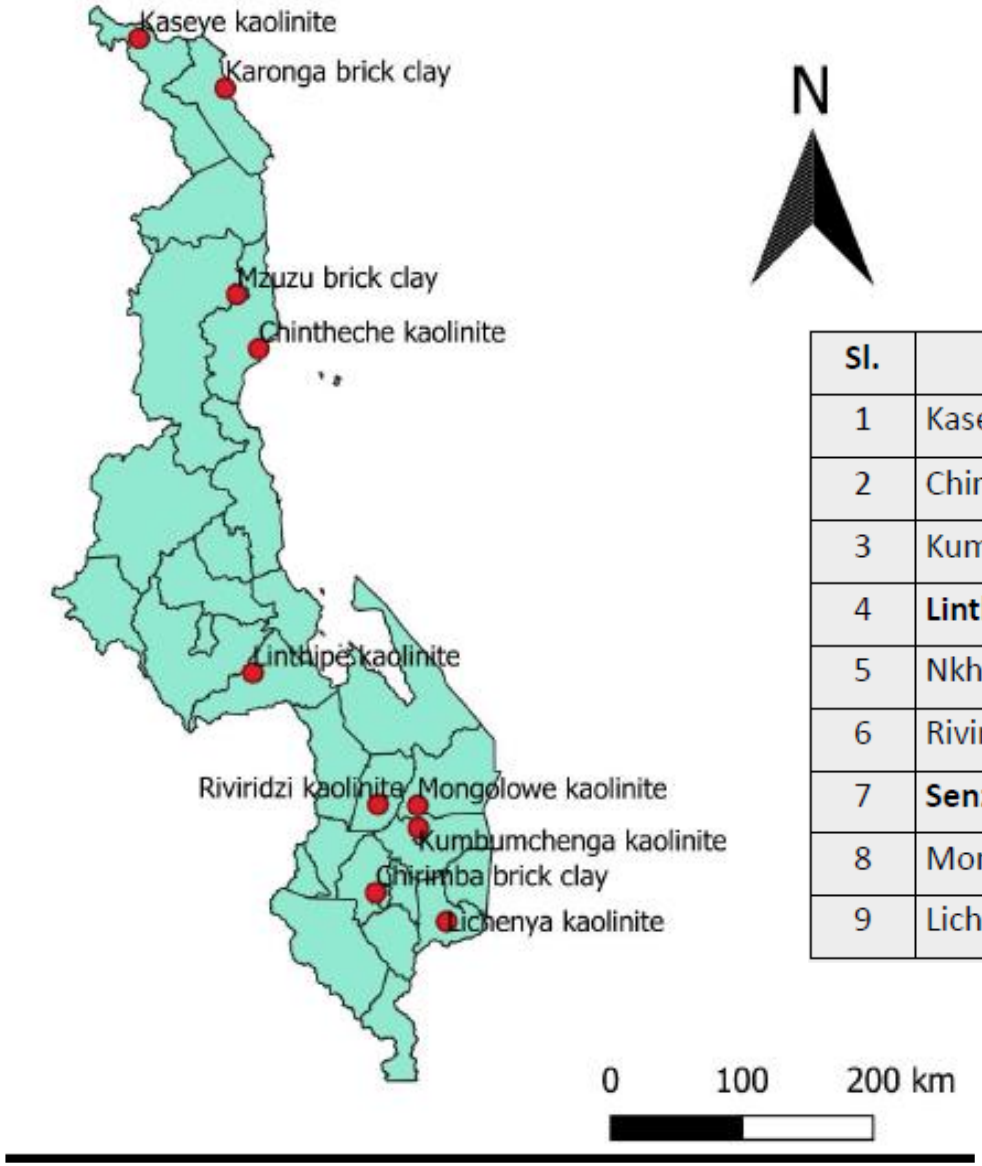
# Properties of LC3 blends with Linthipe clay

| Sl no | Sample identity | % Retaintivity (+ 45 µ) | % Retaintivity (+ 90 µ) | Specific Gravity (g/cc) | Blaine Value ($m^2$/kg) | NC (%) |
|---|---|---|---|---|---|---|
| 1 | OPC | 13.10 | 2.00 | 3.10 | 333 | 30.5 |
| 2 | $LC^3$ | 13.70 | 3.00 | 2.82 | 698 | 33.5 |

| Sl no | Sample identity | Average compressive strength (MPa) | | | | |
|---|---|---|---|---|---|---|
| | | 1 day | 3 days | 7 days | 14 days | 28 days |
| 1 | OPC | 15.2 | 28.4 | 41.5 | 45.2 | 54.9 |
| 2 | $LC^3$ | 13.5 | 30.9 | 37.4 | 42.8 | 52.6 |

# Where to get Kaolinite clays in Malawi

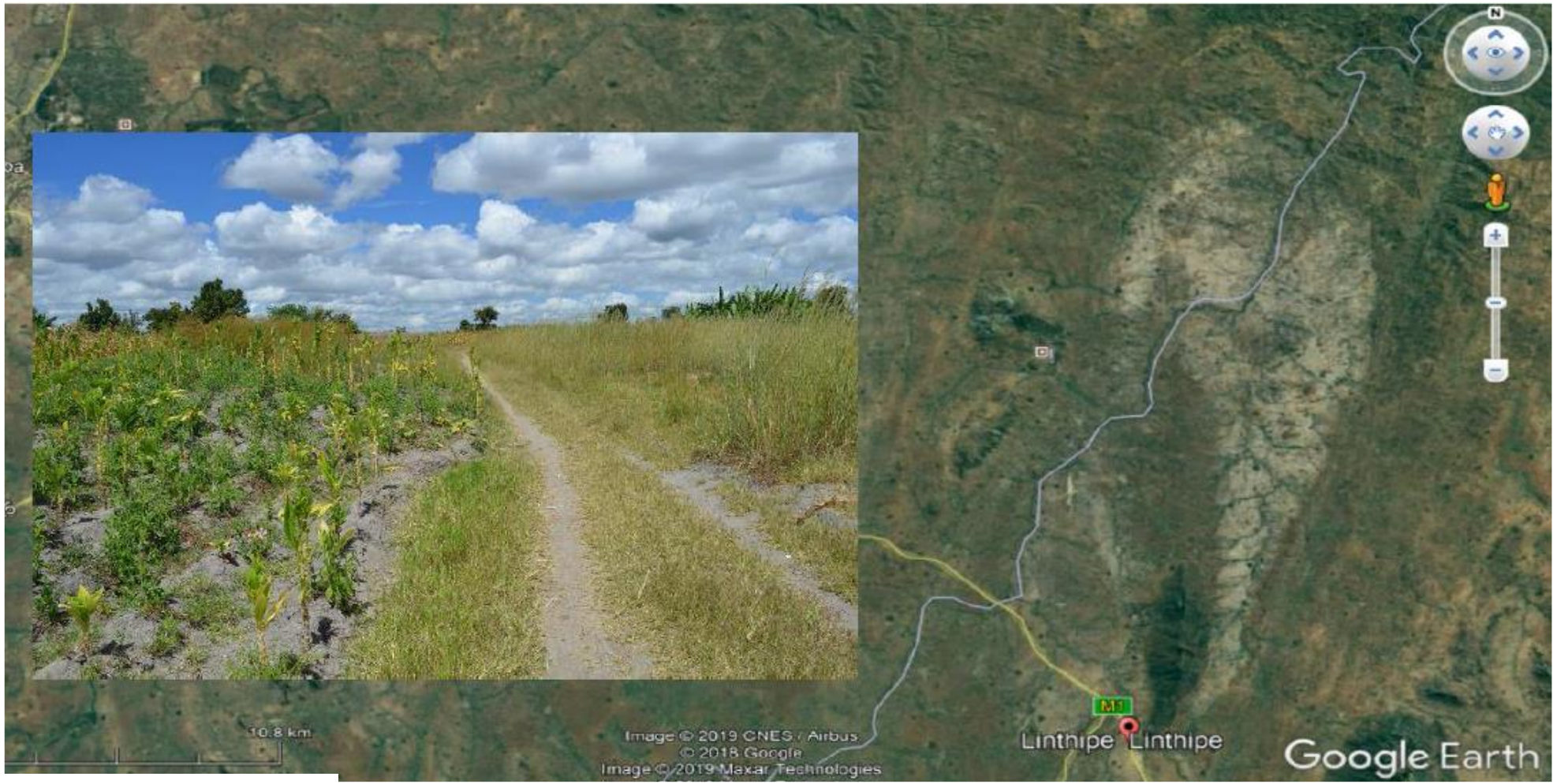



| Sl. | Location | District |
|---|---|---|
| 1 | Kaseye Mission | Chitipa |
| 2 | Chintheche | Nkhata Bay |
| 3 | Kumbachenga | Dowa |
| 4 | **Linthipe** | Dedza |
| 5 | Nkhande | Netcheu |
| 6 | Rivirivi | Netcheu |
| 7 | **Senzani** | Netcheu |
| 8 | Mongolowe | Machinga |
| 9 | Lichenya chambe | Mulanje |

Limestone Calcined Clay Cement

# $LC^3$ clays in Malawi - Linthipe



# $LC^3$ clays in Malawi - Linthipe

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# $LC^3$ clays in Malawi - Chileka

# Project implementation partners

- GIZ through German Cooperation and BMZ
  - Private Public Partnership for the Promotion of an Environmentally Friendly Building Material Sector in Malawi (PEFCoM) project
- Technology and Action for Rural Advancement
- Indian Institute of Technology Madras
- The Malawi Bureau of Standards
- Department of Geological Survey (Malawi)
- Cement companies in Malawi i.e. Huaxin, Shayona and CPL

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Limestone Calcined Clay Cement LC3

# Objects of the MBS

- Promote standardization in commerce and industry
- Provide cooperation with representatives of any branch of industry, Government, or any person with the view of bringing standardization
- Assist any ministry, Govt. dept., local authority, statutory corporation in preparation and framing of specifications or codes of practice
- Prepare and issue national standards
- Provide facilities for testing/analysing/examining articles/materials/substances- Including Non-destructive testing (NDT)
- Provide calibration services

# Types of standards


- Specifications or product standards
  - MS 29-1: 27 distinct types of cement
  - MS 414-1 Masonry cement - composition, specs, manufacture, sampling and testing
  - Developed a new national standard DMS 29-5: Portland-com cement CEM II/C-M and Composite cement CEM VI
    DMS 29-5 covers 5 types of cement including CEM II PCC – 50-64% Clinker
- Methods of tests (EN 196 series)
- Codes of practice or guidelines
- Terminology or vocabulary

# Way forward on LC3

- Upscale experimental tests of LC3 cements made from local materials
- Run a pilot industrial level production of LC3 cement
- Conclude Life Cycle Assessments of LC3 cement and cement products

# Other standards recently revised by the Bureau

- Revised MS 71:2000 – Concrete building block-Specification
  - MS 71-1:2021 - Concrete building block-Part 1: Load bearing masonry units
  - MS 71-2:2021 - Concrete building block-Part 2: Non-Load bearing masonry units
  - MS 71-3:2021 - Concrete building block-Part 3: Sampling and testing of concrete masonry units
  - MS 71-4:2021 - Concrete building block-Part 4: Linear Drying shrinkage of concrete masonry units – Test method

# Other research done by the Bureau – Quality of concrete blocks in Malawi

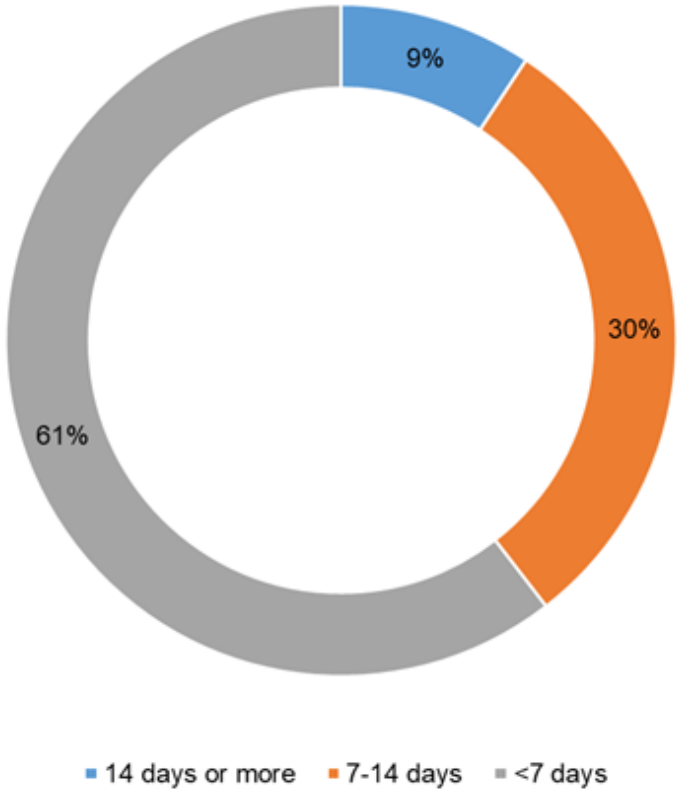


**Figure 4-12 – Storage period of blocks after curing but before sale**

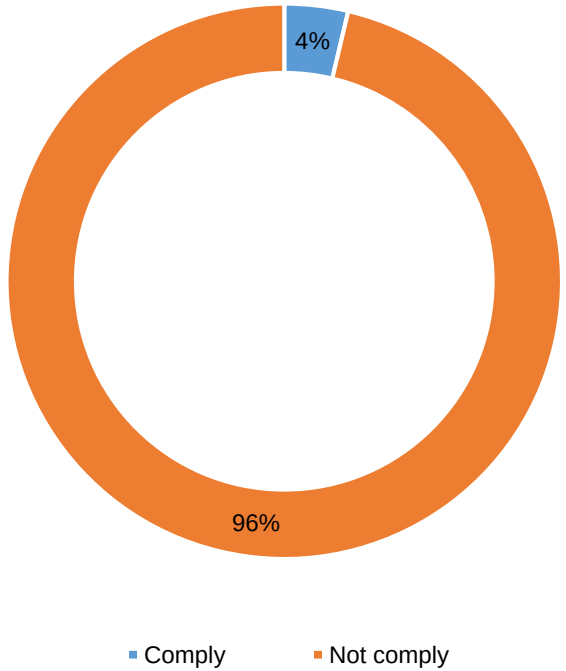


**Figure 4-22 – Compliance levels for block dimensions**

# Other research done by the Bureau – Quality of concrete blocks in Malawi

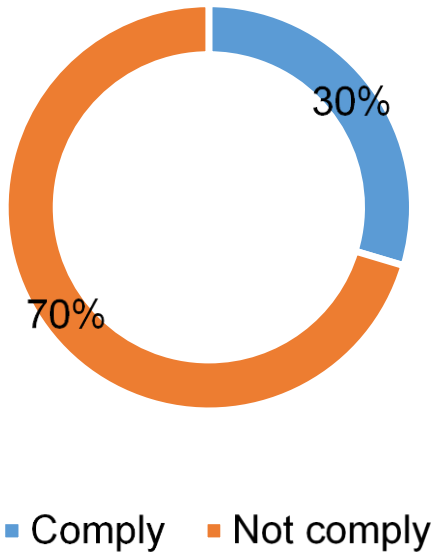


**Figure** Error! No text of specified style in document.**-1 – Level of compliance on compressive strength**

# Challenges in ensuring quality in engineering practice, installations and projects

CHALLENGE

- Poor workmanship – Correction and maintenance waste

SOLUTION

- Regulation of practice using Codes of practice

# Other issues to be pursued in standards

- National Building Code
- National Construction Code



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# Challenges in ensuring quality in engineering products

CHALLENGE

- Poor quality products on the market

SOLUTION

- Development of standards (product specifications) for products not currently covered
- Regulation of imports through the MBS IQMS (Import Quality Monitoring Scheme)
- Regulation of local products – Product certification scheme
- Market surveys
- Testing capacity development

# NDT

## NON DESTRUCTIVE TESTING (NDT)

Non destructive is a testing and analysis technique used by industries to evaluate the property of a material , component, structure or system for characteristic differences without causing damage to the original part.

## WHY NDT?

**Savings** - Material or object being examined to survive the examination unharmed

**Safety** - All NDT techniques (except radiographic testing) are harmless to people

**Efficiency** - Allow for the thorough and relatively quick evaluation of assets, which can be crucial for ensuring continued safety and performance on a job site

**Accuracy** - NDT methods have been proven accurate and predictable, both qualities you want when it comes to maintenance procedures meant to ensure the safety of personnel and the longevity of equipment

## NDT SERVICES WE OFFER

### 01 LIQUID PENETRANT TESTING (PT)

Liquid penetrant testing detects surface-breaking defects such as hairline cracks, surface porosity, leaks in new products and fatigue cracks. It can change invisible defects to visible defects by using liquid dye. Low-tension liquid penetrant is applied into clean and dry surface-breaking defects to spread. After appropriate time, excess penetrant is removed and drawn out by a developer. The defects then appear visible.

PT Weld inspetion | Developer | Cleaner | White Contrast

### 02 ULTRASONIC TESTING (UT) & ULTRASONIC THICKNESS MEASUREMENT

This is the process of transmitting high-frequency sound waves into a material in order to identify changes in the material's properties. This method uses echo signals at an interface, such as the back of the object or an imperfection, to reflect the waves back to the probe. Results are shown as a line plot, with an amplitude on the y-axis representing the reflection's intensity and distance or time on the x-axis, showing the depth of the signal through the material

Our technicians can carry out examinations on a multitude of welded joints including nozzle and node configurations using portable ultrasonic testing with the latest digital sets. We offer other services including wall thickness checking, corrosion mapping, among others.

RMS 2 300 Thickness & corrosion mapping

SIUI CTS-9009 UT Flaw Detector

### 03 MAGNETIC PARTICLE TESTING (MT)

This is a process in which our team identifies imperfections in a material by examining disruptions in the flow of the magnetic field within the material. The inspection method provides detection of linear flaws located at or near the surface of ferromagnetic materials. This is the effective method for locating surface breaking and slight sub-surface defects such as cracking, pores, cold lap, lack of sidewall fusion in welds etc.

MBS team uses the 110v AC hand held electromagnetic yoke magnet ,white paint as contrast background and a black magnetic "ink" composed of iron powder particles in a liquid carrier base to perform method of inspection.

Magnaflux Y1 AC Yoke-Weld Inspection

### 04 RADIOGRAPHY TESTING (RT)

This technique uses x-rays or gamma rays to examine the internal structure of manufactured components in identifying any defects. MBS uses computerized x-ray (RIX-300MC-2) which provides both cross-sectional images of the object under inspection. Images allow the internal structure of the test object to be inspected. With the support of this feature, helps us to have detailed analysis of the internal structure of a wide range of components. With lots of experience, we can evaluate the radiographs to your customer's acceptance criteria and report the findings.

RIX-300MC-2

NDT film processer

### 05 OTHER NDT SERVICES

We have a GPR 8800 transmitter which emits pulses of electromagnetic energy into sub-surface. Changes in the sub-surface are detected based on differences in permittivity. When a change in the sub-surface is encountered, some of the electromagnetic energy is reflected back to the surface. This is detected by a receiving antenna and variations in the return signal are recorded and the information is displayed on a radargram. Some of the more common target material include; metals, Plastics, changes in ground strata and geological features,concrete, Air pockets or voids etc.

We also have Thermal Imaging Cameras, these devices translate thermal energy into visible light in order to analyze a particular object or scene. The cameras process the captured image and display it on a screen. These images can be used for immediate diagnosis or processed through specialized software for further evaluation, accuracy and report output. Thermal imaging cameras take measuring temperature to the next level; instead of getting a number for the temperature you get a picture showing the temperature differences of a surface. the common aplication for these cameras include; mechanical installation, gasdetection, Animal health

Ground Penetrating Radar 8800

Testo 872 Thermal Imager

# Our Contacts

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# Thank you for your attention
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