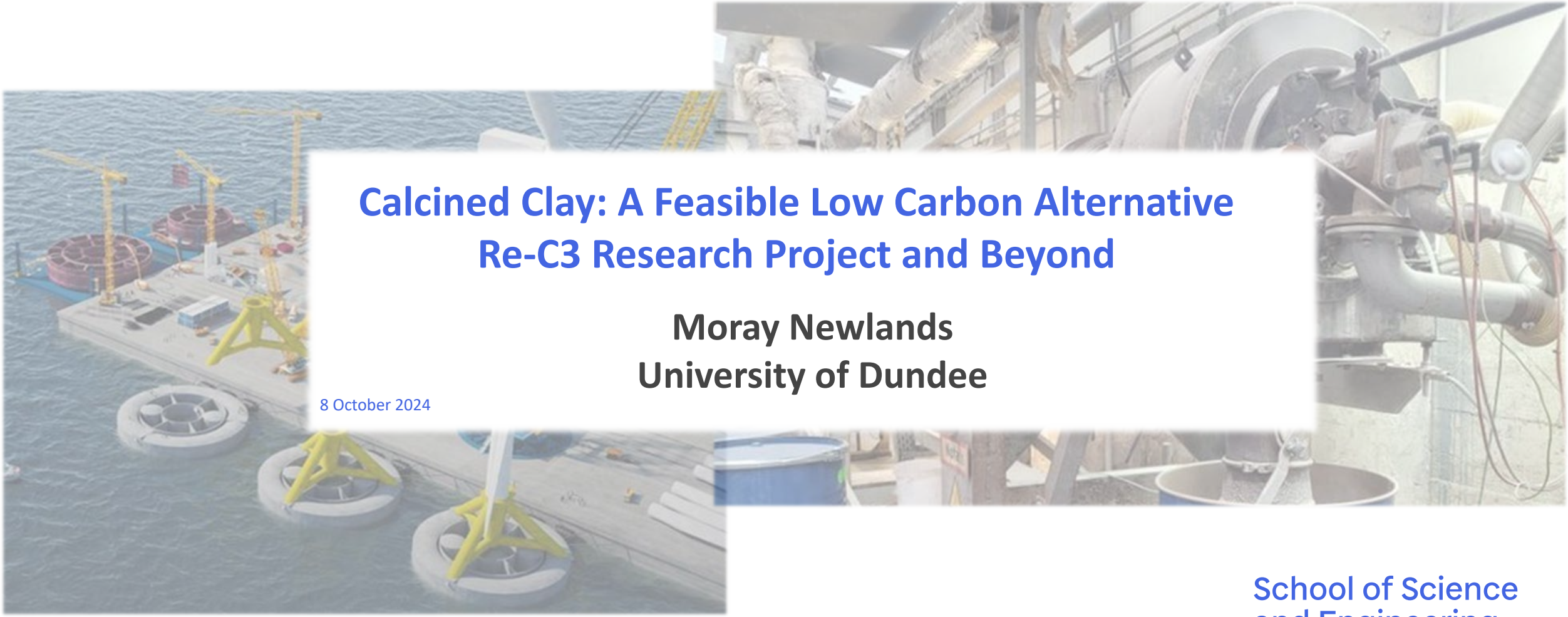


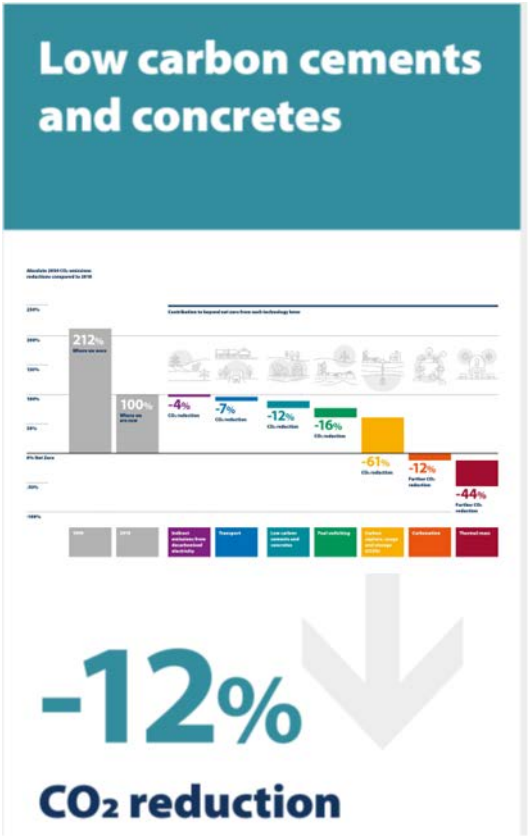
Calcined Clay: A Feasible Low Carbon Alternative
Re-C3 Research Project and Beyond

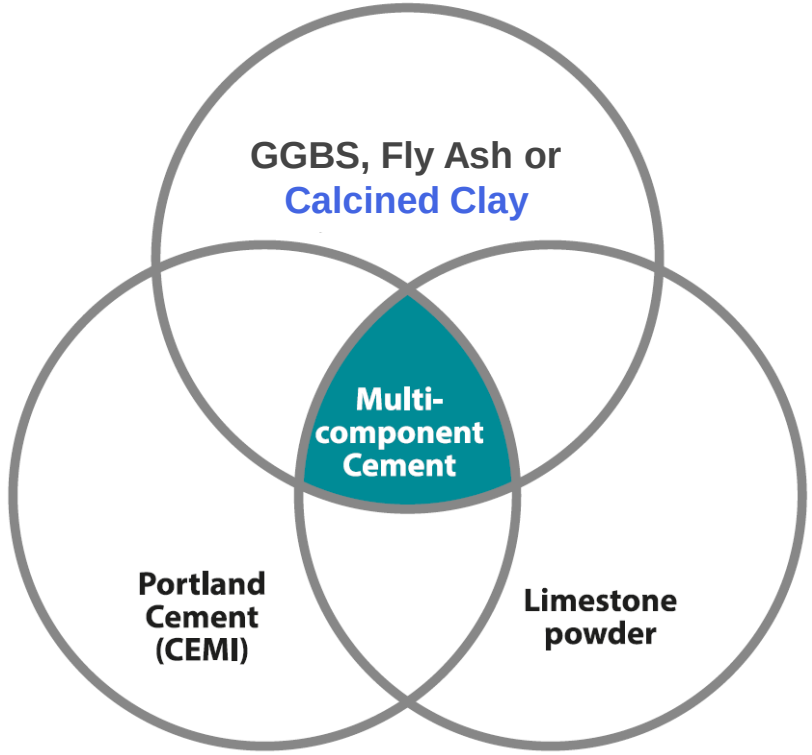
Moray Newlands
University of Dundee

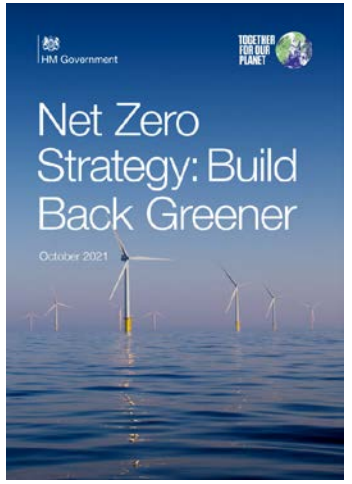
8 October 2024

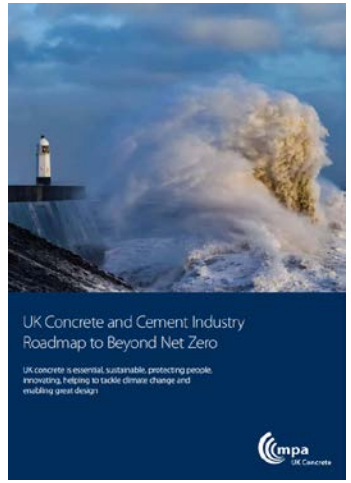
School of Science
and Engineering
University of Dundee

Drivers for Net Zero: UK Cements and Combinations



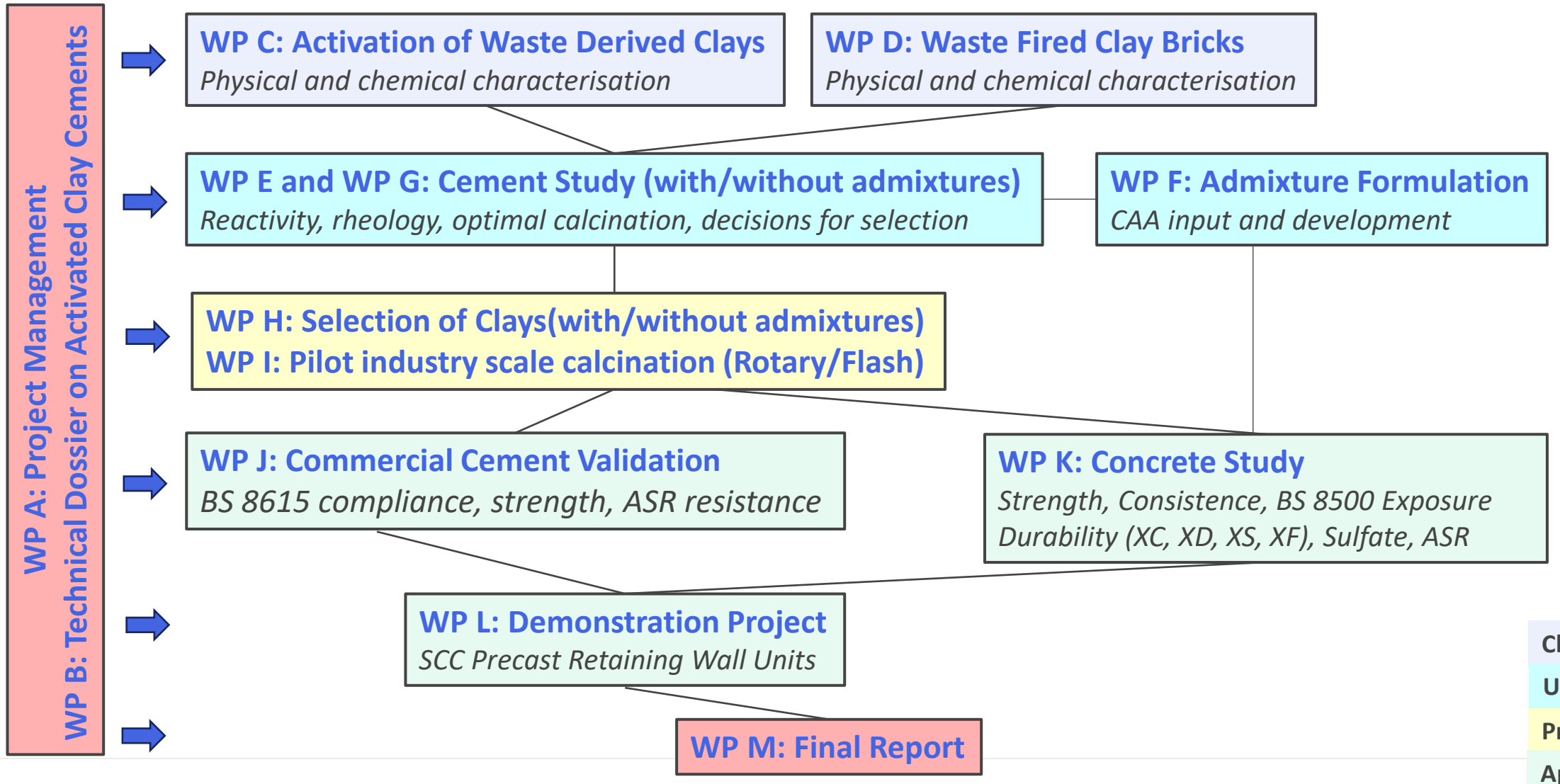






- Low carbon multi-component cements introduced in BS 8500:2023…
- CEM II/B-Q and CEM II/C-M (Q-L) cements already there…
- How much is “encouraged” within DNV design codes? (e.g. C502)

Re-C3 Project: 2 Years - Final Report Published August 2024



Range of Reclaimed Clays provided by industry partners

Inter/Overburden Sources within existing quarries (10 sources)

Brick dust prior to milling

Optimum:

Reactivity/ Calcination Temp/ Rheology/ Kaolinite Content

Selected for at scale calcination
RC2
RC3
RC7
RC9

- RC2 – 5 clays are reclaimed from China clay quarries (kaolinite content approx. 50-90%)
- RC6 & 7 clays are reclaimed from cement quarries (kaolinite content approx. 20%)
- RC8 & 9 clays are reclaimed from cement quarries (kaolinite content approx. 50%)

Pilot Calcination of Test Clays: Denmark and Germany

Flash Calciner

(≈ 850°C for minutes)

Rotary Kiln Calciner

(≈ 800°C for 30 mins)

Pre and Post Calcination Processing (crushing/grinding)

Work Package K: Concrete Test Programme to BS 8500

BS8500 Reference Concretes

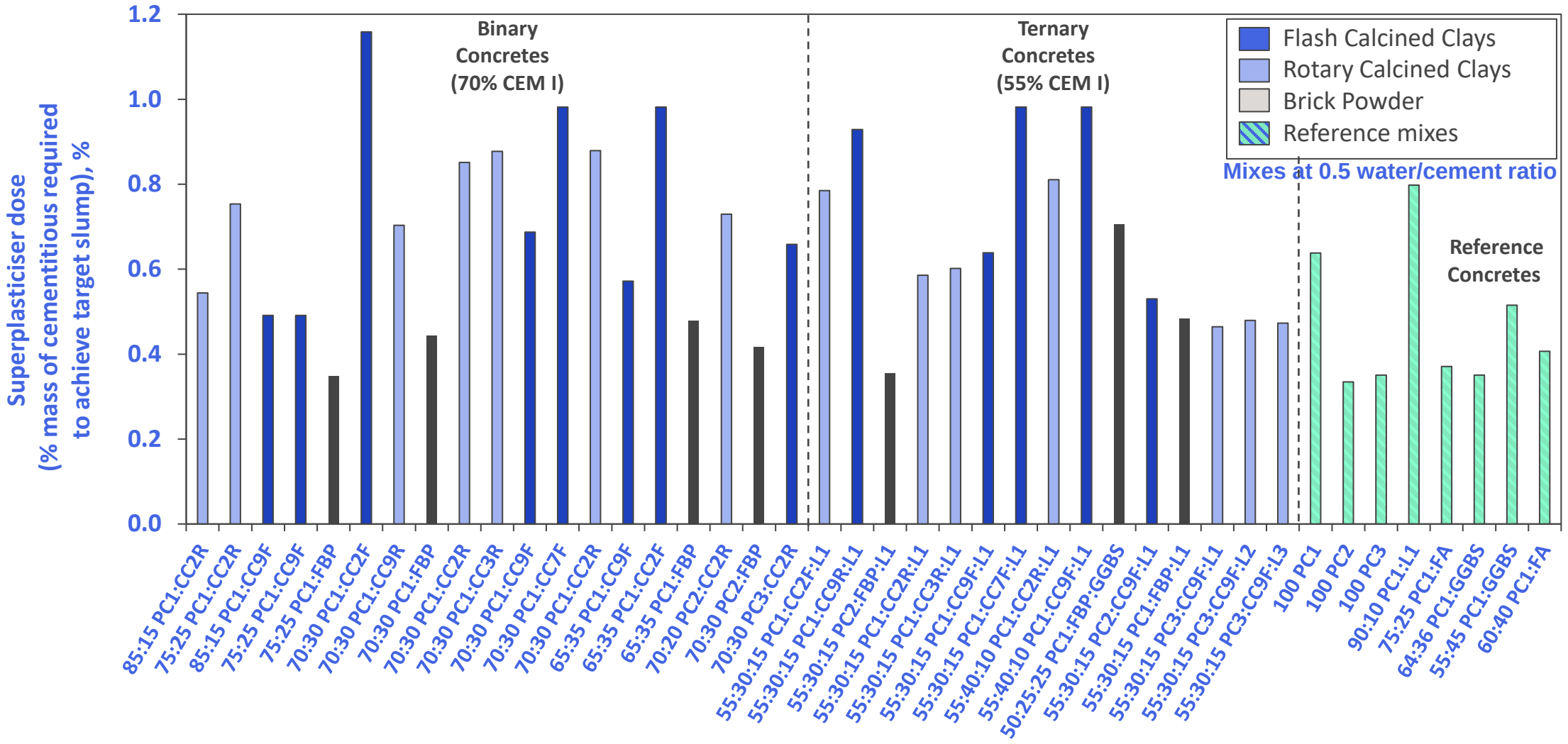
Cement Designation	w/c ratio	Total Powder, (kg/m³)	Combination
CEM I	0.5	340	100% CEM I (S1)
CEM II/A-L	0.5	340	85% CEM I (S1) 15% Limestone (S1)
CEM II/B-V (Full Factorial)	0.35 0.4 0.5 0.6	429 425 340 283	75% CEM I (S1) 25% Fly ash
CEM III/A	0.5	340	64% CEM I (S1) 36% GGBS
CEM III/A	0.5	340	55% CEM I (S1) 45% GGBS
CEM IV/B(V)	0.5	340	60% CEM I 40% Fly ash

Example BS8500 Concrete Mixes

Cement Designation	w/c ratio	Total Powder, (kg/m³)	Combination
CEM II/B-Q	0.4 0.5 0.6	425 340 283	70% CEM I (S1), 30% Brick dust
CEM II/C-M (Q-L)	0.4 0.5 0.6	425 340 283	55% CEM I (S1), 15% Limestone (S1), 30% Brick dust
CEM II/B-Q	0.35 0.4 0.5 0.6	429 425 340 283	70% CEM I (S1), 30% 1R/F calcined clay
CEM II/C-M (Q-L)	0.35 0.4 0.5 0.6	429 425 340 283	55% CEM I (S1), 15% Limestone (S1), 30% 1R/F calcined clay

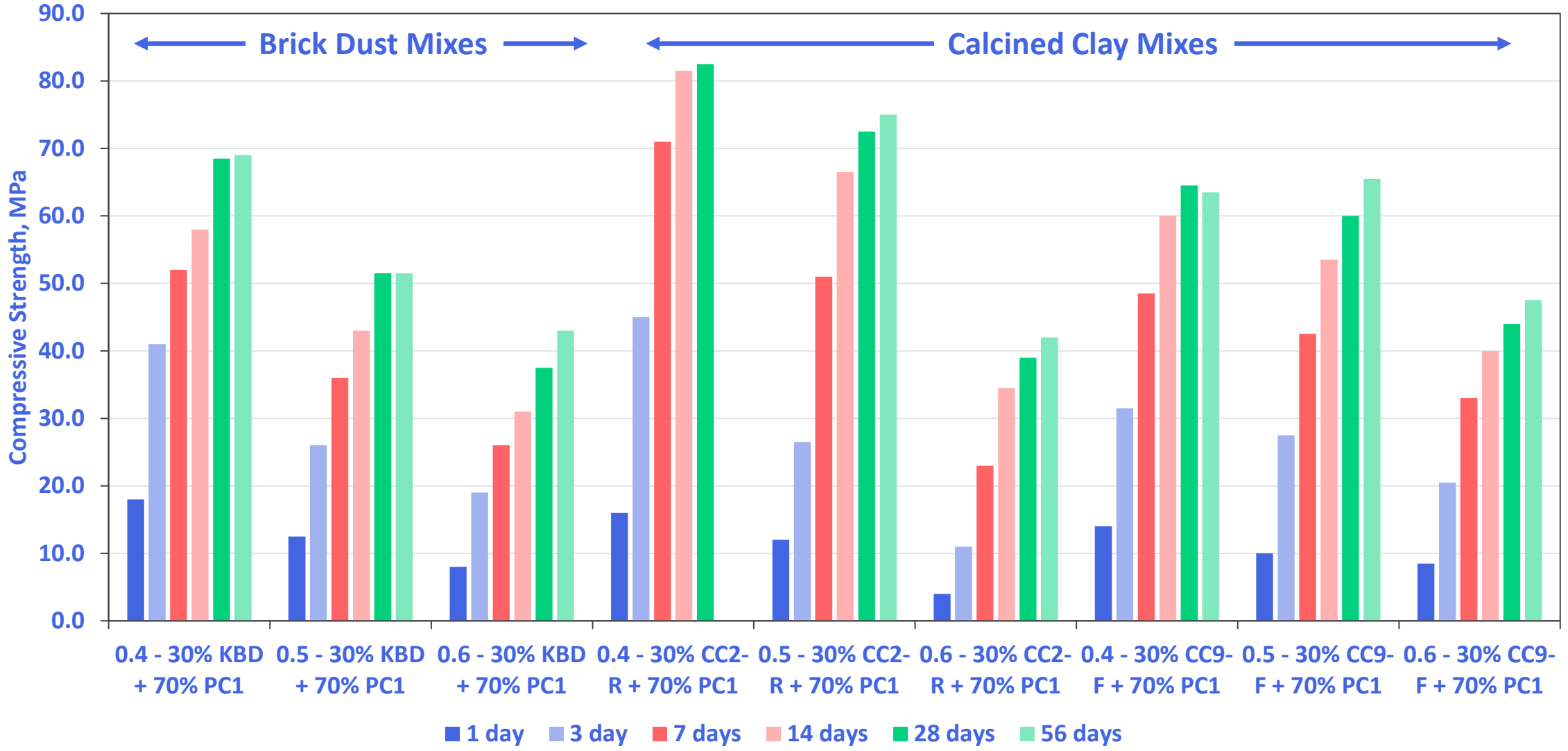
Note: Mixes were dosed with a combination of SP + VMA to achieve required slump (S2/S3)

Superplasticiser doses required to achieve S2/S3 Slump (150 ± 30 mm)



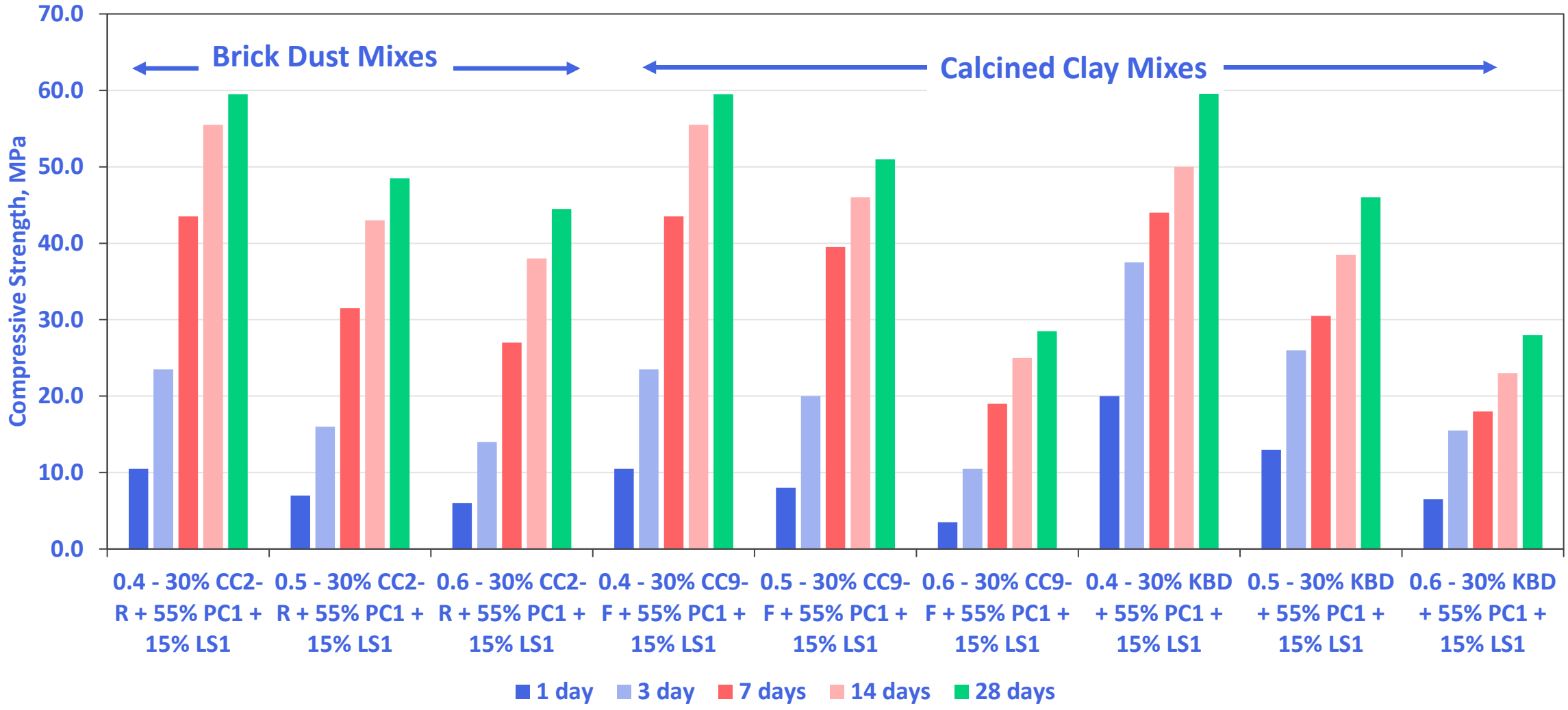
Compressive strength of CEM II/B-Q Concretes

30% BD and Calcined Clay Mixes



Compressive strength of CEM II/C-M (Q-L) Concretes

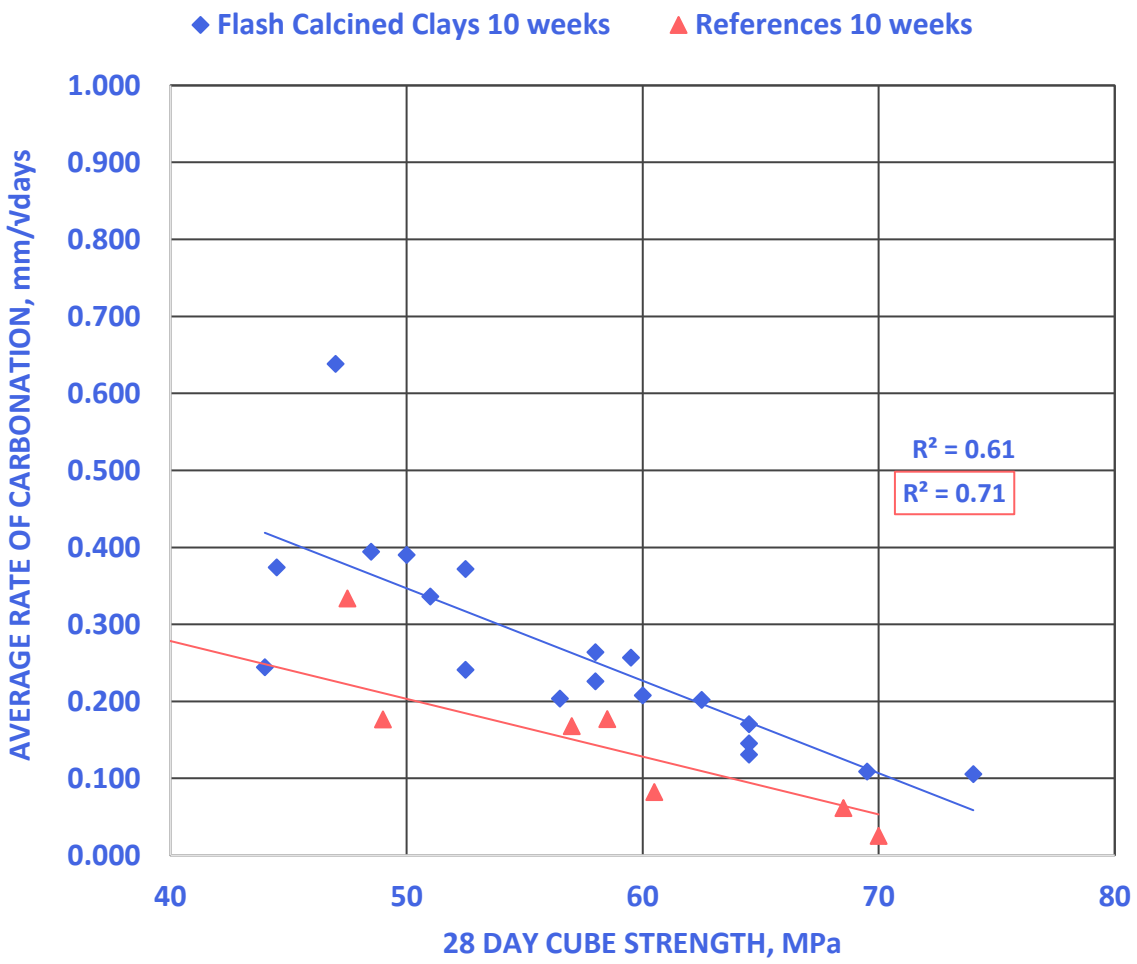
30% Calcined Clay and 15% Limestone



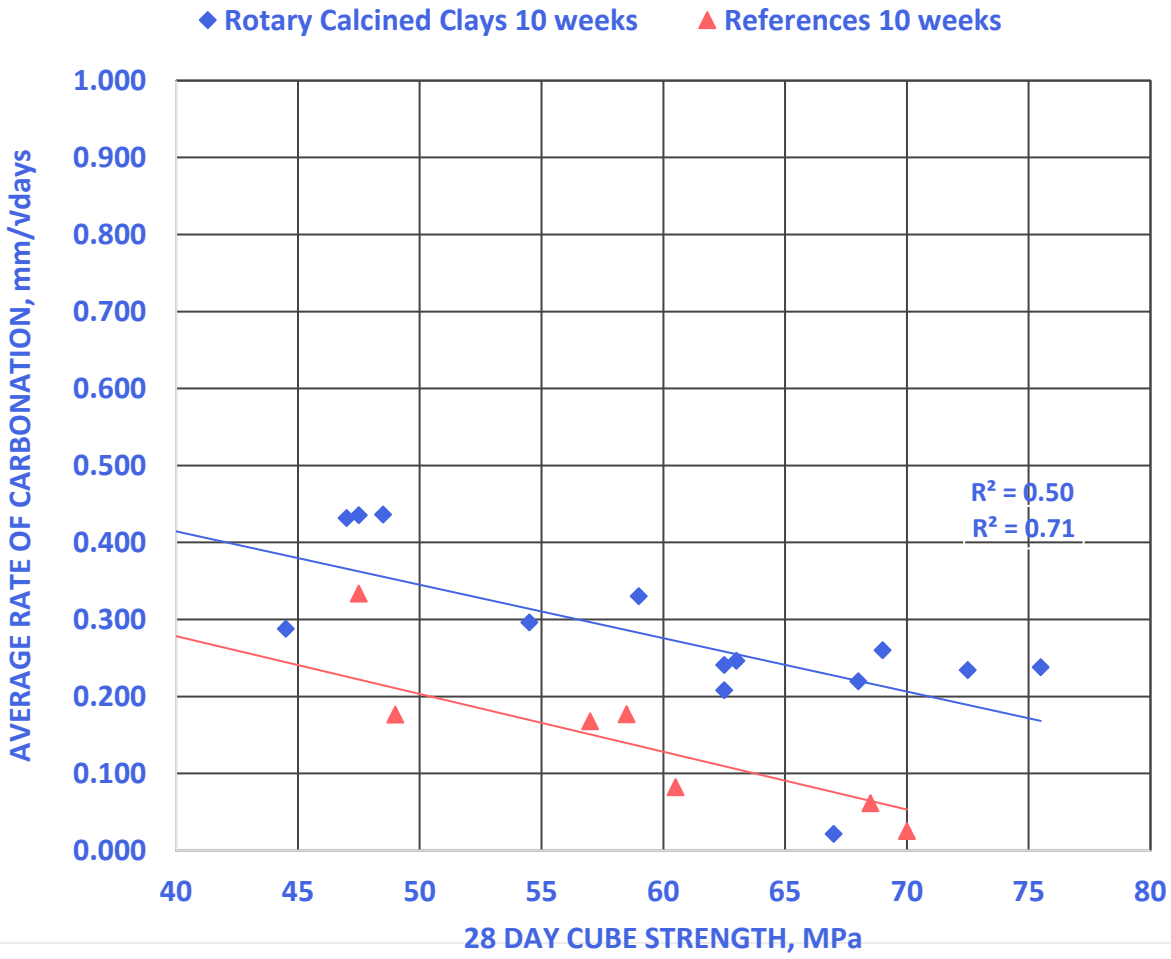
Accelerated Carbonation (BS EN 12390-12)

(3.0% CO_2) after 10 weeks

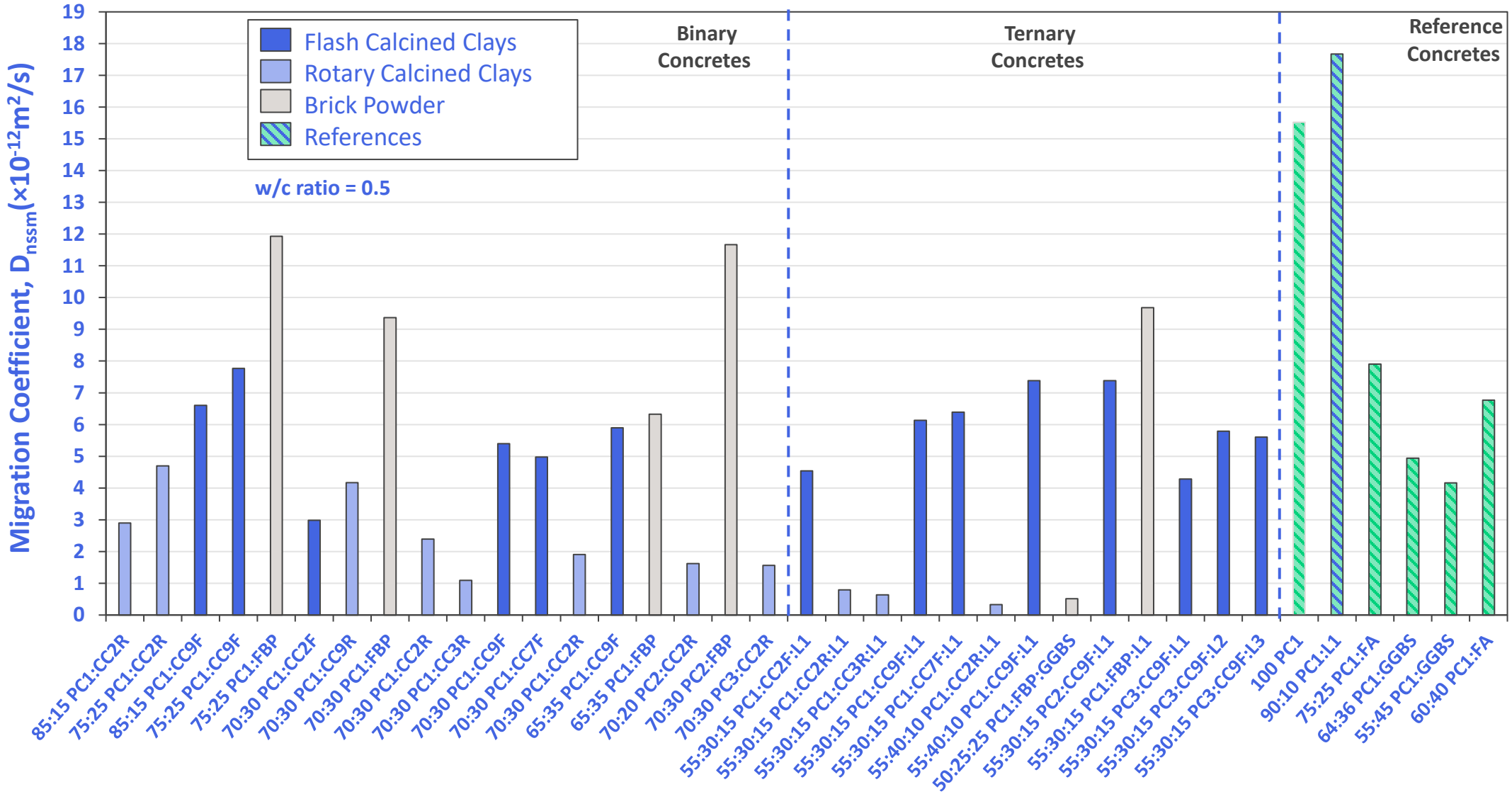
FLASH CALCINED CLAYS



ROTARY CALCINED CLAY



Chloride Migration (BS EN 12390-18)



Work Package L: Demonstration of Re-C3 Self Compacting Concrete

Re-C3 Project Summary Points

- Reclaimed UK clays can produce highly reactive calcined clay cements (even with low kaolinite contents).
- Calcined clay reactions contribute significantly to compressive strength from around 3 days and ‘largely’ complete by 14 days.
- Durability performance: Outdoor sheltered carbonation trends are similar. Chloride resistance is exceptional.
- Demonstrations of these materials in self-compacting concrete show the materials are practical.

New Generation Waste-Derived Cements for Offshore Floating Wind Turbine Bases

WP1: Supply Chain Desk Study
Calcined Clays and Stockpile Ash

WP2: Materials Sourcing and Characterisation
Clay/Ash, Physical/Chemical, Rheology, Heat

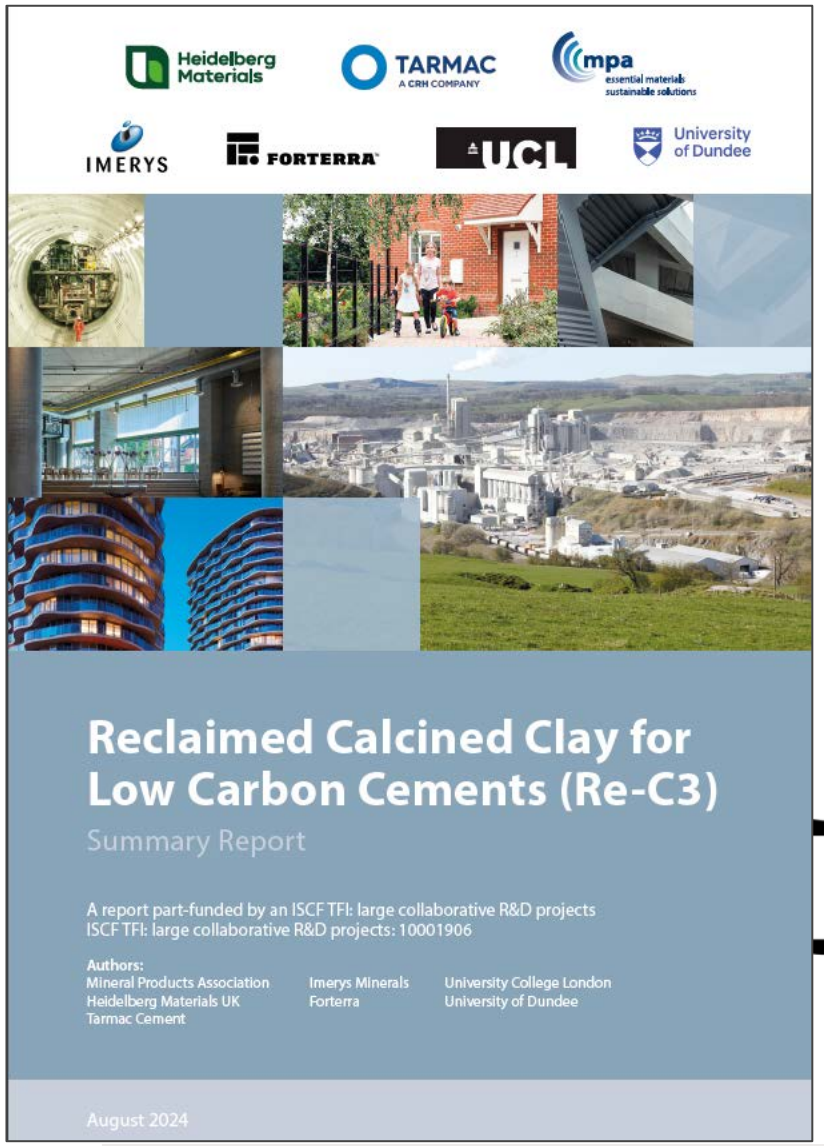
WP3: Development of Concrete Options
Rheology, setting, pumping, early age volume
Manufacturing methods: 3D, fibres, RCC

WP4: Durability in Scottish Deep Water
Steel corrosion, wetting/drying, chlorides/ sulfate, freeze/thaw, biofouling/ invasive species

WP5: End of Life Mapping
Environmental considerations, legislation, recycling/reuse options, recovery of waste

WP6: Development of Guidance
Design guidance, material selection and specification guidance, end of life guidance

Re-C3 Final Report: Summary and Appendices



Re-C3 Final Report

UK Research and Innovation
mpa essential materials sustainable solutions
Hanson HEIDELBERGCEMENT Group
IMERYS
FORTERRA
TARMAC A CRH COMPANY
UCL
University of Dundee

Thank you

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https://cement.mineralproducts.org/Innovation/Reclaimed-calcined-clay-cements.aspx