Concrete Society

Discussion Document 51





Calcined Clay

Benefits and Adoption for UK Concrete

Supplementary Cementitious Materials // Innovation // Low Carbon Concretes // Locally Sourced // Calcined Clay // Circularity // Task Group Report

Acknowledgements

This discussion document is published by the Concrete Society on behalf of a Task and Finish Group led by:

Charlotte Hills	Head of Innovation, HS2
Jon Knights	Lead, Materials & Durability, HS2
Marta de Miguel	Programme Manager, MTC
Joanna Starkie	Sustainable Materials Specialist, PA Consulting
Pete Winslow	Director, Expedition Engineering
Amy Woodward	Sustainability and Innovation Specialist, PA Consulting

Supported by:

Kathryn Ambrose	Sustainability Manager, Sellafield
Natalie Bird	Asset Sustainability Advisor, National Highways
Will Bower	Research Manager, Nuclear Waste Service
Emma Brown	Emissions Strategy Researcher, Heathrow
Thomas Budd	Waste Specialist, Dounreay
Ray Buckingham	Sellafield
Robert Everitt	Civil Engineer, National Grid
Martin Faulds	Principal Civil Engineer, Scottish Water
Roger Griffiths	Manager – Innovation Projects, MPA
David Joseph	Senior Materials Scientist, Anglian Water
Noushin Khosravi	Head of Sustainability, MPA
Andrew Kidd	Director of Environmental Sustainability, LTC
Stafford Lloyd	Innovation Lead, Innovate UK
Sophie McCullagh	Supply Relationship Manager, DfT
Alex Murray	Category Manager – Capital Projects and Infrastructure, NDA
Sumit Pandey	Head of Carbon Assurance and Technical Advice, DfT
Andrew Powell	Innovation Manager, Environmental Agency
David Riley	Head of Carbon Neutrality, Anglian Water
Nick Sumption	Strategic and Operational Director, Sumption Solutions, / I3P
Lily Tozer	Head of Industrial Resource Efficiency and IETF Policy, DESNZ
John Ubaldo	Head of Technical Discipline, TfL
Ian Watt	Delivery Manager, Scottish Water
Imogen Williams	Policy Advisor, DESNZ
Jane Wright	Senior Engineer, TfL

Cover images: Left, Excavated London Clay.
Right, Placing calcined London Clay concrete as permanent works.

Cover images courtesy of HS2.

Contents

Foreword		ii
List of Figures and Tables		iii
1.	**Executive Summary**	**1**
2.	**Strategic Context**	**2**
2.1	Strategic Assessment	2
2.2	Scope	4
3.	**Barriers to Change**	**5**
3.1	Challenges to Overcome	5
3.2	Assessment Programme	5
3.3	Findings	7
4.	**The Requirement**	**9**
4.1	Strategy and Aims	9
5.	**The Case for Change**	**11**
5.1	Benefit Case	11
6.	**Next Steps**	**15**
7.	**References**	**16**

Foreword

The establishment of this Calcined Clay Project was initially brought about by the awareness and understanding of the large amounts of excavation waste arisings being produced on Phase 1 contracts for HS2, which have the potential to be transformed into cementitious materials for concrete.

Within the London sections of the project alone, over 5 million cubic metres of London Clay were being excavated to produce tunnels, cuttings and stations. Moreover, it was acknowledged that there were no facilities to process waste and natural clays for calcining at scale. HS2 recognised the potential and initiated this Project to enable a programme to demonstrate the benefits of lower carbon UK calcined clays as a viable cementitious product to supplement higher carbon cement clinker as part of the solution to reduce embodied carbon in construction products.



Calcined nodules of London Clay.
Courtesy of SCS

A proposal to the Transport Research and Innovation Board (TRIB), part of the DfT, was delivered in December 2023 and gained their support to embark on the assessment of the benefits, barriers and mitigations for the adoption of calcined clay in UK construction.

The Calcined Clay Delivery Group (CCDG) was formed by HS2 and supported by DfT. A Task and Finish Group was convened for this project comprising representation from all Arm's Length Body infrastructure clients, Government Departmental representation, and many other key infrastructure client stakeholders. The work has been ably supported by The Manufacturing Technology Centre, PA Consulting and Expedition Engineering.

The participation of the Group members has been extremely positive, and many have formed an active role in steering the outcomes of this Project through their individual institutional knowledge and experience.

The Project supports the growing UK and international interest in the use of calcined clay as Supplementary Cementitious Materials (SCMs). The Infrastructure Client Group (ICG) is tasked with accelerating the decarbonisation of concrete and steel and its workstreams align closely with this Project. In addition, the project aligns with the recommendations of the Low Carbon Concrete Group, supported by the Institution of Civil Engineers. The Project follows other public initiatives such as Concrete Zero, and the UK Innovate/ SBRI concrete decarbonisation programme and The Concrete Commitment Cohort.

The Calcined Clay Delivery Team consists of:
Jon Knights, Lead, Materials & Durability, HS2
Charlotte Hills, Head of Innovation, HS2
Ellis Lester, Lead Material Engineer - Durability, HS2
Clementine Ewins, Senior Innovation Analysist, HS2
Doug Rigden, Graduate Engineer, HS2
Pete Winslow, Director, Expedition Engineering
Bruce Martin, Associate Director, Expedition Engineering
Amy Woodward, Sustainability and Innovation Specialist, PA Consulting
Joanna Starkie, Sustainable Materials Specialist, PA Consulting
Ella Weston, Consultant, PA Consulting
Steve Nesbitt, Chief Engineer and Sector Director, MTC
Marta De Miguel, Programme Manager, MTC
Adam Edwards, Senior Research Engineer, MTC
Liz Scoffins, Senior Research Engineer, MTC
Rae Davis, Advance Research Engineer, MTC
Harry Leach, Graduate Research Engineer, MTC
Joe Leach, Project Management Apprentice, MTC

List of Figures and Tables

Figure 1
The potential shift needed in Supplementary Cementitious Materials usage to contribute to UK net zero targets 3

Figure 2
Four key issues hindering the adoption of Calcined Clay in the UK, underpinned by multiple contributing barriers 6

Figure 3
The supply-demand deadlock 7

Figure 4
Barriers to adoption and the nine key mitigations that can address them 8

Figure 5
Calcined Clay adoption strategy, to 2030 10

Figure 6
3C model considering cost, carbon and circularity 11

Table 1
Green Cement Technology Tracker, an initiative of LeadIT and GCCA. Data captured as of April 2024 12

Table 2
Embodied carbon of Cementitious materials 13

01

Executive Summary

This discussion document aims to demonstrate the viability of calcined clays as a Supplementary Cementitious Material (SCM) in concrete, addressing concerns over its techno-economic feasibility and challenging current perceptions. The paper recommends a series of interventions to enable behavioural change, demand signalling, and widespread adoption of calcined clay in the UK. These outcomes were facilitated by the Calcined Clay Task and Finish Group.

The UK construction industry faces significant challenges in the procurement and control of emissions for cementitious materials in concrete. With rising demand for cement and increased production costs, there is a net deficit of UK production and a decline in some SCMs, which will increase the cost of supply and reduce resource security.

Calcined clay presents a viable alternative, offering a cost-effective, sustainable solution for UK concrete construction. Calcination is 40% more efficient than CEM I and eligible for up to 55% replacement under British and European standards, achieving 35% less embodied carbon while improving resource security.

Despite its benefits, calcined clay has not been widely implemented in the UK due to a complex system of interconnected barriers. These barriers include informational, techno-economic, cultural, organisational, and regulatory challenges, creating a supply-demand deadlock.

The Delivery Team's value chain assessment highlighted that major supply chain companies are unlikely to make the first move, have no immediate plans to invest in calcined clay and further action could be 7 to 15 years away. Demand-side organisations also need more knowledge and awareness regarding its use. Therefore, intervention is required to break the supply-demand deadlock and access benefits in the UK at scale.

To break the supply-demand deadlock and enable the adoption of calcined clay, the following mitigations are recommended: industry commitments, grants and funding, and awareness campaigns. Public commitments and endorsements from industry are essential to stimulate demand and supply signals. Financial support is needed to demonstrate the commercial and operational feasibility of calcined clay. Awareness campaigns should be initiated to raise awareness and educate stakeholders about the benefits and technical aspects of calcined clay.

The strategy to increase the use of calcined clay involves several key steps. First, establishing a small-capacity pilot kiln to test UK clay reserves and resources. Second, encouraging the use of imported calcined clay in low criticality works to build confidence and optimise concrete production. Third, raising awareness and educating key stakeholders to generate commitments and incentivise action. Finally, articulating the value proposition to investors to secure funds for pilot and commercial kilns.

Calcined clay has the potential to form part of the next generation of lower carbon cementitious materials for concrete. However, without sufficient infrastructure and industry commitment, its contribution to carbon reduction targets will not be realised. The recommended strategy and mitigations aim to overcome the barriers to adoption and enable the widespread use of calcined clay in the UK, contributing significantly to the UK's Net Zero journey.

02 Strategic Context

2.1 Strategic Assessment

The UK construction industry is heavily reliant on concrete, a versatile material made by mixing aggregates with cementitious binders, water and chemical admixtures under strict regulatory controls. Annually, over 90 million tonnes of concrete are produced in the UK [1], forming the backbone of the built environment.

Despite significant efforts to reduce emissions, the UK cement and concrete industry still faces substantial challenges in meeting the ambitious Net Zero targets set for 2050, with an interim goal of a 66% reduction by 2035 [2].

Cement clinker production, known as Portland cement clinker or CEM I in Europe, is a major contributor to global carbon emissions, accounting for around 8% of the total, and 1.5% of the UK's emissions. The carbon intensity of concrete can be significantly reduced by replacing CEM I with Supplementary Cementitious Materials (SCMs).

However, the UK is currently facing a series of challenges in the procurement and control of emissions for cementitious materials. The demand for cement is expected to rise by 48% by 2050 [3], and production costs are anticipated to increase by up to 20% due to higher energy demands [4].

Additionally, there is a net deficit in UK production and a decline in some SCMs, such as ground-granulated blast furnace slag (GGBS) and fly ash (FA), which will increase supply costs and reduce resource security.

Major infrastructure clients, who consume over 40% of the UK's concrete production [5], are also significant users of lower carbon SCMs and have their own stringent targets for reducing emissions by 2030 and beyond. The Department for Transport (DfT) and its Arm's Length Bodies (ALBs) have extensive construction portfolios, making them well-placed to influence the construction industry and benefit from innovations in low carbon SCMs.

To address the "perfect storm" of Net Zero targets, resource security, and cost pressures, immediate action is required to scale up alternative options. Calcined clay is identified as a promising alternative that can be rapidly scaled to supplement established SCMs. Calcined clay is a natural pozzolana produced by heating clay materials to activate the clay minerals, creating a binder that can replace a portion of CEM I in concrete.

This process uses around 40% less energy than producing CEM I clinker and can replace up to 55% of clinker in concrete, making it a cost-effective and sustainable solution for UK concrete construction. Moreover, the production and use of calcined clay is adequately addressed under current regulatory UK standards BS 8615, BS EN 197 (Parts 1 and 5) and BS 8500, and consequently there is no barrier to its immediate specification and use.

The UK has abundant clay reserves, both from natural sources and construction excavation waste, which can be utilised through calcination to reduce waste and transportation costs. Despite the global interest in calcined clays and the development of new facilities

worldwide, the UK currently lacks the infrastructure to produce calcined clays at scale. This lack of production facilities has resulted in little demand for calcined clay in UK construction activities.

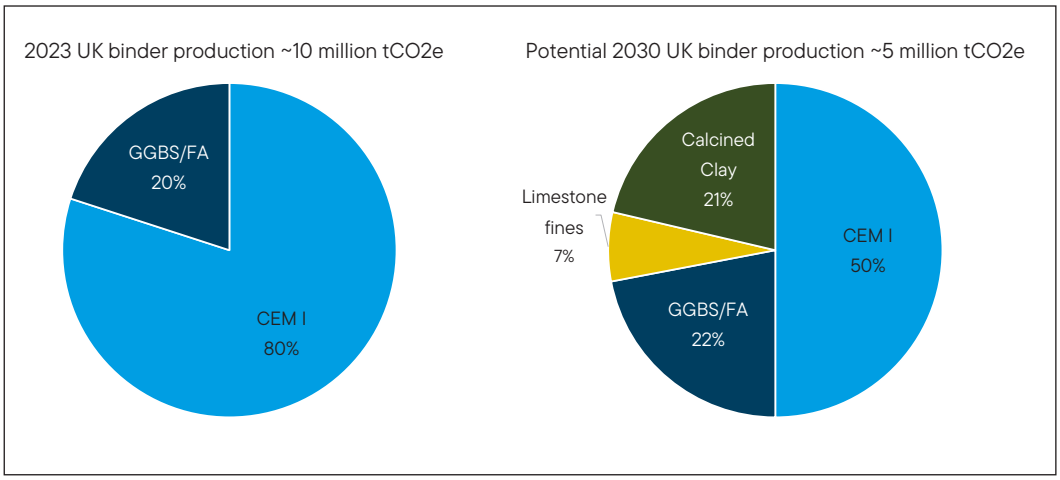


Figure 1: The potential shift needed in Supplementary Cementitious Materials usage to contribute to UK net zero targets [6]

Figure 1 (above) illustrates a conceptual snapshot of current principal SCM use and the potential for change using other replacement materials. Calcined clay has the potential to be a key component of the next generation of low carbon cementitious materials for concrete. However, without the necessary infrastructure and industry commitment, its contribution to carbon reduction targets will not be realised. Immediate action is required to overcome the barriers to adoption and enable the widespread use of calcined clay in the UK, contributing significantly to the country's Net Zero journey.



One million tonnes of tunnel waste arisings at the HS2 logistics hub, London.
Courtesy of SCS

2.2 Scope

This paper aims to demonstrate UK clays for calcination as a viable SCM in concrete, addressing concerns over its techno-economic feasibility and challenging current perceptions. A series of interventions are recommended to enable behavioural change, demand signalling, and widespread adoption of calcined clay. The outcomes of this paper have been facilitated by the Calcined Clay Task and Finish Group, convened to steer and evaluate the findings of the project.

A large body of work has been generated through this project, which cannot be fully presented here. Further information on the background analysis is available on request from the Task and Finish Group.



Northolt tunnel (West) arisings stockpile area, HS2.
Courtesy SCS



Waste arisings being conveyed from the Northolt tunnel drive, HS2.
Courtesy SCS

03

Barriers to change

3.1 Challenges to Overcome

Understanding the barriers to calcined clay adoption in the UK is a crucial initial step to enabling the widespread adoption and scaling up of calcined clay. The insights outlined here were generated to enable the development of informed and targeted solutions that address root causes to overcome the most significant obstacles for adoption, ultimately maximising efforts and resources.

3.2 Assessment Programme

A programme of analysis exploring the barriers to calcined clay adoption and their mitigation was conducted, aiming to:

- Provide detailed insights into the current state of calcined clay implementation.
- Identify why calcined clay hasn't been implemented or scaled yet in the UK.
- Explore potential opportunities for mitigating the identified barriers to adoption.
- Highlight specific, actionable recommendations that address key barriers in the short term and facilitate accelerated deployment of calcined clay.

To develop a comprehensive, evidence-based understanding of barriers to adoption in the UK, rich insights were gained from a diverse set of stakeholders and information sources:

1 **Calcined Clay Task & Finish Group** workshops with the demand side organisations. Three Task & Finish Group workshops were conducted between March and July 2024 with around thirty stakeholders representing the UK's largest concrete users, professional bodies and financers. Targeted activities took place over a series of weeks to identify barriers to adoption and potential mitigation options.

2 **Interviews** with a representative sample of ten targeted organisations from across the production supply chain, including cement and concrete producers, SCM suppliers, and contractors. The interviewee organisations include Heidelberg Materials, Tarmac, Ecocem, Cemcor, Neo-eco, Balfour Beatty, Capital, Laing O'Rourke, Skanska and LKAB.

3 **Further data** was incorporated from secondary sources (research reports, industry publications) and Delivery Group expertise to support findings.

4 **To ensure robust findings**, sensitivity testing was conducted with the Task and Finish Group and a sample of stakeholders to validate the insights captured and assess the robustness of proposed mitigations under different scenarios.

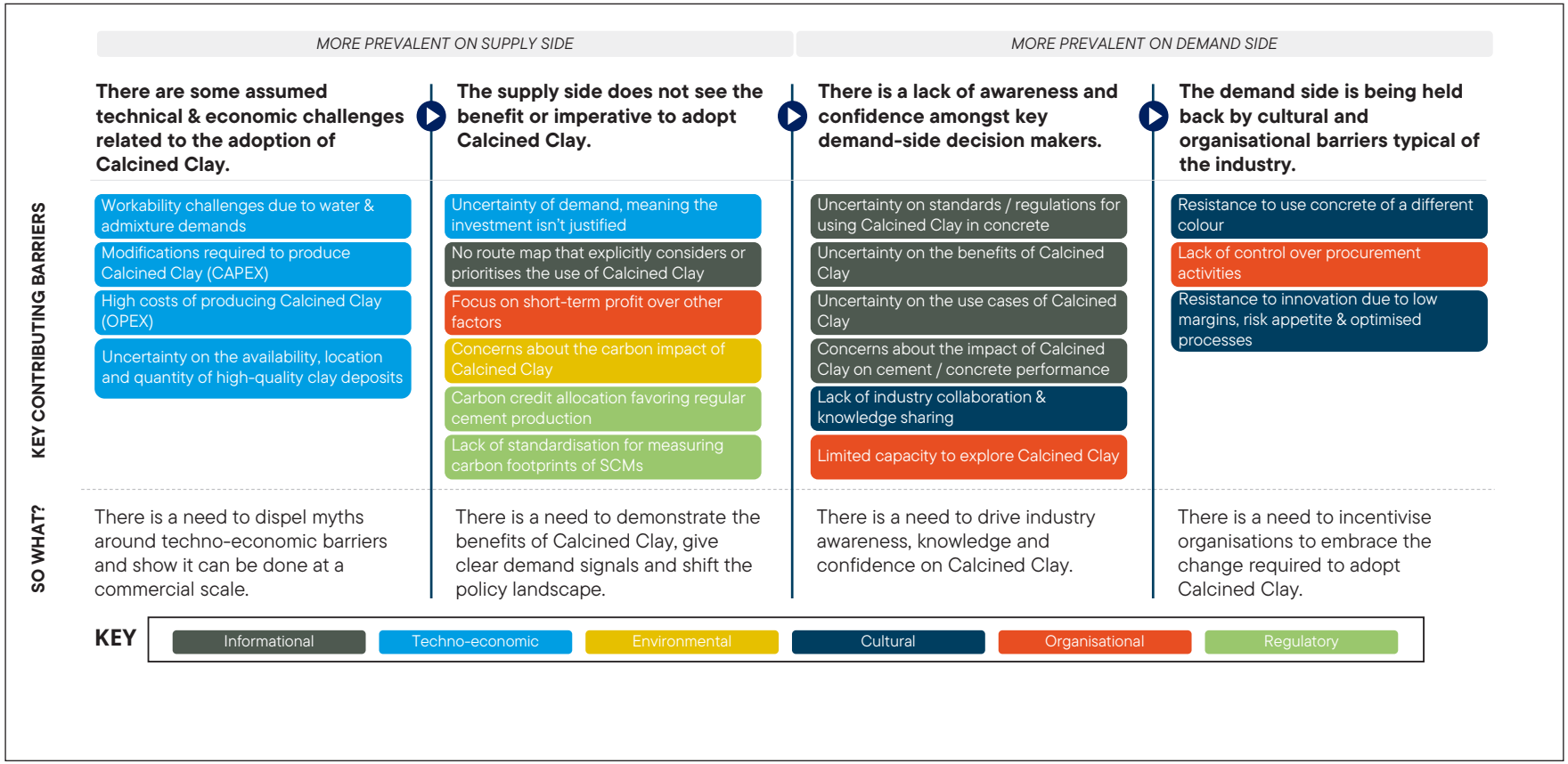


Figure 2: Four key issues hindering the adoption of Calcined Clay in the UK, underpinned by multiple contributing barriers

3.3 Findings

Calcined clay has not been implemented to date in the UK due to a complex system of interconnected barriers. Different types of barriers across various themes – informational, techno-economic, cultural, organisational and four overarching challenges that are hindering the adoption of calcined clay (see Figure 2, page 6). These challenges are:

1 **Informational Barriers:** There is a lack of awareness and understanding of calcined clay's benefits and technical aspects among stakeholders. This has led to misconceptions and a lack of confidence in its use.

2 **Techno-Economic Barriers:** The perceived high costs and technical challenges associated with calcined clay production and use are significant deterrents. There is a need for financial support to demonstrate its commercial and operational feasibility.

3 **Cultural and Organisational Barriers:** The construction industry's entrenched practices and resistance to change hinder the adoption of new materials like calcined clay. Organisational inertia and a lack of leadership commitment further exacerbate this issue.

4 **Regulatory Barriers:** Existing regulations and standards do not fully support the use of calcined clay, creating additional hurdles for its adoption.

The outcome of the assessment indicates that barriers to adoption operate in a vicious cycle and are working together to create a supply-demand deadlock, a 'chicken and egg' scenario where neither supply nor demand has the confidence to move (see Figure 3, below).

The Delivery Teams supply chain assessment of the value chain, barriers and mitigations highlighted that major supply chain companies are unlikely to make the first move, have no immediate plans to invest in calcined clay and further action could be 7 to 15 years away. Meanwhile, demand side organisations required more knowledge and awareness of when and how to utilise calcined clay. Therefore, intervention is required to break the supply-demand deadlock and access benefits in the UK at scale.

With input from key stakeholders across the supply chain, a total of, nine key mitigations were identified that could, in combination, solve all the barriers to calcined clay adoption in the UK that have been identified (see Figure 4, page 14).

Recognising the importance of optimising effort, a comprehensive prioritisation process was conducted within the Delivery Team and with Task and Finish Group members. Barriers were prioritised based on their influence and potential impact if addressed. The analysis showed that demonstrating demand, environmental and financial benefits, viable sources of clay, and product performance will be crucial to unblocking the supply-demand deadlock.

These mitigations aim to break the supply-demand deadlock and enable the widespread adoption of calcined clay in the UK. By addressing the informational, techno-economic, cultural, organisational, and regulatory barriers, the UK can achieve significant progress towards its Net Zero targets and enhance resource security in the construction industry.

1 **Industry Commitment:** Public commitments and endorsements from industry leaders to use calcined clay, stimulating demand and supply signals.

2 **Grants and Funding:** Financial support to demonstrate the commercial and operational feasibility of calcined clay, dispelling techno-economic myths.

3 **Awareness Campaign:** Initiatives to raise awareness and educate stakeholders about the benefits and technical aspects of calcined clay.

4 **Proof of Concept:** Establishing a small-capacity pilot kiln to test UK clay reserves and resources.

5 **Demonstrator Projects:** Encouraging the use of imported calcined clay in low criticality works to build confidence and optimise concrete production.

6 **Communicate Value:** Articulating the value proposition to investors to secure funds for pilot and commercial kilns.

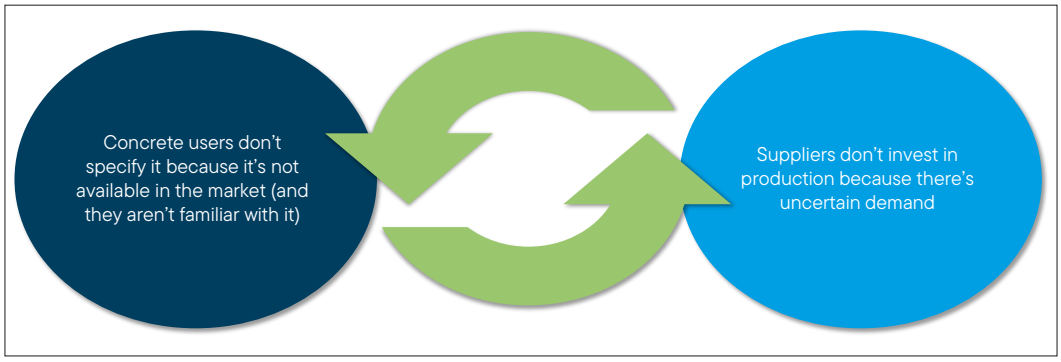


Figure 3: The supply-demand deadlock

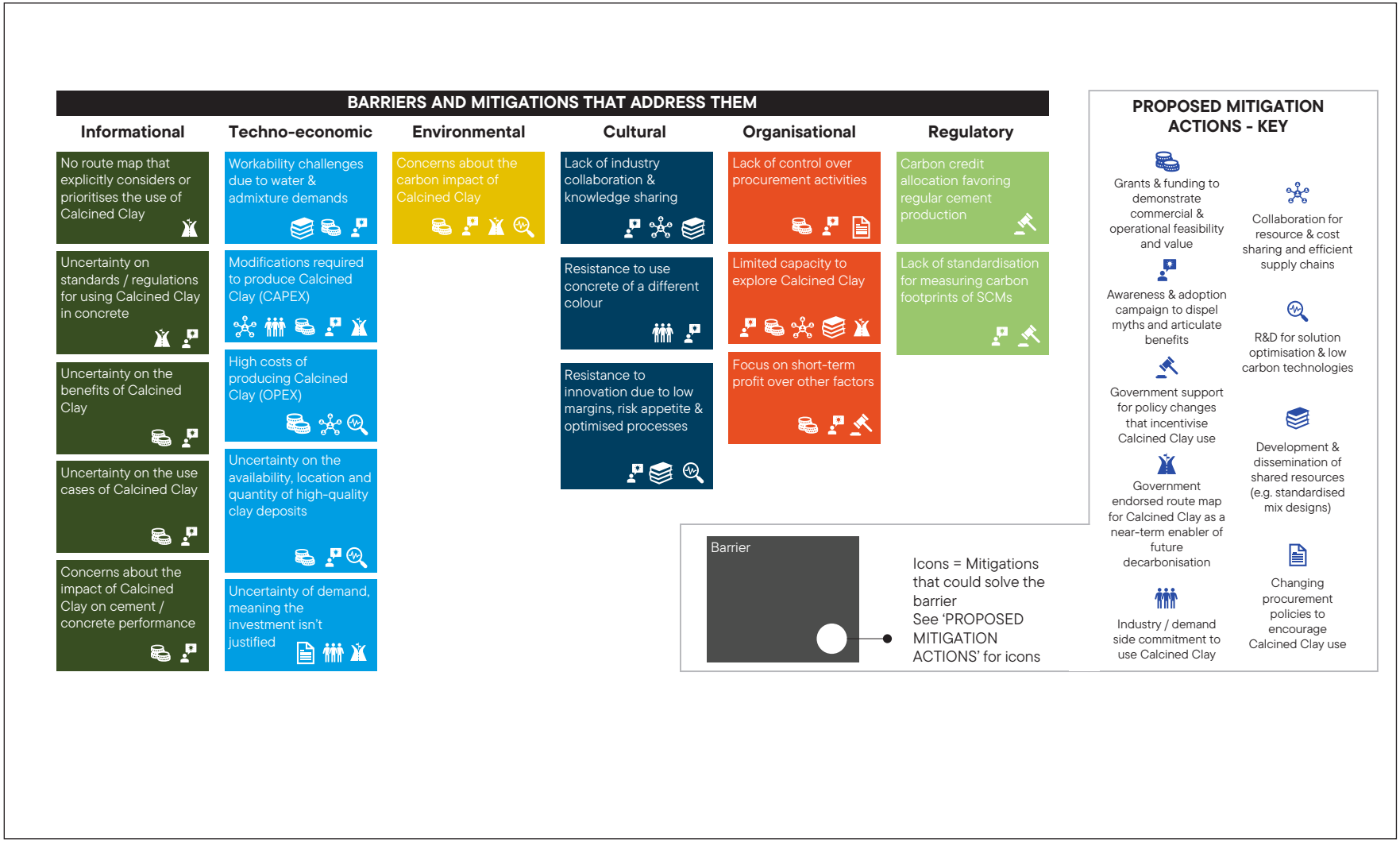


Figure 4: Barriers to adoption and the nine key mitigations that can address them

04

The Requirement

4.1 Strategy and Aims

To support the rapid decarbonisation needed within the UK infrastructure sector and overcome the barriers previously mentioned, there is an urgent need to identify and introduce an alternative SCM into UK cement production. The Task and Finish Group has highlighted opportunities to utilise calcined clay and a willingness among stakeholders to commit to alternatives.

The strategy to increase the use of calcined clay involves several key steps (see Figure 5, page 16):

1 **Build Confidence:** Develop demand signalling by preparing for the adoption of calcined clay and engaging early adopters by addressing technical uncertainties and increasing awareness and confidence to break the demand-supply deadlock.

2 **Define Commitment:** Establish Advance Market Commitments (AMCs) “in principle” to encourage demand-led innovation and procurement of production facilities.

3 **Deliver a Proving Ground:** Launch the procurement of a pilot kiln to test UK clay resources.

4 **Accelerate Scale-Up:** Initiate the pre-development stages for planning and procuring the first UK commercial kiln to induce public or private funding initiatives (estimated capacity of 100,000 tonnes per year by 2027). Further kiln procurement and construction or retrofitting to an anticipated total of 4 million tonnes per year by 2030.

Significant government backing is required to motivate industry to make the move, serving as seed-funding for further public or private financing for major kiln development phases. This strategy aims to develop commercial-scale supply chains for calcined clay in the construction industry by 2030.



Placing calcined London Clay concrete, made with clay taken from the tunnel.
Courtesy SCS

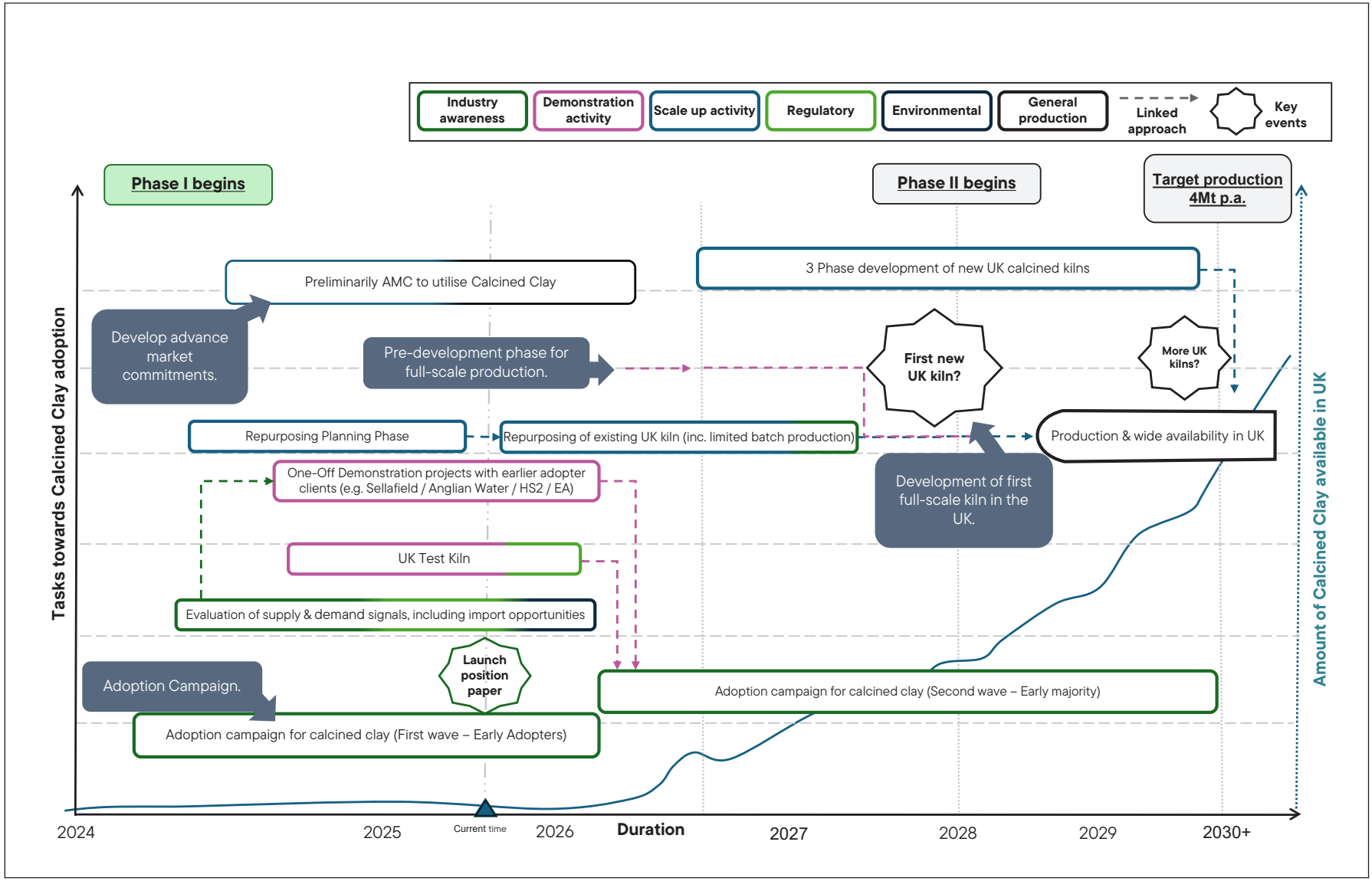


Figure 5: Calcined Clay adoption strategy, to 2030

05

The Case for Change

5.1 Benefit case

The framework for assessing the benefits of calcined clay is based on a '3C model', providing a robust and holistic view of cost, carbon, and circularity to offer insights to multiple stakeholder groups. Depending on which benefit is maximised, the weight of each factor can be adjusted. This section demonstrates how each benefit can be realised, whether it is the lowest carbon for the end user or the most profitable production of calcined clay for the supply chain (see Figure 6, below).

Other benefits are also considered, such as green local job creation, local security of material supply, regulatory landscape, trends and demand, competition, and opportunities for collaboration.

Cost Benefits

Calcined clay is typically produced at 600 to 800°C compared to ~1500°C for Portland cement clinker, representing significant energy savings and a predicted 30% reduction in cost compared to standard CEM I. Further savings could be made by reducing energy for grinding.

Supply chain stakeholders suggest that initial cost savings may not be passed on to end users due to early

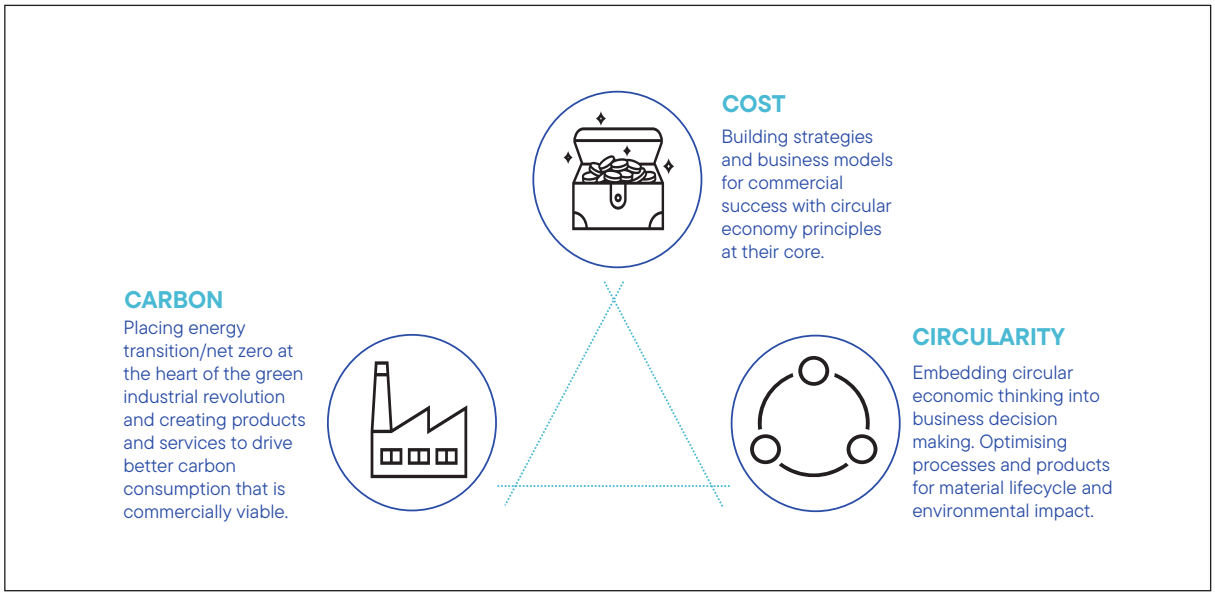


Figure 6. 3C model considering cost, carbon and circularity

adopters matching current prices to achieve higher returns. As calcined clay becomes more widespread, its cost should decrease due to lower fuel costs and the absence of import requirements. The cost benefits illustrate CAPEX and OPEX for a new kiln, with potential retrofitting of existing under-utilised kilns.

CAPEX

CAPEX costs vary widely depending on the size of the facility and the calcining technology used. Breaking ground on a new greenfield site is the highest CAPEX option, whereas converting an existing rotary kiln is the lowest. Analysis suggests that an initial plant in the UK producing 100,000 tonnes per year would have a capital cost of around £30 million. Recent case studies in France corroborate this estimate (see Table 1).

OPEX

OPEX is most dependent on the fuel usage, clay source and the transportation of the clay required. LC3 published a detailed report in 2019 with different financial scenarios for production of LC3 material using a flash calciner or rotary kiln. OPEX costs range from £16.50 to £32.70 per tonne [6].

Holcim has commercialised two calcined clay facilities in France. At the La Malle plant where an existing rotary kiln was transformed to produce 0.18 million tonnes of calcined clay per year for about 6 million Euros. However, this results in the production of calcined clay resulting in a large amount of carbon emissions as a transformed rotary kiln, whilst cost efficient, is not the most production efficient.

The Saint-Pierre-la-Cour Holcim plant cost about 40 million Euros to build but produces calcined clay at 25 to 40 kg carbon emitted per tonne due to a patented technology using advanced processing of calcined clay with flue gas recovery from the adjacent clinker line.

Return on Investment Scenario

A basic scenario has been developed to illustrate the feasibility of calcined clay production from a commercial facility.

A UK plant is built for £30 million with 100,000 tonnes per year capacity, with interest on the total capital of 7% and with OPEX costs of £32 per tonne. This assumes an initial sale point of calcined clay at £150 per tonne for the first 2 years and reducing incrementally down to £100 per tonne over the following 5 years (thus a very competitive/conservative price point). This scenario also assumes 50% of the gross revenue is available (e.g. after on-costs, maintenance, salaries etc.) and that 70% of net revenue is retained (less tax and administration,

Company	Location	Technology	Capacity (Mtpa)		Investment (m USD)
			Calcined Clay	Cement	
Rio Claro	Colombia	Rotary kiln New production line	0.45	2.3	78
Holcim (La Malle)	France	Existing production line	0.2	2	6.58
FLSmidth	Denmark	Electric calciner	-	-	6.62
CBI Ghana	Ghana	-	0.405	0.55	80
Cimangola	Angola	-	0.3	1	-
Holcim (Saint Pierre-la-Cour)	France	Rotary kiln Existing production line	0.12	-	42.7
Heidelberg Materials	France	-	0.8	-	70.5
Vicat Group (Ciplan)	Brazil	Rotary kiln	0.2	-	-
Cimpor (Abijan)	Ivory Coast	Rotary kiln	0.3	0.8	-
Cimpor (Kribi)	Cameroon	Flash calciner	0.2	0.8	-
(CRH) Ash Grove Cement	USA	Rotary kiln Existing production line	0.365	-	-
CIMAF	Burkia Faso	-	-	-	34.18
SCHWENK Zement	Germany	Mechanochemical activation*	0.05		-
Votorantim Cimentos	Brazil	Rotary kiln	0.292	0.7	64.5

Table 1: Green Cement Technology Tracker, an initiative of LeadIT and GCCA. Data captured as of April 2024 [7].
**Mechanochemical activation is an alternative approach to clay activation*

dividends etc.) available for loan payback.

The return on total capital investment is estimated at 12 years. A total profit over a 15 year cycle is estimated at £8.5 million rising to £20 million after 20 years, with an effective net profit of £24 per tonne, even at a competitive price point.

If a 200,000 tonne per year capacity plant is built (at a cost of £35 million), the return on investment is estimated at 6 years, with a total net profit of £71 million over 20 years.

A fleet of calcined clay plants, producing 4 million tonnes of calcined clay per year would produce estimated operational tax revenue of around £40 million per year (as well as £80 million per year in VAT), and would ensure UK resource security, create thousands of jobs and reduce the carbon intensity of UK concrete construction.

Carbon Saving Benefits

A reduction in carbon in this sector by 50% by 2030 is challenging but achievable if proven approaches and technologies are scaled. Calcined clay is a critical component due to its lower embodied carbon and ability to replace CEM I by 30% in most use cases (up to 55% allowable in current standards (i.e. BS EN 197). Up to 80% of concrete produced in the UK does not contain any SCMs and is purely CEM I. Calcined clay could rectify this, providing a cost-effective volume play. Of the 15 million tonnes of cementitious materials purchased in the UK, around 3 million tonnes are SCMs, mainly GGBS, with smaller amounts of fly ash. Decreasing domestic supply of GGBS and fly ash means that the UK is reliant on imports whose cost cannot be readily controlled. Moreover, supply could be disrupted for geopolitical reasons, creating a lack of resource security.

From value chain analysis and stakeholder conversations, calcined clay produced in the UK could have an average embodied carbon of 95 kg per tonne. Mechanical activation of clay is also an area of ongoing research that could yield even lower embodied carbon during production, due to the use of renewable electricity for grinding.

Where CEM I is substituted with 10% limestone fines and 30% calcined clay (CIIB-QL), it is estimated that a 35% embodied carbon saving could be made. scaling up calcined clay production to 4 million tonnes per year could save up to 6.2 million tonnes of embodied carbon, contributing significantly to the UK's decarbonisation targets.

It is important to appreciate that calcined clay concretes do not compete with concretes containing high levels of replacement with GGBS or fly ash in terms of carbon intensity, and nor should they be seen to need to. The addition of a new, cost-effective, scalable SCM to supplement efficient use of GGBS can increase the amount of lower carbon constituents in more of the UK's concrete (see Table 2, below).

Material	Embodied carbon ($kgCO_2e/t$)
CEM I	840
GGBS	155
Fly ash (virgin)	22
Fly ash (recovered)	95*
Calcined clay	48 to 274

Table 2: Embodied carbon of Cementitious materials [8]
**this figure was sourced from UK QAA*

Circularity Benefits

Using waste clay arisings to produce calcined clay is an additional benefit. Calcined clay can be produced using locally abundant materials, reducing reliance on imported materials. Large projects can save on landfill tax and reduce excavation costs by using waste clay. HS2, for example, has the capability to reuse its waste clay, particularly London Clay, for calcined clay production. This could provide significant material sources and benefits for future works, such as rail lines, depots, and stations.

Case studies of NeoCem and Holcim calcined clay plants show that France has effectively broken the supply-demand deadlock by providing funding to incentivise the development of calcined clay plants. UK projects could import calcined clay for proof-of-concept demonstrator projects, but long-term importing would be unfavourable due to reduced carbon savings, elimination of green job creation, and higher costs.

Case Study: NeoCem

NeoCem develops hydraulic binders based on calcined clay in France. Its first industrial-scale calcined clay production facility is located in Saint-Maximin, 30 km north of Paris. The site is designed with an annual capacity of 200,000 tonnes, with 100,000 tonnes already operational. By 2032, NeoCem aims to reach a total capacity of 1 million tonnes across five production sites, with the next expansion planned in the UK.



NeoCem's transition from research and development to production was accelerated through collaboration with SGP, Europe's largest infrastructure program. Agreements with Eiffage in 2021 and 2023 expanded the use of NeoCem's products to concrete and road binders. As a result, all five major French construction companies and leading EU operators are now involved in deploying NeoCem's calcined clays. SGP currently recycles excavated clays and uses lower-carbon cements in its projects.

NeoCem is a laureate of the European Innovation Fund and France 2030. The company has also received several honours, including EY Startup of the Year 2024, Generali EnterPRIZE, and ECO121. In addition, NeoCem holds the EU Sovereignty Seal (STEP Seal), is ICROA-certified, delivers high-integrity carbon credits, and is a member of the Alliance for Low-Carbon Cement and Concrete (ALCC).

NeoCem
low carbon solutions

06

Next Steps

There is still a great deal of work to be done to establish calcined clay as a significant construction resource, particularly to demonstrate its commercial and operational feasibility.

From the Barriers and Mitigations analysis, a strategy to further the adoption and enablement of calcined clay for UK concrete construction is under development. The draft next steps to implement this strategy are summarised below. It is anticipated that the following broad tasks will require collaboration across the entire value chain:

1. **Proof of Concept:** Establish a small-capacity pilot kiln to evaluate the UK's clay reserves and resources. This facility will serve as a leading research centre for further calcined clay and clay activation development.
2. **Demonstrator Projects:** Encourage clients and contractors to use imported calcined clay in low-criticality permanent structures or temporary works. This will enable the supply chain to familiarise themselves with the technical aspects of calcined clay concretes, gain confidence, and optimise concrete production.
3. **Awareness Campaign:** Raise awareness and educate key stakeholders across supply and demand to demonstrate the benefits of calcined clay, incentivise action, and generate outline commitments.
4. **Communicate Value:** Articulate the value proposition to investors to secure funds for a pilot kiln and the first commercial kiln.

07 References

1. **MPA.** UK Concrete and Cement Industry Roadmap to Beyond Net Zero, 2020
2. **HM GOVERNMENT.** Industrial Decarbonisation Strategy, 2021
3. **HERIOT WATT UNIVERSITY.** Centre of Excellence in Smart Construction Research Bulletin, APRIL 2023
4. **ICE.** Low Carbon Concrete Routemap, Low Carbon Concrete Group, 2022
5. **ICE.** Concrete Decarbonisation Accelerator, Infrastructure Client Group, 2024
6. **LC3.** Financial attractiveness of LC3, K. Scrivener, A. Dekeukelaere, F. Avet, L. Grimmeissen, 2019
7. **Lead IT and GCCA.** Green Cement Technology Tracker, C. Lorea, F. Sanchez, E. Torres-Morales, 2025. www.industrytransition.org/green-cement-technology-tracker
8. **MPA.** Factsheet 18: Embodied CO_2e of UK cements, MPA Cement, 2025

All rights reserved. Except as permitted under current legislation no part of this work may be photocopied, stored in a retrieval system, published, performed in public, adapted, broadcast, transmitted, recorded or reproduced in any form or by any means, without the prior permission of the copyright owner. Enquiries should be addressed to the Concrete Society.

All advice or information from the Concrete Society is intended for those who will evaluate the significance and limitations of its contents and take responsibility for its use and application. No liability (including that for negligence) for any loss resulting from such advice or information is accepted by the Concrete Society or its subcontractors, suppliers or advisors.

Readers should note that Concrete Society publications are subject to revision from time to time and should therefore ensure that they are in possession of the latest version.

Discussion Document 51

Calcined Clay

Benefits and Adoption for UK Concrete

This discussion document is published by the Concrete Society on behalf of a Task and Finish Group led by HS2, Expedition Engineering, MTC and PA Consulting.

The findings and views expressed in this report are those of the Task & Finish Group provided by the Calcined Clay Delivery Group, and do not necessarily reflect the views of HMG Department for Transport.

Concrete Society

The Concrete Society
Sandhurst House, 297 Yorktown Road
Sandhurst, Berkshire, GU47 0QA

www.concrete.org.uk

ISBN 978-1-9163325-2-2
© The Concrete Society
December 2025