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# STRONGER CHEAPER GREENER CONCRETE

Discover how graphene-enhanced concrete is helping solve the construction industry's sustainability problem

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CENTRE



# CONCRETENE

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# Construction's big problem

- After water, concrete is the most widely used substance on Earth
- For every 1 tonne of cement, 1.25 tonnes of CO<sub>2</sub> is produced
- 1 tonne of CO<sub>2</sub> occupies a volume of 556m<sup>3</sup>
- Globally, the cement industry produces 4.3bn tonnes of cement per annum, increasing to 5.2bn tonnes by 2030
- In context, global CO<sub>2</sub> from cement production fills a Millennium Dome every 23 seconds
- This excludes concrete production, reinforcement & delivery to site
- Concrete remains critical for the construction industry
- Legislation is forcing the industry to address this CO<sub>2</sub> problem
- Concretene has been designed to significantly reduce CO<sub>2</sub> associated with concrete



# What is graphene?

- Graphene is a single-atomic layer of carbon, forms including nano-platelets, graphene oxide & functionalised graphene
- Its existence was theorised since the 19<sup>th</sup> century but it was first isolated at The University of Manchester in 2004
- Two scientists - Andre Geim and Kostya Novoselov - used sticky tape to remove microscopic layers from graphite (pencil lead), repeating the process until the layer was only one atom thick
- They found it had extraordinary physical properties of strength, lightness, flexibility and conductivity and were awarded the Nobel Prize was Physics in 2010
- Graphene is:
  - 200 times stronger than steel
  - The thinnest material possible at only 1 atom thick
  - Has the largest surface area of any material relative to its size
  - Incredible thermal and electrical properties
  - Only tiny quantities are required for significant gains



# Nationwide Engineering and Manchester: a groundbreaking partnership



- Nationwide Engineering and The University of Manchester's Graphene Engineering Innovation Centre (GEIC) have developed a revolutionary graphene-enhanced concrete
- Result of three years of extensive, cutting-edge research and development
- Uses 2D graphene technology to achieve enhanced performance over traditional concrete
- Results show significant CO2 and cost reductions
- Technology taken out of the lab and deployed in real world applications – as 'living labs'
- Working with early-adopter clients to assist meeting CO2 reduction targets and product development





# Concretene innovation

## What is graphene-enhanced concrete and why do we need it?

- The main goal for stronger concrete is to significantly reduce CO2 associated with concrete, reinforcement and transportation
- Globally, concrete is the most widely used building material, accounting for 8-10% of global CO2
- If the industry were a country, it would be the third-largest CO2 polluter, behind only the USA and China
- Concretene is a graphene-enhanced admixture that can be used in >99% of concretes worldwide
- Concretene influences the hydration process and enhances the microstructural development whilst curing

**30%**

reduction in CO2 emissions

**20%**

reduction in overall cost

**100%**

removal of steel reinforcement\*

**46%**

increase in early tensile shear capacity

**0.01%**

approx. volume of Concretene additive required in concrete mix

\*in certain applications, eg. ground-bearing slab

# Concretene innovation

## How does Concretene achieve these benefits?

- As little as 1kg of Concretene in 10 tonnes of concrete drives down emissions by:
  - Enabling up to a 30% reduction in the volume of concrete required
  - Elimination or reduction of steel reinforcement
  - Reducing cement content of the concrete by up to 50%
- Performance gains include:
  - Significant improved early tensile shear capacity
  - Rapid early compressive strength gain
  - Reduced porosity and permeability enhancing durability, water and fire resistance
  - Longer lifespan & reduced maintenance
  - Concretene reduces the overall construction costs for projects by 10-20% through material and prelim savings

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reduction in CO2 emissions

**20%**

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**100%**

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**46%**

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**0.01%**

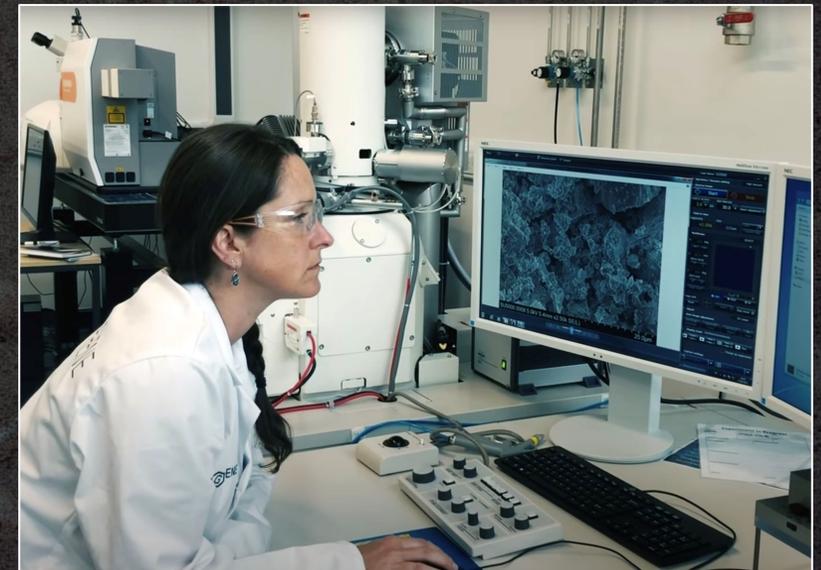
approx. volume of Concretene additive required in concrete mix

\*in certain applications, eg. ground-bearing slab

# Concrete: understanding the science

## How does standard concrete work?

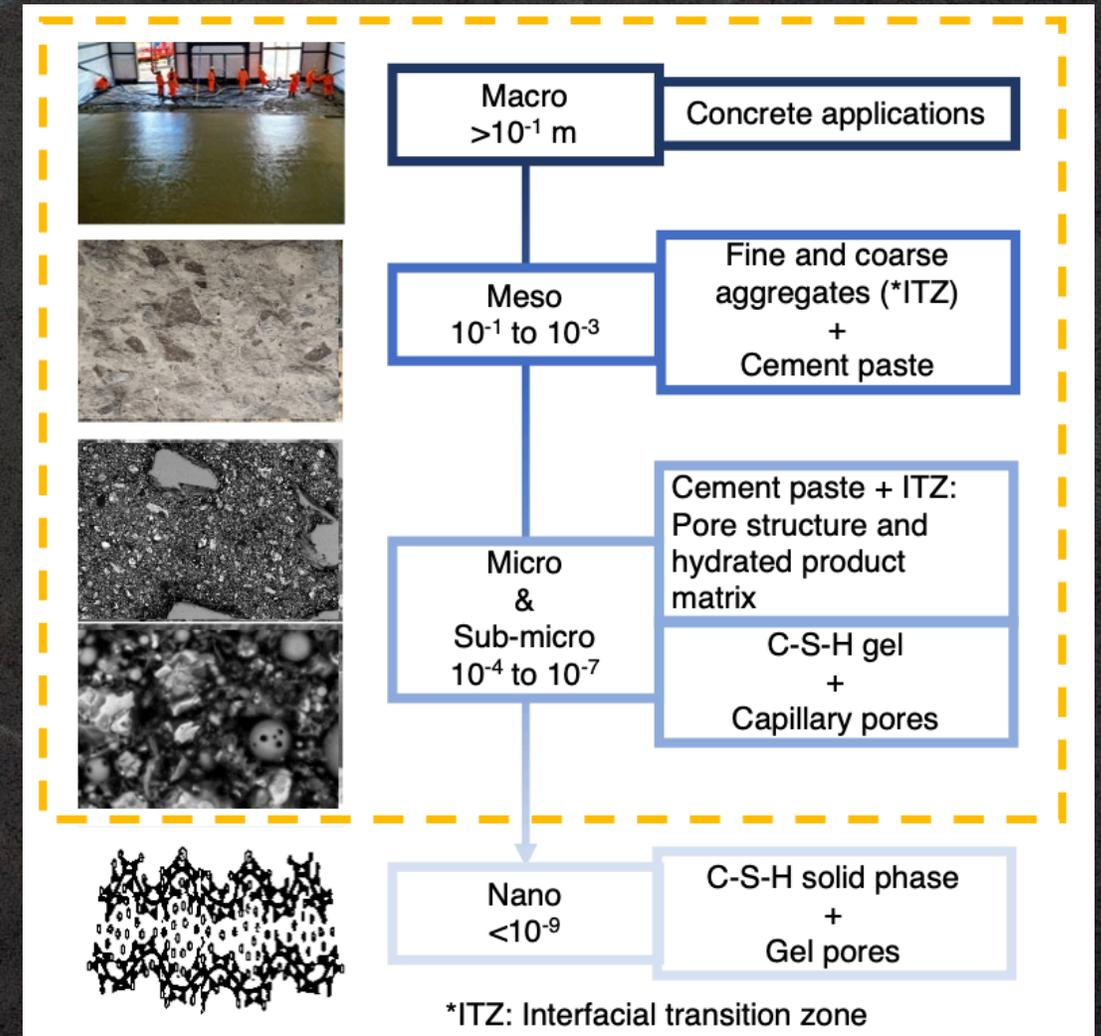
- Concrete properties are determined in the hydration process & microstructural development, by water content, curing conditions, heat of hydration, admixtures, chemical composition and physical properties of raw materials
- During curing of normal concrete:
  - Low tensile capacity
  - Cement hydration constituents fill up most of the water-filled pore space with hydrated products and connect the solid phases of the cement matrix
  - Reinforcement is commonly added to avoid shrinkage and increase tensile capacity
- As a result, concrete relies on steel reinforcement, added cement and a combination of plasticisers, fibre reinforcement & other additives, all of which increase the CO2 output



# Concrete: understanding the science

## And how does graphene-enhanced concrete differ structurally?

- Incorporation of graphene into concrete:
  - Enhances the bridging between aggregates and the matrix
  - Refines the pore structure and matrix of the microstructure
  - Provides nucleation sites for new hydrated product formation
  - Has a filler effect in the system.
- Concretene uses graphene properties and cutting-edge knowledge
- Provides an optimised liquid admixture added to concrete at source & disperses evenly creating a highly enhanced concrete.



# Concrete: understanding the science

## Application example

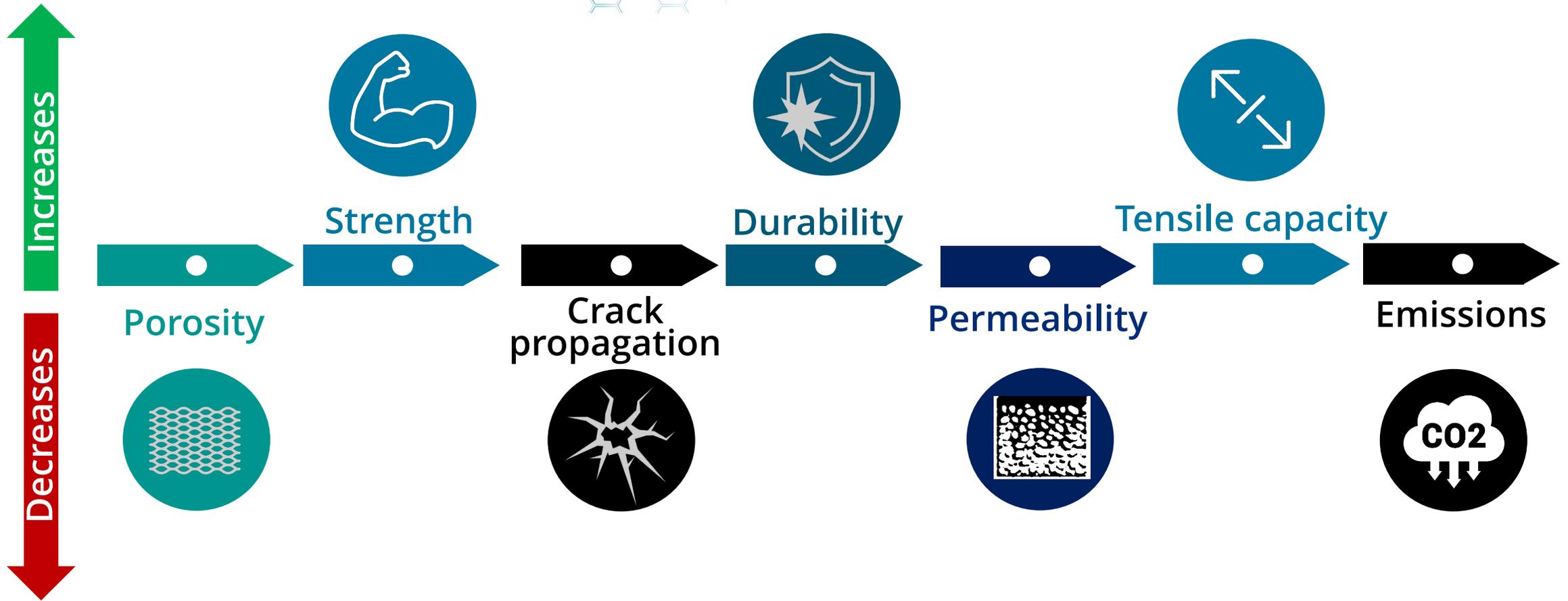
- Slabs and highways:
  - Reduced expansion & construction joints due to anti-crack and non-shrink properties
  - Removal of all reinforcement
  - Thinner slab thickness
  - Increased density – lower porosity reducing water ingress
  - Higher abrasion and wear resistance for increased durability

## Advantages

- Reduced maintenance due to fewer expansion joints
- Reduced build costs due to less materials
- Reduced programme duration and site prelims
- Longer whole life cycle of structure
- Significant CO2 reductions



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# Concretene innovation

## How will I need to adapt my business to use Concretene?

- You won't. The material is already being deployed across construction projects
- Uses existing batching plant technology
- Laid using traditional techniques with no additional training required

## What is the scope for roll-out of the system?

- Concretene is designed as an admixture so the technology can be applied worldwide within any concrete batching facility
- Easily distributed via existing supply chain
- Concretene is currently being trialled in rail, air, highway, marine, residential, commercial and civil engineering applications throughout the UK by Nationwide Engineering Group

# 0

**additional staff training or equipment required**

## What about industry standards?

Concretene is undergoing BBA and CE accreditation through the BRE for use with internationally recognised Structural and Civil Engineering Design Codes.

Nationwide Engineering Group is developing partnerships internationally to adopt this technology and deliver unparalleled cost savings and CO2 reduction for the entire construction industry.

# Concretene innovation



## Delivered projects

- Southern Quarter Gym May 2021:
  - World's first graphene-enhanced concrete slab engineered for sustainability
  - 800m<sup>2</sup> internal floor slab
  - Power floated finish
  - 30% reduction in slab thickness
  - 100% reduction in reinforcement and construction joints
  - Removal of edge thickenings
  - Total cost savings = £22k



# Concretene innovation



## Delivered projects

- Netherhampton Farm Residential Development
  - World's first residential graphene-enhanced concrete raft
  - 1150m<sup>2</sup> structural foundation
  - Used as test site for large volume applications
  - 'Living lab' for long-term data analysis
  - Significant early strength gain allowed follow on trades to commence within 15 hours

[https://www.linkedin.com/posts/nationwide-engineering-group\\_concretene-pour-netherhampton-farm-activity-6842026506697474048-jf5p](https://www.linkedin.com/posts/nationwide-engineering-group_concretene-pour-netherhampton-farm-activity-6842026506697474048-jf5p)



# Concretene innovation



## Delivered projects

- Innovation District Manchester, August 2021:
  - First project in £1.5bn development
  - External GEC heavy goods parking bay slab
  - Designed for full highway loading criteria
  - 37% reduction in slab thickness
  - 100% reduction in reinforcement, expansion and construction joints
  - Zero shrinkage or cracking
- Cemex independent results:
  - 24-hr Concretene: 107% stronger than control batch
  - 4-day Concretene: 50% stronger than control batch

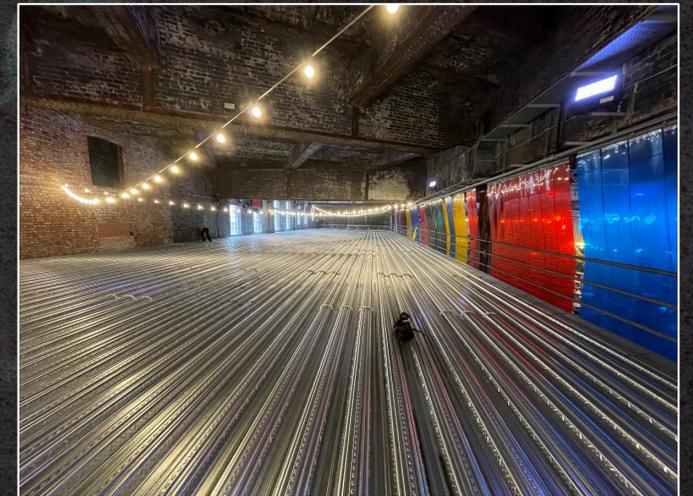
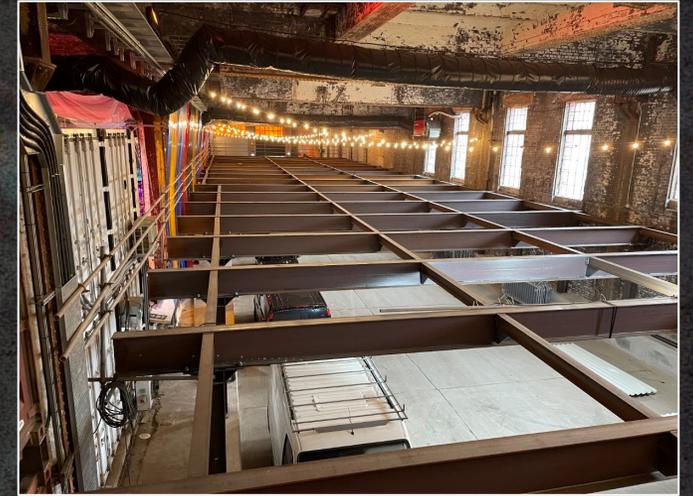


# Concretene innovation



## Forthcoming projects

- Mayfield Depot, October 2021:
  - First commercially delivered Concretene project as part of a £2.5bn development
  - First suspended graphene-enhanced concrete slab on metal decking
  - Prototype for high-rise development floor slab applications
  - Power floated finish
  - 850m<sup>2</sup> of Concretene
  - 100% reduction in reinforcement, expansion and construction joints



# Carbon footprint challenges



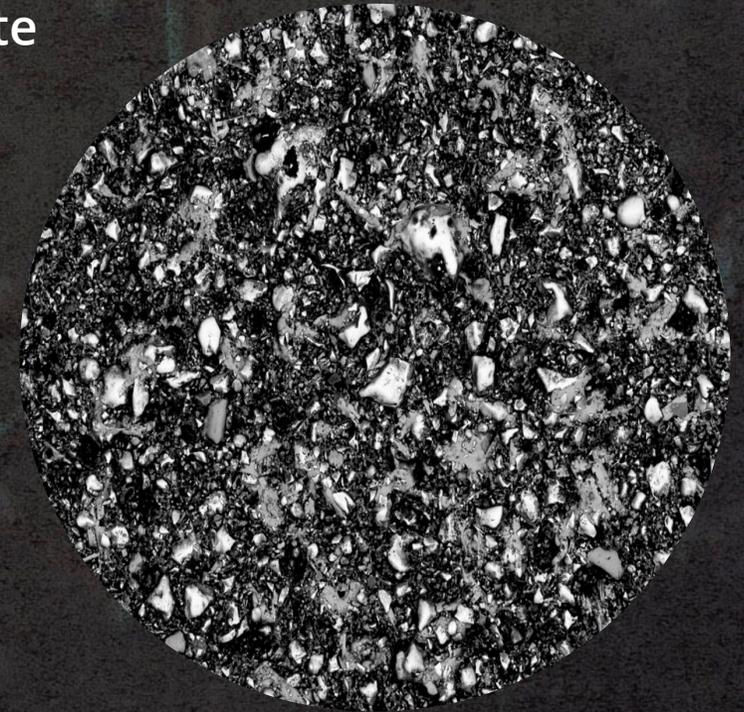
- Construction industry faces significant legislation changes to force CO2 reduction
- Paris Agreement and the UK Climate Change Act has brought in significant CO2 reductions that all building works will need to achieve
- Major clients will demand CO2 reduction technology clearly demonstrated in order to deliver projects going forward
- Part Z of the Building Regulations is being considered now to bring embodied carbon into law from a design stage in all construction
- Tenders will be reviewed and awarded on contractors' ability to demonstrate CO2 reduction technology
- Due to "greenwashing", there are Government bodies including Trading Standards reviewing all CO2 reduction claims and verifying these due to numerous dubious claims
- The industry is significantly underperforming and concrete is one of the largest areas where CO2 emissions are still very high

# Carbon footprint challenges



## How will Concretene help?

- Existing low CO2 concretes in the market:
  - Are they what they seem?
  - Can they achieve the required structural performance?
- Concretene offers a step-change opportunity to lower concrete CO2 – offering real-world substantial savings
- Assist your clients to achieve construction CO2 reduction targets
- Competitive edge during tendering
- Be part of ground-breaking low CO2 innovation development



# Concretene innovation



## Ongoing research

- Advanced testing:
  - Reduce cement content by 50%
  - Use of 100% recycled aggregate
  - Remove structural reinforcement
  - Alternative to air entrained concretes
- Developing concrete to have thermal properties
  - Wind farm HV and UHV cabling
- Developing concrete to have electrical properties
  - Heated floor slabs and road pavements
  - Improved building thermal mass
- Increased density for improved barrier properties
- Screeds, mortars, grouts and 3D printing applications



To find out more, visit:



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