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Next-generation climate change resilient permeable pavements

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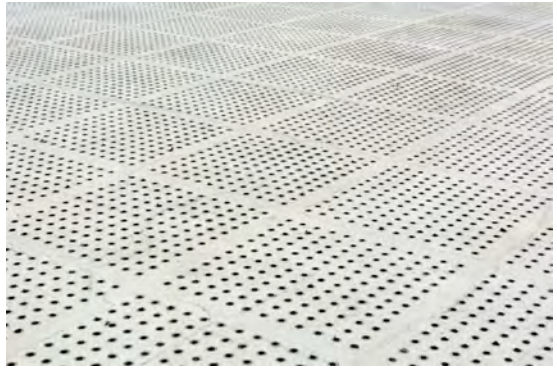
Overview

- Urban flooding
- Benefits of permeable pavements
- Challenges with current generation permeable pavements
- Kiacrete development, properties and applications
- White City Campus trial site
- Future work



- In 2019, the global cost of flooding was £60 bn
- Cost of flooding is projected to increase to £500 bn by 2030
- Climate change increases the likelihood of major storm events by 59%

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Conventional permeable pavements

- Permeable pavement – a mitigation strategy used for urban flooding
- An important, cost-effective, sustainable drainage system
- Primarily used in low-traffic environments
- They mitigate flooding, improve skid resistance and minimise the heat island effect
- Global market predicted to be £18 billion by 2025

Conventional permeable pavement cross-section

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Challenges with current permeable pavements

- Permeable pavements are not widely used as they have a number of well-known challenges:

1) Highly susceptible to clogging
2) Poor freeze-thaw resistance
3) Low strength

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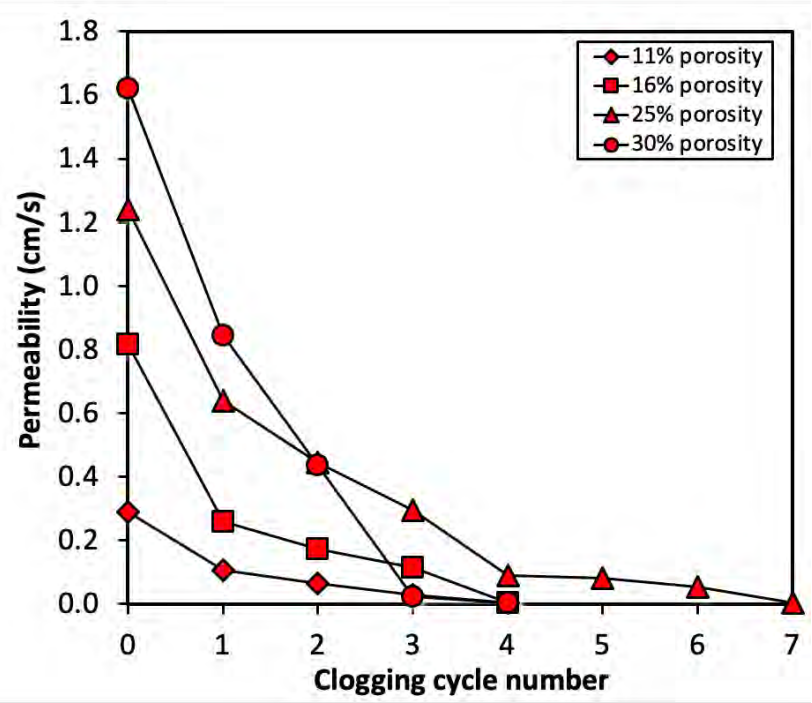
1) Susceptibility to clogging

- Debris build-up on the surface and in the pore structure leads to clogging
- This clogging causes serviceability problems and premature degradation



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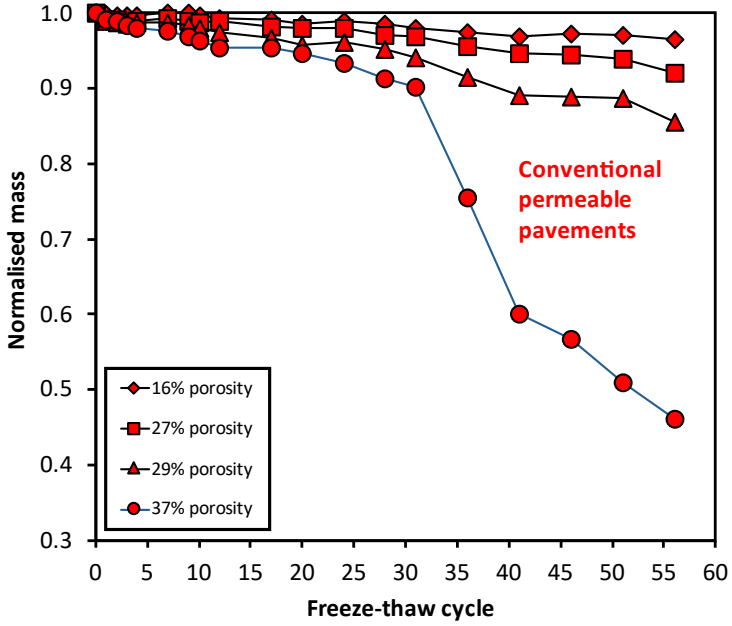
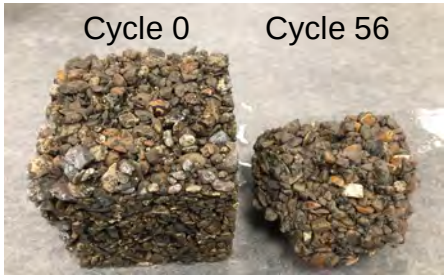
2) Freeze-thaw resistance



- The ability to withstand the detrimental cyclic freezing and thawing forces
- It defines the resistance of a pavement to water freezing and expanding pressure
- Conventional permeable pavements have a significant drop in mass (i.e. deterioration) when exposed to repeated cycles



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3) Pavement strength

- The compressive strength of conventional permeable pavement ranges from 6-32 MPa
- This means that the current permeable pavement applications are limited to low load-bearing scenarios
- Therefore more extreme loading applications cannot benefit from the advantages of permeable pavements

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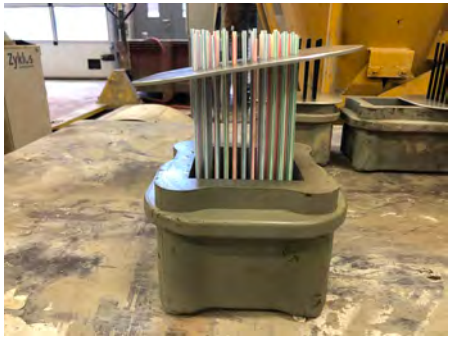
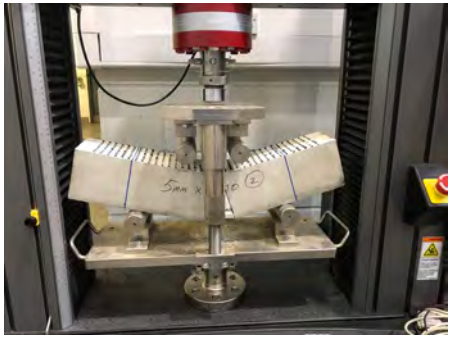
Kiacrete

- To solve these problems, we developed Kiacrete with:
  i. A new engineered pore structure
     - Increases permeability
     - Reduces clogging
     - Improves freeze-thaw resistance
     - Increases strength
  ii. A higher strength cementitious mix
     - Increases strength
     - Improves freeze-thaw resistance






Conventional
Kiacrete

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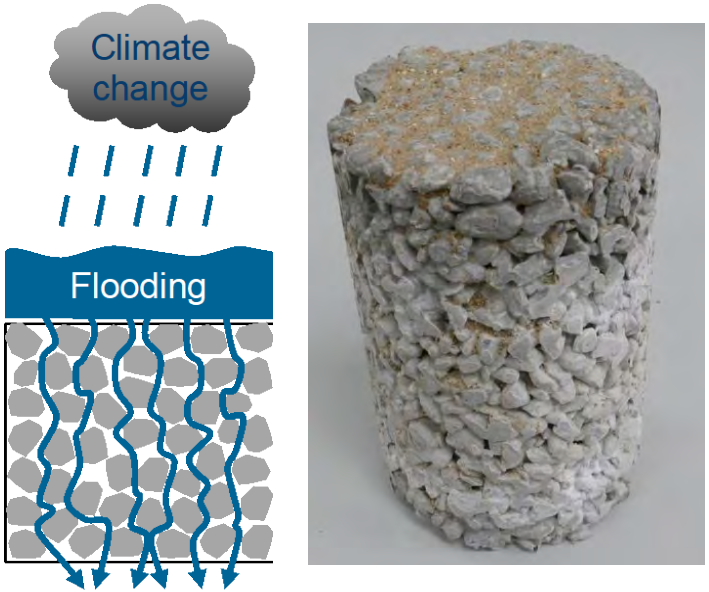
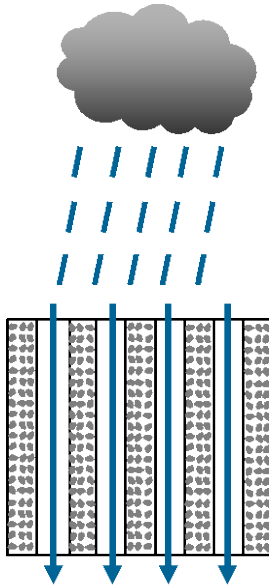
1) Improved clogging resistance





Conventional permeable pavement is prone to clogging

Kiacrete is a next-generation clogging resistant permeable pavement

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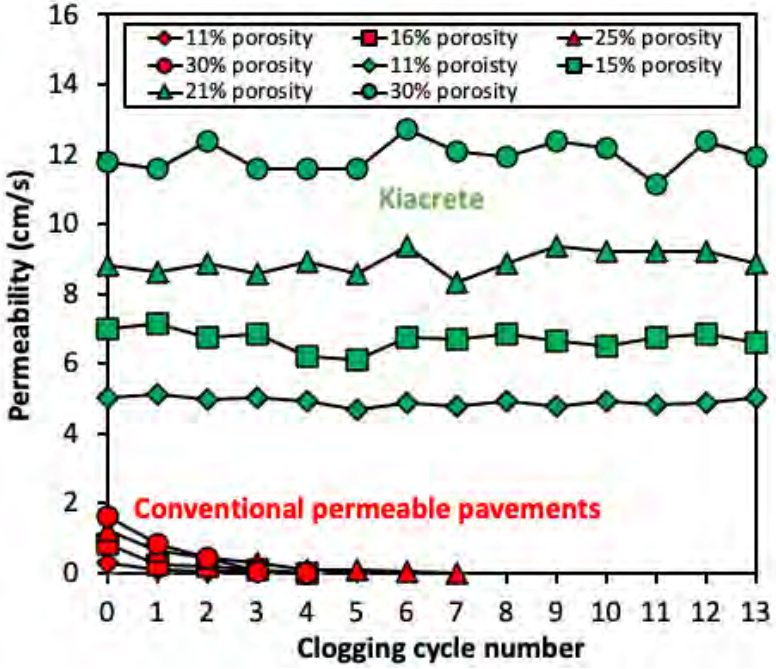
1) Improved clogging resistance



- The permeability of Kiacrete is 10x as high as conventional alternatives
  - e.g. Tarmac permeable asphalt (≤0.69 cm/s) and permeable concrete (≤1 cm/s) are far less permeable
- Kiacrete has better long-term drainage performance
- Permeability of Kiacrete does not reduce when exposed to clogging
- Permeability remains constant over 13 accelerated clogging cycles

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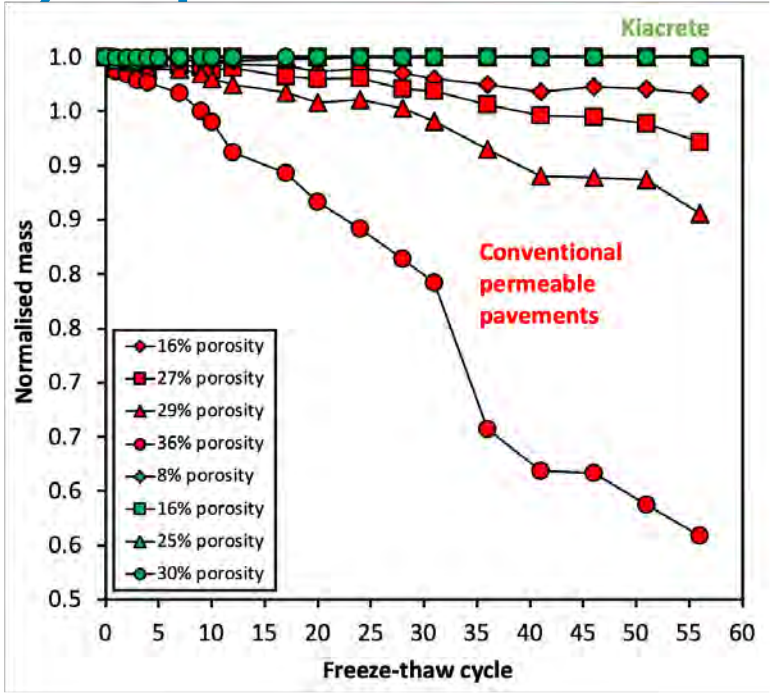
2) Improved freeze-thaw resistance



- Kiacrete is highly resistant to degradation caused by freeze-thaw cycles compared to conventional permeable pavements
- Simulated 56 freezing and thawing cycles (-20 to +20°C)
- Kiacrete's mass remained unaffected, demonstrating its superior durability against frost action

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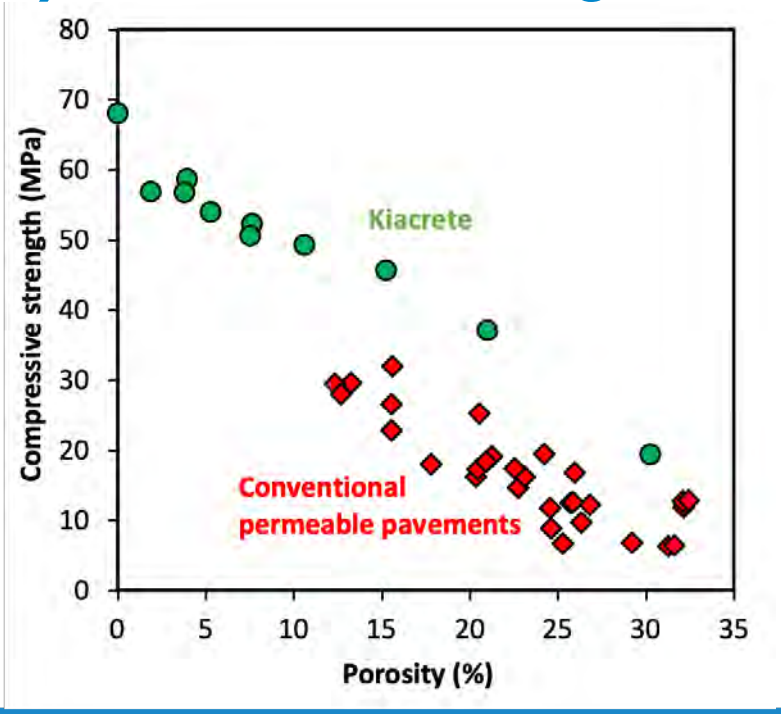
3) Increased strength



- Inverse relationship between porosity and strength
- The highest strength conventional permeable pavement has a low porosity and even lower permeability
- The strength of Kiacrete is 2x as high as conventional alternatives
- Due to the engineered pore structure, even the highest strength Kiacrete will have sufficient permeability
- Kiacrete's high strength increases the range of applications for permeable pavements

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Kiacrete applications

a) Multi-storey car parks
b) Highways
c) Critical national infrastructure
d) Airport infrastructure assets

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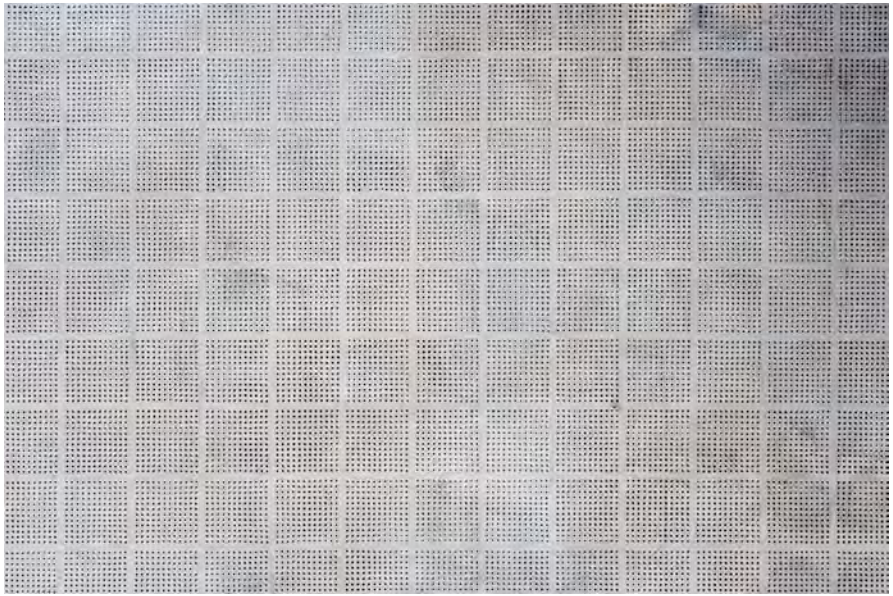
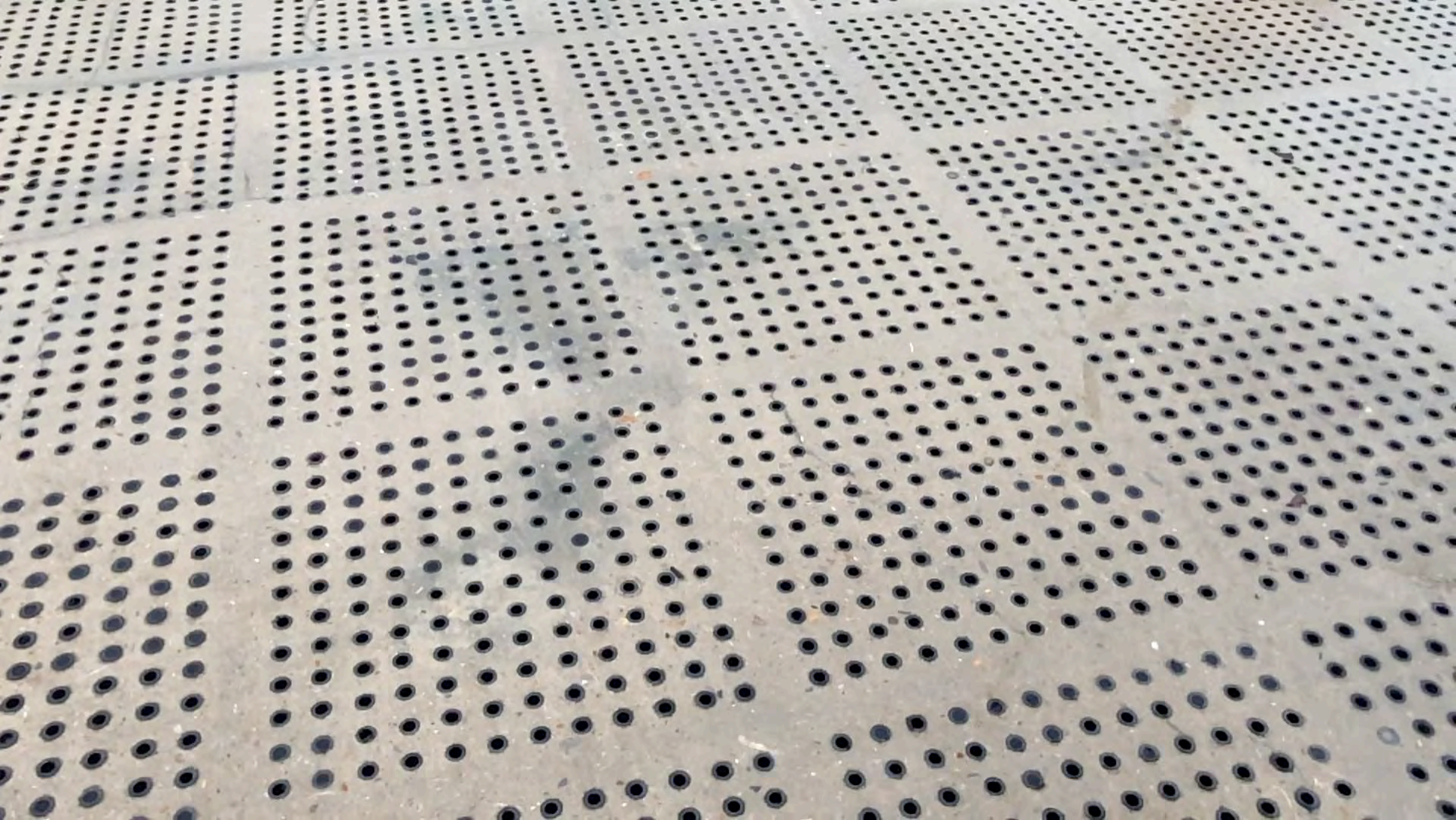
Kiacrete trial site at White City





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Long-term drainage and durability performance monitoring

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RAEng Research Fellowship

- Recently awarded a RAEng Research Fellowship
- I will develop next-generation climate change resilient permeable infrastructure for a net-zero future
- Focussed on extreme loading (airport) and weather conditions (ice and snow)

Royal Academy of Engineering

Newcastle University

UNIVERSITY OF LEEDS

National Green Infrastructure Facility

Inverness airport

Stantec

ARCADIS

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RAEng Research Fellowship

- Large-scale delivery of Kiacrete at one of the aprons at Inverness Airport

Inverness airport

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Role of Kiacrete in achieving a net-zero target

- Kiacrete contributes towards 5 Sustainable Development Goals and net-zero through:
  1. Reduced emissions:
     - Less concrete used through the engineered pore structure
     - Eliminating regular maintenance due to increased clogging resistance
     - Use of recycled material and low carbon concrete
     - More durable with a longer service-life than other permeable alternatives
  2. Potential for groundwater recharge
  3. Decreased urban heat island effect
  4. Mitigating the impact of flooding and ice/snow build-up
  5. Increased safety (reduced flooding, ice/snow build-up and hydroplaning/skidding accidents)

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Summary

- Climate change increases the likelihood and severity of extreme weather events
- Conventional permeable pavements offer a solution to this but they have well known drawbacks
- Kiacrete is a next-generation permeable pavement mitigating these problems
- It has been deployed at scale at White City
- Further research to be conducted through RAEng Research Fellowship
- Kiacrete contributes towards the Sustainable Development Goals and net-zero

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