

Durability Assessment of FRP in Harsh Environments

Asaad Biqai

Eleni Toumpanaki, Ian Hamerton, Manjola Caro

BCI PGR Symposium

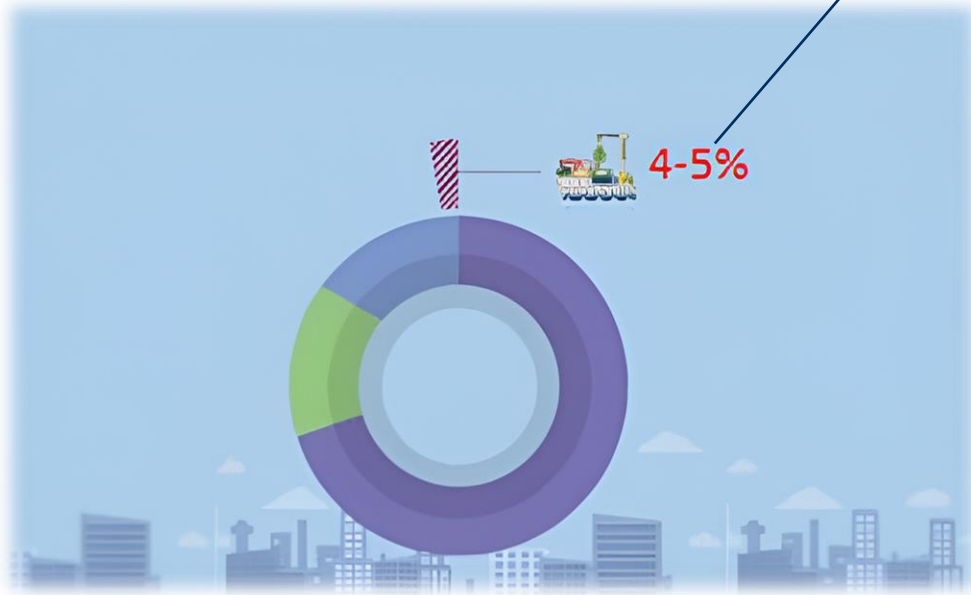
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EPSRC Centre for Doctoral
Training in Composites Science,
Engineering and Manufacturing

Costs of Corrosion Repair in the UK

Annual cost of corrosion for most EU countries is approximately **4-5%** of the gross national product



Pritchard, O., Hallett, S., & Farewell, T. (2013). Soil corrosivity in the UK – impacts on critical infrastructure. Infrastructure Transitions Research Consortium

£344bn

estimated value of
England's roads

187,000

miles in England's
road networks

£4bn

spent on maintaining
England's roads, 2012-13

**4,400 miles of
carriageway and
9,000 bridges**

in the strategic road network maintained by the Highways Agency. It is 2 per cent of all roads, but carries a third of all vehicle traffic and two-thirds of all road freight movements in England

152

local highway authorities, including Transport for London, which maintain the local road network

**183,000 miles
and more than
52,000 bridges**

in the local road network, including 113,000 miles of streets and lanes (unclassified roads)

£10.3 billion

central government funding allocated to road maintenance, April 2015 to March 2021

National Audit Office (2014). Maintaining strategic infrastructure: roads. Department for Transport and Highways Agency



FRP Durability Key Factors

Fibre Factors:

- a. Fibre Type (G, B, C, AFRP)
- b. Fibre Volume Fraction
- c. Fibre Diameter
- d. Fibre Strength & Modulus

Matrix Factors:

- a. Resin Type (E – VE – **P**)
- b. Degree of Curing
- c. Crosslinking Density
- d. Glass Transition Temp (T_g)

Production Factors:

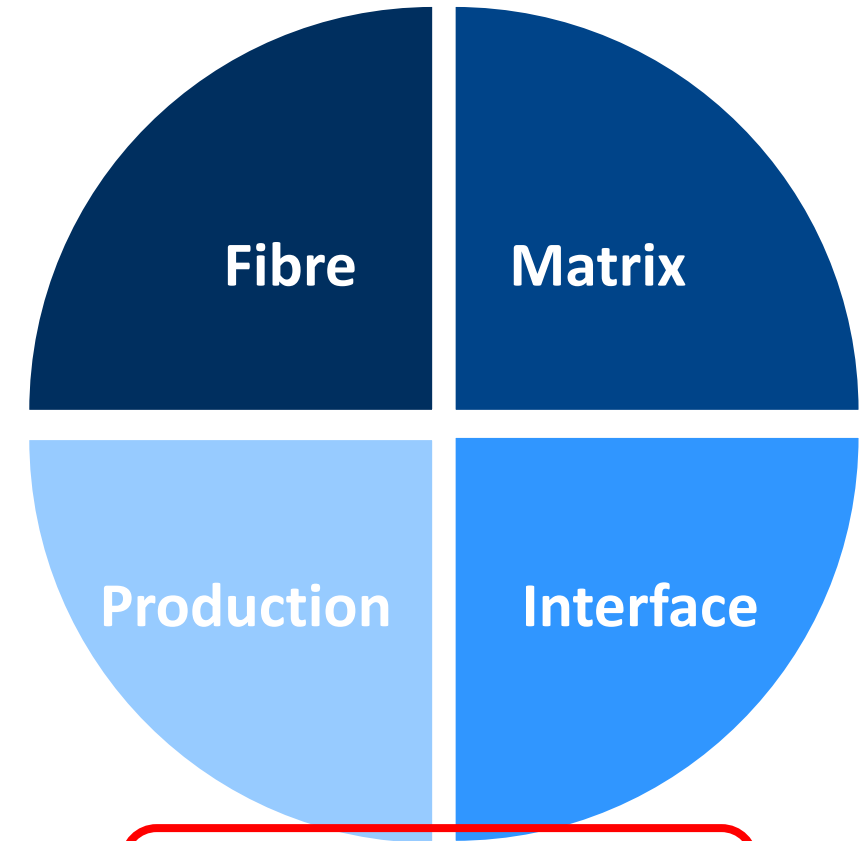
- a. Void Content
- b. Curing Condition
- c. Material Purity
- d. Fibre Alignment

700 VE Resin Samples

Interface Factors:

- a. Interfacial Bond Strength
- b. Sizing Condition

970 Samples / 650 meters FRP



2500 kg of Concrete



Concrete Pore Solution Replication

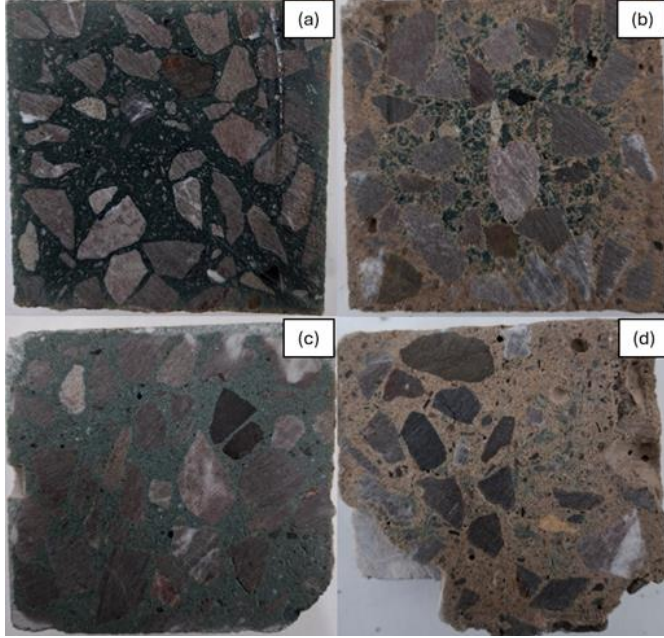


Figure: 28 Days Cured Samples. (a): Hoffmann-Water, (b): Hoffmann-Air, (c): Cemfree-Water, (d): Cemfree-Air



1. Leaching Analysis
2. pH Analysis
3. $[\text{OH}^-]_{\text{leaching}}/[\text{OH}^-]_{\text{pore}}$ Analysis
4. Ion Chromatography
5. Carbonation Analysis
6. SEM-EDX Assessment
7. XRD Assessment
8. Compressive Strength
9. Split Tensile Strength

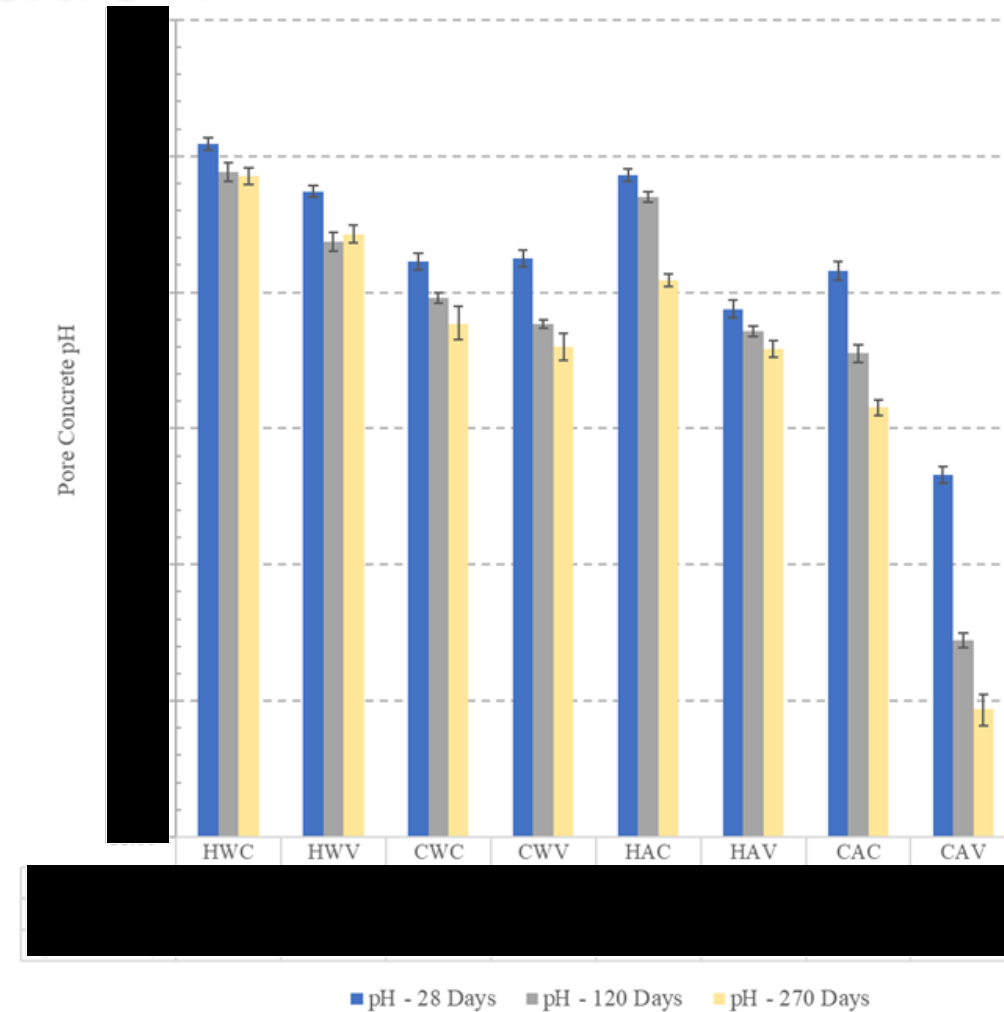


Figure: Concrete Pore pH Change with Cement Type and Curing Time



Concrete Pore Solution Replication

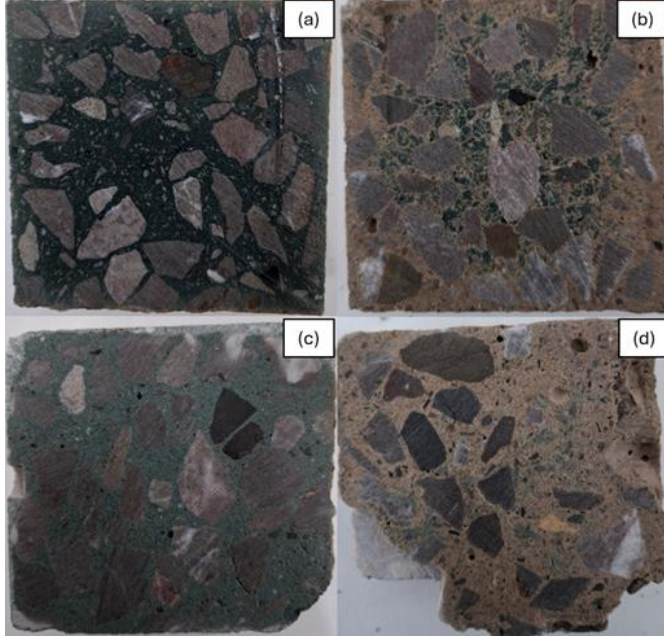


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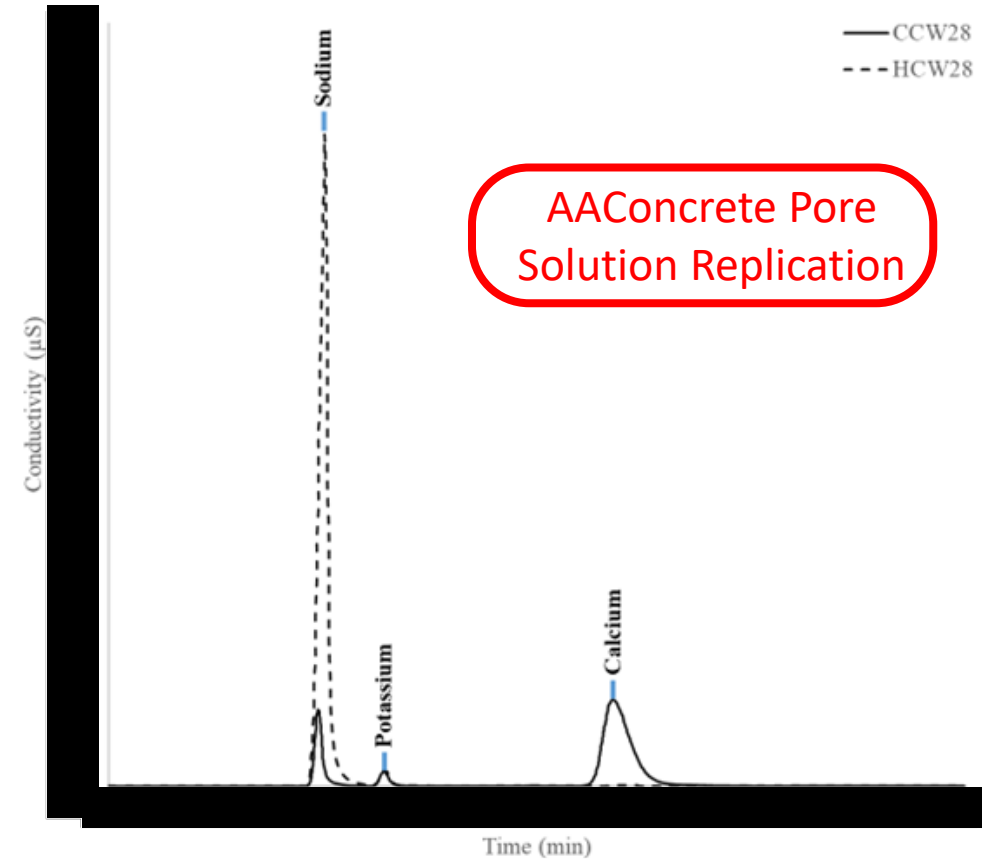


Figure: Ion Chromatography of Leached Concrete - Cations



FRP Durability in Alkaline Environment

Accelerated / Aggressive

Direct Exposure to Concrete

Direct Exposure to Alkaline Solution @ Room Temperature

Direct Exposure to Alkaline Solution @ 60°C



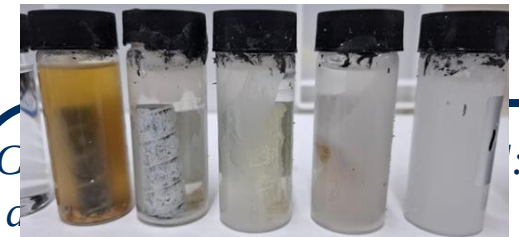
Realistic



B.

Diffusion

Analysis
Analysis (DMA)



b. Split Tensile Testing
c. Pull-Out Testing

FRP Durability in Alkaline Environment

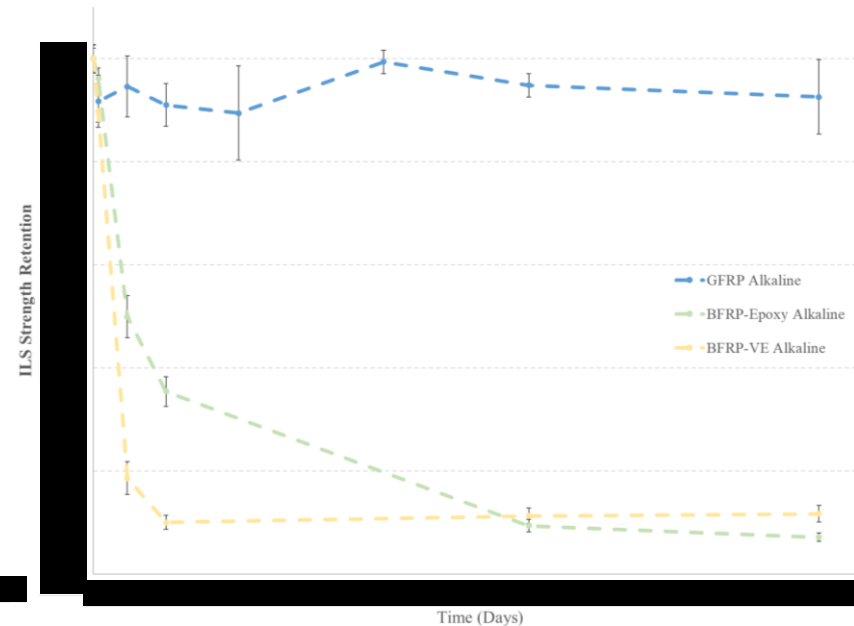
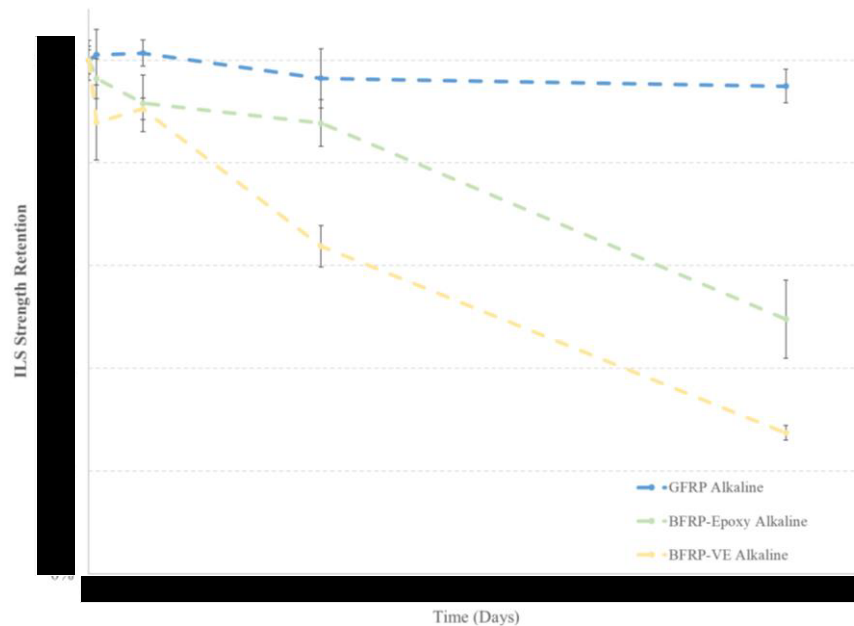
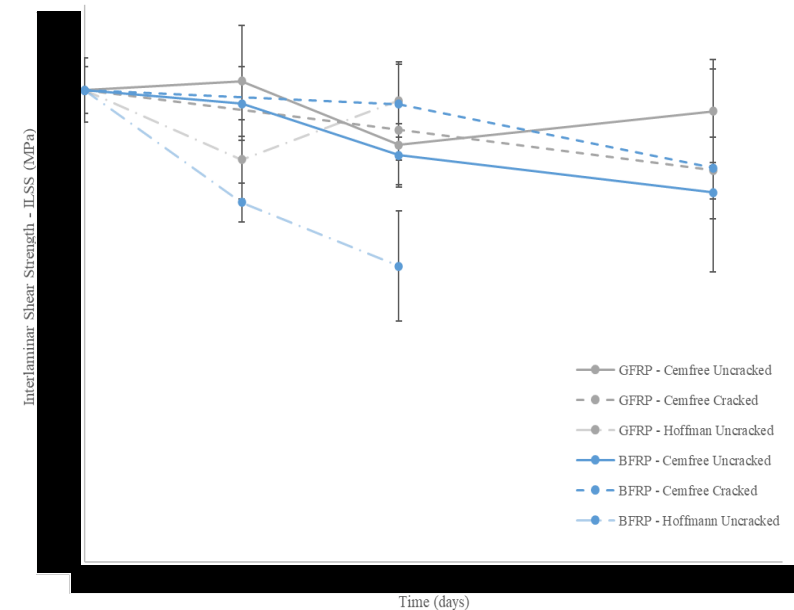
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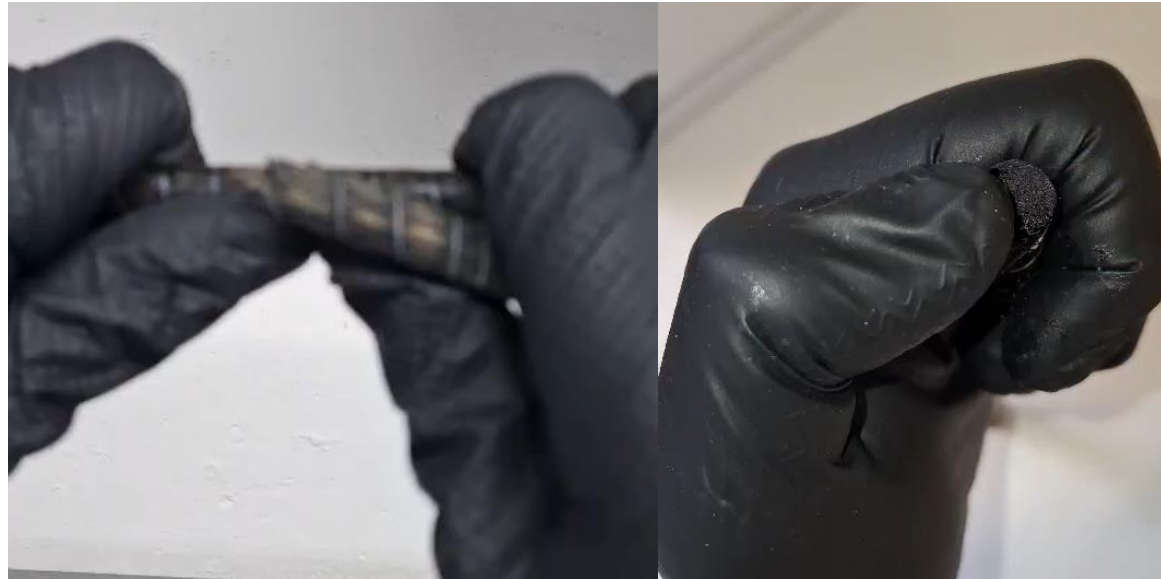
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FRP Durability in Alkaline Environment

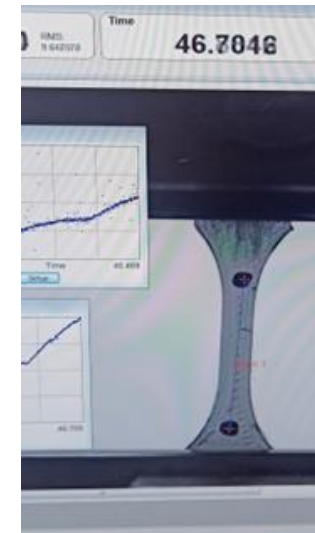
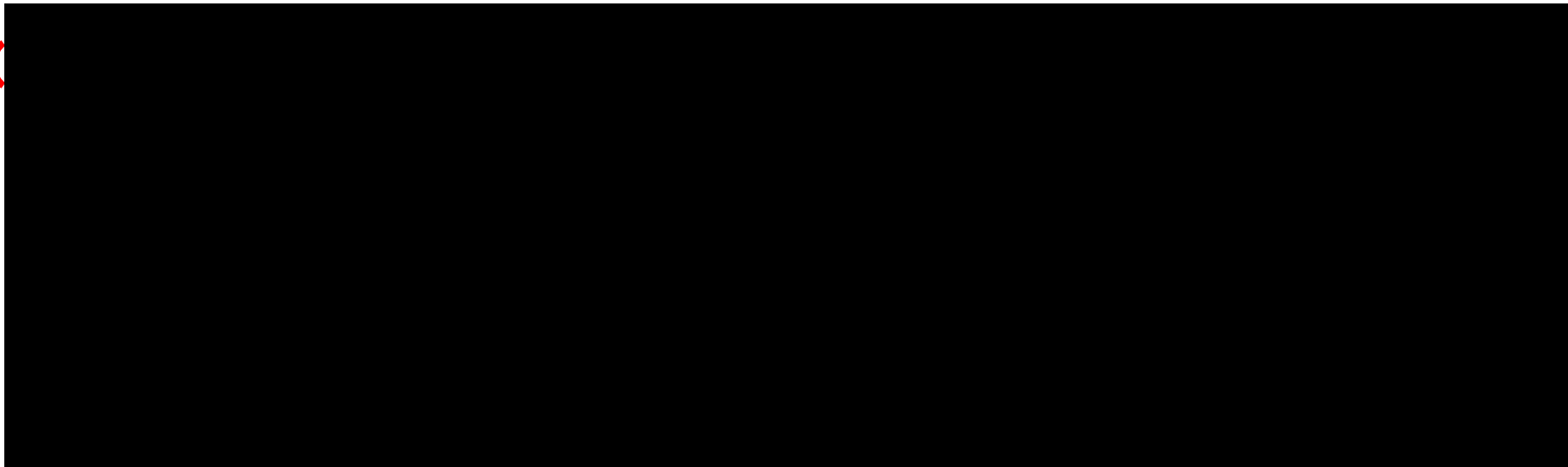
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Realistic



Acknowledgements

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Thank you!

Asaad.biqai@bristol.ac.uk



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