circular ocean

Recycling and reuse of discarded waste fishing nets in building materials

Ida Bertelsen
ARTEK, DTU Civil Engineering

ARTEK Event, Sisimiut
April 12th - 14th 2016

Northern Periphery and Arctic Programme 2014–2020

EUROPEAN UNION
Investing in your future
European Regional Development Fund

Motivation

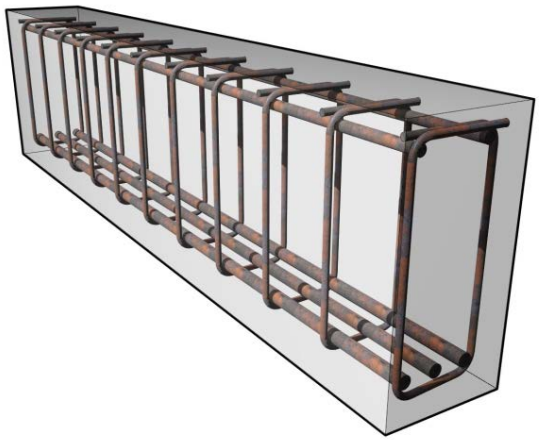
- Reuse of waste fishing nets in remote areas within the NPA region
- Use of local resources and waste materials to improve construction materials
- Create local business opportunities within the NPA region

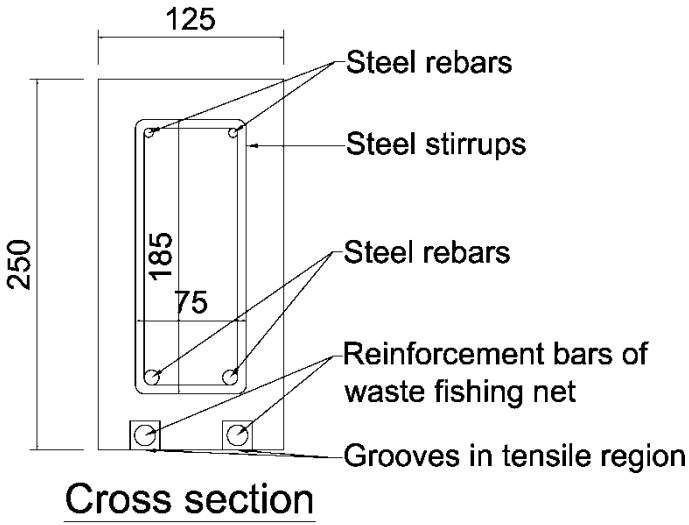
Introduction – Fishing nets

- Large fishing industries
- Great amounts of non-biodegradable waste fishing gear
- Fishing nets are commonly made of Polyethylene, Nylon (Polyamide) or Polyester
- Fishing nets as reinforcement of concrete structures
- Method for strengthening of existing concrete structures and prolonging of life-time: **Near-surface mounted reinforcement** (NSMR)

Introduction – Concrete structures

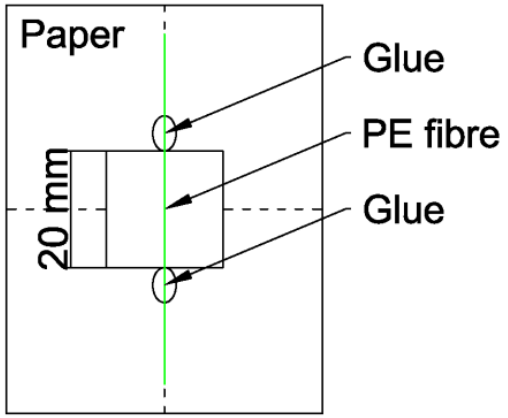
- Steel reinforcement are used in traditional concrete structures
- Fishing net lines have a high tensile strength and are non-corrosive
- **Synthetic reinforcement bars of fishing nets**. Commonly made of carbon, glass or aramid fibres
- Near-surface mounted reinforcement (NSMR) method is used to **strengthen existing concrete structures**

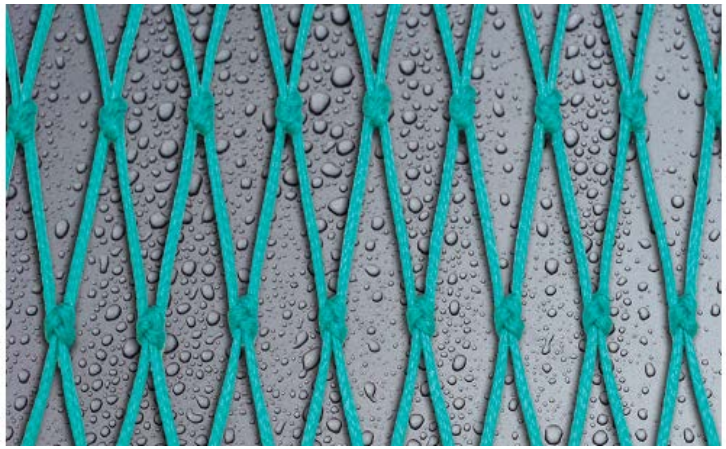




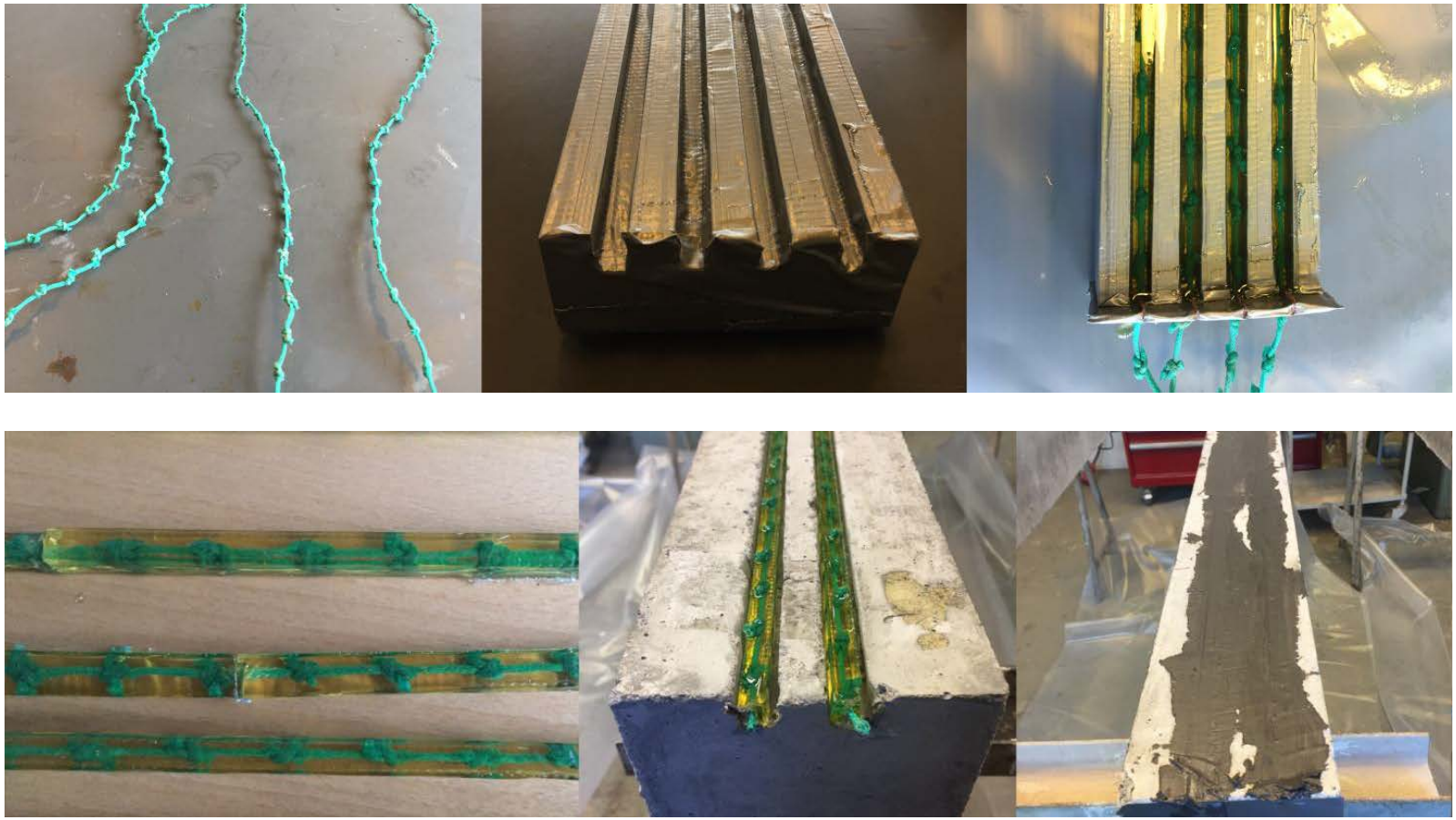
Materials and methods – Single fibres

- Tensile testing of single fibres of PE fishing nets
- Comparison of new and waste fibres
- Immersion of fibres in alkaline solution and SEM analysis
- Casting of concrete beams
- Flexural bending test of concrete beams



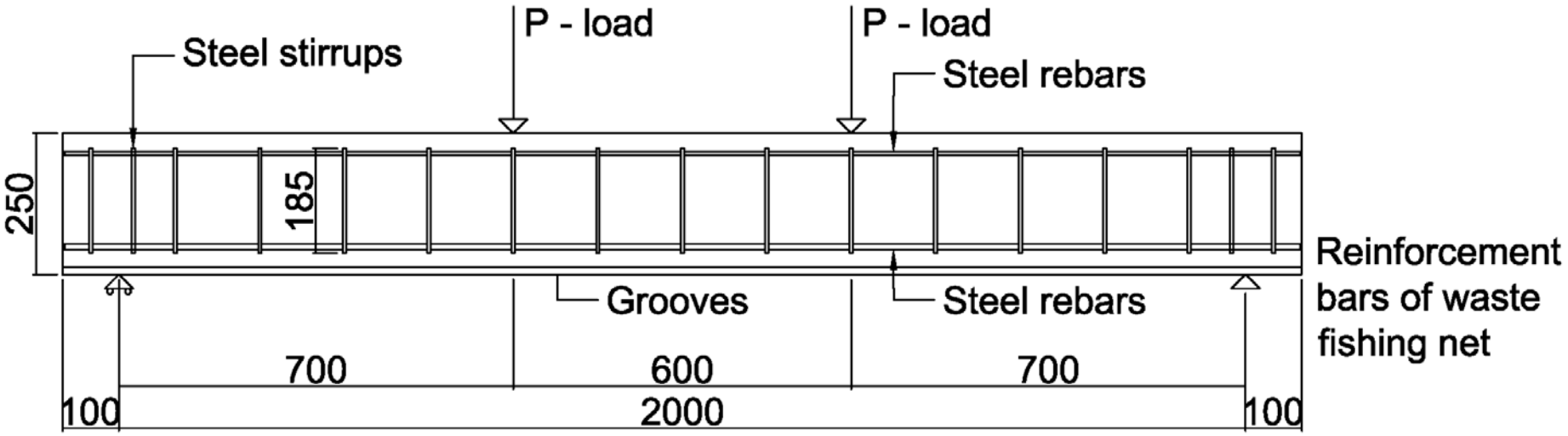


Materials and methods – Fishing net bars



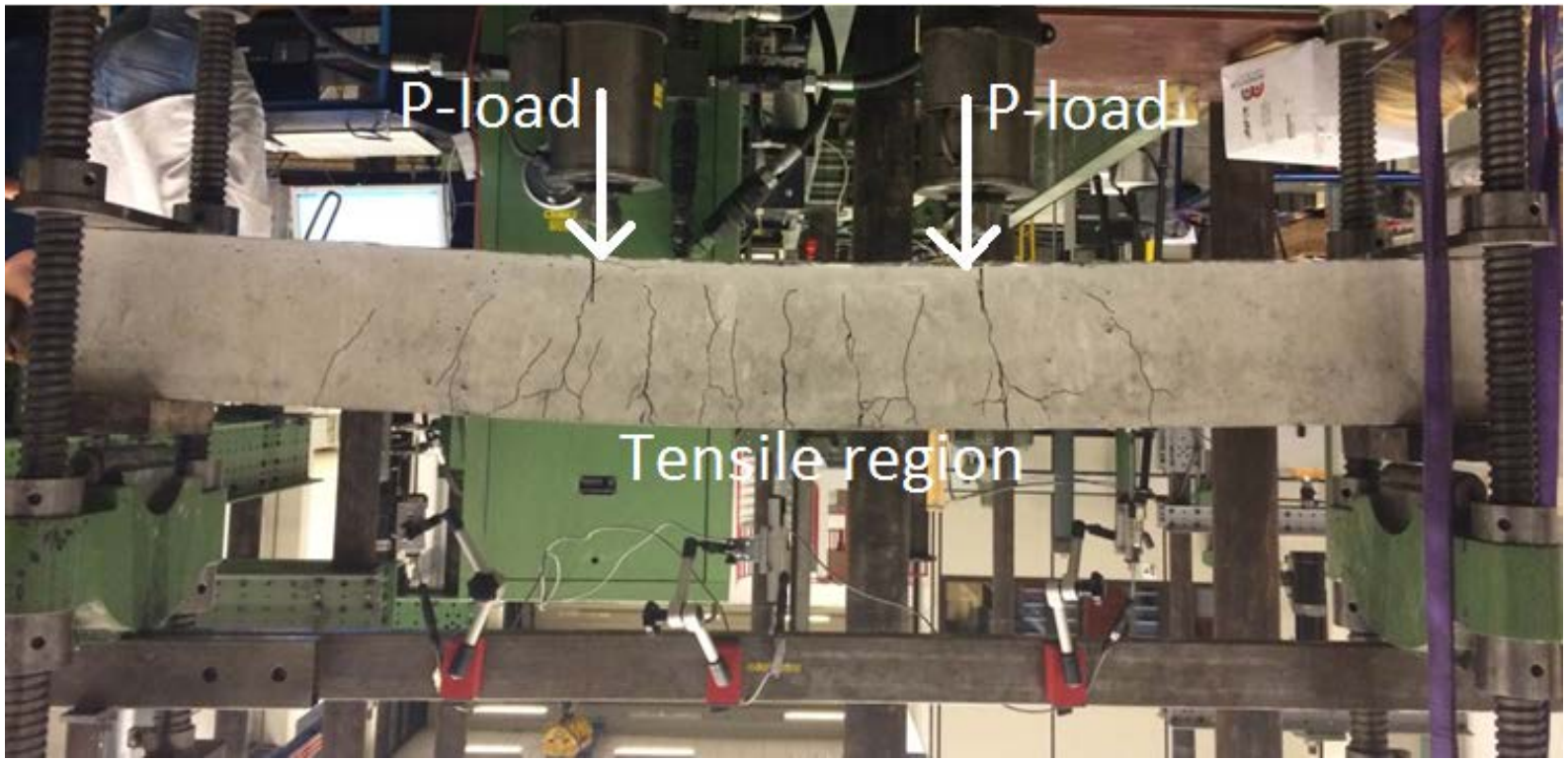
Materials and methods – Concrete beam

- Concrete beam reinforced with:
- Steel rebars and bars of fishing net lines (longitudinal)
- Steel stirrups (Vertical)
- Load application, P [kN]



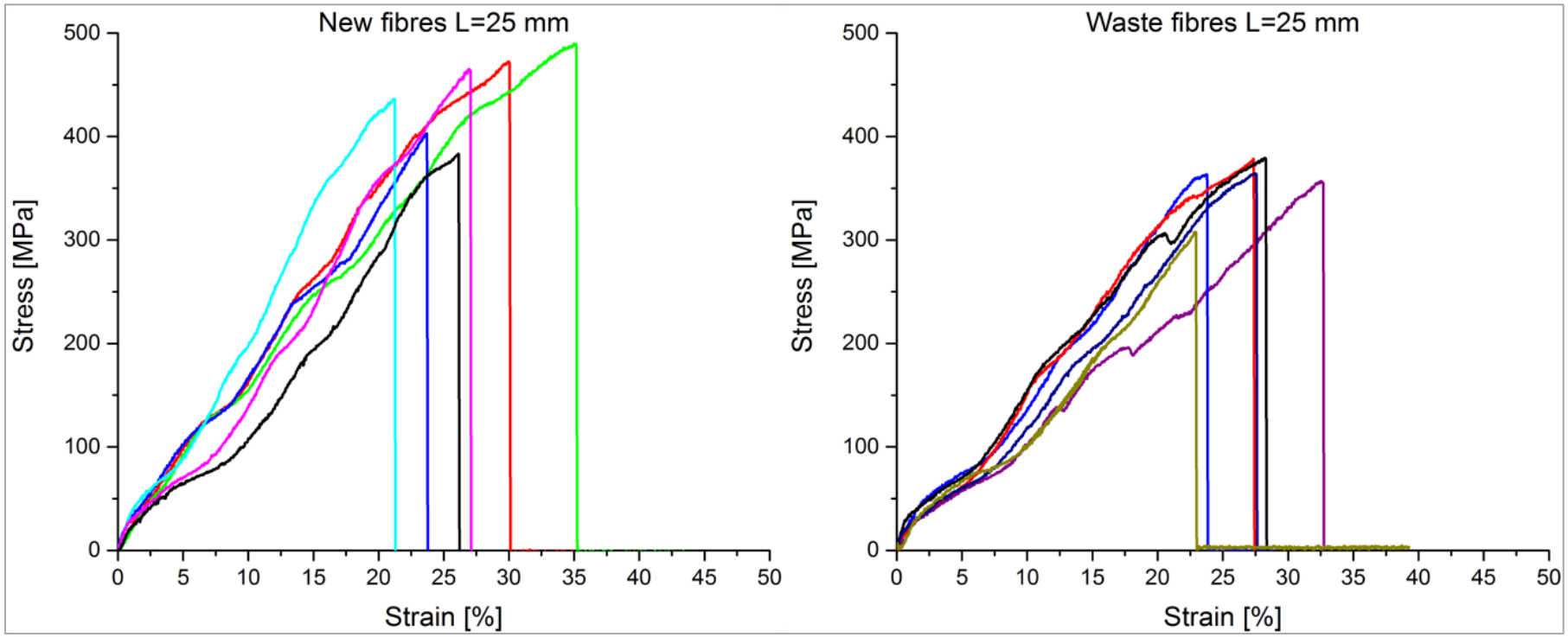
Materials and methods – Concrete beam

- Flexural bending of concrete beams reinforced with steel rebars, steel stirrups **and** NSMR bars of fishing nets



Results - Tensile testing of fibres

- Determination of tensile properties: Stress-strain relationship



Results – Tensile testing of fibres

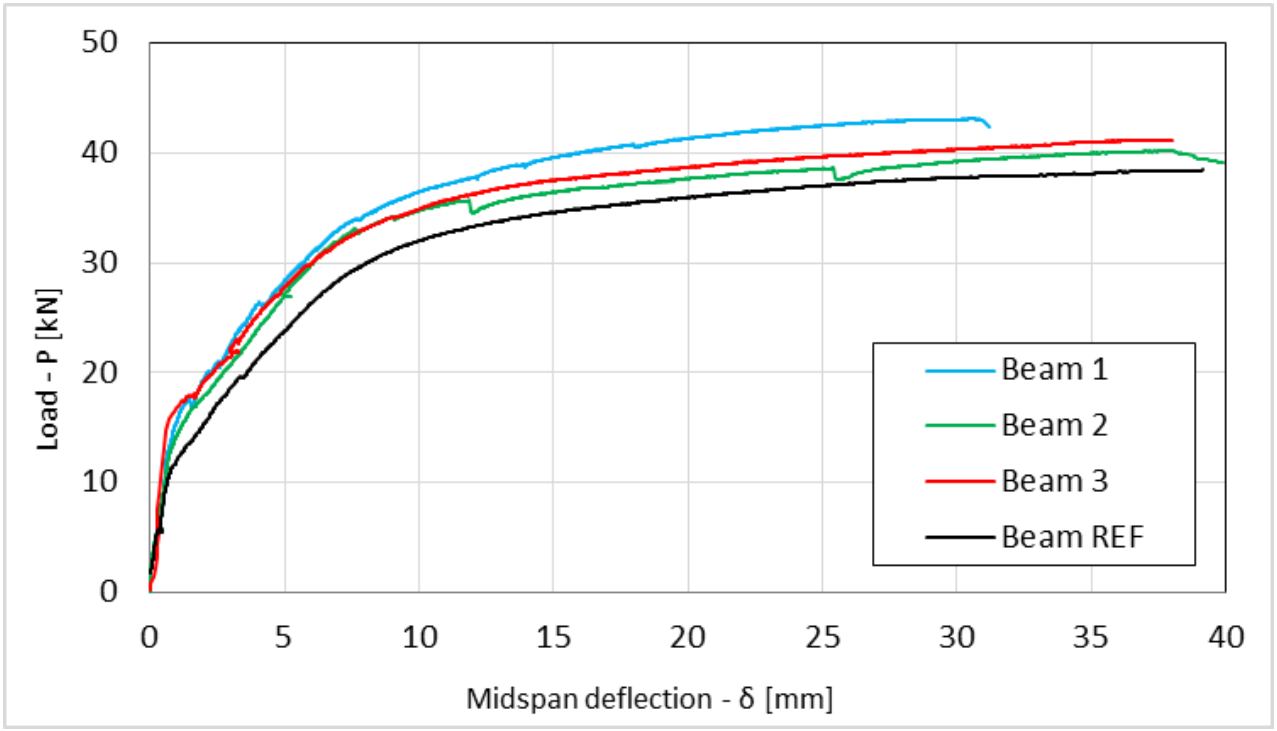
- Tensile strength is 20 % higher for new fibres compared to waste fibres
- Comparison of tensile properties with other types of reinforcement bars

Tensile properties of Waste fibres and New fibres - Unconditioned								
Fibre length l_0 = 20, 25, 30 mm	Peak strength F_{max} [N]		Tensile strength σ_t [MPa]		E-modulus E [GPa]		Peak strain ε_t [%]	
Waste fibres	24.5	(3.9)	346	(55)	1.3	-	29	(4.6)
New fibres	29.7	(2.7)	420	(39)	1.4	-	29	(4.7)
Mean values. Values in parenthesis (x) is standard deviation								

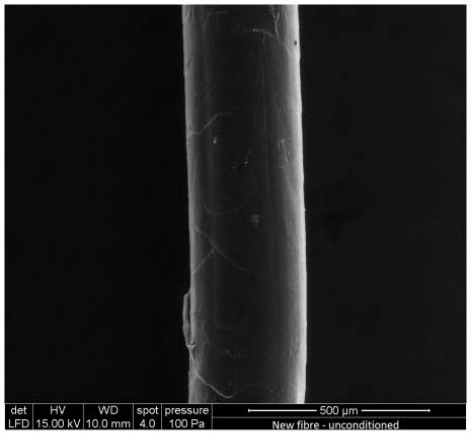
Comparison of tensile properties with other FRP bars [ACI 440, 2006]					
	Fishing net	Steel bar	Glass FRP	Carbon FRP	Aramid FRP
Tensile strength [Mpa]	350-420	276-520	480-1600	600-3700	1700-2540
Elastic modulus [GPa]	1.2-1.4	200	35-50	120-580	40-125
Rupture strain [%]	25-30	6 -12	1.2-3.1	0.5-1.7	1.9-4.4

Results – Flexural bending tests

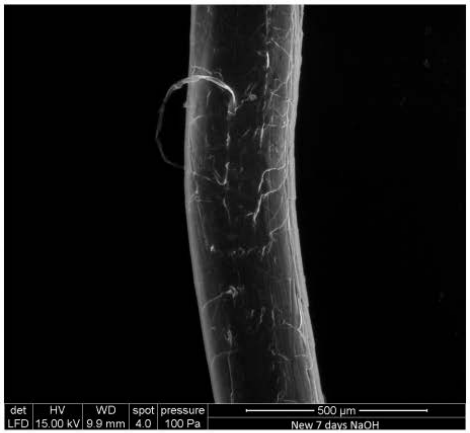
- Reference beam (REF) failed at lower loads
- Concrete failed before reinforcement bars of waste fishing nets



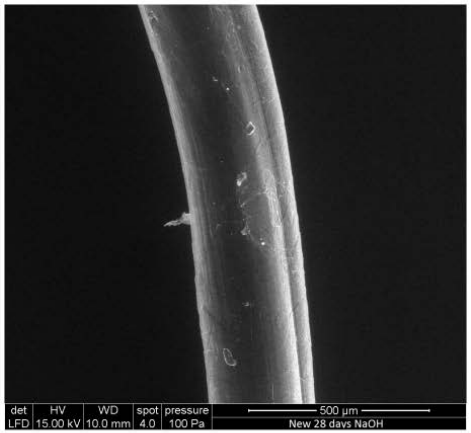
Results – SEM Analysis



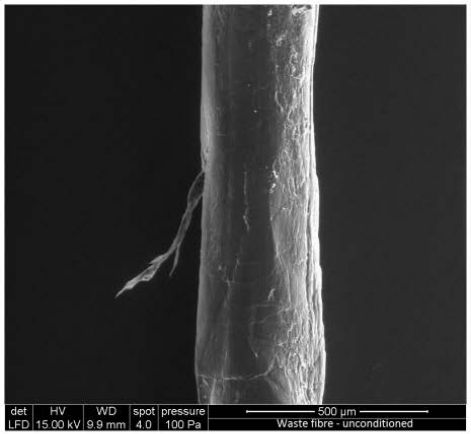
(a) New fibre - unconditioned



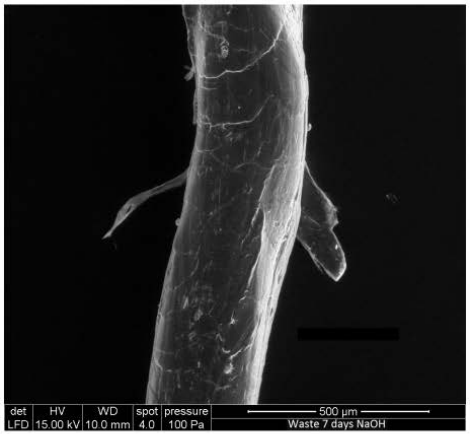
(b) New fibre - 7 days NaOH



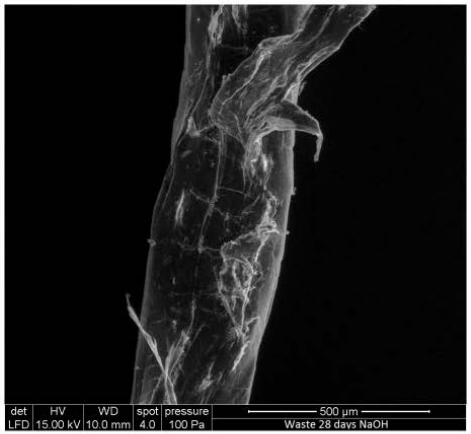
(c) New fibre - 28 days NaOH



(a) Waste fibres - unconditioned



(b) Waste fibres - 7 days NaOH



(c) Waste fibres - 28 days NaOH

Discussion and Conclusion

- Alternative to epoxy resin for casting of FRP bars
- Tensile strength of fishing nets corresponds well with other materials used as reinforcement bars for Near-surface mounted reinforcement method
- Very low stiffness (E-modulus) results in large strains
- Larger flexural strength of concrete beams reinforced both steel- and fishing net reinforcement
- Other types of fishing nets might be more appropriate (higher stiffness)

Acknowledgement

- Thanks to Northern Periphery and Arctic Programme for financial support, and to master students Nina Sigvardsen and Amanda Bonnerup

Thank you for your attention