Recycled fishing nets as reinforcement of existing concrete structures

Ida Bertelsen[1]*, Nina Sigvardsen[1], Amanda Bonnerup[1], Jacob W. Schmidt[1], Lisbeth M. Ottosen[1]

[1] Department of Civil Engineering, Technical University of Denmark. 2800 Lyngby, Denmark

* Speaker, e-mail: imgber@byg.dtu.dk

Short Description of the Abstract

New solutions for reuse of discarded fishing nets in the Northern Periphery and Arctic (NPA) region are investigated as part of the project *"Circular Ocean"*. Fiber-reinforced polymer (FRP) bars of waste fishing nets were produced and used as near-surface mounted (NSM) reinforcement, which is a method for strengthening of existing concrete or masonry structures.

Abstract

Construction materials in remote areas within the NPA region are a scarce resource why utilization of local resources and waste materials as replacement of e.g. steel reinforcement in concrete structures is desirable. The large fishing industry within the NPA region generates a great amount of waste materials, including fishing nets and trawls that still have a high tensile strength, despite the degradation state when discarded. Fishing nets are commonly made of polyethylene, polypropylene or nylon (polyamide), which are all non-corrosive materials.
Traditional concrete structures are reinforced with steel rebars, which have the disadvantage of corroding under inappropriate circumstances. Near-surface mounted (NSM) fiber-reinforced polymer (FRP) reinforcement is a promising technique for strengthening existing concrete structures and thereby prolonging their lifetime (De Lorenzis & Teng, 2007). The method is typically used if the tensile strength of the concrete structure is insufficient. FRP bars are commonly made of carbon, glass or aramid fibres (ACI 440.1R, 2006).
In this study a method for using waste fishing nets as NSM reinforcement bars in concrete beams was developed and bending tests were performed.

Casting of concrete beams with steel reinforcement and NSM FRP bars were carried out in the following steps (Bonnerup & Sigvardsen, 2015): Casting of concrete beams with steel reinforcement (curing time: 14 days); casting of FRP bars from lines of fishing nets (curing time: 7 days); casting of FRP bars into grooves in the surface of concrete beam with epoxy. The cross sections of the concrete beam are shown in Fig. 1.

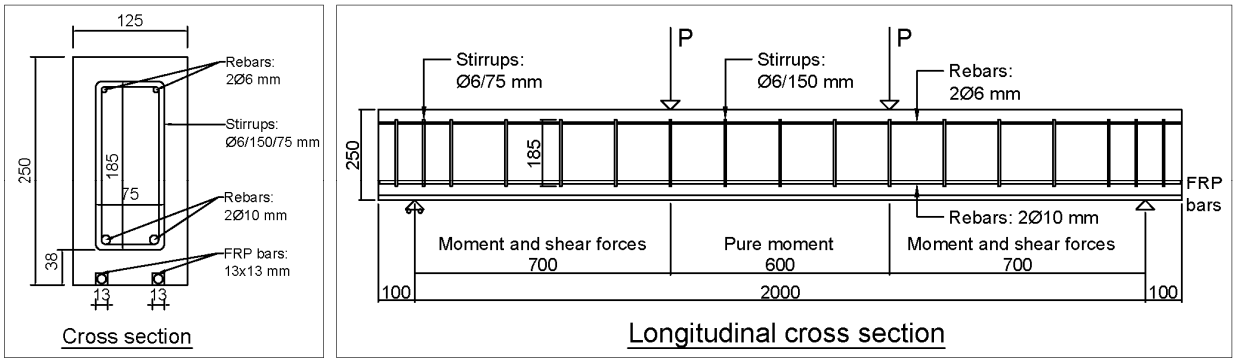

Figure 1 Details of reinforcement and load application method for four-point loading

The concrete had obtained an average compressive strength of 25 MPa after 14 days of curing. The fishing nets used for FRP bars were of type 5.5 Braided Polyethylene from Vónin, collected at the dump in Sisimiut. Vónin is the leading supplier of fishing gear in Greenland.
Polyethylene is not a common material for FRP bars due to the low Young's modulus. ACI 440.1R (2006) and ACI 544.1R (1996) examined different types of fibers used as fiber reinforcement and FRP bars in concrete, respectively. Polyethylene has a low Young's modulus (75-685 MPa) and a high elongation at break (3-80 %) compared to steel (200 GPa; 6-12 %), glass (35-51 GPa; 1.2-3.1 %) and carbon fibres (120-580 GPa; 0.5-1.7 %).

To evaluate the effect of FRP bars on the strength and deformation properties of a concrete beam, a four-point load-bending test was performed in a load-controlled machine on a clear span of 2000 mm. See Fig. 1. The deflection was measured in the mid-span of the beam. The tests were performed on three beams with both steel and FRP reinforcement bars, Beam 1-3, and one beam with only steel reinforcement, Beam REF. The tensile strength and Young's modulus of lines of fishing nets and FRP bars were determined.

The results from the load-bending test show that failure occurred between the two loads, P, and happened due to cracking of the concrete for all beams. No cases of failure of the lines of fishing net were observed, which can be explained by the long yielding phase and rupture strain (deformation) of polyethylene (ACI 544.1R, 1996). The beams reinforced with FRP bars of fishing nets obtained a load about 5-12 % higher than Beam REF. For Beam 1-3, the linear elastic region and yield point were furthermore prolonged. The cracks in the tensile region were for Beam 1-3 were primarily distributed in the middle of the beam and not over the whole length as observed for Beam REF.
The tendencies mentioned above show that FRP bars of fishing nets have a small positive effect on the flexural and shear strength of the concrete beam and on the crack development.

The main problem with FRP bars of waste fishing nets as strengthening of existing concrete structures within the NPA region is related to the epoxy coating, which is used to create good bonding properties between concrete and FRP bars, and to protect the nets from degradation in the alkaline environment in concrete. Epoxy is toxic, difficult to deposit correctly and expensive to import, why it appears illogical to import a material with such environmental and economical disadvantages. Future studies should focus on how to produce FRP bars without epoxy coating, and on investigating the deterioration rate of the nets in alkaline environments.
According to this study, there is potential in using fishing nets as FRP bars for strengthening of existing concrete structures, though much future research is required before it can be implemented as a trustworthy reinforcement method in the NPA region.
Another idea for implementation of waste fishing nets in concrete materials is to cut the nets down to fibres and use it as fibre reinforcement. For this method, no epoxy or similar is required, and it was successfully done with fibres of nylon fishing nets by Spadea et al. (2015).

Acknowledgement: This research is supported by the Northern Periphery and Arctic Programme.

ACI Committee 440.1R, (2006). Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars. *American Concrete Institute, Detroit.*

ACI Committee 544.1R, (1996). State-of-the-Art Report on Fiber Reinforced Concrete. *American Concrete Institute, Detroit.*

Bonnerup, A. & Sigvardsen, N., (2015). Use of Discarded Fishing Nets as Near Surface Mounted Reinforcement in Concrete Beams. *Unpublished report, Arctic Technology Centre, DTU. http://find.artek.byg.dtu.dk/pubs/search/?topic=Byggeri*

Lorenzis, L.D. & Teng, J. G. (2007). Near-surface mounted FRP reinforcement: An emerging technique for strengthening structures. *Composites Part B: Engineering, 38(2),* 119-143.

Spadea, S., Farina, I., Carrafiello, A., & Fraternali, F. (2015). Recycled nylon fibers as cement mortar reinforcement. *Construction and Building Materials*, *80*, 200-209.