

## **A Review on the Strength of Fishing Net; The Effect of Material, Yarn Diameter and Mesh Size**

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**Abstract:** Fishing net can be varies in netting material, yarn diameter and mesh size. The main objective of this research is to review the strength of fishing net that produced from different materials and the effect of different yarn diameter and mesh size on the mechanical performance of the fishing net. Different materials, yarn diameters and mesh size can influence the performance of the fishing net. Polyamide (PA) material tends to have the highest tensile strength properties compared to Polypropylene (PP) and Polyethylene (PE) material. The increase of yarn diameter can have higher tensile strength, higher breaking load and the elongation at break to the fishing net. The higher the mesh size of the fishing net could give a good drag coefficient, higher bending stiffness and higher breaking strength. Furthermore, based on the review from previous studies, the best solution is recommended to the netting material, yarn diameter and the mesh size of the fishing net.

**Keywords:** Fishing Net, Strength Characteristic, Mesh Size

### **1. Introduction**

Fishing net defined as a large piece of open meshed material formed by knotting a relatively thin thread. The netting used in fishing net varies in materials, size and construction. Synthetic polymeric fibres such as high-density polyethylene (HDPE), polyethylene terephthalate (PET) and polyamide (PA) are commonly used to make the fishing net. Synthetic fibres are more popular as the material of fishing net because of non-biodegradable properties, high breaking strength, better uniformity in characteristics, long service life and low maintenance cost [1].

However, every fishing net has different types of structure, materials and yarn size which give different result on the physical and mechanical performance of the fishing net. The lack of strength in fishing net also can cause severe outcome such as escape of fish, structure failure of nets, economic losses and environmental hazards [2]. 'Ghost fishing' that can be harm to the sea life and affect the marine environment also can be occur due to low breaking strength of the fishing net. The strength of the netting material also related to the yarn or thread diameter [3]

The objectives of this study are to review the strength of fishing net produced from different materials and to investigate the effect of different mesh size and different yarn diameter on the mechanical performance of the fishing net from the previous research.

## 2. Search scope

Several procedures were followed to ensure a high quality review of the literature on this topic. Two databases were searched including Google Scholar and Science Direct. First, the search was completed based on a wide range of key terms and the Boolean operators had been used, such as 'fishing net AND strength characteristic' OR 'mechanical properties AND yarn diameter fishing net'. At this stage, a total of publication 146 publications were retrieved. Then, the result were filtered by 'article type' such as review articles and research articles. Due to this, 118 documents were removed, and only 28 articles remained. The results by years were then filtered between year 2000 to 2020, and 2 documents were discard, leaving 26 documents to screen for the next stage. The articles were reviewed thoroughly for the title and abstract. The next step of the review involved the understanding of the full content of all the collected articles. The main focus of the research, the methods used, and the main contributors to the papers were then reviewed. The reference section at each article found has been used as 'snowball' effect in order to find additional articles to support the review. The article that meet the specified selection criteria in term of the strength characteristic based on different material, the effect and the mechanical properties of fishing net based on different mesh size and yarn size is continuous to the result and discussion parts. The search process uncovered 14 reviewed articles published from 2000 to 2020.

## 3. Results and Discussion

Table 1 shows below displays 14 papers made up of research and review articles.

**Table 1: Outcome from previous studies**

Author (s) and year of publication	Characteristics	Finding
(Amaral et al., 2013)	Fishing net made with natural fibres, which have been replaced by PA, but recently by PP and PE.	This article provides the materials revolutions of the fishing net which occurred in order to improve mechanical strength and stability of the fishing net against environment conditions.
(Song et al., 2005)	PA and PP	This paper shows the tensile strength of PA higher than PP with the strength of PA is 896 MPa while PP is 413 MPa.
(Gieysztor & Lisbeth, 2016)	PE	This study shows the tensile strength of PE fishing net is in the range of 310 to 445 MPa.
(Thomas & Sandhya, 2019)	PA6, PP, PE	This study shows the tenacity of PA6, PP, and PE. PA6 has the highest tenacity that is 9 g/den while PP is 7 g/den and lastly PE is 5g/den.
(Mousa, 2017)	PP and PA	This study related to the properties of tensile strength of the polymeric. As

		stated, tensile strength of PP is 553-759 MPa while PA is 897 MPa.
(Thomas & Sandhya, 2019)	PE and PA 6	This article provide the contents of the elongation of break of the different fibres. PA 6 tend to have higher elongation of break compared to PE.
(Mousa, 2017)	Yarn diameter 1: 1.20mm Yarn diameter 2: 1.75mm	This study shows the result of tensile strength from different yarn diameter. Higher yarn diameter can produce higher tensile strength of fishing net. Tensile strength produces by yarn diameter 1 is 20.6 kN/m while yarn diameter 2 is 35.1 kN/m.
(Moe et al., 2007)	From this study, there are many yarn diameter have been investigated ; 1.10mm, 1.23mm, 1.45mm, 1.61mm, 1.93mm, 2.15mm, 2.50mm,2.71mm and 2.79mm.	From this journal article, higher diameter of material fishing net has higher strength properties of fishing net.
(Thomas & Hridayanathan, 2006)	Different yarn diameter of PA 6 yarns has been evaluated for the strength characteristics.	This study analyse that higher yarn diameter can give good strength properties to the fishing nets.
(Meenakumari, 2009)	Diameter of PA multifilament twines, monofilament twines and PP multifilament twines and monofilaments have been investigated toward the breaking load, N.	This study provides the content of the higher diameter of twine netting yarn can give good properties to the breaking load of the fishing net.
(Thomas et al., 2009)	PA monofilament yarns of different diameters have been tested.	From the study, the different yarn diameter of netting material could give a different of breaking loads and elongation at breaks.
(Neill et al., 2016)	Two different mesh size have been evaluated in this study. Mesh size 1 is 119.6 mm while mesh size 2 is 129.4 mm.	This article shows the result on the different mesh size toward the different in tenacity and bending stiffness.
(Sala et al., 2004)	PA netting material with the different on length of mesh and different of mesh opening have been investigated.	From the result, with the different length of mesh and mesh opening could give a different towards the breaking strength and elongation at break.
(Bruno Thierry et al., 2020)	Different mesh size have been investigate to find the effect towards the drag of fishing net.	This study shows that the relationship between the different of mesh size to the effect of drag. Mesh size in part

determines the net porosity and thus affects the drag coefficient.

### 3.1 Strength characteristics of fishing net based on different material

PA netting material has demonstrated as the highest tensile strength among other material that is PE and PP. Table 2 shows the tensile strength of fishing net material based on previous studies[5] [6]. The tensile strength of PA is 896 MPa while PE is 310-445 MPa. PP has the lowest tensile strength that is 413 MPa. It concludes that PA has the good strength characteristics that can withstand the heavy flow of the water and can used longer as the netting material. Fishing net that have a high breaking strength also can prevent from the ghost fishing, which occurs when abandoned or discarded nets continue to catch fish or other marine species [1]. Furthermore, PA is used as netting materials in India because of the softness, lightness, elastic recovery, stretch ability and high abrasion [1].

**Table 2: Tensile strength of each synthetics fibers [5][6]**

Synthetic fibre	Tensile strength, MPa
Polyamide	896
Polypropylene	413
Polyethylene	310-445

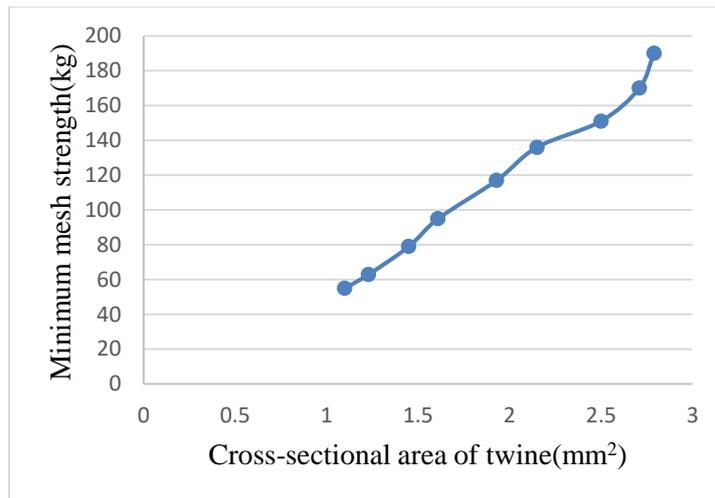
### 3.2 Effect of different yarn diameter of fishing net

Different yarn diameter can give different performance of the fishing net as higher number of yarn diameter can improves the tensile strength of the yarn and fabric [15]. Table 4 shows the effect of yarn diameter of PA multifilament netting material towards the breaking load and elongation. Based on Table 3, the higher the yarn diameter of netting material, the higher breaking load and higher elongation can be obtained. The same pattern also can be seen in other material reported by Meenakumari.,2009, such as PA monofilament, PP multifilament and PE twisted monofilament [11]. Moreover, good breaking load and elongation give a good characteristics toward the strength of the netting material.

**Table 3: Properties of PA multifilament [11]**

Diameter, mm	Breaking load, N	Elongation, %
0.37	28.19	23.5
0.50	54.24	32.2
0.62	75.0	32.4

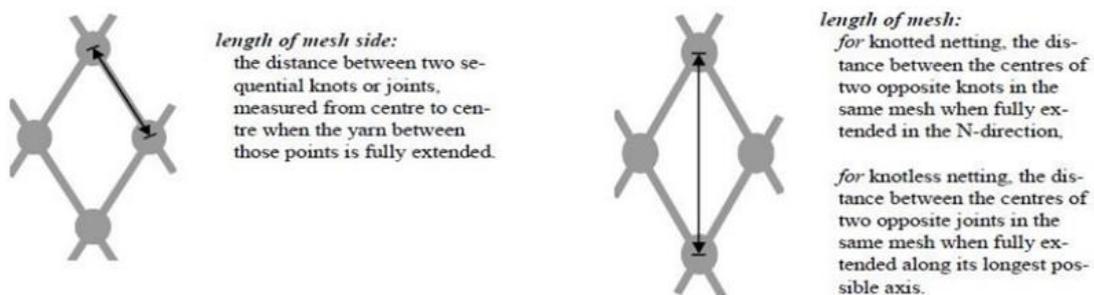
High number of yarn diameter can improves the tensile strength of the yarn and fabric [15]. It has been proved by a study from Moe et al., 2007, [9] that different twine cross sectional area result to different mesh strength. Based on Figure 1, the higher cross-sectional area of twine can have higher mesh strength. For example, the yarn size of 1.10 mm<sup>2</sup> can produced 55 kg minimum mesh strength while twine area of 2.79 mm<sup>2</sup>, 190 kg minimum mesh strength can be obtained. However, higher yarn diameter are more visible and are easily detectable by the lateral line sense organs of the fish [1].



**Figure 1: The effect of twine area and the minimum mesh strength [9]**

### 3.3 Effect of different mesh size of fishing net

Fishing nets are also characterized based on their mesh size, which refers to the spacing or the thread length bounded between the knots as shown in the Figure 2. Different mesh size also can give different performance to the fishing net. Based on reviewed paper, the effect on the mesh size is associated with the drag coefficient, bending stiffness and the breaking strength.



**Figure 2: Mesh size of fishing net [8]**

A study by Sala et al., 2004, [13] investigated the relationship between different length of mesh and the mesh opening towards the breaking strength and elongation of the fishing net. It can be concluded that the higher mesh size can be good to the strength characteristic of the fishing net. For example, the netting that have length of mesh is 48.9 mm and mesh opening 46.5 could produce 1.779 kN breaking strength and 60.60 % of elongation while the netting that have length of mesh is 46.0 mm and the mesh opening is 44.2 mm only have 0.964 kN breaking strength and 52.00 % of elongation.

According to study from Bruno Thierry et al., 2020 [14], the increasing in the mesh size decreases the drag coefficient. This study reported that it is important to design fishing net with higher mesh size as it can decrease the drag coefficient and could reduce 30.00 % in fuel consumption during the tow and minimize the impact on ecosystems.

A study from Neill et al., 2016, [12] had investigated four different mesh size of the netting material towards the tenacity and bending stiffness. The mesh size measurements were made with an ICES spring loaded gauge set at 4 kg spring tension and with a standard EU wedge gauge. Table 5 shows the data collected from the study.

**Table 4: Mesh size and the properties [12]**

Netting material	Mesh size			Tenacity, N/tex	Bending stiffness, kN mm <sup>2</sup>
	ICES gauge (mm)	Wedge gauge (mm)	Rtex (g/km)		
120mm low tenacity	119.3	124.1	8000	0.34	0.69
120mm medium tenacity	119.6	124.5	9524	0.30	0.64
120mm high tenacity	119.6	125.3	12392	0.28	1.10
130mm medium tenacity	129.4	132.9	9524	0.30	0.80

Based on the Table 4, different mesh sizes can influence bending stiffness and the tenacity. 120 mm high tenacity netting with the higher mesh size tend to have higher tenacity and bending stiffness. This can be advantage to the fisher, as the bending stiffness increase, the mesh resistance to open also increase. The increase of mesh size also can increase the bending stiffness which could give advantage to the reduce ability of fish to deform meshes when attempting to escape [12].

#### 4. Conclusion

The purpose of this study is to review the strength of fishing net produced from different material and to investigate the effect of different mesh size and yarn diameter on the mechanical performance of the fishing net has been achieved. Based on the review results, PA material tends to have the highest tensile strength properties compared to PP and PE material. PA netting material is more suitable to be used to prevent the 'ghost fishing' and also it can protect the environmental conditions.

Other than that, the effect of the different yarn diameter on the mechanical properties also been review. Based on five reviewed paper, the increase of yarn diameter can have higher tensile strength, higher breaking load and the elongation at break to the fishing net. Lastly, the effect on the mesh size is associated with the drag coefficient, bending stiffness and the breaking strength. The higher the mesh size of the fishing net could give a good drag coefficient, higher bending stiffness and higher breaking strength.

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#### References

- [1] Fibres, N. (2017). Chapter 3 Recent trends in fishing gear materials. 39–56.
- [2] Zheng, Z. Q., Wan, R., Chang, Z. Y., Zhang, Y., & Tao, J. (2019). Analysis of plane netting with twine breakage in aquaculture net cage. *Journal of Marine Science and Technology (Taiwan)*, 27(1), 72–76. [https://doi.org/10.6119/JMST.201902\\_27\(1\).0009](https://doi.org/10.6119/JMST.201902_27(1).0009)
- [3] Nations, F. and A. O. of the U. (n.d.). *Handling Live Fish On The Farm*. Retrieved July 2, 2020,

from

[http://www.fao.org/fishery/static/FAO\\_Training/FAO\\_Training/General/x6709e/x6709e08.htm](http://www.fao.org/fishery/static/FAO_Training/FAO_Training/General/x6709e/x6709e08.htm)

- [4] Amaral, G., Bushee, J., Cordani, U. G., KAWASHITA, K., Reynolds, J. H., ALMEIDA, F. F. M. D. E., de Almeida, F. F. M., Hasui, Y., de Brito Neves, B. B., Fuck, R. A., Oldenzaal, Z., Guida, A., Tchalenko, J. S., Peacock, D. C. P., Sanderson, D. J., Rotevatn, A., Nixon, C. W., Rotevatn, A., Sanderson, D. J., ... Junho, M. do C. B. (2013). High Performance Technical Textiles. In *Journal of Petrology* (Vol. 369, Issue 1). <https://doi.org/10.1017/CBO9781107415324.004>
- [5] Song, P. S., Hwang, S., & Sheu, B. C. (2005). Strength properties of nylon- and polypropylene-fiber-reinforced concretes. *Cement and Concrete Research*, 35(8), 1546–1550. <https://doi.org/10.1016/j.cemconres.2004.06.033>.
- [6] Gieysztor, I. M., & Lisbeth, M. (2016). Engineering properties of fibres from waste fishing nets.
- [7] Thomas, S. N., & Sandhya, K. M. (2019). Netting Materials for Fishing Gear with Special Reference to Resource Conservation and Energy Saving. December, 55–70.
- [8] Mousa, M. A. (2017). Low-Cost Fishing Net-Reinforced Cement Matrix Overlay for Substandard Concrete Masonry in Coastal Areas.
- [9] Moe, H., Olsen, A., Hopperstad, O. S., Jensen, Ø., & Fredheim, A. (2007). Tensile properties for netting materials used in aquaculture net cages. *Aquacultural Engineering*, 37(3), 252–265. <https://doi.org/10.1016/j.aquaeng.2007.08.001>
- [10] Thomas, S. N., & Hridayanathan, C. (2006). The effect of natural sunlight on the strength of polyamide 6 multifilament and monofilament fishing net materials. 81, 326–330. <https://doi.org/10.1016/j.fishres.2006.06.012>
- [11] Meenakumari, B. (2009). Fishing gear materials chapter-5.pdf.
- [12] Neill, F. G. O., Kynoch, R. J., Blackadder, L., Fryer, R. J., Eryas, A. R., Notti, E., & Sala, A. (2016). The influence of twine tenacity , thickness and bending stiffness on codend selectivity. 176, 94–99. <https://doi.org/10.1016/j.fishres.2015.12.012>
- [13] Sala, A., Lucchetti, A., & Buglioni, G. (2004). The change in physical properties of some nylon (PA) netting samples before and after use. *Fisheries Research*, 69(2), 181–188. <https://doi.org/10.1016/j.fishres.2004.05.005>
- [14] Bruno Thierry, N. N., Tang, H., Liuxiong, X., You, X., Hu, F., Achile, N. P., & Kindong, R. (2020). Hydrodynamic performance of bottom trawls with different materials, mesh sizes, and twine thicknesses. *Fisheries Research*, 221(October 2019).
- [15] Malik, Z. A. (2015). And Woven Fabric A thesis submitted by In accordance with the requirements for the degree of in Textile Engineering Department of Textile Engineering Faculty of Engineering Mehran University of Engineering & Technology. December. <https://doi.org/10.13140/RG.2.1.1730.6965>