ROPES

Catenary curve moorings are rigged from a combination of sinking and buoyant ropes. The properties of each rope perform specific functions or impart specific features to the mooring. As more than 90 per cent of any deepwater FAD mooring is comprised of rope, consideration of the properties and performance characteristics of rope to be used is very important.

ROPE RECOMMENDATIONS

The rope recommendations below take account of all the important considerations mentioned above for weight and breaking strength. They must be taken as minimum requirements. Specifications are listed in both metric and U.S. systems of measure.

U.S. rope manufacturers typically list rope weight in terms of either cft or cfm:

- 1 cft = 100 feet (30.5 metres)
- 1 cfm = 100 fathoms (183 metres)

### UPPER (SINKING) ROPE

<table>
<thead>
<tr>
<th>Material</th>
<th>Nylon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>8–12 strand, plaited</td>
</tr>
<tr>
<td>Measure</td>
<td>Metric</td>
</tr>
<tr>
<td>Size</td>
<td>19 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>21.8 kg/100 m</td>
</tr>
<tr>
<td></td>
<td>48.0 kg/220 m</td>
</tr>
<tr>
<td></td>
<td>0.218 kg/m</td>
</tr>
<tr>
<td>Breaking strength</td>
<td>400 kg</td>
</tr>
</tbody>
</table>

### LOWER (BUOYANT) ROPE

<table>
<thead>
<tr>
<th>Material</th>
<th>Polypropylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>8–12 strand, plaited</td>
</tr>
<tr>
<td>Measure</td>
<td>Metric</td>
</tr>
<tr>
<td>Size</td>
<td>22 mm</td>
</tr>
<tr>
<td>Minimum weight</td>
<td>20.4 kg/100 m</td>
</tr>
<tr>
<td></td>
<td>45.0 kg/220 m</td>
</tr>
<tr>
<td></td>
<td>0.204 kg/m</td>
</tr>
<tr>
<td>Breaking strength</td>
<td>300 kg</td>
</tr>
</tbody>
</table>
ROPE MATERIAL

The quality and performance of any rope depends on the material the rope is made from and the way it is manufactured. Important characteristics include specific gravity (whether the material floats or sinks in seawater), breaking strength, strength-to-size ratio, elongation and elasticity, resistance to cyclic and shock loading, abrasion resistance, and durability.

All these properties should be considered when selecting rope, to ensure that the rope will have the strength to hold FADs on station while presenting minimum drag and will perform according to the needs of the mooring design.

Rigging moorings from ropes made of natural fibres or blended synthetic fibres is not advised. Natural fibres are susceptible to attack by organisms and often rot in seawater.

Blended synthetic fibre ropes are often designed for special purposes and made from materials which have widely different characteristics.

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**Rope material**

- **Natural**
  - Manilla
  - Hemp
  - Jute

- **Synthetic**
  - Sinking
    - Polyester
    - Nylon
    - Blends
  - Buoyant
    - Polypropylene
    - Polyethylene
    - Blends

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**Nylon**

The recommended material for the upper mooring rope is nylon. As the specific gravity of nylon is 1.14, it sinks in seawater. Nylon is one of the strongest, most widely available, synthetic fibre ropes. The breaking strength of nylon decreases slightly when wet, but a 19 mm nylon rope can have a wet breaking strength as great as 8,300 kg.

Nylon is elastic. It will stretch up to 17 per cent of its length under a working load equal to 20 per cent of its ultimate breaking strength. Nylon rope can withstand both the routine cyclic loading (stretch and recoil) caused by ocean swells, and the shock loading (strong, sudden jerks) which will affect a FAD mooring during rough seas and stormy weather.

Nylon is durable. It resists surface wear and internal abrasion caused by flexing and stretching. Nylon also withstands ageing and deteriorates only slightly from exposure to sunlight. Nylon does tend to stiffen somewhat with prolonged immersion in seawater.

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**Polypropylene**

The recommended material for the lower mooring rope is polypropylene. Having a specific gravity of 0.91, polypropylene floats. Its buoyant property can be used to lift weight. Polypropylene has moderate breaking strength, ranging between 4,200 and 8,200 kg for 22 mm rope. In seawater, the breaking strength of polypropylene actually increases slightly.

Polypropylene has good elastic properties. It can be stretched by about nine per cent of its length and still return to its original length. Polypropylene has excellent shock loading capabilities.

Polypropylene is fairly durable. The single most important exception to its durability is that it does deteriorate with exposure to sunlight. Some manufacturers offer treatments which increase polypropylene’s resistance to sunlight.
**ROPE CONSTRUCTION**

Different rope constructions can produce dramatically different characteristics—even in ropes that are identical in every other way. The rope constructions most commonly seen in FAD moorings are 3-strand twisted and either 8- or 12-strand plaited. Although 3-strand rope has been widely used for FAD moorings, it is not recommended. Three-strand construction produces characteristics which, even when the utmost care is taken in rigging and deploying FADs, can result in rope failure and premature FAD loss. **The rope construction recommended for deepwater FAD moorings is 8- or 12-strand plaited.**

The next sections describe the similarities and differences between 3-strand twisted and 8- or 12-strand plaited rope constructions.

**Breaking strength**

One of the most important properties of a rope is strength. Breaking strength is one property which does not vary between ropes of twisted and plaited construction. Plaited and twisted ropes made from the same material, and of the same size and weight, will have identical breaking strengths.

For example, consider two 19 mm nylon ropes, each weighing 48 kg per 220 m coil. The only difference between the ropes is construction. One rope is 3-strand twisted and the other is 8-strand plaited. The breaking strength of the ropes is identical, at approximately 6,400 kg.

Although construction does not create a difference in breaking strength between 3-strand twisted and plaited ropes, it does produce differences in other rope properties which can affect the lifespan of FAD mooring systems. Three-strand twisted construction has several major disadvantages.
Twisting, kinking and hockling

Perhaps the single most undesirable property of twisted rope construction is the tendency for the rope to unlay and form hockles. Whenever 3-strand is twisted against the regular lay of the rope, kinks form as the rope begins to unlay. As the rope unlays further, kinks turn into hockles, which cause permanent damage to the rope. A single hockle can decrease the rope’s breaking strength by 30 per cent. Once a hockle forms, no amount of straight pull can remove it from the rope.

Hockles commonly form when force stretches the rope under tension while one end of the rope is free to rotate (a working mooring), or from improper handling of the rope.

Features of plaited ropes

Ropes of plaited construction contain an even number of strands, which are often paired. Equal numbers of strands run in opposite directions, and are interlocked. Because strands are interlocked, plaited ropes cannot unlay, and cannot hockle. Because equal numbers of strands run in opposite directions, there is no built-in tendency for plaited ropes to twist. These ropes are said to be torque-free or torque-balanced.

Moorings twist and turn continuously during deployment and with the routine sea-keeping motion of the buoy. This action leads to the formation of hockles in 3-strand rope. Consequently, plaited rope is the only rope construction recommended for moorings.

Load distribution and breaking points

Load is distributed unevenly in 3-strand ropes. At times a single strand may bear most of the load or strain on the mooring, and this may cause rapid deterioration of the rope. In plaited rope construction, load is distributed evenly over all the strands and this prevents premature breakdown of the rope. Splices form a weak point in 3-strand systems. Break tests show that when 3-strand ropes are spliced end-to-end, the splice will give, or the rope will break at the splice, before the main rope breaks. The splice does not form a weak point in plaited ropes. Identical break-tests on plaited ropes have shown that, because load is distributed evenly, the main rope breaks—not the splice.
ROPE SIZE AND WEIGHT

Never base selection of ropes of any material on size alone. Always consider size (diameter) and weight together. Rope size can be misleading, because production methods and rope designs differ from one manufacturer to the next. Ropes listed as the same size may contain very different amounts of material. The only sure way to tell exactly how much material (nylon, polypropylene, etc.) the rope contains is by knowing the weight of a standard length of rope. It is the amount, or weight, of material in a standard length of rope that determines certain rope characteristics, such as breaking strength, working load, the cyclic and shock loading forces it can withstand, and, in the case of polypropylene, buoyancy.

The weight of a standard length of rope is the rope’s weight:length ratio (kg/m). Weight:length ratios are commonly reported in terms of kilograms per 100 metres (kg/100 m), kilograms per 220 metres coil (kg/220 m), or in U.S. measure as pounds per 100 feet (lb/cft), or pounds per 100 fathoms (lb/cfm; 1 cfm = 600 feet = 183 m).

Breaking strengths differ in same-sized ropes having different weight:length ratios (containing different amounts of material). Heavier rope has greater breaking strength, has a greater workload rating, and can withstand greater shock loads.

The minimum recommended weight for 19 mm nylon mooring rope is 48 kg/220 m coil. (weight:length ratio: 0.218 kg/m)

Polypropylene material is buoyant

215 kg

Polypropylene thread

Polypropylene block

215 kg

25 kg

25 kg

The amount of polypropylene material needed to lift a specific weight does not change, whatever form the polypropylene is in.

Rope weight and breaking strength

<table>
<thead>
<tr>
<th>Weight</th>
<th>Breaking strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>52 kg</td>
<td>8,400 kg</td>
</tr>
<tr>
<td>35 kg</td>
<td>5,000 kg</td>
</tr>
</tbody>
</table>

Consider both size and weight when selecting rope. Ropes of the same size can have different weights, and therefore different breaking strengths.

Apart from the strength of the rope, the weight:length ratio of the polypropylene rope has another important function: because polypropylene is buoyant, the heavier the rope, the more hardware it will lift from the bottom.

The amount (weight) of polypropylene material needed to lift a specific weight will never change. In seawater 215 kg of polypropylene material supplies enough buoyancy to lift 25 kg. It does not matter if the 215 kg of polypropylene material is compressed into the smallest block possible, or if it is stretched into a fine thread 1 km long.

The minimum recommended weight for 22 mm polypropylene mooring rope is 45 kg/220 m coil. (weight:length ratio: 0.204 kg/m)