Synthetic slings, grommets, wire ropes and tension members.

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Lifting of loads in almost all cases requires the need for slings or grommets in combination with shackles and other lifting gear such as lifting- and spreader beams. Usually lifting slings and grommets are made of steel wire rope. So are stay wires for cranes, suspension bridges and other tension members. Depending of its application the right steel wire rope construction is selected. Today we see more and more the application of high performance synthetic fibers, for the construction of slings, grommets, wire ropes and tension members. There are quite a number of manufacturers of synthetic wire ropes, who manufacture a variety of wire ropes for different applications, mainly made of polyester fibers. When we talk about high performance fibers, these are limited to fibers like: Dyneema® (DSM), Spectra® (Honeywell), Twaron® /Technora® (Tejin) and Kevlar® (Dupont) and some others. Again each with its specific field of application.

Why use synthetic ropes

When will we use synthetic ropes instead of steel ropes? Overall, synthetic ropes are more versatile, cause less injuries, are less detrimental to the environment, last longer and are significantly lighter when comparing at identical strength. See below the specific advantages:

- Fiber ropes can be as strong as steel, and depending on the type of fiber used, on average five times lighter. They are a lot easier to handle and contribute a lot to safety, as they are much less likely to cause injuries due to handling and weight.
- Synthetics are more buoyant then steel and can be designed to float or be buoyant neutral for water applications. Especially for lowering of heavy loads into deepwater, the length and weight of the steel lifting tackle will limit the net lift capacity at great depths significantly.
- Synthetic lines can be designed to be UV resistant and require no lubricants or maintenance oils that would be detrimental to the environment. They do not corrode.
- High Performance fibers have a high modulus and therefore make them ideal when a cable with no or limited stretch is required.
- Synthetic lines will last as long, if not longer than steel if cared for properly. Many synthetics are also heat and fire resistant.
- Synthetic slings or grommets are softer then steel and consequently do not damage the painted surfaces of loads easy.
- Synthetics wire ropes can be made in almost unlimited lengths and manually be repaired by splicing if they break

Higher purchase cost but operational benefits

	Specific density	Chemical Resistance	UV Resistance	Tensile strength	Heat Resistance	E-Modulus
HMPE (Dyneema®SK75)	0.96	Very Good	Very Good	3200 Mpa	Upto 70^o	110 GPa
Twaron® (Aramide)	1.45	Good	Good	2950 Mpa	Very Good	108 GPa
Polyester	1.38	Good	Good	37 Mpa	-40^o to +100^o	2 Gpa
Carbon Fibers	1.76	Very Good	Very Good	4900 Mpa	Very Good	230 Gpa
Steel (Pre-stressing strands)	7.8	Good	Very Good	1860 Mpa	Good	200 Gpa

Unfortunately the cost of these high performance fibers is still quite high compared to steel wire ropes (initial investment cost about 3-4 times more then steel ropes) and that is one of the reasons why they are still not widely used. Experience shows that initial costs can be offset by operational benefits (faster working with fewer people, less damage to loads, improved safety etc.). Let's compare the specific data of various yarn materials in the table below:

It must be noted that carbon fibers are usually not applied in wire ropes, but more in tension members and stiff structures, such as golf clubs, mountain bikes or airplane fuselage sections etc. FibreMax of the Netherlands can also make flexible tension members using carbon fibers with pin/socket end connections, which find applications in stay wires of sailing yachts, lifting beams and cranes.

Polyester slings and grommets

The bulk of synthetic slings used today is made from nylon or polyester. Slings made from these fibers are different from slings made from high performance fibers in a few ways. They are more heavy and stretch significantly more under load. The stretch (elongation under load) of polyester slings is approx. more then 10 x compared to the very stiff high performance yarns like Aramide (Kevlar®, Twaron®) and HMPE (Dyneema®, Spectra®). Polyester can be bought at a lot lower cost and therefore is widely used as mooring lines on ships and in the lifting industry as fiber slings and grommets. Due to the fact that they are vulnerable to mechanical damage, caused by sharp objects or edges on cargo, a much higher Factor Of Safety (FOS) is applied then for steel slings and grommets (7 compared to 5 for steel). In Europe a FOS of 7 is applicable (for general purpose lifting, as embedded in the European Machinery Directive), while in the USA a FOS of 5 can be used for fiber slings as well. Unfortunately these rules and regulations have not yet been harmonized. In daily use of polyester round slings, in the WLL class of up to 25 tons, it makes sense to use this higher FOS, but when higher WLL's (>160 ton) are used it would be logical to apply a lower FOS.

HMPE (Dyneema®, Spectra®) Slings and grommets

For High Performance slings and grommets and engineered lifts it makes sense to lower the FOS even more and reach levels, which are equivalent to steel wire ropes (FOS = 3-4). Discussions are ongoing between a number of offshore contractors associated in IMCA (International Marine Contractors Association) to reduce the FOS of lifting slings and grommets made of Dyneema. The construction of synthetics slings and grommets can be made according a few basic principles. One is to take a braided rope and splice a loop at each end of the rope resulting in a conventional sling with at each end an eye. A lift sling can also be made from woven material and sewed together, or made as a round sling, in which all the yarns are wound around a two pinions and protected by i.e. a polyester jacket.

For lifting of steel coils at the Corus steelworks, Technotex in Holland together with DSM Dyneema® developed a 20 ton round slings (MBL = 140 t) of 4 m (only 13 kg) which have found a very useful application in replacing the previously used steel slings (approx. 70-100 kg). The slings made from Dyneema® are cut resistant and last a lot longer then the steel slings used in the same application. Next to a longer lifetime these slings also increase the speed of lifting and decrease the damage to the coils. Furthermore job satisfaction of the Corus employees has increased as they are now

handling low weight slings instead of the burdensome steel sling. Also lifting tower sections for wind turbines find a useful application in HMPE slings, as they do not damage the coating of the piles.

Deepwater applications - using the neutral buoyancy
Last year Jumbo was involved in the transportation and installation of five buoyancy cans each with a weight of 350 tonnes. The cans were shipped from Pori in Finland to the Gulf of Mexico and installed in 2500 m deep water. In order to handle the Buoyancy Cans efficiently, Jumbo used a set of 600 tonne SWL HMPE (Spectra®) grommets delivered by Whitehill (USA). The reason for selecting HMPE (Spectra®) grommets was necessary as the 430 tonnes riser was handed over to the 900 tonnes crane block of Jumbo's Heavy Lift Vessel Fairplayer at 200 m water depth with the help of ROV's (Remotely Operated Vehicles). The slings made from HMPE can easily be handled by a ROV as they are neutrally buoyant.
Another factor which should be taken into account using HMPE slings is safety and speed of operations. When heavy steel slings or grommets are rigged to a load, the weight requires handling with additional lifting aids like a crane or forklift or other tackle, whereby the synthetic slings can in many cases be handled manually (They are in many cases 1/7 of the weight of steel slings). Injuries to personnel are less likely to occur compared to using steel slings and grommets.

Braided ropes compared to parallel ropes.
Normally a synthetic rope is constructed from a number of strands braided together. Due to this construction these ropes are torque free and can be repaired when they break. This is not the case with a twisted steel wire rope. Many companies are involved in research and development work in order to manufacture a synthetic rope that one day can replace the steel wire rope in cranes and hoisting equipment.

A lot of progress has been made during the past years. Applications for such ropes are deepwater winch systems that can lower loads to the seabed at -3000 m and more. Jumbo Offshore has now a steel wire rope winch system in it's mv Fairplayer and can go down to 3100 m, but still is faced with the loss of net pay load due to the weight of the steel wire rope tackle. This can be improved significantly when synthetic ropes can replace the 50 mm steel hoisting wire rope. One of the areas that is looked upon is the lifetime of the rope running over sheaves with a D/d = 20, which is similar to steel. A braided rope can be used as hoisting cable or slings lifting in the basket. This is not the case for parallel cables. These cables, constructed by means of the so-called endless winding process are manufactured by FibreMax in the Netherlands. Originally developed as stay wires for the mast of the ocean racers, they have now entered the Offshore Industry and are developing mooring lines and tethers for Floating Production Units (FPSO's). Due to the parallel construction, these ropes cannot be used as lifting slings the same way as can be done with a braided rope. They are though ideal as light weight tension members and offer a remarkable break load in relation to weight and wire rope diameter. Another advantage is the perfect end fitting at each end of then cable, which is can be a precisely machine pin hole connection, making it very suitable for stay wires in cranes. The reduction in weight consequently increases the net lifting capacity of the crane.

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