

in depth

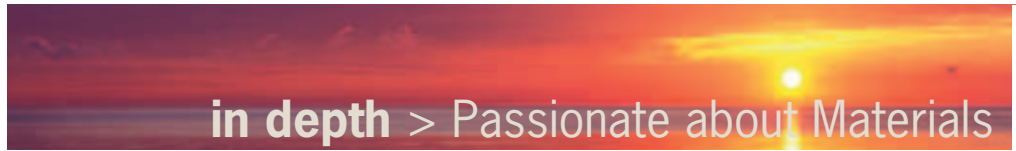
Passionate about ...

Materials



From the humdrum to the exotic, Hugh Williams, chief executive of IMCA, explores the enormous variety of materials that make life so exciting in the offshore construction industry.

Soon after I joined the offshore industry with my modest structural engineering skills I was asked to analyse and approve a drawing using large pieces of wood! I'd done some work with reinforced concrete and steel, but wood?



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The offshore industry has lots of surprises and the exotic materials used are not only varied but also the source of great interest to those who produce them, design with them and use them.

Of course the offshore environment is a tough one, no more so than on the materials used out there. The material challenges come, for example, from extreme and hard-to-predict loading; from the wet, salty, corrosive, abrasive, and often very cold environment; from special demands and from the physical distance from shore where recourse to repair and assistance might be easier. Repairs and replacements are usually very expensive, so there is a significant reward in getting it right.

So there's lots to do for material scientists, design engineers and those building structures for, and operating equipment in, the marine environment.

■ Steel

Much of the steel used offshore is normal mild steel or high yield steel, with typical yield stresses of about 250 and 350 N/mm², but the steel strands in exotic wires have very different characteristics with yield stresses of 1650 N/mm² and even up towards 2500 N/mm², while the low temperatures in projects near the poles also have a significant impact on the choice of steel.

Steels used in the production of oil and gas must be able to withstand very high working temperatures and pressures as well as resist the aggressive chemicals coming out of the reservoir. Exotic steel materials are often used in pipes either throughout the whole cross-section or as a liner. These materials come with their own welding challenges. In addition, welding underwater (wet), or dry in underwater pressurised habitats is only successfully achievable after considerable experimental research.

Particular attention is paid to quality. Some offshore components are not redundant structures as they are effectively monofilaments. This means that a failure in one place could be catastrophic as there is not a secondary structure to take the load. Pipelines, chains and wire ropes are examples, so their designers and inspectors have to take extra care to see that the material, and any joint, is of the right standard all along its length.

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■ Weight

Weight is often at a premium offshore as many of the structures are floating. One recalls Brunel's history – his critics predicted that a ship could not be made large enough to carry sufficient fuel (coal) to cross the Atlantic. They were wrong because they used the wrong calculations, but this serves to illustrate that the weight of any vessel, including construction vessels, is very important and determined in large measure by achieving its necessary strength, capacity to float and transit, before looking at its ability to support the equipment it has on board – its ultimate purpose. This applies to offshore platforms, subsea oil field equipment and subsea vehicles too, so weight saving is at a premium.

This leads the designer to look at light but strong materials like aluminium and glass reinforced plastic (GRP). Despite its fire risks and corrosion challenges in the marine environment or in combination with other materials, aluminium is used in various structures offshore while GRP is used, for example, in piping.

■ Syntactic foam

Weight is also the reason for using this type of material offshore. A number of components which are submerged, perhaps to 3km below sea level, require buoyancy. This may be in the form of a submerged buoy to hold up the catenary of a pipe, or it may be in blocks used to achieve neutral buoyancy in an ROV.

Building strong steel buoyancy boxes doesn't create enough uplift benefit because steel is so heavy, so this is where these foams come in. Ideally, they are very light and easy to mould into the shapes required. They should be robust, so that dynamic contact with something else during handling or operations does not damage them. They should also be able to withstand multiple immersions or very long periods under water – often at significant pressure – without breaking down either through structural deterioration, by absorbing water (buoyancy deterioration) or compression (buoyancy which is not constant). Such design specifications are very tough to meet, especially over a long period of time.

■ Man-made fibres

Steel rope is heavy. Like the ship analogy above, a very long rope hanging vertically down into the sea (several kilometres) uses much of its tensile capacity simply to support its own weight. This won't be satisfactory if an engineer wants to lower a 300T structure 3km onto the seabed. Fibre ropes are approximately neutrally buoyant so they do not pay this underwater weight penalty at all, but there's no such thing as a free meal! The fibre ropes need to be manufactured, stored and handled very carefully to avoid damage or deterioration if the designer's desire is to be realised. Polyester ropes are widely used and, sometimes, Aramids such as Kevlar, with yield stresses of perhaps an amazing 3620 N/mm².



■ And finally back to wood

This is widely used offshore, but mostly in temporary structures. Here the temporary loads can be hard to establish, but engineers can design successfully if they have adequate knowledge of the timber quality and its characteristics. This may need to allow for deflections, and recognise varying strength with or across the grain, as well as the influences of age, previous loading history and dampness.

I guess I have explored my own (structural) bias in this article, but of course there are also myriad materials in the fantastic equipment on platforms and vessels offshore which are used to complete the exciting projects in offshore construction. Remember, the designer has to choose the most suitable material for every single component.

■ Further information

More details on engineering in the marine contracting industry can be found in other articles in this series, including *I want to be an offshore engineer*.

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