Case study

Hywind offshore floating foundations

The Hywind Scotland Pilot Park near the Scottish coast is the first commercial wind farm of its kind. Completed in September 2017, this unique project utilised 27,000 tonnes of MagnaDense as a heavy aggregate in high density concrete and as loose ballast in the wind turbine foundations.

LKAB Minerals

High density concrete and loose bulk ballast

The design concept is based on a floating spar-type platform which is anchored to the seabed. The floating spar's turbine is much taller than the hull and has a moving rotor that harnesses the strong offshore winds in the North Sea. The waves, currents and winds are strong external forces and keeping the very heavy and tall floating wind turbines upright in open sea is a big challenge. A lot of weight is needed to achieve a low centre of gravity in the structure. Production of the hull and the installation of heavy concrete within the bottom section started in Spain in 2016.

Shore and offshore ballasting

High density concrete was produced and placed within the substructure at Navantia wharf in Fene, Spain, before being shipped to Stord, Norway. The foundations were then transported to Hardangerfjord.

After uprighting and water ballasting of the foundations, the MagnaDense loose bulk ballast was installed in the floating foundations. Each structure was ballasted with approximately 5,000 tonnes of the heavy aggregate and an additional 1,100 tonnes of concrete ballast. The tower and turbine were mated to the substructure before towing to its final destination.

Ballasting foundations

More than 27,000 tonnes of MagnaDense was shipped to the Bergen area for ballasting the five floating foundations. The foundations themselves were transported by water from the Navantia shipyard in Spain, to the northern waters next to Bergen.

During this phase, Van Oord Offshore was responsible for ballasting the floating wind turbine foundations. Ed Nagtegaal, Project Manager for Van Oord Offshore B.V. states **"Transporting the MagnaDense by conveyor belts is a very stable process. It is possible to transfer the material up to 2,500 tonnes per hour. Bridging in the holds of our vessels did not occur."**

At a speed of 300mt/hr, MagnaDense was placed into the foundations via a conveyor belt. Each structure was filled with 5,100mt of MagnaDense.

MagnaDense Concrete
... pumped with a Putzmeister plunge pump

Foundation bottoms

The steel bottom section of each foundation contains approximately 270m^3 of concrete, with a density of 4.05t/m^3. The concrete was produced and installed by Spanish local ready-mix company Fonsan. MagnaDense concrete and loose ballast in the steel formwork was completed with a Putzmeister plunge pump into the steel pipes, each with 14m diameter.

These two metre thick bottoms, for the floating turbines, provided the necessary counterweight, ensuring the foundation could be positioned upright. MagnaDense was placed from the heel on the branch.

Deep water farms

In the Scottish part of the North Sea, water depth exceeds 100 metres. For water depths over 50 metres, the floating foundation is a very favourable and economic solution.

New concepts need new ideas: we are proud to be part of innovative projects and find new uses for existing materials. MagnaDense offers excellent properties, such as a submerged weight of 2,000 - 3,100kg/m^3. Because of this, it fulfils the needs to control static and dynamic loads, not only for floating but also for gravity based solutions. Used as loose bulk ballast fill, or as aggregate for heavy concrete (≤4,000kg/m^3), the lowest point of gravity is reached easier using MagnaDense.

MagnaDense quality guaranteed

For this wind project, the total volume of MagnaDense required was sampled five times, for which additional analytics was completed at three different locations. We took samples from our own port in Narvik, which were sent to SGS, an independent analytical agency. Van Oord then took samples at the port of arrival. MagnaDense was tested for bulk and saturated density, as well as for particle size distribution (PSD). This was to make sure the whole lot was homogeneous.

Hywind Scotland Pilot Park

This unique wind farm pilot project consists of five floating turbines. Each Hywind tower with its 176 metres above the water surface and the blades with a span of 75 metres is impressive and much larger than conventional and typical wind turbines in use.

These huge turbines can generate more power, up to 6MW each - enough to power 20,000 households. Key to producing energy, and utilising as much of the capacity as possible, is strong and constant winds. Placement further out from the coast, where the waters are deeper, was critical. A floating design was needed to realise the ambitious project goals. Equinor invented and invested in this pilot wind farm to demonstrate cost efficient and low risk solutions for commercial scale parks.

PROJECT FACTS: Hywind

Project owner: Equinor (formerly Statoil)
Concrete producer: FonSan
Ballast installation: Van Oord Offshore
MagnaDense (bottom ballast): 1,100m^3
Bottom ballast density: 4.05t/m^3
Eccentric ballast volume: 150m^3
Eccentric ballast density: 3.1t/m^3
Loose dry bulk ballast MagnaDense volume: <5,100mt
Loose dry bulk ballast density: <4.1t/m^3

In the case of Hywind Scotland, MagnaDense offered the best price/quality for the chosen design. Given its high specific density and very good compaction properties as a loose bulk material, it results in more weight in less volume. It also has excellent properties as a concrete aggregate for producing high quality and high density concrete, making it ideal for the bottom ballast that functions as a counterweight.

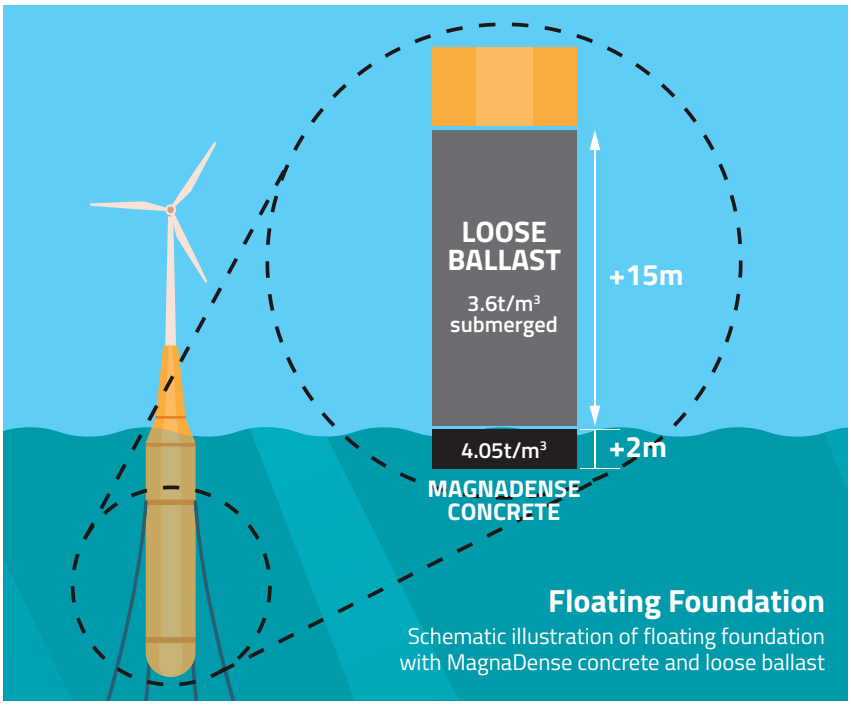
The technology used in the pilot project has been tested with excellent results in a demonstration project off the coast of Norway. Floating wind represents a new and significant renewable energy source that will complement an existing and expanding array of alternative energy projects in the world.

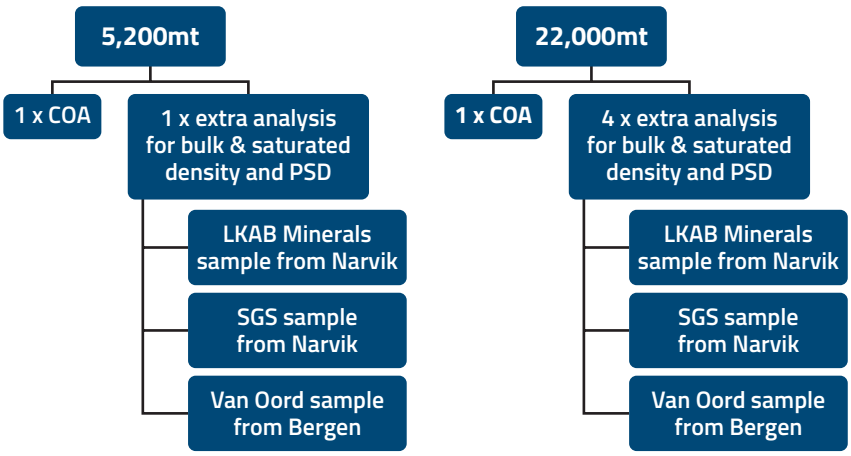
A natural high density solution

MagnaDense is suitable as an aggregate and loose ballast for many applications. It has a specific gravity between 4.7 and 5.2t/m³ and is available in different fractions. It has CE certification and is approved to EN12620. Weight aside, it shows similar characteristics to standard density concrete. MagnaDense concrete can be placed by skip or pump.

Financial sustainability

As a value-added service and to support the financial sustainability of the project, we offered our customer the generous opportunity to return the over-supply of MagnaDense upon completion of the project. This ensured that costs were controlled and prevented any spoil of unused product.





Flow chart illustrating the sample trail performed to guarantee MagnaDense quality

Facts about MagnaDense

Compliance with standards:
EN 12620 and DIN 6847-2
Particle Density (dry): 4.8 - 5.1 t/m³
H_2O Absorption: <0.3%
Particle Shape: Angular
Surface Texture: Rough

Available in different grades to suit different applications

We are leading the transformation of our industry toward a sustainable future.

LKAB Minerals, the international industrial minerals division of LKAB, develops and delivers circular, critical and climate-efficient mineral products. LKAB Minerals has sales representation, offices, production units and deposits in 12 countries in Europe, Asia and the US and employs around 400 people.

LKAB Minerals is part of the Swedish company LKAB, one of the world's leading producers of highly upgraded iron ore products and a major supplier of mineral products for other industrial sectors.

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