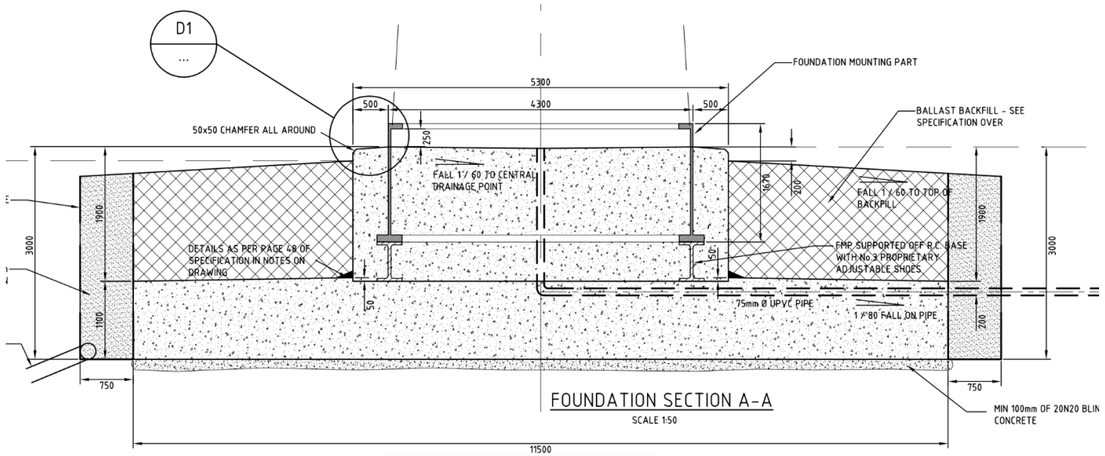
SSE Renewables

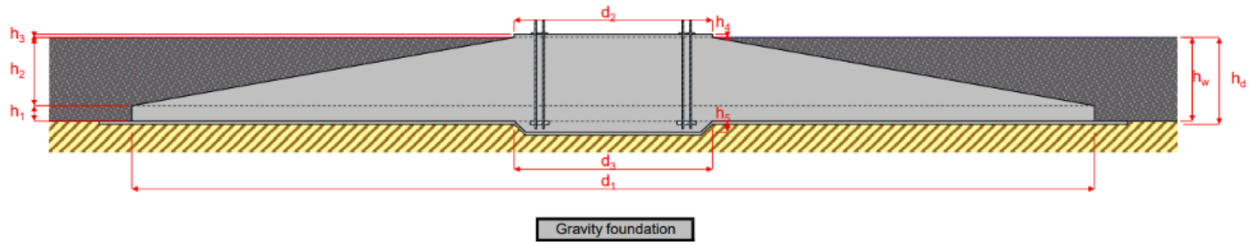
Low Carbon Concrete and new Technologies

February 2024

The Background

- Within 10 years onshore wind turbines have grown from 65m in height to the hub, to 120m.
- Increased forces being transferred to the foundation.
- Concrete volumes increased from 600m³ to 1000m³. With corresponding increase in steel volume.
- Consultants stick to the status quo.
- SSE driving the adoption of change via our Design Standards to ensure carbon content is in the consultant's minds during the design.
- Ensure this forms a suitable weighting in the Tender Scoring process.





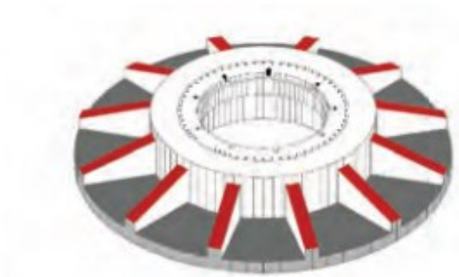
Gravity foundation

Opt. No.	Dimensions										Quantities		Design information		
	d_1 [m]	d_2 [m]	d_3 [m]	h_1 [m]	h_2 [m]	h_3 [m]	h_4 [m]	h_5 [m]	h_w [m]	h_d [m]	Concrete [m³]	Reinf. [t]	Bearing pressure [kPa]	Limiting condition	Design type
1	29.80	6.00	6.00	0.500	2.200	0.100	0.100	0.350	2.700	2.800	997	140	175	Soil stiffness	Fully submerged

But what can we do?

- SSE working with Strathclyde University on novel solutions to reducing the load being transferred to the foundation from extreme winds loading. Creating *weak links* in the foundations which can be easily replaced if they yield during extreme winds.
- SSE are looking at innovative foundation designs from designers across Europe which have smaller foundation footprints.
- Consider reinforcement alternatives such as basalt – Does anyone have experience of this?
- Utilising alternative concrete with lower carbon content – more on that later!
- Combining some of the above is the dream!! But they are very low on the TR scale so difficult for organisations like SSE to adopt.
- All new Technologies are expensive – how can they be funded within tight project financial limits.

SOFT-SPOT® Solution



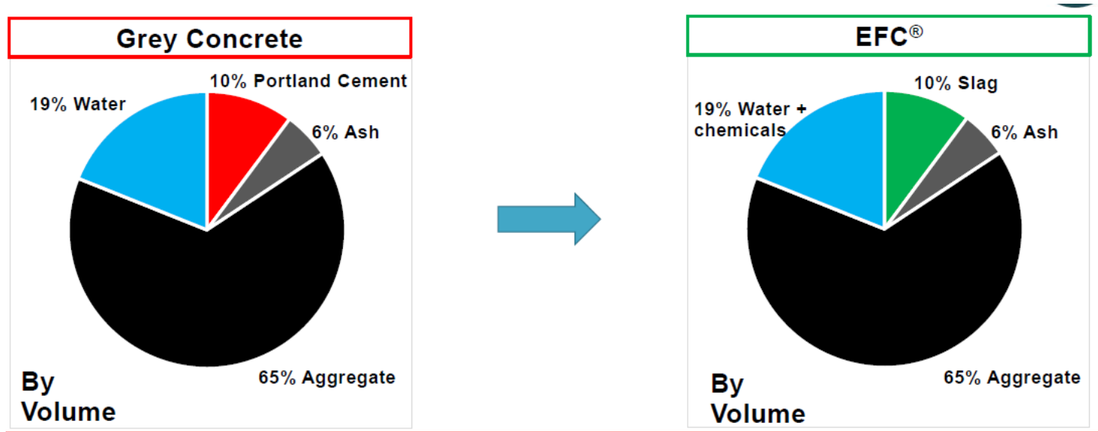
Ribbed Foundation

Let’s focus on Low Carbon Concrete

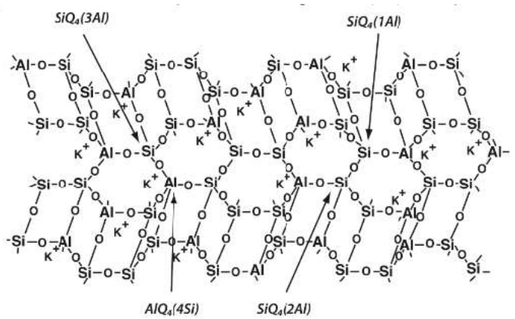
- Scottish water, Scottish Power, Network Rail, SSE & Transport Scotland are part of the Low Carbon Concrete Partnership. Had anybody heard of this before?
- Start to review concrete specifications and aim to target improvements in concrete that will suit as many partners as possible.
- Aim to impact the Market and adopt bold behaviour changes along with innovation in concrete standards.
- What are the alternatives to GGBS etc.
  - Clays – Lower heat and thus less energy to produce material used as SCM.
  - Magnesium Oxide Cement

Let’s focus on Low Carbon Concrete

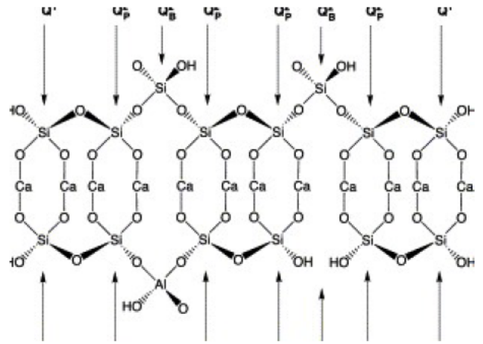
- Latest revision of BS8500 allows for greater mix of Limestone to reduce CO2.
- One future option is EFC which replaces cement with a geopolymer binder. As it doesn’t contain cement is it officially concrete?
- Still use PFA so will suffer the same availability problems.
- EFC benefits include improved durability under Sulphate, Chloride and Acid



Geopolymer Molecular Structure



OPC (CSH) Molecular Structure



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BS8500 update

- Since the 1980s, the UK experience of using supplementary cementitious materials (SCMs) has been combining Portland cement (CEM I) with either fly ash or ground granulated blast furnace slag.
- In 2021, the cement standard EN 197-5, was published and allowed cements with up to 65 per cent of the Portland cement clinker to be substituted with two or more SCMs, so providing multi-component equivalents to the binary combinations that have become well established in the UK. Extensive testing was carried out on these new multi-component cements, which has led to the update in BS 8500:2023 that will enable the specification of these lower carbon concretes.
- With the new standards now available, the CEM I content in concrete can be replaced with up to 20 per cent of limestone powder, an SCM that can be sourced locally across the UK. For every 5 per cent of limestone powder used, a 5 per cent CO2 reduction can be delivered per tonne of concrete.
- With the potential to use these new concretes across all mainstream applications, the associated carbon saving could add up to an annual saving of 1 million tonnes of carbon dioxide”

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