DeepWind
North of Scotland Offshore Wind Cluster

OFFSHORE WIND CONCRETE SUBSTRUCTURES CONFERENCE

Concrete Substructures for Offshore Wind – Aberdeen October 3rd, 2023

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ENSURING WATERTIGHTNESS

DESIGNING & BUILDING CONCRETE FLOATERS

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SCIENTIFIC FACTS

Absolute watertightness does not exist…

SCIENTIFIC FACTS

But designing concrete structures for functional watertightness compared to operational conditions is possible…!

BOUYGUES TP ON THE OFFSHORE WIND MARKET

Part of civil engineering branch of international multiservice company Bouygues SA

8,700 employees

Total turnover €3.25BN

650 Technical department staff

Turnkey contractor for major industrial projects worldwide

Offshore wind references:

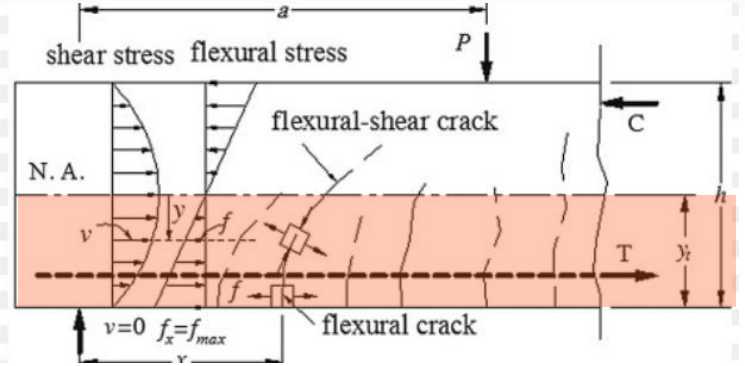
- Construction of first floating turbine operating in France (2MW, commissioned 2018)
- EPCI contractor for commercial project of Fécamp windfarm (500MW, to be commissioned 2024)
- OO-STAR concrete floating concept owner

Fécamp GBS windfarm (2020)

MECHANISM OF WATER TRANSPORTATION

Micro-structure of concrete

- Porosity, Permeability, Diffusivity can be adjusted via design of the concrete mix
- Permeability to chloride ensures the durability
- **Controlling the pouring conditions = dense and sound hardened concrete**



Composite nature of concrete

- Cracks are inherent to concrete
- Cracks are to be limited in depth and width to ensure that a part of the thickness ensure plain tightness function
- **Construction methods to ensure conserved designed functions**

Long term behaviour

- Low w/c concrete harden for years, improving the properties with time
- Autogeneous healing with low w/c concrete in water

N'kossa concrete floating barge (1994)

CONCRETE MIX DESIGN

Calibration of the concrete mix with local components and specified criteria

- Selection of components (aggregates, sand, cement, water, additives)

Design concrete mix for early age, rheology, construction methods, hardened properties etc.

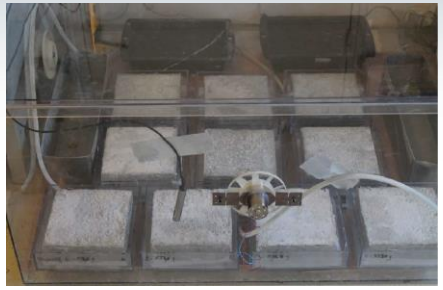
- Confirmation of the mix, tests in laboratory

Testing stability of the formula through sensitivity studies

- Industrial scale qualification (with batching plant)

❖ ***Experience from past major works built into concrete mix design***

❖ ***Intricate knowledge of local supply chain and specialists is key to designing appropriate concrete mix***



Calibration of long-term behaviour

- $humidity = C \cdot grad(\overrightarrow{param})$

  transport laws, parameters – C - to be benchmarked

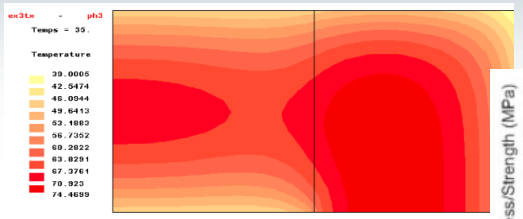
- Correlation with parameters to confirm the expected behaviour, tests

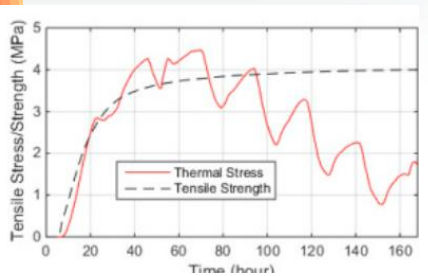
Floatgen floating foundation construction (2016)

STRUCTURAL DESIGN

By design

- Classify the type of event (construction, operations, accident)
- Adjust combinations and associated coefficients
- Evaluate crack width as per criteria
- Evaluate RCZ and associated remaining compression value
- Adjusting prestressing to cope with the criteria





During construction

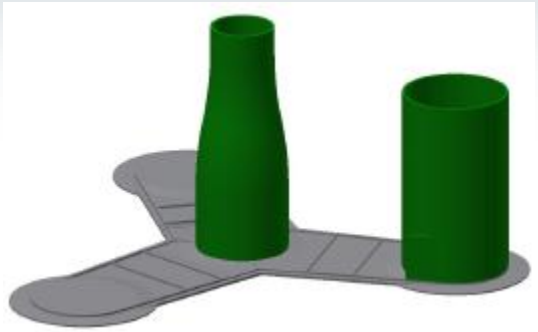
- During construction, control of hydration heat
- Construction dispositions to be taken

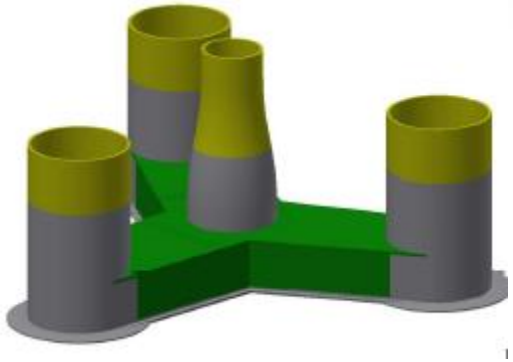
(vibration, time for formwork removal, cure etc.)

❖ ***Taking into consideration construction methodology in the design phase***

Monaco port extension – Concrete caissons (2020)

BUILDING WATERTIGHT STRUCTURES



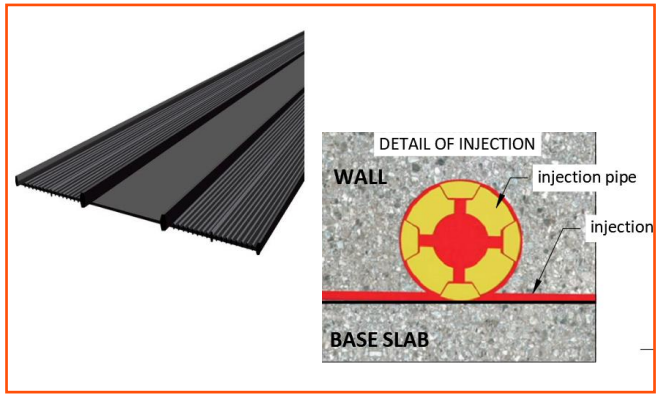


N'kossa concrete floating barge (1994)

- Cold joints between all major construction phases

For one structure, the length of cold joints is several hundreds of meters.

- Reinforcement coupler and prestressing injection ducts
- Water-stop joints and injection pipes



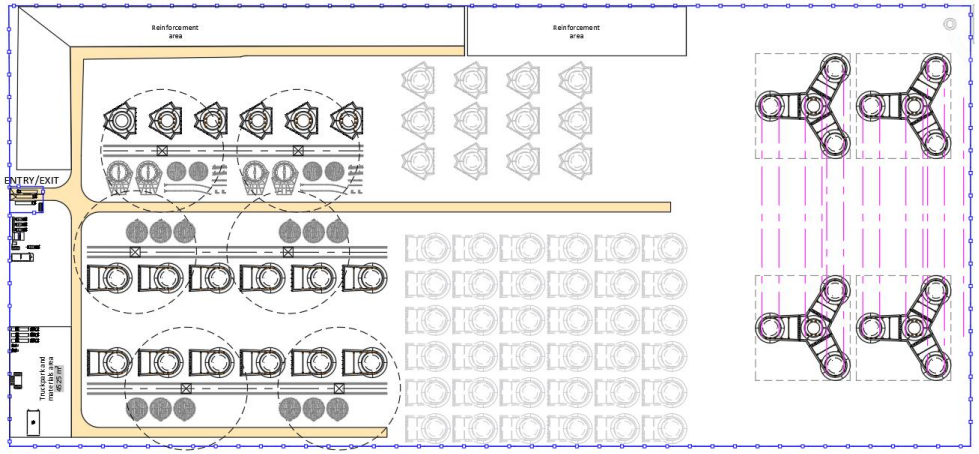
SOLUTION FOR PRECAST ASSEMBLY

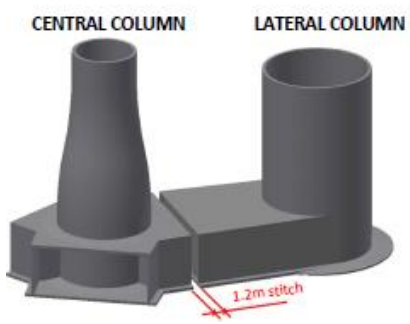
Adapting to different construction scenarios

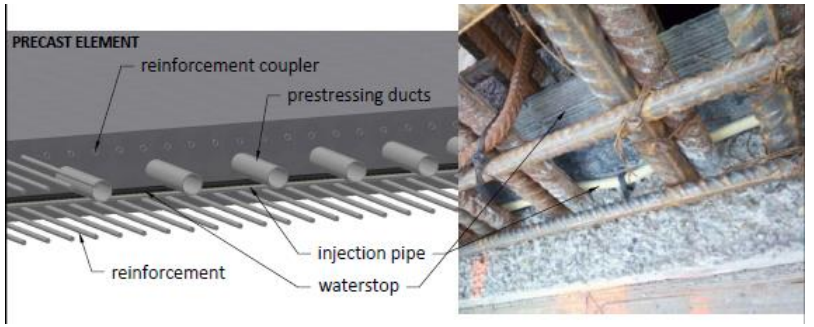
- Production site constraints
- Schedule imperatives
- **The same standard techniques remain applicable**

❖ ***Innovative combination of well proven techniques and technologies***

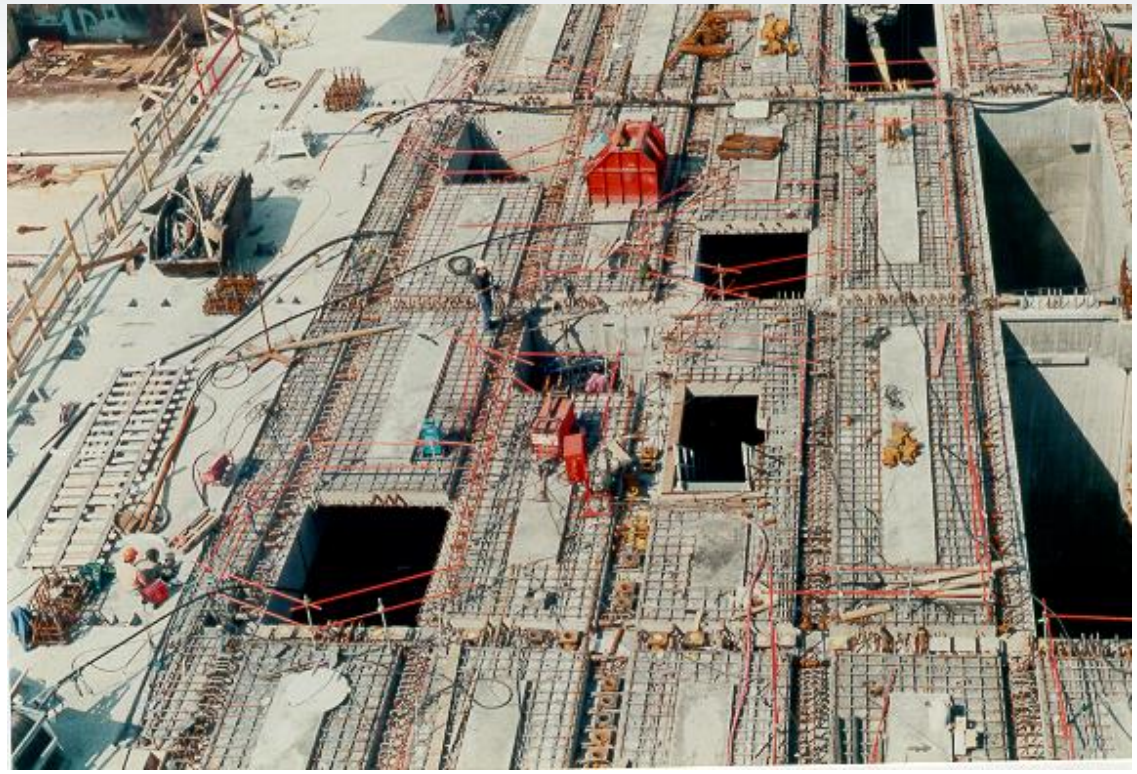
Fécamp GBS windfarm (2020)







PROVEN BY EXPERIENCE – N'KOSSA FLOATING BARGE



Commissioned in 1995…

…still operating in 2023, and counting … !

merci.

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