Konstruksjonsdagen 2026 01.09.2026, Havtil

Aldringsutfordringer på betongkonstruksjoner

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Equinor



EQN concrete installations

11 assets & 1 windfarm with concrete substructures:

- Hywind Tampen (2022)
- Troll A (1995)
- Troll B (1997)
- Heidrun (1995)
- Sleipner A (1993)
- Gullfaks C (1989)
- Oseberg A (1988)
- Gullfaks B (1987)
- Gullfaks A (1986)
- Statfjord C (1984)
- Statfjord B (1981)
- Statfjord A (1977)

9 GBS's, 1 semi-sub, 1 TLP and
1 wind park with concrete floaters
(spar-buoy)



















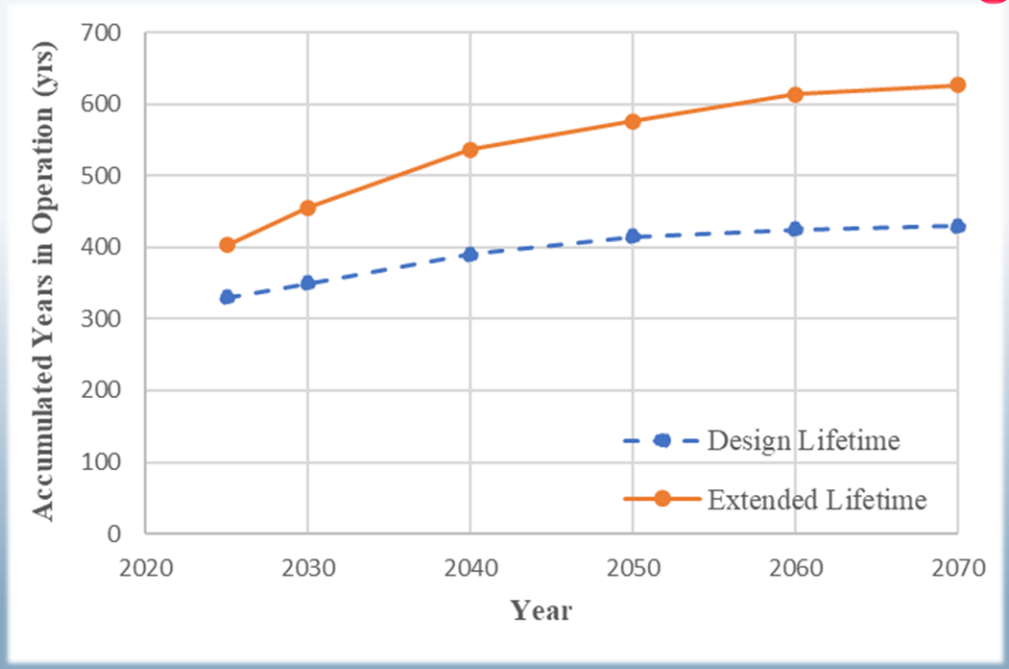






Original and extended lifetime





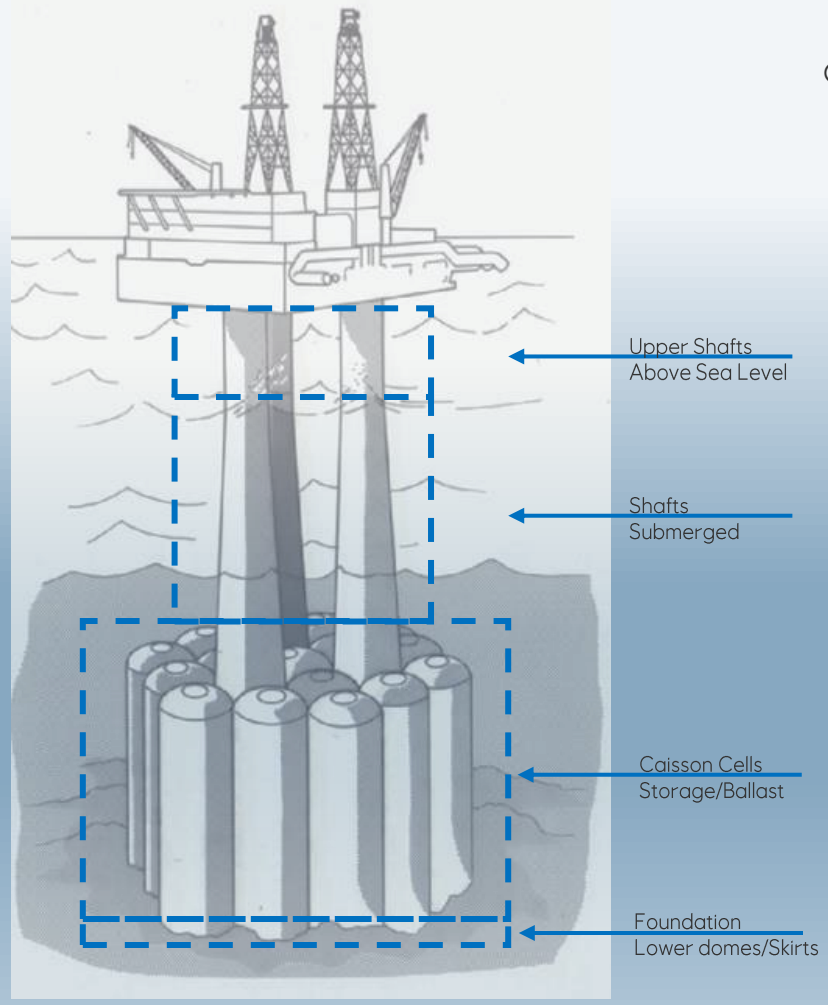
~400 years accumulated lifetime a.p.

~620 yrs in operation by 2070

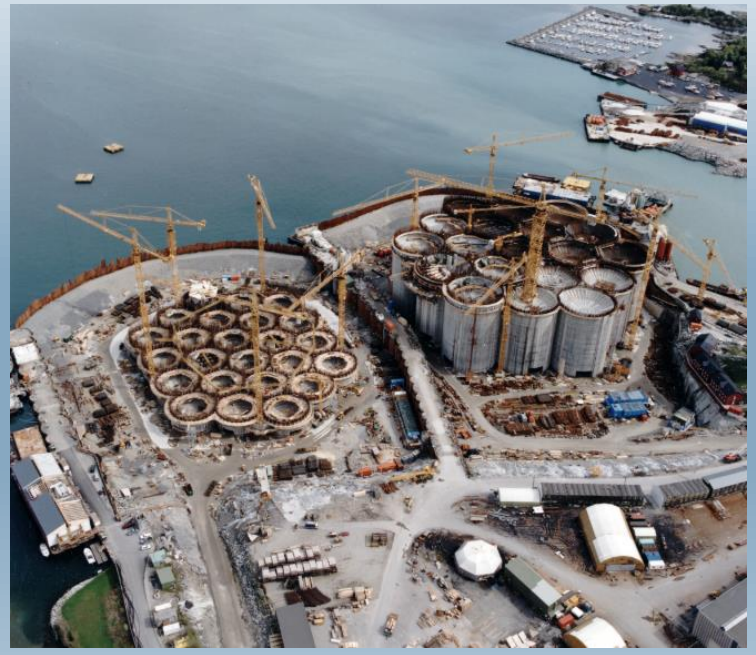
~20 new builds equivalent

~85.000t CO_2 savings per installation

Offshore concrete GBS: Aspects for long-term performance

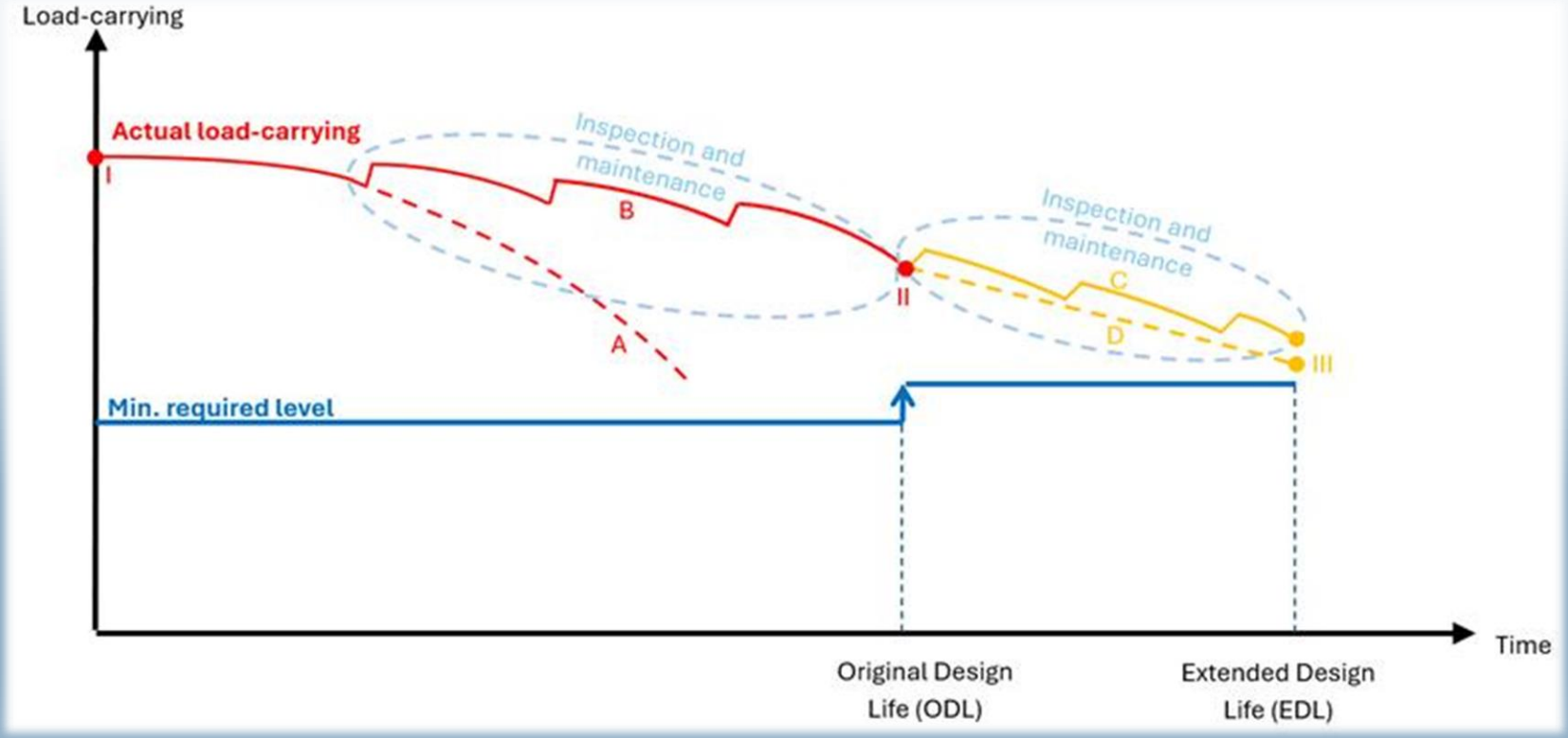


- Massive structures resting on seabed based on gravity incl. uncertain soil conditions and long-term effects –> SPM (N-005)



- Most aging challenges are triggered/"accelerated" due to **deviations in execution** ("real world" vs. design)
- Post-tensioned concrete normally not sensitive to fatigue i.e. suitable for extension IF well maintained
- Some areas w/ stricter requirements than ULS due to tightness
- Focus on exposed surfaces above sea level, dry shafts and areas with high utilization

Schematic of load-carrying development



Inspection and maintenance program vital to meet intended design life - **and particularly in case of extended lifetime**

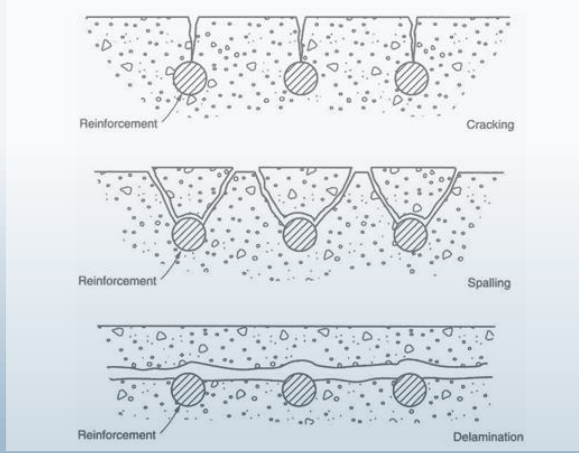
Min. required level is "moving" according to development in regulations, functionality and new knowledge

Reasonable effort in maintance put prior to ODL limits an expected larger maintance cost increase between ODL and EDL

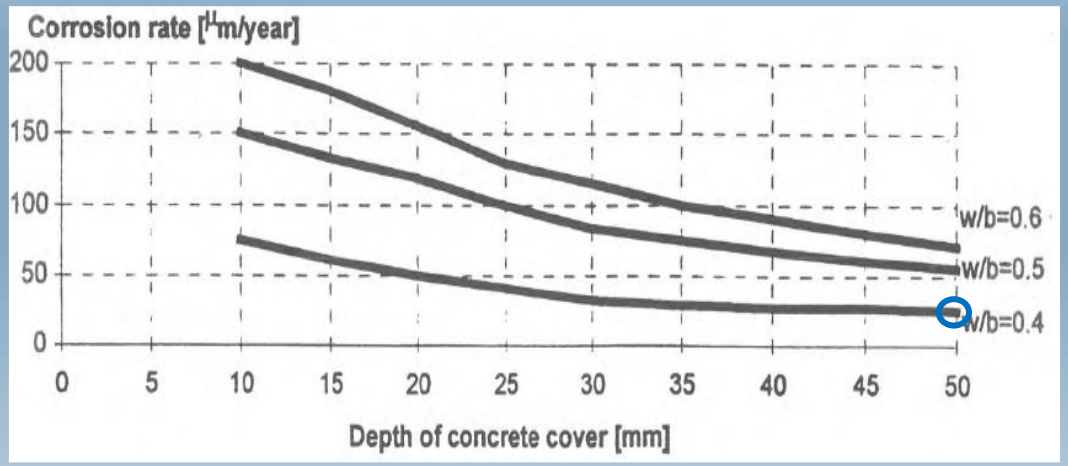
Deterioration mechanism (corrosion)

Corrosion in reinforcement

- Initiated by chlorides
- Initiated by carbonation



Neville, A. M. (2011), Properties of concrete



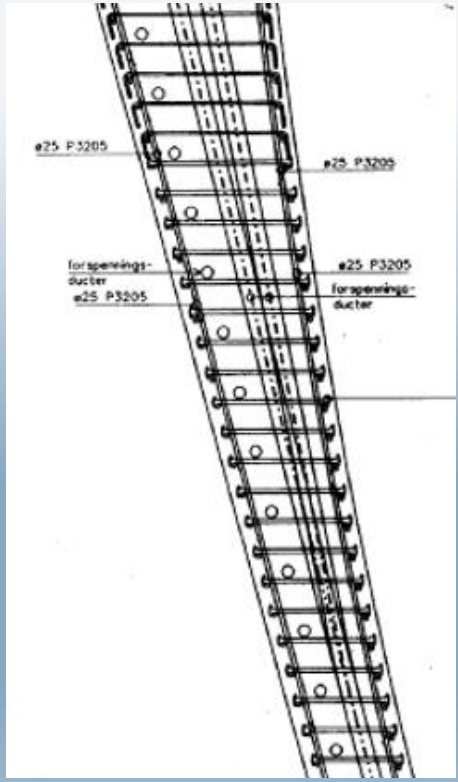
Duracrete (1997), EU-founded R&D project about realistic lifetime assessment of concrete structures

Drivers

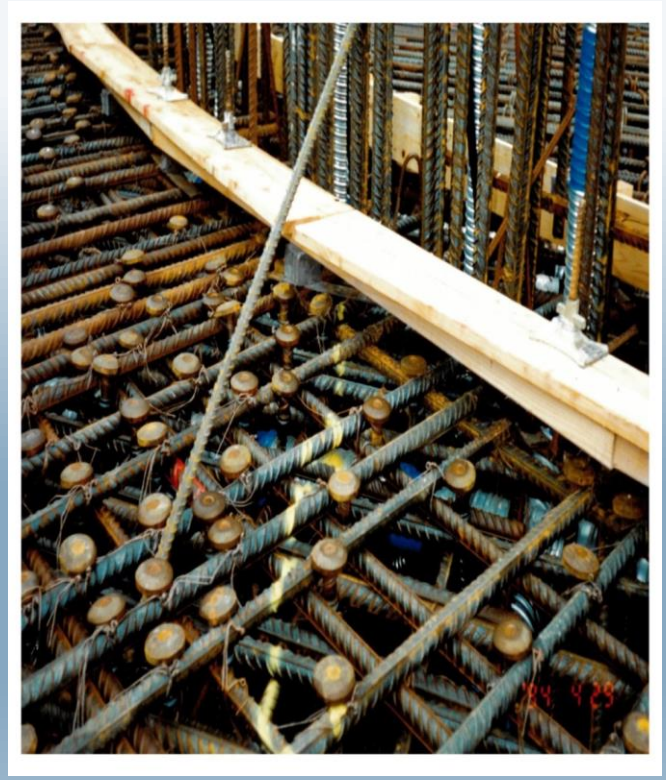
- Low cover (non-conformance)
- Poor casting/high permeability (non-conformance, w/c ratio, additives)
- Early age cracking/load-induced cracking
- Poor curing (temperature, too fast curing etc.)

Reinforcement Corrosion – "Real life"

Design



As-built

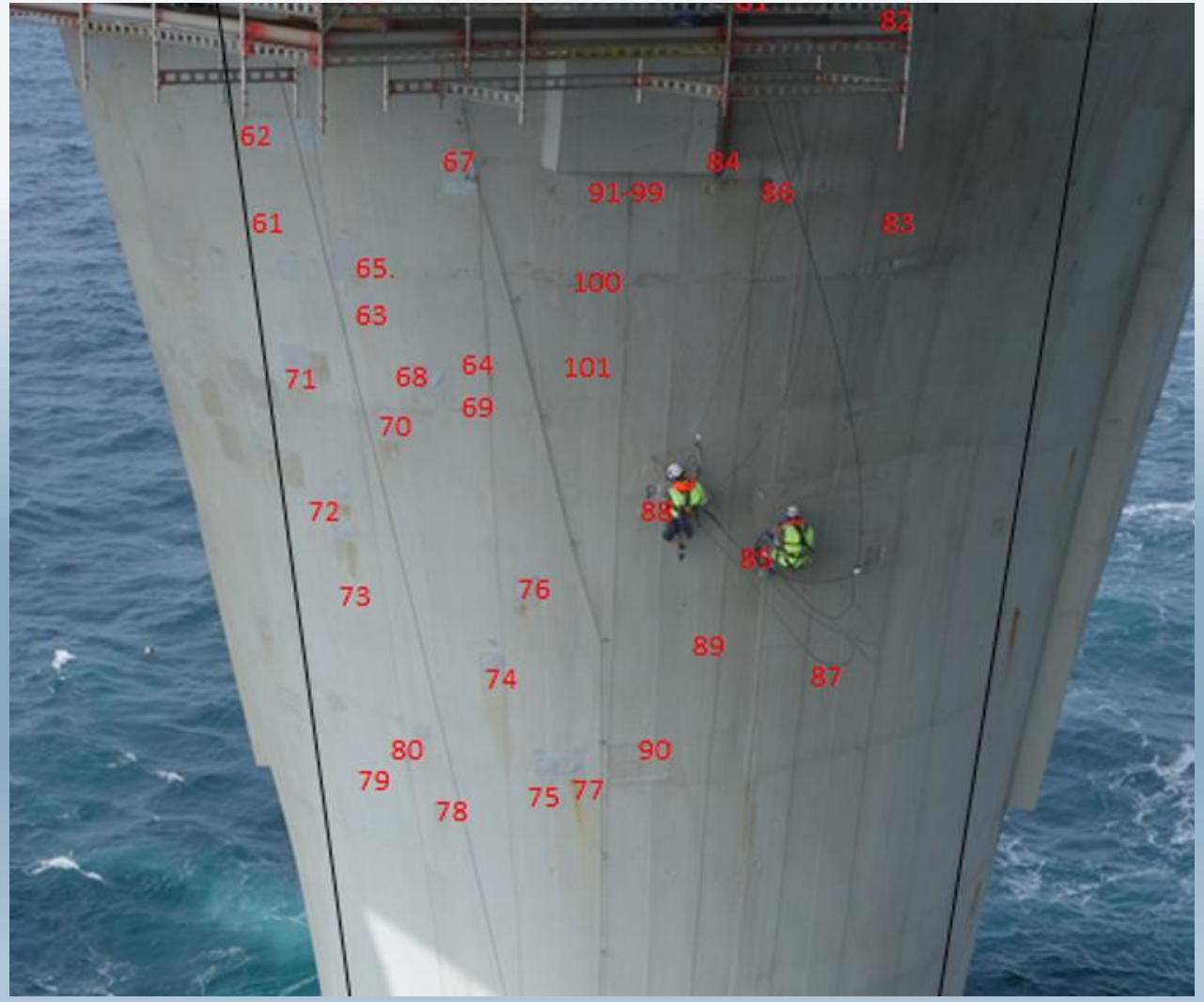


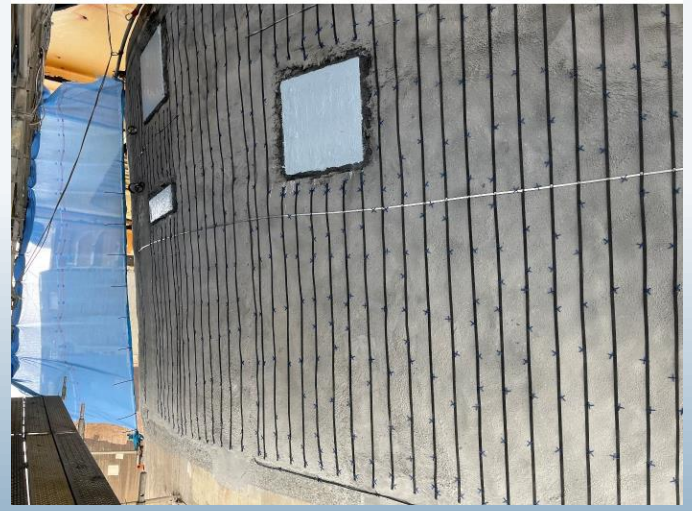
Deterioration in-service (pitting corrosion at outermost rebar layer)





Systematic inspection and repair





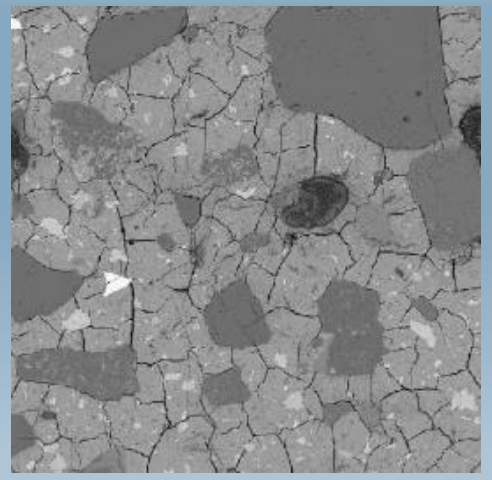


Deterioration mechanisms (concrete)

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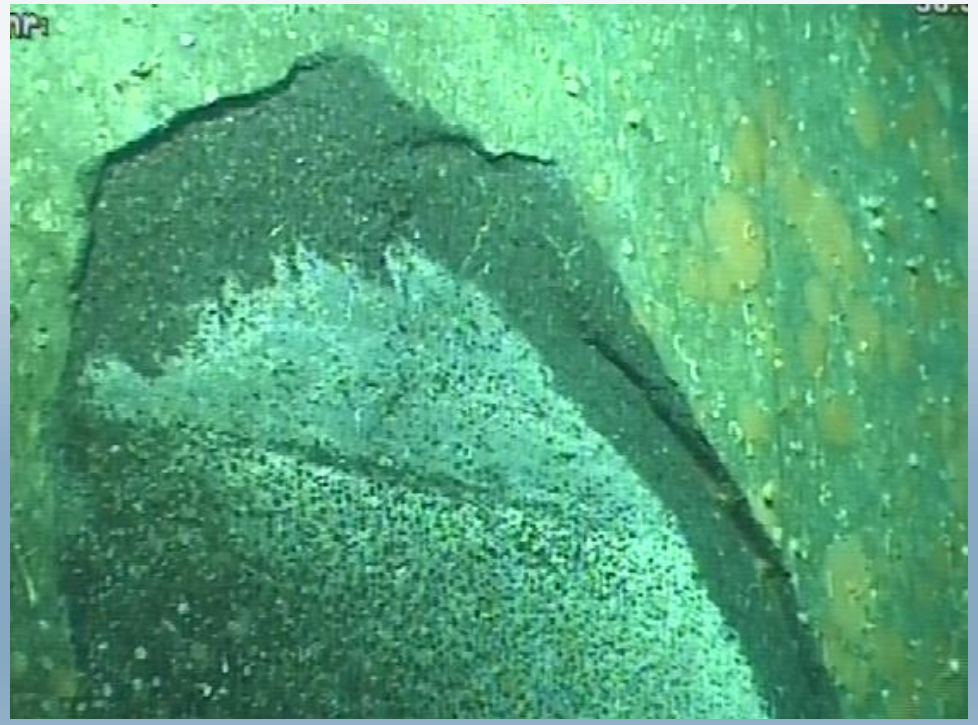
- Hydration heat (delayed ettringite formation)
- Chemical decomposition (sulfate, alkali-silica reaction, acid, thaumasite etc.)
- Freeze and tow
- Mechanical decomposition (wave slamming, ice abrasion etc.)

- Too fast drying during hardening
- Too high hardening temperature
- Too large permeability (non-conformance, w/c ratio, additives)
- Concrete mix design

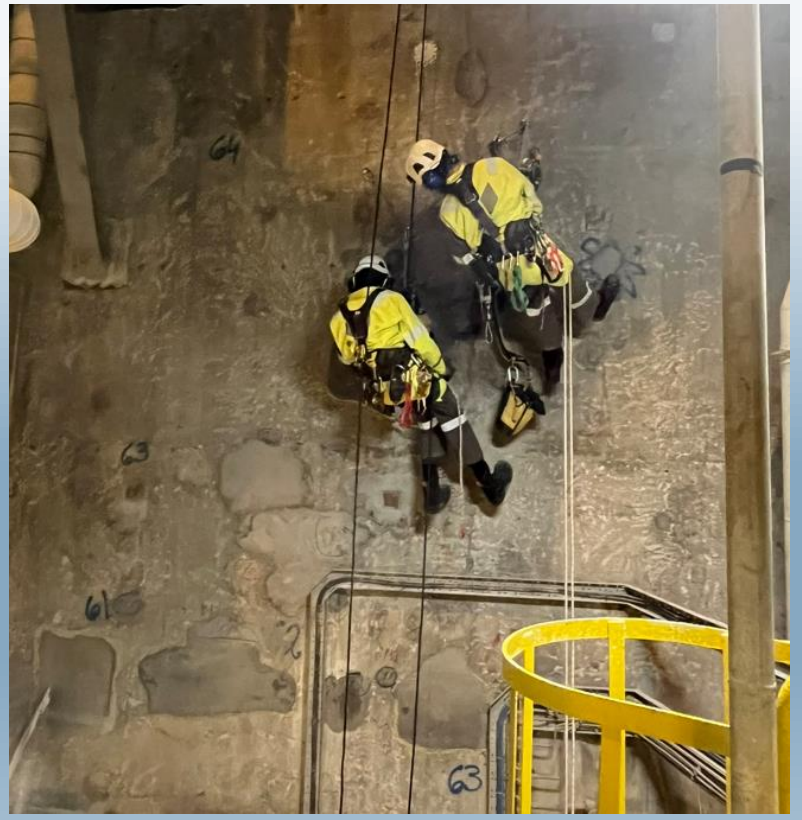


Symptoms: Internal expansion, cracking and reduction of stiffness, tensile, compression strength over time

Concrete spalling, delamination, repairs



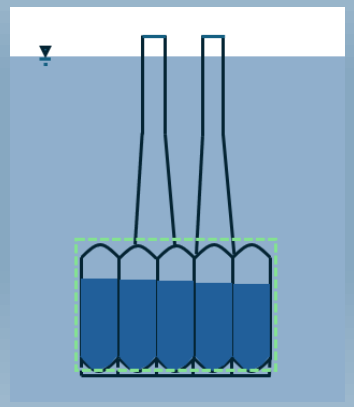




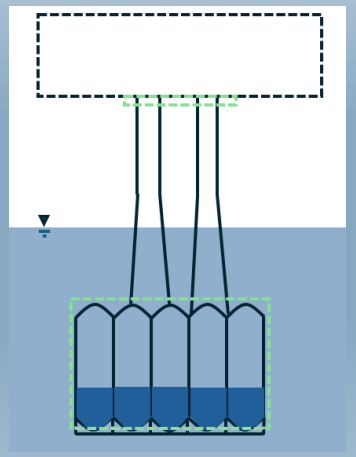
Aging wrt. integrity

Concrete structures are generally **robust** with inherent margins

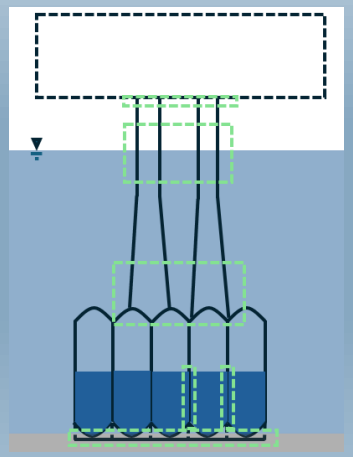
However, integrity risk due to aging needs to be assessed considering **actual utilization levels,** governing **design phases** together with best-available inspection data and **deterioration rate** predictions



Mating



Tow to field



In-service

Typical Checklist for assessing concrete structures (in line with N-005)

Category	*Items/activities*
As-built	Concrete quality Size of concrete cover Reinforcement amount Non-conformances
Operation	Chloride profiles (depth of chloride ingress) Rebar corrosion (pitting, corrosion depth) Cracked concrete (crack width, length, orientation) Spalling (fracture surface) Prediction of long-term development (e.g. corrosion rate) Condition of coating if applied Casting joints
Structural assessment	Incorporation of as-built information Identification of highly utilized areas Inclusion of deterioration mechanism incl rate (e.g. corrosion) New knowledge and relevant standards wrt. loads and capacity Modifications, operational manual Perform new design checks for ULS/ALS (FLS if governing)

Current update of ISO19903



- Ongoing update of the ISO offshore concrete standard including requirements, design principles, execution, inspection and condition monitoring
- Better integration towards the development within execution, concrete mix (low CO_2 emission) and substructures for low-carbon industry (offshore wind)
- DIS in May 2027

Conclusive remarks

- Up to date **7 out of 11 large** offshore concrete structures have been prone to lifetime extensions
- Even in the harsh environment in the North Sea, this has been **successfully** obtained thanks to **proper & frequent inspection, monitoring and maintenance** program
- Although not maintenance free, concrete structures demonstrates **long-term sustainability** well suited for life-time extensions given the increasing demand to circular economy
- Aging challenges are mostly due to deviations in execution. Structural deterioration can be **kept "under control" with proper mitigations**
- Structural integrity for existing assets can be confirmed with **as-is data, deterioration rate predictions and operational measures**





Thank you for your attention

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