Installation Response of 5.5 m Diameter Driven Piles in Carbonate Soil – The Ichthys Development

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- 220 Km north-west of Western Australia in 250 m WD
- Central Processing Facility (CPF) and Floating, Production, Storage and Offtake (FPSO) facility, and subsea development
- Facilities designed to survive 10,000yr cyclonic event
- Facilities moored to seabed by 28 (CPF) and 21 (FPSO) driven anchor piles
Soil Conditions

Carbonate SILT / MUD

Carbonate Silty SAND / SAND

LIMESTONE (Calcarenite)

Carbonate Silty MUD / Sandy MUD
Anchor Piles – Key Features

- Diameter = 5.5 m
- Embedded Length = 48.0 m (63.6 m total)
- Padeye = 3.0 m (CPF) / 3.5 m (FPSO) b.m.l.
- Submerged Weight = 400 t (CPF) & 426 t (FPSO)
- Dynamic freefall arrestors
- Static freefall arrestors
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Vent area = 1.2 m² – 1.7 m²
To restrict pile freefall to maximum of ~1 m/s
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- Dynamic freefall arrestors
- Static freefall arrestors
  - Located to be above Calcarenite layers at final penetration
  - Additional bearing areas of 3.3 m² (CPF) and 4.1 – 5.1 m² (FPSO)
Pile Installation Response – Blow counts

- Piles mostly installed under self weight to depth of calcarenite layer
- Limited driving to advance piles through calcarenite, often followed by pile freefall
- Relatively easy driving (< 25 blows/0.25m at 100 - 200 kJ) thereafter
Pile Installation Response - SRD

SRD back-calculated considering actual hammer energies during driving.

Driving through calcarenite indicated end bearing pressures ($q_b$) of ~40 MPa reducing to ~20 MPa very quickly.

Confirms the ‘easy driving’ expectation indicated by Puech et al (1990) based on experience from Persian Gulf.

Subsequent driving consistent with LB predictions by geotechnical designer, further highlighting the low skin frictions mobilised in these soils.
Freefall Arrestor Performance

![Dynamic Freefall Arrestor](image)

- **Pile Freefall Velocity (m/s)**
- **Soil Resistance to Driving, SRD (MN)**

0 0.25 0.5 0.75 1

0 10 20 30 40

Freefall:
- P15
- P17

Driving:
- P15
- P17

- **Self Weight Penetration**
- **Increased resistance as cruciform reaches target horizon**

Blow count (blows/0.25m)

0 10 20 30 40 50

0 10 20 30 40 50

Depth (m)
Conclusions

- Ichthys anchor piles represent some of the largest piles installed in carbonate soils offshore Australia.
- Installation response consistent with general experience of driving in region, and other parts of the world (i.e. Persian Gulf).
- Installation response consistent with LB estimates made in design, highlighted the low skin friction mobilised in these soils during pile installation.
- Dynamic and static free fall arrestors used to control pile freefall and provide additional axial capacity at target depth performed as expected by design.
Thank you for listening

Heerema Aegir DCV (2013)

Lifting from barge

Upended pile