GROUND IMPROVEMENT

FROM AN ENGINEERING GEOLOGICAL PERSPECTIVE

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23-11-2018

THIS PDF CONTAINS ONLY A SELECTION OF THE SLIDES SHOWN DURING THE PRESENTATION AT THE SYMPOSIUM

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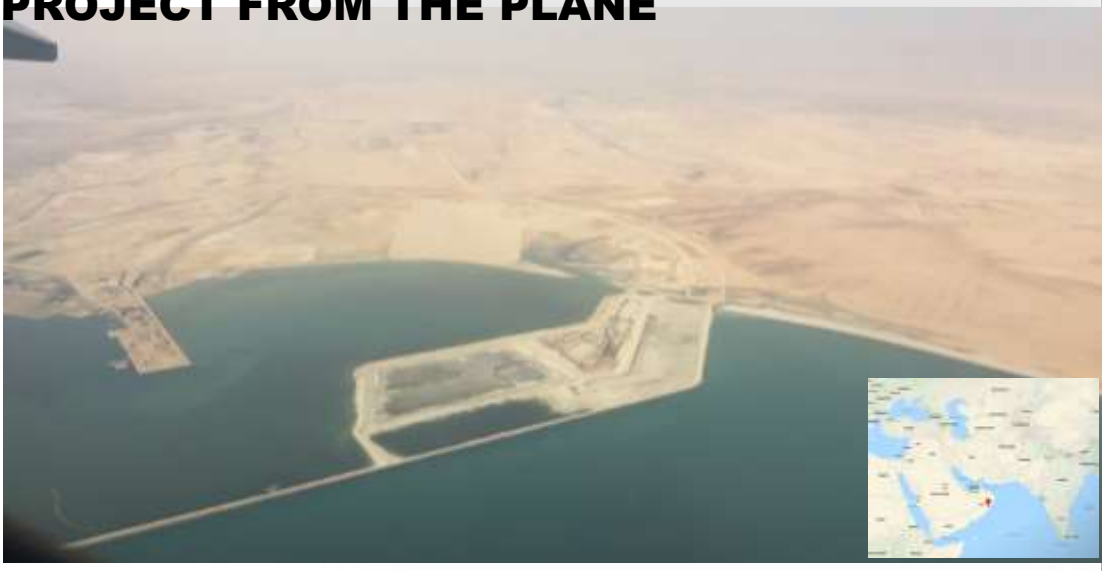
INDEX

RESUME

1997 – 2003	**DELFT UNIVERSITY**
	Engineering geology
2003 – 2005	**COFRA (FAMILY OWNED)**
	Assistant project manager
	Geotechnical engineer
2006 – 2007	**CRUX ENGINEERING**
	Geotechnical engineer
2008	**COFRA (BOSKALIS OWNED)**
	Manager geotechnical department
	Business development

INDEX

PROJECT FROM THE PLANE



MATERIAL

REQUIREMENTS

QC-SPT REQUIREMENT

- qc >10MPa (rolling average)
- 1m cumulative in profile is allowed >6MPa and< 10MPa
- SPT >18 blows per 30cm
- Carbonate correction factor !

LIQUEFACTION REQUIREMENT

- M=6.5 PGA 0.05 at bedrock 475 year

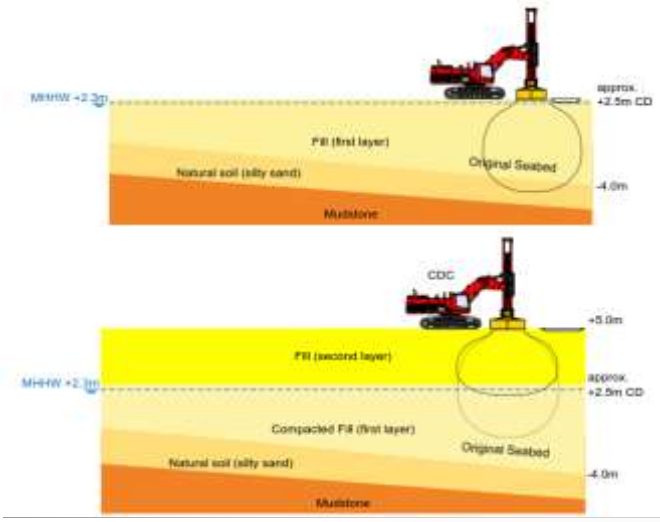
LOAD SETTLEMENT BEHAVIOR

REQUIREMENT ID	LOADING	MAX. PERMISSABLE TOTAL SETTLEMENT
1	Self-settlement of the finished reclamation with no additional load applied	75mm after 50 years
2	150kPa applied over a 5m x 5m at the final surface level of the reclamation	100mm after 50 years
3	150kPa uniform surcharge applied at the final surface level of the reclamation	120mm after 50 years
4	50kPa uniform surcharge applied at the final surface level of the reclamation	125mm after 50 year
5	50kPa uniform surcharge applied at the final surface level of the reclamation	100mm after 20 year
6	50kPa uniform surcharge applied at the final surface level of the reclamation	90mm after 1 year

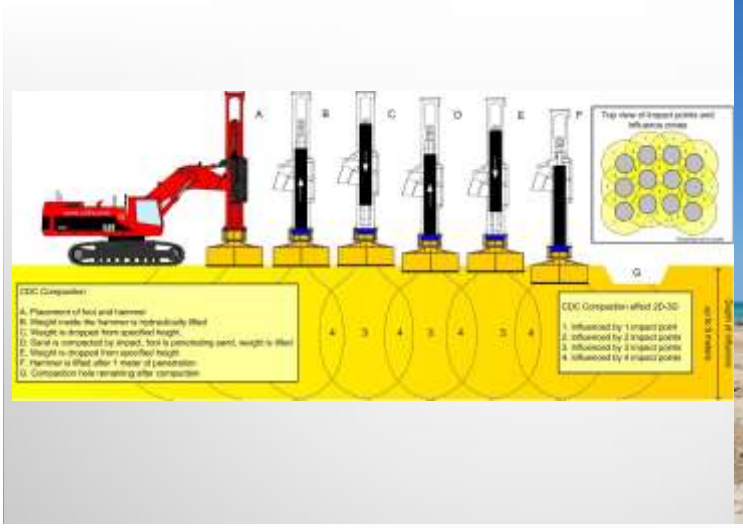
MDD REQUIREMENT TOP 1.5 METERS

- 95-98% MDD

COMPACTION APPROACH



METHOD OF COMPACTION



VIBRATIONS

CHALLENGES

- Silty sand layer above bedrock
- Unknown carbonate correction factor at the tender stage
- Compaction level near water table

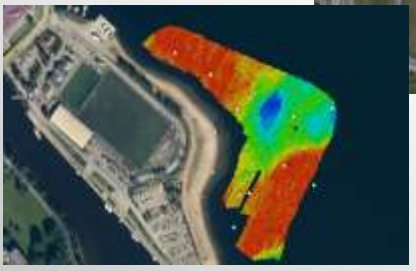
SILTY SAND

EFFECT OF PVD

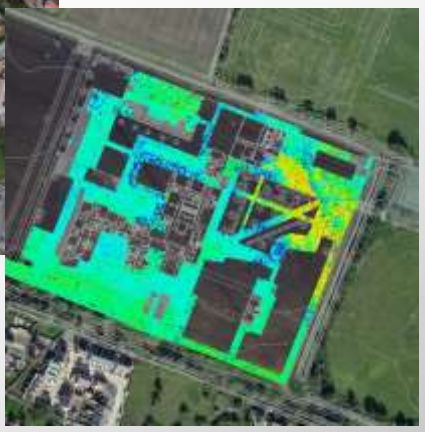
UNFORTUNATELY – NO GPS LOGGING

Push force at specific depth

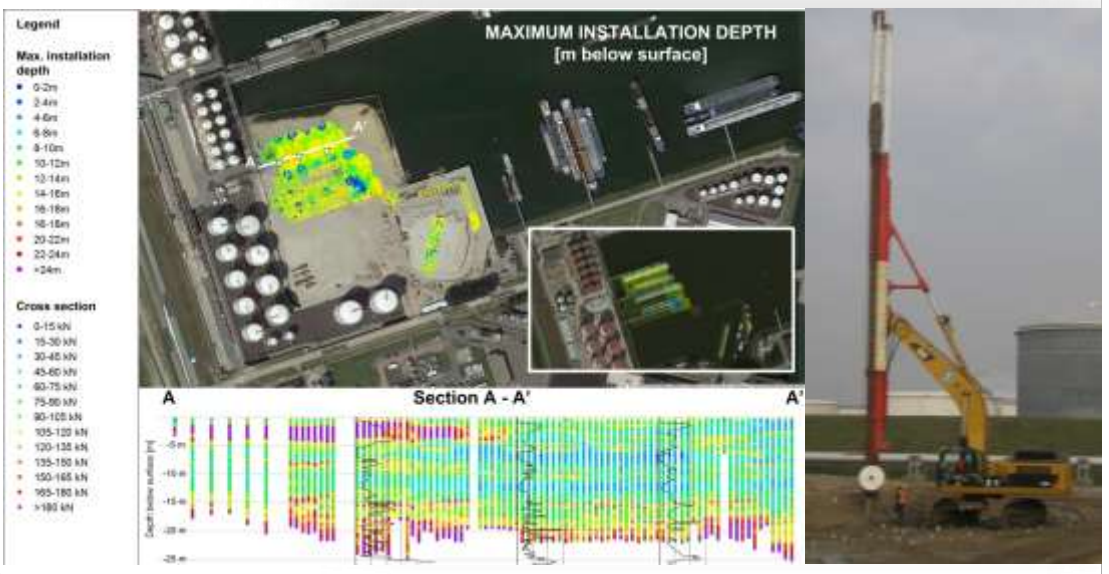
Depth map



Highly optimized drain designs



PROFILING



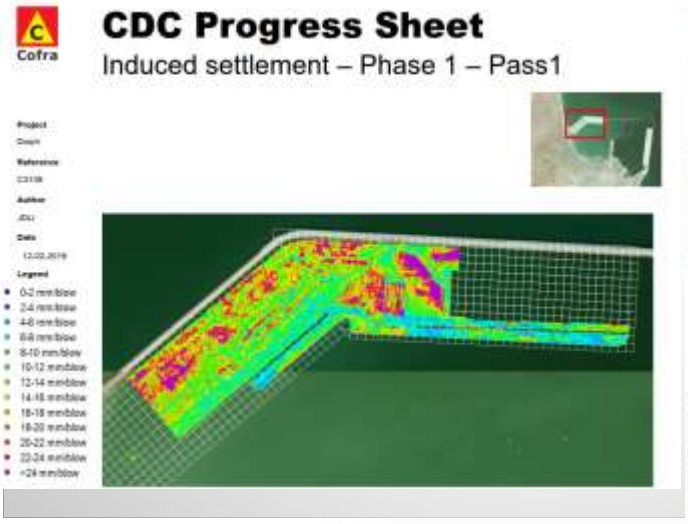
CALCAREOUS CONTENT

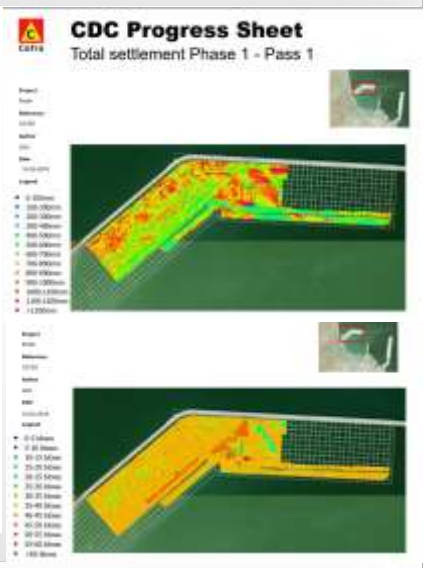
- >90% calcareous (caCO3)
- High peak stresses cause crushing during CPT testing
  - qc calcareous < qc silica
  - Literature shows a large spread in correction factors (1.4-2.0)
  - Correction factor depending on relative density

LARGE VOLUME CHANGES

WATER TABLE

COMPACTION DATA





21

22

OPTICAL ILLUSION

INDEX

AUSTRALIA 2011-2012

CALCAREOUS MATERIAL

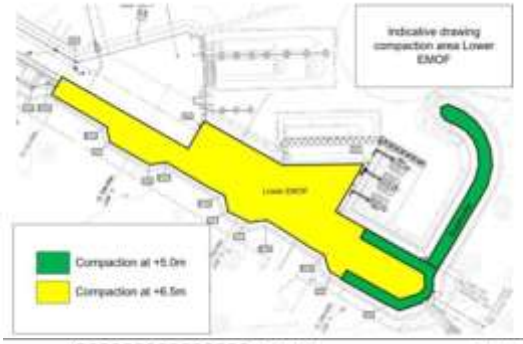
REQUIREMENTS

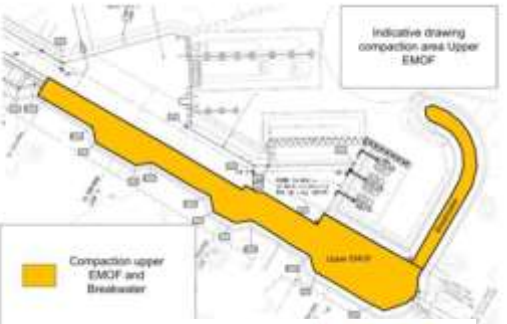
Target values compaction

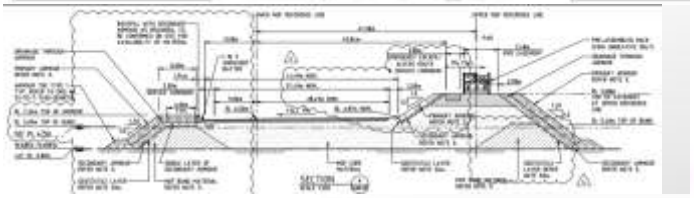
- E-modulus from +2.0m till +6.5m: 60 MPa (breakwater and slope area up to +5.0m)
- E-modulus from +6.5m and above: 100MPa (breakwater and slope area up from +5.0m)

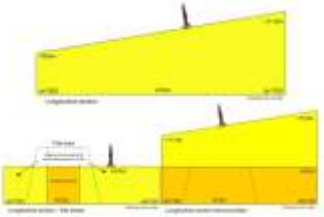
27

COMPACTION APPROACH









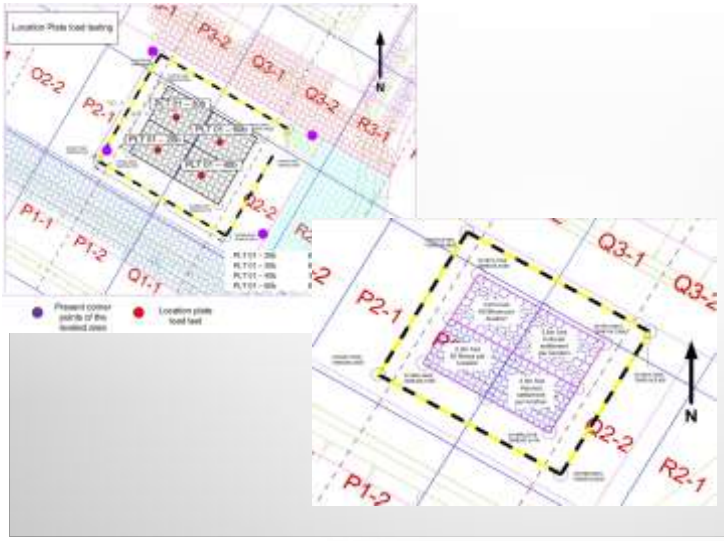
28

CHALLENGES

- Remote location with no land based accommodation
- Class A nature reserve
- Material – how to test
- Time pressure


Cofra

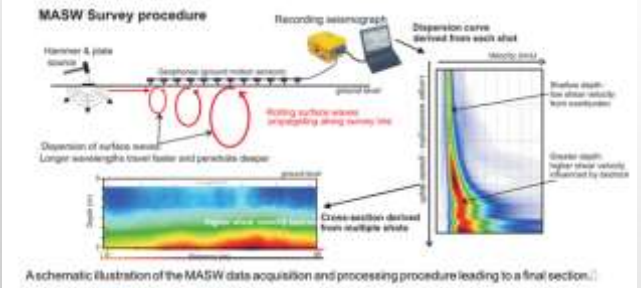
TRIAL



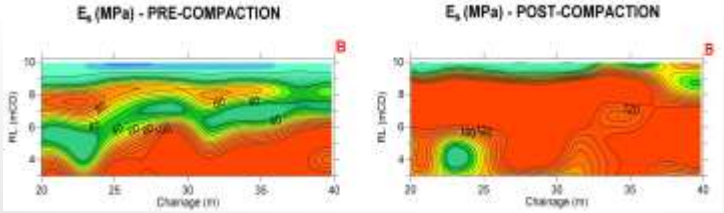
TESTING

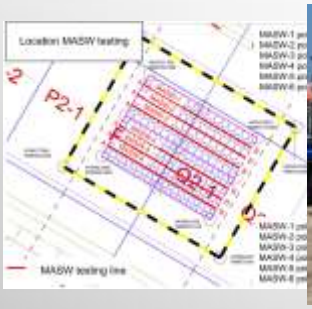
- Material too coarse for SPT and CPT testing

- Plate load testing
- MASW (multichannel analyses of shear wave) testing



COMPACTION RESULTS



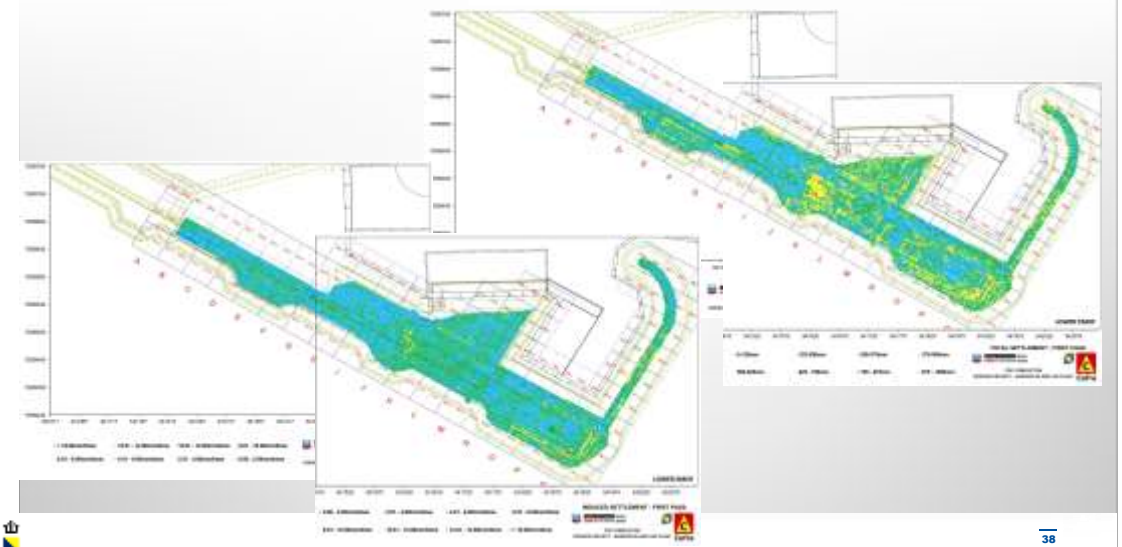


35

36

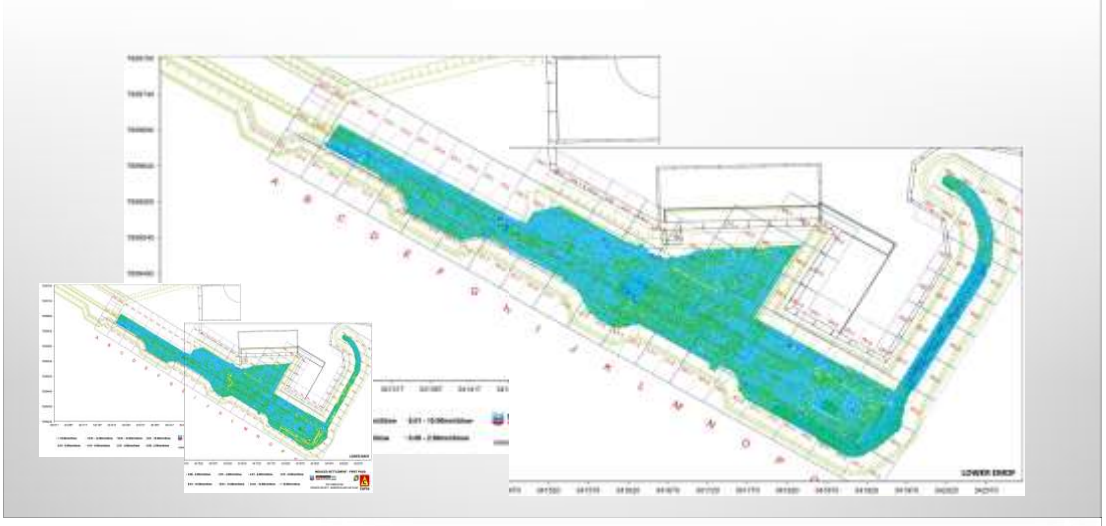
37

HANDOVER CRITERIA: LOGGERDATA



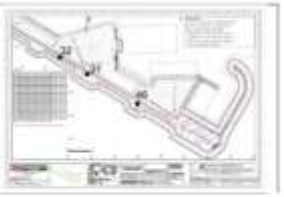
38

FINAL INDUCED AFTER SECOND PASS



HANDOVER CRITERIA: PLATE LOAD

PLT test ID	Date	Northing	Easting
PLT #31 - PMOF S1 - Final	26-12-2011	7699582.25	341389.88
PLT #32 - PMOF S1 - Final	21-03-2012	7699656.33	341265.10
PLT #46 - HLF South - Final	31-05-2012	7699462.40	341601.78



PLT test ID	Compliant	E-modulus [Mpa]						Stress [kPa]					
		1	2	3	4	5	6	1	2	3	4	5	6
PLT #31 - PMOF S1 - Final	Yes	169	142	131	149	155	168	54	102	205	308	405	508
PLT #32 - PMOF S1 - Final	Yes	194	127	123	139	151	173	54	102	203	309	406	519
PLT #46 - HLF South - Final	Yes	157	123	122	120	123	126	56	104	211	315	406	515

THANK YOU FOR YOUR ATTENTION