THE BIG 5 International Building & Construction Show

Supporting Partner

DEEP FOUNDATIONS INSTITUTE DFI

5 - 8 DECEMBER 2022
DUBAI WORLD TRADE CENTRE

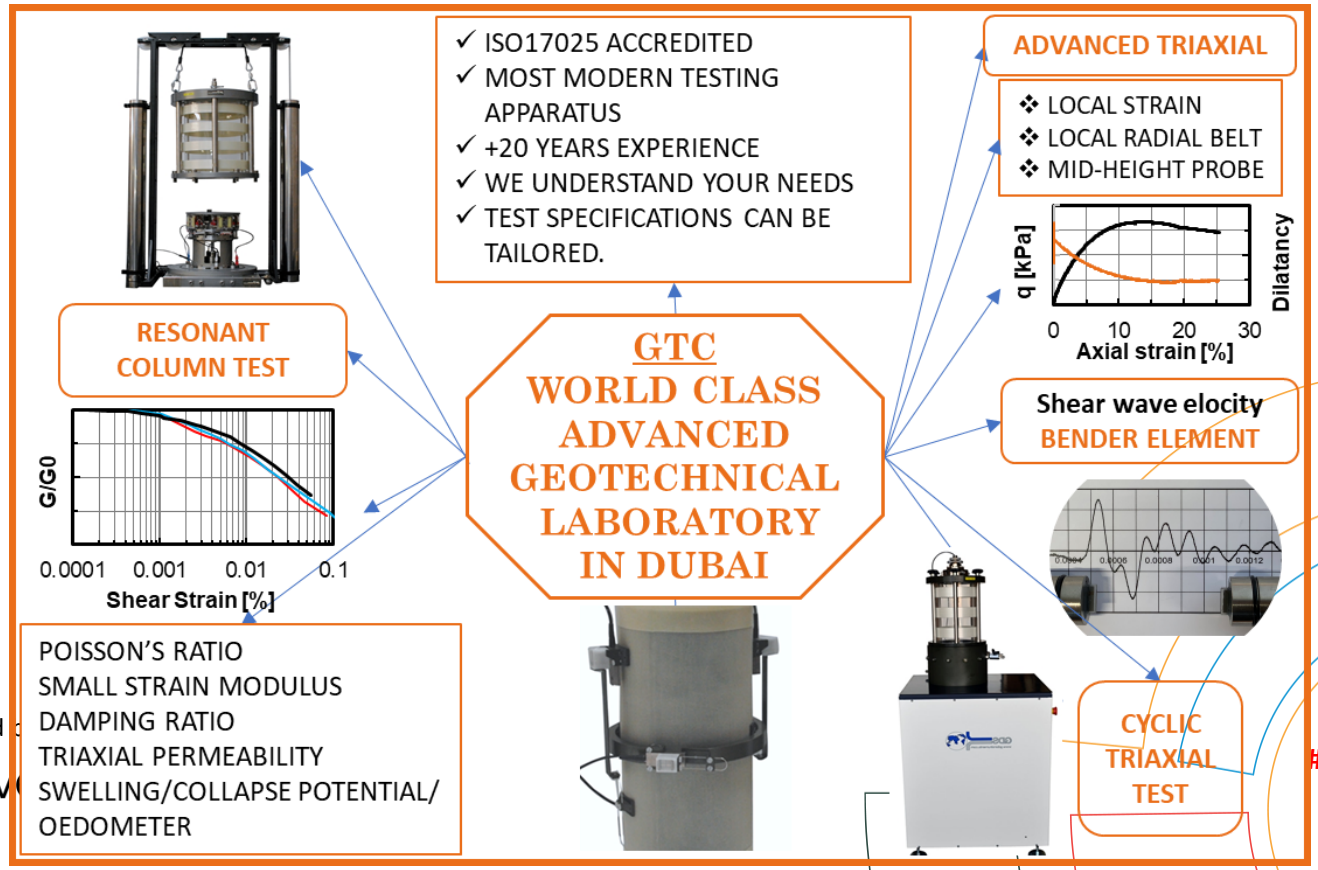
USING ADVANCED LAB TESTING TO ADDRESS SOME COMMON GEORISKS IN UAE

Dr MAN BUI AND ENG. EMAD SHARIF

DFI GEOTECHNICAL SUMMIT, THE BIG 5 GLOBAL 2022
5th December 2022, 16:30– 16:50
Sheikh Saeed Hall 2, Theatre 2 – Dubai World Trade Centre

ABOUT GTC LABORATORY IN DUBAI

ISO 17025:2017 Accredited by EIAC (Emirates International Accreditation Centre)



Organized

#THEBIG5EXHIBITION

www.thebig5.ae

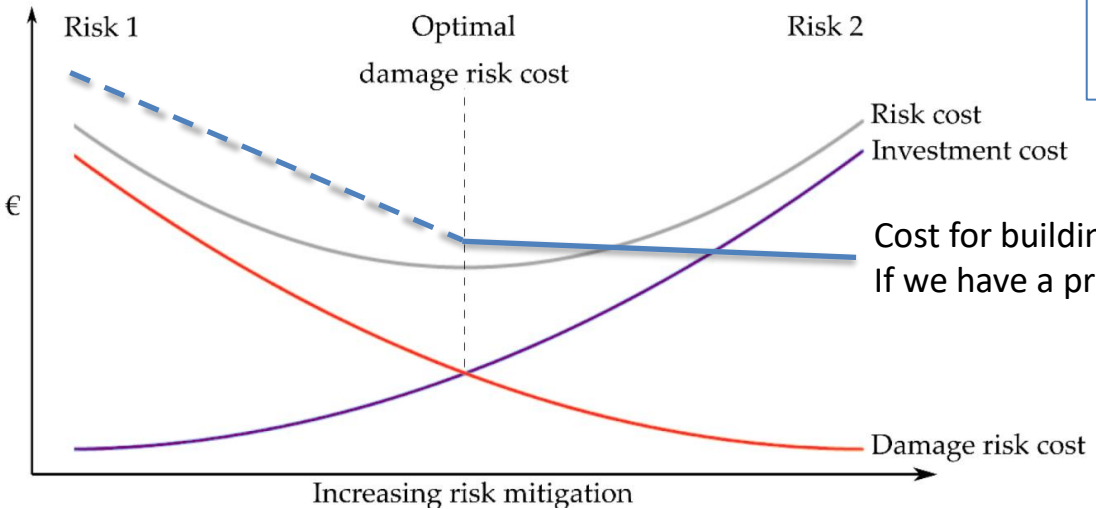
THERE ARE SOME COMMON GEORISKS IN UAE

SUCH AS:

- Collapsible of calcareous sand under shallow foundations
- Excessive permanent settlement after long term cyclic loads
- Large scale Surface settlement due to machine/ equipment vibration, especially for oil and gas facilities.
- Stability of deep excavation
- Uncertainties (various unknown) in site investigation due to technical limitations, site difficulties, site variations
- Actual soil behaviours, that hardly determined using in situ tests

GEORISKS VS DAMAGED RISK COST

Risk Management, How to eliminate/ mitigate risk



Note: Using high factors of safety in foundation design may not eliminate the risks. The key is to address the right risks

Cost for building foundation can be reduced
If we have a proper investment in soil investigation

Site Investigation Overview

ADVANCED LAB TESTING IS A CRUCIAL PART to ADDRESS THE GEORISKS

GTC

Site Investigation Overview

Desk study,
Geological Survey

Site Investigation

In-situ tests
CPTu,
SPT,
Vane shear,
DMT
HFT,
PMT
Geophysics

Soil sampling
Trial pits
Boring
Drilling
(U/D/B)

Laboratory Tests
(what Parameters required?)

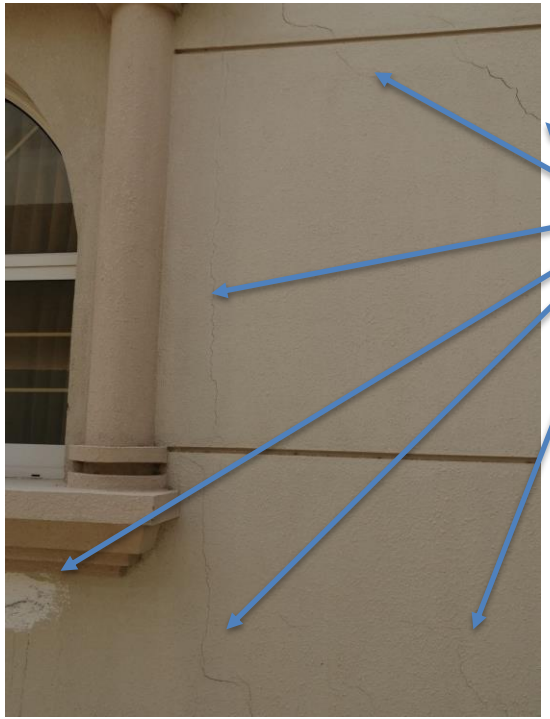
A key Objective is the outcome of the soil investigation can address the Risks

1. Stress history
2. Soil type and stratigraphy
3. Index property (PSD, Density, M/C, LL-PL, etc.
4. Consolidation/permeability
5. Shear strength (DSB, DSS), Un/Drained TXL, multiple stage TXL, UCS
6. E_0, G_0, G/G_0 (RCT, BE, small train)
7. Cyclic resistance (CTXL, CSS, CNS)
8. Damping Ratio
9. Soil-steel/concrete interface Frictional angle

Special Capacity And The Values of Advanced lab testing?

POPULAR WALL CRACKS IN PRIVATE VILLAS

Example of wall cracks of a private villa supported by shallow foundations on sand at al Warga, Dubai



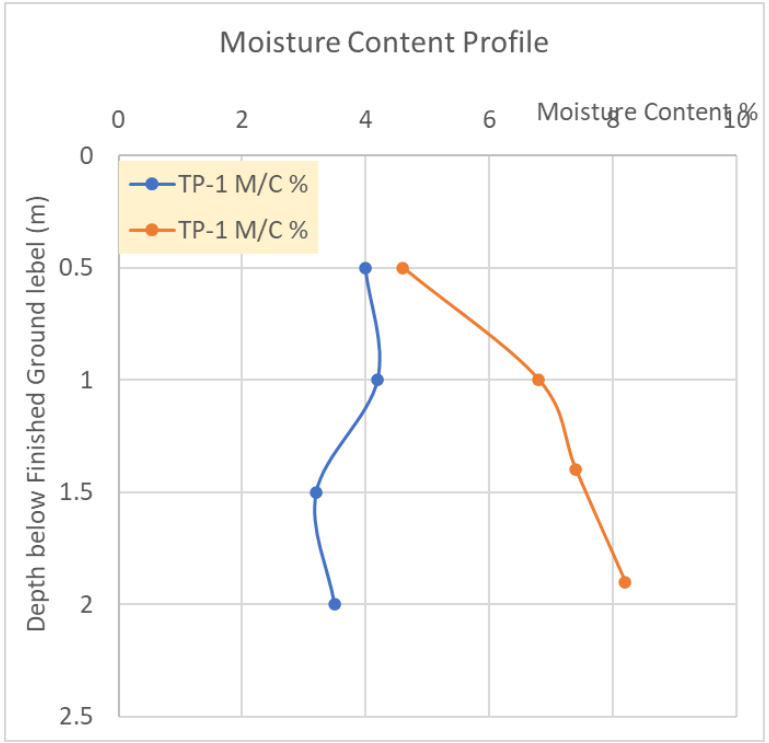
Various serve cracks from front wall, back wall, sidewalls, first floor, second floors with various crack directions, led to high cost for remediation

What are the reasons?

Can we prevent wall cracks?

dmg events

THE SAND BENEATH THE FOUNDATION

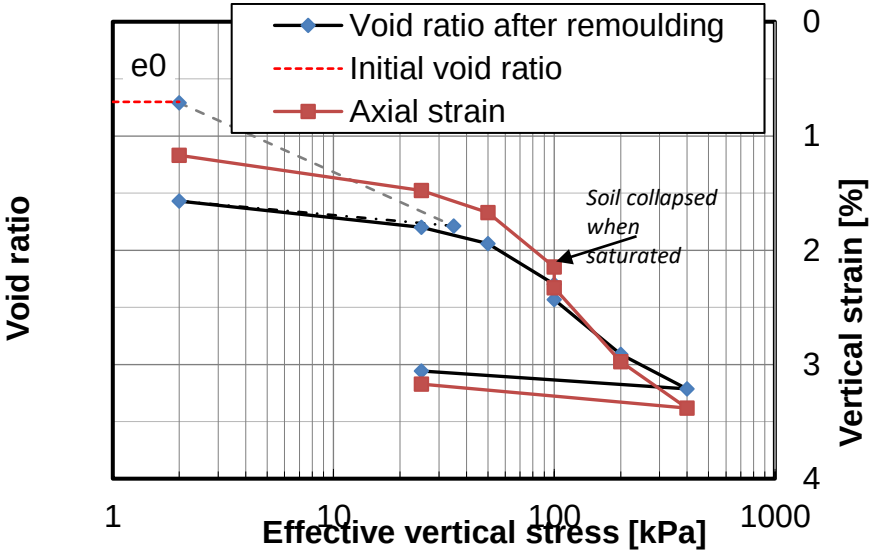


- No GWT encountered in trial pits to 2.0m BGL
- Relatively higher water content at TP2 (5%-8%) increasing with depth.
- Water pipe line was previously broken and repaired, as clarified by the owner.

➔ Softened soil, reduction in soil shear strength and stiffness.

MEASUREMENT OF COLLAPSIBLE INDEX

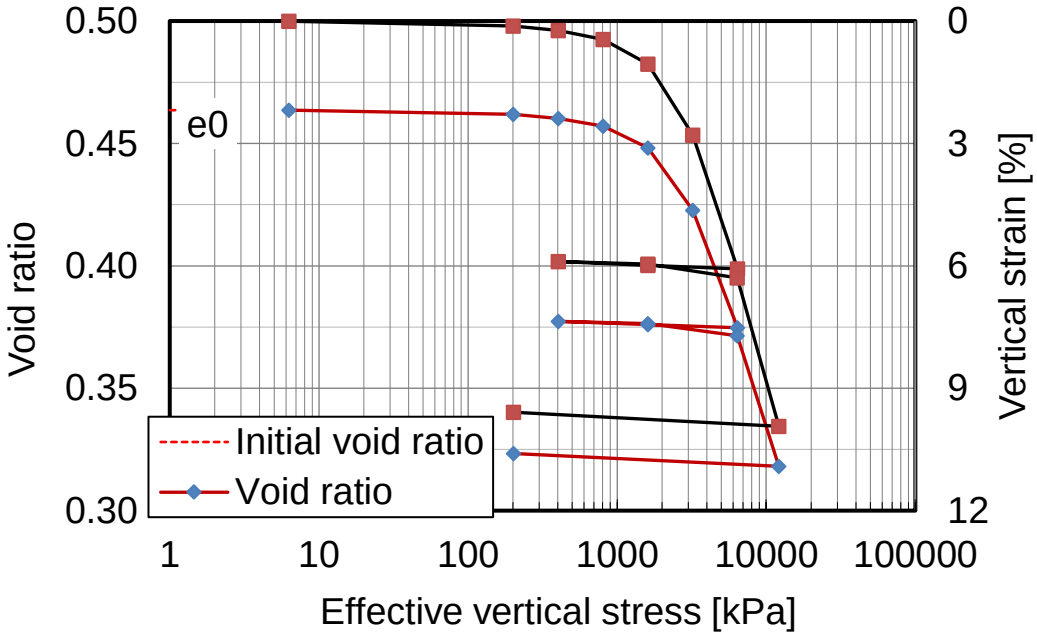
MODERN 1D CONSOLIDATION SYSTEM WITH TAYLORED TESTING PROCEDURE



- SLIGHTLY COLLAPSE INDEX (0.42%)
- => Confirmation of the Different settlement e.g. of 12mm for a layer of 3m (2 time the foundation width) thickness of calcareous sand

Large scale oedometer tests

To remove the effect of particle size, and high pressure applied

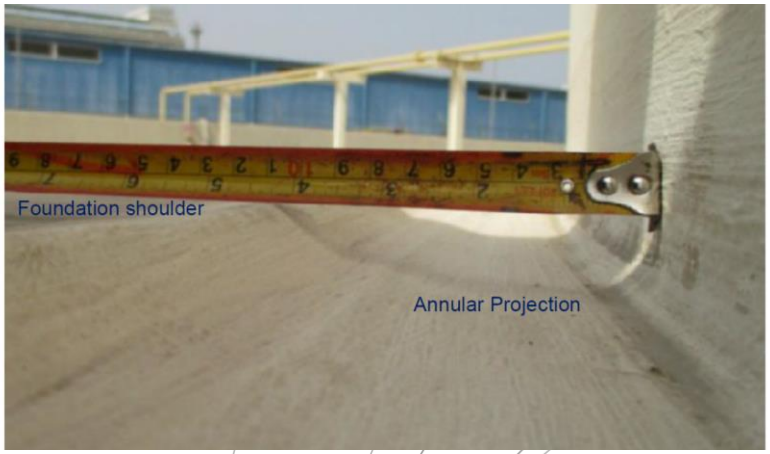


Particle size can be up to 20mm
Max pressure = 12 MPa (D= 100mm) or 20MPa (D=83mm)

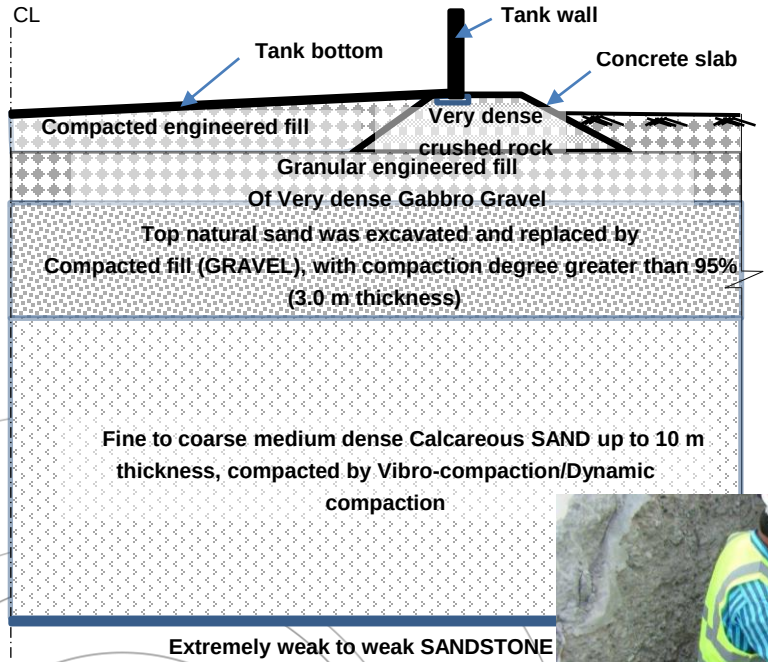
EXCESSIVE PERMANENT SETTLEMENT AFTER LONG TERM CYCLIC LOADS

ESPECIALLY FOR OIL AND GAS FACILITIES

Different settlements beneath tank bottom annulus after 10-year operation exceeded acceptable limited as per API standard.



ASSESS THE FOUNDATION SETTELEMENT



Multichannel analysis of surface waves (MASW) technique

Very dense soil, 95%-100%.

TOTAL SETTLEEMNT ESTIMATED = 20-25MM

OUR FEM CONFIRMED THIS➔ THERE SHOULD BE SOMETHING ELSE?

CREEP TEST IN TRIAXIAL CELL

BENEFIT OF LARGE SAMPLE SIZE & STRESS HISTORY SIMULATION

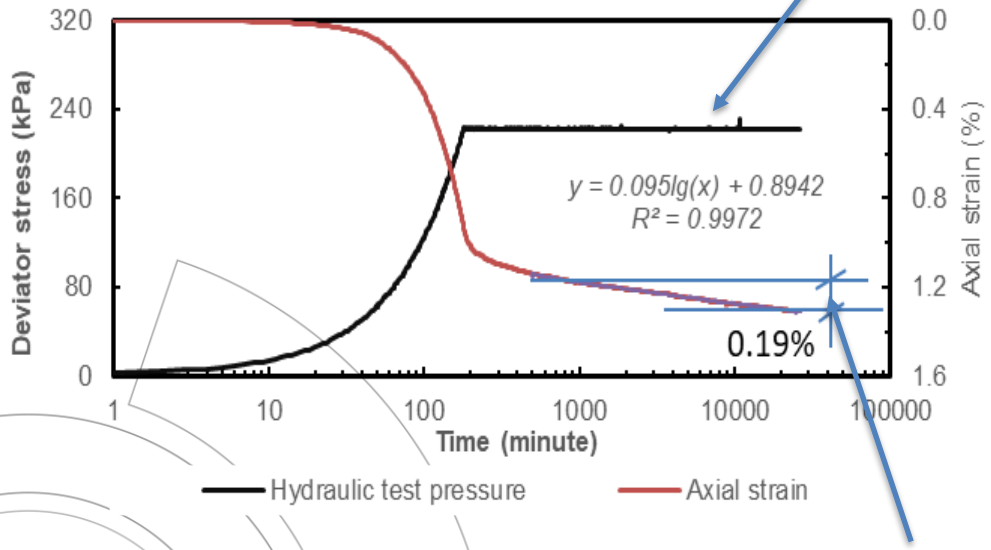
Stage	For granular fill		For calcareous sand	
	s'_r (kPa)	s'_v (kPa)	s'_r (kPa)	s'_v (kPa)
Overburden pressure	45	45	145	145
Superstructure	45	75	145	175
Hydrostatic test loading	45	265*	145	345*
Hydrostatic test unloading	45	75	145	175

* Note: the summation of the hydrostatic test pressure, dead weight of the tank

CREEP TEST IN TRIAXIAL CELL

Creep Test Results

Hydraulic-test load of 190 kPa > 170 kPa Oil pressure

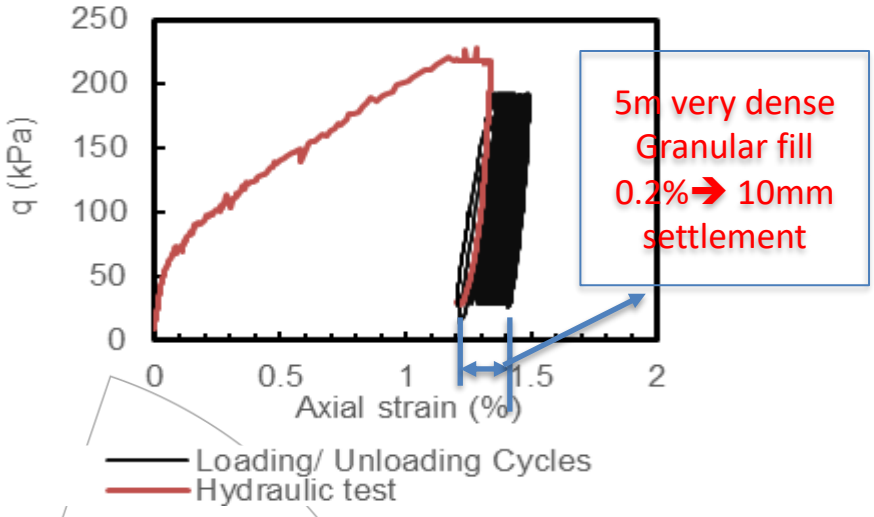


- Creep monitored until almost deformation ceased.
- Creep could contribute up to 19 mm settlement for a 10 m layer of sand in the field << than the measurement settlement
- Meaning the Creep settlement may not be the major factor causing the excessive settlement of the tank.

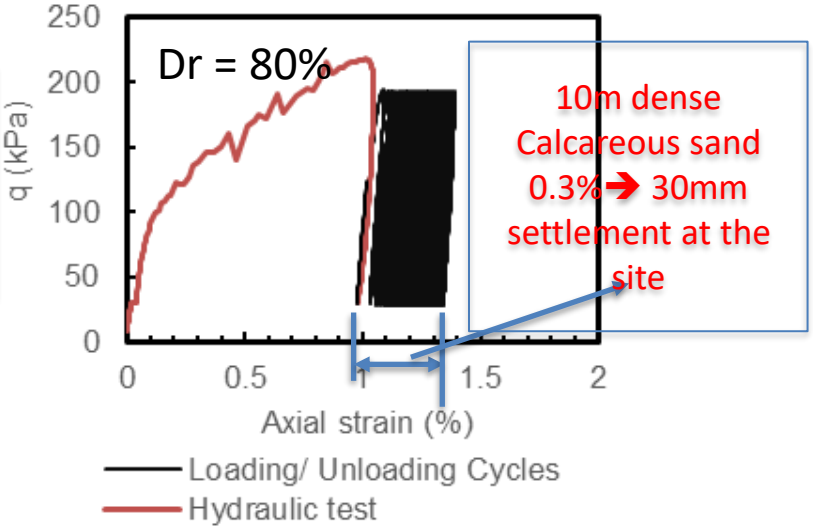
0.19% per cycle of log time

Simulation of the oil Tank operation in 10 Years

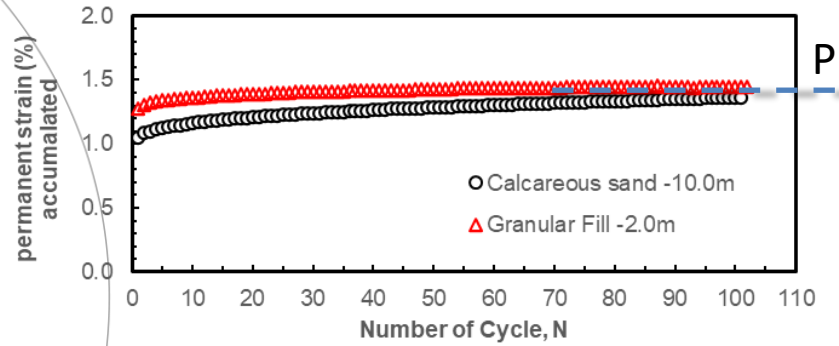
Using very Low frequency cyclic Triaxial tests in drained condition for both calcareous sand and granular fill



5m very dense Granular fill 0.2%➔ 10mm settlement



10m dense Calcareous sand 0.3%➔ 30mm settlement at the site



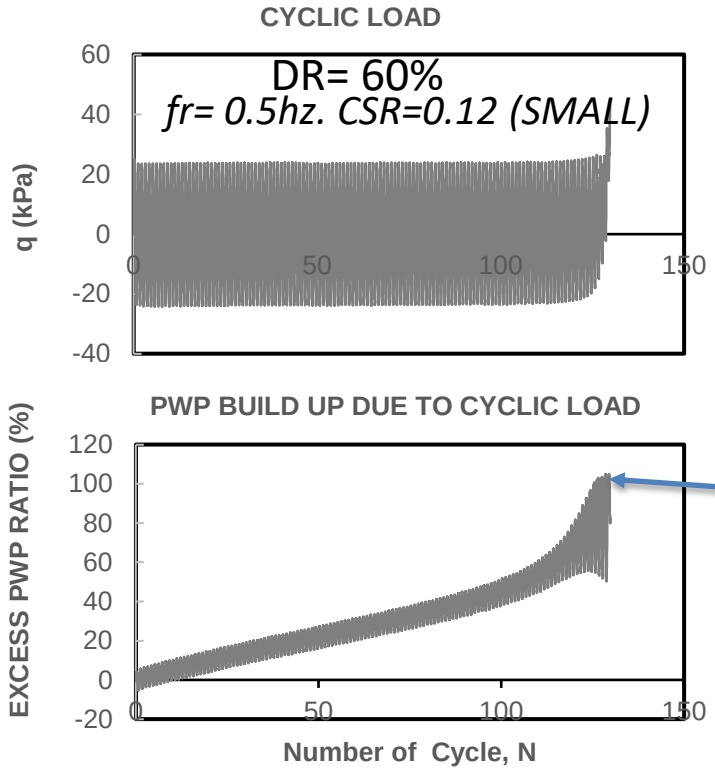
Plateau of cyclic Stiffness

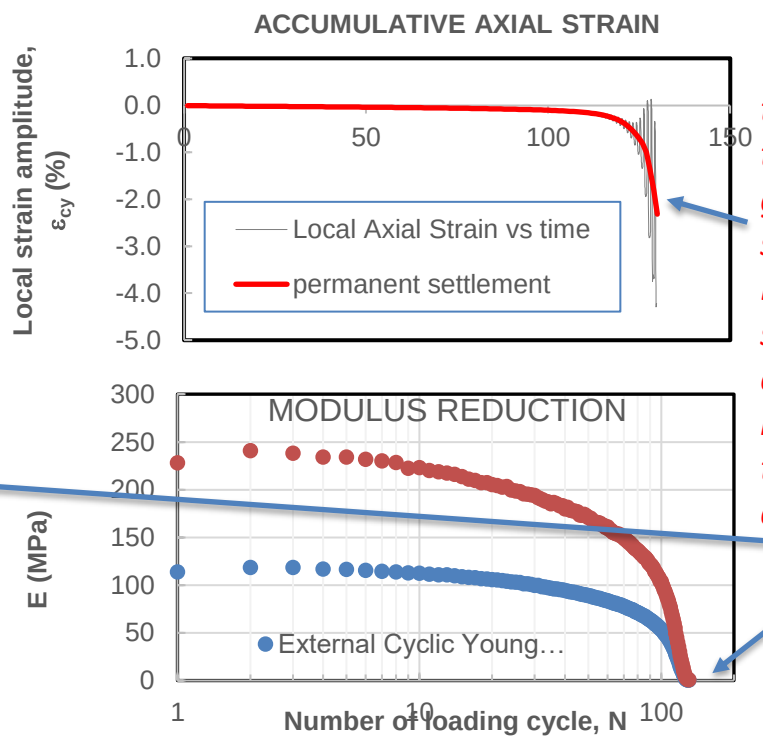
Some remarks from the laboratory simulation of oil tank

- The process of filling and emptying of the tank has caused the major settlement accumulated with time, observed for both dense calcareous sand and very dense granular engineering fill.
- It is likely that no further settlement taken place in the granular fill and in calcareous sand after 75 and 95 loading cycles, respectively, thanks to the stiffening effects in fully drained condition under cyclic load.
- Creep could partially contribute to the settlement but not represent the actual loading mode of the tanks, and Creep underestimated the long-term settlement of the tank.
- The creep rate of dense calcareous sand measured in the laboratory under effective stress of 190 kPa, was 0.19% per logarithmic time cycle, which exceeds the estimates made by empirical relations for 10 years period, whereas residual vertical strain resulted from cyclic loading and unloading is much higher.

Ground/surface subsidence due to machine/engine vibration

ESPECIALLY FOR OIL AND GAS FACILITIES ON CALCAREOUS SAND e.g. ARTIFITIAL ISLAND

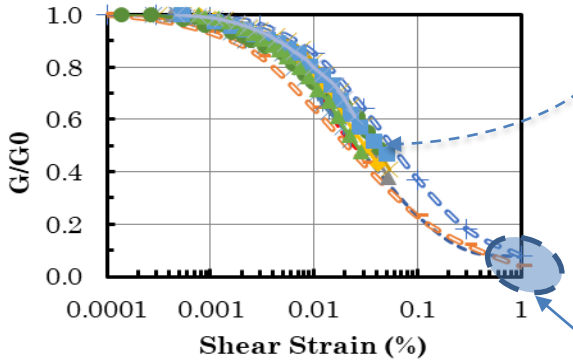


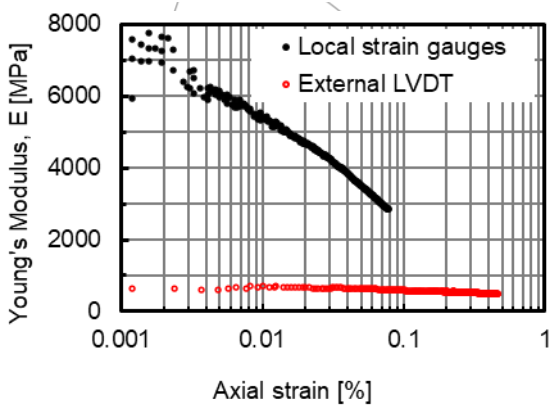


the red line is the permanent ground settlement, Became significantly after 120 loading cycles, then liquefied after 127 cycle

Higher lateral movement in Deep excavation than acceptable limit

Soil Nonlinear behavior



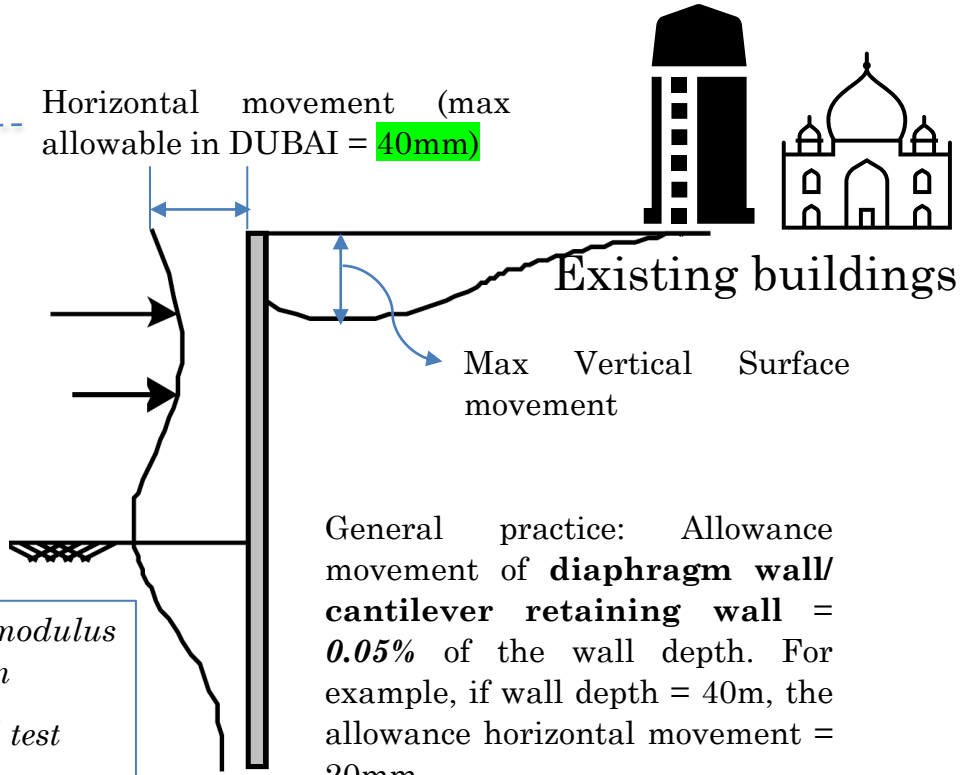


Young modulus obtained from

Conventional test

➔ *not economical solutions*

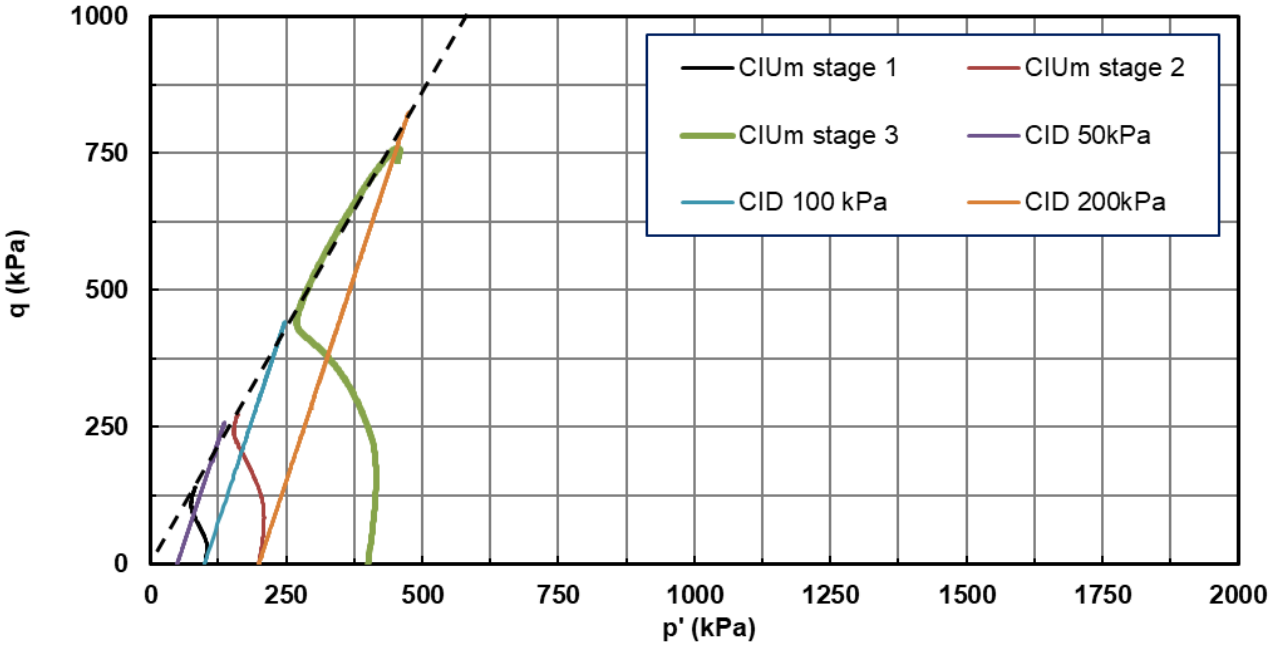
Horizontal movement (max allowable in DUBAI = 40mm)



General practice: Allowance movement of **diaphragm wall/ cantilever retaining wall** = ***0.05%*** of the wall depth. For example, if wall depth = 40m, the allowance horizontal movement = 20mm

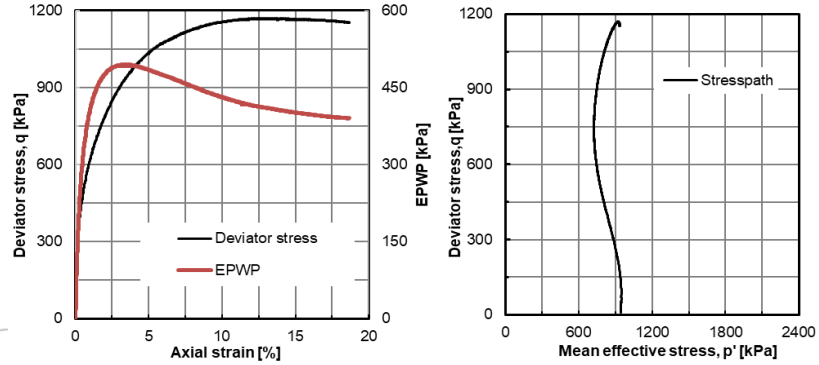
Uncertainties In Measurement of c & ϕ for Sand & Soft Rock

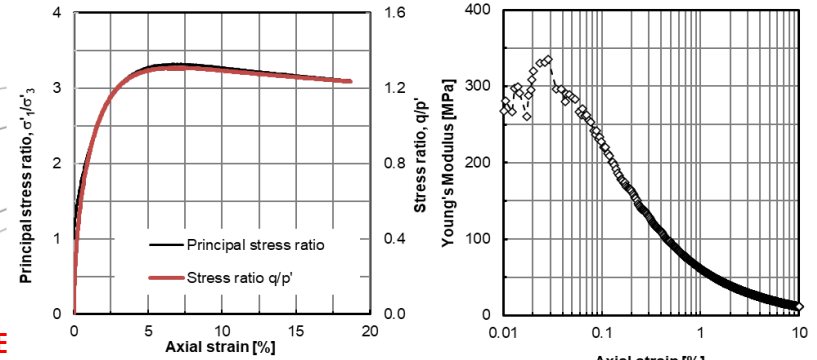
Multiple stage triaxial test, set of three CID tests

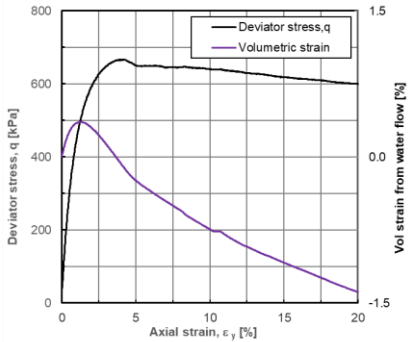


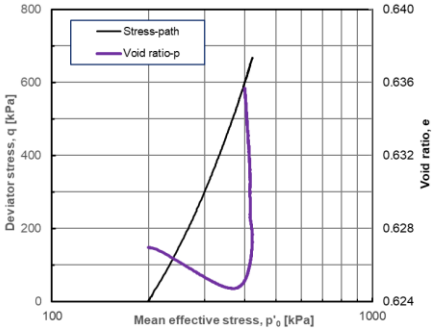
Soil Drained vs undrained behavior

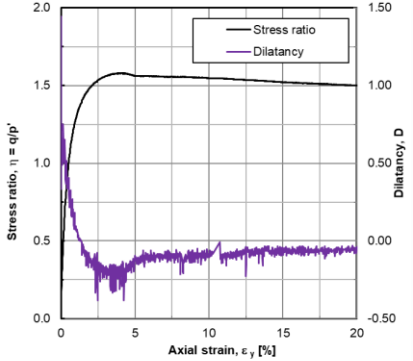
In triaxial tests, especially for Soil pamarmeters calibrated

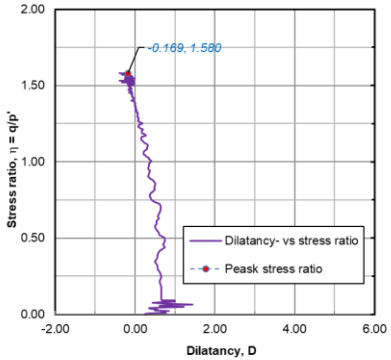






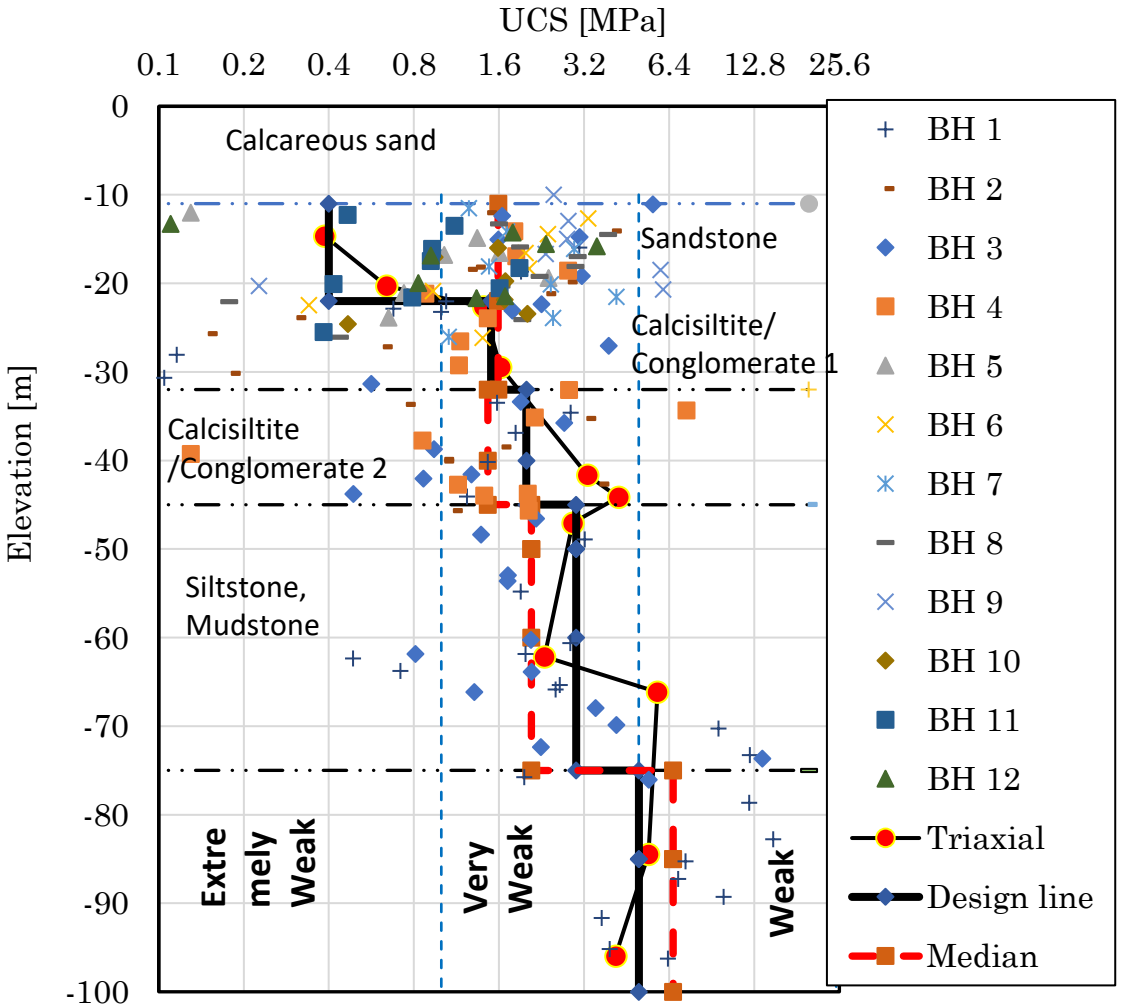






Uncertainties in UCS Test Results will affect the design of Bored pile For Highrise Building

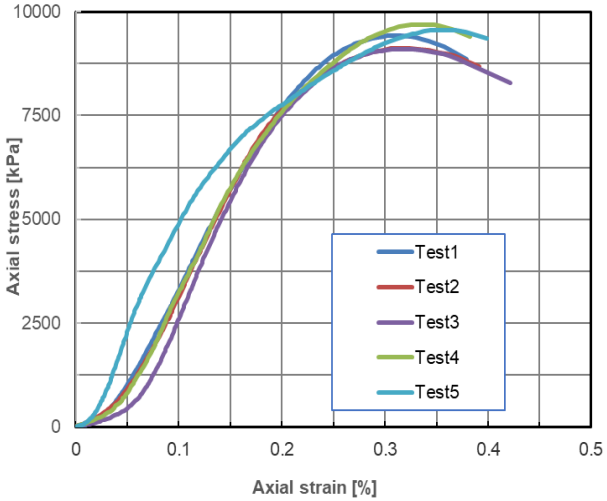
PILE BEARING CAPACITY
AND SETTLEMENT



Reduce uncertainties in UCS Test

Testing procedure & specimen conformity assessment

sample	L/D	Bulk Density (g/cc)	Dry Density (g/cc)	Moisture content (%)	UCS (MPa)	e50 (%)	E50 (MPa)
No #8	2.03	2.03	1.84	10.2	9.43	0.13	3682
No #1	2.03	2.03	1.85	10.0	9.12	0.13	3626
No #3	2.03	2.04	1.86	9.6	9.11	0.13	3439
No #6	2.02	2.03	1.86	9.5	9.70	0.13	3690
No #4	2.04	2.03	1.84	10.7	9.56	0.10	4935



#THEBIG5EXHIBITION

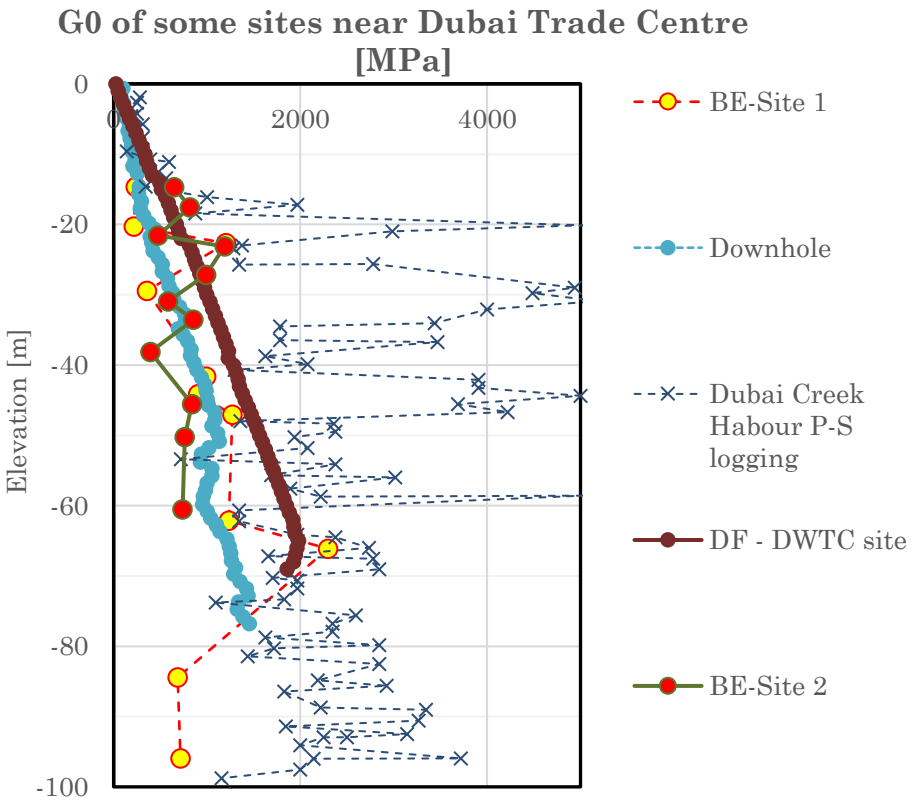
www.thebig5.ae

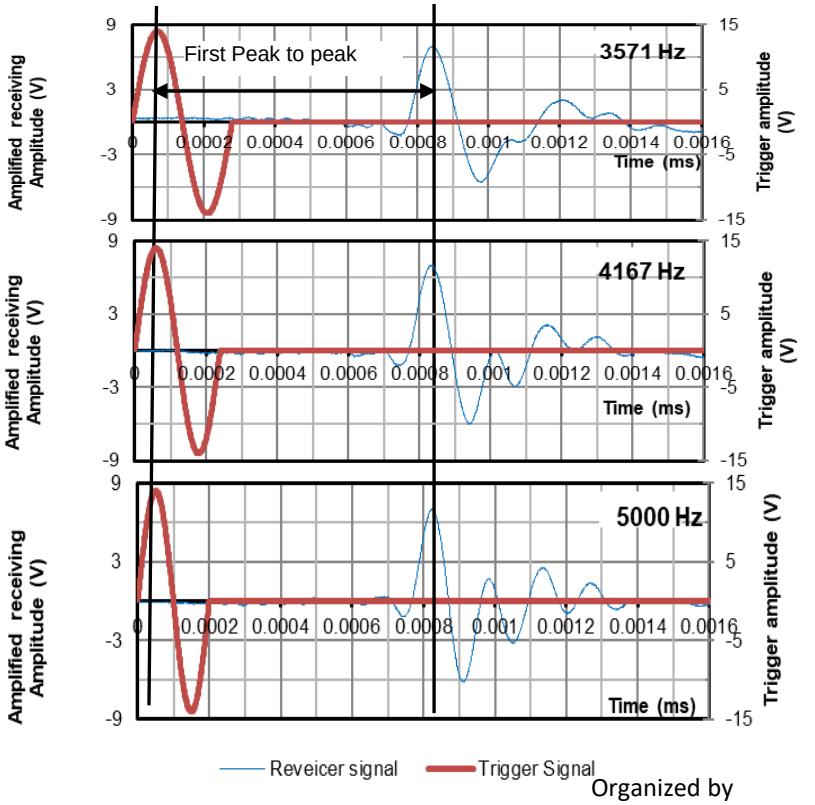
Organized by

dmg events

REDUCE UNCERTAINTIES IN GEOPHYSICS SURVEYS

CONSISTENCY IN BENDER ELEMENT TEST





Organized by

dmg events

Concluding remark and suggestion

- For any project, a small and early investment in Advanced laboratory testing will yield a ***much greater return value*** for the project owner.
- All the key georisks shall be determined and addressed as early as possible from soil investigation stage .
- Advanced lab testing techniques as presented above shall be used to reduce BOTH the risk damaged cost and reduce the foundation building cost.

Q & A

#THEBIG5EXHIBITION
www.thebig5.ae

Organized by
dmg events

THANK YOU


Talks
Concrete
Talks
Facilities Management
Talks
Geotechnical & Engineering
Talks
HVAC R
Talks
Offsite & Modular
Talks
Project Management
Talks
Solar
Talks
Stone Design
Talks
Technology
Talks
Urban Design & Landscape