MEASURING AND COMPARING SOIL PARAMETERS FOR THE HARRY NICE BRIDGE

Roger A. Failmezger, P.E., F. ASCE, D. GE
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Drs. John Schmertmann and Silvano Marchetti at DMT’15
SUBSURFACE INVESTIGATION

• Performed CPT, DMT, PMT, VST, SPT and Seismic with True Interval (0.50 m) DMT Module

• Development of Heavy Seafloor Direct Push System—like performing soundings on land

• Discuss what techniques we used to more efficiently perform these tests

• Compare the undrained shear strengths and deformation moduli from the tests
  • Tests were performed in clusters at the north and south ends of the channel
Subsurface Information from 1939
15-TON CAPACITY SEAFLOOR DIRECT PUSH SYSTEM

Base Area = 192 sq. ft.
Using Spreader Frame to Keep Slings Vertical
Lowered system below decking and swung system towards barge

Added rods and casing as system was lowered to seafloor

My new work platform system will have 16ft by 16 ft opening with hinged fold down decking

Mud was so soft that rods would have fallen by their weight up to 40 feet

Used clamp is pull position to lower rods at 2 cm/sec until mud could support their weight
SEISMIC HAMMER SYSTEM

- Used large pendulum hammer with trip release from crane to generate shear wave
- Used 300 pound donut hammer with trip release from crane to generate compression wave
  - Worked but always found speed equal to 1500 meters/sec—speed of wave travelling through water
PERFORMING DILATOMETER USING SEAFLLOOR SYSTEM
ADVANTAGES OF SEAFLOOR DIRECT PUSH —LIKE PUSHING ON LAND

• Testing starts at the mudline
  • measure the strength and deformation properties of very soft muds
• Probes are pushed at a constant 2 cm/sec rate—meets ASTM D5778 for CPT and D6635 for DMT Specifications
  • Waves do not alter this rate or cause pinching of cables
• Rod pushing avoids zone between barge deck and mudline of parasitic rod buckling or lateral movement of casing
• 3-inch casing attached to the top of the seafloor system and extended to the barge deck serves as fixed reference to measure the tests depths
  • does not move with either waves or the tide and provides accurate measurements
  • attached hydraulic and air hoses to casing
P-Y ANALYSES FROM DILATOMETER SOUNDING

- Material Index, $I_0$
- Strain at 50% Ultimate Lateral Soil Resistance, $\varepsilon_{50}$
- Pile Deflection for Mobilization of 50% of Soil Resistance, $y_0$ (cm)
- Ultimate Soil Resistance, $P_u$ (kN/m)
VERTICAL PILE CAPACITY FROM CPT SOUNding

- End Bearing F.S. = 3.0
- Friction Resist. F.S. = 2.0
PRESSUREMETER TESTS

• Used Texam Unit and performed strain controlled tests
  • About 40 data measurements/test
• Measured pressures with a digital gauge—accurate to 1 kPa
• Used 74 mm tri-wing bit for cohesive soil and 76 mm tri-cone bit for cohesionless/cemented soil
  • High quality borehole critical—experienced drillers important
Corrected Pressuremeter Test Results

![Graph showing corrected pressuremeters test results](image_url)
VANE SHEAR TESTS

• Used AP van den Berg I-VANE
• Vane Motor at bottom of hole turned vane and measured torque
  • No parasitic rod friction
• Computer at surface read values from connecting cable and displayed results while performing test
• Peak: turned vane 0.1°/sec for ¼ revolution
• Rapid turning 6°/sec for 10 revolutions
• Remolded: turned vane 0.1°/sec for ¼ revolution
STANDARD PENETRATION TESTS

• Used 125 mm diameter steel casing telescoped inside 200 mm diameter steel casing
• Added bentonite and polymers to the river water to make drilling mud—added soda ash to reduce the pH
• Used NWJ drill rods (35 mm ID) for good mud circulation
• Drill rods and Steel Casing were quite heavy for drill crew to maneuver
  • Used crane on barge to either lower or remove them from hole
  • Drilled lowered front jacks moving drill derrick out of way
  • Crane could handle 110 feet (34 m) with each of its two hoists
• Crane significantly improved efficiency of drilling/sampling operations
TRUE INTERVAL SEISMIC TEST

\[ V_s = \frac{(S_2 - S_1)}{\Delta t} \]

\[ G_0 = \rho \cdot V_s^2 \]
EXAMPLE SEISMIC WAVES

RECORDED WAVES

REPHASED WAVES
TRUE INTERVAL SEISMIC TESTS

- Contract required both compression and shear seismic tests to 55 meters below mudline
  - Compression waves measured the speed through incompressible water (1500 m/s—wasteful)
- Cemented layers prevented penetration from top to bottom
- Drilled 125 mm hole to 56 m
- Lowered SDMT probe to 55 m carefully aligning sensors
- Backfilled with washed fine gravel about 5 m above test
- Performed seismic tests (multiple strikes) and then raised probe 1 m for next test
- Used large hammer from seafloor to generate waves
Dilatometer penetration causes has much smaller shear and volumetric strain to soil.
STANDARD PENETRATION TEST

• Predicting modulus from N-value has wide range of correlation factors
  1) the energy not being measured
  2) dynamically penetrating the soil
  3) the soil being strained to failure
  4) remolding of the soil

Coeff. Of Var. =0.67 – quite high
For 95% certainty sett less than 25 mm, then ave sett =7.5 mm
CONE PENETRATION TEST

• Wide scatter of $\alpha$ factor to obtain deformation modulus from tip resistance
• 1) straining the soil to failure
  2) remolding the soil
  3) stress history unknown

➤ Need site specific correlation values to get modulus
• **Advantages:**
  - Economical to perform numerous tests at close intervals
  - Strains soil to intermediate levels similar to the structure
  - Measures the effect of soil stress history
  - Computation error when one uses an average $M$ value for a layer—make layers same thickness as test interval

SITES WERE LOCATED MAINLY IN VIRGINIA, USA

![Graph showing deformation modulus vs. oedometer data, with data points for residual and alluvial sites.](image-url)
SOUTHWEST OF RIVER CHANNEL

Enlarged scale for upper 15 meters

SOUTH END OF RIVER CHANNEL
NORTH END OF RIVER CHANNEL

Enlarged scale for upper 15 meters

Graph showing undrained shear strength versus depth with various markers and lines representing different test methods.
DMT--Marchetti

PMT = E_o / α * 1.48 for ν = 0.33

CPT = α q_T where α = 8
CONCLUSIONS

• Seafloor direct push system efficiently pushed DMT and CPT—like performing them on land—the way to go!

• Successfully measured seismic waves with true-interval seismic DMT probe and seafloor hammer to 55 meters below mudline

• Undrained shear strength and deformation modulus values compared favorably with DMT, PMT, VST and CPT with properly chosen correlation factors

• Adjust the investigation as data are collected
  • 1939 data—inadequate—show sandstone instead of cemented sand layers
  • Upper clays much softer than thought
  • Lower soil much stiffer and stronger than thought—needed more pressuremeter tests

• Ideally, investigations could include direct push sounding and soil boring adjacent to each other and performed simultaneously
  • If direct push sounding has penetration refusal before desired depth, perform pressuremeter tests in boring to get high quality data in that missing in-situ test zone
  • Best use of costly barge time
THANK YOU QUESTIONS?

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