TESTS SPECIFICATIONS
DMT - MARCHETTI FLAT DILATOMETER
SDMT - MARCHETTI SEISMIC DILATOMETER

A. DMT TEST INTRODUCTION

The test consists in advancing a blade shaped probe into the ground using common field machines (usually a static penetrometer or a drill rig) and stopping at each test depth, usually every 20 cm, for collecting two pressure readings. The circular steel membrane, mounted on one side of the blade, is used for measuring two pressure readings which correspond to two fixed levels of the membrane deformation.

The Standard test procedure is described in detail in the following documents:

- ASTM (2001) "D 6635-01 Standard Test Method for Performing DMT", Book of Standards Volume 04.09
- CEN-Eurocode 7 (1999) - "Flat dilatometer test (DMT)", Part 3, Section 9

B. DMT EQUIPMENT

B. 1 Pushing machine

The machine may be a static penetrometer with a 20 t effective pushing capacity, combined with a set of push rods (ϕ_{ext} between 36 and 50 mm) or a drill rig. In this second case at least 2-3 m of push rods, connected to the DMT blade, must have a diameter ϕ_{ext} between 36 and 50 mm, while the others rods above may have a larger diameter. An electric-pneumatic cable runs inside the pushing rods and connects the blade to the surface equipment. When using a drill rig, the cable runs inside the push rods and exits laterally from a slotted adaptor, which connects the push rods to the larger diameter rods. The cable is then taped externally to the larger diameter rods.

B. 2 Original Marchetti Dilatometer equipment

The equipment shall be the original Marchetti Dilatometer set with no construction modification and shall include:

- Marchetti Dilatometer blade (95 x 200 x 15 mm), having a 1.1 mm expansion membrane
- Original Marchetti measuring control unit
- Electro-pneumatic cable between the Dilatometer and the control unit
- Gas tank, either compressed air or nitrogen, with pressure regulator able to supply up to 80 bar

C. DMT TEST PROCEDURE

C. 1 Preliminary Check

The maximum curvature of the blade, defined as the maximum clearance under a 150 mm long straight edge placed along the blade parallel to its axis, shall not exceed 0.5 mm.

The maximum coaxiality error of the blade, defined as the deviation of the penetration edge from the axis of the rods to which the blade is connected, shall not exceed 1.5 mm.

The membrane shall be clean of soil particles, free of any deep scratches, wrinkles or dimples and expand smoothly in air upon pressurization.

The control unit and tubing shall be checked for leaks before starting the test, by connecting the blade to the pneumatic-electric cable and checking for any pressure drop in the system. Leakage in excess of 100 kPa/min shall be considered unacceptable.

C. 2 Calibration

Using the supplied calibration tools, the pressure measurements of ΔA-suction and ΔB-expansion, corresponding to the membrane displacement in free air of 0.05 mm and 1.1 mm, must be taken carefully. The acceptable ranges are: ΔA 5-30 kPa and ΔB=5-80 kPa. Membranes with calibration values outside these ranges shall be replaced.

When a membrane is replaced, the new one shall be exercised to stabilize the calibration constants by means of 5 cycles. Each cycle consist in pressurizing the membrane in free air up to 500 kPa and then deflating.

The calibration procedure must be repeated at the end of the DMT test performed in each location. If at least one of the values of ΔA and ΔB measured before inserting the blade into the soil and after retrieval differ by more than 0.25 kPa, then the test readings performed between the two successive calibration procedures shall be discarded.

The test shall be performer by personnel holding the required training certificate issued by the manufacturer.

C. 3 Test layout

The dilatometer is advanced vertically into the ground stopping at depth intervals of typical 20 cm. At each test depth the following readings are taken:

- A-reading: the pressure at which membrane lifts off, which occurs when the acoustic signal turns from on to off
- B-reading: the pressure necessary to expand the membrane of 1.1 mm from its center, when the acoustic signal turns from off back to on

The A-reading should be obtained between 10-20 sec after penetration has stopped, the B-reading between 10-20 sec after A. If requested, the C-reading may taken as the pressure that acts on the membrane when, deflating the gas after B, the membrane returns to the original closed A position, re-activating the acoustic signal.

When there is a non-penetrable layer of soil, it may be drilled using a casing with ϕ_{int} at least of 100 mm. Push rods and blade are then lowered to the bottom of the hole and the test may continue below.

C.4. DMT Results

For each test location the following data shall be provided:

- Location and date of the test
- values of A and B recorded at each depth
- Initial and final values of DeltaA and DeltaB for each test location

The field readings (A, B, C) shall be processed. Final graphs and printouts shall include:

- Material index Id, correlated to the soil type (sand, silt, clay)
- Horizontal stress index Kd
- Dilatometer modulus Ed
- Constrained modulus M = 1/mv
- Undrained shear strength Cu (in cohesive soils)
- Friction angle (in sand)
- Earth pressure coefficient Ko (in cohesive soils)
- Overconsolidation ratio OCR (in cohesive soils)

D. DISSIPATION TEST 'DMT-A'

If requested, DMT-A Dissipation tests may be performed at specific test depths. When the blade is advanced to the dissipation test depth, a stopwatch is started as soon as penetration stops. A sequence of only A readings is taken, deflating as soon as the signal deactivates. The A readings are taken at time intervals that approximately double each time (es. 15 sec, 30 sec, 1 min, 2 min etc.). The A-readings are plotted linearly against a logarithmic time scale, describing the decay curve of the total pressure σ_h with time. The data processing software identifies the inflection point T_{flex} of the decay curve and providing estimates for both the consolidation and permeability coefficients according to Totani et al. (1998)

E. SDMT TEST INTRODUCTION

The Seismic Dilatometer Marchetti (SDMT) is the combination of the standard Flat Dilatometer (DMT) with a seismic module for the measurement of the shear wave velocity Vs and, optionally, also of the compression wave velocity Vp.

The standard test description and procedure is described in detail in the following document:

- ASTM (2008) 'D 7400-08 Standard Test Methods for Downhole Seismic Testing'

F. SDMT EQUIPMENT

F. 1 Pushing machine

Same indications as in section B.1.

F. 2 Original Marchetti Seismic Dilatometer equipment

The equipment shall be the original Marchetti Seismic Dilatometer set with no construction modification and shall include:

- Seismic probe: containing two receivers for the shear wave at the vertical distance of 0.5 m and, optionally a receiver for the compression wave. The electronic board inside the probe is able to amplify and digitize the electrical signals of the receivers according to the D 7400-08 ASTM standard specifications.
- Seismic acquisition control unit, connected to the seismic probe with the same cable of the traditional DMT test and to a laptop computer with a standard USB cable.
- SDMT Elab software for data acquisition and data processing.

The wave source, generally a hammer hitting a beam, may be constructed directly by the user according to specifications provided by the manufacturer.

G. SDMT TEST PROCEDURE

G. 1 Wave source positioning and sensor orientation

The beam of the shear wave source must be positioned so that the (horizontal) direction of the hammer hitting it, is perpendicular to a line between the center of the beam and the rods. The beam of the compression wave may placed in any direction. In both cases, the closer the beam to the rods, the better (generally between 0.30m-1.20m).

The sensitive axis of the shear wave receivers is the direction going inside the sensors of the SDMT probe. Before starting penetration, the SDMT probe must be rotated so that the sensitive axis of the receivers is parallel to the direction of the hammer hitting the beam. The sensitive axis of the compression wave receiver is in the correct vertical position, no matter the orientation of the SDMT probe.

G. 2 Test procedure for Vs

At each test depth penetration is stopped, typically at depth intervals of 0.50 m (or 1.0 m). When the hammer strikes the beam, the generated shear wave is recorded by the two receivers. The data is sent to the laptop computer where both seismograms are plotted. The SDMT Elab software evaluates the delay in the arrival of the shear wave and provides the interpretation of Vs real time.

G. 2 Data Processing for Vs

The shear wave velocity Vs is obtained as the ratio between the difference in distance between the source and the two receivers (S2-S1) and the wave arrival delay between the first and the second receiver (Δt).

At each test depth at least three distinct measurements shall be taken. The repeatability of Vs is a good indicator of the quality of the results, which are usually considered acceptable if the correlation coefficient is within 3%. When the test location is close to important vibration/interference sources (es. railway stations, power plants, etc), the available advanced features of the software may be used for filtering the signals and processing manually the final Vs results.

G.3 SDMT results

For every test location the following documentation shall be provided:

- Diagram and printouts of Vs with depth
- Diagram and printouts of G_0 with depth
- Printouts of the repeatability of Vs and the corresponding correlation coefficient
- Seismograms: recorded and rephased (one for each test depth)

H. Vs TEST PROCEDURE IN NON PENETRABLE SOILS

Vs measurements may be performed also in non penetrable soils (es gravel, rock, etc), where the DMT test is not possible. Below is the recommended step by step procedure:

- Drill a borehole to the final test depth, with an outer casing having $\phi_{ext} \geq 100$ mm.
- During rod extraction, stop every meter and pour an equivalent volume of fine gravel (particle size 5-12 mm, without fines) in the borehole. Drop a weight with a metric rope down the borehole, to compact the gravel and to check the correct height increase of the backfill.
- Once the backfill is completed, perform Vs test inside the borehole as in a penetrable soil.

More details of this test procedure are available at the following reference:

- Totani et al (2009), Totani, G., Monaco, P., Marchetti, S. & Marchetti, D. (2009). *Vs measurements by Seismic Dilatometer (SDMT) in non penetrable soils*. Proc. 17th ICSMGE, Alexandria, Egypt, 2 : 977-980
- See also Instrumentation SDMT