



Transport
Roads & Maritime
Services

Test method T224

Determination of the ultrasonic velocity of
soil or rock

OCTOBER 2012



Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added	D.Dash	May 1999
		Date on Test Method Revised to Agree with Date on Revision Summary	D.Dash	Feb 2001
Ed 2/ Rev 0	All	Reformatted RMS template	J Friedrich	October 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'

The most recent revision to Test method T224 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T224

Determination of the ultrasonic velocity of soil or rock

1. Scope

This test method sets out the procedure for the determination of the ultrasonic velocity of soil or rock core, irregular rock specimens or in-situ rock masses by the Pulse Delay Method.

2. Apparatus

- (a) An Ultrasonic Pulse Generator (UPG) with variable pulse rate frequency, pulse width and delay.
- (b) An Oscilloscope with at least two traces, external triggering and variable time base
- (c) Two piezoelectric transducers with transmitting and receiving transducers interchangeable
- (d) Two long coaxial cables with male connectors
- (e) Two short coaxial cables with male connectors
- (f) One coaxial cable with one male and two 3.5 mm banana plug connectors
- (g) Silicone grease
- (h) Spatula
- (i) Large outside diameter calipers readable and accurate to 0.5 mm
- (j) Millimetre rule
- (k) Diamond saw with blade, of diameter suitable to cut the specimen under test
- (l) Equipment for determination of moisture content in accordance with Test Method T262

3. Preparation

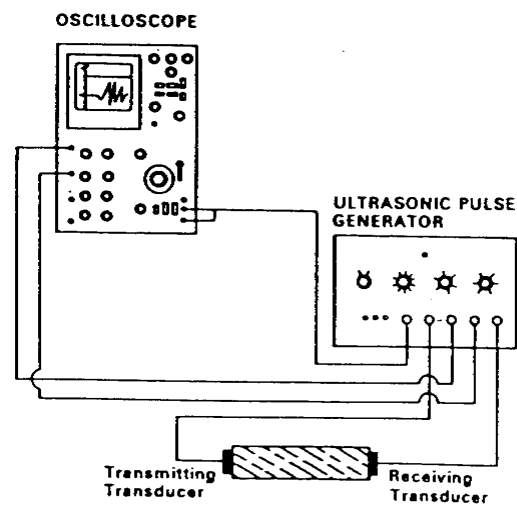
Trim the rock core and irregular rock specimens with a diamond saw. Cut two parallel faces perpendicular to the direction of measurement at a separation preferably of 150 to 300 mm. Smooth the faces preferably by lapping to remove the irregularities of the saw cut.

Treat undisturbed or remoulded soil samples in a similar fashion with two parallel faces being cut with a sharp knife perpendicular to the desired direction of measurement.

4. Assembly and Preliminary Adjustment of Equipment

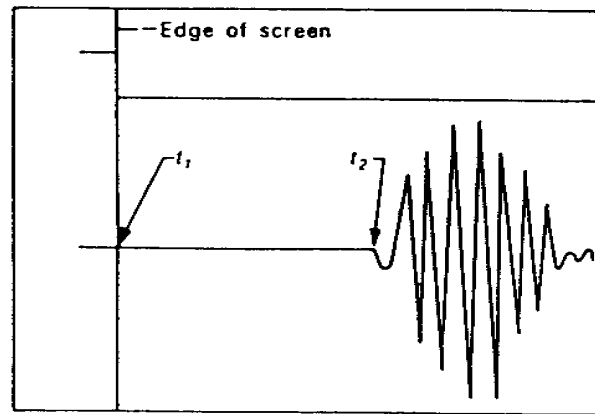
- (a) Prior to the measurement of ultrasonic velocities the Oscilloscope must be adjusted to obtain two sharp traces. The procedure for this adjustment is given in Appendix "A".
- (b) Set volts/div control (outer 15) to 2 volts/div for channel 1 and to 0.2 volts/div for channel 2.
- (c) Set variable time base control (outer 16) to 10 sec/div.
- (d) Set trigger source switch (20) to "External".
- (e) Set trigger coupling switch (21) to "AC Slow".
- (f) Set trigger slope switch (22) to "+ ve".
- (g) Connect "CRO1" terminal of the UPG to channel 1 input terminal (12) via a short coaxial cable (male/male).
- (h) Connect "CRO2" terminal of the UPG to channel 2 input terminal (12) via a short co-axial cable (male/male).
- (i) Connect "Trigger" terminal of the UPG to the "Trig" terminals (19b and 19c) via a short co-axial cable (male/banana plug) with the black banana plug connecting to the middle terminal (19b) and the red banana plug connecting to the lower terminal (19c).

- (j) Connect the two piezoelectric transducers to terminal "Pulse In" and "Pulse Out" respectively via long coaxial cables (male/male).
- (k) Ensure all controls on the UPG are fully turned clockwise.
- (l) Turn power switch of UPG to "On" position.



5. Procedure

- (a) Turn "Trigger Level" Control (4) of Oscilloscope anticlockwise until the upper trace (channel 1) initially disappears then re-appears.
- (b) Turn "Delay" control of UPG anti-clockwise until the 1 cm "step" on the upper trace (channel 1) coincides with the left hand edge of the screen. The position control (17) of the Oscilloscope may be used to set the "step" also. As the "step" on the upper trace indicates the initiation of the pulse at the transmitting transducer and therefore "zero time" its position should be set with extreme care.
- (c) Apply a small amount of silicone grease to the face of each transducer with a spatula.
- (d) Press the transducers onto each of the pre-cut surfaces working out excess silicone grease by a rotary action. Apply hand pressure to the transducers throughout the measurement if the sample is rock so as to close micro-fractures joints, etc normally closed under geostatic pressure. If the sample is soil or extremely weathered rock care should be taken in applying pressure to the transducers so as to avoid shearing of the sample.
- (e) The pulse delay time between the transmitting and receiving transducers can be measured as the time difference "Td" between "zero time" and the first down kick of the lower receiving trace as indicated on the following figure.



Schematic diagram showing typical trace of longitudinal wave. The total travel time of the longitudinal wave is calculated between t_1 , the pulse input, to t_2 , the first arrival.

By varying the Time/Div setting (outer 16) between 10 and 50 sec and the volts/div setting (outer 15) of channel 2 a sharp down kick and a large time scale setting can be achieved. The time difference "Td" should be read to an accuracy of:

1 sec for a 10 set Time/Div setting

2 sec for a 20 sec Time/Div setting

5 sec for a 50 sec Time/Div setting

- (f) Measure the distance "D" between the two measurement surfaces with vernier calipers and read to the nearest millimetre.
- (g) Determine the moisture content to the nearest 0.1% by the procedure described in Test Method T262 Determination of Moisture Content of Aggregates (Standard Method).

6. Calculations

- (a) a) Calculate the ultrasonic velocity V in metres/sec from the formula:

$$(b) \quad V = \frac{D \times 1000}{Td}$$

- (c) Where: D = transducer separation in millimetres (mm)

- (d) Td = pulse delay time in microseconds (μ sec)

- (e) Calculate the error in the measured ultrasonic velocity V from the formula:

$$V = \pm \left(\frac{Td \times \Delta D + D \times \Delta Td}{Td \times Td - Td \times \Delta Td} \right) \times 1000$$

- (f) Where ΔD = the error in distance measurement of ≈ 0.5 mm.

- (g) Td = the error in time measurement of:

- (h) $\pm 0.5 \mu$ sec for 10 μ sec Time/Div setting

- (i) $\pm 1.0 \mu$ sec for 20 μ sec Time/Div setting

- (j) $\pm 2.5 \mu$ sec for 50 μ sec Time/Div setting

7. Reporting

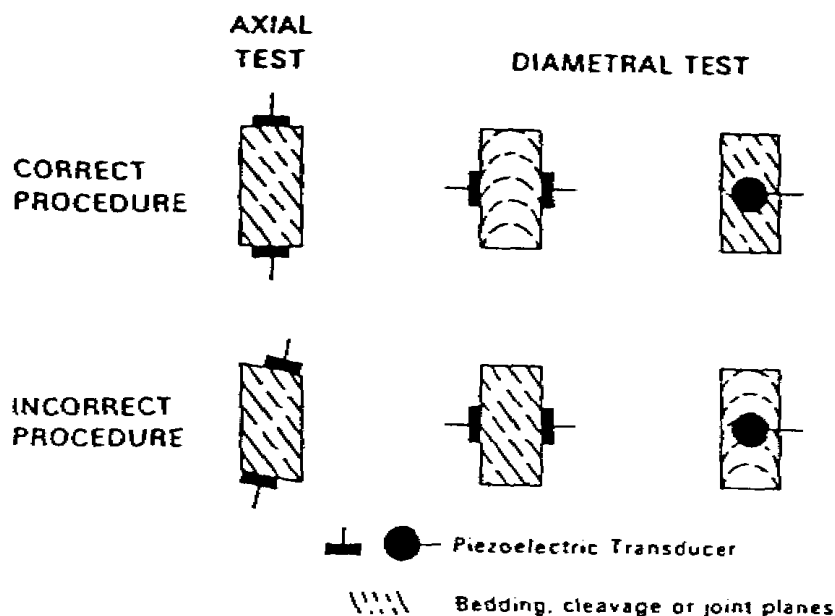
Report the following for each measurement:

- The ultrasonic velocity to the nearest 10 metres/sec
- The accuracy of the measurement to the nearest 10 metres/sec
- Type of test - axial, diametral, etc
- Material type
- Orientation of bedding, joints, cleavage etc
- Moisture content of sample, %

8. Techniques

- Diametral ultrasonic velocity measurements as well as axial ultrasonic velocity measurements are frequently required on core specimens to ascertain velocity anisotropy.

Diametral measurements should be conducted with the two transducers pressed firmly against the core (after silicone grease has been applied). The faces of the transducers should be parallel and the lines of contact should be diametrically opposed. The transducers should be carefully located with respect to bedding, joint or bedding planes when diametral core velocity measurements are being undertaken. The underlying figure sets out the correct and incorrect procedure for the measurement of axial and diametral velocities.



- If a cable fault is suspected each cable may be connected to a transducer and the "Pulse Out" terminal of the UPG. If no ticking sound is heard an internal cable fault or a faulty transducer can be inferred. Checking with another transducer will differentiate between the above two.

Appendix A: Determination of the ultrasonic velocity of soil or rock

The following procedure should be followed to align and focus traces prior to connecting the Oscilloscope to the Ultrasonic Pulse Generator.

- (a) Switch at rear of instrument to centre "chop" position.
- (b) Switch (1) at right bottom of amplifier unit to upward "chop" position.
- (c) Push in Knob (2) at left bottom of amplifier unit
- (d) Turn power switch (3) "on".
- (e) Set trigger level knob (4) to "free run".
- (f) Adjust astigmatism (5), focus (6), and intensity (7), to obtain a sharp trace with the variable Time/Div switch (16) set on 2m sec.
- (g) Set mode switch (11) to "normal" position
- (h) Set mode switch (outer 14) to "normal" for channels 1 and 2 and to "off" for channels 3 and 4. Adjust position control (inner 14) such that the trace for channel 1 is 2 cm from the top of the screen, and the trace for channel 2 lies along the centreline of the screen.
- (i) Set AC - ground - DC switch (13) of channels 1 and 2 to "AC" position.
- (j) Turn calibration control of amplifier unit (inner 15) clockwise until it clicks into "Cal" position.
- (k) Turn calibration control of time based unit (inner 16) fully clockwise to calibrate. Ensure "Uncal" light is out.

