Test Method Q258A: Dynamic modulus of deformation – light falling weight device – accelerometer type

1 Source

This method is based on ASTM E2835: *Standard Test Method for Measuring Deflections using a Portable Impulse Plate Load Test Device* and TP BF-StB Part B 8.3: *Dynamic Plate Load Testing with the Light Drop Weight Tester*.

2 Scope

This method describes the procedure to determine dynamic modulus of deformation of a soil

The test involves the soil receiving an impact of maximum force transmitted through the fall of a drop weight onto a circular load plate of radius r that is assumed to be rigid. Force is selected during calibration, by adjusting the drop height, so the maximum normal stress under the load plate is 0.1 MPa during the test. The resulting deflections are measured at the centre of the top of the load plate. These deflections are used to calculate the dynamic modulus of deformation (E_{vd}).

These data may be used for quality control of compacted layers of earthworks with fine and coarse grained materials up to a maximum particle size of 63 mm. It is suitable for materials with a dynamic modulus of deformation in the range of 15–70 MPa. It is not a replacement for proof rolling.

3 Apparatus

Where appropriate, the working tolerances of particular apparatus are contained in Table 1. Examples of the apparatus are shown in TP BF-StB Part B 8.3: *Dynamic Plate Load Testing with the Light Drop Weight Tester* Figure 2 (Note 9.1).

The following apparatus is required:

3.1 Light drop weight tester as follows:

a) Force generating device (falling mass), 10 kg, capable of being raised to a pre-determined fixed height and dropped onto a steel spring assembly. Providing a maximum impact force of 7.07 kN. The resulting force pulse transmitted to the surface shall provide a half-sine or haversine-shaped load pulse with a time of loading of 17 ms and produce a peak load with a resolution of 0.1 kN.

b) Load plate, 300 mm diameter, 20 mm thick and mass of 15 kg, rigid and capable of transferring the impulse load to the surface.

c) Deflection sensor, attached to the centre of the load plate, capable of measuring the maximum vertical plate movement in the range of 0.3 mm to 1.5 mm with a resolution of 0.02 mm. The instrument shall be constructed to measure the vertical plate deflection at the centre of the point of impact.

d) Data processing and storage system, able to store and display load and deflection data. The peak load and deflection measurements are to be recorded within a time of 50 ms or longer.

3.2 Suitable tools for levelling and smoothing the material surface.

3.3 Fines, dry fine sand or dry native fines passing a 0.600 mm test sieve.

3.4 For checking the device:

a) steel rule, one metre long, with a resolution not exceeding one mm

b) rigid and level base, with a total mass not less than 200 kg, for example, concrete floor; the same base must be used for the duration of the calibration

c) base plate, steel, 340 mm diameter and mass of 30 kg, rigid and capable of transferring the impulse load to the rubber; must be able to be attached to the load plate with a quick clamping device, and

d) rubber mats, at least one capable of providing a one mm settling. Mats 500 mm square with thickness three mm, 10 mm and 25 mm, hardness of 60 IRHD and conforming to AS 5100.4 have been found to be suitable.

4 Calibration

Undertake calibration of the force generating device and deflection sensors at least once every 12 months using the procedure in TP BF-StB Part B 8.3: *Dynamic Plate Load Testing with the Light Drop Weight Tester* (Note 9.2). When the device is returned from calibration, undertake the check in Section 5 and record the mean of the maximum settlement of the load plate under load (S_{max}) from the 10 drops as the reference settlement value.

5 Operational checks

To ensure the device is operating normally, the checks are to be undertaken before use as follows:

5.1 Verification (frequency: daily before use)

5.1.1 Remove the device from carry case and place near the base.

5.1.2 Using the steel rule, measure the drop height of the device. Compare the measured drop height and the drop height recorded on the calibration certificate. If necessary, adjust the drop height to match the drop height recorded on the calibration certificate.

5.1.3 Sweep the surface clean and place the rubber mat on the base.

5.1.4 Using quick clamps, attach the base plate to the load plate.

5.1.5 Perform 10 drops as detailed in Steps 6.6.1 to 6.6.5

5.1.6 Using the 10 resulting maximum settlement of the load plate under load (S_{max}) determine the minimum and maximum values and the mean value.

5.1.7 Compare the minimum and maximum values from Step 5.1.6, and if they differ by more than 0.04 mm remove the device from service for calibration.

5.1.8 Compare the mean value from Step 5.1.6 with the reference settlement value from Section 4, and if the absolute difference is more than 0.02 mm remove the device from service for calibration.

5.2 Checking drop height (frequency: before use on site)

5.2.1 Remove the device from carry case.

5.2.2 Using the steel rule, measure the drop height of the device. Compare the measured drop height and the drop height recorded on the calibration certificate.

5.2.3 If the drop height needs adjustment, perform the verification detailed in sub-section 5.1. If the device does not pass verification, remove the device from service for calibration.

6 Procedure

The procedure shall be as follows:

6.1 Remove any loose material and vegetation from around the test site to create a flat and level surface to undertake the test. The site should be 1.5 times larger than the diameter of the load plate.

6.2 Sweep all loose material from the test site and sprinkle fine sand or native fines on the surface, then smooth the surface.

6.3 Place the load plate on the prepared test location.

6.4 Rotate the load plate left and right to an angle of 45 degrees.

6.5 Perform three falling mass drops for seating, with the procedure for each drop as follows:

6.5.1 Raise the falling mass to the pre-set drop height and secure into release mechanism.

6.5.2 Adjust guide rod to vertical.

6.5.3 Release falling mass and allow to fall freely.

6.5.4 Catch the falling mass after rebound.

6.5.5 Record the resulting maximum settlement of the load plate under load (S_{max}) and maximum deformation speed of the load plate under impact load (V_{max}).

6.5.6 If the load plate tilts, the seating deflections (S_{max}) differ from one another by more than 10 percent, a faulty drop occurs, the load plate is displaced, or the guide rod moves, then the test is not valid. Position the test device at a new location and start the test procedure from Step 6.1. Testing cannot be repeated at the same location.

6.6 Perform three falling mass drops for analysis, with the procedure for each drop as follows:

6.6.1 Raise the falling mass to the pre-set drop height and secure into release mechanism.

6.6.2 Adjust guide rod to vertical.

6.6.3 Release falling mass and allow to fall freely.

6.6.4 Catch the falling mass after rebound.

6.6.5 Record the resulting maximum settlement of the load plate under load (S_{max}) and maximum deformation speed of the load plate under impact load (V_{max}).

6.7 If the load plate tilts, a faulty drop occurs, the load plate is displaced, or the guide rod moves, then the test is not valid. Position the test device at a new location and start the test procedure from Step 6.1. Testing cannot be repeated at the same location.

6.8 If required, obtain a sample of the soil and determine the moisture content as detailed in Test Method AS 1289.2.1.1 or record the moisture condition of the soil (dry, moist, wet).

7 Calculation

Calculations shall be as follows:

7.1 Calculate the mean deformation speed of the load plate under impact load from Step 6.6 as follows:

$$v_{max} = \frac{v_{max1} + v_{max2} + v_{max3}}{3}$$

where v_{max} = mean deformation speed of the load plate under impact load (mm/s)

$v_{max1}, v_{max2}, v_{max3}$ = maximum deformation speed of the load plate under impact load (mm/s)

7.2 Calculate the mean maximum settlement of the load plate under load from Step 6.6 as follows:

$$s_{max} = \frac{s_{max1} + s_{max2} + s_{max3}}{3}$$

where s_{max} = mean maximum settlement of the load plate under load (mm)

$s_{max4}, s_{max5}, s_{max6}$ = maximum settlement of the load plate under load from mass drops 4, 5 and 6 (mm)

7.3 Calculate the impact duration (as follows:

$$s/v = \frac{s_{max}}{v_{max}}$$

where s/v = impact duration (ms)

s_{max} = mean maximum settlement of the load plate under load (mm)

v_{max} = mean deformation speed of the load plate under impact load (mm/s)

7.4 Calculate the dynamic modulus of deformation as follows:

$$E_{vd} = 1.5\ r\ \frac{\sigma_{max}}{s_{max}}$$

where E_{vd} = dynamic modulus of deformation (MPa)

r = radius of load plate (mm)

σ_{max} = normal stress under load plate (usually 0.1 MPa)

s_{max} = mean maximum settlement of the load plate under load (mm)

8 Reporting

The following shall be reported:

8.1 The location at which the test was performed.

8.2 The date tested.

8.3 A description of the material tested.

8.4 Test device details, such as make, model and serial number.

8.5 Test configuration details, such as plate diameter.

8.6 A tabulation of maximum settlement to the nearest 0.001 mm and maximum deformation speed to the nearest 0.1 mm/s for each drop (Step 6.6).

8.7 Impact duration to the nearest 0.001 ms.

8.8 Dynamic modulus of deformation to the nearest one MPa.

8.9 Moisture content of the soil or the moisture condition of the soil, that is, wet, moist or dry, if required.

8.10 The number of this Test Method, that is Q258A.

9 Notes on method

9.1 This method is suitable for devices such as the Zom ZFG 3000, HMOP LFG, Terratest 4000, Terratest 5000 and Olsen LWD-1.

9.2 Until a NATA-accredited calibration facility is available in Australia, a calibration agency accredited by the German Federal Highway Research Institute (BASt) will be acceptable. The calibration frequency would remain at 12 months.

Table 1 – Test apparatus requirements

Apparatus	Requirement	Tolerance
Falling mass		
Mass (kg)	10.00	± 0.10
Maximum impact force (kN)	7.07	See Note
Duration of impact (ms)	17	± 1.5
Guide rod		
Mass (kg)	5.00	± 0.10
Load plate		
Diameter (mm)	300.0	± 0.5
Plate thickness (mm)	20.0	± 0.2
Mass (kg)	15.00	± 0.25

Note: Maximum impact force is defined by adjusting the drop height during calibration. The duration of impact is adjusted during calibration.