ZORN LWD Cue Card

Practical tips for using the ZORN Light Weight Deflectometer

Important note for valid performance of the Dynamic Plate Load Test:

The LWD load plate always needs to be in full contact with the test surface. There must be no single larger grains directly under the load plate. To smooth out any unevenness, a thin 'layer' of dry medium sand may be applied, but this must only compensate for unevenness under the load plate.

Measuring range

The ZORN LWD Light Weight Deflectometer is available with two different loading devices with the following characteristics:

- 10 kg drop weight with max. 7,070 kN (standard) impact force
- 15 kg drop weight with max. 10.605 kN (1.5 times) impact force

Selection of the suitable falling weight should be based on the expected bearing capacity or desired degree of compaction of the material to be tested. The 10 kg device is initially recommended for testing natural soils or material of unknown bearing capacity.

▶ The 10 kg loading device is suitable for tests on unbound, coarse-grained or mixed-grained soils with a maximum grain size of 63 mm. In addition, also for stiff to firm, fine-grained soils* and comparable building materials.

(*according to DIN 18196 or analogue national standards)

▶ The 15 kg (10.605 kN) loading device is suitable for testing layers of natural or artificial aggregates with an expected high bearing capacity. This includes, for example, crushed rock, certain recycled materials and slag. In addition, the 15 kg loading device is suitable for comparative testing of the bearing capacity of soils after stabilization with binding agents.

10 kg Falling weight (F_{max} 7,070 kN)	Deflection (s_{max})	Deformation modulus (E_{vd})	Deflection (s_{max})	15 kg Falling weight (F_{max} 10,605 kN)
Not applicable		100 MPa (MN/m²)	0,338 mm	Highly compacted soil/aggregates, excellent load bearing capacity. Foundation for heavy traffic roads.
Very well compacted soil, high bearing capacity. Suitable for heavy traffic roads (e.g. motorways).	0,321 mm	70 MPa (MN/m²)	0,480 mm	Very well compacted soil, high bearing capacity. Suitable for heavy traffic roads (e.g. motorways).
Well compacted soil, good bearing capacity. Foundation for interurban, connecting roads.	0,450 mm	50 MPa (MN/m²)	0,680 mm	Well compacted soil, good bearing capacity. Foundation for interurban, connecting roads.
Low compacted soil, reasonable bearing capacity. Foundation for e.g. low-load traffic & parking lots.	0,750 mm	30 MPa (MN/m²)	1,130 mm	Not applicable
Low or non-compacted soil, low bearing capacity. Not directly suitable for construction.	4,500 mm	5 MPa (MN/m²)		Not applicable

Calibrated deflection range

The s/v ratio

The s/v ratio of maximum deflection (s_{max}) to maximum plate speed (v_{max}) is a useful supplement to the deformation modulus E_{vd}. Based on comprehensive empirical studies, this value provides important information on the quality of compaction and the expected effectiveness of further compaction efforts.

In addition to E_{vd}, the s/v ratio helps both quality inspection and contractors to make decisions on site, e.g. to increase layer thickness, soil improvement or soil replacement.

The s/v ratio must always be considered in conjunction with the individual load plate deflections (s_1 - s_3) and the resulting E_{vd} value!

If s/v < 3,5 ms

- The soil is well compacted and has reached its optimum. The E_{vd} value is as expected.

If s/v > 3,5 ms

Check the following possible causes:

- The soil is insufficiently compacted (look at individual deflections, s_1 - s_3 decreasing with a clear difference between drops).
- The thickness of the compacted soil layer is insufficient. The impact force of the LWD reaches through the top layer into the underlying soil. Maximum measuring depth 50-60 cm.
- Material is too soft (e.g., brittle recycling material, soil with residues of organic components).
- Water content too high (or high water-table)
- The material itself is difficult to compact (poor grading, unfavourable sieve curve).

Correlations and reference values

In practice, the question often arises as to the comparability of the results of the static and dynamic plate load tests or the degree of compaction, i.e. the ratio between the actual dry density on site and the maximum (Proctor) dry density of the same soil.

While it is not yet possible to establish a mathematical correlation between E_{v1}/E_{v2}, E_{vd} and D_{Pr}, empirical values do exist for various soil classes. These can be found in technical guidelines such as German ZTV E-StB (Supplementary Technical Conditions of Contract and Guidelines for Earthworks in Road Construction).

Soil class (DIN 18196)	Static Deformation Modulus E_{v2} in MPa	Dynamic Deformation Modulus E_{vd} in MPa	Proctor Density D_{Pr} in %
GW, GI	≥ 100 ≥ 80	≥ 50 ≥ 40	≥ 100 ≥ 98
GE, SE, SW, SI	≥ 80 ≥ 70	≥ 50 ≥ 40	≥ 100 ≥ 98

Source: ZTV E-StB 2017, Section 14.3.5. Evd values each for 10 kg drop weight with max. 7.070 kN impact force.

In Germany, the following load-bearing capacity requirements apply to the foundation level (surface of the subsoil or substructure that has been levelled). Based on the relevant soil classification, these values can help to guide LWD users also in other regions.

Soil class (DIN 18196)	Static Deformation Modulus E_{v2} in MPa	Dynamic Deformation Modulus E_{vd} in MPa
General	≥ 45	(≥ 25)*
After soil treatment	≥ 70	(≥ 40)*
GW, GI	≥ 100	≥ 50
SW, SI	≥ 80	≥ 40

Source: ZTV E-StB 2017, Section 4.5.2 (except* guide values ZORN Instruments)
The requirements stated refer to a 10 % minimum quantile with 8 LWD test positions per 1.000 m²

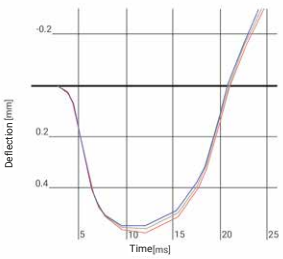
Interpretation of measured values

The following sample results are based on real tests with the ZORN LWD Light Weight Deflectometer. They provide reference points for categorizing your own tests, particularly in the event of unexpected results.

1

Test on an optimally compacted soil with good bearing capacity. Individual deflections slightly decreasing with small differences between drops. Mid-range E_{vd} value and s/v < 3.5.

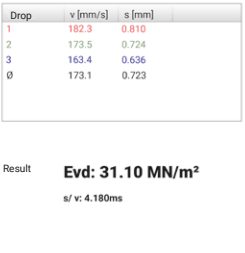
Recommendation: Finish compaction work!

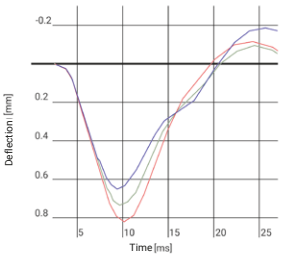


2

Test on insufficiently compacted soil. Individual deflections strongly decreasing with significant differences between single drops. E_{vd} value below possible optimum, s/v > 3.5.

Recommendation. Continue compaction!

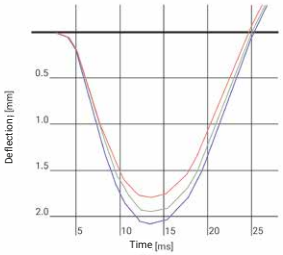




3

Testing on soaked ground or high water table terrain. Large individual deflections increasing in the course of the test. E_{vd} value insufficient and s/v well above 3.5.

Recommendation. Allow to dry and repeat test if necessary! Coordinate further measures!



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FAQs

Further examples can be found in the FAQ section of our website.

E_{vd}

Find out more about assigning the degree of compaction with the static and dynamic deformation modulus.