

Asphalt Tester Modified Light Weight Deflectometer

Supplementary notes on opening asphalt pavements to traffic
(German FGSV no. 733)

Dynamic deformation modulus E_{vd} Asphalt
(ZORN INSTRUMENTS 2010)



BACKGROUND : Standards and Procedures

In Germany and many other countries, road pavements are preferably made of asphalt; mostly being conventional bitumen-mineral mixes. More recently, also so-called modified asphalt mixes have been used that promise, for example, lower energy consumption during construction or allow the use of recycled material as components.

The construction of asphalt pavements itself is regulated by numerous technical standards including many test procedures that are supposed to guarantee the long-term, safe and economical use of roads.

Surprisingly, many of these test standards date back to the early days of industrial road construction, in the 1920s and 1930s. Innovation in testing is slow to catch on with modernisation in materials and construction equipment.

OUR GOAL : Asphalt Testing with a LWD

As pioneers of the Dynamic Plate Load Test, ZORN INSTRUMENTS have had their sights set on the use of Lightweight Deflectometers (LWD) for asphalt for some time. Or rather, the transfer of LWD operating principles to a field test device that would enable a reliable evaluation of the load-bearing capacity of asphalt pavements. That similar to the use of LWDs on unbound soils for road substructures.

Branded in-place testing devices within that field are the (Heavy) Falling Weight Deflectometer (FWD) or the Benkelman beam. Monitoring the relative compaction of hot asphalt during paving with nuclear density gauges is also common.

These methods surely provide important characteristic values, but also have eminent weaknesses. Both in terms of the significance and interpretation of test results and in terms of their user-friendliness.

THE CHALLENGE : Surface vs. Substructure

The deformation behaviour of asphalt differs considerably from that of unbound sand, gravel or ballast layers. Strength and stiffness are generally much higher. Load resistance of asphalt is temperature-dependent. And, as experience shows, load bearing properties change over the period of use. The number of available asphalt material mixtures and installation methods is also much greater than for soil substructure.

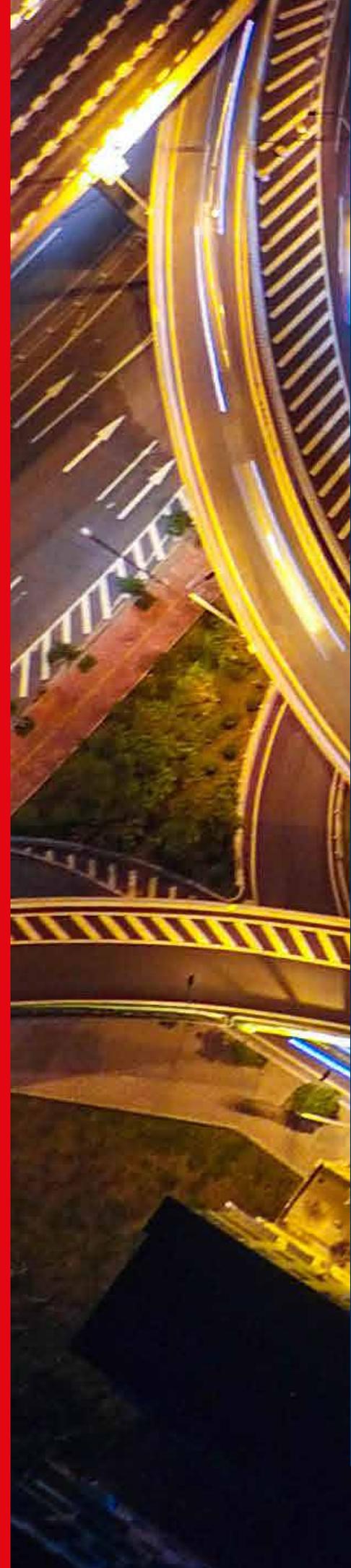
In order to produce a measurable deformation of the asphalt surface with the limited impact force of a LWD (realistic maximum approx. 10 kN), the ZORN Asphalt Tester uses a tempered steel plunger instead of a load plate. Depending on the planned application, several exchangeable plungers can be used, with diameters between 12 and 50 mm.

A 15 kg, ergonomically shaped falling weight with catch handle falls onto the test plunger from a height of 520 mm and generates an impact force of 9,420 kN with an impact duration of 17 ms. The resulting pressure under the plunger surface for a 50 mm plunger is 4,8 MN/m² (MPa).

There is a disc spring assembly mounted inside the falling weight (ZORN patent) ensuring a uniform force distribution on the plunger. The falling weight can be caught effortlessly when bouncing back.

A precise sensor measures the acceleration of the test plunger with each impact. From this acceleration value, the device automatically calculates the maximum penetration depth (deflection s) as well as the speed at which the plunger moves.

In parallel, a second sensor determines the surface temperature of the asphalt.



ZORN ASPHALT TESTER : a modified LWD

Prototypes of an asphalt tester LWD had been available from ZORN already since 2010, but have now been radically revised.

The device hardware can be taken apart into three component blocks that can easily be lifted by one person and transported in any passenger car. At the test site, the operator swiftly reassembles these three blocks in a few simple steps.

When put together, the ZORN Asphalt Tester does not require a separate trolley or similar device for transport on site. The operator simply rolls the device comfortably between measuring points on large, integrated wheels. Once there, the drop weight section is moved from transport into the measuring position with a click and testing can begin.

The ZORN Asphalt Tester is controlled wirelessly by means of a tablet computer. The tablet computer is connected to the sensors of the tester via Bluetooth (acceleration & temperature). The easy-to-use control software also offers the possibility to seamlessly create test reports and send them to co-workers or clients online. ZORN Asphalt Tester - consistently digital and connected!

The revolutionary ZORN Asphalt Tester can be used alternately for the following test procedures.

- Release test according to "Supplementary notes on opening asphalt pavements to traffic" (H VVA), FGSV Germany, edition 2022
- Determination of the elastic surface deformation and determination of a deformation modulus $E_{vd \text{ Asphalt}}$ (non-standardized)

RELEASE TEST : according to H VVA

These German FGSV supplementary notes were published in 2022. They describe a procedure in which the deformation behaviour of an asphalt layer is continuously measured during the cooling phase by means of a modified LWD device.

The aim of this test is to help determine the appropriate cooling time for asphalt pavements before opening them to traffic, depending on the deformation behaviour of a freshly roller-compacted asphalt surface. The test can be used instead of or in addition to the known fixed cooling times (for Germany according to technical regulation ZTV Asphalt-StB, with 24 h / 36 h standard cooling periods).

For the deformation behaviour evaluation, a modified LWD device is used; according to the principles of an axial-dynamic plunger indentation test. Immediately after compaction, 5 consecutive load impacts are applied to the asphalt surface. Based on the resulting deflection and deflection differences, the deformation behaviour of the fresh asphalt surface can be assessed at the respective measuring point.

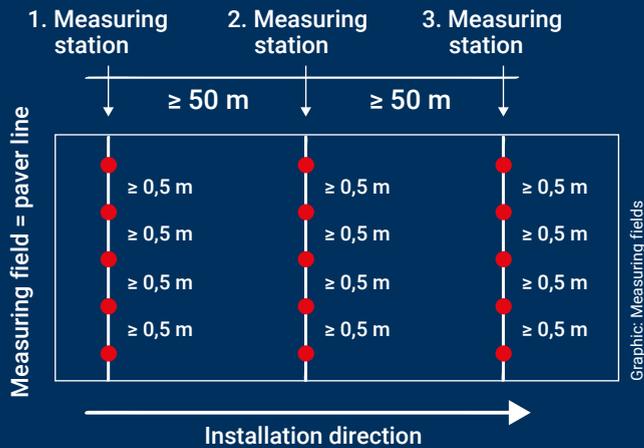
A release coefficient " A_{VF} " is determined for this test by comparison of the measured mean dynamic deflection s_m of the plunger with a defined reference deflection s_{ref} .

$$A_{VF} = 1 - \left(\frac{s_m - s_{ref}}{s_m + s_{ref}} \right) \times 100$$

A_{VF} = release coefficient in %
 s_m = mean dynamic plunger deflection in mm at the measuring point
 s_{ref} = reference deflection in mm



A total of 15 measuring points in 3 measuring stations over a distance of 100 Meters form the measuring field required for a complete test.



- At least three measuring stations per measuring field
- Five measuring points per measuring station
- Five load impulses per measuring point
- One load impulse provides one measured value

The test device used is a modified Light Weight Deflectometer (LWD) according to German technical standard TP BF-StB, Part B 8.3 (or ASTM E2835 respectively). For use as an asphalt test device, in difference to the load plate, a test plunger (non-bevelled, flat, diameter 50 ± 0.1 mm) is loaded by a falling weight with a mass of 15 kg, producing an impact force of 9.42 kN, with an impact duration of (17 ± 1.5) ms.

If all 15 measuring points show a value $A_{VF} = 100\%$, the road can be opened to rolling traffic.

DYNAMIC DEFORMATION MODULUS : $E_{vd \text{ Asphalt}}$

A further application for the ZORN Asphalt Tester, which is particularly interesting for research and university studies, is the determination of elastic surface deformations and a Dynamic Deformation Modulus for asphalt ($E_{VD \text{ ASPHALT}}$).

Based on theoretical considerations of Weingart et al., ZORN INSTRUMENTS have offered a prototype style LWD Tester for asphalt for some time (ZORN AT 3000). Technically, the device is also based on the principle of an axial-dynamic plunger penetration test.

This asphalt tester determines the penetration depth and speed of test plungers of different diameters under a dynamic load. Using the measured maximum penetration depth (deflection) and a set of further variables, a deformation modulus is determined according to the following formula.

$$E_{vd \text{ asphalt}} = 2 \times (1 - \mu^2) \times r \times \frac{\sigma}{s}$$

$E_{vd \text{ asphalt}}$ = Stiffness modulus (MPa)
 μ = Poisson's ratio (use 0.5 as the default)
 σ = Maximum contact stress (kPa)
 s = Maximum deflection (mm)

Although well a dozen of these test devices has been used by research institutions in Europe and the United States, a technical standard for this test still has to be published in future.



EXPERIENCE : the Precious Asset

- Since 1870: Product development, design and manufacturing from a single source at ZORN
- Since 1950: Specialisation in the field of dynamic test equipment
- From 1990: Germany-wide introduction of the ZORN ZFG Light Weight Deflectometer and recording of the dynamic plate load test in the "Technical Test Specifications for Soil and Rock in Road Construction".
- Since 2000: international standardisation of the Light Weight Deflectometer with ZORN
 - Austria: RVS 08.04.04 (March 2008)
 - Spain: UNE 103807-2:2008 (July 2008)
 - USA: ASTM E2835
 - Russia: N° 52068-12 (State Register approved measuring instruments)
 - Australia: Q726B Deflections - Portable Impulse Plate Load Test Device
 - Belgium: SB 250 versie 4.1, 4.16.2 (April 2019)
 - Switzerland: VSS 70 313 (July 2019)
- Since 2020: Quality inspection on construction sites with ZORN ZFG daily, thousands of times, worldwide
- Active exports to more than 100 countries
- At least 75,000 ZORN devices sold (13,000 ZFGs)

SERVICE CONCEPT : the Basic Idea

- Direct purchase as an end customer or via the specialist trade: ZORN test devices plus competent advice - always, personally, and free of charge.
- Passing on user knowledge: ZORN practical seminars with over 2,200 participants since 2008
- Digitalisation in construction becomes reality: ZORN Viewer App, ZORN D plus App, ZORN FG-WebApp
- ZORN support on all channels: telephone, email, web or even in person
- ZORN Support 24/7: many documents and information available online at any time

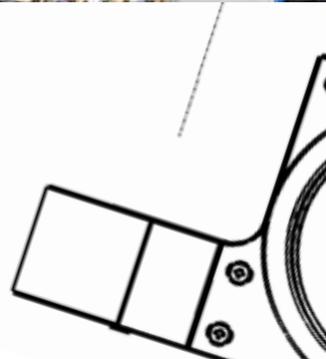
CALIBRATION : the Important Detail

- No valid test without calibration: ZORN calibration stations for the Light Weight Deflectometer nationally and worldwide
- For short journey or delivery: BAST certified ZORN test benches in Germany: 2x Stendal, 1x Munich, 1x Hamburg
- For faster processing international: ZORN certified test benches in Austria, Australia, Belgium, Poland, Russia, Slovenia and USA
- The GERMANY reference: Calibration level for the Light Weight Deflectometer at the Federal Highway Research Institute (BAST): a ZORN product
- From a single source: calibration, maintenance, pick-up/-delivery service
- Double calibration reminder: in the device, by email



Annual Calibration:

According to German test specification TP BF-StB Part B 8.3, Light Weight Deflectometers have to be calibrated every year.





Subject to change without prior notice.
Status: 10/2022

WORLD CONVENIENCE : the Special touch

- Hanseatic down-to-earth: Founded by master mechanic Wilhelm Schließer in 1870: over 150 years of "Made in Germany"
- Around the world with precision mechanics in the genes: from ZORN safes, sewing machines and bicycles to high-precision testing equipment.
- Family business anchored in the Altmark in the 5th generation: Bianca Zorn - Owner and Managing Director
- Ball, test needle and scale: the components of a Brinell hardness tester form the ZORN logo

PRECISION : the Precision Engineering Gene

- In addition to its own laboratory, material and road test equipment, ZORN regularly manufactures prototypes, small series and special workpieces for clients from the food processing, medical technology and automotive industries, among others.
- Clients benefit from the work of experienced ZORN designers and highly qualified employees on state-of-the-art turning and milling machines. Surface finishing and individual assembly round off the offer.

KNOWLEDGE : the Strong Passion

- Cooperation with universities, colleges and scientific institutions, participation in research associations: indispensable for ZORN
- User training and information events: ZORN Fuel for Improvement
- ZORN Training and internships: Not only for our own junior staff
- Bachelors, Masters and semester theses: YOUR project at ZORN



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