ZORN INSTRUMENTS

www.zorn-instruments.com

ZORN DYNAMIC CBR

Laboratory and Field Testing

According to TP Gestein-StB Part 5.6 (Germany)

Made in Germany

PREFACE : Road Construction

The main function of the subbase of roads is to distribute traffic loads applied to the surface to the underlying subgrade in a way that, as far as possible, there is no long-term impairment to the road structure in its entirety.

Design engineers and constructors are using technical key characteristic that enable a reliable assessment of the load-bearing capacity of a subgrade as well as a practicable dimensioning of the subbase to be built. For example, with regard to the required layer thicknesses depending on the construction material used.

KEY TECHNICAL CHARACTERISTICS : CBR

The so-called CBR value (California Bearing Ratio) has become such an established key measure for assessing the strength of subgrade material and for dimensioning the layer thickness of the road base, especially in the US and other English-speaking countries.

CBR is measured with a standardized penetration test that was developed in the 1930s by the California Division of Highways (USA), originally for pavements of airfield surfaces.

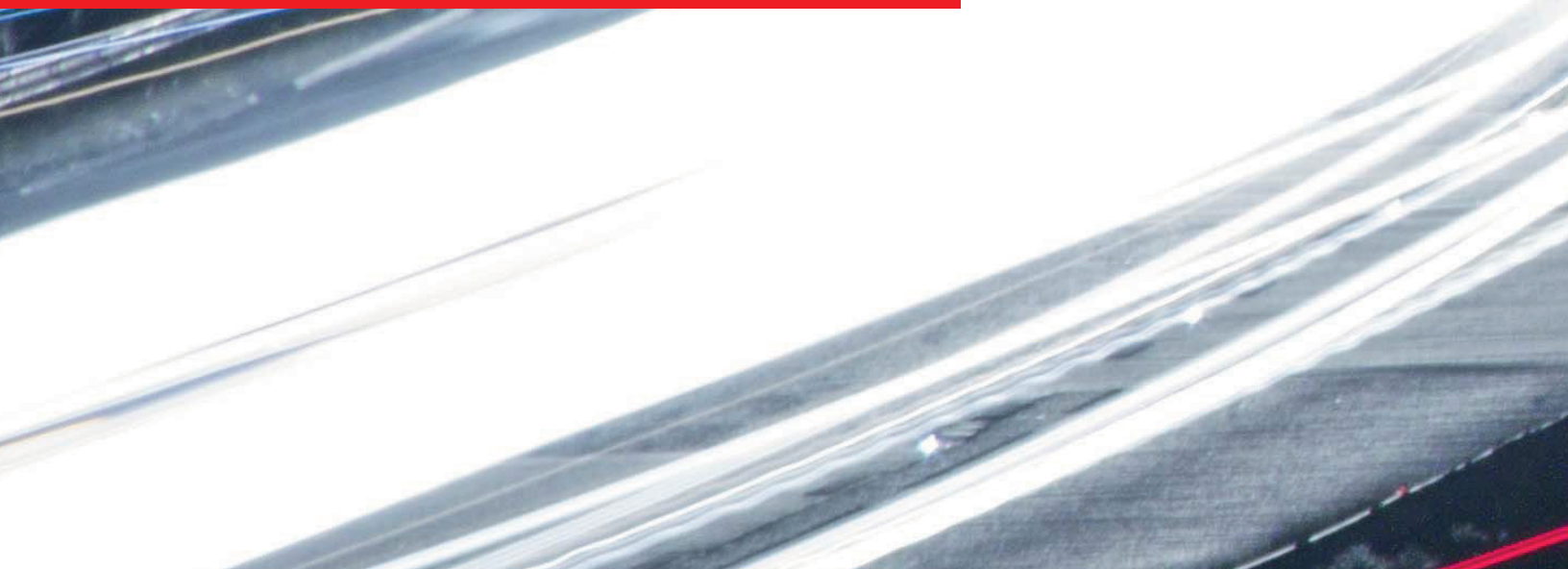
CBR TEST : the Original

CBR can be carried out as a laboratory or field test. Both variants are well-standardized (ASTM D1883, D4429 or DIN EN 13286-47, among others).

In the laboratory test, a soil sample taken from the construction site is first compacted in a mould consistent with the Proctor density test. Then a 50 mm diameter plunger is pressed into the sample at a constant speed (1.27 mm/min) to a defined depth, first 2.5 and then 5 mm. The load required for this is measured and then put in relation to the load required for the same penetration depth in a reference material (originally wide-graded, crushed Californian limestone). The result is expressed as a percentage value.

In simple terms, the closer the reported CBR value is to 100 per cent (%), the higher the bearing capacity of a material or material mix.

In the CBR field test, the same 50 mm plunger is pressed directly into the soil surface at the construction site. The required load as well as the penetration depth are determined via dial gauges. A counterweight is needed for the test, usually a truck or construction vehicle.



RELEVANCE : CBR Values

The CBR principle is simple and the classic test procedure provides a very tangible technical characteristic. This is probably one of the reasons why CBR has been established for many decades. CBR measurements form the basis for establishing the layer thicknesses of pavement substructures in numerous technical guidelines, very prominently e.g., in the British CD 225 (Design for new pavement foundations).

However, the significance and thus the usefulness of the CBR value are not undisputed.

The measurement depth of the test is comparatively low. And, as with the Proctor test, the laboratory CBR test is carried out on a disturbed soil sample at optimum water content. Transferring the results back to real construction site conditions is therefore only useful to a limited extent. Although the CBR field test is carried out directly on the construction site, it is time-consuming and often presents the person carrying out the test with considerable practical problems. The results for both laboratory and field tests are generally difficult to reproduce.

IMPORTANT! The classic CBR test is based on the empirically determined behavior of a reference material that had originally been sparsely characterized. For alternative soil performance characteristics, such as stiffness moduli or shear strength, there meanwhile exist very user-friendly test methods and devices (e.g., the Light Weight Deflectometer for the dynamic plate load test).

ALTERNATIVE METHODS : CBR Determination

CBR can be empirically related to the results of plate load tests or penetrometer soundings.

Where dynamic cone penetrometers (DCP) are used, CBR values are derived from the resistance values of the cone tips when they are driven into the ground. Results are based on evaluations and empirical correlations with the conventional CBR.

The best-known device here, certainly is the KESSLER DCP from the United States. The procedure and DCP design are based on research, completed by the US Army Corps of Engineers. Using their correlation tables, the KESSLER DCP enables time-saving, CBR based verification of the bearing capacity of soils down to depths of 1.50 meters, e.g. for unpaved runways.

ZORN INSTRUMENTS : dynamic CBR

Dynamic CBR, developed by ZORN INSTRUMENTS, represents a comparatively new alternative to the conventional CBR.

This method combines the principle of a test plunger from the original CBR test with the practical advantages of the dynamic plate load test with a Light Weight Deflectometer (LWD).

A test plunger with 50 mm diameter is dynamically loaded with a defined impact force of 7.070 N. This load generates a corresponding pressure amplitude of 3.6 MPa. The resulting plunger deflection is measured and then used to calculate the Dynamic CBR value according to the following formula.

$$CBR_d = \frac{24{,}26 \times p}{s^{0{,}59}} \; [\%]$$

Dynamic CBR values come out as a percentage (%), analogous to the conventional test.

The main theoretical basis for this Dynamic CBR has been research work in Germany, in the 1980s and 1990s, by Weingart and Floss, among others.

USE AND RELEVANCE : dynamic CBR

Similar to dynamic plate load tests with the Light Weight Deflectometer (LWD), the operator only needs a few minutes to determine Dynamic CBR. The short test duration thus enables a large number of tests to be carried out in the same time that would be required for a classic CBR test or other alternative methods. The Dynamic CBR device guarantees performance of reliable tests with the greatest possible repeatability. The Dynamic CBR calculation is carried out automatically.

Dynamic CBR equipment for laboratory and/or field tests is available from ZORN INSTRUMENTS both as a stand-alone device or as an accessory to ZORN ZFG Light Weight Deflectometers.

Dynamic CBR proves to be a complex strength value for soil and aggregates that depends not only on the material strength but also on grain shape, grain roughness, grain composition, content of fines, water content and other variables. The dynamic CBR value can therefore be used not only to assess the load-bearing capacity and compactability of a building material mixture, but also to evaluate its sensitivity to frost.

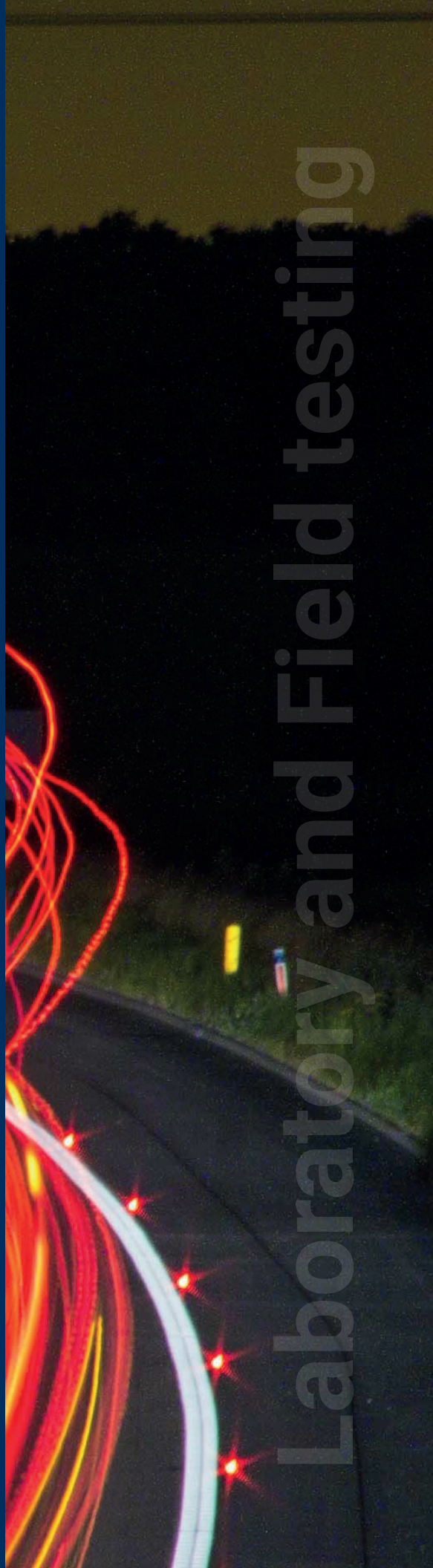
In Germany, the laboratory test method for determining Dynamic CBR is described in technical test specification TP Gestein-StB Part 5.6 (2008) and may currently be used for construction materials with a grain content > 22 mm of ≤ 50 mass%.

However, the Dynamic CBR potential goes beyond this and is also promising for other applications.

Recent University research has shown, reliable correlations can e.g., be determined between dynamic and conventional CBR for recycled concrete aggregate (RCA). Recycled concrete is growing as an alternative subbase material in road construction. However, the material tends to be stiffer than conventional sand, gravel or aggregate mixes, which limits the use of other test methods, like e.g., the LWD. Thus, the use of Dynamic CBR with reference to existing technical regulations on classical CBR is conceivable.

- Gravel, broken granite and limestone (0/32 mix, Proctor dry density 2.16 to 2.26 g/cm³): CBR_d = 0,43 to 0,55 x CBR and $CBR_{d,m}$ = 0,6 x CBR ($CBR_{d,m}$ mean CBR_d value of two impacts)
- Recycled concrete aggregate RCA (0/32 mix, Proctor dry density 1.85 to 1.87 g/cm³): CBR_d = 0,77 to 0,88 x CBR and $CBR_{d,m}$ = 1,05 to 1,10 x CBR ($CBR_{d,m}$ mean CBR_d value of two impacts)

Source: Zentrum Geotechnik, TU München (2017)



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.

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

Subject to change without prior notice.
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