Forschungsgesellschaft für Straßen- und Verkehrswesen
Earthworks and Foundation Engineering Task Force

Supplementary Technical Terms and Conditions of Contract and Guidelines for Earthworks in Road Construction

ZTVE-StB 94

Issue 1994 as amended in 1997

14.2.5 Indirect testing methods

Where it is difficult or excessively time-consuming to perform compaction measurements and standard Proctor tests pursuant to Sections 14.2.2 and 14.2.3, e.g. because of the material properties, or such measurements and tests cannot be conducted to the required extent because of the specified laying performance, the following test methods which indirectly characterise the compaction status may be adopted:

(1) Static plate pressure test to DIN 18134;

(2) Dynamic plate pressure test to TP-BF Part B 8.3

(3) Subsidence test using Benkelman's beam to TP-BF Part 9;

(4) Penetration resistance tests using ramming or pressure penetration to DIN 4094, while special vibratory sounding rods too may be employed for services trenches;

(5) Testing by settlement measurements following the individual compacting passes for rockfills and soils with stones in excess of 200 mm or those containing a major percentage of gravel and stones;

(6) Dynamic measurement of the acceleration performance of the work roller used for compacting, or of a special gauge roller.

The test methods to be adopted in the particular case shall be indicated in the specification.

Usually, test methods (2) and (4) can be quickly employed. Therefore, when these methods are used, the minimum scope of testing can be increased when compared to test methods pursuant to Sections 14.2.2 or 14.2.3, thus adding to the statistical meaningfulness and reliability of the test results. The scope shall be indicated in the specification.

On commencement of testing, calibration tests shall be conducted to determine the relationship between the outcome of the test method chosen and the required value indicated in the specification. Where this is not required or impractical, the owner and the contractor may agree and resort to indicative figures based on own experience or accepted experience of others, for the test method chosen, as a reference for the tests.

The following tests are recommended for testing in service trenches and in confined workplaces:

(1) The dynamic plate pressure test to TP-BF Part B 8.3 for placement in layers of backfill materials of all kind, or for shallow service trenches;

(2) Penetration resistance testing for preferably non-cohesive backfill materials, using special service-trench sounding rods, for placement in layers or for shallow service trenches (0.7 metres deep);

(3) Penetration resistance testing by means of ramming penetration to DIN 4094, for preferably non-cohesive backfill materials and deep service trenches.

14.3 Testing the modulus of resilience on the formation

To test the bearing and deformation performance of the formation as a supporting medium for the pavement, compliance with the requirements applicable to the modulus of resilience E_{v2} pursuant to Section 3.4.7.2 shall be demonstrated. To this end, the methods M 1, M 2 or M 3 as per Section 14.1 shall be adopted by analogy.

Testing shall be conducted by employing the static plate pressure test to DIN 18134 or, alternatively, by means of the following test methods:

(1) Dynamic plate pressure test to TP-BF Part B 8.3

(2) Subsidence test using Benkelman's beam to TP-BF Part 9;

(3) Dynamic measurement of the acceleration performance of the work roller used for compacting, or of a special gauge roller.

The dynamic moduli or subsidence derived from the alternative test methods call for prior calibration using the modulus of resilience E_{v2}, or reference to existing and accepted empirical values. Application of these test methods shall be subject to prior agreement between the owner and the contractor.

Reference to alternative test methods called for or to be ruled out shall be included in the specification.

Testing the modulus of resilience on the formation shall not be required where

(1) the foundation or the substructure is consolidated by means of binders, or

(2) it is ensured on the grounds of local experience or through compaction tests that the required moduli of resilience are achieved.

Forschungsgesellschaft für Straßen- und Verkehrswesen
Local Road Construction Working Committee

Supplementary Technical Terms and Conditions of Contract and Guidelines for Excavations and Digging-up in Traffic Areas

ZTVA-StB 97

Issue 1997

1.7.2 Testing the compaction in earthworks

1.7.2.1 Test methods

The test method to be employed to verify the compaction shall be coordinated jointly with the contracting body and the relevant transport department or authority.

1.7.2.1.3 Dynamic plate pressure test as an indirect test method

Instead of performing a static plate pressure test, an investigation may be conducted using the dynamic plate pressure test to TP BF-StB Part B 8.3.

The setup is particularly suited for service-trench construction as the test can be quickly performed by an operator. The scope of testing can be increased as necessary; also, tests of the individual layers placed (thickness not greater than 30 cm) can be readily performed.

Assessment of the E_{vd} value measured is a function of the backfill material. Correlation values relating to the static plate pressure test for the soil prevailing or intended to be backfilled shall be determined by way of attempt.

To this end, one may resort to correlation values regionally available with road construction offices, civil engineering offices, public utility undertakings, or earthworks testing institutes.

For non-cohesive backfill materials, correlation values can be readily determined (Annex 14).
For cohesive soils, checking the moisture content is an additional requirement.

1.7.2.1.4 Penetration resistance tests as an indirect test method

Assessment of trench backfilling is also possible by penetration resistance tests using ramming or pressure penetration to DIN 4094 or other equipment developed for this purpose.

The minimum required number of impacts shall be determined for the required degree of compaction for the types of soils involved.

To this end, empirical values available with the relevant transport department or public utility undertaking may be used as a basis. When the lightweight sounding rod is driven displacement of soil causes the top zone to loosen. Therefore, the numbers of impacts within the upper 50 cm are not suited for comparison. It is recommended to load the bottom plate by means of an appropriate equivalent load (concrete rings or the like) so that comparable figures are achieved at from the top edge of trench backfill.

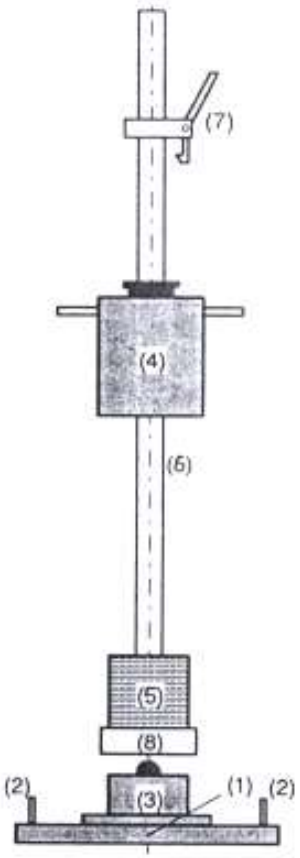
Annex 14

Determination of correlation values using the Lightweight Drop-Weight Tester (to TP BF-StB Part B 8.3)

1. The dynamic plate pressure test using the Lightweight Drop-Weight Tester is a rapid test method employed to determine the dynamic modulus of resilience E_{vd}. This approach is advantageous over the static plate pressure test in that a load abutment is not required for performing the test. The test is conducted within minutes by a single person, even under confined site conditions if necessary. Compared to the static plate pressure test, performing the dynamic test is very economic.

   The Lightweight Drop-Weight Tester consists of the following components and assemblies:

   - Load plate;
   - Settlement measuring instrument physically arranged in the centre of the load plate and normal to the loaded surface;
   - Loading mechanism consisting of drop weight, spring element, guide tube or guide rod with release mechanism.



(1) Load plate
(2) Handles
(3) Settlement measuring instrument
(4) Drop weight
(5) Spring element
(6) Guide tube or guide rod
(7) Release mechanism
(8) Anti-tilt device

Schematic drawing of the Lightweight Drop-Weight Tester

The test method is intended to determine the overall settlement of soil as caused by a defined impact-like load. The test method can be employed to determine the dynamic modulus of resilience in the range from 10 to 125 MN/m². In the test the soil is subjected to an impact load produced by a drop weight allowed to drop onto a circular rigid load plate having a radius r. The dynamic modulus of resilience is a parameter characterising the deformability of the soil. It is calculated from the settlement amplitude s of the load plate as measured under impact load, and the maximum stress under the load plate, using the following equation:

$$E_{vd} = 1.5\ r\ \sigma / s\ .$$

The test method is suited for coarse-grain and mixed-grain soils with a maximum grain size of 63 mm. Prior to the test, the test surface is levelled to the greatest extent possible by pushing or turning the load plate. Loose soil is removed. Dry medium sand can be applied to compensate for roughness as may be present.

The measuring site is pre-loaded by three impacts such that the load plate is well set. The next step is to perform another three (measuring) impacts and measure the related settlement amplitudes.

On fine-grain soils (silts, clays) the test can only be performed and evaluated properly if the consistency of the soils concerned is in the range from stiff to solid. In case of doubt, the moisture content (which decisively influences the outcome of the test) of these and of mixed-grain soils should be determined at various depths up to 1.5 times the plate diameter, under the surface of the area being tested. The test must not be considered for evaluation where impact loading causes lateral displacement of the load plate, e.g. in case of an excessively sloped formation.

2. For earthworks, ZTVE-StB 94 permits the dynamic plate pressure test pursuant to the Technical Test Specifications for Soil and Rock in Road Construction, TP BF-StB, Part B 8.3 to be used as an indirect test method for determining the degree of compaction D_{Pr} or as an alternative method for testing the modulus of resilience E_{v2} on the formation. The result of the dynamic plate pressure test is the dynamic modulus of resilience E_{vd}. Adopting the dynamic plate pressure test requires that, prior to this, correlation values be determined with the degree of compaction or the modulus of resilience. Also, one may resort to existing or accepted empirical values available.

3. To determine correlation values for the backfill soils to be used it is recommended to proceed as detailed below:

   Following apparently adequate and completed compaction of the backfill material, perform a static plate pressure test in the centre of the service trench while taking into account the conditions described in the test specifications. As a next step, perform two dynamic plate pressure tests at 30 cm spacing.

Furthermore, following the static plate pressure test, determine the moisture content of the backfill soil. Repeat this procedure at further locations in the service trench. Then, relate the mean values of the measured E_{vd} data to the mean values of the E_{v2} data of the static plate pressure tests, provided the moisture content at the individual test sites does not vary to any great extent.

Where correlation values related to the degree of compaction are to be determined, first assess the achieved degree of compaction by sampling two cylindrical core specimens, or through a digging for the balloon instrument. Subsequently, perform dynamic plate pressure tests, again at a spacing of about 30 cm (refer to Fig. 1).

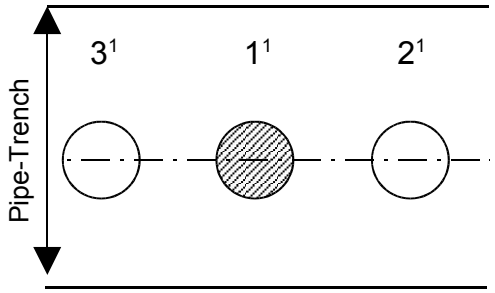
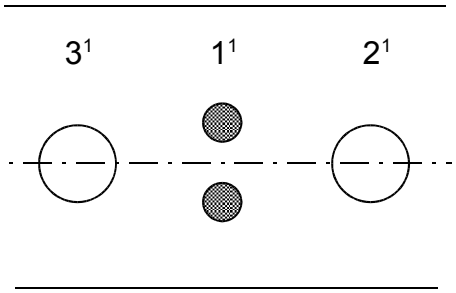
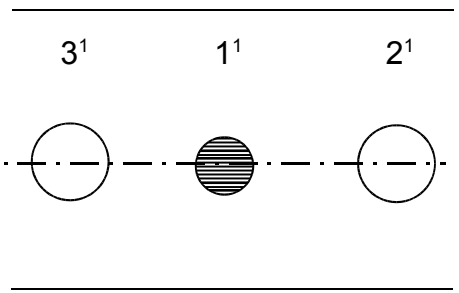
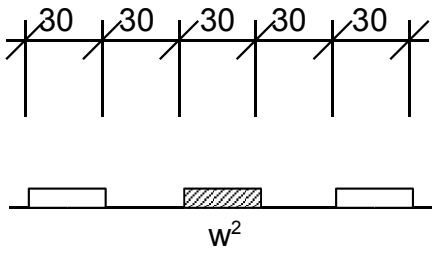
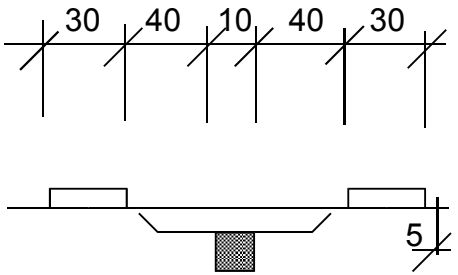
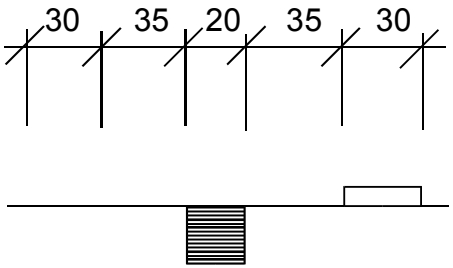
The correlation values so determined between the E_{vd} value and the E_{v2} value, or the E_{vd} value and the degree of compaction D_{Pr} can then be used for any number of follow-up tests using the Lightweight Drop-Weight Tester provided identical backfill material is being tested. It is recommended to have the correlation values be determined jointly by the principal and the contractor, so agreement on the test method is achieved.

Where no specific correlation values are available for the backfill material to be used, the figures given in the following table may be used for reference:

E_{v2}	E_{vd}
MN/m²	MN/m²
120	60
100	50
80	40
45	25

In the light of current knowledge, extrapolation of the above figures is not acceptable for E_{v2} requirements in excess of 120 MN/m².

1: Comparative investigations adapted to determine correlation values

	Figure 1	Figure 2.1	Figure 2.2
Comparison to	**Static plate pressure test**	**Degree of compaction of cylindrical core specimen collector**	**Degree of compaction for the balloon instrument**
Top view			
Section			
	[1] Test sequence w^2 Moisture-content determination Dimensions in cm	Symbols: Lightweight drop-weight tester; Plate pressure tester	Cylindrical core specimen collector; Balloon instrument

3.1.3.3 Testing

Section 2.3.3.6 ZTVT shall be amended as follows:

The plate pressure testers employed shall be calibrated by authorised calibration boards at least once a year. The Contractor shall furnish the Principal with evidence of the calibration performed.

Pursuant to the requirements laid down in DIN 18 134, the single-gauge method shall be adopted.

Section 2.3.4 ZTVT shall be amended as follows:

The static modulus of resilience E_{v2} shall be demonstrated as required, at least for every started 6,000 m² of sub-base.

To determine the bearing resistance the dynamic plate pressure test using the Lightweight Drop-Weight Tester to TP BF-StB Part B 8.3 may be agreed upon as an alternative to the static plate pressure test.

The dynamic modulus of resilience E_{vd} shall be demonstrated as required, at least for every started 600 m² of sub-base.

The following provision shall apply to widening / sectionwise construction:

Preferably, the dynamic plate pressure test shall be employed to determine the bearing resistance.

Irrespective of the type of plate pressure test chosen, a test shall be conducted as required, at least for every started 200 meters length of construction.

The following equivalent figures shall apply:

E_{v2} *in MN/m²*	E_{vd} *in MN/m²*
180	80
150	70
120	60
100	50
80	40
60	30
45	25
20	15

The equivalence between the static modulus of resilience E_{v2} and the dynamic modulus of resilience E_{vd} is a function of the type of soil, the moisture content, and the degree of compaction achieved. In case of adequate compaction ($E_{v2} / E_{v1} \leq 2.5$) the calculated E_{vd} values are expected to conform to the equivalent E_{v2} values. In the event of inadequate compaction ($E_{v2} / E_{v1} \geq 2.5$) the E_{vd} values which would be equivalent to the E_{v2} value are not reached.
Where the required ratio of E_{v2} / E_{v1} or the required E_{vd} value is not reached, re-compacting is essential.
It is only in the latter case that the afore-mentioned equivalence values should be included in the contract arrangement.

General Administrative Order for "Road Construction Technology" No. 6 / 1997

Backfilling of service trenches, ZTVE-StB 94, Section 8 Compaction testing by means of the Lightweight Drop-Weight Tester pursuant to TP BF-StB, Part B 8.3

For service trenches the backfill material shall be compacted within the road structure such that the requirements laid down in ZTVE-StB 94, Section 3.3.2 are met. The governing variable shall be the degree of compaction D_{Pr}.

Where it is difficult or excessively time-consuming to perform compaction measurements and Proctor tests necessary to determine the degree of compaction, indirect test methods too may be adopted pursuant to ZTVE-StB 94, Section 14.2.5. These include the dynamic plate pressure test using the Lightweight Drop-Weight Tester as per TP-BF Part B 8.3 which is suited for a number of applications including quality testing of the backfill of service trenches. For the dynamic plate pressure test to be employed it is an essential prerequisite that a relationship exists between the degree of compaction D_{Pr}, the static modulus of resilience (E_{v2}) and the dynamic modulus of resilience (E_{vd}).

Table 8 of ZTVE-StB 94 summarises the indicative figures for cross-assignment of the degree of compaction D_{Pr} and the modulus of resilience E_{v2} for coarse-grained soil groups. For coarse-grained soil groups too there is a good correlation between the static and the dynamic moduli of resilience as ascertained by the "Test Technology" Working Committee of Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV).

In contrast, for mixed-grain and fine-grain soil types, only an approximate cross-assignment of the parameters D_{Pr} / E_{v2} / E_{vd} is possible because of an insufficient statistical significance.

The cross-assignment of the parameters D_{Pr} / E_{v2} / E_{vd} is clear from the attached Table, taking into account the afore-mentioned aspects. When performing the dynamic plate pressure test pursuant to TP BF-StB, Part B 8.3 it is highly desirable that the tabulated figures be referenced in evaluating the compaction of backfill material in service trenches. The Table also reflects the requirements to be met by mineral aggregate as per ZTVT for sub-bases on the formation; these too can be verified by using the Lightweight Drop-Weight Tester.

For preservation of evidence it is recommended that, upon completion of a backfill, the DPL lightweight ram sounding rod or the the DPM medium-heavy ram sounding rod be employed for ram sounding. These, however, do represent a substitute for direct compaction testing by means of the procedure described.

When performing the dynamic plate pressure test the following must be taken into account:

1. A specific moisture content is required such that dense packing of backfill materials of fine-grain and mixed-grain soils is achieved. If the moisture content is less than the optimum (dry side of the Proctor curve) the degree of compaction may not be sufficient despite a high modulus of resilience. If the 'as-placed' moisture content excessively differs from the optimal moisture content for compacting the degree of compaction may not be adequate despite a high modulus of resilience (E_{v2}). Therefore, the moisture content must be determined at any rate.

2. For trench widths of less than 60 cm, the edge zones may influence the modulus of resilience of the backfill material such that a 'mixed' value is measured; hence, the dynamic plate pressure test merely provides a coarse indication. Calibration of the E_{vdyn} values by means of density determinations may be required as a function of the local conditions prevailing (cf. ZTVE, Section 14.2.5).

3. **In case of major operations, at least one density determination must be performed for verification. At least three E_{vd} measurements in this area.**

4. As little time is needed to perform an individual measurement the dynamic plate pressure test is excellently suited to verify a compaction test pursuant to ZTVE-StB 94, Sections 3.3.1.2 and 14.1.4. To this end, measure the E_{v2} value at the same spot following each compaction transition, so the maximum figure that can be achieved is determined. A density test performed in the same location will reveal the density level reached. Thus, the number of compaction transitions required can be defined as a function of the E_{vd} value to be specified.

When employing the dynamic plate pressure test it is essential that the competent building material and soil inspection board be involved.

In conclusion, it is worth mentioning that the FGSV "Test Technology" Working Committee referred to above prepare and attend to comparative investigations using the Lightweight Drop-Weight Tester. In the light of hitherto gathered experience (refer to Table) the contemplated comparative investigations aim to obtain statistically significant information from the test methods. The competent building material and soil inspection board is aware of the forthcoming project.

Backfilling of Service Trenches

Verification of compaction using the Lightweight Drop-Weight Tester as per TP BF-StB, Part 8.3

Cross-assignment of degree of compaction / modulus of resilience
(according to ZTVE-StB 94, Tables 2, 3, 8, 9,
as well as ZTVT-StB 95, Table 2.1 and Directive DB - A2015)

Soil Group	Degree of Compaction D_{Pr}	Modulus of Resilience E_{v2}	Modulus of Resilience E_{vd}
DIN 18 196	%	MN/m²	MN/m²
GW, GI, $GU_{1)}$, $GT_{1)}$ as per ZTVT	≥ 103	≥ 120	≥ 60
GW, GI, GU, GT as per ZTVE	≥ 100	≥ 100	≥ 50
	≥ 98	≥ 80	≥ 40
	≥ 97	≥ 70	≥ 35
GE, SE SW, SI	≥ 100	≥ 80	≥ 40
	≥ 98	≥ 70	≥ 35
	≥ 97	≥ 60	≥ 32
Mixed-grain soils $GU_{2)}$, $GT_{2)}$, SU, ST e.g. stony soil	≥ 100	≥ 70	≥ 35
	≥ 97	≥ 45	≥ 25
Fine-grain soils: U, T	≥ 97	≥ 45	≥ 25
Mixed-grain soils GU*, GT*, SU*, ST*	≥ 95	≥ 30	≥ 20

[1)] GU / GT Soils containing not more than 7% w/w of less than 0.063 mm fraction (ZTVT mineral aggregate in 'as-placed' condition)

[2)] GU / GT Soils containing 7-15% w/w of less than 0.063 mm fraction

Deutsche Bahn

Guideline to Using the Lightweight Drop-Weight Tester in Railway Construction	NGT 39 Sheet 1

Supersedes DR-A 2015

Content **Sheet**

1 Scope

This Guideline shall apply to using the Lightweight Drop-Weight Tester as per TP BF-StB Part B 8.3 [1] in railway construction so as to determine the dynamic modulus of resilience E_{vd}. This dynamic plate pressure test is adapted to verify the bearing resistance of soils. It is particularly suited for bearing-resistance testing of dynamically loaded structures.

2 Measuring range / Testable soil

The dynamic plate pressure test as per TP BF-StB Part B 8.3 [1] may be used:
- with a measuring range of 10 N/mm² ≤ E_{vd} ≤ 125 N/mm²;
- for soils with circular, cubic, non-broken grain without limitations; also for soils containing uo to 30% broken material (cf. Section 8);
- for mineral soils containing a grain size d > 63 mm ≤ 15%.

3 Test equipment

- Lightweight drop-weight tester as shown in Fig. 1, consisting of:

  - Load plate: weighing 15 kg; 300 mm dia.
  - Drop weight: weighing 10 kg
  - Guide rod: weighing 5 kg
  - Damping system: Cup springs

- Settlement measuring instrument (elastic settlement)

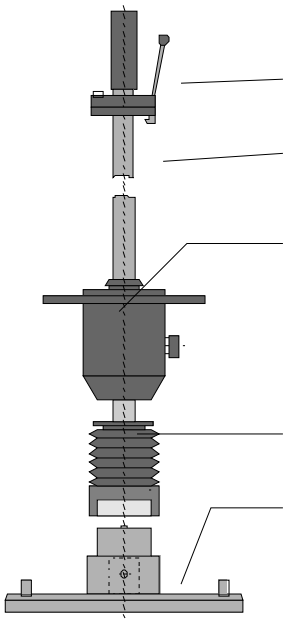


Figure 1: Sketch of Lightweight Drop-Weight tester

4 Measuring principle

This test method measures elastic deformation resulting from a specified dynamic load application (α = 0.1 N/mm²).

A drop weight is used to apply through the damping system an impact load of the range to be tested. The elastic deformation so produced (settlement amplitude s of the load plate) is recorded by means of the settlement measuring instrument, and related to the recorded load. The dynamic modulus of resilience E_{vd} in N/mm² (= MN/m²) is indicative of the existing bearing resistance.

The depth of action is about 1.5 times the diameter of the load plate (approx. 400-500 mm).

5 Requirements to be met by test equipment

The dynamic modulus of resilience is determined at a stress α = 0.1 N/mm² under the load plate. This stress is roughly equivalent to load exerted by running trains at the formation top. In order to guarantee this value each tester is supplied by the manufacturer is a calibrated condition. Calibration may only be performed by authorized inspection boards. Thus, a height of drop results which is specific of the particular tester and is indicated on the equipment.

The tester may only be used with manufacturer's genuine parts which were employed for the calibration.

The test equipment is required to be re-calibrated at intervals of two years if the results are intended to be used as a basis for acceptance of railway structures.

The test equipment is required to be inspected annually at the manufacturer's; such inspections also include calibrating. Whenever variations compared to previous settings are noted re-calibration becomes necessary.

6 Test procedure

6.1 Pre-test requirements

Tests with the Lightweight Drop-Weight Tester must be performed by skilled and adequately trained personnel who have completed training in the specific vocation (e.g. building materials inspector).

The surface to be tested must be levelled by means of tools or by turning and pushing the load plate. Minor roughness can be compensated for by means of fine or medium sand. Full support of the load plate is essential; it must not tilt. The surface to be tested may be sloped up to 5%. The shipping lock of the drop weight should be released immediately prior to the measurement.

Check the drop height and readjust if necessary.

6.2 Measuring procedure

Place the load plate on the prepared formation to be tested (do not allow to drop). Install the guide rod and hold it in vertical position. Lift the drop weight until it engages the lift limiter; then, allow to drop in free fall to produce the impact. Once the drop weight has bounced onto the damping system it must be caught.

Adopt this procedure to perform initially three 'adjustment' impacts so as to prevent the result from being influenced by an effect of plastic deformation, and make sure that the load plate fully rests on the surface to be tested. Then, perform three measuring impacts. Place one foot on the load plate to prevent it from getting displaced and from bumping.

Prior to the test, record information about the test site and the date of the test, together with the particular test number.

Collect typical samples (spaced approx. 100 mm from the load plate from a depth of about 150 mm) of the soil to obtain meaningful data for classification of the soil be tested and determine its moisture content. The moisture content and the soil identification in compliance with DIN 18 196 must be indicated in the test report along with the E_{vd} value. Soil specimens collected from the immediate vicinity for density determinations may also be used to determine the moisture content. Where a test lot is believed to have an invariable moisture content the scope of specimen collection should be reduced.

7 Evaluation

The dynamic modulus of resilience E_{vd} is calculated by the following formula:

$$E_{vd} = \frac{1.5 \cdot r \cdot \sigma}{s}$$

where:

r = Radius of the load plate, in mm
σ = Stress under the load plate, in N/mm²
s = Deformation amplitude, in mm (mean value)
1.5 = Factor including a multitude of laws which must be taken into account when loading the soil by a circular plate

The local computer printout provides evidence that the bearing-resistance test has been conducted. It must reflect the following information:

- Station ID
- Date
- E_{vd} values
- Type of structure
- Physical location
- Height
- Soil group as per specification or screening characteristic.

When assessing the test results the following must be taken into account:
- Any variation of the moisture content from the optimal value;
- For cohesive soils with I_c values ≥ 1, the E_{vd} values are only acceptable in conjunction with density records (dry branch of the Proctor curve).
- Measurements performed immediately upon completion of compacting work that produces pore water pressure may yield data which are too low, and may have to be complemented by follow-up measurements.

Changes to the requirements of the minimum figures given in Table 1 are subject to prior approval of the expert service. To this end, comparative tests would have to be conducted for reference.

8 Bearing resistance requirements in quality testing

Quality testing within the meaning of this Guideline calls for application of the requirements detailed in Table 1 (according to DS 836, EzVE 2). To accept a test lot proceed as detailed in ZTVE-StB 94, Section 14 [5].

The dynamic moduli of resilience E_{vd} required as per Table 1 are bearing-resistance requirements which may be adopted on an 'equal rights' basis when referred to the modulus of resilience E_{v2}. Correlation coefficients E_{v2} - E_{vd} may only be defined in isolated cases where the soil is highly homogeneous (screening characteristic, moisture content, etc.) and comparative investigations yielding statistically significant findings have been conducted.

Type of route			Track Formation				Formation			
			D_{Pr}	E_{v2} [N/mm²]	Dependencies	E_{vd} [N/mm²]	D_{Pr}	E_{v2} [N/mm²]	Dependencies	E_{vd} [N/mm²]
NEW LINE	1. Continuous main tracks of main lines (except for city railways)		1.00	120	U > 15	50	1.00	80	GE,GI,GW,GU SI/SW	40
									All other soil groups	35
	2. Continuous main tracks of city railways and branch lines		1.00	100	U > 15	45	0.97	60	GE,GI,GW,GU SI/SW	35
									All other soil groups	30
	3. Other tracks		0.97	80	U > 15	40	0.95	45	GE,GI,GW,GU SI/SW	30
									All other soil groups	25
MAINTENANCE	Existing railway routes	4. v > 160 kmph	0.97	80	U > 15	40	0.95	45	GE,GI,GW,GU SI/SW	30
									All other soil groups	25
		5. v ≤ 160 kmph	0.95	50	U > 15	35	0.93	20	GE,GI,GW,GU SI/SW	25
									All other soil groups	20

Table 1 Bearing-resistance requirements

Formation protection layers prepared continuously with material U < 15 must satisfy the values for PSS U > 15.

When broken grain > 30% is added to natural mineral materials of cubic grain size, different values have to be specified by geotechnical experts as a function of the material and the percentage added. It may be necessary to conduct comparative test bed investigations prior to commencement of construction. This equally applies when PSS (FSS) materials with layer thicknesses < 0.3 meters are used.

The following bearing-resistance requirements apply to formation treated with hydrated lime or quicklime:

For type of route refer to Table 1		1. E_{vd} [N/mm²]	2. E_{vd} [N/mm²]	3. E_{vd} [N/mm²]	4. E_{vd} [N/mm²]	5. E_{vd} [N/mm²]
Soil stabilized with lime	≤ 48 h after compacting	40	35	30	30	25
	> 48 h after compacting	45	40	35	35	30
Cohesive soil improved with quicklime		40	35	30	30	25