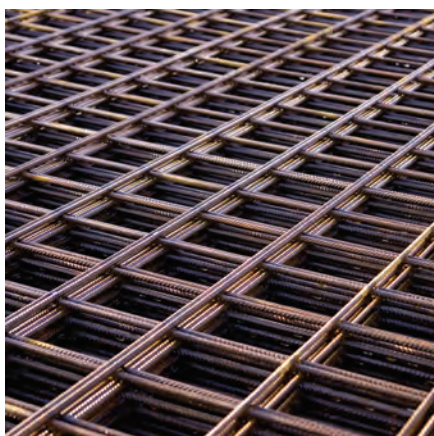
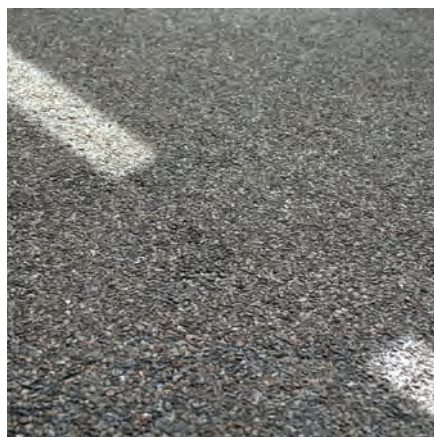


Testing Machines and Systems for Building Materials



1 Zwick Roell – passionate about customer orientation

Zwick at a glance

For more than 150 years the name of Zwick Roell has been synonymous with technical expertise, innovation, quality and reliability in materials and component testing. As world leaders in static testing, while experiencing significant growth in fatigue testing systems, we enjoy our customers' confidence.

Through innovative product development, a comprehensive product range and worldwide service and support, this family concern delivers tailor-made solutions to meet the most demanding requirements of research and development and quality assurance in over 20 industries.

With around 1,000 employees, a production plant in Ulm, Germany, additional subsidiaries in Europe, the USA and Asia, plus agencies in 56 countries worldwide, the Zwick brand name guarantees the highest product and service quality.

Specialists in testing construction materials

Asphalt, binders, cement – with Toni Technik's testing machines and instruments you can test anything! This is possible thanks to universal components, specially developed solutions, an almost unlimited range of accessories and our intelligent *testXpert*® testing software.



Fig 1: Administration building, Zwick Roell AG and Zwick GmbH & Co.KG. Ulm

Toni Technik testing machines are ideal for investigating material properties under quasi-static and dynamic loading, compression tests being the most frequent type. Our testing machines can perform tests to all current standards.

Toni products – in a class of their own

Design and production today are dominated by the quest for the smallest possible dimensions and minimal weight. The demand is for extremely lightweight construction combined with maximum strength. This results in components made of new types of material, leading to a rapid increase in the demands placed on testing methods and procedures. Comparative assessment is a thing of the past – only highly developed testing technology with closely linked 'measuring' and 'testing' can satisfy these exacting

requirements and provide the information needed to achieve both material-related and application-related conclusions. Similarly, the data needed for simulation and review of results can only be supplied by the modern testing machine.



Fig. 2: Toni Technik Baustoffprüfsysteme GmbH, Berlin

2 Modern construction materials – a broad spectrum of materials, properties and structures

Modern construction materials consist of various raw materials, including natural and man-made minerals, plastics, wood or metals, and are available in an extremely wide range of product forms: powder, bulk materials, films and foils, boards, bricks and moldings, or prefabricated components such as wall panels, beams, stairs etc. They are used to produce foundations, walls and ceilings, to protect and visually enhance surfaces, for sealing joints and faces or for thermal insulation. They are employed in buildings of widely disparate size and function and for infrastructure such as roads, bridges and dams.

During manufacture, storage, transport and especially as part of a finished structure, construction materials are subjected to mechanical loading. Examples of this include pressure exerted by earth, water, wind and by sections of the building above them; gravitational and movement forces imposed by people and machines; shocks caused by earthquakes or movements or slippage of various subterranean earth layers.

The well-being and safety of countless human beings depends on the reliable performance and the strength and stability of such structures to a degree found in hardly any other branch of technology. For this reason the properties of the materials used must be carefully researched, then tested appropriately. Standards and guidelines define the composition and properties of a wide range of materials, while test standards define how these properties are to be tested.

The table headed 'Test standards and testing machines' contains the principal test standards for construction materials and indicates the testing machines and instruments used for this.

Strength and deformation properties

Strength and deformation are of central importance in construction materials testing and the technology employed is therefore primarily targeted at these characteristics. Particular criteria must be taken into consideration, depending on the materials involved and the specimens or components produced from them.

Construction-materials testing- machines for a wide range of situations

The different properties of construction materials and the specimens, components and structures produced from them call for testing machines with suitably matched performance profiles.

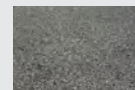
The universal testing machines available from Zwick's standard range are all-purpose machines for static tests. Large test areas and test strokes, interchangeable test fixtures and measured-value transducers enable specimens and components with differing shapes, dimensions and properties to be tested.

Toni Technik's compression and flexure testing machines are ideally matched to the specific requirements of standardized compression and flexure tests on specimens of mineral-based construction materials such as mortar, cement and concrete. For example, load frames, compression platens and drives must meet the specific requirements of concrete testing – which also brings benefits for mortar and cement testing; alternatively, combinations of compression and flexure testing machines facilitate rapid switching from one type of test to another with minimal equipment change.

Segmente



Cement and binders
CEM I - IV, special cement



Asphalt
asphalt concrete, mastic asphalt, melted asphalt



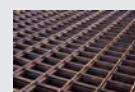
Concrete
lightweight concrete, fiber-reinforced concrete, high-performance concrete



Timber
timber materials, construction timber, chipboard



Construction chemicals
plaster, mortar



Structural steel
reinforcing steel, tie-rods, wire rope, ties



Glass and ceramics
construction glass, roof tiles, bricks, stoneware

2.1 Testing cement and other binders

This term covers all types of hydraulic and non-hydraulic binders and mixtures. The focus of the testing machines and instruments is on cement, the basic material for most binders. Included here also are all kinds of mortar (gypsum mortar, lime mortar and cement mortar), including ready-mixed or dry mortar and adhesives with a mineral or semi-mineral base. Special testing devices are used to test the adhesive strength of tile adhesive in shear and tension. Determination of Young's modulus is becoming increasingly important; among other things it reveals the influence of synthetic fibers on compression strength and flexural strength.

Tests in accordance with the various international standards (DIN, EN, ISO, ASTM etc.) relate to the effect of additives such as construction chemicals, granulated cinder, fly ash, sand, gravel etc. Specimens may come in the form of cubes, cylinders, prisms, beams, cores, tubes, plates, bricks, panels and structures.

Specimen preparation and manufacture

The most important, if not the most critical part of binder testing is the standard-compliant, reproducible preparation and manufacture of specimens/prisms. For this reason strict quality criteria regarding accuracy and user-friendliness apply to the equipment and devices used. Standard specimen preparation devices, such as three-way molds, can be found in Toni Technik's 'Global Testing Solutions' catalog.

Specimen material preparation with the ToniMIX mortar mixer

Using a mixer from the ToniMIX range guarantees compliance with standardized mixing speeds and stirrer/mixing bowl geometry. In the automated version the mixing process is pre-programmed in accordance with various standards. Special features include:

- automatic sand and water metering (optional)
- clear shield
- optional dust extraction unit
- especially robust design

To cater for the special requirements of construction chemicals a version is available which allows individual sequences (mixing times and speed, amounts of water) to be programmed and stored.



Fig. 2: ToniMix mortar mixer

Specimen compacting with ToniVIB vibrating table or jolting table

The Toni Technik vibrating and jolting table models guarantee standard-compliant compacting, ensuring correct specimen strength, an important characteristic in the context of quality monitoring.



Fig. 3: Vibrating table for standard-compliant specimen compacting (controlled)

Specimen molds		prisms, cubes, cylinders
Mortar mixer	ToniMIX	manual, automatic, programmable
Spec. material compacting		jolting table
Spec. material compacting	ToniVIB	vibrating table (controlled)
Specific surface (Blaine)	ToniPREM	standard-compliant, Dyckerhoff principle
Setting behavior (Vicat)	ToniSET	aut. 1, 6, 8 or 12 test areas for cement, mortar, plaster
Hydration heat	ToniCAL	differential calorimeter for cement, mortar, or concrete
Free lime content	ToniLIME	
Le Chatelier	ToniCHAT	up to 16 specimens

Fig. 1: Specimen manufacture and testing instruments

Testing setting behavior with the ToniSET automatic Vicat needle instrument

Setting behavior is a critical technical factor in the processing of binders and is usually determined in time-consuming manual tests using a Vicat needle instrument. The application-oriented development of construction materials, invariably featuring new special properties, has led to a continual increase in the number of these tests performed, to the point where they are becoming an economic burden. The traditional characteristic values of 'Start of setting' and 'End of setting' are not always sufficient for comprehensive evaluation of setting behavior, the entire chronological sequence of the setting now being required.



Fig. 1: ToniSET One



Fig. 2: ToniSET Classic

Another problem lies in the difficulty in maintaining standardized environmental conditions (temperature and humidity) during manual testing. The ToniSET automatic needle instruments are designed to solve this problem by providing fully automatic testing of one or more specimens, in an air atmosphere or underwater as required. The underwater test has the advantage of enabling environmental conditions (temperature, humidity) to be maintained at an optimum level. The single-position instrument uses integral micro-processor control. All three versions, for 6, 8 or 12 specimens, are controlled by Windows-based software, allowing individual test intervals to be selected for each specimen. The setting status of the various specimens can be read off

in individual program windows whenever required.

Standardized testing of cement volume stability-ToniCHAT Le Chatelier water-bath

The Le Chatelier test simulates the possible expansion of cement due to incomplete hydration. 16 specimens in Le Chatelier rings can be mounted in a bath of boiling water, with automatic, highly precise (accurate to 0.1°C) control of the heating cycle – e.g. heat up to 100°C within 30 min. and maintain this temperature for 3 hours. Set time and temperature can be varied in accordance with requirements.



Fig. 4: ToniCHAT Le Chatelier water bath



Fig. 3: ToniSET

Measuring the specific surface area with ToniPERM automatic Blaine instruments

The Blaine Specific Surface Area method provides indirect measurement of grain size and has a decisive influence on the strength values of cement. For this reason, fast, simple, exact determination of this dimension is of fundamental importance in both laboratory and production (at cement mills).

ToniPERM Standard Model 6568

This instrument is used to determine the specific surface area of powdered materials. Time is measured in accordance with EN 196-6, which requires a defined volume of air to permeate a bed of powder. Measurement, test-sequence control and evaluation are performed automatically.

ToniPERM Model 6565

This is an automated, processor-controlled Blaine instrument which is particularly suitable for rapid determination of operating characteristics. It consists of a micro-processor control unit and a measuring turret with one or two measuring cells. The powder being tested is compacted to a defined volume in the measuring cell (Dyckerhoff principle). Following positioning of the measuring cell on the measuring turret and input of the test-specific specimen-data, the test is performed and evaluated completely automatically. The Blaine value is obtained from the individual values of a pre-selected number of cycles, being averaged from the values from two measuring cells where required.



Fig. 1: ToniPERM Standard

Heat-flow differential calorimeters for determining hydration heat - ToniCAL Cement, ToniCAL Concrete and ToniCAL Mortar

These instruments are used to determine the setting heat of hydraulic binders and concrete. A computer connected to them continuously records the heat development rate (joules/gram) against time. The hydration heat released (joules/mass x time) can be displayed graphically or in table form as an instantaneous or cumulative value during or after the test and can be interpolated automatically. High measuring accuracy and reproducibility ensure reliable evaluation of heat development (hydration heat) and the influence of additives on the setting behavior. Each instrument consists of a control unit with temperature controller, amplifier, temperature display and computer interface, plus a separate insulated calorimeter vessel containing the measuring cylinder for test substances and inert sample, together with the temperature measurement chains comprising a multitude of thermo-sensors, plus a heat source.



Fig. 2: ToniCAL Cement 6-cell differential calorimeter

The ToniCAL Cement is available with one, three or six measuring cells and can optionally be fitted with a unit for mixing in chemical additives, including during measurement, and a temperature conditioning unit. It requires only 10 g of substance. Due to the coarse-grained, highly inhomogeneous nature of the fresh concrete mixture, however, the ToniCAL Beton requires approximately 5.3 liters (for a concrete-cylinder 150 mm in diameter and 300 mm high). The ToniCAL Mortar, which can also be used for cement and concrete (max. grain size 8mm) requires 50 to 150 g.



Fig. 3: ToniCAL differential calorimeter installed in a temperature conditioning unit

ToniLIME instrument for determining free-lime content

This instrument is used to determine the free, unbonded lime content of cement or cement clinker. This is done by measuring the conductivity of a cement solution in heated glycol. The menu-driven test-sequence enables fast, safe handling with short test times. Test results are available more quickly than with other methods, allowing rapid correction of the furnace settings and the burning process.



Fig. 1: ToniLIME instrument for determining free lime content

2.2 Testing concrete

Concrete – a construction material which places special demands on testing technology

The strength of concrete normally lies between 20 N/mm² and 50 N/mm² and can be as much as 200 N/mm² or more in the case of high-strength and fiber-reinforced varieties. Due to its extremely brittle nature, its strain at break is only in the region of a few tenths of a percent. In relation to the height of the cubic or cylindrical compression specimens, this means deformations of only a few hundredths of a millimeter – scarcely more than a hairsbreadth! It is also significantly less than the elastic deformation of the testing-machine load-frame. Young's modulus for concrete is between 15,000 and 45,000 N/mm² (depending on the cement stone, cement-stone volume and aggregate and any reinforcing via fibers etc.).

Specimen shapes and dimensions

Concrete has a heterogeneous structure, making large specimens necessary. These are either cubes with equal edge lengths of 100, 150, 200 or 300 mm or (bored) cylinders with diameters of 100, 150, 200 and 300 mm and with a height equal to twice the diameter.

Test load and test-load distribution

Large specimens require correspondingly high test loads, usually 600 to 6,000 kN. Distribution of the test load over the entire (large) area under compression is critical in deciding whether the test results have a narrow scatter range and reflect the actual strength of the concrete, or contain considerably lower values with a wide range of scatter.

High stiffness and low deformability are the reasons why even small variations in the surface under compression (rough areas, grooves, dirt etc.), deflection of the compression platens or asymmetrical deformation of the machine frame (skewed compression platens) result in local variations in compression loading and premature failure in the area of highest loading. Force reduction at the formation of the first crack causes immediate elastic recovery of the load frame, accelerating the failure process. The test results are also affected by differing or varying loading speeds.

Influences of this kind result in unreliable test results with a scatter range which may be more than 20 % below the actual strength. The true strength of the concrete cannot be determined in this way. These influences can be drastically restricted by means of the following measures.

- a) Testing-machine load-frames must possess high longitudinal and transverse stiffness so that asymmetrical elastic deformations remain negligible if, for example, the specimen is not centered exactly.
- b) Compression platens must be extremely stiff, with hardened (≥ 55 HRC) and ground (mean roughness ≤ 0.0016 mm, flatness deviation ≤ 0.03 mm over 250 mm) bearing faces.
- c) The upper compression platen must be mounted so as to make full-face contact with the specimen following force closure; the angular position taken up must not change as the test load increases.
- d) Due to the extremely small specimen deformations the loading speed must be force-controlled in order to be reproducible.

By these means measured-value scatter can be reduced to less than 1% and the actual strength of the concrete determined. The type of load application is visible in the fracture images of the specimen. The 'strain cylinder test' is used to check and verify the effectiveness of these measures. This test was specially developed for compression testing machines used for concrete (max. test load > 1200 kN) and is part of the European Testing Standards and national supplements. All Toni Technik compression testing machines are tested in this way before delivery. In addition a suitably adapted strain cylinder was developed for compression testing machines used for cement, mortar etc. (max. test load 100 – 1200 kN).

Special construction materials

For the majority of special construction materials, standard series-production testing machines can be used with little or no modification, including for example testing machines for:

- aerated concrete (beam elements and cubic specimens)
- lime sandstone (small and large formats)
- fireproof materials (bulk and bricks)
- insulating bricks (backing) and thermal insulating materials.

Compression and flexure testing machines

Toni Technik compression and flexure testing machines are primarily used for determining the compression strength and flexural or tensile flexural strength of specimens and components made of mineral-based materials including mortar, plaster, cement and concrete. Other construction materials such as aerated concrete, lime sandstone, bricks, insulating bricks and fireproof materials are also regularly tested using Toni Technik products. Depending on version and equipment, deformation-dependent properties such as Young's modulus and deformation at break can be determined also, or the entire force-deformation sequence (test diagrams) can be recorded and evaluated. The *testXpert*[®] software has significantly expanded the range of test evaluation, while the machines are compatible with the special demands of relatively large specimens and components made of mostly brittle, non-homogeneous materials. The machines are assembled to order from modular components, including the following:

- load frame for compression and flexure tests
- measurement and control system
- hydraulic station
- displacement transducer and deformation transducer.

Test frame

Compression strength testing generally requires considerably greater test loads (by a factor of 2 to 15) than those used in flexure tests. Changing load cells and test fixtures (compression platens, flexure fixtures) is not practicable due to the great weight of the compression platens. Test frames are accordingly designed for compression or flexure tests only and the testing actuator, load cell and test fixtures are permanently installed. All 2, 3 or 4-column test frames used for compression tests possess extremely high longitudinal and transverse stiffness to minimize asymmetrical deformation, even with slightly off-center force transmission. Force application (universal ball-joint/compression platens) is so arranged that the testing-machine requirements for compression strength tests on concrete to EN 12390-4, Annex A, are safely and reliably satisfied.

Load cell

The test load is measured using strain-gage load cells or via oil-pressure transducers as required. The load cells are located above the upper compression platen or the die and the oil-pressure transducer is positioned on the testing actuator. The error limit of $\pm 1\%$ of the relevant measured value (Class 1 to EN ISO 7500-1) applies to a measurement range from 1 % to 100 % of nominal force.

ToniTROL measurement and control system

ToniTROL is designed to enable efficient, economical compression and flexure testing of construction materials. Its functions include acquiring, processing and displaying measured values, monitoring and controlling the test sequence and controlling the test speed. The system is accommodated in a compact, space-saving housing, while stand-alone operation is greatly simplified by logical menu navigation.

Special features of ToniTROL:

- up to 3 different test frames (for tensile, compression and/or flexure) can be connected, with automatic switching and parameter adaptation
- test-speed control according to test load (standard), piston travel or deformation (option) – can also be changed during test
- saveable test programs, optional cyclic and stepped test sequences, for determination of Young's modulus.

Data exchange via ToniDAT

Bi-directional or unidirectional data transfer between ToniTROL and a PC or laboratory information system (LIMS) can be retrofitted at any time.

Hydraulic station

The ToniNORM Powerbox contains all the units required to supply hydraulic and electric power and is available in various versions. Test speed can be controlled in one of two ways (see following).

Bypass control

With this type of control, piston travel is controlled via the return flow, so that only the pressure which is actually required is developed in the actuator. The oil does not normally require cooling. A servo valve located in the Powerbox allows all test frames connected to be operated economically.

Feed control

With this type of control the flow of oil to the actuator is controlled. System pressure is always present at the servo valve. The resulting higher power losses require oil cooling. Each test frame connected to a common Powerbox requires its own servo valve. Advantage: short response times and highly accurate control.



Fig. 1: ToniTROL

Displacement and deformation transducers

The following can be connected to ToniTROL for measurement of optional specimen deformation, with associated measurement electronics and software:

- displacement transducer
- transducer for measuring compression platen separation
- transducer for measuring specimen deflection
- transducer for measurement of longitudinal/transverse strain for determination of Young's modulus.

These transducers enable test speed to be travel or deformation-controlled. This allows travel at constant speed even after the force reduction following the first crack, for example to measure the adhesive strength of steel fibers in concrete.

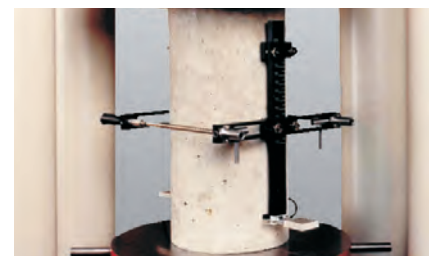


Fig. 2: Deformation transducer for Young's modulus determination



Fig. 3: Deformation transducer for the PCI test



Fig. 4: Deformation transducer for measuring deflection

Testing machine configurations

Task-specific testing machines and systems are assembled from the above elements. This enables a wide range of solutions, from a simple single-purpose machine for standard quality monitoring, to testing-machine combinations for quick, easy changes between compression and flexure tests, to sophisticated testing systems for use in research.

ToniPRAX

is a compact, expandable testing-machine combination for standard-based testing in binder laboratories.

ToniCOMP

is an ergonomically optimized machine combination for efficient, high-volume standard-based testing in binder laboratories.

ToniPACT(EN) and ToniCON (ASTM)

ToniPACT(EN) and ToniCON (ASTM) are compact compression testing machines for concrete. Test frame, hydraulic power-pack and ToniTROL measurement and control system are grouped in a space-saving unit.

ToniZEM

is a compact compression testing machine for binder specimens.



Fig. 2: ToniCON compression testing machine



Fig. 3: ToniZEM



Fig. 1: ToniCOMP V compression and flexure testing system

ToniNORM

ToniNORM is a flexible, modular system for efficient, economical strength tests on all types of construction materials. Compression and flexure test-frames for maximum test loads of 10 to 10,000 kN can be combined to form all-round multi-purpose testing systems to suit individual testing requirements. This allows tests with extremely different test loads to be performed, whether flexure tests on lightweight mortar or compression tests on high-strength concrete.

ToniTOP compression test systems with variable test area (crosshead adjustment)

The requirements of material testing establishments and research laboratories place particularly severe demands on compression testing machines. Key aspects include flexibility of test-area dimensions, longitudinal and transverse stiffness of the test frame, accuracy and dynamics of the measurement and control system and the entire testing software. Dynamic testing frequencies up to 4 Hz can be achieved with these testing systems. For high-strength concrete, steel-fiber-reinforced concrete etc. the stress/strain behavior following maximum compressive stress (test diagram) is a key criterion. These tests are only possible if the load frame is extremely stiff and the drive equipped with displacement or even deformation control capable of very fast response. Tests of this type are performed on both standard samples and larger components (e.g. complete wall panels), requiring a height-adjustable test area.



Fig. 1: ToniPRAX with ToniNORM 3000, with specimen measuring station for cube testing



Fig. 2: ToniTOP compression test system

ToniFLEX and ToniVERSAL

These ranges contain test frames for maximum test loads up to 1000 kN, individually equipped with adjustable crosshead. They combine a high level of flexibility with a wide range of all-round application.



Fig. 3: ToniFLEX flexure test frame

Complete system-laboratory solutions

The system-laboratory offers a complete solution for efficient performance of tests on construction materials. The result of analysis incorporating a holistic view of test sequences, it improves the cost-effectiveness of testing via a functional, systematic approach.

ToniLAB

The ToniLAB system laboratory consists of several function-units selected and arranged to suit the testing situations involved, including their organization and spatial constraints. Each function-unit is an operationally and ergonomically optimized combination of testing instrument and laboratory bench for performing defined testing tasks. Layout proposals are created in advance in accordance with customers' requirements. Standard layouts are available at short notice to enable cost-saving budgets to be set in advance of new builds or rebuilds.



Fig. 1: ToniLAB system laboratory for efficient specimen preparation

We possess many years' experience in this area, combined with a deep-seated knowledge of application and planning. For static or dynamic component-testing systems, both individual testing units and modular systems are available, based on strong floors with test portals and individual testing

actuators. Single testing units invariably cover only a limited range of specimens and testing situations. However, measured against the complexity of testing options they have a favourable cost-performance ratio. Strong floors can be used for testing all or any large components, almost without restriction.

Strong floors for testing large or specially loaded components

For components subjected to high loadings, in particular reinforced bearing structures, large-diameter pipes, wall panels etc, testing specimens manufactured in parallel is not sufficient. Tests on 1:1 scale finished components are what is needed, requiring large-scale testing systems, mostly used for very high test loads.

The multitude of problems associated with testing a wide range of disparate components cannot always be solved using standard testing devices. As a rule, each component-testing system requires individual, task-specific planning.



Fig. 2: Strong floor for component testing

2.3 Testing gypsum products

Tensile, flexural and penetration tests on gypsum plasterboard

Various national and international standards relate to the testing of gypsum plasterboard or drywall (DIN 18180, EN 520, ASTM C 473). Zwick's testing machines and fixtures cover the relevant requirements and provide simple solutions for tensile, tensile shear and flexure tests on gypsum plasterboard. In addition, test devices for hardness and penetration testing are available.

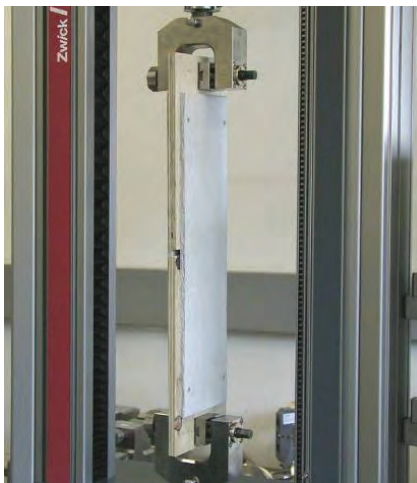


Fig. 1: Tensile test on plasterboard

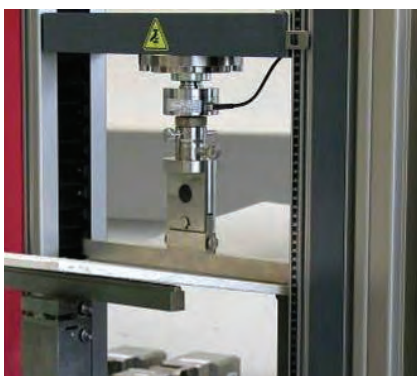


Fig. 2: 2-point flexure test on plasterboard

2.4 Testing glass and ceramics

Flexure tests on glass

The ever-increasing demands of clients and architects are bringing us closer and closer to the limits of what is technically possible in the field of construction. Compared to steel construction, glass construction still has very few standards. Computer control is often not possible, making destructive testing necessary to test the structure and document it accordingly.

Zwick supplies devices to enable the standardized tests to be performed, including 4-point flexure tests on construction glass to EN 1288-3 or the double-ring flexure test on flat specimens to EN 1288-5. Zwick also provides solutions for individual testing requirements.



Fig. 3: 4-point flexure test on construction glass

Flexure tests on roof tiles

Zwick's special 3-point flexure test kit enables tests to determine the flexural strength of clay roofing tiles (clay roofing tiles for discontinuous laying as per EN 538). Concrete roofing tiles and fittings can also be tested for flexural strength (as per EN 491).

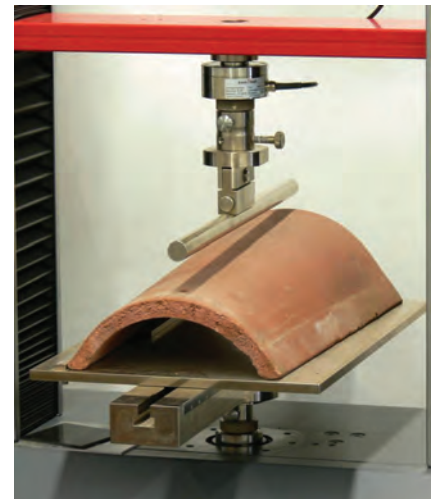


Fig. 4: Determining flexural strength



Fig. 5: Testing tiles

Testing tiles

Zwick developed this test device for determining the adhesive strength of plaster or adhesives on tiles (e.g. to EN 1348). Adhesion tests at an angle of 90° are possible, while several tiles can be bonded to the concrete slab simultaneously and pulled off one after the other by simple position changes.

Zwick provides other solutions for tests on tiles, such as the 3-point flexure test to EN 12002 and determination of shear strength to EN 12003.

2.5 Testing asphalt with servo-hydraulic testing machines

The introduction of EU standard EN 12697 -24 / -25 / -26 established a uniform basis for tests on asphalt. This standard defines test methods for determining deformation, stiffness and fatigue properties of asphalt. The tests are carried out using servo-hydraulic testing machines, with a test load of 10 –25 kN and at temperatures between –25 °C and 40 °C; the temperature must be maintained at a constant level to within 1 K during the test, making a temperature chamber with accurate control a necessity.

Dynamic indirect tensile test

The dynamic indirect tensile test is used both to determine stiffness and as a fatigue test.

Specimens mounted in a test frame are subjected to a haversine compressive load of 0.5 – 10 kN and the resulting deformation perpendicular to the test axis is determined in accordance with EN 12697-26, Annex C

Cyclic compression test Test device for uniaxial cyclic compression test:

The uniaxial cyclic compression test is used to determine permanent deformation and creep properties. The specimen is subjected to trapezoidal compressive load pulses and the deformation is recorded via 2 opposing LVDT displacement transducers in accordance with EN 12697-25, Method A.

Triaxial cell:

In the triaxial cyclic compression test the specimen is supported at the circumference by adjustable air pressure in order to prevent transverse strain. The test is performed to EN 12697-25, Method B.

4-point alternating flexure test

The 4-point alternating flexure test is used to determine fatigue resistance and dynamic stiffness

- as per EN 12697-24, Annex D
- dynamic alternating flexure test
- LVDT 2 mm displacement transducer
- motorized specimen clamping
- special erosion-machined joints for free specimen holder movement
- low gripping-force influence
- up to 2 million sinusoidal load cycles at a testing frequency of 30 Hz
- temperature range 2 ° to 20 °C
- self-locking grips with motorized adjustment for secure, play-free specimen gripping
- minimal local stresses in specimen due to low static gripping forces (approx. 130 N)
- friction-free joints on grips for free rotation and horizontal translation, eliminating friction effects



Fig. 1: Servo-hydraulic testing machine with temperature chamber



Fig. 2: Test device for uniaxial cyclic compression test

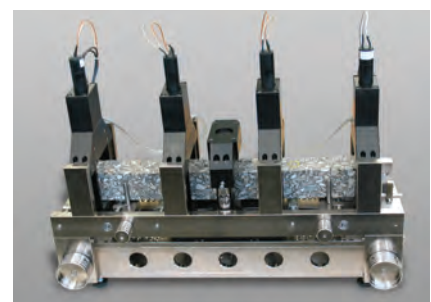


Fig. 3: Test device for 4-point alternating flexure test

2.6 Tests on timber

Tensile tests

Zwick can supply numerous solutions for tests on timber, both for standard tests and for customized testing.

- EN 311: determination of surface soundness of timber materials
- ASTM D 1037 and EN 320: chip board and fiberboard – determination of screw withdrawal resistance parallel to axis
- EN 160: determination of tensile strength perpendicular to board surface

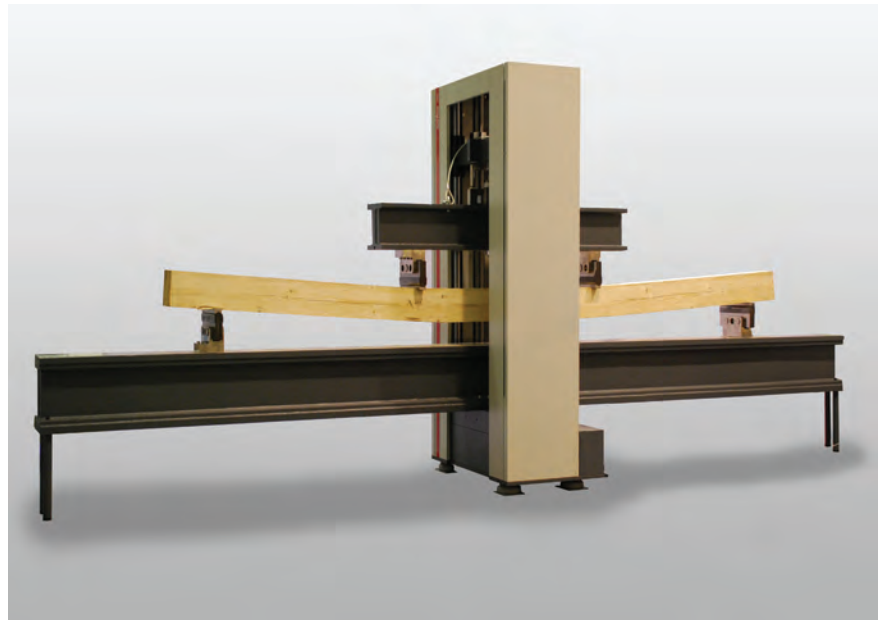


Fig.. 3: 4-point flexure test on construction timber

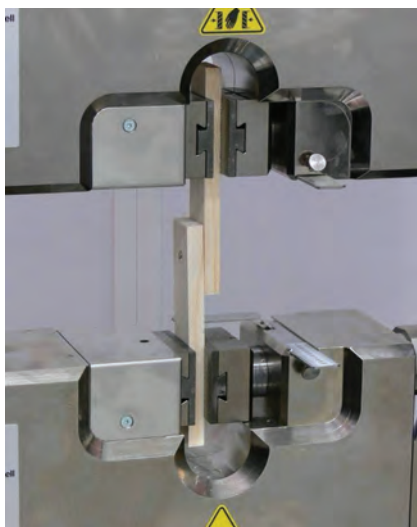


Fig. 1: Tensile shear test

Flexure test

As a sustainable raw material, timber is now seeing increased use in the construction industry as a building material. This requires a check on, amongst other things, its flexural properties via a 3-point flexure test in accordance with DIN 52186.

Zwick can also supply a 4-point flexure test kit for testing construction timber. This is especially suitable for larger specimens subjected to higher loads (up to 600 kN).

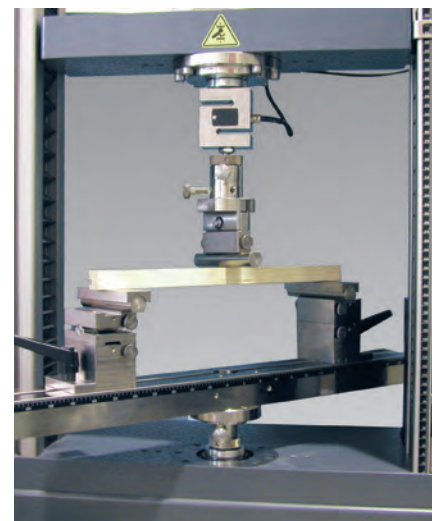


Fig. 4: 3-point flexure test

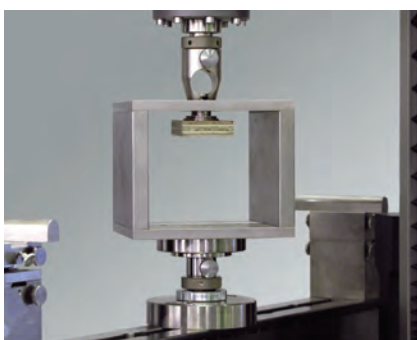


Fig. 2: Determining surface soundness and layer strength of timber

2.7 Profiles and rebars

Tensile test

Because concrete is very strong in compression, but less so in tension, it is reinforced with embedded steel rods. Reinforcement steel is mostly produced in diameters ranging from approximately 5 mm to around 60 mm. Strain measurement on the specimen as required for precise determination of yield point is increasingly being performed with the Makro extensometer, which records strain safely and reliably up to break without incurring any damage to itself.

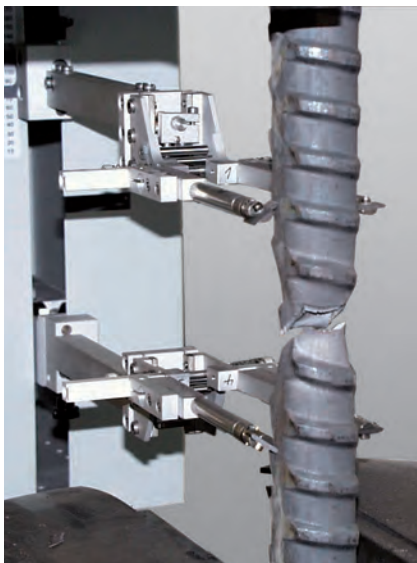


Fig. 1: Tensile test on ribbed reinforcement steel using Makro extensometer

Flexure test

Flexure tests on reinforcing steel are used to test ductility. The specimen must not suffer any reduction in strength and must show no cracks on visual inspection. Various die radii and anvils are specified depending on the standard involved. The bend angle is generally 90° or 180°.

For this test Zwick uses hydraulic testing machines together with flexure test kits in accordance with the standards. If required, two test areas can be set up for electro-mechanical testing machines and used for flexure and tensile tests, eliminating the need to modify the test arrangement.

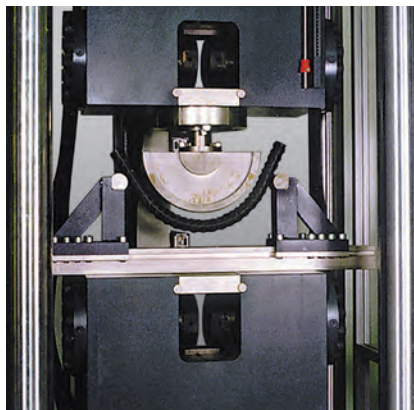


Fig. 2: Flexure test kit for ribbed rebar

Tensile shear test

The spot welds of reinforcing mats and meshes are tested for shearing. Specimens are removed from welded mats and meshes and placed in special positive-clamping specimen grips. The grips used for this type of test must be matched exactly to the diameter and spacing of the ribbed wire in order to avoid influencing the shear forces. Zwick has many years' experience in this area and has developed a comprehensive range of accessories.

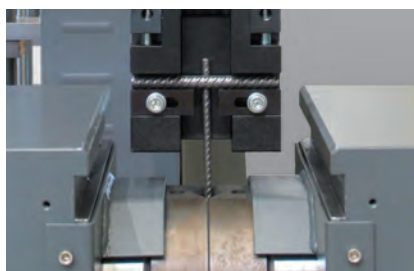


Fig. 3: Weld-seam test, T-connection

Fatigue test

Reinforcement steels must, according to the standard, display a defined level of durability which must be verified. These fatigue tests can be performed most quickly and economically using resonance testing machines. Zwick's Vibrophores provide the ideal solution for this application (up to 600 kN). Specimen diameters can be up to 36 mm; from 14 mm they must be embedded, for which there is an embedding device.



Fig. 4: Specimen grips and specimen embedding for ribbed rebar

3 Standards and test devices

Contents	Test standard	Test means / test device
1 Test devices: Construction, test device's test, accuracies		
<ul style="list-style-type: none"> Tensile, compression and bending testing machine Concrete testing - Strain cylinder test for compression testing machines 	ISO 7500-1, ASTM D76, ASTM E 4, EN 10002-4, DIN 51220, DIN 51 233 EN 12390-4, DIN 51302-2	
2 Sampling and preparation		
<ul style="list-style-type: none"> Production of standard specimen Storage of standard specimen 	DIN EN 196 DIN EN 196	Mortar mixer Laboratory equipment
3 Test methods		
Building materials in general		
<ul style="list-style-type: none"> Longitudinal and transversal strain test on building materials 	DIN 18 555-4	Compression testing machine Deformation transducer
Binders		
<ul style="list-style-type: none"> Cement testing Determination of cement fineness Setting test Compressive/ bending strength of cement Ductility of tiling adhesives 	DIN EN 196, (DIN 1164) DIN EN 196-6, ASTM C204 DIN EN 196-3, ASTM C191 DIN EN 196-1, ISO 679 PCI-cube test	Automatic Blaine Apparatus Automatic Blaine Apparatus Automatic needle tester Compr./bending testing machine
Ceramics		
<ul style="list-style-type: none"> Testing of red bricks Testing of roof tiles (concrete roof tiles) Testing of ceramic pipes Testing of refractories 	DIN EN 772 DIN EN 538, DIN EN 539-1, DIN EN 491 EN 295 DIN 51010-4, ISO 5013, DIN EN 993-7, EN ISO 10545	Materials testing machine Materials testing machine Materials testing machine Materials testing machine
Concrete		
<ul style="list-style-type: none"> Compressive strength test Determination of the Young's modulus Flexural tensile strength (metallic fibre concrete) Splitting tensile strength (eg cobblestone) Hydraulically bound mixtures (Young's modulus) 	DIN 1048-4, DIN EN 206 DIN 1048, ISO 6784, Ö-Norm B3303 EN 14651 EN 1338 EN 13286-43	Compression testing machine Deformation transducer Bending testing machine Compression testing machine Compression testing machine
Glass fibre reinforced concrete		
<ul style="list-style-type: none"> Simple bending test Complete bending test Tensile strength of glass fibres in concrete 	Pr DIN EN 1170-4 Pr DIN EN 1170-5 GRCA S 0104/0184	Materials testing machine Materials testing machine Bending testing machine
Steel for reinforcement of concrete, prestressing, strands, anchor grips		
<ul style="list-style-type: none"> Tensile and bending tests Rebend test Determination of the weld shear strength 	ASTM A 615, BS 4482, BS 4483, BS 4449, DIN 488- 1...7, EN 10080 BS 4482, BS 4483, BS 4449, DIN 488-1...7, EN 10080 BS 4483	Materials testing machine Materials testing machine Materials testing machine

Contents	Test standard	Test means / test device
<ul style="list-style-type: none"> • Dynamic fatigue test 	BS 4449, DIN 488-1...7, EN 10080	Vibrophore
<ul style="list-style-type: none"> • Test of steel wires for the reinforc. of concrete 	DIN 696	Vibrophore
<ul style="list-style-type: none"> • Bending test on welded wire mesh 	BS 4483, BS 4461, BS 4482	Materials testing machine
<ul style="list-style-type: none"> • Bond classification of deformed bars 	BS 4482, BS 4449	Materials testing machine
<ul style="list-style-type: none"> • Determination of the shearing force at break of welded knots of welded wire mesh or reinforced cages 	DIN EN 1737	Materials testing machine
<ul style="list-style-type: none"> • Determination of the strength of weld joints in welded wire mesh 	ISO 10287	Materials testing machine
<ul style="list-style-type: none"> • Determination of the total strain at maximum tensile force 	ISO 10606, ISO 15630	Materials testing machine
<ul style="list-style-type: none"> • Steel bars for concrete reinforcements 	JIS G 3112	Materials testing machine
<ul style="list-style-type: none"> • Steel for the reinforcement of concrete: ribbed bars 	SI 739	Vibrophore
Components		
<ul style="list-style-type: none"> • Testing of drain pipes, PVC rigid 	DIN 1187, ISO DIS 8771	Materials testing machine Drop weight tester
<ul style="list-style-type: none"> • Testing of drain pipes and multipurpose pipes made of PVC-U and PE-HD for traffic routes and civil engineering 	DIN 4262-1	Extrusion plastometer Materials testing machine Drop weight tester
<ul style="list-style-type: none"> • Testing of the creep characteristics of thermoplastic pipes 	ISO 9967	Materials testing machine
<ul style="list-style-type: none"> • Testing of the ring rigidity of thermoplastic pipes 	ISO 9969	Materials testing machine
<ul style="list-style-type: none"> • Reinforced concrete pipes and corresponding 	DIN 4035, ENV 10080	Materials testing machine
<ul style="list-style-type: none"> • Determination of the compressive strength of paving stones 	DIN 18501	Compression testing machine
Timber		
<ul style="list-style-type: none"> • Determination of the compressive strength parallel to the direction of grain 	DIN 52185	Materials testing machine
<ul style="list-style-type: none"> • Determination of the bending strength 	DIN 52186, ISO 3133	Materials testing machine
<ul style="list-style-type: none"> • Determination of the shear strength in direction of grain 	DIN 52187, ISO 3347	Materials testing machine
<ul style="list-style-type: none"> • Determination of the tensile strength parallel to the direction of grain 	DIN 52188, ISO 3345	Materials testing machine
<ul style="list-style-type: none"> • Determination of the fracture impact strength 	DIN 52189-1, ISO 3348	Pendulum impact tester
<ul style="list-style-type: none"> • Determination of the compressive strength vertical to the direction of grain 	DIN 52192, ISO 3132, BS 373	Materials testing machine
<ul style="list-style-type: none"> • Determination of adhesive strength in tensile shear test 	DIN EN 302 DIN EN 314-2	Materials testing machine
<ul style="list-style-type: none"> • Determination of adhesive strength in tensile shear test (plywood) 	DIN EN 314-2	Materials testing machine
<ul style="list-style-type: none"> • Determination of bending Young's modulus and the bending stress of wood materials with thickness > 3 mm 	DIN EN 310	Materials testing machine
<ul style="list-style-type: none"> • Bending test 	DIN 52352, DIN 52371, DIN 52362-1	Materials testing machine

Contents	Test standard	Test means / test device
<ul style="list-style-type: none"> Determination of the vertical tensile strength on chipboards, fiberboards and cement-glued chipboards 	DIN 52365, DIN EN 319	Materials testing machine
<ul style="list-style-type: none"> Determination of the parallel screw pull-out resistance on fibre boards 	DIN EN 320	Materials testing machine
<ul style="list-style-type: none"> Determination of lift-off strength 	DIN 52366, DIN EN 311	Materials testing machine
<ul style="list-style-type: none"> Mechanical properties of fibre plates and chipboards 	ASTM D 1037	Materials testing machine
Thermal insulating materials		
<ul style="list-style-type: none"> Thermal insulating material for the building trade, compression loading 	EN 826, ASTM C 165	Materials testing machine
<ul style="list-style-type: none"> Thermal insulating material for the building trade, deformation at compression and temperature loading 	EN 1605	Materials testing machine
<ul style="list-style-type: none"> Thermal insulating material for the building trade, long-term creep behaviour at compression loading 	EN 1606	Materials testing machine
<ul style="list-style-type: none"> Thermal insulating material for the building trade, tensile tests vertical to the panel's plane 	EN 1607	Materials testing machine
<ul style="list-style-type: none"> Thermal insulating material for the building trade, tensile tests in the panel plane 	EN 1608	Materials testing machine
<ul style="list-style-type: none"> Thermal insulating material for the building trade, flexural loading 	EN 12089	Materials testing machine
<ul style="list-style-type: none"> Mineral fibre insulating slabs, compressive stress and compressive strength 	DIN 52272-1	Materials testing machine
<ul style="list-style-type: none"> Mineral fibre insulating slabs, tear strength vertical to the insulation plane 	DIN 52274	Materials testing machine
<ul style="list-style-type: none"> Insulating plates, load bearing capacity 	ASTM E 1803	Materials testing machine
<ul style="list-style-type: none"> Finished parts for pipe insulation, break load and calculated modulus of rupture 	ASTM C 446	Materials testing machine
<ul style="list-style-type: none"> Insulating blocks, breaking load and bending strength 	ASTM C 203	Materials testing machine

Date 03/2012

Zwick Roell AG

August-Nagel-Str. 11
D-89079 Ulm
Phone +49 7305 10 - 0
Fax +49 7305 10 - 200
info@zwickroell.com
www.zwickroell.com

Toni Technik

Baustoffprüfsysteme GmbH

Gustav-Mayer-Allee 25
D-13355 Berlin
Phone +49 30 - 46 40 39 21/23
Fax +49 30 - 46 40 39 22
info@tonitechnik.com
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