UDC 669.14-422.2:669.714:693.554:620.1 June 1986

Reinforcing steel
Reinforcing steel bars
Testing

DIN 488 Part 3

Betonstahl; Betonstabstahl; Prüfungen

Supersedes April 1972 edition.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

See Explanatory notes for connection with EURONORM 80 and 82 published by the European Coal and Steel Community, and with an international standard in preparation by the International Organization for Standardization (ISO).

The DIN 488 series includes:

DIN 488 Part 1	Reinforcing steel; grades, properties, marking
DIN 488 Part 2	Reinforcing steel; reinforcing steel bars; dimensions and masses
DIN 488 Part 3	Reinforcing steel; reinforcing steel bars; testing
DIN 488 Part 4	Reinforcing steel; reinforcing steel fabric and wire; design, dimensions and masses
DIN 488 Part 5	Reinforcing steel; reinforcing steel fabric and wire; testing
DIN 488 Part 6	Reinforcing steel; quality control
DIN 488 Part 7	Reinforcing steel; verification of weldability of reinforcing steel bars; test procedure and evaluation

Dimensions in mm

1 Field of application

This standard serves to determine the properties specified in DIN 488 Part 1 and to check the dimensions specified in DIN 488 Part 2 for ribbed reinforcing steel bars of grades BSt 420 S and BSt 500 S.

See DIN 488 Part 7 for procedure and evaluation of tests for verifying the weldability of reinforcing steel bars, and DIN 488 Part 5 for the methods of testing reinforcing steel fabric and wire.

2 Cross-sectional area and size

The cross-sectional area, A_s, shall be determined from the mass of a section of bar by means of equation (1):

$$A_s = \frac{1{,}274 \cdot G}{l} \quad (1)$$

and the corresponding nominal size, d_s, by means of equation (2):

$$d_s = 12{,}74 \sqrt{\frac{G}{l}} \quad (2)$$

In both equations, the mass of the section of bar, G, shall be expressed in g and its length l in mm, so as to give the cross-sectional area in cm^2 and the nominal size in mm.

3 Surface configuration

3.1 Height of oblique ribs

The height of the ribs in the middle, h_s, and the height of the ribs at the quarter points, h_{sv}, shall be determined, to the nearest 0,01 mm, for each row of ribs as the mean of measurements made on not less than 2 ribs per row having the same angle of inclination, β.

3.2 Spacing of oblique ribs

The spacing of the ribs, c_s, shall be determined in the case of non-twisted bars to the nearest 0,1 mm as the mean of the centre-to-centre distance values for not less than 11 ribs in each row.

In the case of cold twisted bars, the distance between the centres of two oblique ribs that do not exhibit any twist relative to each other and hence are about one pitch apart shall be measured; the value thus found shall be divided by the number of intervals between the two points (see also DIN 488 Part 2, June 1986 edition, figures 2 and 4).

3.3 Width, inclination to bar axis, flank inclination and gap between opposing ends of oblique ribs

Crest width b_s, the angle of inclination of the ribs to the bar axis, β, the flank inclination angle α and the gap between opposing rib ends, e, shall be checked using suitable measuring methods, taking the mean values obtained from measurements made, in each row, on not less than 2 successive ribs having the same angle of inclination.

3.4 Height and crest width of longitudinal ribs

In the case of cold twisted bars, the height and the crest width of the longitudinal ribs, h_1 and b_1, shall be measured at several points on the specimen.

Continued on pages 2 to 6

3.5 Relative rib area

The relative rib area is understood to mean the area of the rib projected on a plane of section perpendicular to the bar axis, relative to the nominal circumference and the mean rib spacing. If

- the rib spacing, c_s, is larger and/or
- the oblique rib height, h_s or h_{sv}, is smaller and/or
- the height of the longitudinal ribs, h_l, in the case of cold twisted bars is smaller and/or
- the gap between opposing rib ends, e, is larger

than the values specified in DIN 488 Part 2, the mean relative rib area, f_R, shall be determined using equation (3):

$$f_R = \frac{1}{\pi \cdot d_s} \sum_{n=1}^{k} \frac{\frac{1}{m} \sum_{l=1}^{m} F_{R\,(n,l)} \cdot \sin \beta_{(n,l)}}{c_{s(n)}} + \frac{1}{j \cdot d_s} \sum_{n=1}^{i} h_{l(n)} \qquad (3)$$

The second summand applies only for cold twisted bars and shall only be taken into account up to a value of 30 % of the total value of f_R.

In equation (3), $F_R = \sum_{n=1}^{x} (h_{s(n)} \cdot \Delta l)$ is the area of a longitudinal section of a rib (see figure 1);

h_s is the average height of any portion of an oblique rib of length Δl subdivided into x segments;
β is the angle of inclination of the ribs to the bar axis, in °;
d_s is the nominal size of the bar, in mm;
c_s is the spacing of the oblique ribs, in mm;
k is the number of rows of oblique ribs on the circumference;
m is the number of oblique rib inclinations per row;
i is the number of longitudinal ribs;
h_l is the height of the longitudinal ribs, in mm;
$j \cdot d_s$ is the pitch for cold twisted bars;
.. (n); (n, l) are variables.

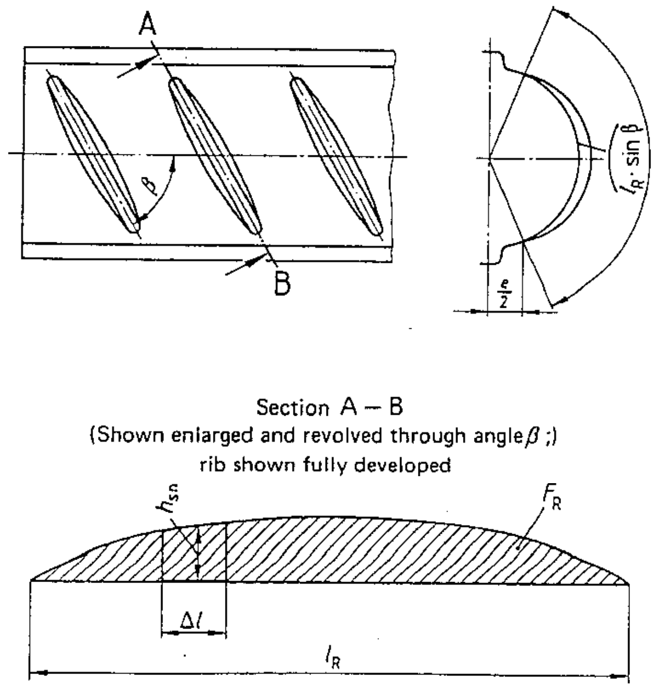

Figure 1. Determining the area of the longitudinal section, F_R, of an oblique rib in the rib axis

4 Mechanical and technological properties

4.1 Tensile test

Compliance with the values of yield strength, 0,2 % proof stress, tensile strength and elongation after fracture as specified in DIN 488 Part 1, September 1984 edition, table 1 shall be verified as described in DIN 50 145.

For this purpose, and as a departure from DIN 50 145, unmachined test pieces having a clear length between grips of about $15 \cdot d_s$ shall be used. If the yield stress cannot be easily recognized, the 0,2 % proof stress shall be determined.

The cross-sectional area of the bar to be considered for calculating the yield strength and tensile strength shall be determined as in clause 2.

Prior to testing, test pieces taken from cold twisted bars may be conditioned (aged) for half an hour at a temperature of 250 °C and then cooled in air to an ambient temperature of 15 to 35 °C as specified in DIN 50 014. The test report shall state whether this has been done. In cases of arbitration, the test in the aged condition shall be determining.

4.2 Fatigue test (for bars embedded in concrete)

4.2.1 Test conditions

The fatigue test shall be carried out on bars embedded in concrete, which have been bent. The test shall be carried out on three bars the sizes of which lying in the lower and upper limit and in the middle range of the rolling schedule, the small nominal sizes ($d_s \leq 8$ mm) being used for the stirrups of the test pieces. For this purpose, bar benders of the kind typically employed on construction sites shall be used for bending the stirrups to $d_{br} = 4 \cdot d_s$ and the longitudinal bars to $d_{br} = 15 \cdot d_s$. In the case of the longitudinal bars, the bending shall be performed in such a manner that there are always oblique ribs on the inside of the curvature. The bent bars shall be aged (heating to 250 °C, holding at this temperature for half an hour followed by cooling to ambient temperature). No subsequent deformation (e.g. re-aligning) is permitted. The shape and dimensions of the test pieces and of the reinforcement can be seen from figures 2 to 4.

During the test, the compressive strength of the concrete β_w shall not change substantially and shall be not less than 40 N/mm². Testing shall start at the earliest when the age of the concrete is 14 days and at the latest at an age of 60 days.

The fatigue strength shall be determined for a maximum stress of $\sigma_0 = 0{,}7 \cdot R_e$ or $0{,}7 \cdot R_{p\,0,2}$, the actual values being substituted for R_e and $R_{p\,0,2}$.

The number of ultimate load cycles shall be $2 \cdot 10^6$.

The test shall be carried out in a pulsator under load control with the dead weight of the test pieces to be taken into account. The test frequency shall not exceed approximately 300 load reversals per minute.

4.2.2 Sample preparation and test procedure

The dimensions of the test piece and of the reinforcement are illustrated in figures 2 to 4. To ensure secure anchorage, short lengths of bar of the same thickness shall be welded to the bar undergoing the test at positions above the supports; alternatively, other suitable measures shall be adopted. The concrete cover on the longitudinal reinforcement specified at 25 mm shall be maintained by suitable bar spacers. The separators for inducing defined cracks in the concrete shall receive cut-outs in the vicinity of the bar, so that there cannot be any contact with the bar under test. Their thickness shall not exceed 3 mm.

The concrete shall be made with Portland cement Z 35 F as specified in DIN 1164 Part 1. The proportion of cement shall be 300 kg/m³ and the particle size shall range from 0 to 16 mm. The grading curve shall be chosen so that it lies in range 3 as specified in DIN 1045. The consistency shall conform to that of a K 2 plastic concrete as specified in DIN 1045. The concrete shall be compacted with immersion vibrators.

After the concrete has been placed, the test pieces shall be covered with wet cloths for 7 days. For each test piece three 20 cm cubes for determinig the compressive strength on the date of testing shall be made and treated in the same manner as the test pieces.

The test piece shall be mounted on pivoted roller bearings.

The steel stresses shall be calculated using figures 2 to 4 from the mid-beam moment

$$M = P \cdot a + M_G \qquad (4)$$

where

P is the test force;

a = 35 cm;

M_G is the moment due to dead weight and the loading system, and

assuming a steel-to-concrete modulus of elasticity ratio of $n = 15$.

4.3 Rebend test

Bend the bars at a temperature between 15 and 25 °C round the mandrel specified in DIN 488 Part 1, September 1984 edition, table 1, with a bend angle of about 90°, age them by heating to 250 °C[1]) and hold at this temperature for half an hour, allow them to cool to ambient temperature and then rebend through at least 20°. This test shall be deemed to have been passed if examination reveals neither incipient cracks on the side in tension when rebending nor any fracture of the test piece. The bars shall be bent using bar benders of the type typically employed on construction sites and shall be so positioned that the oblique ribs bear with their maximum height against the bending roll. The rolls of the bar benders shall be freely rotatable. No spacers to avoid crushing shall be used. The rebend test may also be carried out on suitably modified materials testing machines.

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[1]) In cases of arbitration, the temperature shall be 100 °C.

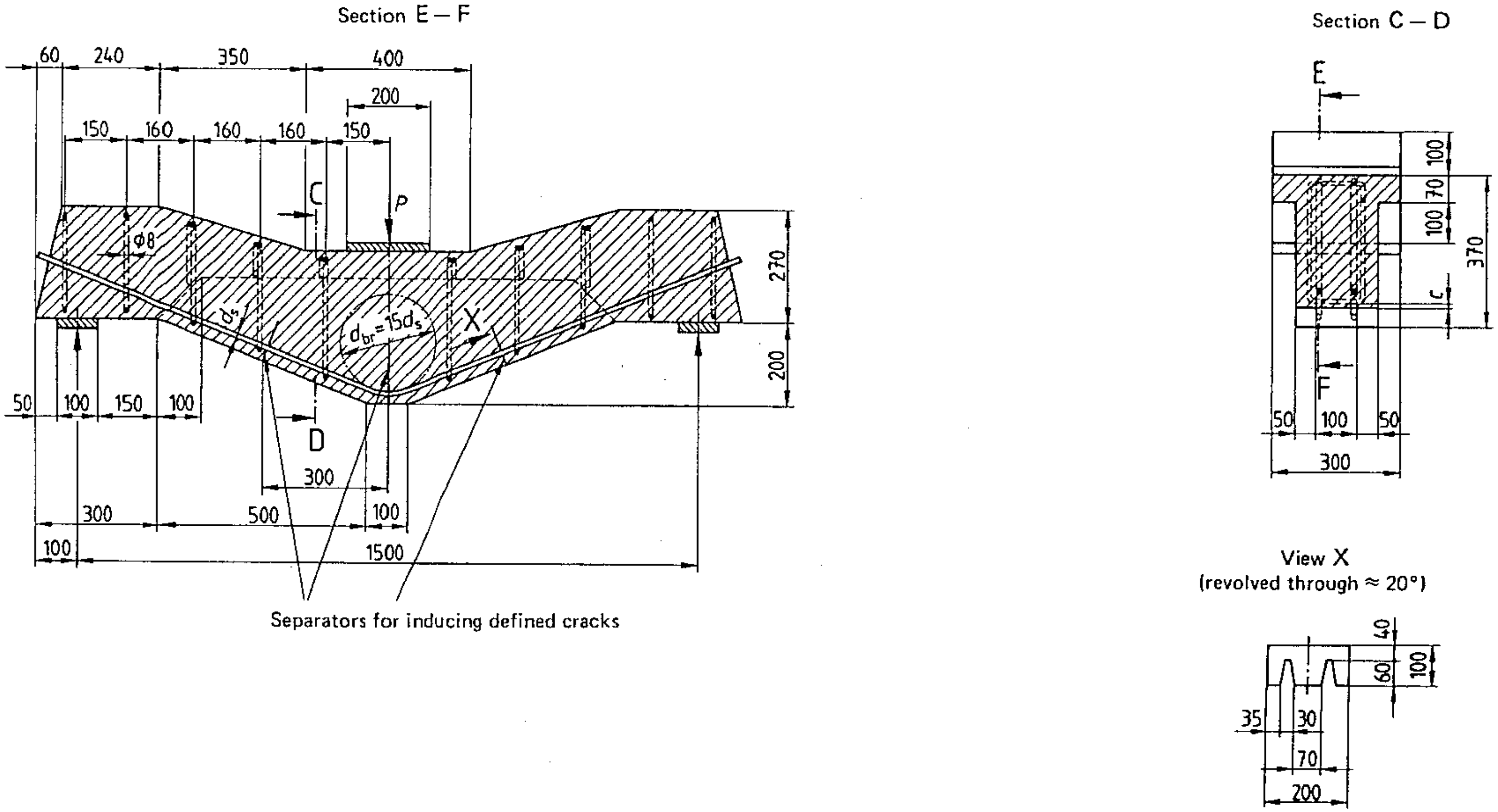
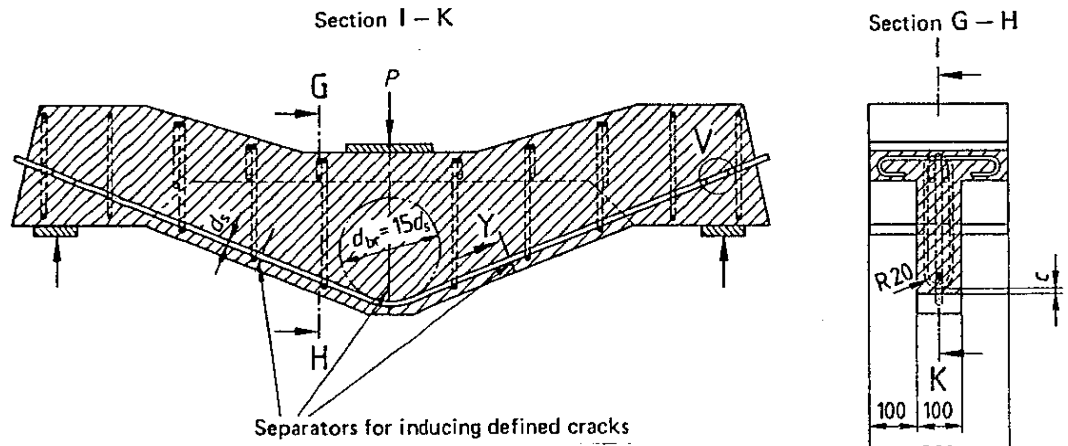


Figure 2. Test piece for fatigue testing of embedded, bent bars with nominal sizes less than 12 mm (diameter of curvature, $d_{br} = 15 \cdot d_s$)

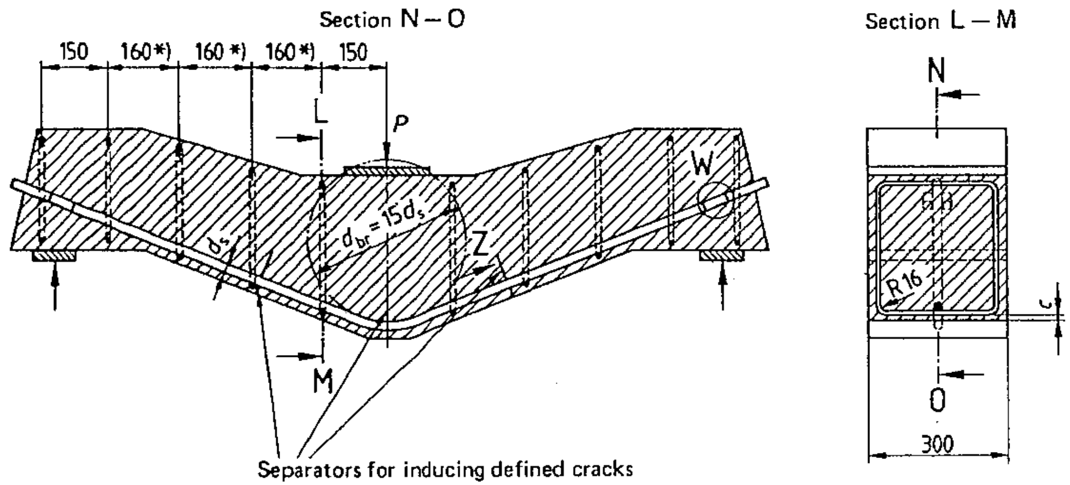
Concrete cover on longitudinal bar = 25 mm

Concrete cover on stirrups c = 17 mm



Other dimensions as for figure 2.

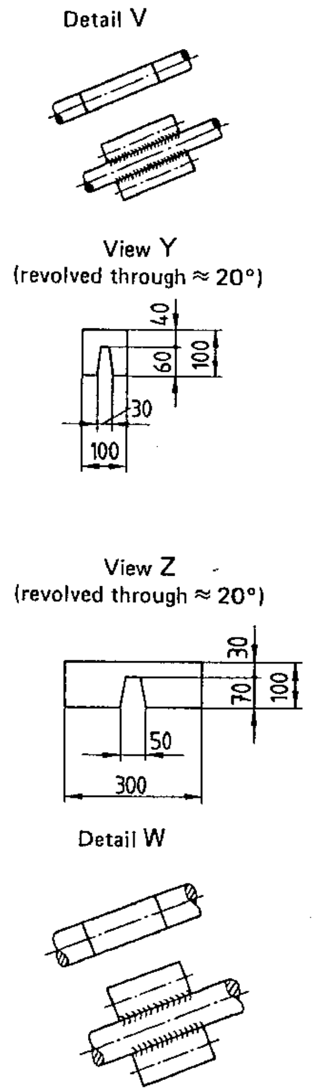
Figure 3. Test piece for fatigue testing of embedded bent bars with nominal sizes from 12 to 16 (diameter of curvature, $d_{br} = 15 \cdot d_s$)



Other dimensions as for figure 2.

Figure 4. Test piece for fatigue testing of embedded bent bars with nominal sizes from 20 to 28 (diameter of curvature, $d_{br} = 15 \cdot d_s$)

*) For nominal size d_s = 28 mm, 5 stirrups shall be spaced at 120 mm.



Concrete cover on longitudinal bar = 25 mm
Concrete cover on stirrups c = 17 mm

Standards referred to

DIN 488 Part 1	Reinforcing steel; grades, properties, marking
DIN 488 Part 2	Reinforcing steel; reinforcing steel bars; dimensions and masses
DIN 488 Part 5	Reinforcing steel; fabric and wire; testing
DIN 488 Part 7	Reinforcing steel; verification of weldability of reinforcing steel bars; test procedure and evaluation
DIN 1045	Concrete and reinforced concrete; design and construction
DIN 1164 Part 1	Portland, iron Portland, blast furnace and trass cement; concepts, components, requirements, delivery
DIN 50 014	Climates and their technical application; standard atmospheres
DIN 50 145	Testing of metallic materials; tensile test

Previous editions

DIN 488 Part 3: 04.72

Amendments

The following amendments have been made in comparison with the April 1972 edition (see also Explanatory notes).

a) The field of application has been brought into line with the classification into grades as specified in DIN 488 Part 1.

b) The equation for determining the relative rib area (see subclause 3.5) has been amended.

c) The specifications on testing weldability have been deleted.

d) Further information regarding the test pieces to be used in the fatigue test (see subclause 4.2 and figure 2) have been given.

Explanatory notes

This edition of DIN 488 Part 3 has been prepared in the context of the discussions on the revision of the technical delivery conditions for reinforcing steel by a joint committee of the *Normenausschuß Eisen und Stahl* (Iron and Steel Standards Committee) and the *Normenausschuß Bauwesen* (Building Standards Committee). The following are the main amendmends that have been made compared with DIN 488 Part 3, April 1972 edition:

a) Consistent with the agreements regarding the classification into grades and surface configuration of the products as specified in DIN 488 Parts 1 and 2, the field of application of DIN 488 Part 3 now covers obliquely ribbed bars of grades BSt 420 S and BSt 500 S. All specifications and information relating to plain and transversely ribbed bars have been deleted.

b) The equation for determining the relative rib area in subclause 3.5 has been amended; in its revised version it is universally applicable to BSt 420 S (with different rib spacings on the two halves of the bar) and BSt 500 S (with alternating inclination of the ribs to the bar axis in one of the two rows), and to BSt 500 M ribbed reinforcing steel fabric (where the bar is provided with three rows of ribs).

c) Figure 2 covering nominal bar sizes under 12 mm gives additional information on the shape and dimensions of the test pieces for the fatigue test on embedded bars.

d) The specifications regarding test procedure and evaluation for verifying weldability have been combined and given in DIN 488 Part 7.

e) For reinforcing steel the following international documents have been published or are in preparation:

EURONORM 80, Reinforcing bars (not for prestressing) (March 1969 edition, the revised edition was adopted in 1985);

EURONORM 82, Steel for the reinforcement of concrete with an improved bonding action; dimensions, masses, tolerances (February 1979 edition);

ISO/DP 6935/2, Steel for the reinforcement of concrete; deformed bars (currently the 5th draft proposal of September 1981, with document number ISO/TC 17/SC 16 N 211).

These international documents specify or provide that the tensile test in cases of arbitration be carried out on test pieces that have been conditioned for one hour at 100 °C. Similarly, in the case of the rebend test it has been specified that the test pieces are to be conditioned at 100 °C (instead of 250 °C). The other test conditions are largely in agreement with the content of the present standard. The international standards, however, do not include any data on fatigue testing.

International Patent Classification

E 04 C 5/03

G 01 N 3/00