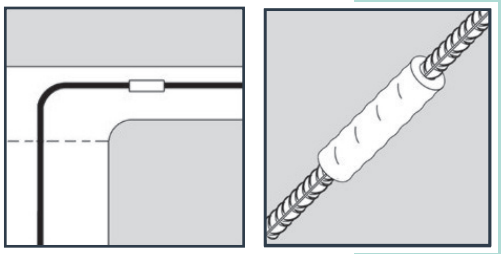
DYWIDAG-SYSTEMS INTERNATIONAL

DSI

DYWIDAG Reinforcement Systems

FLIMU-System



Mechanical Connection and Anchorage of Reinforcing Steel Bar by means of Extruded Couplers Nominal Diameter: 16 to 32 mm "FLIMU-System"

Approval Number
Z-1.5-150
Validity
29 September 2009 -
30 September 2014

D E U T S C H E S I N S T I T U T F Ü R B A U T E C H N I K
(Institute for Construction Engineering)
Statutory Body

10829 Berlin, 29th September 2009
Kolonnenstrasse 30 L
Telephone: (030) 78730-0
Telefax: (030) 78730-320
Reference: I 19-1.1.5-32/08

APPROVAL CERTIFICATE

Approval Number: Z-1.5-150

Applicant: DYWIDAG-Systems International GmbH
Siemensstrasse 8
85716 Unterschleissheim

Object of Approval: Mechanical Connection and Anchorage of Reinforcing Steel Bar by means of Extruded Couplers
Nominal Diameter: 16 to 32 mm
"FLIMU-System"

Valid until: 30th September 2014

The aforementioned Object of Approval is hereby generally approved by the supreme construction authorities in accordance with building legislation.
This approval certificate comprises eight pages and four appended sheets.
This certificate supersedes the approval certificate No. Z-1.5-150 dated 8th April 2005.
The Object of Approval was first approved on 1st May 1988.

I. GENERAL PROVISIONS

1 This approval constitutes demonstration of usability and applicability resp. of the object as called for by state construction regulations in Germany.

2 As far as in this approval requirements are set for special know-how and experience of the personal in charge of the performance of construction products and construction methods as per § 17, section 5 of the classic construction rules according to the state regulations, it must be considered that this know-how and experience can also be proofed by equivalent verifications of other member countries of the European Union. If necessary, this is also valid for the provision of equivalent verifications in line with the Treaty on the European Economic Area or other bilateral agreements.

3 This approval does not replace the permissions, consents and certificates as required by German law for carrying out construction projects.

4 Approval is granted without prejudice to third party rights, particularly private protection rights.

5 Beside the regulations in the "Special Provisions", the manufacture and supplier of the object shall submit to the user a copy of this approval certificate; furthermore they shall inform the user that this approval certificate shall be available at the construction site. On request, a copy of this approval certificate shall be submitted to all involved authorities.

6 This approval may only be copied in its entirety. Any excerpt to be published from this approval certificate shall be subject to approval of Deutsches Institut für Bautechnik. The text and the drawings of advertising literature shall not be inconsistent with the approval certificate. Translations of the approval certificate must contain the indication that the wording is not as authorized by Deutsches Institut für Bautechnik.

7 This approval will be given revocable. The provisions of this approval may be amended or modified and in particular whenever new technical findings justify this measure.

II. SPECIAL PROVISIONS

1 Object of Approval and Application Range

1.1 Object of Approval

(1) Object of this approval is the mechanical connection and anchorage of reinforcing steel bars by means of extruded couplers (see Appendix 1) – in the following named as Extruded Coupler Splice.

(2) The extruded coupler splice will be produced at site by means of a reducing ring (die) by continuous cold-extruding a steel coupler joining the butted ends of reinforcing steel bars. Thus a connection is created between the ripped surface of the reinforcing steel and the inner surface of the extruded coupler through which the full bar load will be transferred.

(3) Bars with equal or unequal surface deformation – e.g. bars with skew ribs as per DIN 488-1[1] and bars with threaded ribs as per approval certificate – may be connected with extruded couplers.

(4) The nominal diameter of the connecting reinforcing steel bars ranges from 16 to 32 mm. Also, bars with different diameter may be connected as long as the diameters are neighbouring in the standardized diameter sequence (extruded reducing coupler).

(5) Reinforcing Steel Bars with threaded ribs (GEWI-Steel) and reinforcing steel bars Ø 32 mm require an approval certificate.

1.2 Application Range

Reinforcing steel bars will be anchored and spliced according to the provisions of DIN 1045-1[1], sections 12.6 and 12.8.

Splices and anchorages with reinforcing steel BSt 420 S may be used only for predominantly static loading.

2 Provisions for the Construction Product

2.1 Properties and Composition

2.1.1 Material Properties

The basic material for the extruded couplers and anchorages is specified in the Appendix Sheets 1 and 2. The necessary requirements for the material properties, as per mentioned codes, must be fulfilled.

2.1.2 Geometry

(1) The geometrical dimensions as well as the permissible tolerances are specified for the extruded couplers in Appendix Sheet 1, Table 1 and for the extruded reducing couplers in Appendix Sheet 1, Table 2.

(2) The geometrical dimensions for the anchor piece, anchor plate and anchor nut are specified in Appendix Sheet 3, Table 3.

2.2 Manufacture and Identification

2.2.1 Manufacture

(1) The couplers will be cut to the required length in the manufacturer plant. For positioning the reducing ring (die) at the later assembly at site, one front side of the coupler will be chamfered outside.

(2) Depending on the used material, the anchorage components will be either cast in their final shape or cut to size.

2.2.2 Identification and Packing

(1) In the manufacturer plant each coupler and each anchorage component must be marked with the manufacturer symbol as illustrated in the Appendices 1 and 2 as well as with the data about the joining nominal diameter and the type of reinforcing steel.

(2) The packing of the extruded couplers and the delivery note must be marked by the manufacturer with the conformity symbol (Ü-Symbol) according to the conformity symbol decree issued by the Länder (German States). The identification may be applied only when the requirements have been met according to section 2.3.

2.3 Conformity Verification

2.3.1 General

(1) For every manufacturer plant with conformity certificates based on in-house production checking and periodical external inspections including a first testing of the construction product, the confirmation of conformity of the construction product with the provisions of this approval will be provided according to the following provisions.

(2) For granting of the conformity certificate and external inspection including the nearby carried out production tests, the manufacturer of the construction product has to appoint both a certification institution and an inspection agency which are acknowledged in this field.

(3) The Institute of Construction Engineering must receive as information a copy of the issued conformity certificate from the certification institution.

2.3.2 In-House Production Checking

(1) In every manufacturer plant, an in-house production checking has to be established and implemented. The manufacturer understands by the meaning “in-house production supervision” to undertake a continuous inspection of production, which ensures, that the manufactured construction product complies with the provisions of this approval certificate.

(2) The in-house production checking shall at least include such measures which are defined in the "Principles for Approval – and Inspection Tests of mechanical connections – edition May 2007.

(3) Verification of the material properties of the basic material for couplers must be attested with an Inspection Certificate according to DIN EN 10 204[3], section 2.3.

(4) Hardness tests for inspecting the strength must be performed at least once a day or after every 500 couplers.

(5) According to statistical criteria, 5 % of the manufactured couplers must be sampled and the dimension values for length, outer diameter, inner diameter and wall thickness (at 90° staggered points) inspected, using suitable gauges.

(6) The productive amplitude of the manufactured extruded coupler splice under jobsite conditions must be checked for each diameter at least once per year.

(7) The results of the in-house production checking shall be recorded and evaluated. The evaluations shall at least include the following information:

- Description of construction product and basic material with constituent parts respectively
- Way of checking or testing
- Dates of manufacture and testing of the construction product and basic material or the constituent parts respectively
- Results of checking and testing and if applicable comparison with the requirements
- Signature of responsible person for the in-house production checking

(8) The records shall be kept for a period of at least 5 years and submitted to the nominated inspection agency for the external inspection. On request, they have to be submitted to the Institute of Construction Engineering and the responsible Supreme Construction Authorities.

(9) In case of insufficient test results, the manufacturer must immediately arrange the necessary measurements in order to abolish the defect. Construction products which do not comply with the requirements must be handled in such a way to exclude any confusion with complying products. After abolishment of the defect - as far as technically possible and as verification of the defect removal - the corresponding test must be repeated immediately.

2.3.3 External Inspection

(1) In every manufacturer plant, the in-house production checking shall be periodically reviewed by the external inspection agency according to the mentioned principles as per section 2.3.2 (2), but at least twice a year.

(2) Within the scope of external inspection, specimen for random samples shall be taken according to the mentioned principles as per section 2.3.2 (2).

(3) Within the scope of continuous inspection regarding the performed tensile tests, the evaluations must be checked according to section 4.3.2 (4).

(4) The results of certification and external inspection shall be kept for a period of at least 5 years. They are to be submitted by the certification institution or inspection agency to the Institute for Construction Engineering and the responsible Supreme Construction Authorities on request.

3 Provisions for Planning and Design

3.1 General

(1) For planning and design applies section 1.2 as well as the following provisions.

(2) All bars in a cross-section may be spliced (full splice).

(3) The position and dimension of coupler splices and anchorages must be illustrated in the reinforcement shop drawings and the conditions of the installation instructions must be fulfilled.

3.2 Permissible Loadings

3.2.1 Predominantly Static Loading

Splices and Anchorages of this approval may be loaded to 100 % at a predominantly tensile load like an unspliced bar.

3.2.2 Not predominantly Static Loading

For the design according to DIN 1045-1[2], a verification against fatigue as per section 10.8 of this code must be carried out. For splices and anchorages with reinforcing steel BSt 500 S, nominal diameter 16 to 32 mm, $\triangle\sigma_{Rsk}$ = 90 N/mm² must be considered as characteristic value of the fatigue strength, constantly for the stress cycles endured range from zero up to 2 mill. load cycles.

For the stress cycles endured range from 2 to 10 mill. load cycles a rise factor k_1 = 3 and for those higher than 10 mill load cycles a rise factor k_2 = 5 has to be considered for the progress of the characteristic stress amplitude (compare DIN 1045-1[2], figure 52).

Splices and anchorages with reinforcing steel BSt 420 S may be used for predominantly static loading only.

3.3 Concrete Cover and Bar Distance

(1) For the concrete cover over the outer edge of a coupler or an anchorage element as well as for the clear distance of outer edges of couplers or anchorage elements apply the same values as for unspliced bars according to DIN 1045-1[2], section 6.3 or section 12.2.

(2) The – possibly larger – distances required for the installation are not affected by this.

3.4 Centre- and Edge Distances of Anchorages

(1) Valid are the centre- and edge distances as specified in Appendix Sheet 3.

(2) In case the anchorages cannot be positioned in one cross section level as per 3.4, then they must be staggered at least 1,5 times of the centre distance in bar direction.

(3) If it is necessary to deviate of the distances as specified in section 3.4 (1) and (2), the absorption of the transverse tensile stresses by the transverse reinforcement or by transverse compression must be verified by calculation.

3.5 Bendings

(1) The scheduled bending of a bar may start at a distance of at least 5 x d_s from the end of a coupler (d_s = nominal diameter of the bent bar).

(2) If spliced bars are bent with special equipment in the manufacturer plant, the distance from the coupler end may be reduced down to 2 x d_s.

4 Provisions for the Performance

4.1 General

(1) The extruded coupler splices shall be produced by trained personnel only. For this purpose, the applicant must submit written working instructions.

(2) Only couplers identified as described in section 2.2.2 shall be used.

(3) The dimensions and the arrangement of the couplers must comply with the information given in the design drawings (shop drawings of the reinforcement).

(4) No special requirements are stipulated to the evenness of the cut-ends of the reinforcing bars to be spliced, however, the squeezing which occurs at shear cuts must not extend beyond the cross-section area of the bars.

(5) If the diameter measured across the ribs is greater than that specified for the inner diameter of the coupler as shown in Appendix Sheet 1, Table 1, the ribs may be grind-off correspondingly.

(6) The required position of the coupler (for reducing couplers the values as mentioned in Appendix Sheet 1, Table 2 have to be kept) must be easy to examine both during and after production of the coupler splice by means of suitable markings on the bar ends.

4.2 Extrusion Tool and Extrusion Process

(1) The extruded coupler splices must be produced by using the special tools which the applicant developed for this kind of connections.

(2) For each size of extruded coupler splice, exclusively the reducing ring (die) designed for this size may be used.

(3) One of the bars to be spliced must be movable in longitudinal direction.

4.3 Inspections

4.3.1 Suitability verification before commencing work

(1) Under jobsite conditions, two extruded coupler splices of each diameter shall be produced.

(2) The load capacity of coupler splices must be tested with required equipment by experienced personnel.

(3) Tensile tests up to the failure shall be performed; the test results shall be recorded according to Appendix Sheet 4 and evaluated with the there mentioned notes.

4.3.2 Continuous Inspection

(1) Each coupler splice must be checked visually whether the coupler has been extruded uniformly over the entire length.

(2) In case the number of coupler splices produced at the construction site is less than 200, the suitability verification as per section 4.3.1 will be sufficient.

(3) For every 200 coupler splices produced, at least one tensile test must be performed by an acknowledged institution (compare 2.3.3). Here, the types of splices and the dimensions performed must be recorded representatively.

(4) The checking by means of a tensile test is deemed to be passed if one of the following conditions – the kind of failure a) to c) must be mentioned – is fulfilled:

a) Fracture of a bar outside of the splice or anchorage.

b) Failure of the splice or anchorage (fracture of coupler or anchorage, fracture of bar in the coupler or anchorage area and pullout of bar of the coupler) above a test load of $F_{min.}$ = 1,3 x specified yield load of bar = 1,3 x $R_{e,nom}$ x $A_{s,nom,bar}$.

c) Failure (bar fracture in the coupler or anchorage area or pullout of bar of the coupler) at an ultimate load below $F_{min.}$ but above 1,1 times nominal yield load of the bars, as long as the load capacity of the splice is at least 95 % of the actual load capacity of the bar and the uniform elongation at maximum load is at least 3 % in case of splice failure.
The actual bar carrying capacity and the uniform elongation $A_{gt,v}$ must be determined at the bar which participated in the failure.

with:

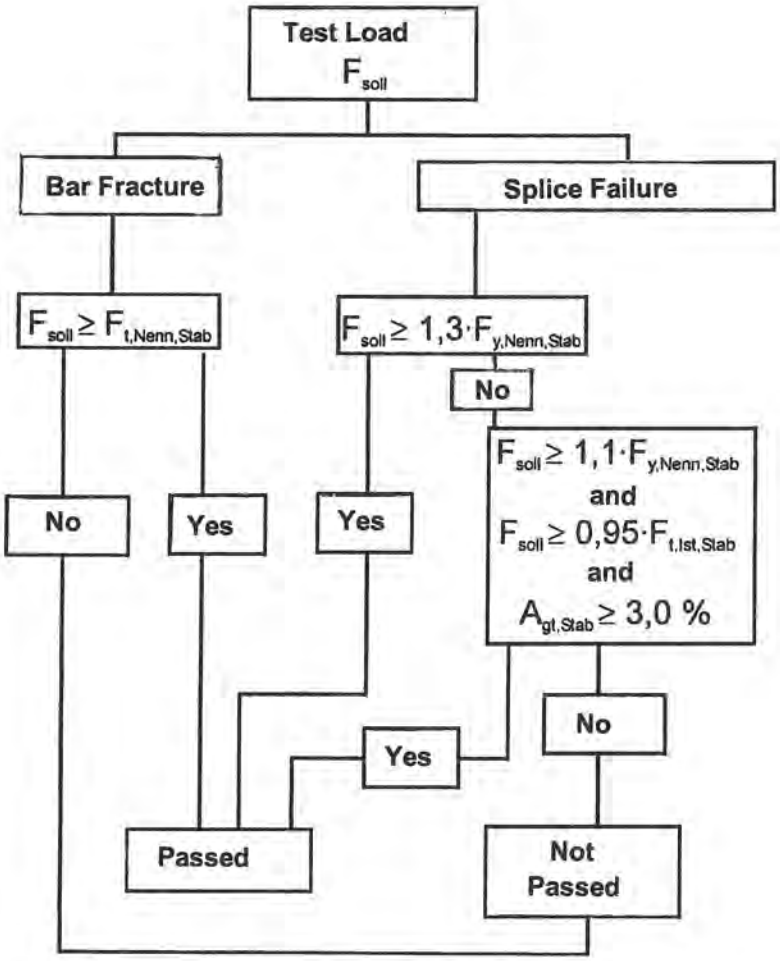
$F_{t,Nenn,Stab}$ = Nominal Ultimate Load of Bar

$F_{y,Nenn,Stab}$ = Nominal Yield Load of Bar

$F_{t,Ist,Stab}$ = Actual Ultimate Load of Bar

Häusler certified

1	DIN 488-1:1984-09	Reinforcement steel – Part 1: Types, Properties, Identification
2	DIN 1045-1:2008-08	Concrete, reinforced and prestressed concrete structures – Part 1: Design and construction
3	DIN EN 10204:2005-01	Metallic Products – Types of Inspection Certificates; German Version EN 10204:2004



with:

$F_{t,Nenn,Stab}$ = Nominal Ultimate Load of Bar

$F_{y,Nenn,Stab}$ = Nominal Yield Load of Bar

$F_{t,Ist,Stab}$ = Actual Ultimate Load of Bar

Häusler certified

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1 DIN 488-1:1984-09 Reinforcement steel – Part 1: Types, Properties, Identification

2 DIN 1045-1:2008-08 Concrete, reinforced and prestressed concrete structures – Part 1: Design and construction

3 DIN EN 10204:2005-01 Metallic Products – Types of Inspection Certificates; German Version EN 10204:2004

EXTRUDED COUPLER SPLICE (FBM)

Material:
Precision Steel Tube according
DIN EN 10305-1:2003-02 E235+N
Material No. 1.0308

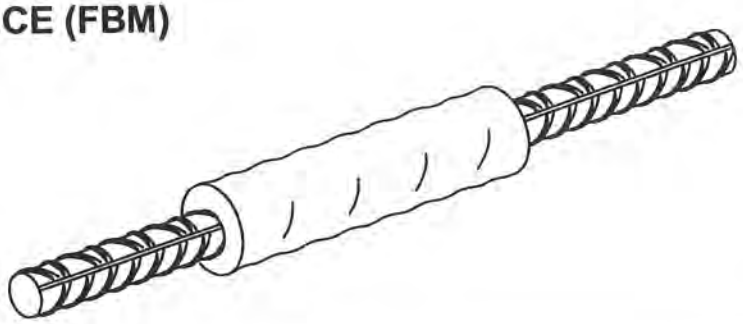
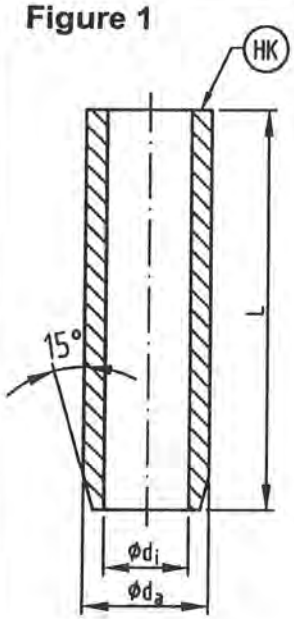


Figure 1



Extruded Coupler

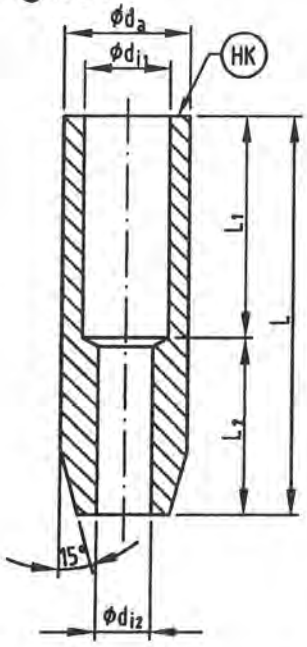
Table 1

Nominal Dia. Reinforcing Steel d_s [mm]	Outer Dia. d_a [mm]	Inner Dia. * d_i [mm]	Coupler Dimensions Length L before Extruding Process L [mm]
16	$28^{\pm 0,15}$	$19^{\pm 0,2}$	$130^{\pm 2}$
20	$34^{\pm 0,15}$	$23^{\pm 0,2}$	$150^{\pm 2}$
25	$45^{\pm 0,2}$	$30^{\pm 0,2}$	$160^{\pm 2}$
28	$48^{\pm 0,2}$	$32^{\pm 0,2}$	$170^{\pm 2}$
32	$58^{\pm 0,5}$	$38^{\pm 0,5}$	$230^{\pm 2}$

*) Inner Diameter may also be smaller for Reinforcing Steel with lower deviation

Remarks: (HK) | Manufacturer Symbol

Figure 2



Extruded Reducing Coupler

Table 2

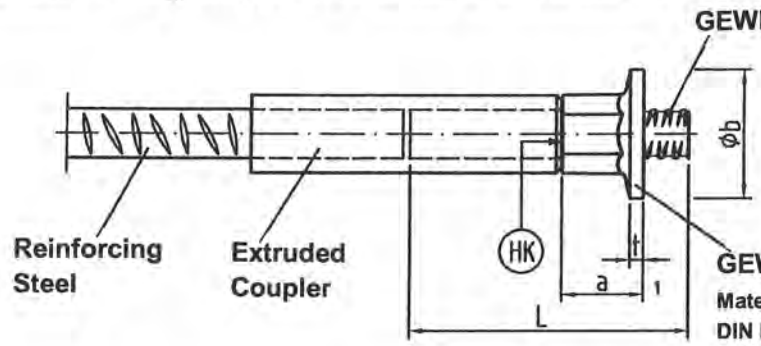
Nominal Dia. Reinforcing Steel d_{s1} / d_{s2} [mm]	Coupler Dimensions and permissible Tolerances Outer Dia. d_a [mm]	Inner Dia. * d_{i1} [mm]	d_{i2} [mm]	Length L [mm]	L_1 [mm]	L_2 [mm]
20/16	$34^{\pm 0,15}$	$23^{\pm 0,2}$	$19^{\pm 0,2}$	$140^{\pm 2}$	75	65
25/20	$45^{\pm 0,2}$	$30^{\pm 0,2}$	$23^{\pm 0,2}$	$155^{\pm 2}$	80	75
28/25	$48^{\pm 0,2}$	$32^{\pm 0,2}$	$30^{\pm 0,2}$	$165^{\pm 2}$	85	80
32/28	$58^{\pm 0,5}$	$38^{\pm 0,5}$	$32^{\pm 0,5}$	$200^{\pm 2}$	115	85

*) Inner Diameter may also be smaller for Reinforcing Steel einer sein with lower deviation

Remarks: (HK) Manufacturer Symbol

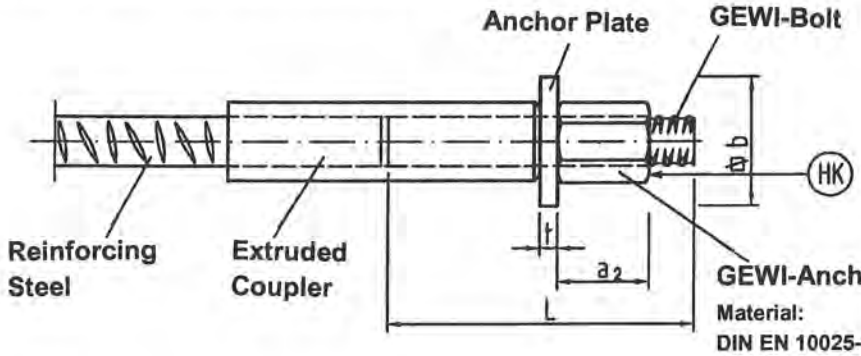
Figure 3 Examples for End Anchorages

At Tensile- and Compressive Load with Anchor Piece



Material:
DIN EN 1563: 2003-02 GJS-500-7 (EN-JS 1050)
DIN EN 1562: 2006-08 GJMB-550-4 (EN-JM 1160)

At Tensile- and Compressive Load with Anchor Plate and Anchor Nut



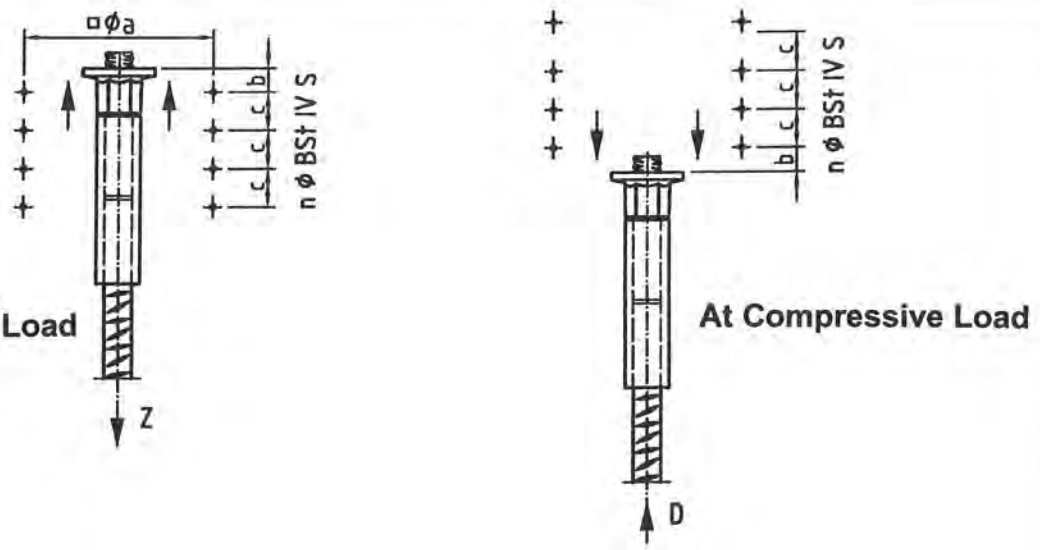
Material:
DIN EN 10025-2: 2005-04 S355-JO+N (1.0553+N)
DIN EN 10083-2: 2006-10 C45+N (1.053)
DIN EN 1563: 2003-02 GJS-500-7 (EN-JS 1050)
DIN EN 1562: 2006-08 GJMB-550-4 (EN-JM 1160)

Remarks: (HK) Manufacturer Symbol (impressed)

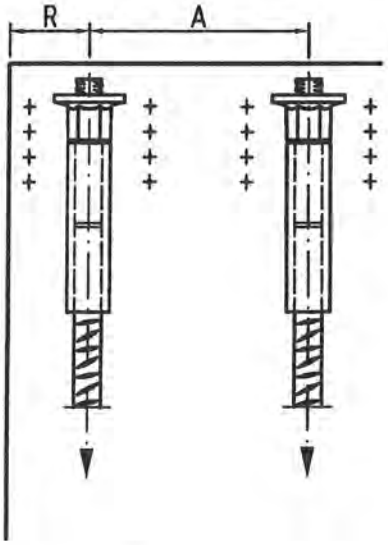
Table 3

Nominal Dia. Reinforcing Steel	Torque Moment	GEWI-Bolt		Extruded Coupler	Anchor Piece	Anchor Nut	Anchor Plate		
							Thickness	Outer Dimension	Hole Dia.
d_s [mm]	M_{kont} [kNm]	d_s [mm]	L [mm]		a_1 [mm]	a_2 [mm]	t [mm]	[mm]	[mm]
16	0,20	16	140	see Appendix 1	35	50	8	50	20
20	0,35	20	165		40	65	10	60	25
25	0,70	25	180		45	75	12	70	30
28	0,95	28	200		50	85	14	85	33
32	1,60	32	240		60	90	15	100	38

Figure 4



Non-staggered Anchorage



Staggered Anchorage

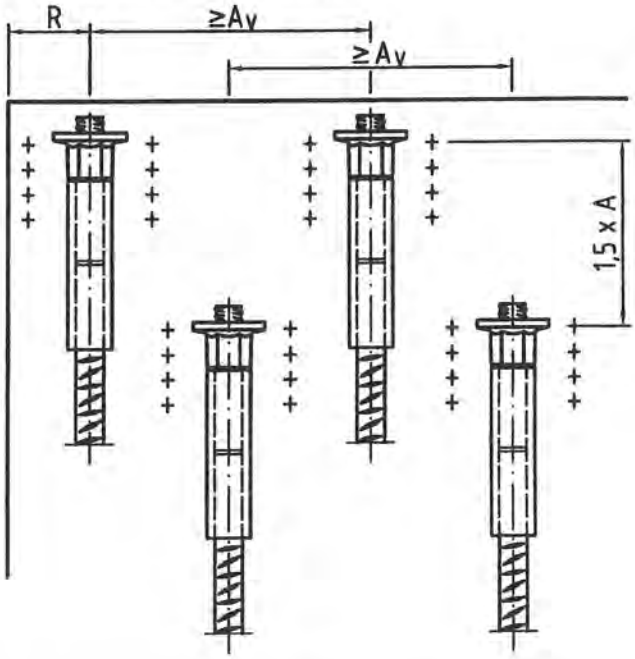


Table 4

Nominal Dia. Reinforcing Steel	Centre Distance		Edge Distance	Additional Reinforcement				
d_s [mm]	A [mm]	A_V [mm]	R [mm]	n [mm]	d_s [mm]	a [mm]	b [mm]	c [mm]
16	100	105	70	3	6	70	20	30
20	130	140	85	3	6	100	20	30
25	145	165	90	4	6	120	15	30
28	165	190	100	4	6	140	10	40
32	180	200	110	3	8	155	20	50

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Centre- and Edge Distances for Concrete at least C 20/25 acc. DIN 1045-1 ($f_{ck} \geq 20$ N/mm²)

FLIMU – System BSt 500 S, BSt 420 S, Ø 16 – 32 mm

Appendix Sheet 3 to Approval Certificate Nr. Z-1.5-150 vom 29. September 2009

Reducing Ring (Die) – Inner Diameter (Nominal) d_{Ri}

Bar Dia. d_s [mm]	16	20	25	28	32
d_{Ri} [mm]	$25^{+0.5}_{-0.2}$	$31^{+0.5}_{-0.2}$	$40^{+0.5}_{-0.2}$	$44^{+0.5}_{-0.2}$	$51{,}6^{+0.5}_{-0.2}$

Required Ultimate Load of the Splice and Anchorage

Reinforcing Steel BSt 500 S

Kind of Failure: (see section 4.3.2.(4))	Required Ultimate Load (kN) For Nominal Rebar-Dia. d_s (mm)				
	16	20	25	28	32
a)	111	173	270	339	442
b) *)	131	204	319	400	522

Reinforcing Steel BSt 420 S

Kind of Failure: (see section 4.3.2.(4))	Required Ultimate Load (kN) For Nominal Rebar-Dia. d_s (mm)				
	16	20	25	28	32
a)	93	145	227	284	371
b) *)	110	171	268	336	438

*) The herewith required values must not be achieved due to failure according to the kind of failure c) (see section 4.3.2. (4)) with the there given required carrying capacity and requirements to the uniform elongation.

Austria
DYWIDAG-Systems International GmbH
Alfred-Wagner-Strasse 1
4061 Pasching/Linz, Austria
Phone +43-7229-610 49 0
Fax +43-7229-610 49 80
E-mail dsi-a@dywidag-systems.at
www.dywidag-systems.at

Belgium and Luxembourg
DYWIDAG-Systems International N.V.
Industrieweg 25
3190 Boortmeerbeek, Belgium
Phone +32-16-60 77 60
Fax +32-16-60 77 66
E-mail info@dywidag.be
www.dywidag-systems.com

France
DSI-Artéon
146 Avenue du Bicentenaire
Z.I. Dagneux
01122 Montluel Cedex, France
Phone +33-4-78 79 27 82
Fax +33-4-78 79 01 56
E-mail dsi.france@dywidag.fr
www.dywidag-systems.fr

Germany
DYWIDAG-Systems International GmbH
Schuetzenstrasse 20
14641 Nauen, Germany
Phone +49-3321-44 18 0
Fax +49-3321-44 18 38
E-mail suspa@dywidag-systems.com
www.dywidag-systems.de

DYWIDAG-Systems International GmbH
Max-Planck-Ring 1
40764 Langenfeld, Germany
Phone +49-2173-79 02 0
Fax +49-2173-79 02 20
E-mail suspa@dywidag-systems.com
www.dywidag-systems.de

DYWIDAG-Systems International GmbH
Germanenstrasse 8
86343 Koenigsbrunn, Germany
Phone +49-8231-96 07 0
Fax +49-8231-96 07 40
E-mail suspa@dywidag-systems.com
www.dywidag-systems.de

DYWIDAG-Systems International GmbH
Siemensstrasse 8
85716 Unterschleissheim, Germany
Phone +49-89-30 90 50 100
Fax +49-89-30 90 50 120
E-mail dsihv@dywidag-systems.com
www.dywidag-systems.com

Italy
DYWIT S.P.A.
Via Grandi, 64
20017 Mazzo di Rho (Milano), Italy
Phone +39-02-934 68 71
Fax +39-02-934 68 73 01
E-mail info@dywit.it
www.dywit.it

Netherlands
DYWIDAG-Systems International B.V.
Veilingweg 2
5301 KM Zaltbommel, Netherlands
Phone +31-418-57 89 22
Fax +31-418-51 30 12
E-mail email@dsi-nl.nl
www.dywidag-systems.com

Norway
DYWIDAG-Systems International AS
Industrieveien 7A
1483 Skytta, Norway
Phone +47-67-06 15 60
Fax +47-67-06 15 59
E-mail adm@dsi-dywidag.no
www.dywidag-systems.com

Poland
DYWIDAG-Systems International Sp. z o.o.
ul. Przywidzka 4/68
80-174 Gdansk, Poland
Phone +48-58-300 13 53
Fax +48-58-300 13 54
E-mail dsi-polska@dywidag-systems.com
www.dywidag-systems.pl

Spain
DYWIDAG Sistemas Constructivos, S.A.
Avd/de la Industria, 4
Pol. Ind. la Cantuena
28947 Fuenlabrada (Madrid), Spain
Phone +34-91-642 20 72
Fax +34-91-642 27 10
E-mail dywidag@dywidag-sistemas.com
www.dywidag-sistemas.com

United Kingdom
DYWIDAG-Systems International Ltd.
Northfield Road
Southam, Warwickshire
CV47 0FG, Great Britain
Phone +44-1926-81 39 80
Fax +44-1926-81 38 17
E-mail sales@dywidag.co.uk
www.dywidag-systems.com/uk

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