SAS Tie Rod Manual

Basic dimensioning and design recommendations

SAS SYSTEMS

Table of Content:

SAH
Stahlwerk Annahütte

Introduction/Scope

The SAS Tie Rod Manual is issued in line with other SAS system application manuals featuring basic design and dimensioning recommendations for distributor and site applicant. It is meant as a link between marketing brochures and local governing standards; and as a guide to select a suitable SAS Tie Rod system based on project specifications at hand. The SAS Tie Rod accessory drawings in connection with the load capacity tables can be used as guidance for material breakdown and order.

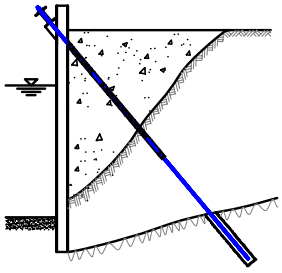
Reference to applicable standards, approvals and related publications can be found towards the end of this manual. An overview of various SAS thread bar grades and diameters is provided at the back page, where you will also find our contact details if you wish to obtain more information about the SAS Tie Rod System or any other of our SAS systems - you are welcome to try our service!

SAS Tie Rod System Description

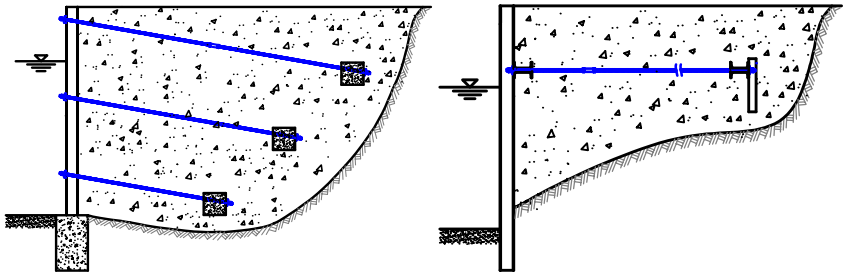
SAS Tie Rod systems can be used for marine and geotechnical applications like coffer dam, sheet pile wall and retaining walls. Retaining load is transferred from wall through waling and tie rod, dead man or pressure grouted anchorage into the ground.

Used as marine tie or tie rod the SAS Tie Rod system provides the following key features/advantages over tie rods with cut or mechanically rolled-on thread:

- The continuous thread can be cut and coupled at any length, hence higher flexibility in ordering, installation and stressing compared to bars with short rolled-on thread end.
- No protective thread cover as needed for protection of cut or rolled-on thread.
- Low notching risk of the hot rolled thread, hence low safety factor of bar shaft applies.
- High steel grade, hence increased load transfer at equal bar diameter.
- Accessories remain threadable over State-of-the-art corrosion protection.



Grouted tieback anchorage into ground



Deadman tieback anchorage into soil

Load Capacities/ Load Resistance

Load capacities of the tie rods depend on the design methods with their applicable safety factors. Traditional design methods apply global safety factors to the structural analysis in order to overcome all unknowns.

The new European safety philosophy at the other hand applies different (partial) safety factors to action and resistance load respectively various structural elements. The EAU 2004 (Recommendation of the Committee for Waterfront Structures - Harbours and Waterways) is following the new European safety philosophy.

Conventional tie rods made from smooth, round steel bars have threaded ends made by cutting or rolling, i.e. by re-profiling of the surface.

Contrary, the continuous SAS thread is receiving its unique profile during the hot rolling process of the bar. For this reason the notch tendency of the SAS thread bar can be neglected. Therefore no additional verification of threaded ends ($F_{tt,Rd}$) is required. The entire thread bar length can be regarded as shaft.

Working Load Capacity according to EAU 2004 and EuroCode 3 (EC3) DIN EN 1993-5

Anchor Load Z_d (inducing load) (EAU 2004 - 8.2.6.3 Analysis of structural integrity of round bars)

Z_d [KN] = $Z_{GK} * \gamma_G + Z_{QK} * \gamma_Q$

Z_{GK} = Static load

γ_G = Safety factor on static load = 1.35

Z_{QK} = Live load

γ_Q = Safety factor on live load = 1.50

Anchor Resistance R_d (EAU 2004 - 8.2.6.3 Analysis of structural integrity of round bars)

$Z_d \leq R_d$ $R_d = F_{tg,Rd}$

R_d = Design anchor load

= Characteristic anchor load R_k / γ_M Safety factor

$F_{tg,Rd}$ = Tension resistance anchor shaft: $A_{shaft} * f_{y,k} / \gamma_{M0}$

A_{shaft} = Cross area anchor shaft [mm^2]

$f_{y,k}$ = Yield stress [N/mm^2]

γ_{M0} = Safety factor shaft = 1.10

WORKING LOAD CAPACITIES OF SAS TIE ROD ACCORDING TO EAU 2004 AND EC3

Bar Ø [mm]	30	32	35	36	40	43	47	50	57	63.5	65	75
Steel Grade	**Working Load Capacity [kN] of SAS Tie Bar Diameter 30 to 75 mm**											
SAS 500		365			573			891		1.440		
SAS 670	431		586			884			1.582	1.929		2.691
SAS 1050		694		881	1.086		1.498		1.959		2.529	3.354

Working Load Capacity according to EAU 1990, BS 6349 and PTI

EAU 1990, British Standard 6349 (Maritime Structures) and PTI (Recommendations for Prestressed Rock and Soil Anchors) are following the limit state design method, applying a global safety factor to the structural analysis.

The Anchor Load (Resistance) has to meet or surpass the Design Load. According to BS, and EAU 1990 the maximum anchor Load (Resistance) is computed by applying a safety factor to the yield strength of the tie rod. For tie back anchors according to PTI a safety factor is applied to the characteristic ultimate tensile strength (UTS) of the bar anchor.

$A \leq F_s * R_e / \gamma_s$

A	=	Anchor load	[kN]
F_s	=	Cross area of tie rod	[mm^2]
R_e	=	Yield stress	[N/mm^2]
γ_s	=	Safety factor on R_e (EAU 1990)	= 1.69
		Safety factor on R_e (BS 6349)	= 2.00

$A \leq F_{PU} * \gamma_P$

A	=	Anchor load	[kips]
F_{PU}	=	Characteristic tensile strength of bar	[kips]
γ_P	=	Safety factor on F_{PU} (PTI)	= 0.60

WORKING LOAD CAPACITIES OF SAS TIE ROD ACCORDING TO EAU 1990

Bar Ø [mm]	30	32	35	36	40	43	47	50	57	63.5	65	75
Steel Grade	**Working Load Capacity [kN] of SAS Tie Bar Diameter 30 to 75 mm**											
SAS 500		238			370			576		1.035		
SAS 670	279		379			572			1.024	1.248		1.741
SAS 1050		447		565	700		970		1.238		1.635	2.171

WORKING LOAD CAPACITIES OF SAS TIE ROD ACCORDING TO BS 6349

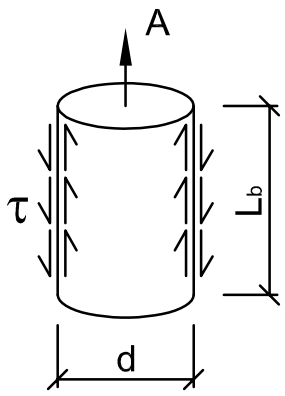
Bar Ø [mm]	30	32	35	36	40	43	47	50	57	63.5	65	75
Steel Grade	**Working Load Capacity [kN] of SAS Tie Bar Diameter 30 to 75 mm**											
SAS 500		203			315			490		880		
SAS 670	237		323			487			870	1.061		1.480
SAS 1050		380		480	595		825		1.078		1.390	1.745

WORKING LOAD CAPACITIES OF SAS TIE BACKS ACCORDING TO PTI (USA)

Bar Ø [inch]	1 1/4	1 3/8	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	3
Steel Grade	**Working Load Capacity [kips] of SAS Tie Bar Diameter 1 1/4 to 3 inch**								
SAS 500	67	85	106			164		299	
SAS 670	76	104		157			280	342	477
SAS 1050	114	145	178		245		360	465	617

Load Transfer into Ground

The load of tie rods and tie backs may be transferred through a dead man or pressure-grouted anchor into the surrounding ground. For pressure-grouted anchorages the minimum load transfer length can be presumed to equal the bond length along the drill hole surface:



$L_b = A / (\pi * d * \tau_\omega)$

L_b = Load transfer length
A = Anchor load
d = Diameter of grout annulus
τ_ω = Working bond stress

$\tau_\omega = \tau / \gamma_p$
γ_p = Safety factor = 2.0

Empirical bond stress values at soil to cement grout interface for pressure grouted tie rods:

Soil / Rock Type	Empirical Bond Stress Value [τ]	
	N/mm² [MPa]	PSI
Cohesive Soil	0.10	15
Sand	0.15	20
Gravel	0.20	30
Weathered Marl, Chalk, Soft Shales	0.15 - 0.80	30 - 120
Soft Limestone, Slates, Hard Shales, Sandstone	0.80 - 1.70	120 - 250
Dolomite Limestone	1.40 - 2.10	200 - 300
Granite, Basalt	1.70 - 3.10	250 - 450

The relative rib area of SAS thread bars is exceeding that of standard rebars. For this reason a bond stress of τ_c = 4.3 N/mm² for the serviceability limit state can be assumed between SAS thread bar and surrounding cement grout of more than 40 N/mm² strength.

For permanent ground anchors a safety factor of 2.0 should be applied to the bond stress value at the grout/ground interface.

According to DIN 1054 the actual serviceability limit state for load transfer length (bond length) of pressure-grouted anchors shall be determined by load tests in the field.

The lowest resulting value of a minimum of 3 cyclic load tests according DIN EN 1537 shall be used to compute actual bond length requirements.

Corrosion Protection Systems

In view of the soil aggressiveness defined with DIN EN 12501 and the expected lifetime according to DIN EN 1537, the tension ties must be protected by a suitable corrosion protection system. For SAS Tie Rods the following corrosion protection systems are available:

- Sacrificial corrosion of unprotected steel
- Denso Flex wrapping
- Hot-dip galvanized coating
- Epoxy coating
- Heat-shrink sleeves
- Double corrosion protection (DCP)

Recommended corrosion protection systems in light of performance life and soil corrosiveness:

Lifetime [years]	Corrosion Protection System	Soil Aggressiveness[1)]		
		low	medium	high
temporary < 2 years	Sacrificial corrosion of unprotected Steel	✓	✓	✓
	Denso Flex Wrapping			
	Epoxy coating		✓	✓
	Hot-dip galvanizing		✓	✓
	Heat-shrink sleeve			
	Double Corrosion Protection (DCP)			
semi-permanent 2 to 7 years	Sacrificial corrosion of unprotected Steel	✓	✓	✓
	Denso Flex Wrapping			
	Epoxy coating	✓	✓	✓
	Hot-dip galvanizing	✓	✓	✓
	Heat-shrink sleeve			
	Double Corrosion Protection (DCP)	✓	✓	✓
Permanent > 7 years	Sacrificial corrosion of unprotected Steel	✓	✓	
	Denso Flex Wrapping	✓		
	Epoxy coating	✓	✓	
	Hot-dip galvanizing	✓		
	Heat-shrink sleeve		✓	✓
	Double Corrosion Protection (DCP)	✓	✓	✓

1) in accordance with DIN EN 12501

Corrosion of bare steel in the ground:

Steel elements may be oversized to allow for loss of cross sectional area due to corrosion. Depending on the ground conditions EN 14199 is suggesting the following loss of thickness of bare steel in the ground may be considered:

Soil condition	Coresponding soil corrosiveness	Yearly loss of steel thickness due to corrosion [mm]
Undisturbed natural soils (sand, silt, clay, schist,...)	low	0.012
Polluted natural soils and industrial grounds	medium	0.030
Aggressive natural soils (swamp, march, peat,...)	**medium**	0.033
Non-compacted, non-aggressive fills (clay, schist, sand, silt,...)	**medium**	0.022
Non-compacted and aggressive fills (ashes, slag,...)	**high**	0.058

The values above are for guidance only. Local conditions should be considered and suitable values taken into account.

According to British Standard BS 8002 "Earth Retaining Structures" provision should be made for corrosion of tie rods of not less than 0.05 mm/year.

Denso Flex Wrapping:

Denso Flex tape consists of a chemical fibre fleece which is coated by petrolatum mastic. Denso Flex wrapping provides a good protection against corrosion and mechanical damage to thread bar and accessories. The wrapping can be conducted at the factory, before delivery, or at site. Possible transportation/handling damages can easily be repaired at site.

Accessories like nuts and couplers are not threadable over the wrapped thread bar.

Hot Dip Galvanizing:

Hot dip galvanized SAS thread bars meet requirements of DIN EN ISO 1461, BS 729, and ASTM A 153 standards with a minimum average coating thickness of 85 µm respectively 610 gram per m^2.

Hot-dip galvanization has a long track record for being a good corrosion protection to steel. During the process of galvanizing zinc and iron react together and form an alloy layer that is very resistant against mechanical damage.

Special accessories are available for the hot-dip galvanized SAS thread bar system. While maintaining full load transfer capabilities, these accessories remain threadable over the galvanized thread bars.

Epoxy coating:

Epoxy powder coated thread bars meet BS 7295, ASTM A 934, or A 775 standards. The minimum thickness of coating is 250 ± 50 µm. A complete line of special SAS accessories was designed to remain threadable over the coated bars while maintaining full load transfer.

For small damages that occurred during transportation or site handling of the epoxy coated thread bars, an epoxy repair kid is available.

Heat-Shrink Sleeves:

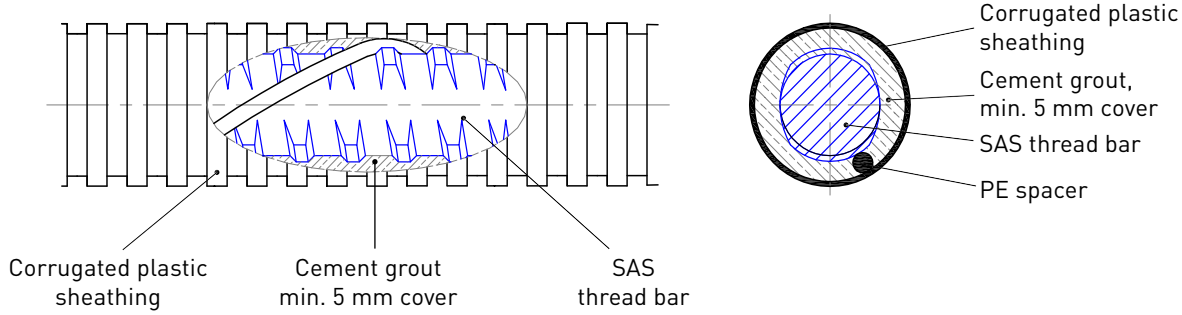
Heat-shrink sleeves are available with internal sealing material that closes small leaks and damages. With a minimum of 1 mm wall thickness according to DIN EN 1537, heat-shrink sleeves provide very good protection against corrosive environmental impact and mechanical damage.

Double Corrosion Protection (DCP):

According to international standards double corrosion protection of steel tensile members has preference for permanent applications, in particular if exposed to highly corrosive environments.

DCP is provided by centralizing the thread bar in a corrugated plastic sheathing and by filling the annulus between the bar and the sleeve with a non-shrink cement grout to produce a minimum of 5 mm cement grout cover. The corrugated plastic sheathing is sealing the bar from moisture and environmental impact, the cement-grout is producing an alkaline environment around the bar.

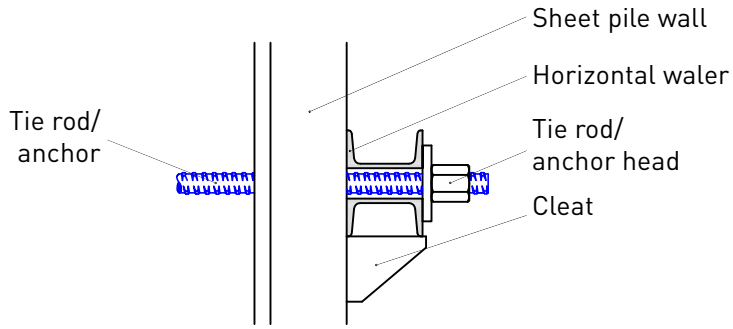
Pre-assembled and Pre-grouted double corrosion protected SAS thread bars may be delivered on custom order ex works Annahuette, Germany.



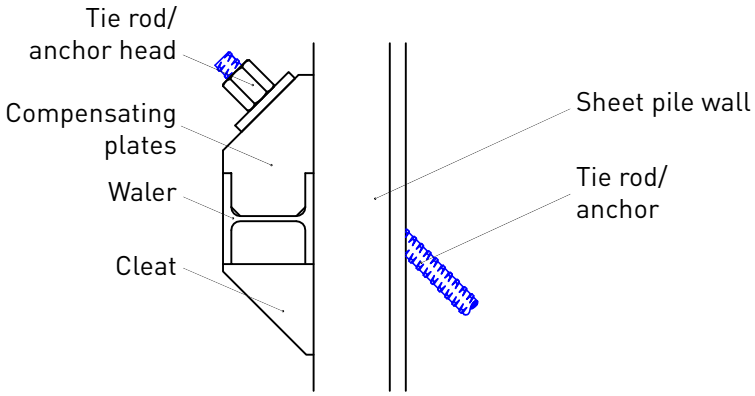
SAS Tie Rod Connection Details

Anchor Head Connection Excamples

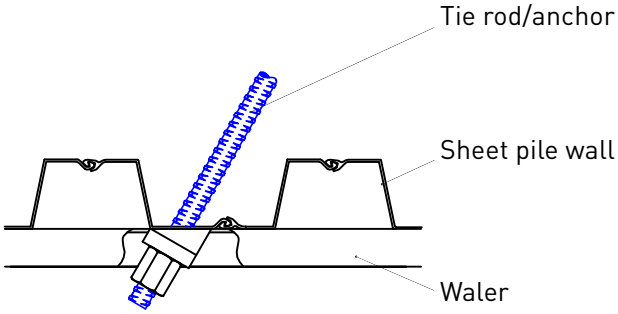
Conventional horizontal sheet pile anchorage



Inclined installation

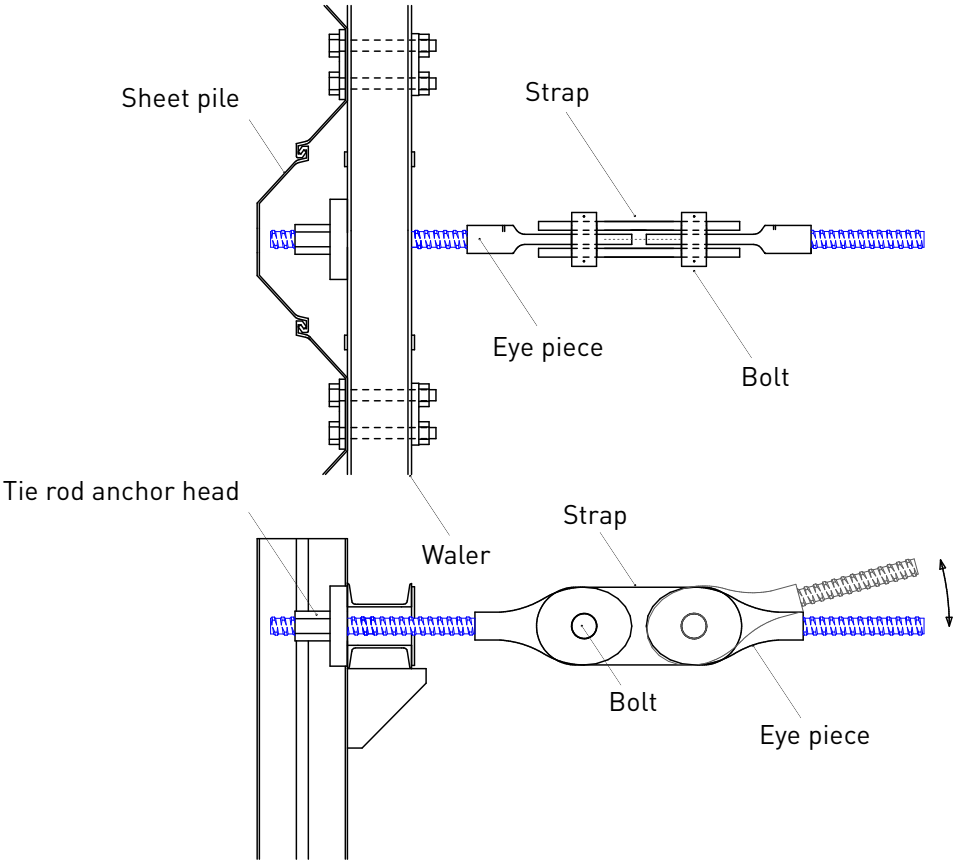


Angular installation

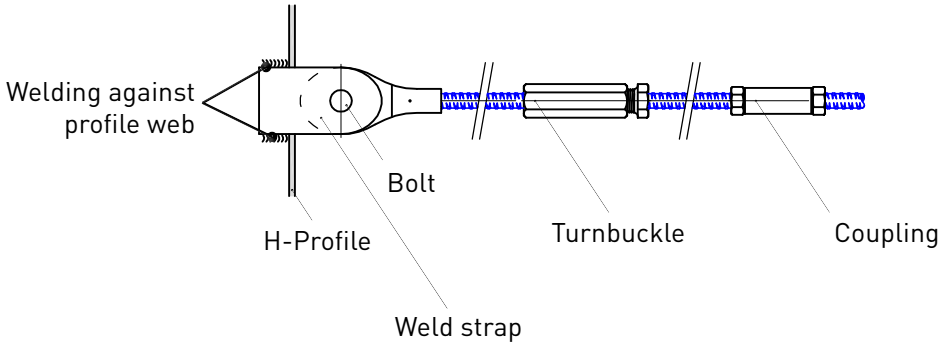


Application Examples of Eye Piece Connections

Eye piece - strap connection

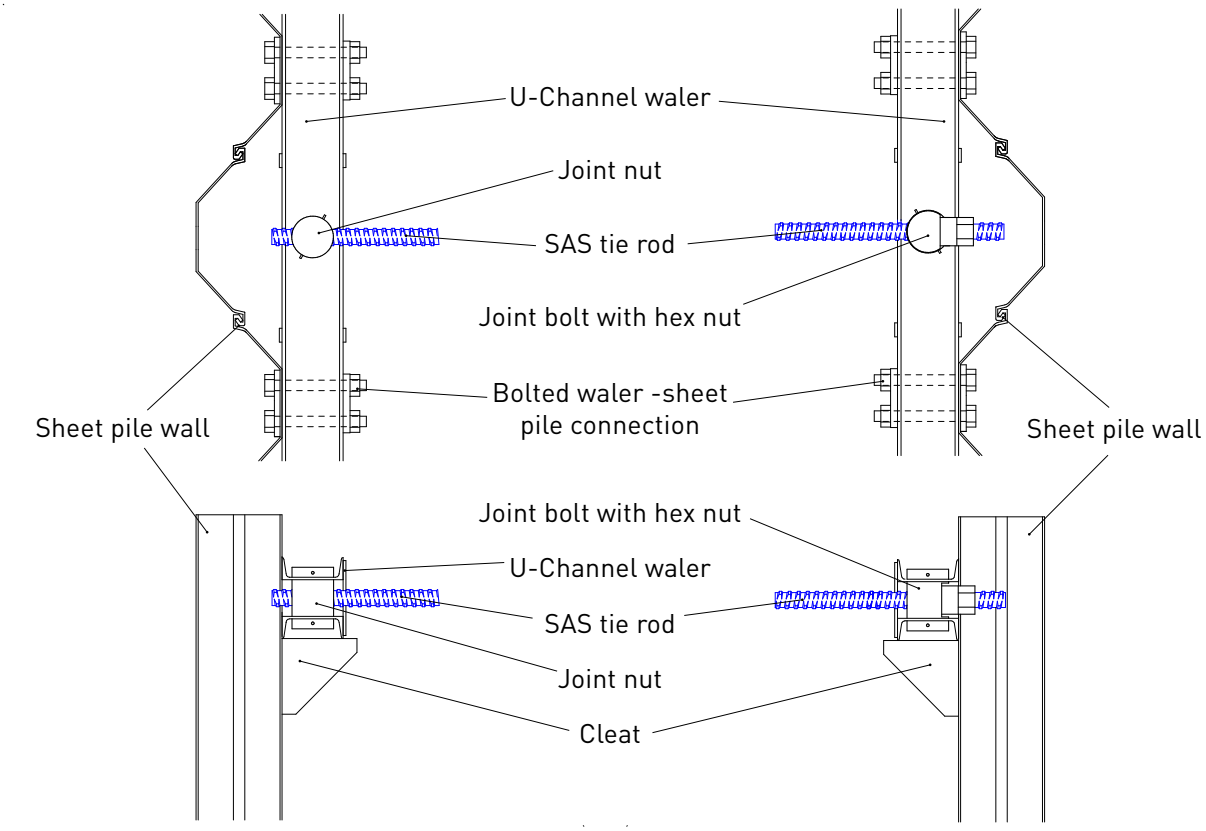


Eye piece - weld strap connection

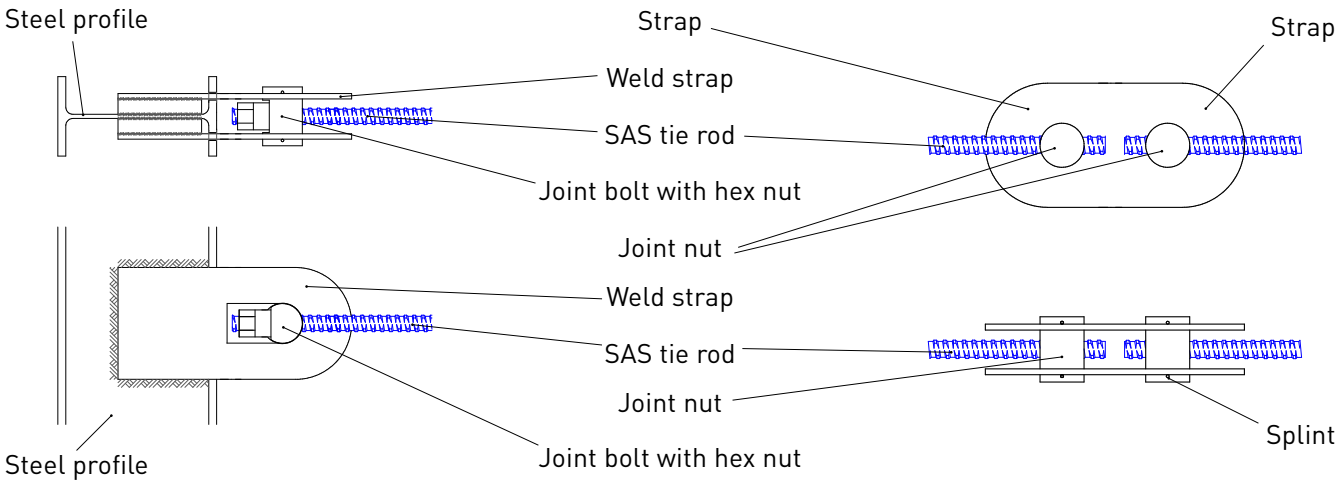


Application Examples of Joint Bolt/Nut Connections

Joint nut/bolt - waler connection

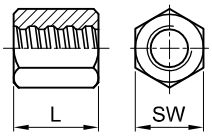


Joint bolt - weld strap connection

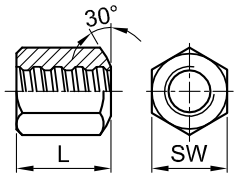


Joint bolt - strap connection

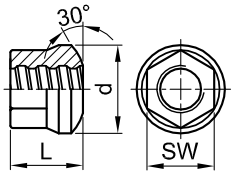
SAS Tie Rod System Accessories



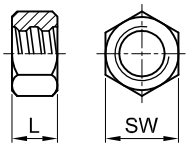
ANCHOR NUT, flat



BULL NOSE NUT, 30°



DOME NUT, 30°



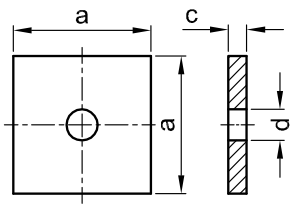
LOCK NUT, short

SAS 500	T 2002-Ø	T 2963-Ø	T 2944-Ø	T 2040-Ø
Ø [mm]	SW x L [mm]	SW x L [mm]	SW x L [mm]	SW x L [mm]
32	55 x 60	55 x 60	50 x 60	50 x 30
40	65 x 70	65 x 70	65 x 70	60 x 35
50	80 x 90	80 x 90	80 x 85	80 x 50
63.5	100 x 115	100 x 115	-	90 x 75
SAS 670	**TR 2002-Ø**	**TR 2963-Ø**	**TR 2944-Ø**	**TR 2040-Ø**
30	55 x 65	55 x 65	46 x 60	50 x 30
35	65 x 70	65 x 70	-	55 x 40
43	80 x 90	80 x 90	-	70 x 50
57.5	90 x 120	90 x 120	-	90 x 60
63.5	100 x 145	100 x 145	-	100 x 70
75	100 x 130	100 x 130	-	100 x 80
SAS 1050	**WR 2002-Ø**	**WR 2963-Ø**	**WR 2001-Ø[1)]**	**WR 5005-Ø**
32	55 x 90	55 x 90	60 x 90	42 x 22
36	60 x 110	60 x 110	65 x 100	46 x 25
40	70 x 120	70 x 120	70 x 115	50 x 25
47	80 x 140	80 x 140	80 x 135	60 x 30
57	90 x 120	90 x 120	-	90 x 35
65	100 x 130	100 x 130	-	90 x 40
75	105 x 145	105 x 145	-	105 x 50

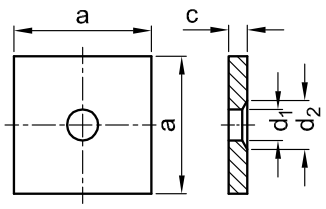
Threaded accessories for galvanized and epoxy coated bars have an "EP" suffix and are approx. 20 % longer.

All accessories are designed for nominal ultimate load transfer.

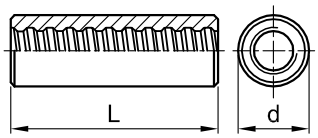
1) For SAS thread bar of grade 1050/1035 (grade 150) the Dome Nut has 55° dome angle.



ANCHOR PLATE, flat nut



ANCHOR PLATE, 30° nut

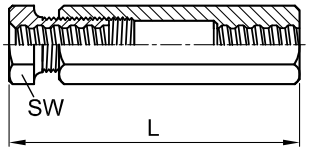


COUPLER, standard

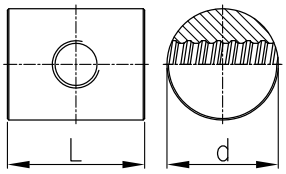
SAS 500	T 2139-Ø	T 1928-Ø	T 3003-Ø
Ø [mm]	a x c x d [mm]	a x c x d_1 x d_2 [mm]	d x L [mm]
32	120 x 20 x 40	120 x 20 x 40 x 50	52 x 140
40	150 x 30 x 47	150 x 30 x 47 x 60	65 x 160
50	190 x 45 x 58	190 x 45 x 58 x 75	80 x 200
63.5	245 x 50 x 70	245 x 50 x 78 x 110	102 x 260
SAS 670	**TR 2139-Ø**	**TR 1928-Ø**	**TR 3003-Ø**
30	145 x 35 x 40	145 x 35 x 40 x 50	55 x 150
35	170 x 40 x 47	170 x 40 x 47 x 60	65 x 170
43	210 x 50 x 58	210 x 50 x 58 x 75	80 x 200
57.5	275 x 60 x 75	275 x 60 x 70 x 90	102 x 250
63.5	300 x 65 x 82	300 x 65 x 78 x 100	114 x 300
75	325 x 70 x 88	325 x 70 x 88 x 120	108 x 260
SAS 1050	**WR 2139-Ø**	**WR 1928-Ø**	**WR 3003-Ø**
32	180 x 40 x 38	180 x 40 x 38 x 50	60 x 200
36	200 x 45 x 45	200 x 45 x 45 x 60	68 x 210
40	220 x 45 x 50	220 x 45 x 50 x 70	70 x 245
47	240 x 55 x 58	240 x 55 x 58 x 80	89 x 280
57	285 x 65 x 70	285 x 65 x 70 x 90	95 x 240
65	325 x 70 x 78	325 x 70 78 x 110	105 x 260
75	370 x 80 x 88	370 x 80 x 88 x 120	114 x 290

Threaded accessories for galvanized and epoxy coated bars have an “EP” suffix and are approx. 20 % longer.

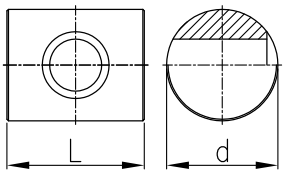
All accessories are designed for nominal ultimate load transfer.



TURNBUCKLE



JOINT NUT



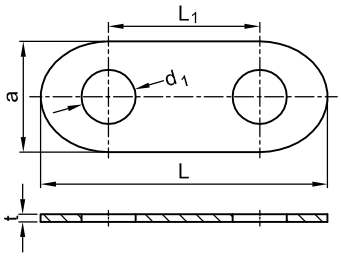
JOINT BOLT[1)]

SAS 500	T 3105-Ø	T 2020-Ø	T 2021-Ø
Ø [mm]	SW x L [mm]	d x L [mm]	d x L [mm]
32	60 x 225	-	-
40	80 x 270	80 x 120	80 x 120
50	100 x 305	-	-
63.5	-	150 x 185	150 x 185
SAS 670	**TR 3105-Ø**	**TR 2020-Ø**	**TR 2021-Ø**
30	65 x 260	-	-
35	80 x 275	120 x 193	120 x 193
43	90 x 325	140 x 212	140 x 212
57.5	100 x 395	150 x 222	150 x 222
63.5	100 x 405	190 x 265	190 x 265
75	110 x 405	190 x 279	190 x 279
SAS 1050	**WR 3105-Ø**	**WR 2020-Ø**	**WR 2021-Ø**
32	-	140 x 32	140 x 32
36	-	-	-
40	-	-	-
47	-	-	-
57	-	-	-
65	-	-	-
75	130 x 440	-	-

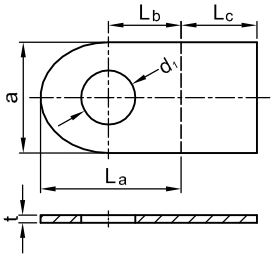
Threaded accessories for galvanized and epoxy coated bars have an “EP” suffix and are approx. 20 % longer.

All accessories are designed for nominal ultimate load transfer.

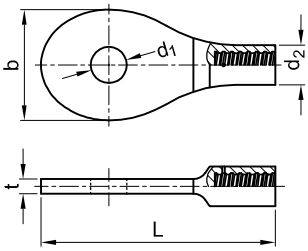
1) To be used in connection with anchor nut 2002-Ø.



STRAP CONNECTION
joint bolt & joint nut



WELDING PLATE[1)]
joint bolt & joint nut



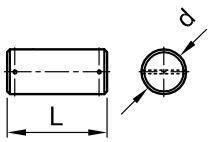
EYE PIECE

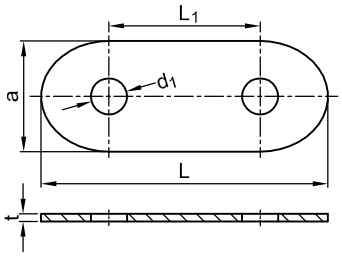
SAS 500	T 2022-Ø	T 2023-Ø	T 2080-Ø
Ø [mm]	a x t x d_1 x L x L_1 [mm]	a x t x d_1 x L_a x L_b [mm]	b x L x t x d_1 x d_2 [mm]
32	-	-	-
40	-	-	-
50	-	-	-
63.5	425 x 20 x 155 x 885 x 360	425 x 20 x 155 x 885 x 180	267 x 565 x 35 x 87 x 96
SAS 670	**TR 2022-Ø**	**TR 2023-Ø**	**TR 2080-Ø**
30	-	-	-
35	273 x 20 x 123 x 605 x 252	273 x 20 x 123 x 303 x 126	168 x 354 x 23 x 58 x 75
43	335 x 20 x 145 x 741 x 306	335 x 20 x 145 x 371 x 153	208 x 440 x 25 x 68 x 92
57.5	425 x 20 x 155 x 885 x 360	425 x 20 x 155 x 443 x 180	267 x 565 x 35 x 87 x 96
63.5	455 x 30 x 195 x 1019 x 434	455 x 30 x 195 x 510 x 217	308 x 629 x 35 x 98 x 114
75	348 x 730 x 45 x 112 x 116	465 x 40 x 195 x 519 x 221	348 x 730 x 45 x 112 x 116
SAS 1050	**WR 2022-Ø**	**WR 2023-Ø**	**WR 2080-Ø**
32	-	-	-
36	-	-	-
40	-	-	-
47	-	-	-
57	-	-	-
65	-	-	-
75	-	-	-

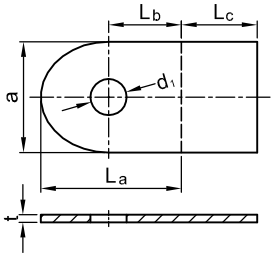
Threaded accessories for galvanized and epoxy coated bars have an “EP” suffix and are approx. 20 % longer.

All accessories are designed for nominal ultimate load transfer.

1) Length of welding flange (L_c) to customer designation.







	BOLT eye piece	STRAP CONNECTION eye piece	WELDING PLATE[1)] eye piece
SAS 500	**T 2081-Ø**	**T 3080-Ø**	**T 3081-Ø**
Ø [mm]	d x L [mm]	a x t x d_1 x L x L_1 [mm]	a x t x d_1 x L_a x L_b [mm]
32	-	-	-
40	-	-	-
50	-	-	-
63.5	85 x 190	267 x 30 x 87 x 662 x 335	267 x 30 x 87 x 331 x 166
SAS 670	**TR 2081-Ø**	**TR 3080-Ø**	**TR 3081-Ø**
30	-	-	-
35	55 x 126	168 x 18 x 58 x 466 x 258	168 x 18 x 58 x 233 x 129
43	65 x 133	208 x 20 x 68 x 566 x 308	208 x 20 x 68 x 283 x 154
57.5	85 x 190	267 x 30 x 87 x 662 x 335	267 x 30 x 87 x 331 x 166
63.5	95 x 163	308 x 30 x 98 x 806 x 428	308 x 30 x 98 x 403 x 214
75	109 x 171	348 x 35 x 112 x 894 x 472	348 x 35 x 112 x 447 x 236
SAS 1050	**WR 2081-Ø**	**WR 3080-Ø**	**WR 3081-Ø**
32	-	-	-
36	-	-	-
40	-	-	-
47	-	-	-
57	-	-	-
65	-	-	-
75	-	-	-

Threaded accessories for galvanized and epoxy coated bars have an “EP” suffix and are approx. 20 % longer.

All accessories are designed for nominal ultimate load transfer.

1) Length of welding flange (L_c) to customer designation.

Referenced Literature

Approvals

ETA-5/0122	SAS Post-tensioning bar tendon system
BMVIT-327.120/0043	SAS 670 Einstab- Kurzzeitanker und Daueranker

Standards

Eurocode EC3/EN1993	Design of steel structures
EAU 1990	Recommendation of the Committee for Waterfront Structures - Harbors & Waterways
EAU 2004	Recommendation of the Committee for Waterfront Structures - Harbors & Waterways
EN 1054	Ground - Verification of the safety of earthworks and foundations
EN 14199	Execution of special geotechnical works
EN 12501-1 & 2	Protection of metallic materials against corrosion. Corrosion likelihood in soil.
BS 6349	Maritime Structures
BS 7295	Fusion bonded epoxy coated carbon steel bars for the reinforcement of concrete
BS 8002	Earth Retaining Structures
DIN 18800	Steel Structures, design and construction
DIN EN 1537	Ground Anchors
DIN EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles
PTI	Recommendations for Prestressed Rock and Soil Anchors
ASTM A 153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 767	Standard Specification for Zinc-Coated Steel Bars for Concrete Reinforcement
ASTM A 775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A 934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

Please note:

With the course of time the SAS Tie Rod system may be changed or updated. In order to reflect and pass-on the state of tie rod application, we encourage you to send to us any suggestions/comments you have to this manual.

For detailed information or updates please contact us directly at:

Stahlwerk Annahütte, Max Aicher GmbH & Co. KG, D-83404 Hammerau / Germany
Research & Development
Tel. +49 (0)86 54 / 4 87-0 • Fax +49 (0)86 54 / 4 87-950
stahlwerk@annahuette.com • www.annahuette.com

Notes:

SAS Thread Bars

Yield Stress / Ultimate Stress	Nom. -Ø	Yield Load	Ultimate Load	Cross Area		Weight	Elongation	
[N/mm²]	[mm]	[kN]	[kN]	[mm²]	[m/to]	[kg/m]	A_{gt} [%]	A_{10} [%]
SAS 500 / *grade 75*								
B 500 / 550	**12**	57	62	113	1123.6	0.89	6	10
	14	77	85	154	826.4	1.21		
	16	100	110	201	632.9	1.58		
DIBt approval	**20**	160	175	314	404.9	2.47		
	25	245	270	491	259.7	3.85		
	28	310	340	616	207.0	4.83		
	32	405	440	804	158.5	6.31		
	40	630	690	1260	101.3	9.87		
	50	980	1080	1960	64.9	15.40		
S 555/700 /*grade 80*	**63.5**	1760	2215	3167	40.2	24.86	5	10
SAS 670 / *grade 97*								
S 670 / 800	**18**	170	204	254	500.0	2.00	5	10
	22	255	304	380	335.6	2.98		
	25	329	393	491	259.7	3.85		
	28	413	493	616	207.0	4.83		
	30	474	565	707	180.2	5.55		
	35	645	770	962	132.5	7.55		
	43	973	1162	1452	87.7	11.40		
	57.5	1740	2077	2597	49.1	20.38		
	63.5	2120	2534	3167	40.2	24.86		
	75	2960	3535	4418	28.8	34.68		
SAS 1050 / *grade 150*								
St 950 / 1050	**18**	230	255	241	510.2	1.96	5	7
	26.5	525	580	551	223.2	4.48		
ETA approval	**32**	760	845	804	153.1	6.53		
	36	960	1070	1020	120.9	8.27		
	40	1190	1320	1257	97.9	10.21		
	47	1650	1820	1735	70.9	14.10		
St 835 / 1035	**57**	2155	2671	2581	47.7	20.95	4	7
	65	2780	3447	3331	36.9	27.10		
	75	3690	4572	4418	27.9	35.90		
SAS V2 580 (1.4301)								
580 / 650	**23**	249	280	430	295.0	3.40		30
stainless	**26**	313	351	540	234.2	4.27		(A_5)
SAS V4 580 (1.4404)								
580 / 650	**23**	249	280	430	291.5	3.43		30
stainless	**26**	313	351	540	232.0	4.31		(A_5)
SAS 900 / 1100 - Type FA / *grade 160*								
St 900 / 1100 - Type FA	**15**	159	195	177	694.4	1.44	3	7
weldable	**20**	283	345	314	390.6	2.56		
DIBt approval								
not weldable **- Type E**	**26.5**	461	568	551	223.2	4.48	4	7
SAS 850 - cold rolled / *grade 120*								
St 850 - Type FS	**15**	140	170	191	666.7	1.50		10
cold rolled, weldable	**20**	245	280	331	384.6	2.60		(A_5)
	26.5	385	490	586	217.4	4.60		

SAS SYSTEMS

Stahlwerk Annahütte Max Aicher GmbH & Co. KG, D-83404 Hammerau / Germany
Tel. +49 (0)86 54 / 4 87-413 • Fax +49 (0)86 54 / 4 87-77413
stahlwerk@annahuette.com • www.annahuette.com

SAH Stahlwerk Annahütte

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