

Lattice girders and steel arches

Category: Lattice girders and steel arches

Overview

Lattice girders have been developed for special demands in the field of tunneling. The system has been extensively tested and used successfully for numerous tunnel projects throughout the world.

Lattice girders ensure an immediate support in the open span area. Contrary to standard solid-web girders, lattice girders are entirely integrated in the shotcrete lining; porous zones and shotcrete spray shadows are avoided.

The load-bearing capacity of lattice girders has been investigated in terms of various loading tests and by numerical analysis. Flexibility regarding geometry and bearing capacity characterizes this passive support system for underground applications.

Main advantage

- Immediate support in the excavation area
- Partial static support action even without shotcrete embedding
- Utilization as a true-to-form template for shotcrete application
- Easy and quick assembly
- Simple handling and installation by a small crew
- Optimum bond and interconnection with the shotcrete lining
- Simple adjustment and shaping to the excavation geometry
- Ideal bearing for spiles and lagging boards
- Spiles may be installed both above or through the lattice girders
- No need for investment in major equipment



System description

- Load-bearing elements according to the particular demands in Tunneling
- Application in combination with shotcrete
- Spatial 3-bar or 4-bar girder construction, connected via stiffening elements (spiders or welded rebars)
- Reduction of girder buckling lengths by stiffeners
- 3-bar girder: single bar by default at the excavation side
- 4-bar girder: application as wallplate beam or stiff cross girder
- Caverns with side drifts: combined use of 3-bar and 4-bar bar girders
- Assembly of the full girder profile by connecting single girder elements
- Load transmission even before shotcrete application
- Integral part of the shotcrete lining reinforcement
- Proven bond according to the design principles of reinforced concrete

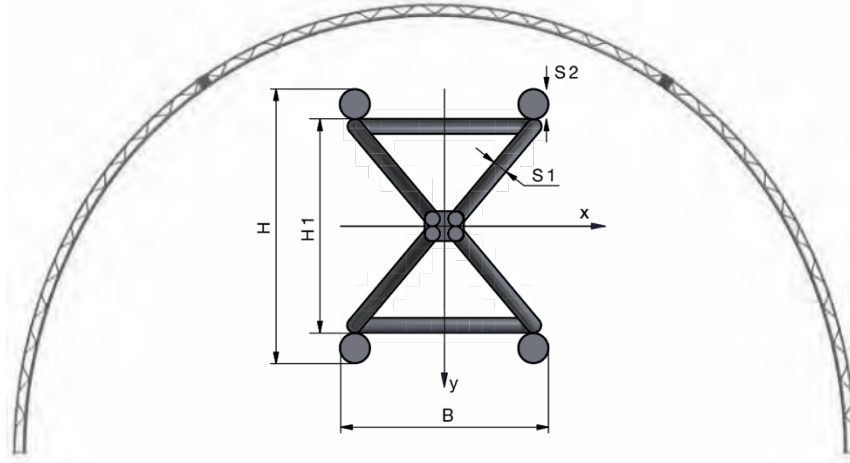


System components

Due to different regional steel (rebar), welding, and manufacturing standards, system components vary. This applies in particular to the type of stiffeners being used. Two common types are so-called spiders as well as welded rebar stiffeners.

Detailed specifications are included in local technical product brochures. In any case, section modulus (W or S) and/or second moment of area (I) are the relevant design parameters. This catalogue presents standard specifications of 3-bar and 4-bar spider girders.

However, lattice girder types with a greater variety of different rebar diameters and dimensions, hence equivalent design parameters, are part of the portfolio.



Manufacturing standards

Region	Hole diameter in.(mm)	Bolt type	Bolt diameter In.(mm)	FASLOC® X-TREME SYSTEM
	<ul style="list-style-type: none"> -Smooth special grade reinforcing steel -ASTM A572 grade 65 -Yield strength ≥ 70 [ksi] (480 [MPa]) -Tensile strength ≥ 80 [ksi] (550 [MPa]) -Elongation $\geq 10\%$ 	<ul style="list-style-type: none"> -Spiders: ASTM A572 grade 70 	<ul style="list-style-type: none"> -Plates: steel grade ASTM A36 or higher -Connecting bolts: ASTM A325N or higher 	<ul style="list-style-type: none"> -According to AWS requirements for gas metal arc welding (GMAW) -Certified welders in accordance with AWS D1.1
	<ul style="list-style-type: none"> -Smooth special grade reinforcing steel ASTM A615 grade 75 -Yield strength ≥ 75 [ksi] (520 [MPa]) -Tensile strength ≥ 100 [ksi] (690 [MPa]) -Elongation $\geq 7\%$ -Alternative: deformed ASTM A615 grade 60 	<ul style="list-style-type: none"> -Spiders: ASTM A615 grade 60 	<ul style="list-style-type: none"> -Connecting bolts: ASTM A307 	<ul style="list-style-type: none"> -Welding specification AWS D1.4-98 -Welding wire specification AWS A5.18 ER-70S-G
	<ul style="list-style-type: none"> -Ribbed reinforcing steel (deformed bar) -Mechanical properties: ASTM A615 grade 60 -(Chilean standard NCH 204) -Chemical properties: ASTM A706 -(enhanced weldability, Chilean standard NCH 3334) -Yield strength ≥ 420 [MPa] (61 [ksi]) -Tensile strength ≥ 630 [MPa] (91 [ksi]) -Elongation $\geq 8\%$ (200 [mm] measuring length) 	<ul style="list-style-type: none"> -Spiders: ribbed reinforcing steel (deformed bar) -Specifications: see girder bars 	<ul style="list-style-type: none"> -Plates and angles: steel grade ASTM A36 or equivalent -Connecting bolts: ASTM A325 or higher 	<ul style="list-style-type: none"> -MIG welding process (GMAW)
	<ul style="list-style-type: none"> -Ribbed reinforcing steel (deformed bar) -Grade NTC 2289 (ASTM A706/A706M) -Yield strength ≥ 420 [MPa] (60 [ksi]) -Tensile strength ≥ 550 [MPa] (80 [ksi]) 	<ul style="list-style-type: none"> -Spiders: round reinforcing steel NTC 161 grade AH - 24 (SAE 1015) -Yield strength ≥ 235 [MPa] (34 [ksi]) -Tensile strength ≥ 363 [MPa] (53 [ksi]) 	<ul style="list-style-type: none"> -Plates and angles: steel grade ASTM A36 or equivalent -Connecting bolts and nuts: SAE J995 G8 	<ul style="list-style-type: none"> -According to AWS requirements for gas metal arc welding (GMAW) -Certified welders in accordance with AWS D1.1
	<ul style="list-style-type: none"> -Ribbed reinforcing steel (deformed bar) -Grade ADN 420 (weldable), IRAM-IAS-U-500-207 -Yield strength ≥ 420 [MPa] (60 [ksi]) -Tensile strength ≥ 500 [MPa] (73 [ksi]) -Elongation $\geq 12\%$ 	<ul style="list-style-type: none"> -Spiders: ribbed reinforcing steel (deformed bar) -Specifications: see girder bars 	<ul style="list-style-type: none"> -Plates and angles: steel grade ASTM A36 or equivalent -Connecting bolts: ASTM A325 or higher 	<ul style="list-style-type: none"> -According to AWS requirements for gas metal arc welding (GMAW) -Certified welders in accordance with AWS D1.1
	<ul style="list-style-type: none"> -Ribbed reinforcing steel -B 500 B or higher -DIN 488-1, OENORM B 4700, or similar 	<ul style="list-style-type: none"> -Stiffeners: DIN 488-1, OENORM B 4700, or Similar 	<ul style="list-style-type: none"> -Plates: S235 (EN 10025-2) -Connecting bolts: 8,8 (EN ISO 898-1) or higher -Allowable tightening torques and mounting pre-load for set metrical screws: VDI guideline No. 2230, sheet 1 	<ul style="list-style-type: none"> -Factory specifications
	<ul style="list-style-type: none"> -Ribbed reinforced steel AS 4671 	<ul style="list-style-type: none"> -Spiders: A1018 or higher 	<ul style="list-style-type: none"> -Plates: AS 3678-250 -Structural bolt assemblies: AS 1252 	<ul style="list-style-type: none"> -In accordance with AS 1554
	<ul style="list-style-type: none"> -Smooth special grade reinforcing steel ASTM A615 grade 75 -Yield strength ≥ 75 [ksi] (520 [MPa]) -Tensile strength ≥ 100 [ksi] (690 [MPa]) -Elongation $\geq 7\%$ -Alternative: deformed ASTM A615 grade 60 	<ul style="list-style-type: none"> -Spiders: ASTM A615 grade 60 	<ul style="list-style-type: none"> -Connecting bolts: ASTM A307 	<ul style="list-style-type: none"> -Welding specification AWS D1.4-98 -Welding wire specification AWS A5.18 ER-70S-G

Specifications 3-Bar Spider Girders SI Units

Designation	S1	S2	S3	Weight 2	H	B	A	Wx 3
[H/S3-S2/B]	[mm]	[mm]	[mm]	[kg/m]	[mm]	[mm]	[cm ²]	[cm ³]
100/18-25/100	10	25	18	7,9			10,00	30
100/20-28/100	10	28	20	9,8	100	100	12,44	35
100/20-30/100	10	30	20	10,5			13,35	38
100/22-32/100	10	32	22	12,3			15,65	42
120/18-25/140	10	25	18	7,9			10,00	39
120/20-28/140	10	28	20	9,8	120	140	12,44	47
120/20-30/140	10	30	20	10,5			13,35	51
120/22-32/140	10	32	22	12,3			15,65	56
145/18-25/180	10	25	18	7,9			10,00	51
145/20-28/180	10	28	20	9,8	145	180	12,44	61
145/20-30/180	10	30	20	10,5			13,35	66
145/22-32/180	10	32	22	12,3			15,65	75
165/18-25/180	10	25	18	7,9			10,00	60
165/20-28/180	10	28	20	9,8	165	180	12,44	73
165/20-30/180	12	30	20	10,5			13,35	78
165/22-32/180	12	32	22	12,3			15,65	90
185/18-25/200	12	25	18	7,9			10,00	70
185/20-28/200	12	28	20	9,8	185	200	12,44	85
185/20-30/200	12	30	20	10,5			13,35	90
185/22-32/200	12	32	22	12,3			15,65	106
220/18-25/200	12	25	18	7,9			10,00	87
220/20-28/200	12	28	20	9,8	220	200	12,44	106
220/20-30/200	12	30	20	10,5			13,35	112
220/22-32/200	12	32	22	12,3			15,65	133

US Customary Units

CP Size H 1 1)		Bar size			Weight 2	H	B	e	I _x	S _x ³	I _y	S _y ³
		S1	S2	S3								
[mm]	[in]	[#]	[#]	[in]	[lb/ft]	[in]	[in]	[in]	[in ⁴]	[in ³]	[in ⁴]	[in ³]
50	1,97	6	8	0,39	6,72	3,70	3,94	2,01	3,44	1,72	2,32	1,18
		6	10		8,26	3,94		1,88	4,68	2,23	2,40	1,22
70	2,75	6	8	0,39	6,95	4,50	5,50	2,42	5,54	2,30	5,06	1,85
		6	10		8,59	4,77		2,20	7,38	2,89	5,14	1,87
95	3,75	8	11	0,39	11,93	5,16	7,09	2,69	12,11	4,47	8,23	2,99
		6	8		7,07	5,50		2,94	8,94	3,04	8,95	2,53
115	4,50	6	10	0,47	8,70	5,77	8,66	2,59	11,74	3,75	9,03	2,55
		8	11		12,05	6,16		3,18	18,88	5,85	14,84	4,19
130	5,12	6	8	0,47	7,94	6,25	8,66	3,37	12,18	3,64	13,91	3,21
		6	10		9,58	6,52		2,91	15,85	4,42	13,99	3,23
130	5,12	8	11	0,47	12,92	6,91	8,66	3,63	25,21	6,95	23,34	5,39
		6	8		7,76	6,87		3,67	15,02	4,09	13,91	3,21
130	5,12	6	10	0,47	9,39	7,14	8,66	3,15	19,38	4,93	13,98	3,23
		8	11		12,73	7,53		3,93	30,62	7,79	23,34	5,39

1) Designation: CPH1-S2, e.g.CP100-8.

2) Approximate weight including spiders (average values without joint and foot plates).

3) Quotient second moment of area and maximum distance from the neutral axis to the outer fiber.

Wallplate beams

- 4-bar girders can be used as wallplate beams for top heading drives
- Installation of 90° axial rotated 4-bar girders in the longitudinal direction
- Wallplate beams serve as bearing and profile template for installation of the girder arch
- Bend-proof frontal connection allows free top heading advancing
- At the same time, wallplate beams are considered as statically effective reinforcement for the foot beam

Joint and Foot Plates

3-Bar and 4-Bar Girders (North America)

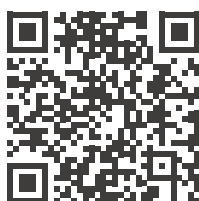
CP Size	Joint plate		Foot plate	
	Size	Length	Size	Unit weight
[mm]	[in]	[#]	[in]	[lb/ft]
50	L4x3x3/8	4 9/16	3/8x5x5	2,7
		4 9/16		
70	L4x3x3/8	5 5/16		
		5 1/2	3/8x7x8	3,8
95	L5x3x1/2	5 3/4		
		6 9/16		
115	L5x3x1/2	6 3/4	3/8x7x8	6,0
		7 1/16		
130	L5x3x1/2	7 11/16		
		7 13/16	3/8x8x9 1/2	8,1
130	L5x3x1/2	8 1/8		
		8 1/8		
130	L5x3x1/2	8 5/16	3/8x8x9 1/2	8,1
		8 3/4		

CP Size	Joint plate			Foot plate	
	Size	Length	Unit weight	Size	Unit weight
[mm]	[in]	[#]	[#]	[in]	[lb/ft]
100	L5x3x1/2	5 1/4	5,6	1/2x5x7	5,0
		5 1/2	5,9		
		5 3/4	6,1		
		6	6,4		
		6 1/2	6,9		
		6 3/4	7,2		
140	L5x3x1/2	7	7,5	1/2x7x9	8,3
		7 1/4			
		7 1/2			
		8	8,5		
180	L5x3x1/2	8 3/8	8,9	1/2x8x10 1/2	11,9
		8 5/8	9,2		
		8 7/8	9,5		
		9 1/8	9,7		
		9 5/8	10,3		
220	L5x3x1/2	9 15/16	10,6	5/8x10x12	21,2
		10 3/16	10,9		
		10 7/8	11,1		
		10 11/16	11,8		
		11 3/16	11,9		

Legal disclaimer

All dimensions, weights, quantities, and specifications are those applicable at the time of this publication and may be amended from time to time. Please contact your local representative for final confirmation of any key specifications.

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