JORDAHL®
anchored in quality

Tunnel

JORDAHL® Anchor Channels

Features

- Quick, efficient anchoring on site
- Simple assembly
- Long-lasting, maintenance-free through the use of corrosion-resistant grades of stainless steel
- Reduced construction time through pre-planning
- Anchoring without damage to the concrete or reinforcement (no physical impact with the iron)
- Suitable without restriction for cracked or uncracked concrete
- Suitable for pre-stressed and post-tensioned structures
- Increased load bearing capacity near reinforcement
- Approved for use with structural elements subject to fire prevention requirements
- European Technical Approval (ETA-09/0338) and General Technical Approval (Z-21.4-151) issued by the German Institute for Structural Engineering (DIBT)

W Profiles

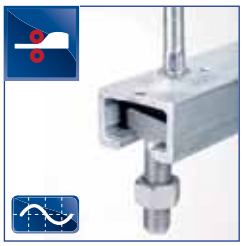
- Hot rolled from a single block
- Free from internal stresses
- Optimized geometry with strengthened channel lips for high tightening torques
- Suitable for dynamic loads
- Resistant to fatigue up to the working load limit
- Verified against explosion - or shock-limit loads

Toothed W and K Profiles

- Universal load capacity also in the longitudinal direction of the channel
- Toothed profiles have General Technical Approval (W profiles: Z-21.4-1690, K profiles: Z-21.4-741)

Toothed W Profiles:

- Suitable for dynamic loads
- Resistant to fatigue up to the work load limit
- Optimized geometry with strengthened channel lips for high tightening torques



K Profiles

- Cold formed profiles
- Uniform material strength

JORDAHL® Bolts

- T-head bolts – matched to JORDAHL® profiles
- Galvanized or from stainless steel
- Strong connections using high bolt tightening torques

work safety

reduces construction time

economical

simple assembly

fire prevention

sustainable construction

Content

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City-Tunnel Leipzig, Germany

The approx. 4 km long City Tunnel Leipzig is being built as a new arterial road for Middle Germany. It is the central building block in the re-structuring of the railway system in the metropolitan area of Leipzig. The new construction of four underground stations and one overground station is planned. It provides better interlinking of the Leipzig tram network and faster direct connections within the regional and long-distance rail network. JORDAHL® is supplying (inter alia) JTA W hot rolled anchor channels. The City Tunnel Leipzig will be constructed using both cut and cover as well as driven construction methods.

Client
Deutsche Bahn AG, Freistaat Sachsen, Leipzig

Construction Company
Alpine Bau Deutschland GmbH


Period of construction: 2003 – 2012

JORDAHL®
Deutsche Kahneisen Gesellschaft mbH
Nobelstraße 51
12057 Berlin, Germany
www.jordahl.de

Anchoring Methods in Tunnel Construction

JORDAHL® anchor channels and bolts are the appropriate system for safe and reliable anchoring of equipment such as overhead lines, signal systems, lighting as well as ventilation and exhaust systems in tunnels and supply structures.

These civil engineering structures must comply with the safety-related requirements for personal protection, fire prevention, corrosion protection and on technical equipment also for years after their provision.

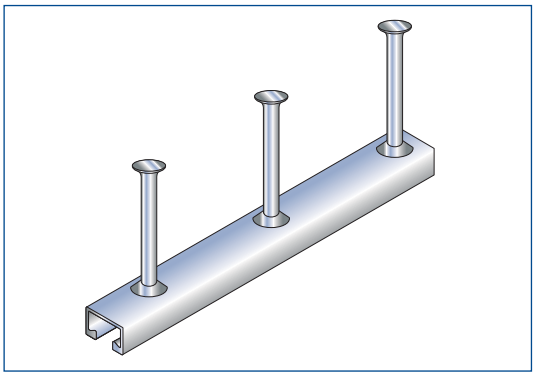
Cast-in JORDAHL® anchor channels have proven themselves world-wide and set the standards in fastening technology.

JORDAHL® anchor channels have European Technical Approval, reference ETA-09/0338, and have National Technical Approval, reference Z-21.4-151.

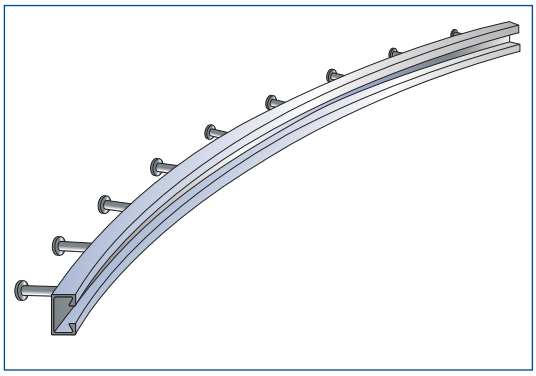
Areas of Application

- Railway tunnels
- Road tunnels
- Utility ducts
- Bridges
- Underpasses

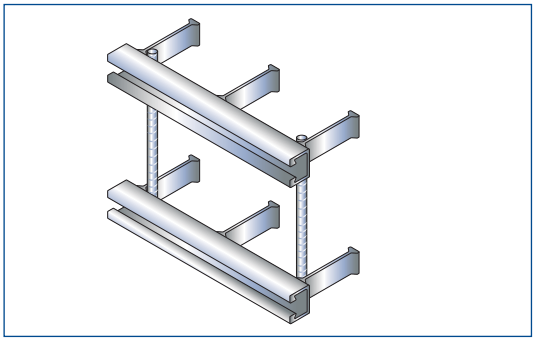
Overview of Channel Variations



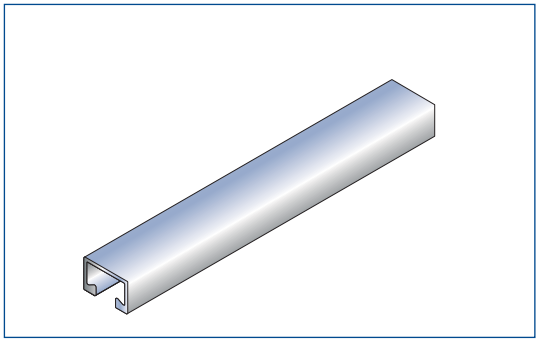
Straight anchor channels, e. g. in road tunnels



Curved anchor channels, e. g. in railway tunnels



Pairs of anchor channels for anchoring overhead lines in railway tunnels



Assembly channels for subsequent installation in utility ducts

Corrosion Protection in Tunnels

The use of anchor channels in tunnel structures, utility ducts, etc. requires that the corrosive conditions of the structure are taken into account. Due to the very high exposure to corrosion, the application areas fall into the corrosivity class C4 or C5. Stainless steels of these classes have a high resistance to corrosion and are therefore most suitable.

Corrosivity Categories: ISO 12944-2	Profile	Anchor	Bolt, Nut, Washer	Intended Purpose
C4 high [1]	Stainless steel 1.4401, 1.4404, 1.4571 (A4) 1.4362 (L4)	Stainless steel 1.4401, 1.4404, 1.4571 (A4) 1.4362 (L4)	Stainless steel 1.4401, 1.4404, 1.4571 (A4-50, A4-70) 1.4362 (L4-70)	Applications with medium corrosion resistance, for example in wet rooms, exposed to weather, industrial atmosphere, close to the ocean and inaccessible areas.
C5 severe	Stainless steel 1.4462 (F4) 1.4529, 1.4547 (HC)	Stainless steel 1.4462 (F4) 1.4529 (HC)	Stainless steel 1.4462 (F4-70) 1.4529, 1.4547 (HC-50, HC-70)	Applications with severe corrosion resistance and high corrosion loading by chlorides and sulphur dioxide (including concentration of the pollutants, for example in the case of components in saltwater and in road tunnels).

[1] Anchor channels and bolts of corrosion class C4 are generally stocked.

Comparison of Zinc-plated with Non-corroding Stainless Steel

Rust formation when using non-corrosion-resistant materials subject to attack from acid or salt

Long-lasting, maintenance-free fastening technology using corrosion-resistant stainless steels also in aggressive environments

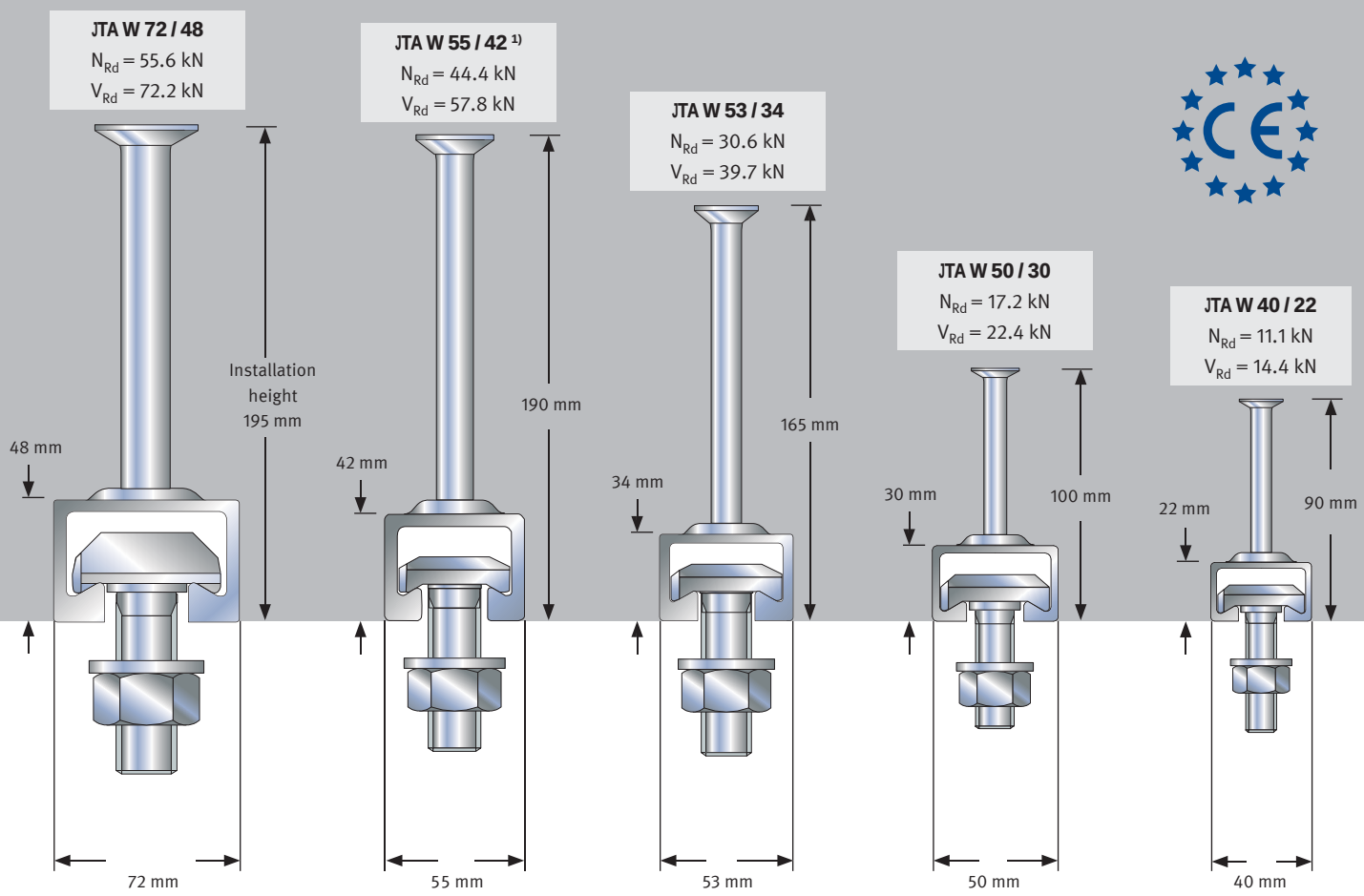
Regulations for the Use of Stainless Steel in Tunnel Construction

- **DIN EN 10088 - "non-corroding steels"**
- **General Technical Approval Z-30.3.6, Annex 1a, Issue 04 / 09:**
  Classification of grades of steel by strength class and corrosion resistance class
- **ZTV-ING:**
  Supplementary Technical Contractual Guidelines for Engineering Structures
  Part 5.1 and 5.2:
  Road tunnel in cut and cover and driven construction methods, Issue 12/07, Point 5.2.8 (1):
  "Fasteners for tunnel installations must be made from non-corroding steel of steel grade 1.4529 or 1.4547 in accordance with DIN ISO 3506 as well as DIN EN 10088."

JORDAHL® Anchor Channels JTA-CE

European Technical Approval ETA-09/0338

Hot Rolled Anchor Channels



Bolts

JA	JB	JB	JB	JC
M 20	M 16	M 10	M 10	M 10
M 24	M 20	M 12	M 12	M 12
M 27	M 24 2)	M 16	M 16	M 16
M 30		M 20	M 20	

1) Only in hot-dip galvanized (HDG)
2) JB M24 is equivalent to JE M24
Profile dimensions may exhibit tolerances.

Material and Design of Profile
- Hot-dip galvanized steel (HDG)
- Stainless steel (A4)
- Standard filler polyethylene (PE) or polystyrene (PS)

Material and Design of Bolts
- Zinc plated (ZP) or hot-dip galvanized steel (HDG)
- Stainless steel

JORDAHL® Anchor Channels

General Technical Approval Z-21.4-1690

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Hot Rolled, Toothed Anchor Channels

JXA W 64 / 44
$N_{Rd} = V_{Rd} = X_{Rd} = 37.8$ kN

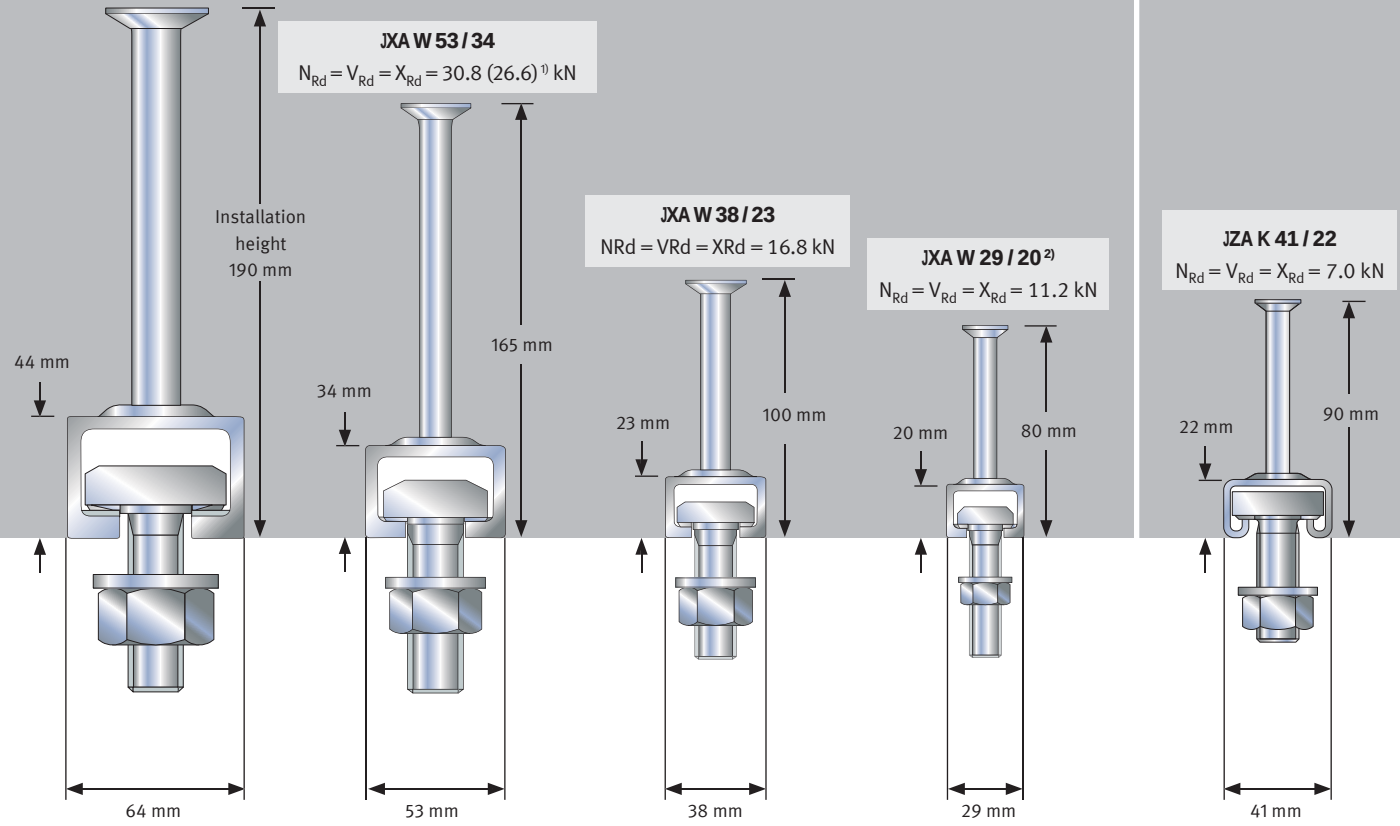
JXA W 53 / 34
$N_{Rd} = V_{Rd} = X_{Rd} = 30.8\ (26.6)^{1)}$ kN

JXA W 38 / 23
NRd = VRd = XRd = 16.8 kN

JXA W 29 / 20[2)]
$N_{Rd} = V_{Rd} = X_{Rd} = 11.2$ kN

Cold Formed, Toothed Anchor Channels (Z- 21.4-741)

JZA K 41 / 22
$N_{Rd} = V_{Rd} = X_{Rd} = 7.0$ kN



Toothed Bolts

JXE	JXB	JXH	JXD	JZS
M 20 M 24	M 16 M 20	M 12 M 16	M 10 M 12	M 12 M 16

N_{Rd} = Design value for axial force
V_{Rd} = Design value for shear force
X_{Rd} = Design value for longitudinal force

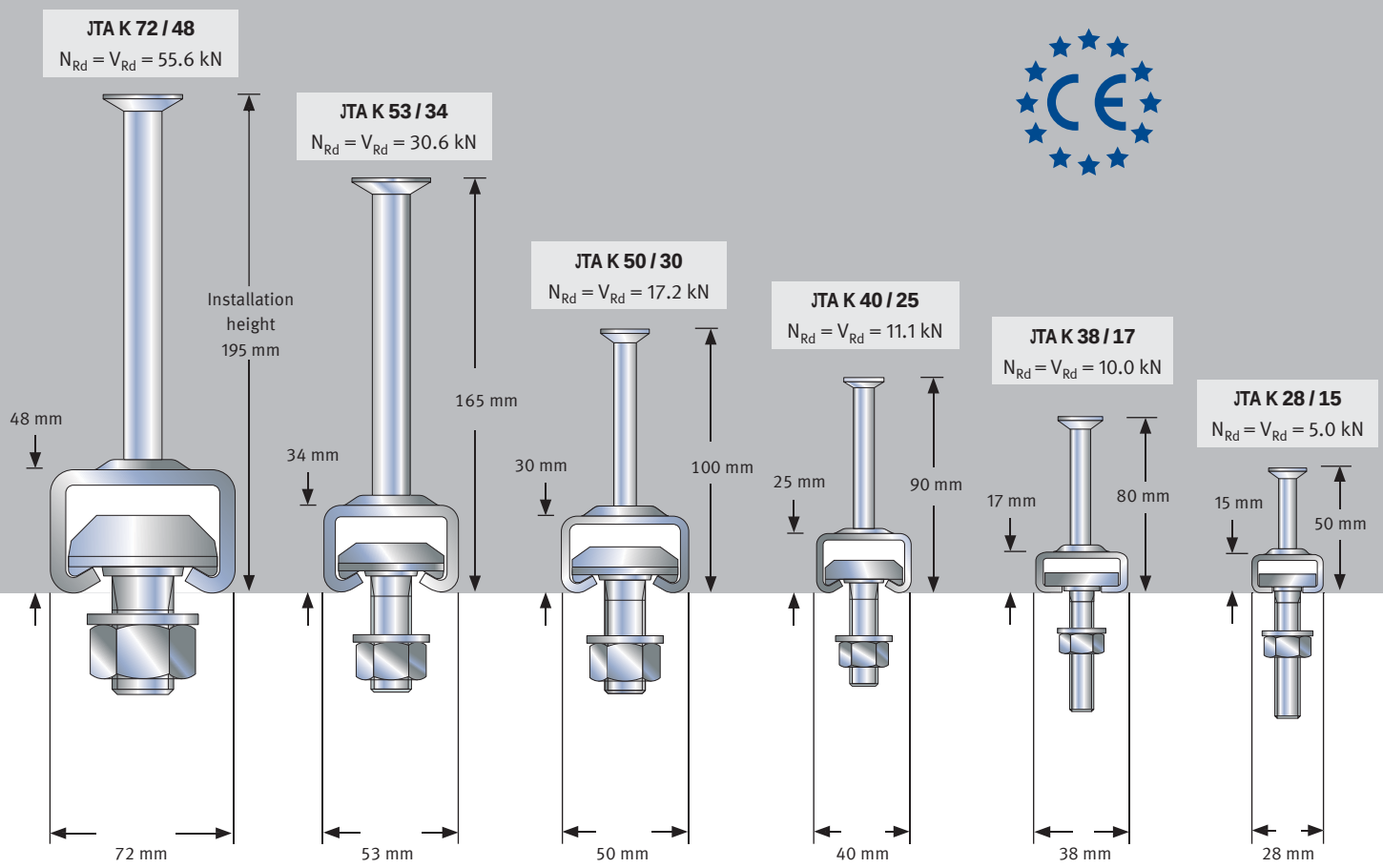
[1)] For profiles made in A4 = 26.6 kN
[2)] Only in hot-dipped galvanized (HDG)

Anchor channels are available in lengths from 100 to 6,050 mm.

JORDAHL® Anchor Channels JTA-CE

European Technical Approval ETA-09/0338

Cold Formed Anchor Channels



Bolts

JA	JB	JB	JC	JH	JD
M 20	M 10	M 10	M 10	M 10	M 6
M 24	M 12	M 12	M 12	M 12	M 8
M 27	M 16	M 16	M 16	M 16	M 10
M 30	M 20	M 20			M 12

Profile dimensions may exhibit tolerances.

Material and Design of Profile

- Hot-dip galvanized steel (HDG)
- Stainless steel (A4)
- Standard filler polyethylene (PE) or polystyrene (PS)

Material and Design of Bolts

- Zinc plated (ZP) or hot-dip galvanized steel (HDG)
- Stainless steel

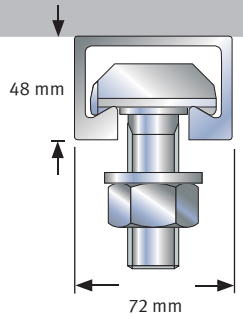
Framing Channels

JORDAHL®
anchored in quality

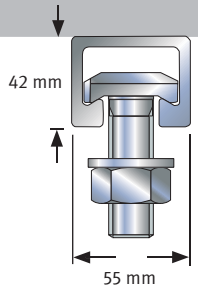
Framing Profile JM, Hot Rolled

Framing channels are available in lengths from 100 to 6,050 mm. Framing channels with slots can be manufactured and supplied as perforated channels upon request.

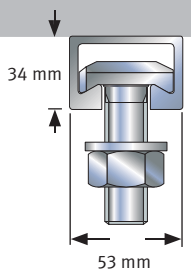
JM W 72 / 48 with JA



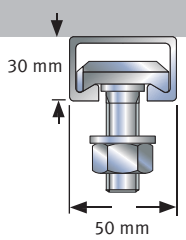
JM W 55 / 42 with JB



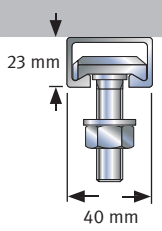
JM W 53 / 34 with JB



JM W 50 / 30 with JB

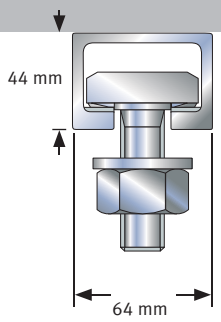


JM W 40 / 22 with JC

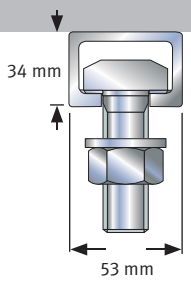


Framing Toothed Profile JXM, Hot Rolled

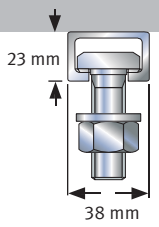
JXM W 64 / 44 with JXE



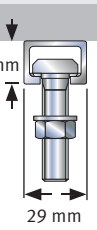
JXM W 53 / 34 with JXB



JXM W 38 / 23 with JXH

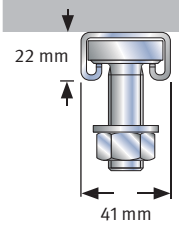


JXM W 29 / 20 with JXD



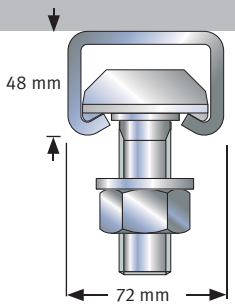
Framing Toothed Profile JZM, Cold Formed

JZM K 41 / 22 with JZS

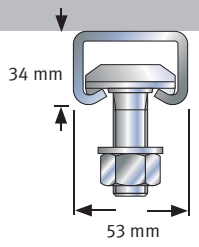


Framing Profile JM, Cold Formed

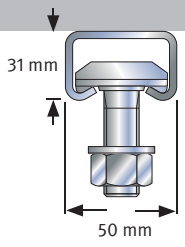
JM K 72 / 48 with JA



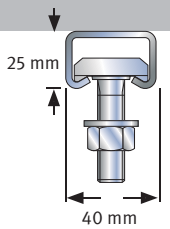
JM K 53 / 34 with JB



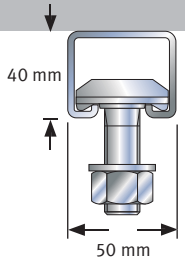
JM K 50 / 30 with JB



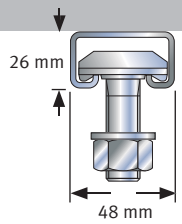
JM K 40 / 25 with JC



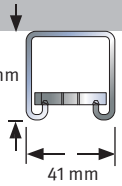
JM K 50 / 40 with JB



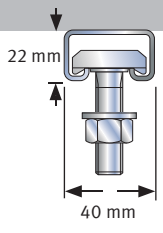
JM K 48 / 26 with JB



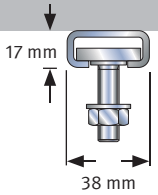
JM K 41 / 41 with JAM



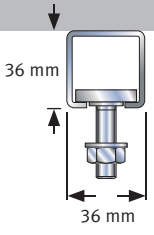
JM K 40 / 22 with JC



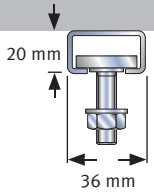
JM K 38 / 17 with JH



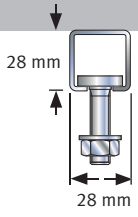
JM K 36 / 36 with JH



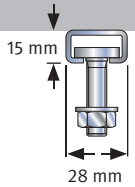
JM K 36 / 20 with JH



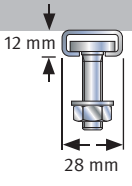
JM K 28 / 28 with JD



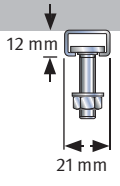
JM K 28 / 15 with JD



JM K 28 / 12 with JD

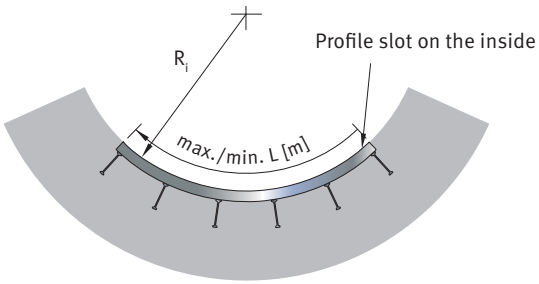


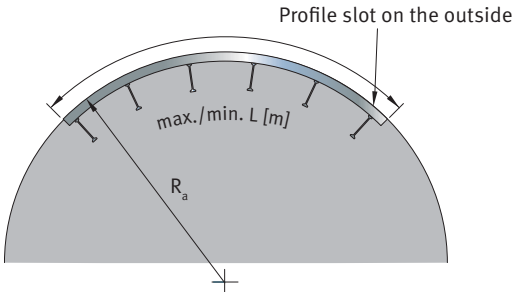
JM K 21 / 12 with JG



Curved JORDAHL® Anchor Channels

On request, JORDAHL® can supply pre-curved anchor channels for curved utility ducts, treatment plants or tunnel construction. It is possible to supply the anchor channels with the fixing slot on either the internal, or external radius of the channel. A high-precision approach is required, e. g. in the case of anchor channels for tubbing segments in tunnel construction. These are curved on site with the aid of specially prepared calipers.





Minimum Bending Radii / Channel Lengths (all Materials)

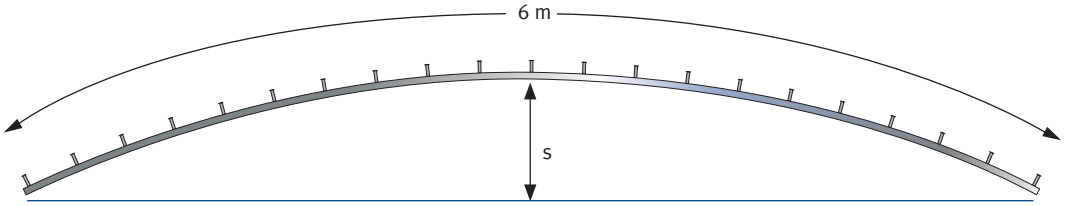
	JTA / JM							JXA / JXM	
Profiles	**K 72 / 48 W 72 / 48**	**W 55 / 42**	**K 53 / 34 W 53 / 34**	**K 50 / 30 W 50 / 30**	**K 40 / 25 W 40 / 22**	**K 38 / 17**	**K 28 / 15**	**W 38 / 23**	**W 29 / 20**
min R_i [m]	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
min R_a [m]	3.0	3.0	2.5	2.0	2.0	1.5	1.0	2.0	2.0
min L [m] Minimum Channel Length	1.5	1.5	1.5	1.5	1.0	0.5	0.5	0.5	0.5
max L [m] Maximum Channel Length	5.5	5.5	5.8	5.8	5.8	5.8	5.8	5.8	5.8

Large Radii

Straight stock lengths can be installed for large radii, as these can be curved into an arc during fastening.

The achievable manual internal diameter gauge for 6-metre lengths can be found from the table.

6-metre Lengths	Achievable Manual I.D. Gauge s [mm]	Corresponding Radius [m]
K 72/48; W 72/48	40	110
K 53/34; W 53/34	75	60
K 50/30; W 50/30	140	32
K 40/25; W 40/22	250	18
K 28/15; K 38/17	550	8

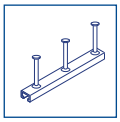


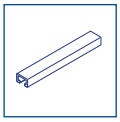
Road Tunnel

JORDAHL®
anchored in quality

Both curved as well as straight anchor and framing channels are used in road tunnels to fasten equipment such as lighting, ventilation, signage, etc. The fastenings are made by mounting in rows as is the case for bridges.

Due to the high risk of increased concentration of chlorides in road tunnels, non-corroding stainless steel material 1.4529 or 1.4547 must be used.





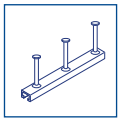
Tiergartentunnel, Berlin, Germany

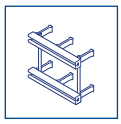
The tunnel construction “Tiergartentunnel”, built between 1995 and 2006, runs below Berlin’s largest city park, the zoological garden, and comprises a combination of civil engineering tunnel constructions for road and rail traffic. The Tiergartentunnel was part of the “Traffic project Deutsche Einheit No. 8 from Berlin to Munich via Halle/Leipzig, Erfurt, Nuremberg”. Approximately 3.6 kilometres of railway tunnels and 2.4 kilometres of road tunnels are included in this construction project. In 2007 ADAC voted the tunnel the safest in Germany.

JORDAHL® supplied JTA K 28/15 anchor channels and a specially manufactured top hat profile as a self-tapping channel made from stainless steel.

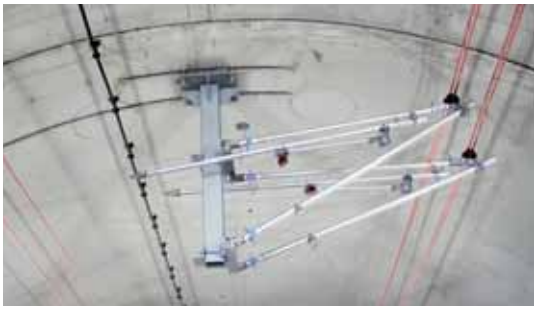
Client
Deutsche Bahn, Senatsverwaltung für Stadtentwicklung Berlin

Railway Tunnel





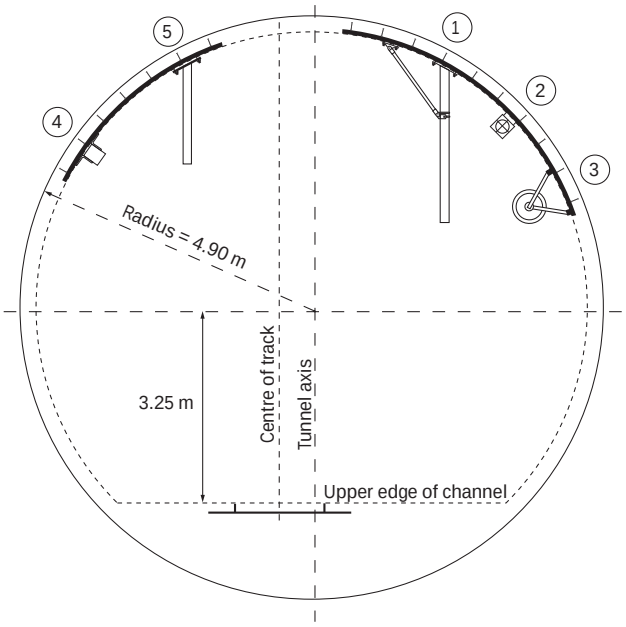
Special requirements are placed on the anchoring of overhead lines on high-speed sections in regard to their load capacity under static and dynamic loads. Speeds up to 300 km/hr generate enormous forces and vibrations in the catenary wires which must also be securely anchored in tunnel sections.



In order to achieve a safe and economic anchoring for these dynamic loads, hot rolled JORDAHL® stainless steel anchor channels are used, preferably the JTA W 53/34-CE type. The profiles have particularly low residual stress and are therefore very durable. Their optimized form facilitates the use of special bolts with increased tightening torque and also the safe transfer of forces in the longitudinal axis of the channel. This is important, e. g. in the event of damage (break in a catenary wire or similar). Short circuit currents of several thousand amps have to be discharged in a very short time.

The smooth contact surfaces of the hot rolled profiles, together with the JORDAHL® special bolts, ensure that this happens without fusing. Thus a dangerous, potential cause of fire is avoided. Stainless steel A4 (material 1.4571/1.4401) also guarantees maintenance-free fastening possibilities for many years even in environments loaded with substantial harmful substances. Subsequent adjustment or relocation of attachments is not a problem.

Single-track Railway Tunnel – Section with Installed Anchor Channels



1) Support point
2) Catenary wire anchoring
3) Guide pulley
4) Anchor point
5) Line feeder

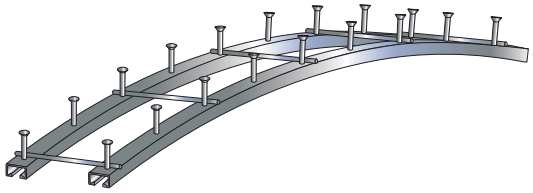
Note

In Germany the fastening of the catenary wire is regulated by the guideline drawings of the Deutsche Bahn AG:

- Anchor channels and bolts for fastening structural components for the control overhead lines in tunnels: 2 Ebs 04.54.24, 3 Ebs 04.54.28
- Rail earthing of anchor channels: 3 Ebs 15.03.31-33 (designed for a short-circuit current of 25 kA)

Earthing of Railway Tunnel

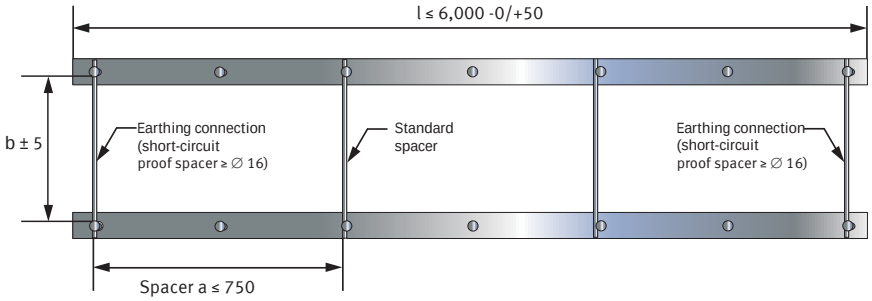
In railway tunnels, due to the tunnel geometry, pairs of curved anchor channels are often installed in order to fix the catenary wires or equipment.



On request, the pairs of anchor channels are made short-circuit proof in the factory. In this case the short-circuit current is conducted across two short-circuit proof, welded-on spacers, ∅ 16. The earthing connection on the ring earth can then be made via an earthing lug (for single tracks) or via the connection to the T anchor or direct welding of the earthing bridge onto the spacer.

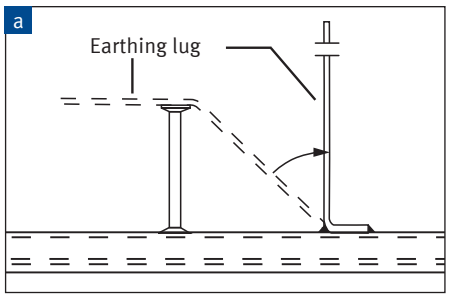
Anchor Channel Pairs with Bar Anchors

(in the plan view) short-circuit proof for $I_K \geq 25$ kA, with A ≥ 200 mm², dimensions in mm

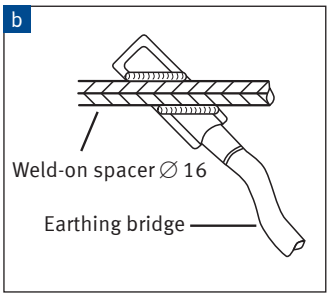


Outgoing Earthing Connections Outside the Anchor Range

(for anchor channels with bar anchors and T anchors)



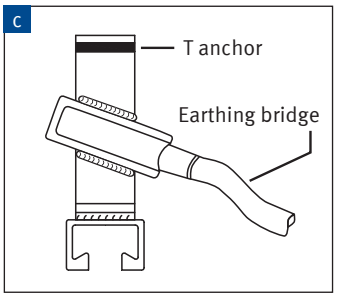
Strap iron 40 × 5 welded in the factory as earthing lug on the back of the channel



Earthing bridge welded short-circuit proof on the strap iron (40 × 5) or short-circuit proof spacer

Outgoing Earthing Connections from the T Anchor

(for anchor channels with T anchors)



Earthing bridge welded with T anchor

U6 City Railway Extension, Stuttgart, Germany

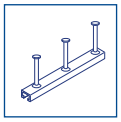
The new section of the U6 connects the urban district of Möhringen with the urban district of Fasanenhof/Fasanenhof Ost. It is 2,750 m long, of which approximately 1,000 m are in tunnel.

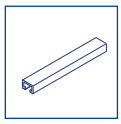
JORDAHL® supplies, inter alia, JTA W 53/34 curved anchor channels.

Construction Company
ARGE U6 Straßenbahnanschluss Fasanenhof
(Arge Wayss & Freytag / Max Bögl)

Period of construction: 2007 – 2010

Utility Ducts





Curved anchor channels are often concreted into cable ducts. For subsequent installation JORDAHL® straight or curved framing channels can be dowelled into the tunnel wall. They facilitate fastening of the equipment for various utilities such as water, gas, telecommunications, among others.

Fastening on curved framing channels

Anchor channels for fastening of water pipes

European XFEL, Hamburg, Deutschland

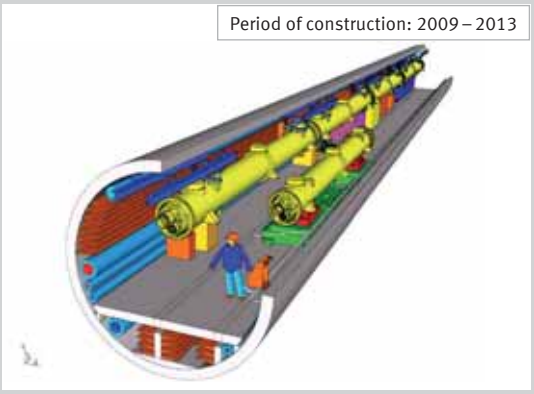
In the western part of Hamburg a research facility is being built with world-wide unique features. The European XFEL (X stands for X-rays, FEL for free-electron laser) will generate ultrashort laser light flashes in the X-ray range. For this purpose almost six kilometres of special tunnel are being built. The tunnel system comprises a 2.1 kilometre long tunnel construction for the electron accelerator and 5 fan-shaped tunnels branching off from it.

For this project JORDAHL® is supplying type JXA W 29/20 toothed anchor channels for fastening the utility lines and measuring equipment in the tubbing segments.

Client
DESY / Germany (Bund, Hamburg, Schleswig-Hostein) and 13 international partners

Architect
IG WTM Engineers / Amberg

Main contractor
ARGE Tunnel XFEL (Hochtief, Bilfinger|Berger)



Simulation of the planned use of the tunnel

Assembly

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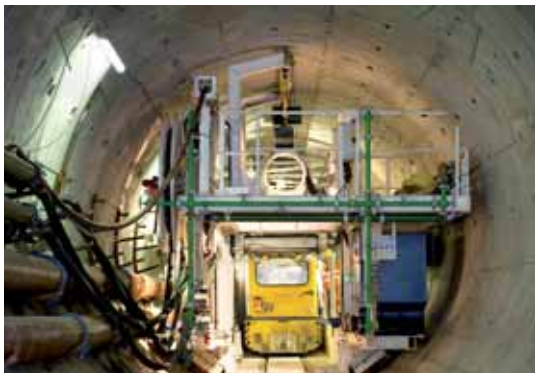
The anchor channels have nailholes and can be fixed directly onto the base of the formwork. The slim anchors ensure that there is no problem inserting the reinforcement. When using formwork carriages JORDAHL® supplies special bolts which can be pushed through the formwork in order to fasten the anchor channels onto the formwork. The positioning of the fastening points requires precise planning by the formwork setter.

Stocking bundles of JORDAHL® anchor channels

Fastening the anchor channels to the reinforcement

Fastening the anchor channels to the formwork



Formwork carriages in the construction of tunnels

References

Germany
Hamm – Warburg: Eggetunnel
Frankfurt am Main – Fulda: Schlüchterner Tunnel
Leipzig: City-Tunnel Leipzig
Stuttgart: U6 Fasanenhof
Kassel: Schulberg Tunnel
Erfurt – Leipzig: Tunnel Osterberg
Cochem: Kaiser-Wilhelm-Tunnel
Hamburg: European XFEL Tunnel

Intercity Link Cologne – Rhein-Main:
Tunnel Ferntaltunnel
Tunnel Ammerich
Tunnel Dernbach
Tunnel Deesener Wald
Tunnel Schulwald
Limburg-Eichheide
Tunnel Kutscheid
Mainzer Tunnel

Intercity Link Ebensfeld – Erfurt:
Tunnel Behringen
Tunnel Sandberg
Tunnel Augustaburg
Tunnel Bleßberg Süd
Tunnel Bleßberg Nord
Tunnel Baumleite

Intercity Link Nuremberg – Ingolstadt:
Tunnel Euerwang
Tunnel Irlahüll
Tunnel Göggelsbuch
Tunnel Geißberg
Tunnel Denkendorf
Tunnel Stammham

Austria
Vienna – Salzburg: High Speed Railway Tunnel Melk
Vienna – Salzburg: High Speed Railway Siegberg Tunnel

England
London: Docklands Light Railway

Denmark
Copenhagen: Metro Copenhagen

Sweden
Stockholm: Road Tunnel Södra Länken
Malmö – Gothenburg: Railway Tunnel Malmö
Malmö: Malmö City Tunnel

Korea
Seoul – Pusan: High Speed Railway

Taiwan
Taipei: High Speed Railway

Australia
Perth: MetroRail City Tunnel

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Deutsche Kahneisen Gesellschaft mbH
Nobelstrasse 51
12057 Berlin
Germany

info@jordahl.de
www.jordahl.de