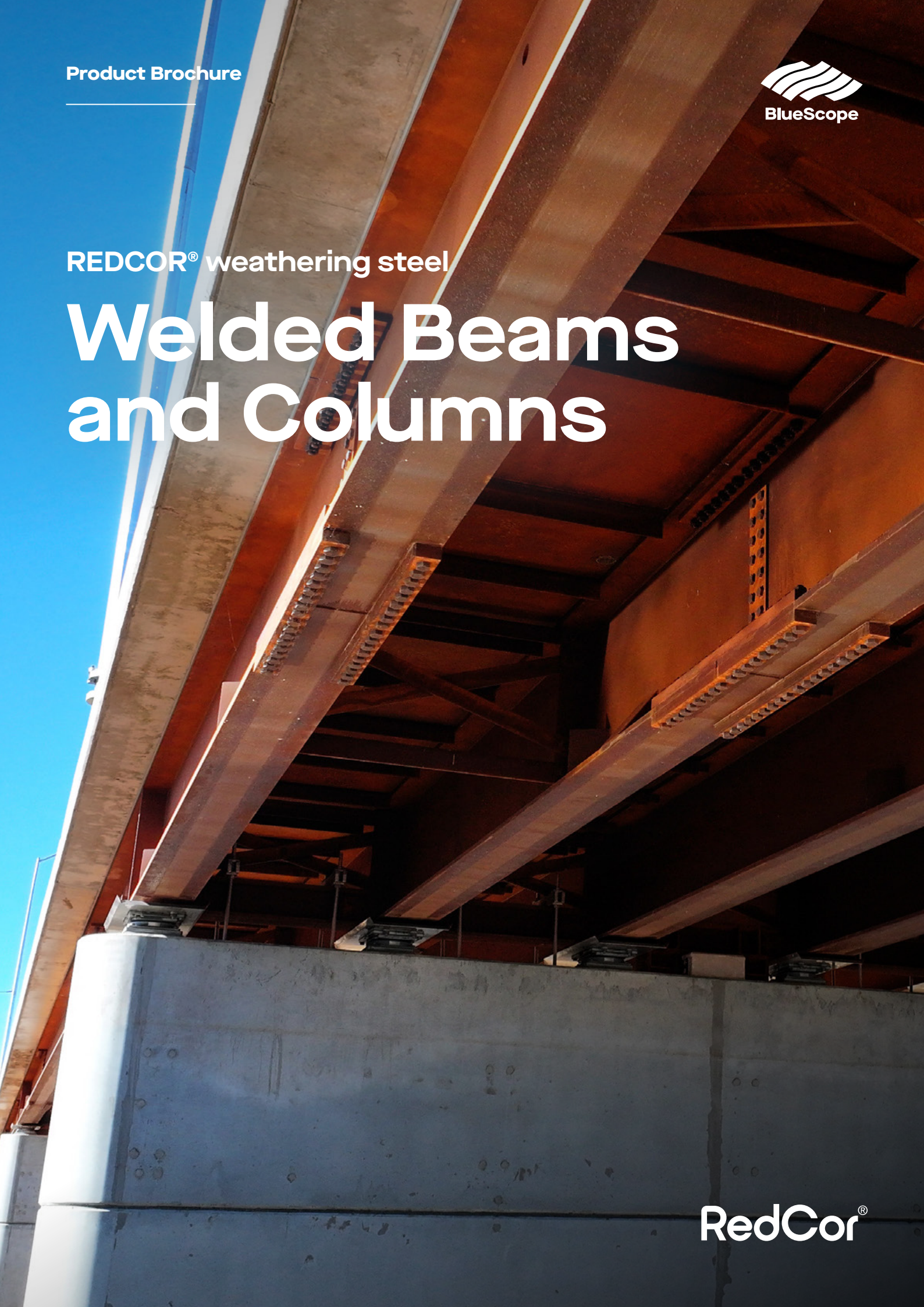
Product Brochure

BlueScope

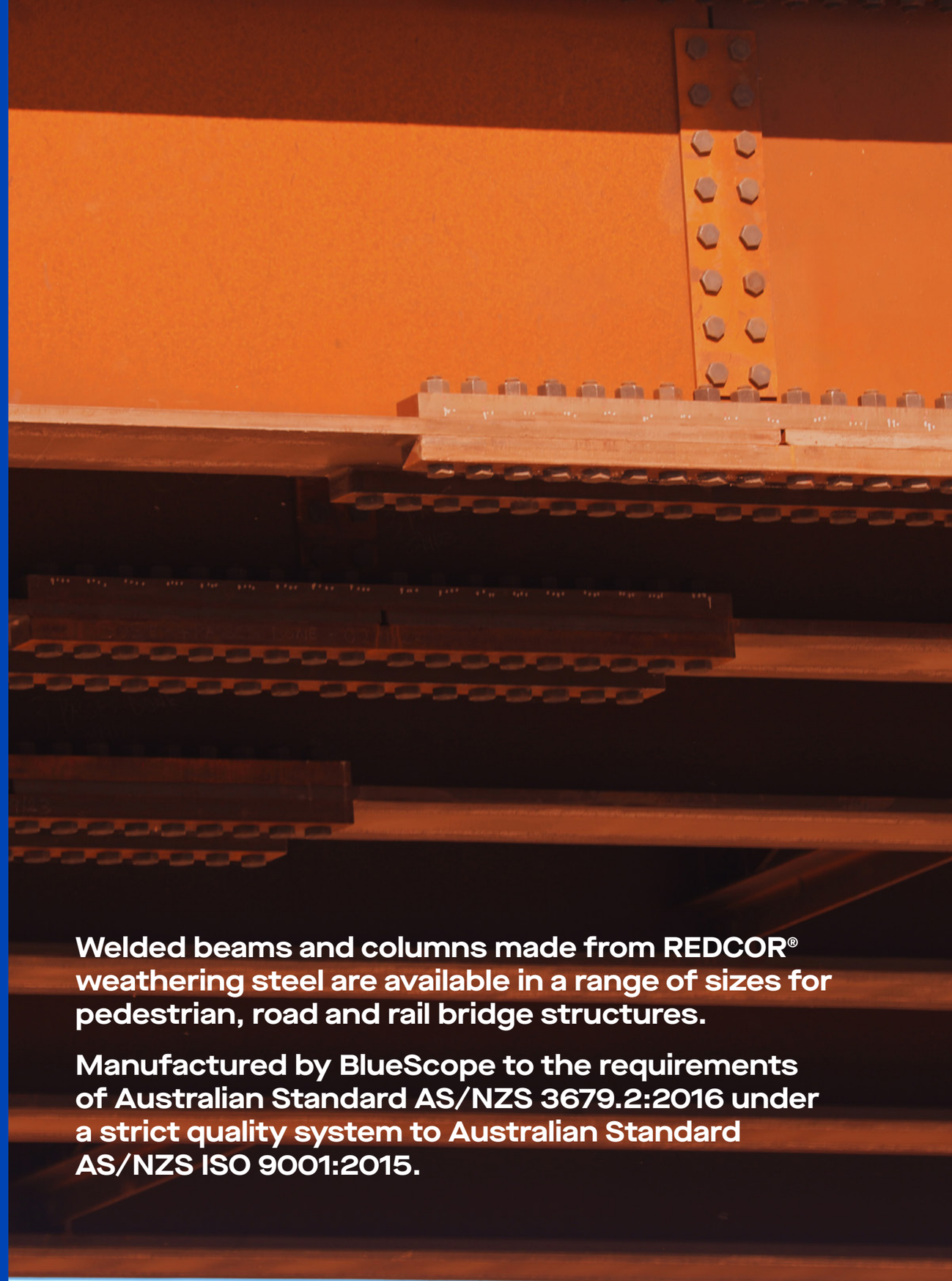
REDCOR® weathering steel

Welded Beams and Columns



RedCor®

Contents



Welded beams and columns made from REDCOR® weathering steel are available in a range of sizes for pedestrian, road and rail bridge structures.

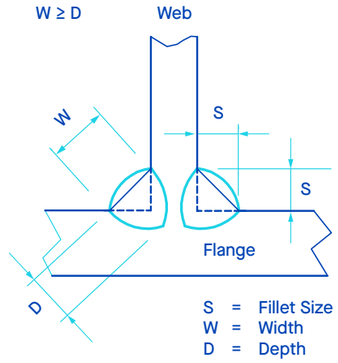
Manufactured by BlueScope to the requirements of Australian Standard AS/NZS 3679.2:2016 under a strict quality system to Australian Standard AS/NZS ISO 9001:2015.

Product Quality

Manufacturing Process – Welds

Welds are made using a fully automatic submerged arc welding process to AS/NZS 1554.1:2014 SP Category (deep penetration fillet weld). Welds are made simultaneously along both flange-web joints in the horizontal fillet position. A tandem arc weld system is used to make each weld; fed into both arc areas are two relatively small diameter wires. The two wires are close enough together so that they operate under a common molten pool of flux, yet are far enough apart that the metal from the first arc has solidified before the metal from the second arc is deposited on top. This technique has several benefits including:

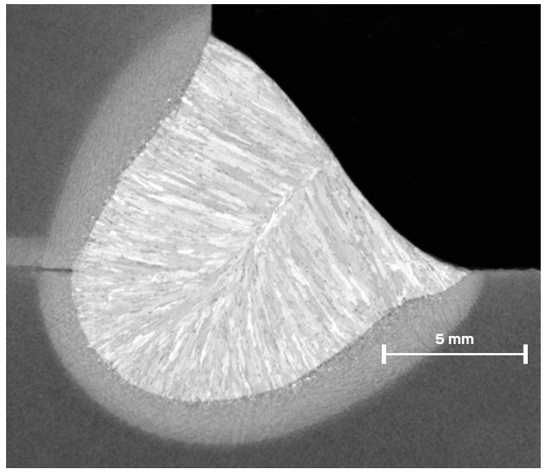
- The lead wire is designed to give deep penetration, while the second is designed to build up throat thickness and provide a consistent, uniform weld profile.
- Relatively thick joints are produced in a single pass without edge preparation and minimal heat distortion.
- Welds made under the protective layer of flux have good ductility, impact resistance and uniformity in appearance.
- Mechanical properties at least equal to those of the parent metal are consistently obtained.
- These welds utilise standard carbon–manganese consumables rather than dedicated weathering steel consumables for BlueScope's REDCOR® weathering steel welded beams which complies with the requirements of AS/NZS 1554.1.
- Due to the deep penetration achieved during welding of the weathering steel parent plate, sufficient alloying element dilution occurs within the weld metal. This ensures that the weld region develops a protective patina consistent with the parent material, providing the intended corrosion resistance.
- Extensive testing has been conducted, including weld metal chemical analysis and long-term atmospheric exposure trials, to confirm that the welds develop a stable and protective patina over time.



Product Testing

The quality of BlueScope's welded products is checked in NATA accredited testing laboratories. Strict metallurgical control is maintained, from receipt of raw materials to dispatch of the final product. Testing of BlueScope's welded beams includes:

- Mechanical testing of the original plates that are used to produce the flange and web to determine the tensile properties and, where required, the Charpy impact properties.
- Web-to-flange tensile testing (T test) is carried out to determine the strength of the weld on a batch basis, as per the standard.
- Macro testing (see below), used to determine weld quality is also carried out on a batch basis, as per the standard.
- BlueScope conducts testing to ensure that the patina formation will provide protection for the weld when used in suitable environments in accordance with design standards. For further information please refer to the Bluescope Weathering Steel Design Guide for Bridges in Australia.

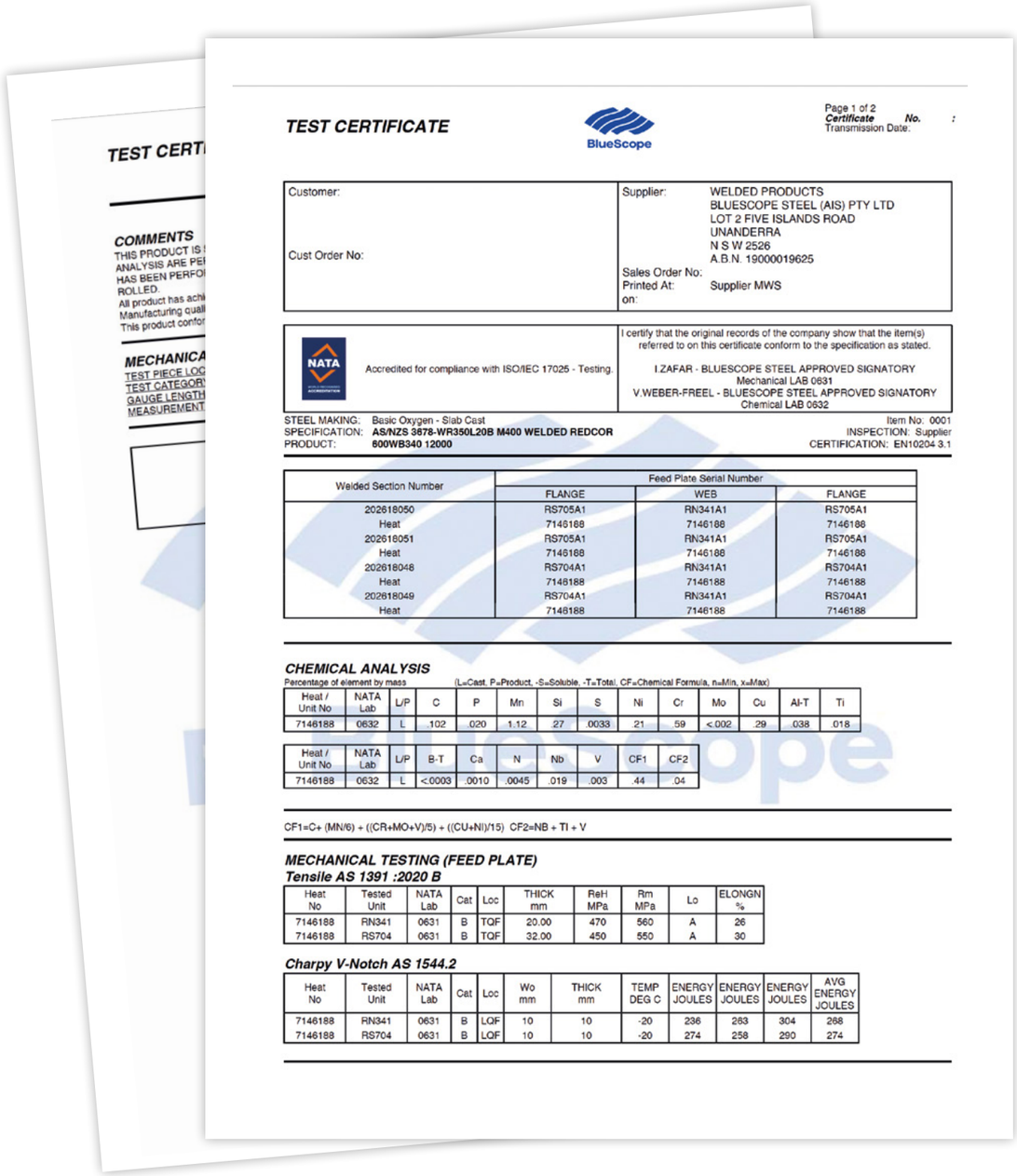


Example of Macro Test

Example of plate weld

Test Certificates

All test results are available on BlueScope's test certificates (an example of which is shown here), which contain all the information as required by the AS/NZSW 3679.2:2016.



TEST CERTIFICATE

BlueScope

Page 1 of 2
Certificate No. :
Transmission Date:

Customer:	Supplier: WELDED PRODUCTS BLUESCOPE STEEL (AIS) PTY LTD LOT 2 FIVE ISLANDS ROAD UNANDERRA N S W 2526 A.B.N. 19000019625
Cust Order No:	Sales Order No: Printed At: Supplier MWS on:

NATA Accredited for compliance with ISO/IEC 17025 - Testing.	I certify that the original records of the company show that the item(s) referred to on this certificate conform to the specification as stated. I.ZAFAR - BLUESCOPE STEEL APPROVED SIGNATORY Mechanical LAB 0631 V.WEBER-FREEL - BLUESCOPE STEEL APPROVED SIGNATORY Chemical LAB 0632

STEEL MAKING: Basic Oxygen - Slab Cast
SPECIFICATION: **AS/NZS 3678-WR350L20B M400 WELDED REDCOR**
PRODUCT: **600WB340 12000**
Item No: 0001
INSPECTION: Supplier
CERTIFICATION: EN10204 3.1

Welded Section Number	Feed Plate Serial Number		
	FLANGE	WEB	FLANGE
202618050	RS705A1	RN341A1	RS705A1
Heat	7146188	7146188	7146188
202618051	RS705A1	RN341A1	RS705A1
Heat	7146188	7146188	7146188
202618048	RS704A1	RN341A1	RS704A1
Heat	7146188	7146188	7146188
202618049	RS704A1	RN341A1	RS704A1
Heat	7146188	7146188	7146188

CHEMICAL ANALYSIS

Percentage of element by mass (L=Cast, P=Product, -S=Soluble, -T=Total, CF=Chemical Formula, n=Min, x=Max)

Heat / Unit No	NATA Lab	L/P	C	P	Mn	Si	S	Ni	Cr	Mo	Cu	Al-T	Ti
7146188	0632	L	.102	.020	1.12	.27	.0033	.21	.59	<.002	.29	.038	.018

Heat / Unit No	NATA Lab	L/P	B-T	Ca	N	Nb	V	CF1	CF2
7146188	0632	L	<.0003	.0010	.0045	.019	.003	.44	.04

CF1=C+ (MN/6) + ((CR+MO+V)/5) + ((CU+NI)/15) CF2=NB + TI + V

MECHANICAL TESTING (FEED PLATE)
Tensile AS 1391 :2020 B

Heat No	Tested Unit	NATA Lab	Cat	Loc	THICK mm	ReH MPa	Rm MPa	Lo	ELONGN %
7146188	RN341	0631	B	TQF	20.00	470	560	A	26
7146188	RS704	0631	B	TQF	32.00	450	550	A	30

Charpy V-Notch AS 1544.2

Heat No	Tested Unit	NATA Lab	Cat	Loc	Wo mm	THICK mm	TEMP DEG C	ENERGY JOULES	ENERGY JOULES	ENERGY JOULES	AVG ENERGY JOULES
7146188	RN341	0631	B	LQF	10	10	-20	236	283	304	268
7146188	RS704	0631	B	LQF	10	10	-20	274	258	290	274

Product Quality

Product Conformity

In compliance with Appendix B of the AS/NZS 3679.2:2016 standard, BlueScope welded products undergo ongoing property assessment by way of the factory production control (FPC) requirement for this standard. Inspections are conducted and properties are reviewed on a regular basis to ensure both the process and the product conform to the standard. BlueScope's FPC system is underpinned by accreditation to ISO 9001:2015.

Third Party Product Compliance Accreditation

In addition to our quality systems and NATA endorsed laboratories, BlueScope's range of AS/NZS 3679.2:2016 welded sections have independent Third Party Certification from ACRS (Australian Certification Authority for Reinforcing and Structural Steels) giving designers and asset owners additional confidence that the beams they are receiving are in full compliance to all relevant standards.

ACRS is an expert, industry-based, third-party product certifier of structural steels to Australian/New Zealand Standards. ACRS operates in accordance with internationally recognised certification principles ensuring compliance to standards, and end-to-end supply chain traceability. ACRS is supported by peak technical bodies such as AustRoads and Engineers Australia.

Product Availability

Grades

Standard

AS/NZS 3678-WR350L20B MOD 400
AS/NZS 3678-WR350L20Z35B MOD 400

Weathering steel welded beams are not currently listed as a standard grade within AS/NZS 3679.2. In response to this, BlueScope's REDCOR® weathering steel welded beams are produced using a modified plate grade derived from AS/NZS 3678, specifically AS/NZS 3678–WR350L20B MOD 400.

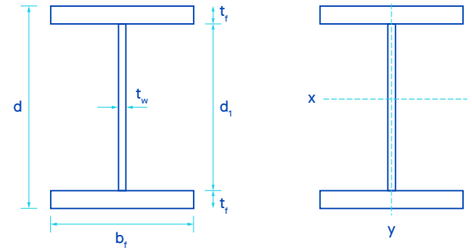
This modified grade has been developed to achieve mechanical properties equivalent to those specified for AS/NZS 3679.2 Grade 400 sections, while also providing enhanced strength characteristics compared to the base AS/NZS 3678–WR350B® weathering steel grade. These beams are made utilising the same manufacturing processes and quality control measures as stated in AS/NZS 3879.2.

Lengths

Standard Lengths 12, 15 & 18 metres

> 18 m lengths available by enquiry.
Welded beams less than 9 m (5.5 m minimum length) are available by enquiry but will be subjected to at least a minimum order quantity of 2 beams.

Construction of Fitzroy River Bridge featuring welded beams made from REDCOR® weathering steel
Kimberley, WA



Properties for Beams and Columns

Dimensions and Properties

Designation		Depth of Section	Flange		Web Thickness	Depth between flanges	Depth between flange centres	Flange clear width			Gross Area of Cross Section	About x-axis				About y-axis				Estimated Torsion Constant	Values used to calculate Torsion Constant				Torsion Constant	Warping Constant
			Width	Thickness																	Torsion Constant (Flanges)	Torsion Constant (Web)	Diameter At Joint			
		d	b_f	t_f	t_w	d_1	d_2	$(b_f-t_w)/2$	d_1/t_w	$(b_f-t_w)/2t_f$	A_g	I_x	Z_x	S_x	r_x	I_y	Z_y	S_y	r_y	~J	J_f	J_w	D	a_1	J	I_w
	kg/m	mm	mm	mm	mm	mm	mm				mm^2	10^6mm^4	10^3mm^3	10^3mm^3	mm	10^6mm^4	10^3mm^3	10^3mm^3	mm	10^3mm^4	mm^4	mm^4	mm		10^3mm^4	10^9mm^6
300WC	**294**	339	500	32	20	275	307	240	13.8	7.50	37500	791	4669	5290	145	667	2667	4028	133	11741	10922667	733333	35.1	0.067	11421	15712
600WB	**339**	624	500	32	20	560	592	240	28.0	7.50	43200	3099	9933	11040	268	667	2668	4056	124	12501	10922667	1493333	35.1	0.067	12181	58443
900WB	**386**	924	500	32	20	860	892	240	43.0	7.50	49200	7428	16078	17970	389	667	2669	4086	116	13301	10922667	2293333	35.1	0.067	12981	132725
1200WB	**427**	1184	500	32	20	1120	1152	240	56.0	7.50	54400	12961	21894	24704	488	667	2670	4112	111	13995	10922667	2986667	35.1	0.067	13674	221432
1200WB	**490**	1200	500	40	20	1120	1160	240	56.0	6.00	62400	15803	26338	29472	503	834	3336	5112	116	24427	21333333	2986667	42.5	0.050	23572	280585

Properties for Assessing Section Capacity

Grade 400																									
Designation		Yield Stress		Tensile Stress	Design Capacity of Joint	Slenderness		Effective Width			Effective Area	Form Factor	About x-axis							About y-axis						
		Flange	Web			Flange	Web	Flange	Web	Section			Flange Slenderness Ratio	Web Slenderness Ratio	Section Slenderness	Plasticity Slenderness Limit	Yield Slenderness Limit	Compactness		Flange Slenderness Ratio	Web Slenderness Ratio	Section Slenderness	Plasticity Slenderness Limit	Yield Slenderness Limit	Compactness	
		f_y	f_y	fu	Øvwj	$\lambda_{e\,(f)}$	$\lambda_{e\,(w)}$	b_{ew}	d_{ew}		A_e	k_f	$\lambda_{e\,(f)}/\lambda_{ey\,(f)}$	$\lambda_{e\,(w)}/\lambda_{ey\,(w2)}$	$\lambda_{s\,x}$	$\lambda_{sp\,x}$	$\lambda_{sy\,x}$		Z_{ex}	$\lambda_{e\,(f)}/\lambda_{ey\,(f2)}$		$\lambda_{s\,y}$	$\lambda_{sp\,y}$	$\lambda_{sy\,y}$		Z_{ey}
	kg/m	MPa	MPa	MPa	kN/mm			mm	mm	mm	mm^2								10^3mm^3							10^3mm^3
300WC	**294**	360	380	480	6.14	9.0	16.5	240	275	500	37500	1.000	0.6	0.1	9.0	8.0	14	N	5187	0.8	0.0	9.0	8.0	22	N	3906
600WB	**339**	360	380	480	6.14	9.0	33.6	240	560	500	43200	1.000	0.6	0.3	9.0	8.0	14	N	10856	1.5	0.0	9.0	8.0	22	N	3907
900WB	**386**	360	380	480	6.14	9.0	51.6	240	583	500	43667	0.888	0.6	0.4	9.0	8.0	14	N	17655	2.3	0.0	9.0	8.0	22	N	3908
1200WB	**427**	360	380	480	6.14	9.0	67.2	240	583	500	43667	0.803	0.6	0.6	9.0	8.0	14	N	24236	3.1	0.0	9.0	8.0	22	N	3909
1200WB	**490**	360	380	480	6.14	7.2	67.2	240	583	500	51667	0.828	0.5	0.6	67.2	82.0	115	C	29472	3.1	0.0	7.2	8.0	22	C	5004

Notes

i. All welds to AS/NZS 1554.1:2014 Category SP (deep penetration).
ii. Web to flange joints develop the minimum tensile strength of a 16 mm web.
iii. Flame cut surfaces not incorporated in welds have a minimum surface roughness of Class 2, as defines in Weld Australia's Technical Note 5.
iv. Compactness nomenclature: C – Compact Section, N – Non-compact Section, S – Slender Section.

Design and Detailing

Design Codes

In Australia, the design for weathering steel bridges should be undertaken in accordance with the relevant parts of Australian Standard AS 5100, especially Part 6.

However, there are a number of requirements, mostly related to detailing and suitability of environment, for weathering steel. These are outlined below.

Material Specification

BlueScope supplies REDCOR® weathering steel to the Australian Standard AS/NZS 3678, with the nominal material properties given in the table 'Properties of AS/NZS 3678 weathering steel' included on page 17.

Allowance for Loss of Thickness

Assuming that the protective rust patina is formed, even with the reduced corrosion rate, an allowance for the expected section loss over the design life of the bridge should be considered. The corrosion allowance is added to each exposed surface and this added thickness for the corrosion allowance cannot be used in the calculation of the structural capacity of the member.

The table below outlines the corresponding corrosion allowance for a bridge design life of 100 years, as specified in AS/NZS 5100.6.

Corrosion allowance

Atmospheric Corrosion Classification (ISO 9223)	Weathering Steel Environmental Classification	Corrosion Allowance (mm/exposed face)
C1, C2	Mild	1.0
C2 (within 1 km from the sea)	Medium	1.5
C3	Medium	1.5
C1, internal	Interior (Box girders)	0.5

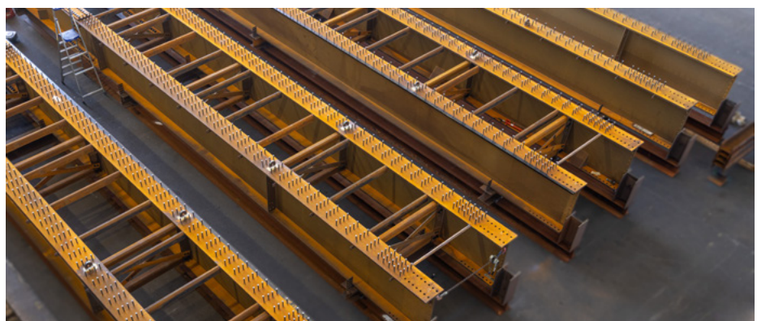
Notes:

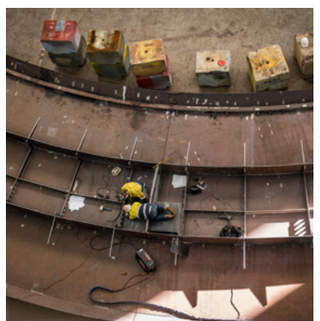
- No allowance is required for interior faces of hermetically sealed hollow sections.
- Internals of box (tub) girders supporting concrete decks should be classified as C1, unless designed to prevent water ingress.
- Allowances to apply to all fillet and partial penetration butt welds.
- Full penetration butt welds do not normally require any additional corrosion allowance, because an allowance has been applied to the parent material thickness.
- No allowance is normally made for weathering steel bolts. Refer to BlueScope Weathering Steel Design Guide for Bridges in Australia.
- Allowances apply to all other structural elements, including stiffeners and bracing etc.
- Weathering steel should not be used for ISO 9223 Classifications C4 and C5 or for certain Classification C3 sites. Refer to Weathering Steel Design Guide for the appropriateness of REDCOR® weathering steel use for bridge design in a specific Australian location.
- No corrosion allowance is required for the top flange surface in contact with concrete deck but other areas of top flange do require corrosion allowance.
- If required, additional guidance on corrosion allowance can be found in the Weathering Steel Design Guide via steel.com.au.

It should be noted that the European Convention for Constructional Steelwork (ECCS) 2021, specifically Section 2.1, Figure 2-2, indicates that in C3 environments, a lower corrosion allowance is required. This illustrates the further potential of REDCOR® weathering steel as an enduring solution for bridges in suitable environments when detailed correctly.

Fitzroy River Bridge featuring welded beams made from REDCOR® weathering steel
Kimberley, WA

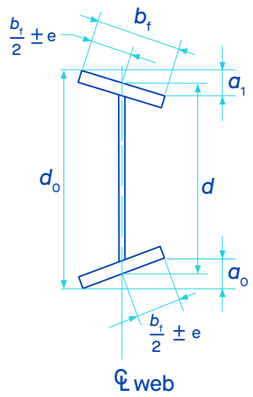
Below: Detail images from fabrication through to installation of various bridge projects across Australia





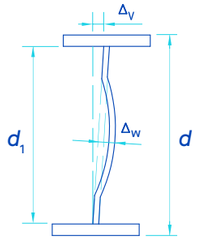
Tolerances

Dimensional Tolerances					
Designation	**Permissible variation of depth (d) mm**	**Permissible variation of flange width (b_f) mm**	**Permissible out-of-square on each flange (a_1 or a_0) mm**	**Permissible Total out-of-square (a_1+ a_0) mm**	**Permissible web off-centre (e) mm**
Beams					
1200WB	± 4.0	+6.0 to -5.0	± 5.0	± 8.0	± 5.0
900WB, 600WB, 300WB	± 3.0				



Notes
i. Dimensions d_o, d, a_1 and a_0 are measured parallel with the centreline of the web.
ii. Dimensions b_f and b_f /2 ± e are measured parallel with the plane of the flange.
iii. Dimension d is measured at the centreline of the web.
For designations of dimensional tolerances for all REDCOR® weathering steel beams refer to Appendix A

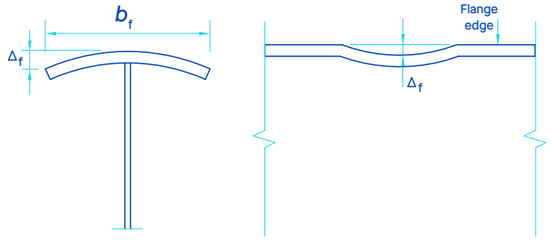
Tolerances on a Web



Tolerance on a Web		
Out of Flatness (Δ_w)	**Permissible deviation from verticality of a web (Δ_v) mm**	
d_1/150	d ≤ 900	± 3
	d > 900	± (d/300)

Straightness Tolerances	
Nominal Size	**Sweep or Camber (mm)**
Beams	Length/1000
≤ 14 m Column	Length/1000, but not more than 10 mm
> 14 m Column	10 mm + (Length – 14000/1000)

Tolerances on a Flange



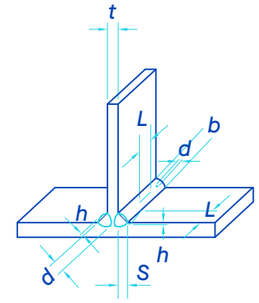
Tolerance on a Flange	
Out of Flatness (Δ_f) mm	
b_f ≤ 450	± (b_f/150)
b_f > 450	± 3

Length Tolerances		
Specified Length	**Permissible variation from specified length (mm)**	
	Under	Over
All lengths	Nil	+50

Standards referenced: AS/NZS 3679:2:2016

Weld Tolerances

L = Length or maximum dimension of individual imperfection measured parallel to axis of weld
ΣL = sum of lengths of imperfections in stated weld length
h = height (depth) of imperfection
t = thickness of (thinner) parent material
b = width of weld face
d = size of pore
S = size of fillet weld



Imperfection (see Note 1)			Maximum allowable dimension or number of imperfections
Type	**Parameter**	**Symbol**	**SP**
Cracks	Length	*L*	No cracks allowed
	Cumulative length	*ΣL*	No cracks allowed
Lack of fusion or incomplete penetration	Length	*L*	Where located more than 3*t* from end of weld, 2*t*/3 but not more than 20 mm.
	Cumulative length	*ΣL*	Where located within 3*t* of end of weld, 3 mm *t* in 6*t* length but proportionally less for shorter length
Undercut-continuous (see Note 2)	Depth	*h*	*t*/20 but not more than 1 mm
Undercut-intermittent (see Note 2)	Depth	*h*	*t*/10 but not more than 1.5 mm
Shrinkage grooves Root concavity	–	–	As for undercut
Overlap (see Note 3)	Length	*L*	*t*, but not more than 10 mm
	Cumulative length	*ΣL*	30 mm in 300 mm but proportionally less for shorter lengths
Toe shape, other than above	–	–	Suitable to permit required in NDE report
Surface pores (see Note 3)	Size of pore	*d*	*t*/3, but not more than 5 mm
	No. of pores	–	2 per 12*t* length
Loss of cross-sectional area (see Note 2)	Loss of area	–	≤ 5%
Reinforcement	Height	*h*	For *S* ≤ 12 mm, 2 mm
Undersize-intermittent (see Note 6)	Leg length	–	*S*/10, but not more than 3 mm

Standards referenced: AS/NZS 1554.1:2014

Notes
1. For adjacent imperfections, see Clause 6.2.3 of AS/NZS 1554.1:2014.
2. Undercut less than 0.5 mm in depth should be disregarded.
3. Where these allowances for overlap and surface pores are detrimental to any surface treatment, they may not be acceptable.
4. For a welding procedure qualification, the assessment of the test piece for compliance with the permissible levels of imperfections should be done with the aid of the macro test specimen. For calculation of the loss of cross-sectional area, internal imperfections are estimated from the macro test specimen.
5. For the calculation of the loss of cross-sectional area, all relevant surface imperfections shall be included. Where lack of root fusion is evident, the inspector is required to assess the approximate depth of the imperfection. The macro test specimen from the welding procedure qualification may need examination for this purpose.
6. The cumulative length of intermittent undersize fillet welds shall not exceed 10% of the length of the weld.

Pre Camber

Pre camber sections are available by enquiry in 5 mm increments from 20 mm up to the maximums listed below. Pre camber is achieved by cutting the required camber into the web prior to welding and eliminates the potential for increased stresses as a result of cambering post the welding process. The tolerances achieved are ±10 mm.

Section	Maximum Camber (mm)	
	12 – 15 m	15.1 – 18 m
300WC295	50	60
600WB340	50	60
900WB387	50	60
1200WB428	30	40
1200WB490	30	40

Bidgee Bidgee Bridge featuring
REDCOR® weathering steel
Rosehill, NSW

Plate Properties

Welded Sections – Base Plate Properties

Welded Sections manufactured to AS/NZS 3679.2:2016 are required to use base plates manufactured to the AS/NZS 3678:2016 standard. Following are the properties of the base plate grades.

Structural Steel – Welded Sections – Standard: AS/NZS 3679.2

Chemical Composition - Welded Sections Base Plate

Cast or Product Analysis, Percent													
Grade (see Note 1)	**C**	**Si**	**Mn**	**P**	**S**	**Cr** (see Note 2)	**Ni** (see Note 2)	**Cu** (see Note 2)	**Mo** (see Note 2)	**Al** (see Note 3)	**Ti**	**Micro-alloying Elements**	**CE** (see Note 4)
AS/NZS 3678	Max.		Max.	Max.	Max.		Max.		Max.	Max.	Max.	Max.	
WR350L20B MOD 400	0.14	0.15-0.75	1.70	0.16	0.030	0.35-1.05	0.55	0.15-0.50	0.10	0.10	0.040	(see Note 5)	

Notes

1. The use of sulphide modification steelmaking techniques for listed grades is permitted.
2. Cr + Ni + Cu + Mo = 1% maximum apply.
3. Limits specified are for both acid soluble and total aluminium.
4. Carbon equivalent (CE) is calculated from the equation based on actual cast or product analysis.
   $CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$
   CE = no specified limit
5. Vanadium: 0.10% maximum. Niobium: 0.06% maximum. Niobium plus vanadium plus titanium: 0.15% maximum.
6. For AS/NZS 3678 WR350Z35L20B MOD 400, has a sulfur maximum of 0.005%.

Strength and toughness properties

Steel Grade[1]	Thickness of Material(t) (mm)	Minimum Yield Stress (MPa)	Minimum Tensile Strength (MPa)	Charpy Impact Toughness[2]
WR350L20B MOD 400	10 to 12	400	480	27 Joules @ -20°C
	12 to 20	380		
	20 to 40	360		

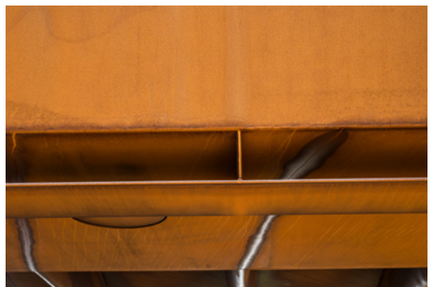
Notes:

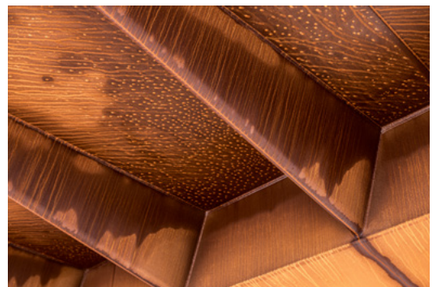
1. The Australian steel grade designations mean:
   WR: represents "weather-resistant" (i.e. improved atmospheric corrosion resistance or weathering steel).
   – MOD400: represents the Nominal Yield Strength in MPa.
   – L20: relates to the impact test temperature (-20°C).
2. Using Charpy 2mm V-notch impact test specimens.

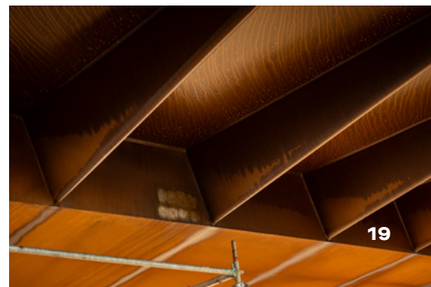
Through-thickness Tensile Properties (z-test)

Steel Grade[1]	Thickness of material (mm)	Minimum Reduction of Area (%)
WR350Z35L20B	15.95<t≤40	35

Causeway pedestrian and cyclist bridges
Heirisson Island, Perth







BlueScope

For further information call 1800 024 402 or visit steel.com.au

Australian Standards referenced in this Product Brochure:
AS/NZS 1554.1:2014 – Structural steel welding
AS/NZS 3678:2016 – Structural steel – Hot-rolled plates, floorplates and slabs
AS/NZS 3679.2:2016 – Structural steel – Welded I sections
ISO 9001:2015 – Quality management systems – Requirements

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