REINFORCEMENT

Manufacture, Processing, Quality & Welding

Scott Munter
Executive Director, SRIA

Eric Lume
National Engineer, SRIA

SRIA promotes Good Design & Detailing

Detailing must allow fabrication

Detailing of reinforcement is the interface between the actual design of the concrete structure and what is to be constructed

Sufficient details must be shown on drawings

Designers must be aware of the practical limitations of construction

Prefabricated column cage

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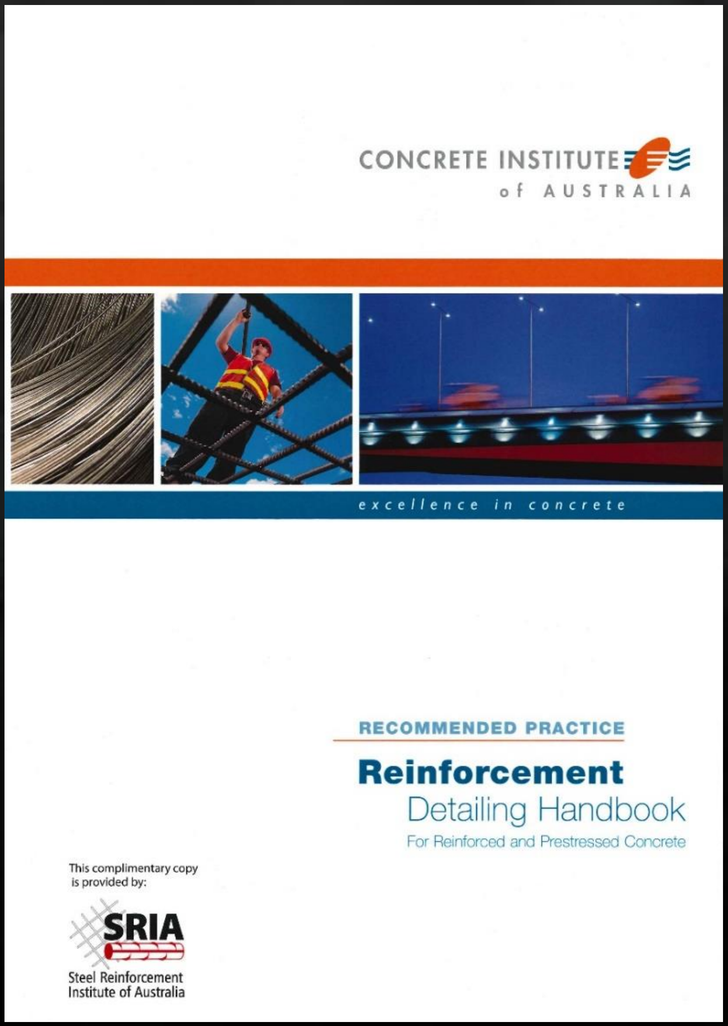
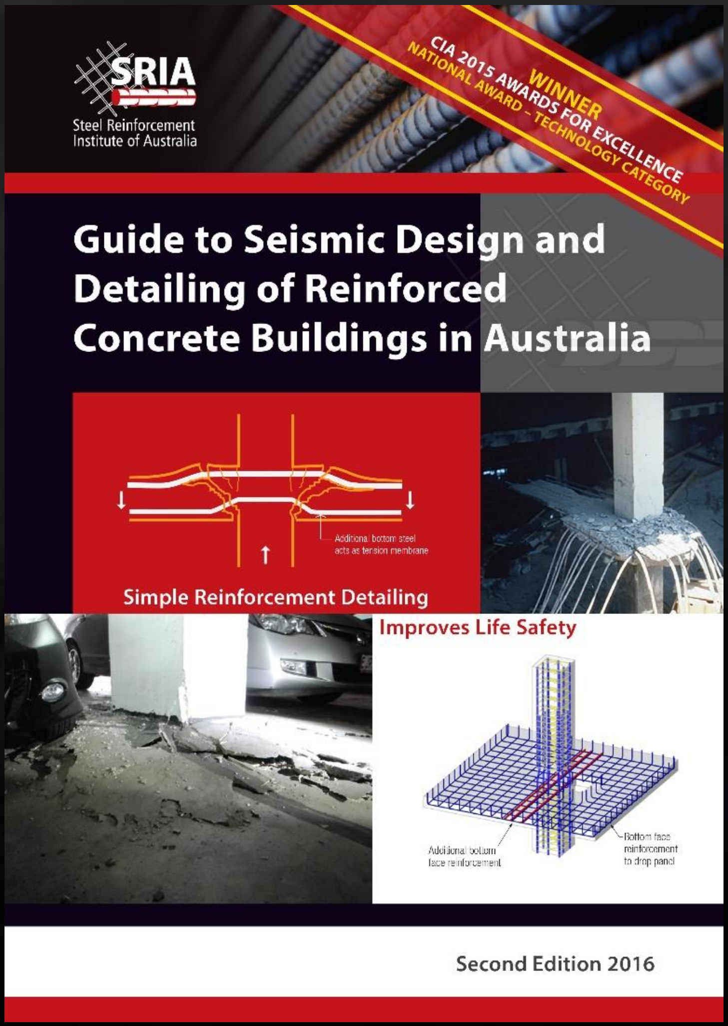
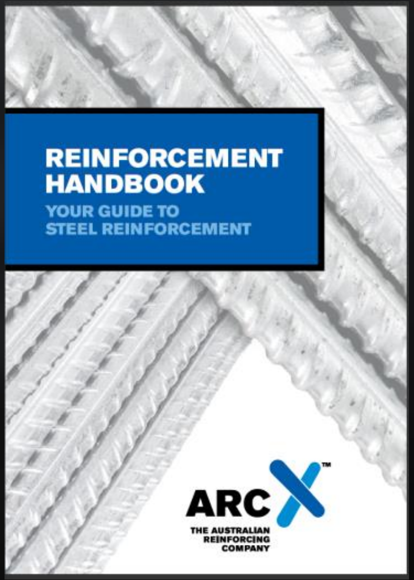
SRIA promotes Good Design & Detailing







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Institute of Australia

Web Site: sria.com.au Technical Notes

Surface Condition of Reinforcement

Unacceptable?

Unacceptable

Severely corroded and pitted steel should not be used unless the material has been checked for strength and cross-sectional area limitations (TN1).

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Development and Lap Splice Lengths

New SRIA Technical Note TN7

Note: Basic Tables contained in Detailing Handbook

Steel Reinforcement Institute of Australia

Development and Lap Splice Lengths

New design rules in AS 3600 – Section 13 Tensile development length

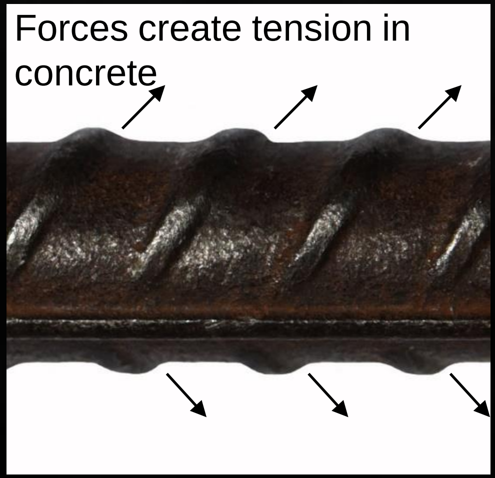
Basic $$L_{\mathrm{sy.tb}} = \frac{0.5 k_1 k_3 f_{\mathrm{sy}} d_{\mathrm{b}}}{k_2 \sqrt{f_{\mathrm{c}}'}} \geq 0.058 f_{\mathrm{sy}} k_1 d_{\mathrm{b}} \qquad (f_{\mathrm{c}}' \leq 65 \text{ MPa})$$

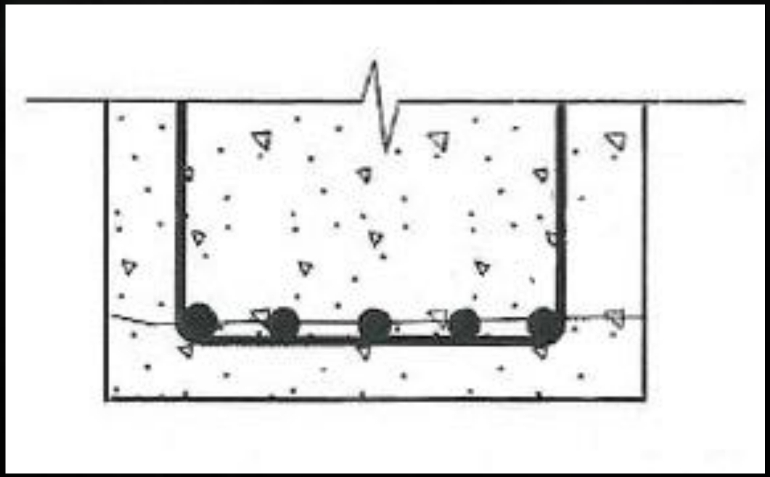
$\times 1.5$ for epoxy - coated bars

$\times 1.3$ for lightweight concrete

Importance of k_1 (bar location), k_2 (bar size) and k_3 (bar spacing)

Anchorage forces create tension in concrete – which can result in splitting





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Development and Lap Splice Lengths

New design rules in AS 3600 – Section 13 Tensile development length

Basic

$$L_{\mathrm{sy.tb}} = \frac{0.5 k_1 k_3 f_{\mathrm{sy}} d_{\mathrm{b}}}{k_2 \sqrt{f'_{\mathrm{c}}}} \geq 0.058 f_{\mathrm{sy}} k_1 d_{\mathrm{b}}$$

$\times 1.5$ for epoxy - coated bars

$\times 1.3$ for lightweight concrete

Refined

$$L_{\mathrm{sy.t}} = k_4 k_5 L_{\mathrm{sy.tb}}$$

When calculating $L_{\mathrm{sy.t}}$, minimum $0.058 f_{\mathrm{sy}} k_1 d_{\mathrm{b}}$ does not apply to $L_{\mathrm{sy.tb}}$

Tensile lap length (basic or refined) $L_{\mathrm{sy.t.lap}} = k_7 L_{\mathrm{sy.t}} \geq 0.058 f_{\mathrm{sy}} k_1 d_{\mathrm{b}}$

Clause 13.1.2.1 of AS 3600

$L_{\mathrm{sy.t}}$ shall be calculated from either:

Clause 13.1.2.2 (basic) - $L_{\mathrm{sy.tb}}$, or

Clause 13.1.2.3 (refined) - $L_{\mathrm{sy.t}}$

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Development and Lap Splice Lengths

Technical Note 7 – Example of General Design Tables

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TECHNICAL NOTE 7

STRESS DEVELOPMENT AND LAP SPLICING OF STRAIGHT D500N TENSILE REINFORCING BARS TO AS 3600-2009

December 2016

TECHNICAL NOTE 7

TABLE G/20/1.0/1.00 – Tensile Development and Lap Lengths | f'_c=20 MPa, k_1=1.0, k_7=1.00 {Eq. 1c: ξ_{cd}=1.0, ξ_{bc}=1.0}

	N10	N12	N16	N20	N24	N28	N32	N36	N40
c_d	BASIC DEVELOPMENT LENGTH (mm) $L_{sy.tb}$								
20	390	500	740	1000	-	-	-	-	-
25	360	470	710	960	1230	-	-	-	-
30	320	430	670	920	1200	1490	-	-	-
35	"	400	630	890	1160	1450	1760	-	-
40	"	390	600	850	1120	1410	1720	2060	2430
45	"	"	560	810	1080	1370	1680	2020	2380
50	"	"	540	770	1040	1330	1640	1970	2340
55	"	"	"	740	1000	1290	1600	1930	2290
60	"	"	"	700	960	1250	1550	1890	2250
65	"	"	"	"	920	1210	1510	1840	2200
70	"	"	"	"	890	1170	1470	1800	2160
75	"	"	"	"	870	1130	1430	1760	2110
80	"	"	"	"	"	1090	1390	1710	2070
85	"	"	"	"	"	1050	1340	1670	2020
90	"	"	"	"	"	"	1300	1620	1970
95	"	"	"	"	"	"	1260	1580	1930
100	"	"	"	"	"	"	1250	1540	1880

	N10	N12	N16	N20	N24	N28	N32	N36	N40
c_d	MINIMUN REFINED DEVELOPMENT LENGTH (mm) $L_{sy.t.min}$								
20	320	390	540	700	-	-	-	-	-
25	320	390	540	700	870	-	-	-	-
30	320	390	540	700	870	1050	-	-	-
35	"	390	540	700	870	1050	1250	-	-
40	"	390	540	700	870	1050	1250	1470	1700
45	"	"	540	700	870	1050	1250	1470	1700
50	"	"	540	700	870	1050	1250	1470	1700
55	"	"	"	700	870	1050	1250	1470	1700
60	"	"	"	700	870	1050	1250	1470	1700
65	"	"	"	"	870	1050	1250	1470	1700
70	"	"	"	"	870	1050	1250	1470	1700
75	"	"	"	"	870	1050	1250	1470	1700
80	"	"	"	"	"	1050	1250	1470	1700
85	"	"	"	"	"	1050	1250	1470	1700
90	"	"	"	"	"	"	1250	1470	1700
95	"	"	"	"	"	"	1250	1470	1700
100	"	"	"	"	"	"	1250	1470	1700

	N10	N12	N16	N20	N24	N28	N32	N36	N40
c_d	BASIC LAP LENGTH (mm) $L_{sy.tb.lap}$								
20	390	500	740	1000	-	-	-	-	-
25	360	470	710	960	1230	-	-	-	-
30	320	430	670	920	1200	1490	-	-	-
35	"	400	630	890	1160	1450	1760	-	-
40	"	390	600	850	1120	1410	1720	2060	2430
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	N10	N12	N16	N20	N24	N28	N32	N36	N40
c_d	MINIMUN REFINED LAP LENGTH (mm) $L_{sy.t.lap.min}$								
20	320	390	540	700	-	-	-	-	-
25	320	390	540	700	870	-	-	-	-
30	320	390	540	700	870	1050	-	-	-
35	"	390	540	700	870	1050	1250	-	-
40	"	390	540	700	870	1050	1250	1470	1700
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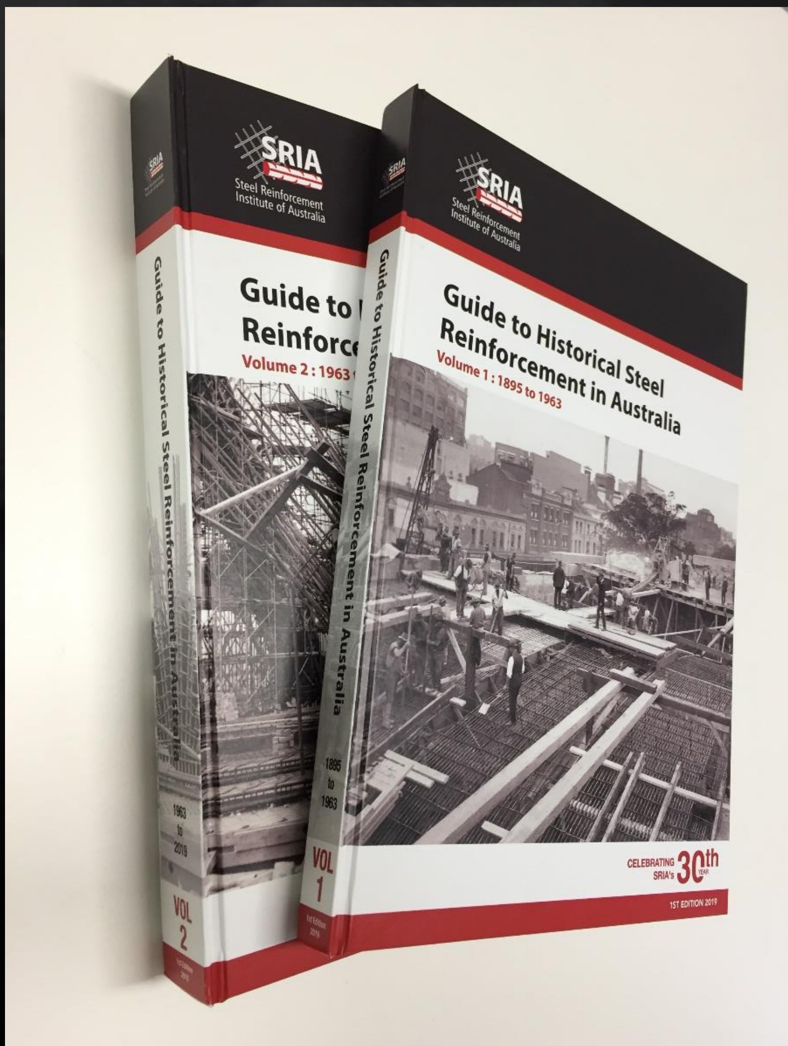
95	"	"	"	"	"	"	1250	1470	1700
100	"	"	"	"	"	"	1250	1470	1700

Note: The tabulated theoretical values of minimum refined development length, $L_{sy.t.min.}$, and minimum refined lap length, $L_{sy.t.lap.min.}$, are minimum possible solutions, based on the values of $(k_4k_5)_{min}$ in Table B.2. They are useful for indicating the lowest possible values achievable using refined design, but may not be appropriate for a particular design situation. Therefore, if they are less than basic development length, $L_{sy.tb}$, or basic lap length, $L_{sy.tb.lap}$, respectively, then refined design may be beneficial, but a designer must calculate the actual values of $L_{sy.t}$ ($\geq L_{sy.t.min.}$) and/or $L_{sy.t.lap}$ ($\geq L_{sy.t.lap.min.}$).

Guide to Historical Steel Reinforcement in Australia



Available to order from sria.com.au home page

Written to address the volume of technical enquiries in this area

Covers reinforcement dating back to 1895

Steel Reinforcement Institute of Australia

Past Reinforcement Types

Divided into Chapters based on Industry Developments

Plain round or square
circa 1895 to 1957
200 MPa

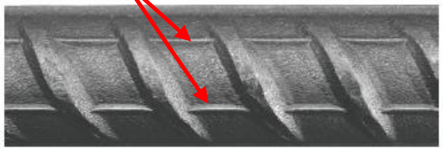
Square twisted 1957
410 MPa

Twisted deformed 1963
CW.60 – 410 MPa

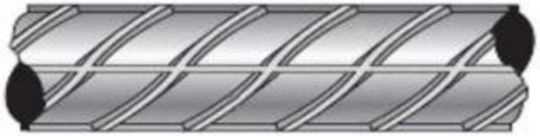
Hot-rolled deformed (QST) 1983
410 MPa

Microalloy (MA) 1983
410 MPa

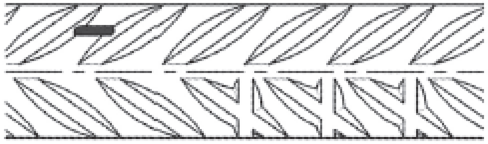
2 half ribs



Hot-rolled deformed (QST) 2001
500 MPa (D500N Bar)



Microalloy D500N 2001



Contistretch D500N 2001

Guide to Historical Steel Reinforcement in Australia

Chapters include:

- Reinforcement properties and developments
- Standards
- Industry Resources
- Concrete Design
- Background to Period
- Symbols Used
- Examples of Drawings
- Project examples

Table A.2 - Suggested Reinforcement Yield Strengths

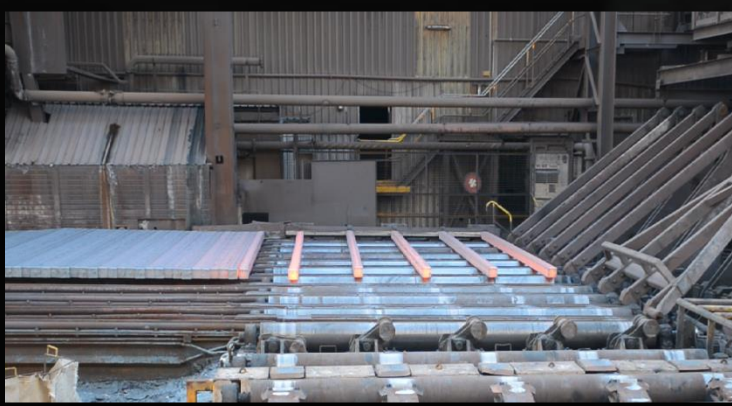
Before 1895	International developments before first use of reinforced concrete in Australia.
1895 to 1920	**Bars:** If the proprietary system cannot be established, use 200 MPa unless samples tested. **Fabric:** Assume 380 MPa.
1920 to 1957	**Bars:** Locally manufactured Hot-rolled plain steel bars or for proprietary systems that cannot be identified, assume 200 MPa unless samples tested. **Fabric:** Assume 380 MPa.
1957 to 1963	**Bars:** Square Twisted, 410 MPa; Hot-rolled plain or deformed, use 200 MPa unless samples tested. If identifiable, intermediate grade, 275 MPa and hard grade, 345 MPa. **Fabric:** Pre 1958, assume 380 MPa and Post 1958, assume 450 MPa.
1963 to 1983	**Bars:** Square Twisted or CW.60, 410 MPa; Hot-rolled plain or deformed, Pre 1965, use 200 MPa and Post 1965, use 230 MPa unless samples tested. If identifiable, intermediate grade, Pre 1965, use 275 MPa and hard grade, Pre 1973, use 345 MPa. **Fabric:** Assume 450 MPa.
1983 to 2001	**Bars:** Hot-rolled plain round or deformed bars Pre 1988, use 230 MPa and Post 1988, use 250 MPa. If deformed high-strength bars are identifiable by the rib pattern, use 410 MPa (1983 to 1988) then 400 MPa (1988 to 2001). **Fabric:** Pre 1995, assume 450 MPa and Post 1995, assume 500 MPa.
2001 to 2019	**Bars:** Hot-rolled plain round or deformed bars, use 250 MPa. If deformed high-strength bars are identifiable by the rib pattern, use either 400 MPa or 500 MPa. Note: At the beginning of the period as AS 3600 (2001) included both Grade 400 and 500 bars, it is essential to determine which Grade of bar was used from the design drawings. **Mesh:** Assume 500 MPa.

Manufacturing of Reinforcement - Billets

Reinforcement made from recycled metal

Scrap melted in EAF

Billet casting
150 x 150 mm in size



Billets allowed to cool slowly
Steel strength 250 to 300 MPa

Stacked in yard

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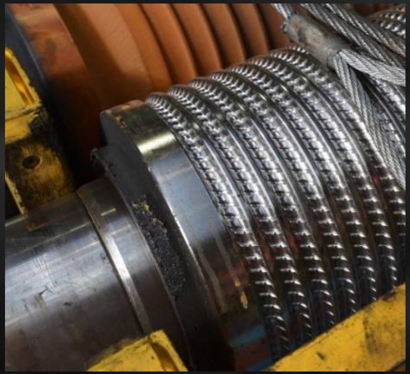
Manufacturing of Reinforcement - Bars

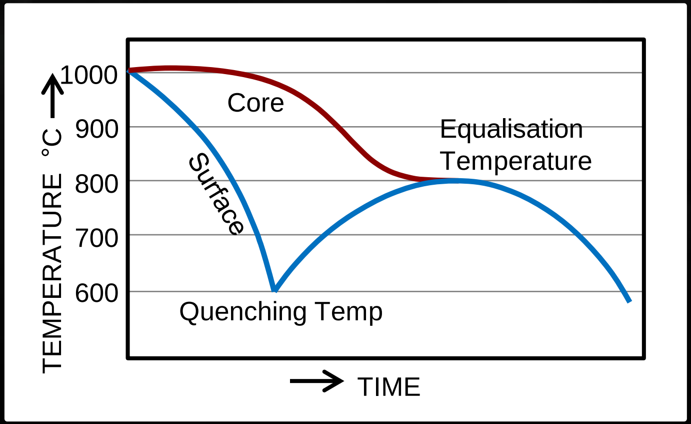
Straight Quenched and Self Tempered (QST) D500N (12 to 40 mm)

Rolling to size



Hot rolling ribbed profile

Quenching process



Schematic diagram on a Time – Temperature Curve

Self-tempering in cooling beds

Microstructure of QST Reinforcing Bars

Coiled Reinforcement

Allows several kilometres of bar in continuous length

10, 12 mm, 16 mm and 20 mm sizes available

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Manufacturing Smooth Rod

Hot rolling rod mill – turning billets into smooth rod (R250N)

‘Wild’ coils of smooth rod 5.5 to 16 mm

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Cold rolled deformed bar

Produce ribbed bar from smooth round rod

Increases yield stress to 500MPa

Coil ribbed bar

Mini cassette roller to deform smooth rod into ribbed bar

Coils of smooth rod

Ribbed bar used for mesh and fitments

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Mesh Processing

Bars resistance welded into sheets of mesh

Typical mesh-making machine

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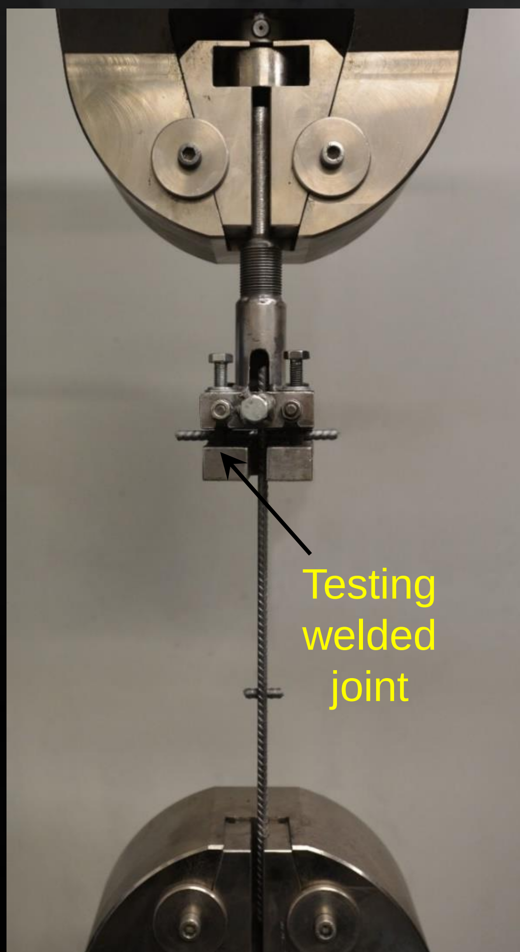
Mesh Processing

Quality of welding and adequate lap are critical

- Each welded joint develops 50% of the bar's yield stress



- Overlap mesh sheets a minimum of 2 cross bars

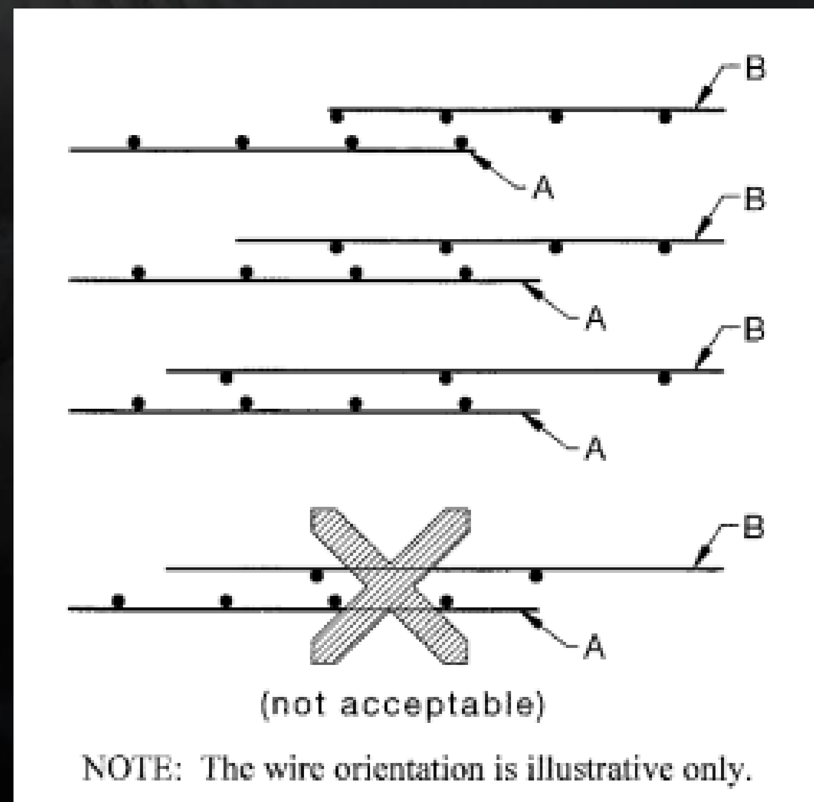


Figure 5.1 from AS 2870

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Reinforcing Bar Classification

All reinforcing bar to comply with AS/NZS 4671 Steel reinforcing materials

AS/NZS 4671 Designation	Yield Stress, R_e MPa	Ductility Class	Description	Typical Size mm
D500N	500	N	Hot-rolled Deformed bar	Coil 10, 12, 16, 20 Straight 12 – 40 Special 50
R250N	250	N	Hot-rolled Plain round	6.5, 10, 12, 16, 20, 24
D250N	250	N	Hot-rolled Deformed bar	12 (pool steel)
D500L	500	L	Cold-rolled Deformed bar	5 - 12
R500L	500	L	Cold-drawn Round rod	5 - 12

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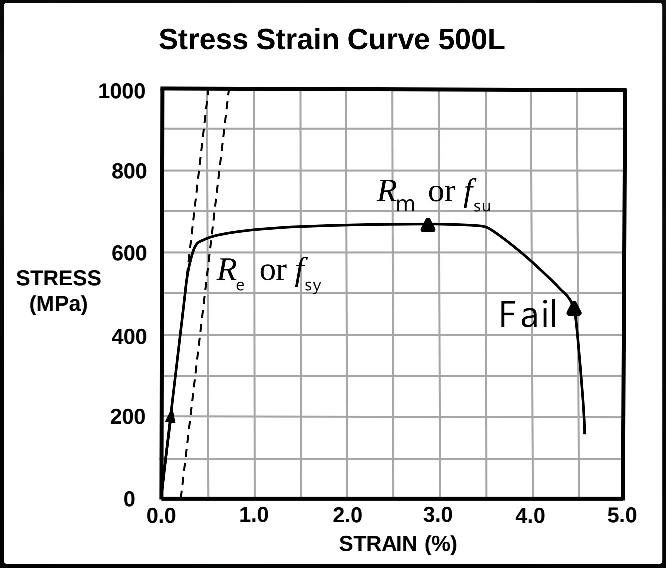
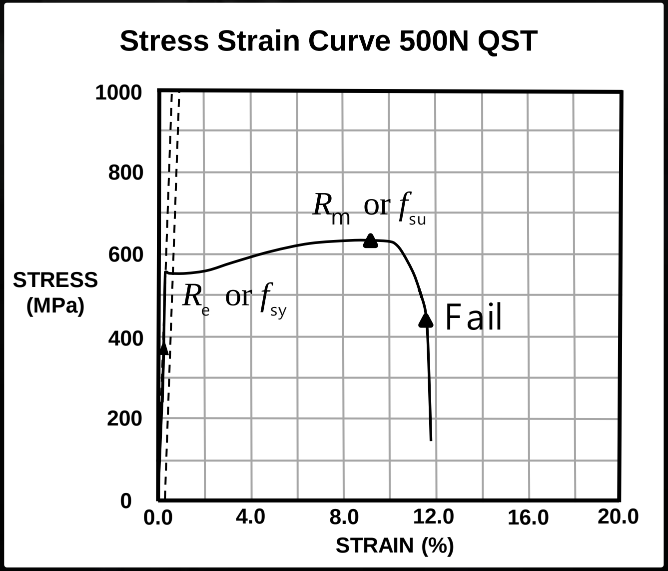
Mechanical Properties (from AS/NZS 4671)

Property	500L	500N	Probability of exceedance
Nominal Diameter (mm)	5 to 12	10 to 40	-
Characteristic Yield Stress (MPa), $R_{ek.L}$ $R_{ek.U}$	500 750	500 650	95% 5%
Ratio: $\dfrac{\text{Tensile Stress}}{\text{Yield Stress}} = \dfrac{R_m}{R_e}$	≥ 1.03	≥ 1.08	90%
Uniform Elongation, A_{gt} (%)	≥ 1.5	≥ 5	90%





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Mechanical Properties

AS/NZS 4671:2019 Steel for the reinforcement of concrete

Property	600N	750N	Probability of exceedance
Characteristic Yield Stress (MPa), $R_{ek.L}$ $R_{ek.U}$	600 750	750 900	95% 5%
Ratio: $\dfrac{\text{Tensile Stress}}{\text{Yield Stress}} = \dfrac{R_m}{R_e}$	≥ 1.08	≥ 1.04	90%
Uniform Elongation, A_{gt} (%)	≥ 5.0	≥ 4.0	90%

Non-standard Grades

Shall meet the ratio and uniform elongation requirements of the nearest lower grade for the applicable ductility class (Cl 7.2.1 of AS/NZS 4671)

AS/NZS 4671:2019 – Remains 'stand alone' document

Aligned with international standards where possible but as differences exist (eg earthquakes steels) published as AS/NZS 4671.

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Limitations of AS 3600:2018

Clause 1.1.2 Application

This Standard applies to structures and members in which the materials conform to the following:

d) Higher reinforcing steel grades > 500 MPa to 800 MPa meeting the requirements of Table 3.2.1. For ultimate limit states the strength of the reinforcement in design models shall not be taken as greater than 600 MPa unless noted otherwise.

Note that for columns, in Clause 10.7.3.3 of AS 3600:2018:

The yield stress of the reinforcement used as fitments can be as high as 800 MPa.

- 800 MPa steel has been in AS 3600 since 2009

Chemical Composition

Type of analysis	Chemical Composition (%) Max					
	All Steel Grades			Carbon Equivalence Value for Class		
	C	P	S			
				500L	500N	500E
Cast analysis	0.22	0.050	0.050	0.39	0.44	0.49
Product analysis	0.24	0.055	0.055	0.41	0.46	0.51
				600N		750N
Cast analysis	0.33	0.050	0.050	0.49		0.49
Product analysis	0.35	0.055	0.055	0.51		0.51

Carbon Equivalence:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

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Correct Chemistry allows Welding to AS 1554.3

Ensuring Quality Reinforcement

Third Party/Independent Certification - ACRS or Equivalent

ACRS Mill Certificate Example

Required by processors as proof that quality reinforcement supplied by mill


VALID TO 31 DEC
2020

PRODUCT CERTIFICATION
www.steelcertification.com

Australasian Certification Authority for Reinforcing and Structural Steels Ltd
Certificate of Product Performance

Certificate Number: 31102

InfraBuild

INFRABUILD STEEL
LAVERTON, VIC, AUSTRALIA

has satisfied the Authority that it complies with the rules of the ACRS Product Certification Scheme, and the relevant ACRS Quality and Operations Assessment Procedures. Where appropriate, and as listed below, it has further satisfied the Authority that it manufactures and/or supplies products that conform with the standards listed below, and is entitled to use the ACRS mark in relation to the products listed on this certificate.

Scope of Certification

Reinforcing Bar Manufactured to AS/NZS 4671:2001

Bar approved under this certificate remains ACRS certified after processing only if cut, or bent, or welded by an ACRS certified processor. For processed bar approval, please refer to the bar processor's ACRS certificate

Full details of the products for which certification has been achieved should be viewed at: *www.steelcertification.com*

By authority of ACRS Board: *Philip Sanders, Executive Director*

Valid until: 31 December 2020

First certified: November 2003

JAS-ANZ
www.jas-anz.org/register

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View original at www.steelcertification.com

1 of 2

AUSTRALASIAN CERTIFICATION AUTHORITY FOR REINFORCING AND STRUCTURAL STEELS LTD | ABN: 40 096 692 545


VALID TO 31 DEC
2020

PRODUCT CERTIFICATION
www.steelcertification.com

Australasian Certification Authority for Reinforcing and Structural Steels Ltd
Products assessed by ACRS to AS/NZS 4671:2001

To be read in conjunction with Certificate Number: 31102

InfraBuild

INFRABUILD STEEL
LAVERTON, VIC, AUSTRALIA

has satisfied the Authority that it complies with the relevant ACRS Quality and Operations Assessment Procedures. Where appropriate, and as listed below, it manufactures products as indicated by "✓", below and is entitled to use the ACRS mark with these products.

Products manufactured :

AS/NZS 4671 Grade 500N Ribbed Bar

Bar	12, 16 mm	✓
	20, 24, 28 mm	✓
	32, 36, 40, 50 mm	✓

AS/NZS 4671 Grade 500E Microalloyed Ribbed Bar

Bar	12, 16 mm	✓
	20, 25 mm	✓
	32 mm	✓

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Ensuring Quality Reinforcement

Third Party/Independent Certification - ACRS or Equivalent

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Required by processors as proof that quality reinforcement supplied by mill

VALID TO 31 DEC
2020

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INFRABUILD STEEL
LAVERTON, VIC, AUSTRALIA

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Scope of Certification

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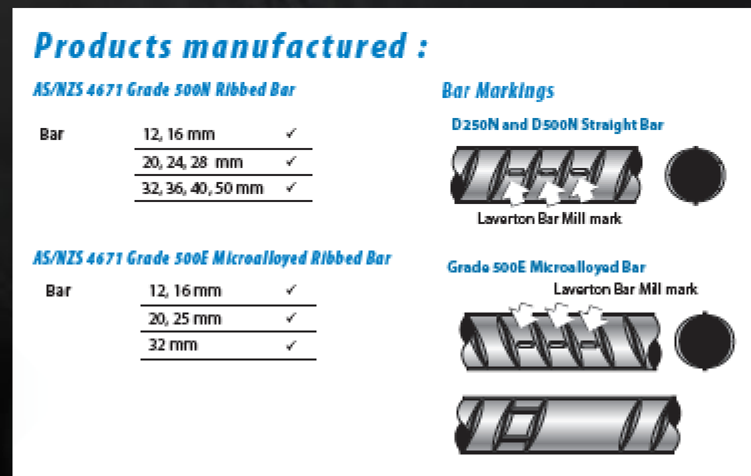

Reinforcing Bar Manufactured to AS/NZS 4671:2001
Bar approved under this certificate remains ACRS certified after processing only if cut, or bent, or welded by an ACRS certified processor. For processed bar approval, please refer to the bar processor's ACRS certificate.

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Ensuring Quality Reinforcement

ACRS Processor Certificate Example

Required by purchasers to prove quality reinforcement delivered to site


VALID TO 31 DEC
2020

ACRS
PRODUCT CERTIFICATION
www.steelcertification.com

Australasian Certification Authority for Reinforcing and Structural Steels Ltd
Certificate of Product Performance

Certificate Number: 811021

AUSREO

AUSREO
WETHERILL PARK, NSW, AUSTRALIA

has satisfied the Authority that it complies with the rules of the ACRS Product Certification Scheme, and the relevant ACRS Quality and Operations Assessment Procedures. Where appropriate, and as listed below, it has further satisfied the Authority that it manufactures and/or supplies products that conform with the standards listed below, and is entitled to use the ACRS mark in relation to the products listed on this certificate.

Scope of Certification

Processing and distribution of carbon steel bars and welded mesh in accordance with AS/NZS 4671, plus the requirements of the "material and construction requirements for reinforcing steel" clauses of AS 3600 Concrete structures and AS 5100.5 Bridge design – Concrete, or the "Reinforcement" clauses of NZS 3109 Concrete Construction

Processed steel reinforcing bar, wire and mesh supplied under this certificate is ACRS certified only if the material is within the scope of certification of the ACRS certified manufacturer. For bar, coil, wire and mesh approval please refer to the manufacturer's ACRS certificates.

Full details of the products for which certification has been achieved should be viewed at: *www.steelcertification.com*

By authority of ACRS Board: *Philip Sanders, Executive Director*

Valid until: 31 December 2020

First certified: November 2008

JAS-ANZ
www.jas-anz.org/register

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View original at www.steelcertification.com

Processing and distribution of carbon steel bars and welded mesh in accordance with AS/NZS 4671, plus the requirements of the "material and construction requirements for reinforcing steel" clauses of AS 3600 Concrete structures and AS 5100.5 Bridge design – Concrete, or the "Reinforcement" clauses of NZS 3109 Concrete Construction

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Steel Reinforcement Institute of Australia

Ensuring Quality Reinforcement

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VALID TO 31 DEC

2020

ACRS

PRODUCT CERTIFICATION

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Australasian Certification Authority for Reinforcing and Structural Steels Ltd

Certificate of Product Performance

Certificate Number: 81102

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has satisfied the Authority that it complies with the rules of the ACRS Product Certification Scheme, and the relevant ACRS Quality and Operations Assessment Procedures. Where appropriate, and as listed below, it has further satisfied the Authority that it manufactures and/or supplies products that conform with the standards listed below, and is entitled to use the ACRS mark in relation to the products listed on this certificate.

Scope of Certification

Reinforcing Mesh Manufacture to AS/NZS 4671:2001

Mesh approved under this certificate is certified only if manufactured from ACRS approved wire. For approval of wire, please refer to the wire manufacturer's ACRS certificate.

Full details of the products for which certification has been achieved should be viewed at: www.steelcertification.com

By authority of ACRS Board: Philip Sanders, Executive Director

Valid until: 31 December 2020

First certified: November 2008

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VALID TO 31 DEC

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Australasian Certification Authority for Reinforcing and Structural Steels Ltd

Products assessed by ACRS to AS/NZS 4671:2001

To be read in conjunction with
Certificate Number: 81102

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has satisfied the Authority that it complies with the relevant ACRS Quality and Operations Assessment Procedures. Where appropriate, and as listed below, it manufactures products as indicated by "✓", below and is entitled to use the ACRS mark with these products.

Products manufactured :

AS/NZS 4671 Grade 500L Mesh		
Square Mesh	SL62	✓
	SL72	✓
	SL81	✓
	SL82	✓
	SL92	✓
	SL102	✓
Rectangular Mesh	RL718	✓
	RL818	✓
	RL918	✓

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Ensuring Quality Reinforcement

Need for an ACRS or equivalent certificate?

Every project should specify one and obtain to guarantee quality

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SRIA Quality Campaign

A Processor Certificate should be obtained for every project

QUALITY GUARANTEED

SRIA supports 3rd Party Certification to guarantee processed reinforcing steel quality.

This means an independent, JAS-ANZ, accredited organisation has assessed the conformance of a members' processed bar and welded mesh and certified that it meets Australian Standards. The certificate verifies that the processed bar and mesh supplied on your project conforms to AS/NZS 4671 – Steel reinforcing materials, and complies with AS 3600 – Concrete structures, AS 5100.5 – Bridge design – Concrete, and AS 2870 – Residential slabs and footings.

WHEN YOUR REO IS SUPPLIED BY AN SRIA PROCESSOR MEMBER

SRIA Steel Reinforcement Institute of Australia

NON-CONFORMING PRODUCTS ENDANGER AUSTRALIA'S BUILDING INDUSTRY
DON'T PUT YOURSELF AT RISK

Understand the severity of the problem

Professor Shergold and Ms Weir made 24 recommendations to the Building Minister's Forum in their report, '**Building Confidence** – *Improving the effectiveness of compliance and enforcement systems for the building and construction industry across Australia*'.

RECOMMENDATION 21: BUILDING PRODUCT SAFETY

That the Building Ministers' Forum agrees its position on the establishment of a compulsory product certification system for high-risk building products.

Gain confidence that your building products conform

The Procurement of Construction Products – A Guide to achieving compliance, written by the Australasian Procurement and Construction Council, will assist in your understanding and procurement of high-risk building products, including why 3rd party product certification should come from a JAS-ANZ accredited organisation.

Download the reports at: www.sria.com.au/industry-reports.html

Ask your SRIA Member for their JAS-ANZ accredited 3rd Party Processor Certification. This is your guarantee of product conformance.

activesteel · ARCX · AUSREO · BESTBAR · BIANCO REINFORCING · LIBERTY · MB Mesh & Bar Pty Ltd. · NEUMANN STEEL · VICMESH* · WIRE INDUSTRIES

* VicMesh application for 3rd party certification pending

And make sure it covers processed steel reinforcement because steel mill certification does not certify all processed bar and welded mesh.

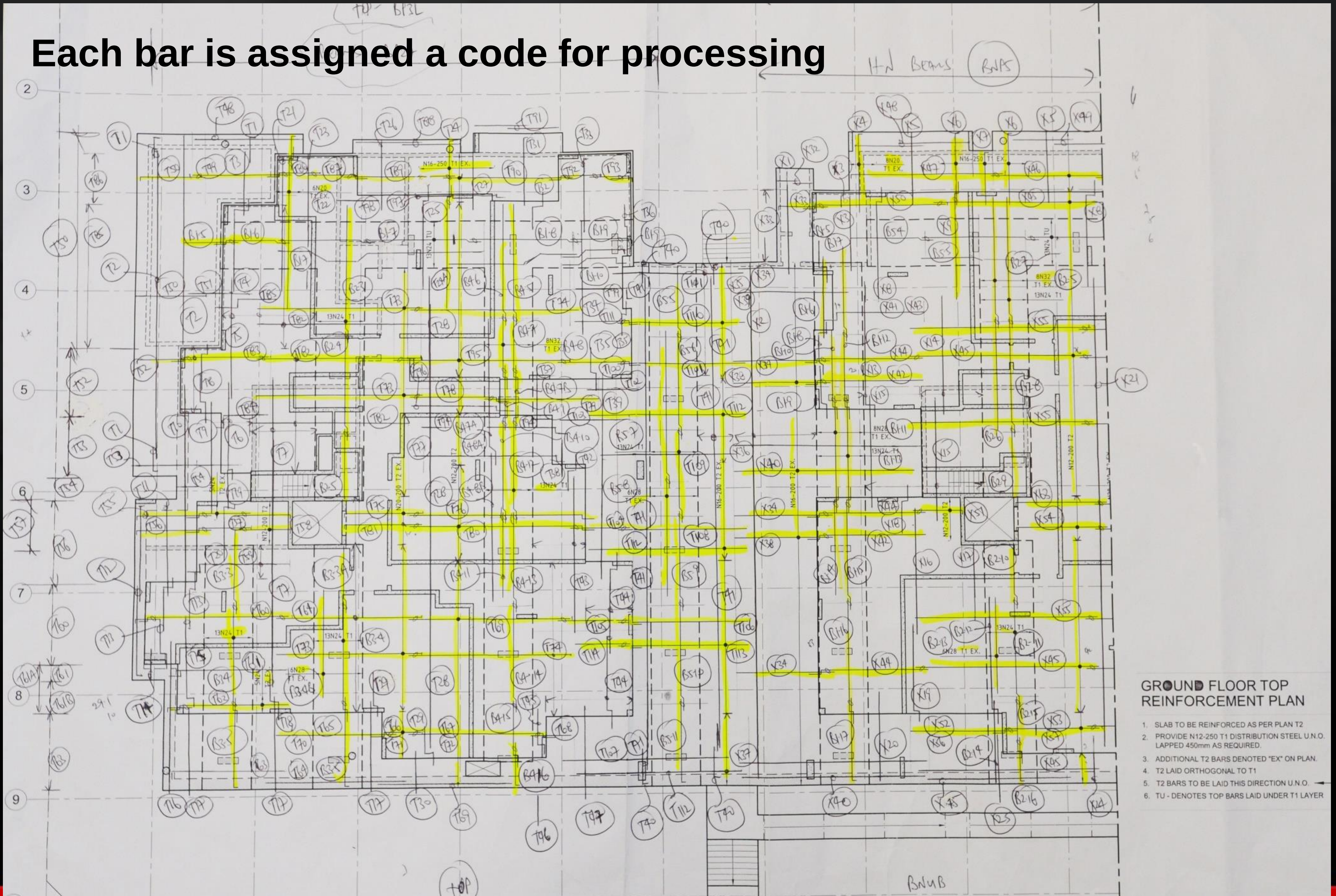
For further information contact the Steel Reinforcement Institute of Australia:
Executive Director: **Scott Munter** | National Engineer: **Eric Lume**
t 02 9144 2602 e info@sria.com.au w sria.com.au
Pymble Corporate Centre, Suite 1 Level 1 Building 1, 20 Bridge St, Pymble NSW 2073
Follow us: facebook.com/steelreinforcementinstitute linkedin.com/company/sria

Scheduling from Design Drawings & Specifications

Develop electronic bar cutting/bending schedules

Scheduling from Design Drawings

Each bar is assigned a code for processing



Cutting & Bending – Off Coil

Bar continually drawn from coil and bent around pin of specific diameter

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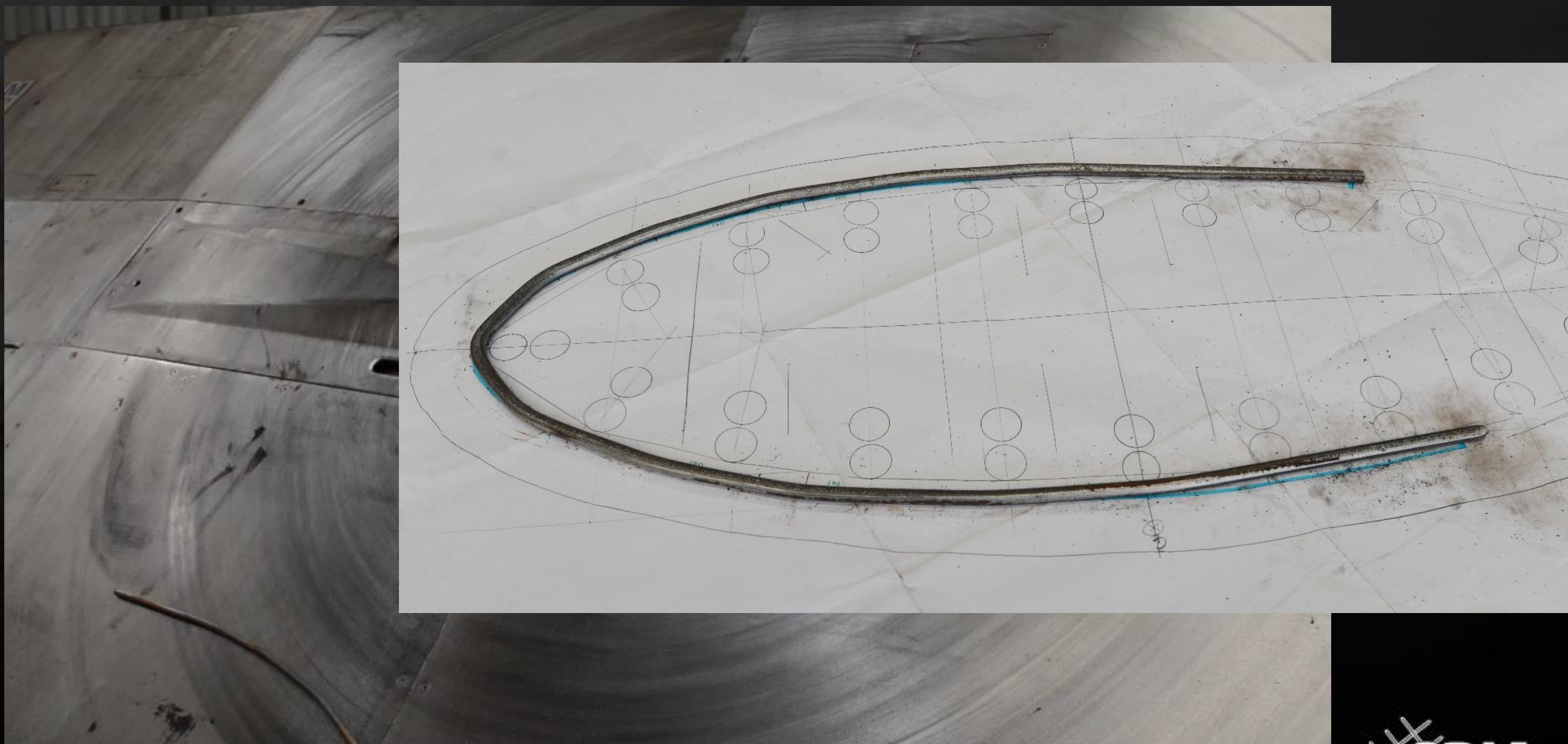
Cutting & Bending – Off Coil

Almost any shape possible – virtual bends



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Cutting & Bending – Straight Bar

Shear line for efficient cutting of stock bar lengths

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Cutting & Bending – Straight Bar

Larger bars also bent around pin of specific diameter

Bending Reinforcement

Clause 17.2.3.2 of AS 3600 – required pin diameters

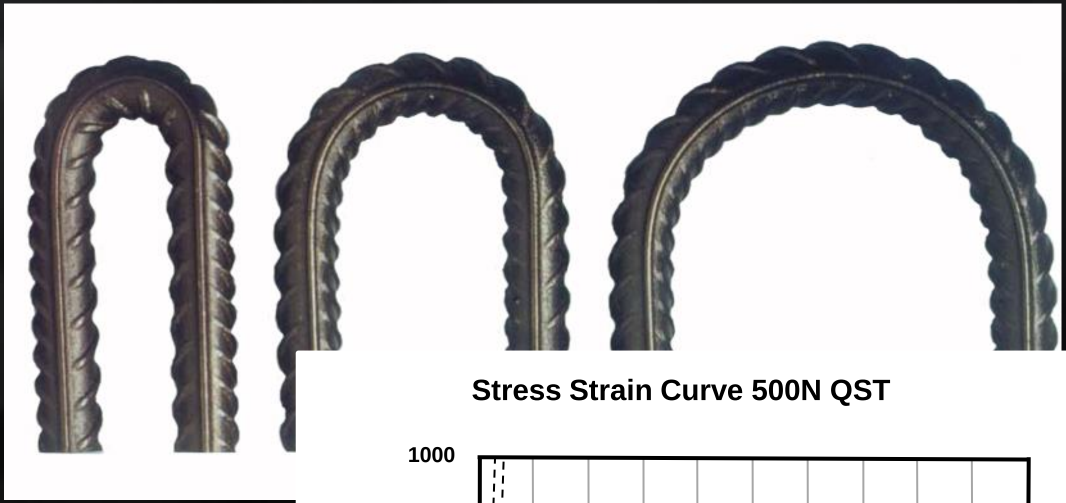
Avoids excessive steel strain and crushing of concrete

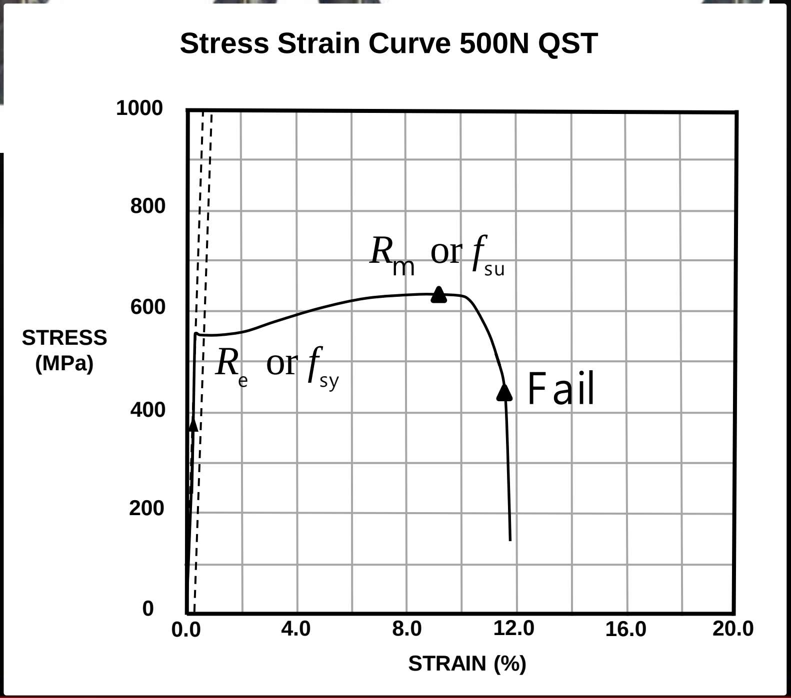
Fitments

500L & R250N	$3d_b$
D500N	$4d_b$

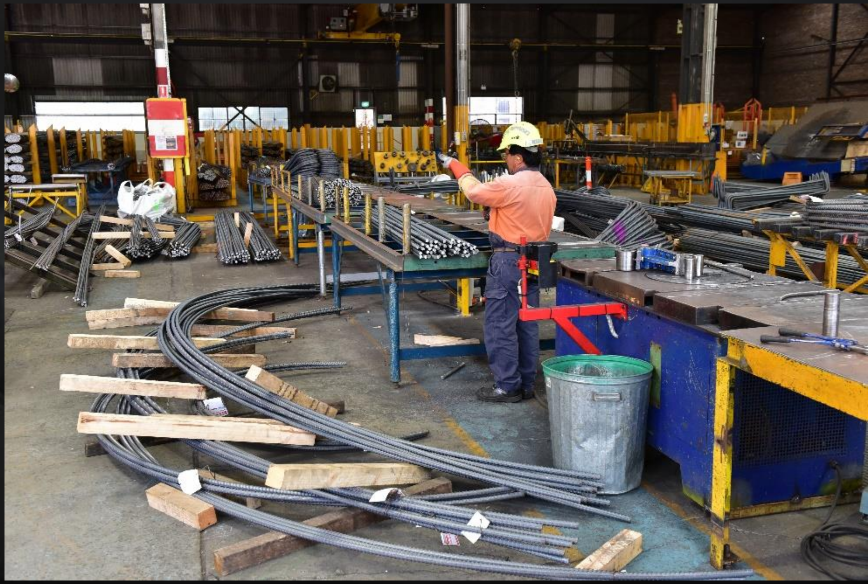
General

D500N	$5d_b$
Galvanised ≤16mm	$5d_b$
Galvanised ≥ 20mm	$8d_b$





Curved Reinforcement



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Bending Reinforcement

Recent bending problems

Bar hit with sledge hammer

Clause 17.2.3.1
Bars shall not be bent using impact, such as with hammers.

AS 3600 Clause 17.2.3 contains requirements for bending reinforcement

Clause 17.2.3.1
Reinforcement partially embedded in concrete may be field-bent provided the bending complies with Clauses 17.2.3.1(a) Cold bending and (b) Hot bending

Bending Reinforcement

Correct Site Practices

Manual and electric bending equipment - preferred

Bends up to 180
Maximum D16 bar
63 mm bending roller

Bends of 90, 135 and 180
Maximum D20 bar
Roller diameter?

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Bending Reinforcement

Incorrect Site Practices

Not bending around correct pin diameter

Over-heating

Maximum 600°C allowed Clause 17.2.3.1

If temp. exceeds 450°C, yield strength taken as 250 MPa

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Bending Reinforcement

Recent bending problem

Galvanised N32 bars bent around 47 mm diameter pin

AS 3600 requires 8 bar diameters for galvanised bars – 256 mm dia. pin

Accept or reject?

Engineer prepared to certify? YES

Authority prepared to accept? NO

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Scheduling & Processing

Stored ready for delivery – 2 to 3 day lead time required

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Fabrication Tolerances

Clause 17.2.2 of AS 3600

Fitments (stirrups & ties):

Plain round bars and wire	-10mm	+0mm
Deformed bars & mesh	-15mm	+0mm

General (bar and mesh)

Length ≤ 600mm	-25mm	+0mm
Length > 600mm	-40mm	+0mm

Fixing Tolerance

Clause 17.5.3 of AS 3600

WHERE CONTROLLED BY COVER

Beams, slabs, columns, walls	-5mm	+10mm
Slabs-on-ground	-10mm	+20mm
Footings	-10mm	+40mm
	(less cover – more cover)	

OTHER

End of reinforcement	-50mm	+50mm
Spacing of reinforcement	greater of 15mm, or 10% of specified spacing	

Note: Designer is responsible to ensure steel can be placed to within tolerances

Keeping Reinforcement in Place

Bar Chairs - AS/NZS 2425 Bar chairs in concrete – Product requirements

Concrete

Plastic

Hurdles

Plastic tipped wire

Keeping Reinforcement in Place

Bar Chairs - Hurdles

- Support reinforcement at heights greater than normal chairs – typically 300 mm to 400 mm max.
- Requirements determined by steel scheduler

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Specifying Bar Chairs

Specify

- Bar chairs to comply with AS/NZS 2425 Bar chairs in concrete – Product requirements
- Type of bar chair - Depends on application

Marine or water retaining application?

Why concrete…………and not plastic?

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Specifying Bar Chairs

Specify

- Bar chairs to comply with AS/NZS 2425 Bar chairs in concrete – Product requirements
- Type of bar chair - Depends on application
- Load capacity - 60, 120, 200 or > 300 kg
- Spacing - To adequately support load
- Chloride permeability (if concrete)
  - Ensures suitability of concrete spacer for exposure

Table 2 from AS/NZS 2425

Maximum charge passed (coulombs)	**Chloride permeability class**
> 4,000	High
2,000 - 4,000	Moderate
1,000 – 2,000	Low
< 1,000	Very low

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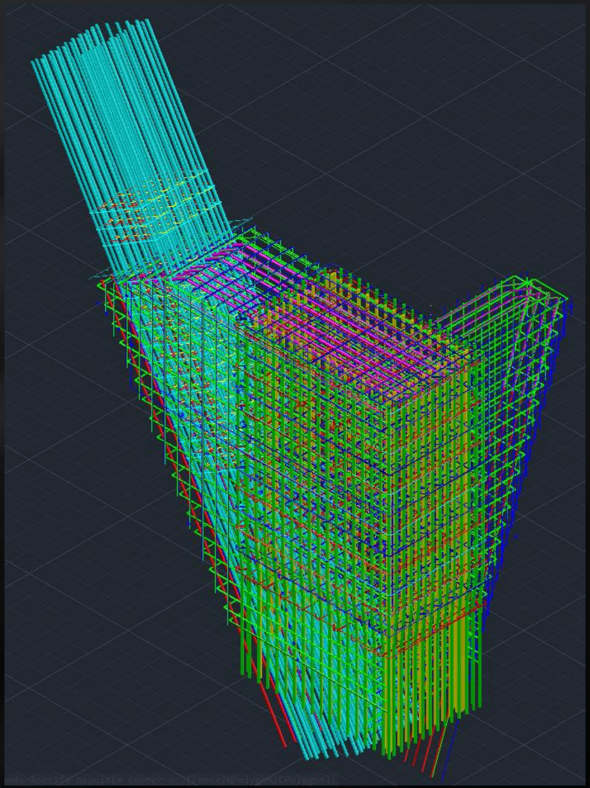
BIM - 3D drafting ideal for complex shapes

Science Museum in Valencia, Spain
Architect: Santiago Calatrava



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Welding of Prefabricated Reinforcement

Types of AS/NZS 1554.3 non-loadbearing welds in cage prefabrications:

- **Non-loadbearing welded joints** – in accordance with Section 3.3
  - These welds hold the cage during fabrication, transport & concreting
  - The welded joint strength does not contribute to the structure
- **Locational Welds** – in accordance with Clause 5.6
  - Used to hold parts of a weldment in alignment until final welds made
  - If left in place & included in prefabrication must meet Table 6.2.
    - Note 6 requirements ensure there is no loss of cross-sectional area or imperfections. If locational welds are too small they will change the bar metallurgy underneath causing insufficient strength when lifted.
    - Amdt 1 Nov 2017 – New Note 7: *"Non-loadbearing welds shall not reduce the full load bearing capacity of the structural elements (see Note 6)"*
  - If weld size does not meet Cl 5.6 requirements their limited heat affect and rapid cooling can lead to cracking
  - If removed properly – minimal (if any) impact.

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Prefabrication of Reinforcement

- The number of welds to locate reinforcing steel shall be kept to a minimum
- Locational Welds - AS/NZS 1554.3:2008, Note 2 to 1.6.2 said
  "tack welds in bent sections of bars are permitted subject to Cl 3.3"
  ERROR AS DELETED IN 2014 PUBLICATION
- Load bearing welds are not permitted on a bend:
  - AS/NZS 1554.3, Clause 1.6.3 requires >2d_b from weld to start of bend
  - AS 3600, Clause 13.2.1 requires 3d_b from part of the bar that has been bent and restraightened
- Welding must be done by person qualified in AS/NZS 1554.3 welding procedures

Weld Images courtesy of
Weld Australia, (WA)

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Lifting of Prefabrication Reinforcement

Locational (non loadbearing) welds used for lifting

- Must be designed by a suitably qualified person
- Must be approved by Design Engineer prior to lifting
- Safe lifting points for fabricated cages shall be clearly marked on the drawings and fabricated cages

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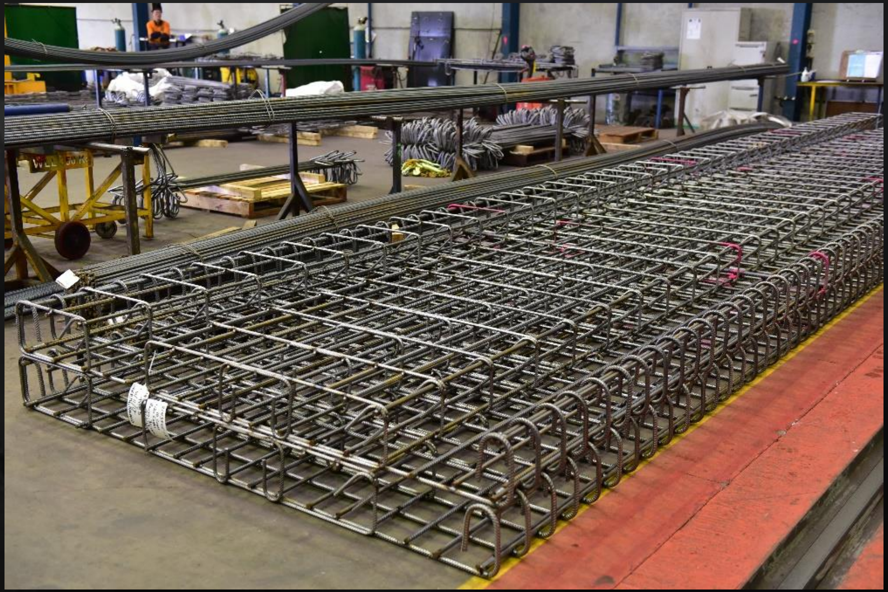
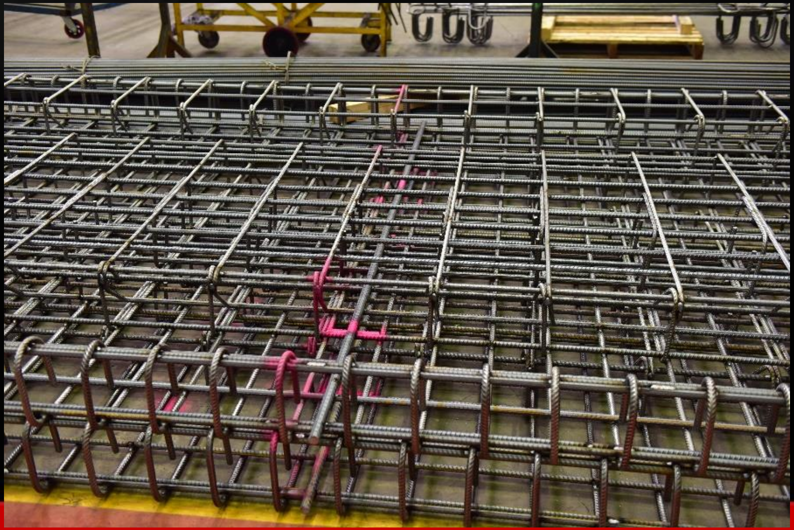
Prefabrication of Reinforcement

Lifting points need to be clearly marked



Bars set up in welding jig

Sydney Light Rail



Lifting points clearly marked

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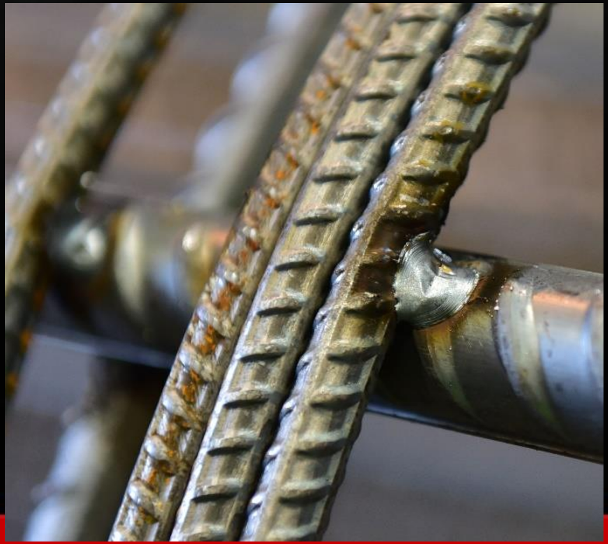
Prefabrication of Reinforcement

Reduces congestion on site and speeds up construction



Pile cages with spiral fitments typically prefabricated by machine welding

Good consistent weld quality with experienced operators in 3rd Party <u>Processor</u> Certified facilities

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Welding of Reinforcement

- **Often specified to be in accordance with AS 1554.3 Welding of reinforcing steels**
- Contractors generally unaware of requirements
- Weld details should be specified by Engineer (refer Section 3)
- Need to study AS 1554.3 carefully
- Some recommendations:
  - Qualify procedure to AS 1554.3
  - Specify procedure/process
  - Do trials
  - Test weld to verify penetration and tensile capacity
  - Bend test if butt welded – for flexural tensile reinforcement
  - If insufficient penetration:

    May need to adjust gap between bars or procedure
  - Due diligence is required

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Consider Mechanical Couplers

Various Types

Examples of couplers

Tapered thread

Sleeve extruded over bar end with parallel thread

Parallel thread

Proprietary bar couplers

Examples of coupling sleeves

Mechanically bolted

Grouted

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Prefabrication of Reinforcement

Large prefabrications become temporary structures

Need to ensure stability – specify bracing if required

University of Nevada Report CCEER 10-07 & Presentation – Stability of Bridge Column Rebar Cages during Construction

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Summary

- SRIA is here to help
- Historic structures require careful consideration
- Steel reinforcement is a high technology product
- Quality assurance is essential
- Bar chairs need to be specified
- Care required with welding
- Ensure stability of prefabricated reinforcement

SRIA Mill and Processor Members

SRIA website provides links to industry
sria.com.au

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