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Steel Reinforcement Institute of Australia

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Guide to Historical Reinforcement

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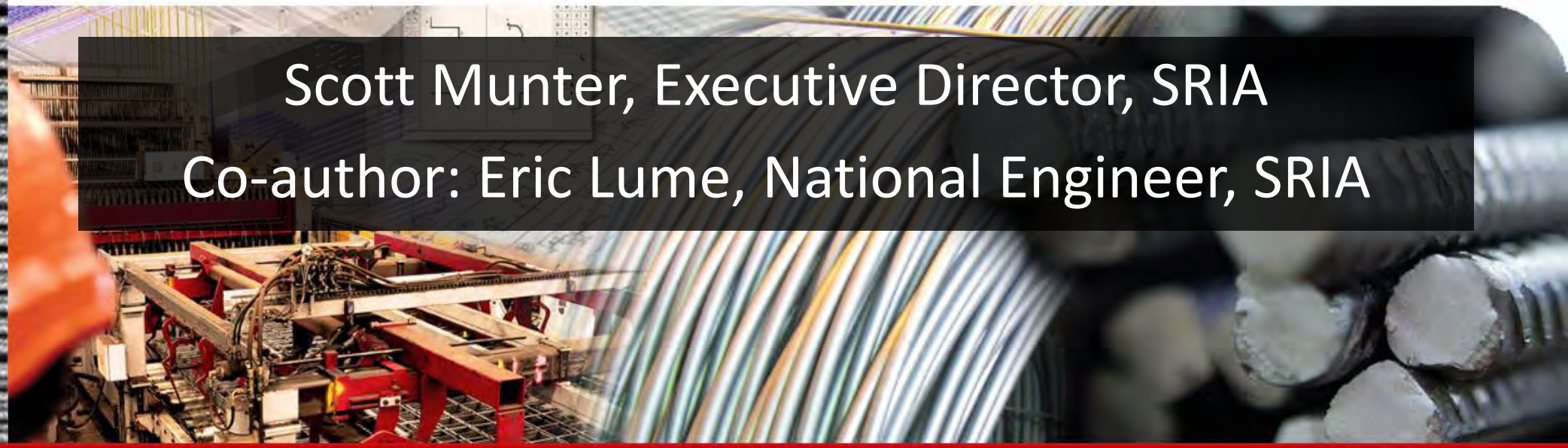

The Importance of Historical Reinforcement Information

- History shows the average life of a reinforced concrete building will typically exceed the design life by a considerable period
- Australia's first reinforced concrete (RC) structure still in service today – 121 years later
- The need to maintain and re-purpose existing building stock (and infrastructure) will increase in future generations
- Replacing existing RC building stock prematurely is not sustainable
- Need to use history and resources to reuse structures wherever possible and make sustainable decisions

Slender existing building stock, George St Sydney

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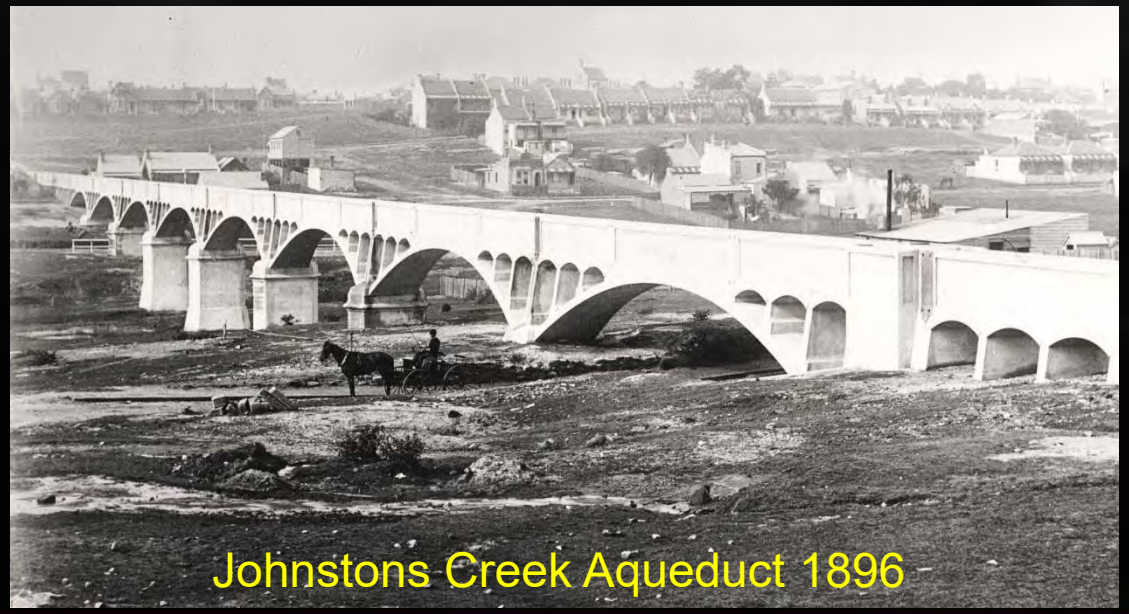
Reinforced Concrete has a Long History

- The use of reinforced concrete in Australia began in 1895 when the contract to build the Johnstons Creek Sewer Aqueduct in Annandale, Sydney was awarded to Carter, Gummow & Co.
- Generous covers and overdesigned concrete mixes are likely reasons for the durability of some of these very early pioneering structures still standing and functioning today.
- In the beginning, RC was called ferro-cement, concrete iron or steel-concrete construction with steel reinforcement produced by companies having patents over their products, often bearing their name.


Johnstons Creek Aqueduct 1896

Fyansford Bridge
Victoria (1899-1900)
Designed by
Monash & Anderson

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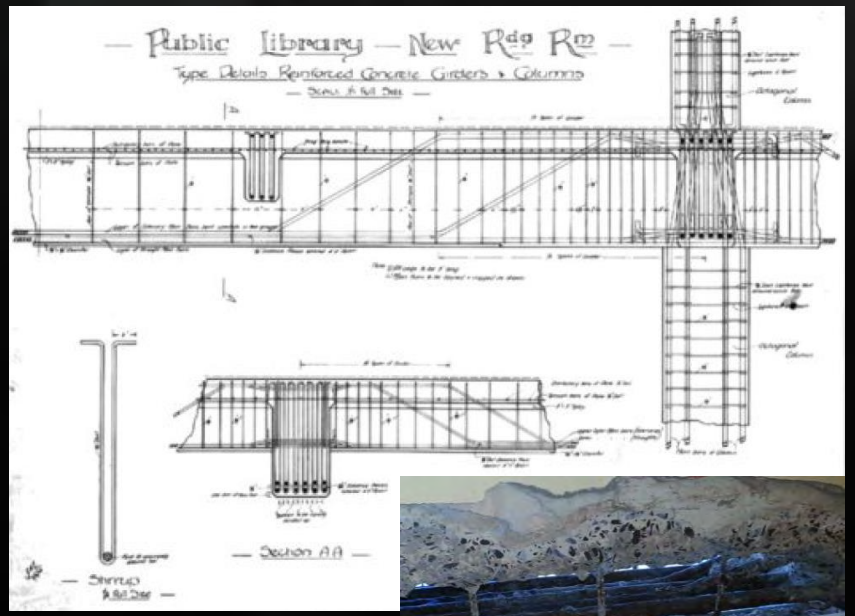
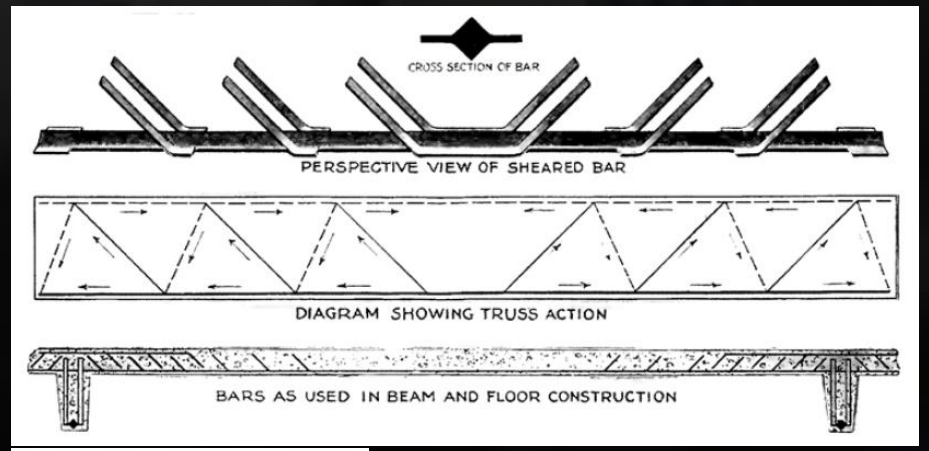
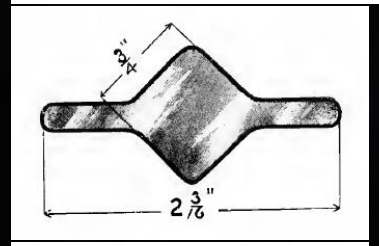
Reinforcement between 1895 & 1920

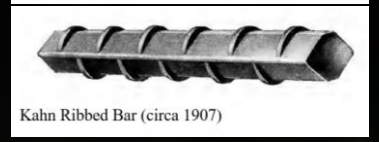
- Much of the reinforcement in the early years, and in particular from 1911, was imported into Australia from the British Reinforced Concrete Engineering Company Limited (B.R.C.)
- Early reinforcement systems (generally Grade 230) were all patented by the inventors
- Common systems used in Australia included the Monier, Kahn and Hennebique Systems



Monier System - Round Bars bent up ends for anchorage

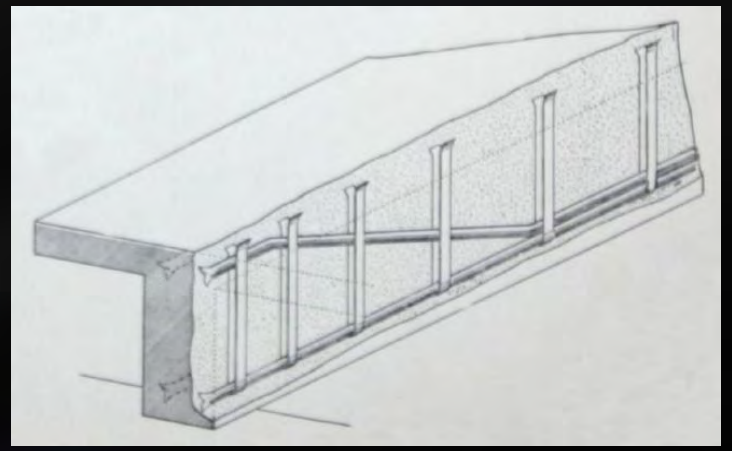






Kahn Ribbed Bar (circa 1907)

Kahn System
- Bar sheared and bent up flanges for anchorage & early rib bars



Hennebique System
- Fishtail ends for anchorage

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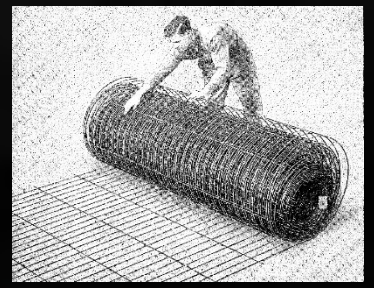
Reinforcement between 1920 & WWII

- An Australian company known as the Australian Reinforced Concrete Engineering Company Proprietary Limited (A.R.C.) was established in 1919. In the early months of 1920, fabric (today know as mesh) was being manufactured at their plant in Sunshine, Melbourne.
- A.R.C. opened a manufacturing factory in NSW in the same year that the first Port Kembla blast furnace was commissioned by Australian Iron and Steel Limited in 1928.
- Early prosperity was driven by supplying rolled mesh product for roads, railways, harbour works, water supplies and sewerage.
- Along with private sector demand, production reached a peak of 7,034 tons in 1929.

1920's Melbourne Tram track



Light rolled out fabric

1920's North Sydney roadway

Flat slab floor to garage (A.R.C. Reinforcements)

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Reinforcement between WWII & 1963

- The importation of bar product was extremely large in 1949 & 1950, principally from the UK in the form of hot-rolled round or square bars.
- Minimum yield strengths of 33,000 psi (228 MPa) were available for bars (hot rolled).
- Minimum yield strengths of 55,000 psi (380 MPa) for wire and fabric products (cold worked).
- 1957 saw the introduction of cold-worked square-twisted bars by A.R.C. having a yield strength of 60,000 psi (414 MPa) – usually taken as Grade 410.
- 1961 saw the introduction of both intermediate and hard grade deformed bars.

Plain round circa, 1895
(Grade 230)

Square twisted, 1957
(Grade 410)

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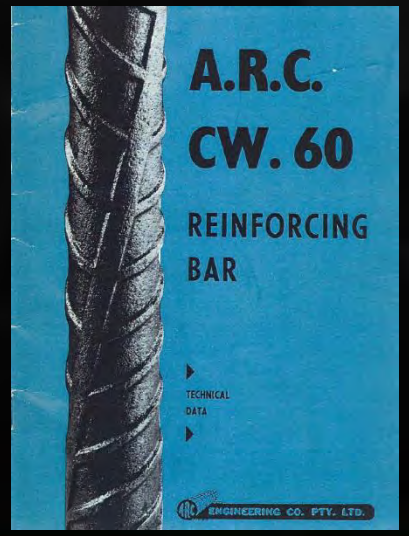
Reinforcement between 1963 & 1983

- A major change occurred in 1963 with the introduction of a hot-rolled deformed bar with a yield strength of 33,500 psi (Grade 228)
- Cold working of this deformed bar by twisting (pitch of 12 bar diameters) resulted in a yield strength of approximately 62,000 psi (427 MPa)
- Referred to as CW.60 bars (cold worked bars having design yield strength of 60,000 psi (414 MPa)
- Welded fabric continued (introduced approx. 1958) to be manufactured from cold drawn high yield strength round wire with a working stress of 30,000 psi and yield strength of 70,000 psi (450 MPa)

Twisted deformed CW.60, 1963 (Grade 410)



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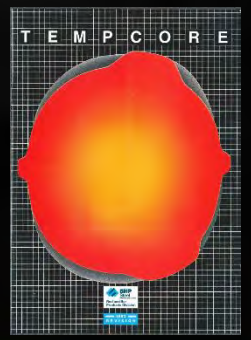
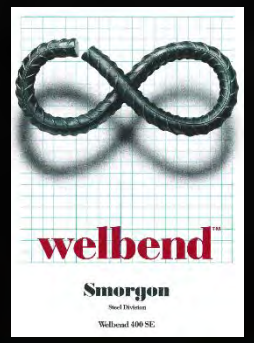
Reinforcement between 1983 & Present

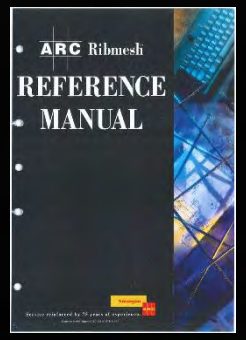
- The next major advancement occurred in 1983, with the introduction of quenched and self-tempered deformed bars (QST).
- BHP's product was known as 'Tempcore'.
- Smorgon steel entered the market in 1983 with an equivalent product known as 'Wellbend'.
- The yield strength was 410 MPa – known as Grade 410Y bar.
- When AS 3600 was first published in 1988, the strength was downgraded to 400 MPa.
- In 1995 the yield strength of mesh product was increased from 450 MPa to 500 MPa with the introduction of a cold rolling process to produce ribbed bars from plain round wire & ductility parameters added in AS/NZS 4671-2001.
- In 2001 the yield strength of bars was also increased to 500 MPa.

Hot-rolled deformed (D500N) 2017





Cold-rolled deformed (D500L), 1995



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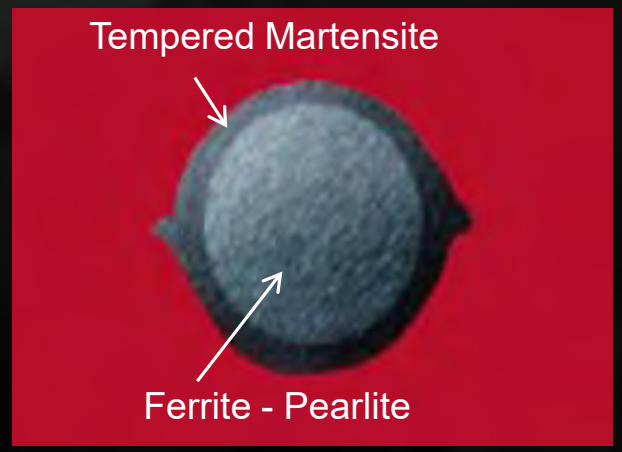
Reinforcement between 1983 & Present

- Development of highly ductile microalloy reinforcement coincided with the 1983 'Tempcore' introduction, when the carbon and CEQ limits were lowered significantly for weldability
- Microalloy high strength achieved from small quantities of grain refining elements
- Alloying with Vanadium (V) and Niobium (Nb)



Quenched and self-tempered bar from 1983

Micro-alloy D500N bar, from 1983

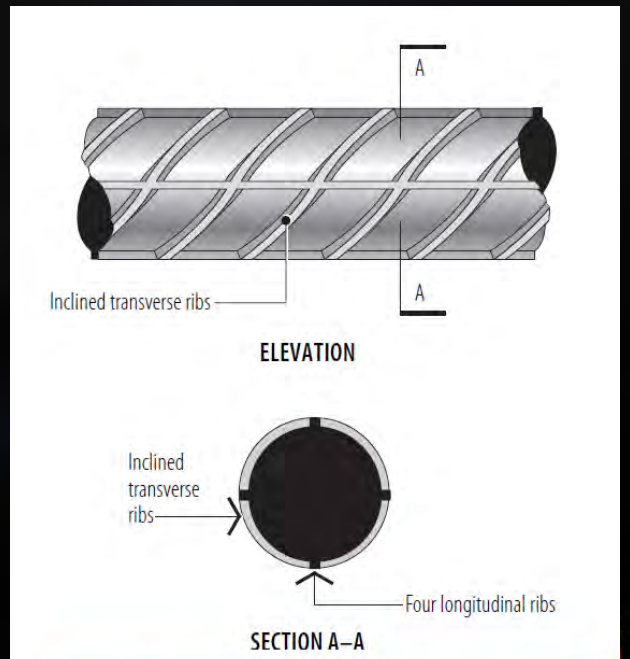


FIGURE 2 *General Identification of Micro-Alloy (Off-Coil) 500N Bars*

Summary: Improvements in reinforcement bar properties

Bar Type	Introduction (year)	Yield Stress (MPa)	Probable Yield Stress (psi)
Plain round	1895	230	33,600
Deformed	1920's	230	33,600
Square twisted	1957 to 1963	410	60,000
Intermediate grade deformed	1960 to 1968	275	40,000
Hard grade deformed	1960 to 1968	345	50,000
Twisted deformed (CW.60)	1962 to 1983	410	60,000
Hot-rolled deformed (410Y)	1983	410	-
Hot-rolled deformed (400Y)	1988	400	-
Hot-rolled deformed (500N)	2000	500	-





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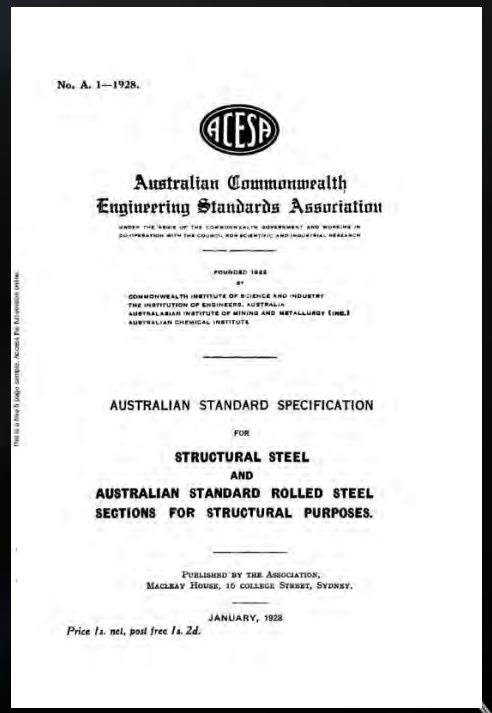
Use of Reinforcement Underpinned by Standards

- **Design Standards**
- 1934 CA 2 Code for Concrete in Buildings (revised in 1937, 1943, 1953, 1958, 1963 and 1973)
  - Allowed design based on permissible stresses
- 1963 revision allowed for ultimate strength design in Appendix A
- 1974 AS 1480 (amended 1975, 1976, 1978 and revised as 2nd Edtn 1982)
- 1988 AS 3600 (revised in 1996, 2000, 2009 another 5th edition by 2019)
- **Material Standards**
- AS No. A.1 released 1928 (revised 1931 and 1940)
- 1958 A.S. No. A.81, A.82, A.83, A.84 and A.92 (with A.92 revised in 1965)
- 1965 A.S. No. A.97
- 1974 AS 1302
- 1991 AS1303 & 1304
- 2001 AS/NZS 4671 Steel reinforcing materials



No. A. 1—1928.

ACESA

Australian Commonwealth
Engineering Standards Association

AUSTRALIAN STANDARD SPECIFICATION

FOR

STRUCTURAL STEEL
AND
AUSTRALIAN STANDARD ROLLED STEEL
SECTIONS FOR STRUCTURAL PURPOSES.

PUBLISHED BY THE ASSOCIATION,
MACLEAY HOUSE, 16 COLLEGE STREET, SYDNEY.

JANUARY, 1928

Price 1s. net, post free 1s. 2d.

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Developing Manufacturing Capability

Mills

- ARC formed in 1919
- BHP – production of steel for rolling into reinforcement
- Smorgon Steel starts in 1983 with electric arc furnace in Laverton, Melbourne
- Humes acquires ARC from Smorgon in 1987 – becomes Humes-ARC
- Smorgon buys Humes in same year – now Smorgon-ARC
- OneSteel acquires Smorgon in 2003
- Liberty House acquires OneSteel in 2017 – now Liberty OneSteel

Mesh Manufacture and Reinforcement Distribution

- Over 60 SRIA Member facilities around Australia manufacturing mesh & processing bar
- All carry third party certification for quality assurance to AS/NZS 4671

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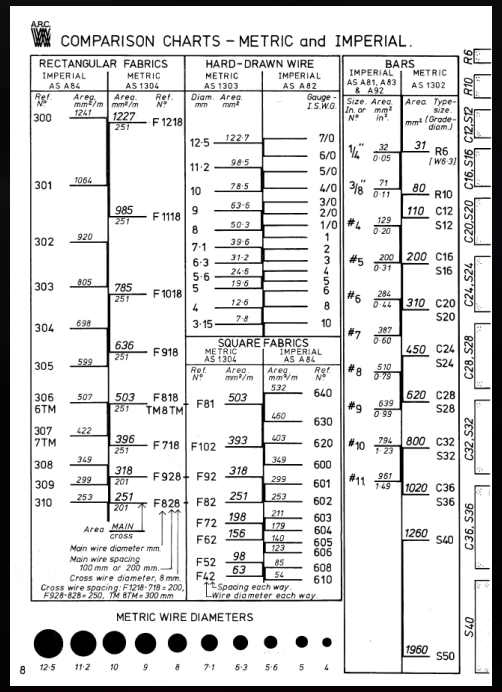
New Guide to Historical Reinforcement

- **Will cover mechanical and dimensional property timeline to meet needs & challenges**
- A major change to the industry occurred in 1970 with the beginning of metrication
- Most common question at SRIA concerns properties and interpretation of imperial sized reinforcing bars & fabric
- NOTE: * The Bar Designation Number refers to the bar diameter in multiples of eights of an inch ie No. 8 bar = 8 x 1/8 in. = 1 inch diameter.

Deformed Bar Designation Number*	Unit weight		Effective Dimensions			
			Diameter (d)		Cross sectional area	
	(lb/ft)	(kg/m)	(in)	(mm)	(in²)	(mm²)
3	0.376	0.599	0.375	9.53	0.11	71
4	0.668	0.994	0.500	12.70	0.20	129
5	1.043	1.552	0.625	15.88	0.31	200
6	1.502	2.235	0.750	19.05	0.44	284
7	2.044	3.041	0.875	22.23	0.60	387
8	2.670	3.973	1.000	25.40	0.79	510
9	3.380	5.029	1.125	28.58	0.99	645
10	4.172	6.108	1.250	31.75	1.23	794
11	5.049	7.513	1.375	34.93	1.49	961

Dimensional and properties of imperial deformed round steel bars (after Table II of A.S. No. A.92-1958 (1) and Table 1 of A.S. A.92-1965 (2))



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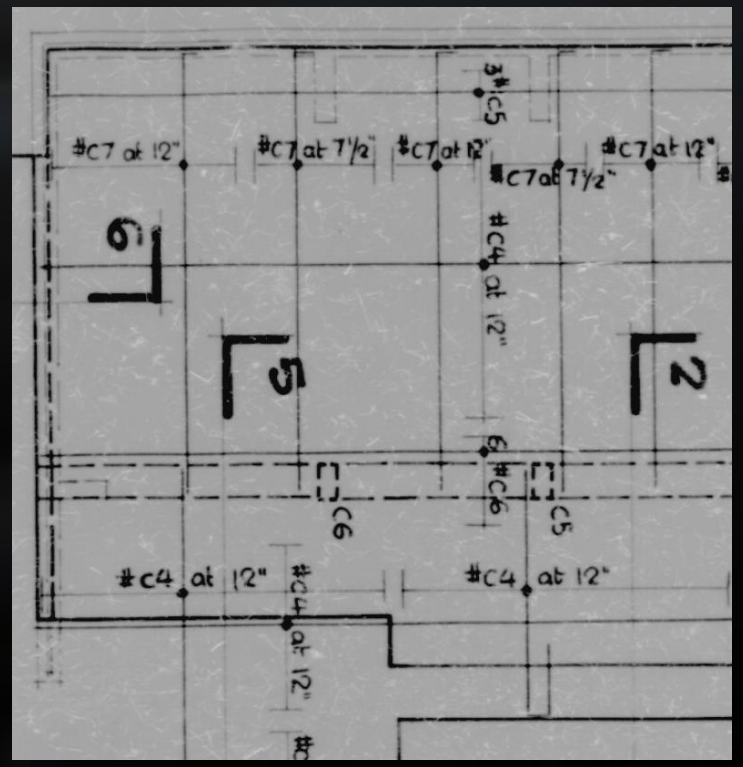
New Guide to Historical Reinforcement

➡ **Will cover the designation of the early reinforcement over time with drawing examples**

- **Symbol**…….Typically denotation on drawing

- **S**…..Structural-grade deformed bars to AS A92 and A97.
- **R**….Structural-grade plain round bars to AS A81.
- **H**….Hard-grade deformed bars to AS A92 and A97
- **C**….Cold-worked deformed bars to AS A83 and A97.
- **T** or **W**….may have been added if the bars were twisted
- **F**….Hard-drawn wire reinforcing fabric to AS A84.
- **W**…Hard-drawn wire to AS A82 (today designated by L).



Example: The designation 6 - #4 CW @ 10” would mean six, number 4 size (or ½ inch) deformed CW.60 bars laid at 10 inch centres.

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Assessment of Historical Structures

- **The basic principle for assessment of historical reinforcement:**
  - Determine year of construction.
  - Identify bar type for period from drawings or sampling.
  - Test mechanical and chemical properties if in any doubt exists.
- **Otherwise**
  - All plain round bars are assumed to be 230 MPa.
  - Plain cold-drawn wire (eg fitments) may be 450 MPa but confirmation of its properties would be required if shear capacity is critical.
  - Post 1958 – mid 1990's all plain welded fabric is assumed to be 450 MPa.
  - Unidentifiable deformed bar is 230 MPa unless verified by bar marks or testing.

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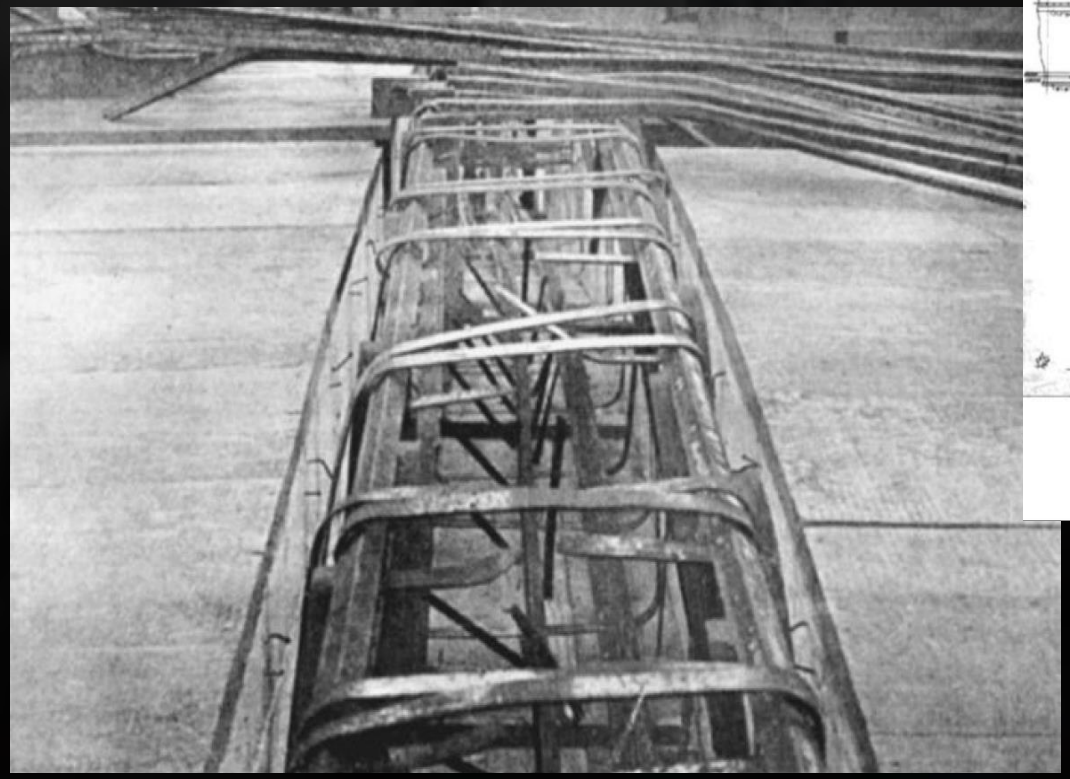
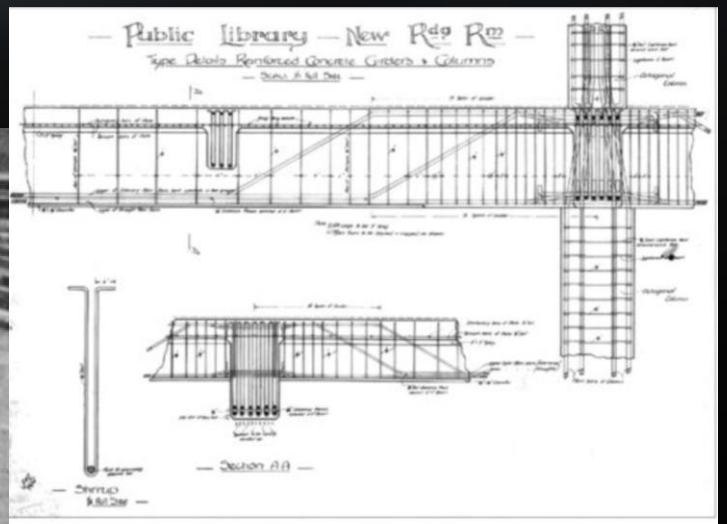
Capacity of Historical Projects

- Use caution when using modern design techniques on historical projects
- Capacity may be governed by anchorage
- Use design methods appropriate to system and period





New Reading Room, type details of reinforced concrete girders & columns,
showing the proposed Monier system reinforcement,
which was to be set aside for the Truscon/Kahn system.
Bates, Smart & McCutcheon Collection, University of Melbourne Archives

La Trobe Journal, No 72, Spring 2003 Image:
1910 Assembly of trussed bars Radial beam of the reading room floor Victoria State Library – Kahn & Truscon system

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Conclusions

The development of the new Guide to Historic Reinforcement in Australia has:

- Emphasised the importance of maintaining our past technical history.
- Demonstrated that this printed technical information is becoming more difficult to source.
- Shown the importance of bringing this knowledge into a single document and capturing it for the benefit of all those that need to check historical buildings.
- Stressed that the preservation of work-as-executed documents by design offices and builders is critical in a digital form.
- Revealed that design offices should not discard their old referenced standards, as these resources are necessary to make future sound, sustainable decisions.
- Developed an SRIA tool to record all future steel reinforcement developments for the benefit of future generations after publishing in 2018.

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- **Mark Turner:** Former SRIA Executive Director and Chairman of BD-084 Steel reinforcing materials

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