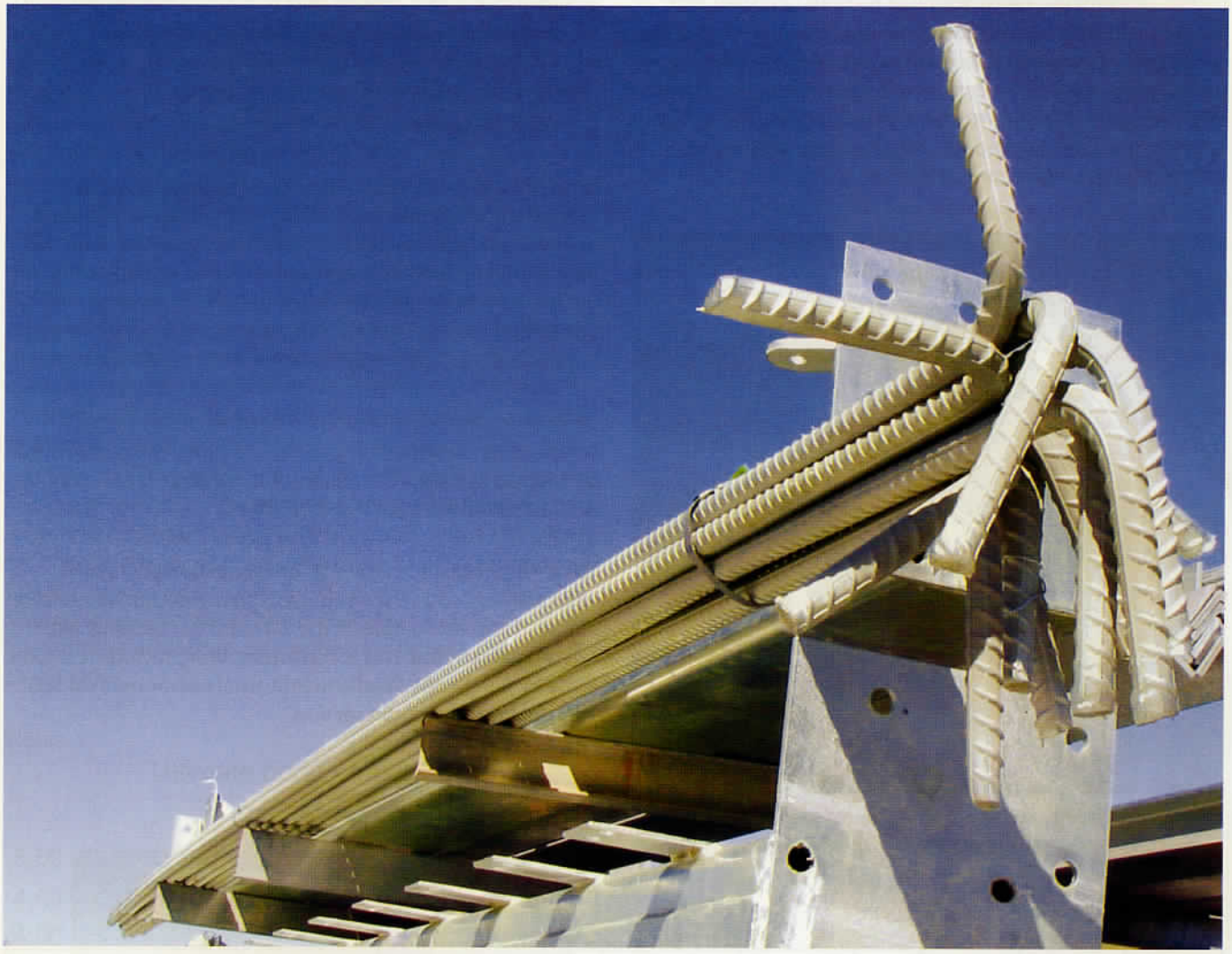
GALVANIZED REINFORCING BAR - TECHNICAL CONSIDERATIONS FOR DESIGNERS

John Robinson - Editor



Most rebar is bent prior to galvanizing. Provided the bend radii requirements of AS/NZS 3600 and AS/NZS 4671 are satisfied, galvanized rebar has no special processing requirements.

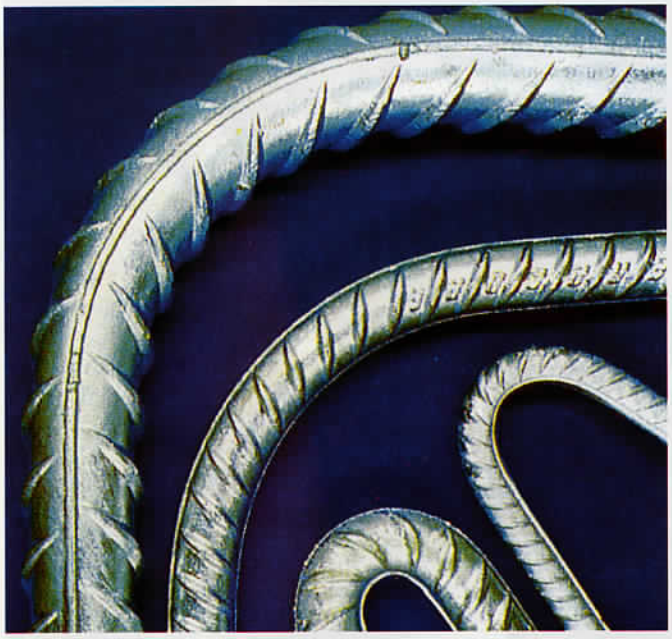
INTRODUCTION

At a recent series of professional development seminars that were conducted jointly by the Australian Steel Institute and Industrial Galvanizers Corporation, at which I was a presenter, a number of the delegates raised questions related to the use of Grade 500N galvanized reinforcing bar. The questions were not related to durability issues, which have been covered in some detail in previous issues of Corrosion Management, but in relation to the technical issues of galvanizing reinforcing bar with respect to affect on bond strength and the risks of embrittlement associated with galvanizing higher strength steel after cold working (bending).

When quenched and tempered and micro-alloyed reinforcing bar (410Y Grade) was introduced to the Australian construction industry in the early 1980s, a great deal of work was done by BHP (now OneSteel) and Smorgon Steel, in conjunction with the Australian Zinc Development Association (AZDA) and the Concrete Institute of Australia to define design parameters for 410Y Grade bar. Previously, 410C Grade bar was the standard, and this double cold-worked material (after bending) was susceptible to embrittlement and rarely specified to be hot dip galvanized as a result, because of the costly heat treatment requirements associated with the safe use of the galvanized product.

The outcome of this research was that 410Y Grade reinforcing bar could be satisfactorily galvanized without any special requirements, and literature published by both the steel producers and the Concrete Institute (in the form of a Practice Note) detailed the technical requirements for galvanizing reinforcing bar.

Since the turn of this century, the rebar grade has been up-rated to Grade 500N standard yield strength, with this higher strength bar being supplied by both OneSteel and Smorgon Steel to the Australian market. There has been little additional information published to indicate whether any other factors need to be considered when specifying Grade 500N rebar. For that reason, this article has been compiled to bring specifiers up-to-date with the requirements for galvanizing the higher strength rebar.



Quenched and tempered rebar has been tested to ensure that galvanizing does not effect its mechanical properties.

AUSTRALIAN STANDARDS

There are two main Australian Standards related to steel reinforcement. These are AS/NZS 4671:2001 *Steel reinforcing materials* and AS 3600: 2001 *Concrete structures.* Neither of these standards contain information on protective coatings for reinforcing bar, other than a very brief mention in AS 3600, Section 19.1.1.2 *Protective coatings,* which states: *'A protective coating may be applied to the reinforcement provided that such a coating does not reduce the properties of the reinforcement below those assumed by the design.'*

GALVANIZING & STEEL STRENGTH

Does hot dip galvanizing have any effect on the mechanical properties of 500 MPa reinforcing bar? While much testing has been done in the past on other steel sections of similar mechanical properties, a series of tests was undertaken by OneSteel Merchant Mills and Industrial Galvanizers Corporation to evaluate the effects of hot dip galvanizing in currently produced OneSteel Grade 500N reinforcing bar.

24mm bar samples from known batches of steel were tested using un-galvanized control samples with associated galvanized samples. The results of these tests, conducted by Amdel laboratories, are listed in Table 2.

The mechanical properties of the rebar showed a slight improvement with respect to yield strength, ultimate tensile strength and elongation of the 24mm D Bar sections after hot dip galvanizing. This is consistent with previous test work done by BlueScope Steel and Industrial Galvanizers on 500 MPa cold formed purlin section.

Table 2

Heat No.	Section: Size (mm) and type	Spec.	NO.	Condition	Projected	YIELD STRESS		TENSILE STRENGTH		ELONG % ON G.L. (U)
					Rib AREA mm²	KN on Section	MPa (N/mm²)	KN on Section	MPa (N/mm²)	
767475	24DBAR	500N	1	Galvanized	452	272.3	602	315.4	698	11
767475	24DBAR	500N	2	Galvanized	452	274.8	608	316.4	700	11
767475	24DBAR	500N	3	Galvanized	452	272.5	603	314.9	697	11
767498	24DBAR	500N	4	Galvanized	452	275.8	610	320.8	710	11
767498	24DBAR	500N	5	Galvanized	452	273.4	605	319.2	706	11
767498	24DBAR	500N	6	Galvanized	452	271.5	601	317.6	703	10
767475	24DBAR	500N	7	As Rolled	452	266.8	590	310.4	687	12
767475	24DBAR	500N	8	As Rolled	452	269.3	596	311.8	690	9
767475	24DBAR	500N	9	As Rolled	452	267.3	591	311.4	689	10
767498	24DBAR	500N	10	As Rolled	452	267.9	593	315.2	697	10
767498	24DBAR	500N	11	As Rolled	452	265.5	587	312.4	691	10
767498	24DBAR	500N	12	As Rolled	452	269.7	597	316.7	701	10

GALVANIZED COATINGS & BOND STRENGTH

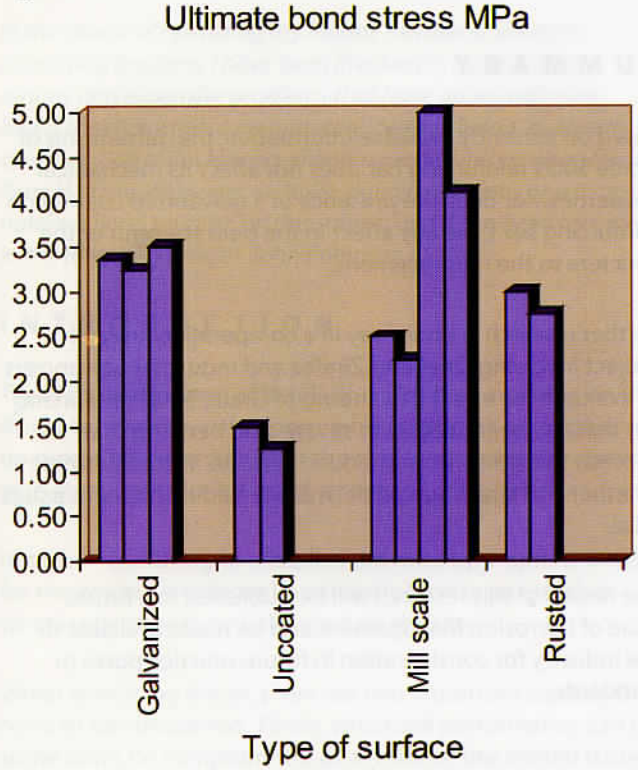
There is a theoretical concern that the bond strength of concrete to galvanized reinforcing bar is compromised because of the potential for the zinc to react with the alkaline component of wet concrete and generate hydrogen bubbles at the interface.

A great deal of research has been done in this area, both in the USA and Australia, and this phenomenon has rarely been able to be substantiated in practice. In fact, in every test case, the bond strength of concrete in contact with smooth galvanized reinforcing bars was found to be higher than black steel bars of the same configuration.

A practical reason for this is that chromate passivation of galvanized items is a standard operating procedure in hot dip galvanizing plants, and residual levels of chromate are present in many cements. Levels of chromate in cement in the order of 35-70 parts per million are considered sufficient to prevent hydrogen evolution on galvanized rebar during concrete cure. Where no chromate is present in the cement, the chromate passivation of the galvanized rebar is deemed to provide the same level of protection.

The graph in Figure 1 illustrates typical comparative performance. These results were the result of test work done by A.W Roberts, et al on the International Lead Zinc Research Organization's Project ZE 222: 1977 and are very similar to other test results done at The University of Newcastle (NSW) Department of Mechanical Engineering Project 2524 by Dr. J.A.Lewis.

Figure 1



INDUSTRY INFORMATION

In 1884, the Concrete Institute of Australia released Current Practice Note 17 – *The use of galvanized reinforcing bar in concrete.* This Practice Note covered guidelines for specifiers that were not dealt with in existing Australian standards with respect to protective coatings for reinforcing bar and galvanized coatings in particular.

In 2002, the Concrete Institute of Australia published a revision of Practice Note 17, with input from Philip Saners, Engineering Manager NSW of Smorgon ARC (Convenor), Dr. Stephen Yeomans, Associate Professor University College, UNSW ADFA and Michael Dennett, Principal Technical Consultant, Galvanizers association of Australia.

This Practice Note introduced information on the Grade 500 N bar. Some important sections of Practice Note 17: 2001 relate to the mechanical properties of galvanized reinfoircing bars.

Section 4.2 states:

'Smorgon Consolidated Industries 'Steelforge500' bar and OneSteel '500PLUS' bar produced to AS/NZS 4671, Grade 500N, easily meet all the requirements of Australian Standards and Codes. Their superior properties are retained after galvanizing and are altered only marginally in bars bent prior to galvanizing.'

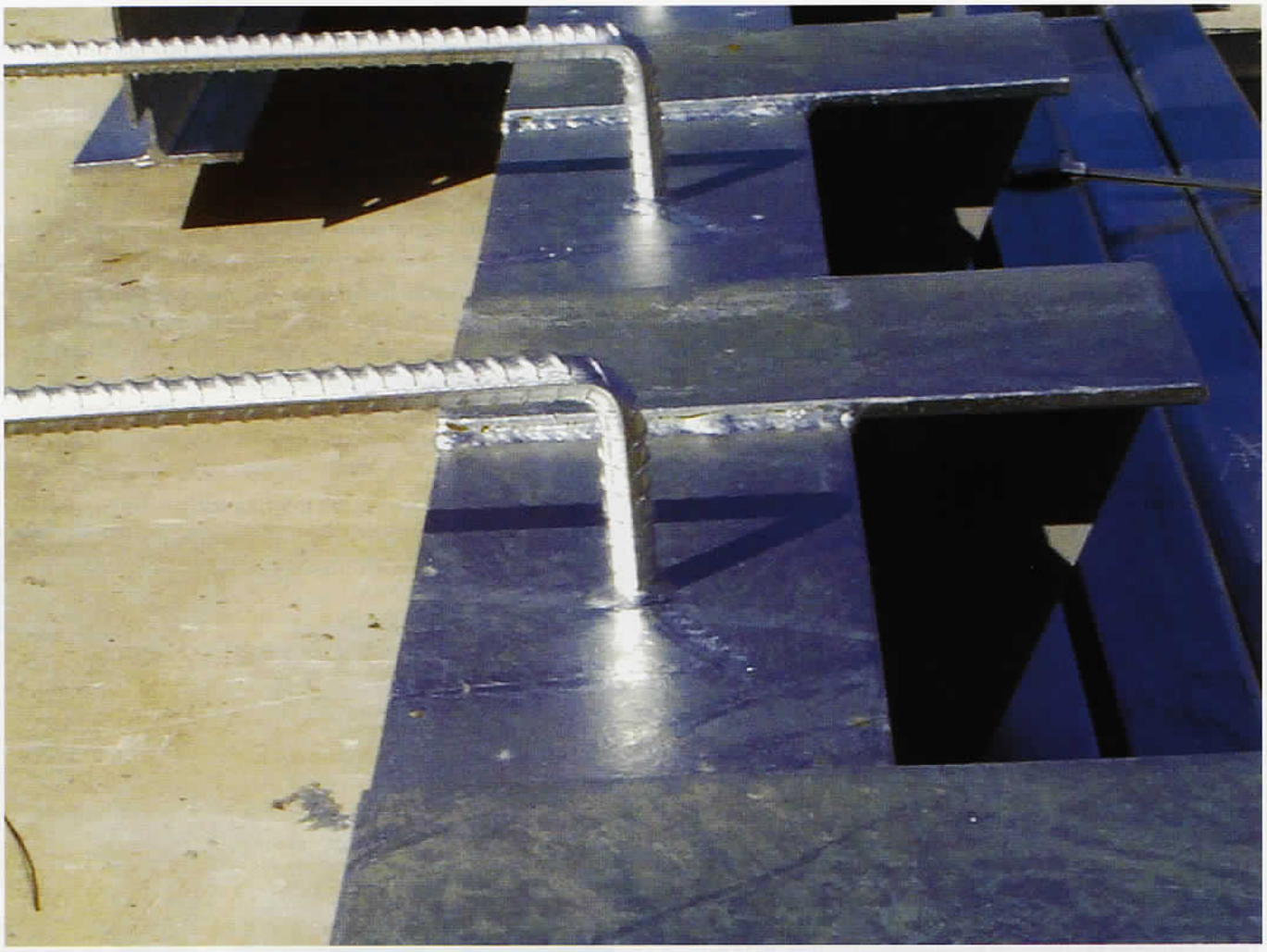
GRADE 500N BAR

Property	***Effect of Galvanizing***
Tensile	No change from un-galvanized condition
Bending	No change from un-galvanized condition
Toughness	Similar to ungalvanized

Galvanizing pre-bent Grade 500N bar

Grade 500N reinforcing bar bent prior to galvanizing remains ductile, allowing straightening and re-bending. The following minimum diameters (for 90° bends) arec recommended in As 3600 if subsequent straightening of the bar is required.*

**Re-bending from these bend diameters may cause cracking of the galvanized coating.*



Grade 500N rebar is routinely hot dip galvanized in many forms and is commonly found on steel fabrications that are cast into concrete, where the anti-corrosion performance of the rebar is critical.

Bar diameter, d mm	***Minimum bend diameter***
16 mm or less	*5 d*
20 mm or greater	*8 d*

Grade 500N that has been galvanized and straightened in accordance with the above practices retains full yield and tensile strength of the original bar. Tensile elongation may be slightly reduced, but still easily meets the requirements of AS/NZS 4671.

The use of heat for bending or re-bending galvanized Grade 500N or any other reinforcing bar should be avoided due to the possibility of the zinc coating causing liquid metal embrittlement.

Copies of Practice Note 17:2001 can be obtained from the Concrete Institute of Australia, PO Box 848, Crows Nest NSW 1585 or from Standards Australia, from where it can be downloaded from the web site.

SUMMARY

Based on currently available information, the galvanizing of Grade 500N reinforcing bar does not affect its mechanical properties, nor does the presence of a galvanized coating on reinforcing bar have any effect in the bold strength of the concrete to the reinforcement.

Further research is underway in a co-operative research project involving OneSteel, Zinifex and Industrial Galvanizers to evaluate the effect galvanizing of Grade 500N reinforcing bar that has been subject to severe cold bending that exceeds the limits recommended in AS 3600, to determine whether and strain ageing or hydrogen embrittlement issues arise.

The results of this research will be published in a future issue of Corrosion Management and be made available to the industry for consideration in future practice notes or standards.

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CORROSION MANAGEMENT

CORROSION MANAGEMENT is published for those interested in the specification, application and performance of protective coating systems.

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These timber poles have been burnt through at the ground line as a result of a grass fire. Coatings & Bushfires feature - Page 4.

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Coatings & Bushfires

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