# INFORMATION BULLETIN: IB 79

*Bending and Re-bending of Reinforcing Bars*

*(Recommended Industry Practice)*

CCANZ
concrete answers

## INTRODUCTION

The bending and re-bending of reinforcement is an issue requiring the attention of everyone within the construction industry. An improvement in construction practices can be achieved if the design, construction, precasting, and transportation industries understand the issues and work towards a common goal of improving techniques.

This information bulletin has been developed to provide clear recommended guidelines for the concrete construction industry on the issue of bending and re-bending reinforcing bars. It also provides a summary of requirements from relevant Standards and an explanation of why various practices are recommended.

***NOTE 1:*** *Although this Information Bulletin addresses the issue of bending and rebending reinforcing bars, it is important to recognise that alternatives, such as the use of mechanical connectors, can alleviate the need for bending and rebending.*

## DEFINITIONS

### Starter bar:

A reinforcing bar partially embedded and protruding from a piece of concrete for splicing to other reinforcing bars.

### Bending:

The action of creating the first bend in a portion of a bar by forcing it around a pin. The bar may be initially straight, or the angle of the bend may be increased. The following actions would be classed as bending:

- putting a 90 degree hook in a portion of a bar that has not been previously bent, and
- converting this 90 degree hook to a 180 degree hook.

### Re-bending:

The action of reversing the bend in a bar. Normally re-bending involves the straightening of an already bent bar.

These definitions are illustrated in **Figure 1** on page 2.

## RECOMMENDED PRINCIPLES

The following are recommended:

1. The bending and re-bending of starter bars should be restricted to situations where it is absolutely necessary.
2. Where bending/re-bending of starter bars is necessary, the bars should be Grade 300E unless specifically instructed otherwise by the Construction Reviewer.
3. The maximum diameter of bars requiring bending and re-bending should be 16 mm.
4. Starter bars required to be bent and re-bent should be cast with the commencement of the bend at least 3 $d_b$ from the concrete face.
5. If rebending Grade 500 bars, the method of manufacture – Micro-Alloyed (MA) or Quenched & Tempered (QT) – must be deter-mined. MA must only be re-bent hot (~750°C). QT reinforcing must not be re-bent at all.
6. Bend diameters of bars shall comply with the diameters in NZS 3109.
7. Bars shall be re-bent only once in compliance with 3.3.8 of Amendment No. 2 of NZS 3109 – refer Re-bending of Reinforcement on page 4 of this Information Bulletin.
8. Bars should be galvanised prior to bending.

These principles are illustrated in **Figures 2 to 5** on pages 2-3.

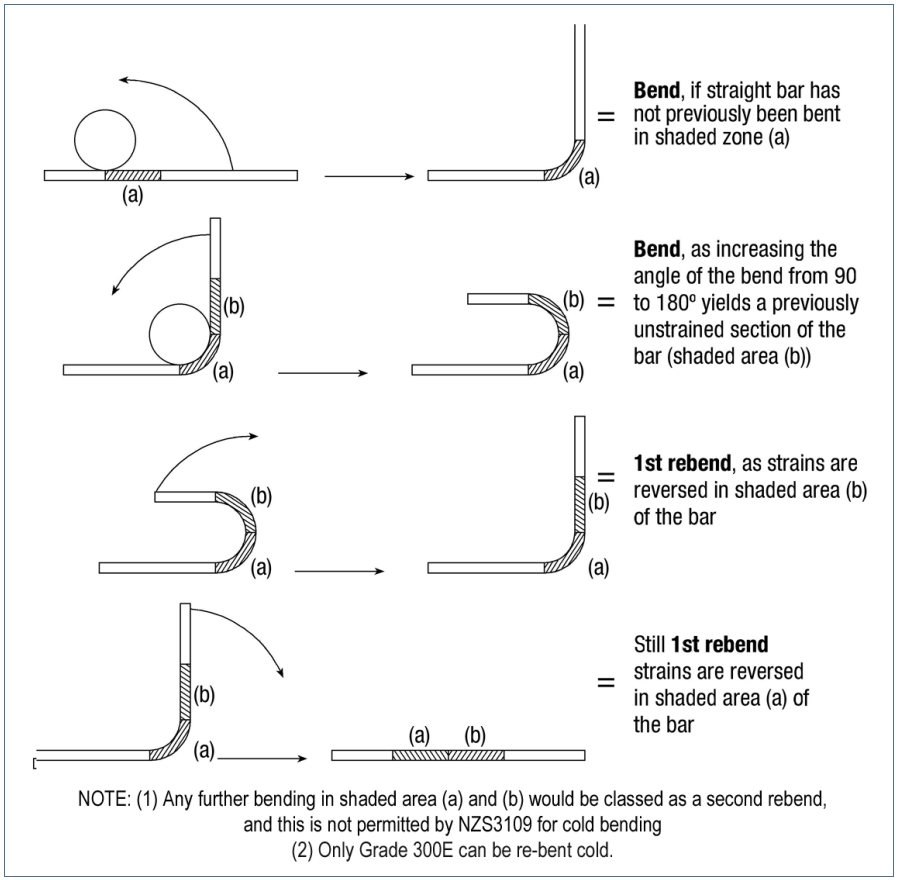


**Figure 1:**
Definition of bending and rebending.

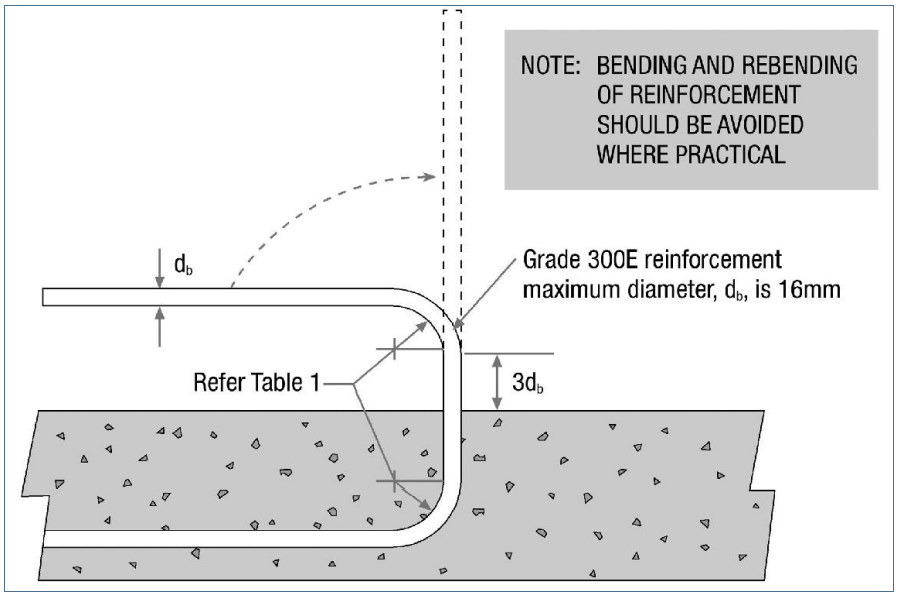


**Figure 2:**
Recommended details for bent and rebent starter bars.

**Figure 3:**
An example of a typical bar bending tool (showing a 12 mm bar being bent around a 60 mm diameter former).

***NOTE 2:*** *The diameter of the bar that is accommodated by the pipe is related to the diameter of the former to ensure compliance with NZS 3109.*

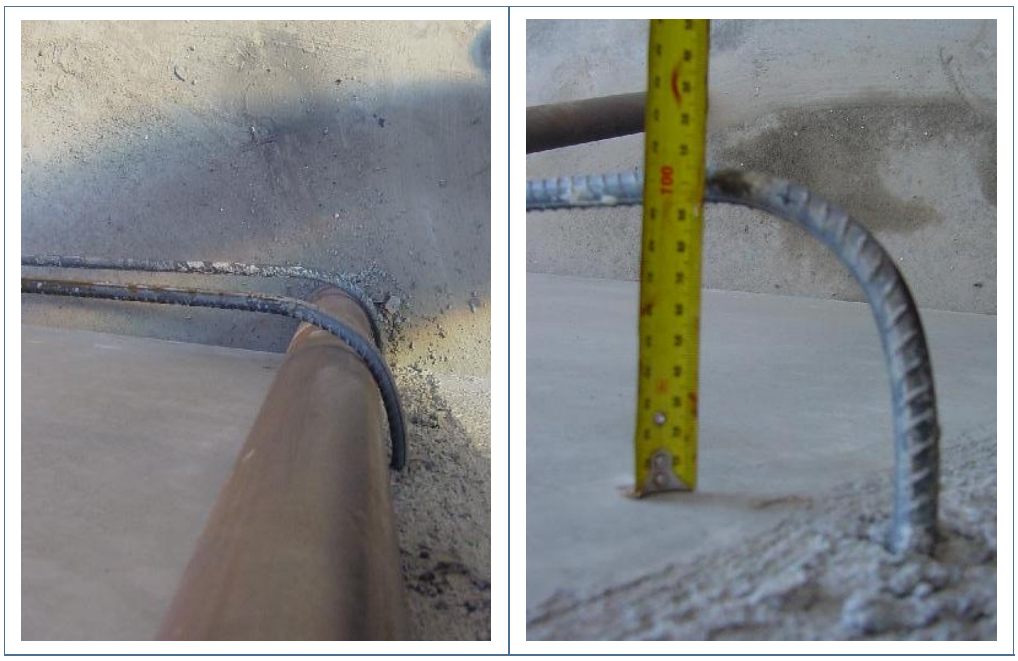

**Figure 4:**
Bending 12 mm bar around 80 mm diameter scaffold tube and the end results.

**Figure 5:**
Re-bending 12 mm Grade 300 bar with a "dog bar", and end result.

***NOTE 3:*** *An appropriate dimensional "dog bar" should be used to ensure that the re-bending complies with 3.3.8 of Amendment No. 2 of NZS 3109.*

***NOTE 4:*** *Grade 500 bars, which have been micro-alloyed, are required to be re-bent at a cherry red temperature in accordance with 3.3.8 of Amendment No. 2 of NZS 3109.*

*[Grade 500 quenched and self-tempered bars are* ***not*** *to be straightened or rebent].*

## SUMMARY OF INFORMATION CONTAINED WITHIN EXISTING NEW ZEALAND STANDARDS

The relevant Standards pertaining to bending and re-bending of reinforcement are:

| | |
|---|---|
| **NZS 3109:1997** | Concrete Construction |
| **NZS3101:1995** | Concrete Structures Standard |
| **AS/NZS 4671:2001** | Steel Reinforcing Materials |

These standards provide information on bend diameters, and restrictions on the number of times a bar can be re-bent. The requirements are summarised in the following sections.

## Minimum Bend Diameters

The minimum bend diameter specified in NZS 3101 and NZS 3109 are summarised in **Table 1**.

**Table 1:** Minimum diameters of reinforcement bends

| $F_y$ (MPA) | Bar Type | Bar Diameter $d_b$ (mm) | Minimum diameter of bend $d_i$ (mm) | |
|---|---|---|---|---|
| | | | Plain Bars | Deformed Bars |
| 300 or 500 | Stirrups and ties | 6–20 | 2 $d_b$ | 4 $d_b$ |
| | | 24 | 3 $d_b$ | 6 $d_b$ |
| | All other bars | 6–20 | 5 $d_b$ | 5 $d_b$ |
| | | 24–40 | 6 $d_b$ | 6 $d_b$ |

## Re-bending of Reinforcement

Amendment No. 2 to NZS 3109 contains the following:

***3.3.8*** *– (Page 14) –* ***Insert new clause:***

*"Grade 300E and Grade 250N quenched and self tempered bars* ***[refer Note 5 below]*** *that have been bent and which are required to be straightened or re-bent may be re-bent once only in accordance with 3.3.1, 3.3.2 and 3.3.4* ***[refer Table 1 above]****.*

*Grade 500 quenched and self tempered bars shall not be straightened or re-bent.*

*Where micro-alloyed Grade 500E or Grade 500N bars that have been bent are required to be straightened or re-bent, the bar shall be heated to 750 ± 75°C (cherry red heat) over the length of the bend and are to be bent at that temperature in accordance with 3.3.1 and 3.3.2. Such heated bars shall be permitted to air cool to ambient temperature with protection from accelerated cooling by wind, rain or similar influences.*

*Any re-bending, may only take place in the plane of the original bend, and shall not bend the bar past the original straight position. Re-bending shall be carried out using smoothly applied force in a continuous action, not using impact loads and using a bending tool that avoids causing surface damage.*

*The surface of all re-bent areas are to be inspected after completion of re-bending and if cracking of bars is found, those bars shall be rejected."*

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***NOTE 5:*** *In New Zealand, the use of Class N bars is discouraged due to their low level of ductility. The Standard reference to quenched and self-tempered is superfluous as these grades can be typically achieved with non-alloyed mild steel.*

# SOME THEORY EXPLAINING THE RECOMMENDED PRINCIPLES

### Why is Grade 300 preferred over 500?

The preference of using Grade 300 over 500 is simply because Grade 300 is a more ductile material. When a bar is bent or rebent, the bar yields and strain hardens. After re-straightening the effects of strain hardening remain in the previously bent section which means that the available ductility is reduced. Grade 300 bars are required by AS/NZS 4671 to have a uniform elongation of 15%, while 10% is required for Grade 500E. The Grade 300 bar has greater capacity to accommodate the strain created by bending.

NZS 3109 allows the re-bending of Grade 500 reinforcement but only if hot bent, this is explained in section 3.6.

### Why is it important to bend the bar around the correct radius?

The tighter the bend, the greater the strains that are created in the bar around the bend. The bend diameters in NZS 3109 have been specified as they have been demonstrated around the world to give a good balance between the need to maintain ductility and provide practical construction solutions. The bend diameter requirements of NZS 3109 are mandatory and they should not be compromised.

### Why limit re-bending to one re-bend?

Each bend and re-bend (straightening) of a bar adds to the residual strains in the bar at the bend. If you bend and straighten a bar twice at the same spot the loss in available ductility will be double that of a singly bent and straightened bar. If you bend and

straighten a bar a number of times in the same spot you will eventually break the bar. If a bar is needed to be bent and straightened multiple times, each bend and re-bend should occur at a different position on the bar to ensure that no one position on the bar is bent and straightened more than once.

### Why should bending be done with one smooth continuous motion?

Bars should never be bent using a jerky motion, or using a hammer. The impact associated with these bending techniques can result in a concentration of stress and strains in the bar, which can cause fracture.

### Why keep the bend 3 bar diameters away from the concrete face?

Keeping the bend away from the concrete face is stipulated to safe guard against accidental bending of the bar at the concrete face. As outlined in section 3.2, the diameter the bar is bent about determines the amount of strain in the bar. If a bar is bent at the concrete face, the strains in the bar can become very large if the bend diameter is small.

### Why should hot bending only be used for micro-alloy reinforcement?

NZS 3109 prohibits the hot bending of quenched and self tempered bars (QST), but allows the hot bending of micro-alloyed bars. To appreciate the reasoning behind this, it is necessary to understand the different processes used to manufacture high strength (Grade 500) reinforcement.

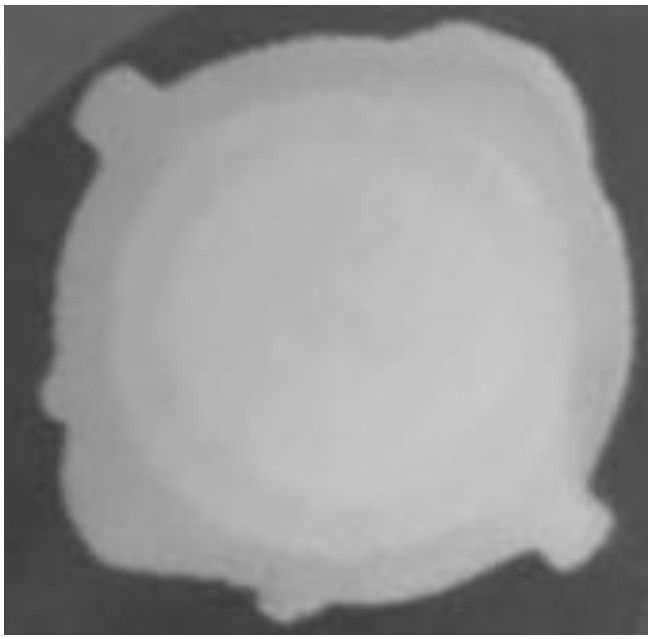

**Figure 6:** QST bar, note the hardened outer surface

When steel is rapidly cooled it becomes stronger but less ductile. In the QST manufacturing process, the surface of the bar is rapidly cooled by water spray as it exits the rolling mill. This cools and hardens the outer surface, which is subsequently tempered by the heat in the core of the bar. **Figure 6** shows an etched cross section of a QST bar. The outer hardened surface can be readily seen.

If a QST bar is heated and then allowed to air cool, the hardened surface will be lost and the strength of the bar will approach that of the core. This loss of strength is the reason for the NZS 3109 restriction on the heating and welding of QST reinforcement.

Micro-alloy bars achieve their high strength by the addition of small amount of alloys. The strength of the bar is not affected by heating, hence heating and welding of micro alloy reinforcement is permitted by NZS 3109.

Heating a bar to "cherry red", has the advantage of relieving the strains within the bar. A bar that is re-bent by heating should maintain all of its available ductility. The reason that Grade 500 reinforcement may only be re-bent using heat is to maintain the available ductility of these bars.

### *How does galvanising affect a bent bar?*

It is recommended that bars be galvanized prior to bending, or if bending before galvanizing is unavoidable, large bend diameters are used to minimize the level of strain. Bars can be embrittled during the galvanising process by absorption of hydrogen atoms during pre-galvanising acid pickling, or by strain aging effects at the elevated temperatures in the galvanising bath. Both of these effects are exacerbated by high levels of work hardening so minimization of strains is sensible.

### Where can I get further information?

Further information on reinforcement can be obtained by contacting the Cement and Concrete Association of New Zealand at www.ccanz.org.nz.

***This Information Bulletin has been sanctioned by Reinforcing New Zealand – the Association of the steel reinforcing industry in New Zealand.***

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