SECTION 23

STEEL REINFORCEMENT DETAILING
23  STEEL REINFORCEMENT DETAILING

23.1  LAYOUT

The layout of a reinforcement drawing shall be in accordance with the principles outlined in Section 22 of this Manual.

Elevations, Plans and Views of bridge components shall be treated as being transparent with the applicable reinforcement details being added.

The prefix “Sectional” shall not be used with any sub-title.

23.2  BAR AND FABRIC DETAILING

The detailing of reinforcement shall be in accordance with the Authority's Manual "Steel Reinforcement Detailing" (Appendix A to this Section).

Irrespective of bar shape, the numbering of reinforcement, whether bars or fabric, shall be in sequential order of bar placement and shall proceed from the bottom to the top of the element under consideration wherever possible and/or practical. Bar marking shall be in accordance with Clauses 2 and 3 of Appendix A to this section.

eg 1 In a pier spread footing, where the bar that is placed closest to the bottom face and placed first, shall be numbered P1 with the next bar being placed being numbered P2, P3 etc

2 In bridge decks where cross girders and/or diaphragms are used, the first bars placed will be in the cross girders or diaphragms as these bars must be placed before the main slab reinforcement. Numbering shall start at D1

The location of reinforcing bars in relation to each other, particularly in connection details such as column to headstock, pile to pilecap and footing to column, should be closely examined to ensure that bars may be easily placed and that concrete compaction in that area can be achieved.

The location of cast-in metal work i.e. dowels, anchor bolts etc. and the location of formed holes shall also be checked to ensure interference is minimised. Where the location of the cast-in item is critical, reinforcement shall be detailed to suit the particular application.

Where interference is of a minor nature only and is not critical e.g. the placing of shear reinforcement, a suitable note to be added to the drawing would be:

"the spacing of . . . . . bars may be adjusted slightly where necessary to clear formed holes and dowels."

Australian Standard bar shapes, as shown in Tables 3.1 (A) and 3.1(B) of AS 1100 Part 501, have been adopted for use along with bar shapes that are commonly used by RTA Bridge Engineering. See RTA Standard Bridge Drawing No RTAB031.

Where the shape of a particular bar does not conform to the “Standard” bar shapes as shown on RTA Standard Bridge Drawing No RTAB031, a “Z” suffix shall be added to the bar shape code with the first non-standard shape being “AZ”. Variations within a particular non-standard bar shape, ie same general shape with different leg lengths, shall be identified
by the use of the next available numerical suffix within that particular bar shape, e.g. “AZ1”, “AZ2”.

Any subsequent non-standard bar shapes shall be numbered 'BZ', 'CZ' etc. and all non-standard shapes shall be clearly defined in the "BAR SHAPES DIAGRAM" so that bending to the correct size and shape can be achieved. Where non-standard bars require fillet bends and hooks, this and any other special features of any non-standard bars shall be specified in the Bar Shapes Diagram.

23.3 DEVELOPMENT AND LAP LENGTHS

23.3.1 General

This Clause provides information on development and lap lengths in common situations.

For information not covered by this Clause refer to AS 5100.5, Section 13.

23.3.2 Development lengths for a bar in tension

Formulae for calculation of development lengths of bars in tension are provided in AS 5100.5, Clause 13.1.

Tables 1 and 2 in Appendix A to this section, contain deemed-to-comply development lengths for Grade D500N bars to develop the full yield strength of the bar including the conditions for their use.

Table 1 contains development lengths of bars in general position, with the exception of bars in a horizontal position with more than 300 mm of concrete cast below the bar. Development lengths for these bars are given in Table 2.

As a general rule, the centre to centre spacing of reinforcement in deck slabs is 150mm, which leaves an approximate clear spacing between the bars of 120mm and in most cases, the splice lengths will need to be calculated separately.

23.3.3 Development lengths for a bar in compression

Development lengths for Grade D500N bars in compression, \( L_{sy,c} \), are given in Table 3 of Appendix A to this section.

The development length of a bar in compression must be straight. A bend or a standard hook are not considered effective in developing stress in reinforcement in compression.

23.3.4 Splicing of reinforcement.

23.3.4.1 General

(i) Where lapped splices are used, the lapped portions of bars shall be in contact.

(ii) Bars in a splice shall provide minimum clear spacing of 1.5 times the diameter of the bar, 1.5 times the maximum nominal size of the aggregate or 40 mm between adjacent parallel bars.

23.3.4.2 Lapped splices for bars in tension
The lap splice length of bars in tension shall be not less than the development length, $L_{sy,t}$, specified in Clause 23.3.2 above.

Tensile reinforcement shall not be spliced at points of maximum stress and not more than 50% of the total area of tensile reinforcement shall be spliced in any section. The following note shall be placed in the General Notes on relevant sheets where reinforcement is detailed.

“Unless shown otherwise on the drawings, laps on adjacent bars on any face shall be staggered (offset) by no less than the lap length”.

Where bars are spliced at points of maximum stress and it is not possible to stagger the splices, the lap length shall be not less than $1.3 \times L_{sy,t}$.

**23.3.4.3 Lapped splices for bars in compression**

For formulae for the length of splices for bars in compression refer to AS 5100.5, Clause 13.2.5.

Lap splice lengths for Grade D500N bars in compression shall, for most applications, be not less than values given in Table 3 of Appendix A to this section.

In cases where the ratio of cross-sectional area of ties, fitments or helixes to the main compression reinforcement exceeds the limits specified in Clauses 13.2.5 (b) and (c) of AS 5100.5, a reduced lap length of 0.8 times the value provided in Table 3 may be applicable.

For identification of bars in compression, the designer may need to be consulted.
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1 INTRODUCTION

Generally, this document has been prepared to conform to the requirements of AS/NZS 1101.501 – Structural Engineering Drawing and Austroads Guide to Bridge Technology – Part 5: Structural Drafting.

Steel reinforcement should be generally detailed as set out in this document and in accordance with the requirements of AS 5100-Bridge Design.

The layout of a reinforcement drawing should follow the procedure set out in Section 22 of the RTA Structural Drafting and Detailing Manual. The elevations, views and plans should be treated as “transparent” and the reinforcement added.

Sub-titles shall be ELEVATION, VIEW and PLAN. The word “Sectional” shall not be used in any title or sub-title.
2. DETAILING OF REINFORCEMENT

A typical example of describing a set of reinforcing bars is:-

Bar mark

A2 14-N16-S-300EF

Information for placing
Spacing of bars along limit line in millimetres
Bar shape code
Bar size in millimetres
Bar structural properties (default grade is D500N)
Number of bars in the set
Bar number in sequence
Structure element denotation

Note:  1. The annotation “mm” is NOT used.
  2. There are NO full stops.
  3. Where possible, the standard bar shapes as shown on RTA Standard Bridge Drawing No RTAB031, shall be used. Where a standard bar shape does not suit the application, a non-standard bar shape shall be created in accordance with Clause 23.2 of the RTA Structural Drafting Manual and Detailing Manual.
  4. A letter should prefix the bar sequence number to aid in detailing bars in various elements of a bridge. For example, “A” could refer to Abutment A, “B” to Abutment B, “P” to piers and “D” to the deck steel.
  5. Where a grade of steel other than D500N (deformed bars, grade 500 steel, normal ductility) is required, the size of bar should be prefixed by a grade designation.

D250N for Grade 250 deformed reinforcing bar, normal ductility
R for plain round reinforcing bar, Grade R250N
W for round reinforcing bar, Grade 500L

Where a Grade 250 deformed reinforcing bar with normal ductility is required, it should be indicated as follows:
A8 14-D250N12-S-300

Other examples include:
A8 14-R12-S-300 (for plain round reinforcing bar, Grade 250N)
A8 14-W10-SP-300 (for plain round reinforcing wire, Grade 500L)
3 NOMENCLATURE

To facilitate use of the method of detailing given in this Manual, the nomenclature given in Figure 3a shall be used.

FIGURE 3a

1 Typical bar
2 Limit line
3 Limit bar - ¶ of BAR or ¶ of a BUNDLE OF BARS
4 Detail line
5 Circle at junction of the typical bar and the limit line
6 Starting dimension to limit bar. Closing dimension is not given, except where non-nominal cover is required. Starting and closing dimensions are necessary when using "EQUAL SPACES" and an approximate dimension for the equal spaces shall be shown.
4. **LINE WEIGHTS**

To obtain uniformity in detailing of reinforcement on drawings the line thicknesses shown in Figure 4a shall be used.

* Use 4mm diameter circle (at Scale 1:1) for bundles of bars.

**FIGURE 4a**
The basic principle of detailing reinforcement is that only ONE TYPICAL BAR, or TYPICAL GROUP of any SET of bars is drawn.

For example, the set of bars shown in Figure 5a would be detailed as shown in Figure 5b.
Figures 5c and 5d show alternative methods for designating the reinforcement. In Figure 5c the bar marking is written on an extension of the limit line, in Figure 5d the bar marking is written directly on the typical bar. However, these methods of detailing should only be considered where overcrowding of the detail would not occur, the preferred method is that which is shown in Figure 5b.
FIGURE 5D

A1 5-N12-S-100EF

A2 7-N12-S-100EF*

A3 8-N12-S-100EF

A4 12-N12-L-100

A5 5-N12-S-100EF*

D1 12-N12-S-100EF

D2 12-N12-L-100

D3 13-N12-S-100

* DENOTES VARIABLE LENGTH BAR
6. **SINGLE BARS OR SETS OF A SMALL NUMBER OF BARS**

Where single bars occur they shall be detailed as shown in Figure 6a.

**FIGURE 6a**

Where a set of a small number of bars occur and space is limited they may be detailed using the most suitable alternative method as shown in Figure 6b.

**FIGURE 6b**

May be used when bars are too close to enclose arrowhead.
NOTE: It may be necessary in some instances to detail all the bars for various reasons, eg:-

a) to ensure that they can be fitted in, OR

b) bars are at an irregular spacing.

Figure 6c shows an example.
When showing bars in elevation do not show bars in section. Figure 6d shows ‘LL’ bars as in section but this is not how they appear in elevation. Figure 6e shows the correct method to use.

**Figure 6e** CORRECT METHOD

PIER ASSUMED

**Figure 6d**

PIER ASSUMED

9 BUNDLES OF P1 2-N28-LL-200 (Indicating 9 bundles of 2 bars)

5 BUNDLES OF P2 2-N28-LL-200 (Indicating 5 bundles of 2 bars)
The term "equal spaces" shall only be used when the spacing of several (say, 7 bars) is to be indicated. Where the spacing of numerous bars, (say, more than 7) needs to be shown and the overall dimension between the limit bars divided by the number of spaces gives a value not ending in 0 or 5, then one of the alternatives shown in Figure 6f shall be adopted.

**ALTERNATIVE 1 (Preferred)**

**ALTERNATIVE 2**

* DIMENSION REQUIRED IF COVER IS NOT NOMINAL

**FIGURE 6f**
7. **NUMBER OF BARS IN A SET**

The number of bars in a set of bars (as shown in Clause 5) is detailed as:-

Bar mark number of bars-bar type bar size-bar shape-spacing

eg A1 14-N12-HT-200

The number of bars for any set of bars, as well as the complete bar description shall be shown once and ONCE ONLY on the drawing, preferably in plan or elevation. When reference is made to the bar in any other view or section, only the bar mark shall be shown.

Typical examples are shown in Figures 7a, 7b, 7c and 7d.

Ideally, the total number of bars should be called up in one or two main views. The remaining views and sections should only be used to show the bar marks and the arrangement of the bars.

(a) **A set of bars**

![Diagram of a set of bars](attachment:image.png)

**FIGURE 7a**
(b) Bundles of bars

When two or more bars are placed side by side (e.g., fittings in a parapet, column, etc.) they shall be called up in bundles and shown by two lines.

![Figure 7b: Bundles of Bars](image)

Note: Where bars are drawn in a bundle a line of thickness of 0.5mm may be used for the typical bars (but not the limit bar).

Not all the bars need to be shown where the number within a bundle exceeds a practical pictorial representation. In this case one or two lines are sufficient to represent the bundle.

Figure 7c shows a bundle of bars in section, Figure 7d shows the set of the same bundles of bars in elevation. Figure 7e shows the correct representation of the bars in elevation.

![Figure 7c: Section](image)  
![Figure 7d: Elevation](image)
In a small area they are detailed as:

- **CIRCLE 4mm**
- **A2 2-N16-A-200**

Allow 1.5mm between bars for clarity. Allowing for scaling eg Scale 1:20 allow 30mm between bars.

**FIGURE 7e: CORRECT METHOD**

Where there are several sets of bars or bundles of bars in a small area they are detailed as:-

- **10 BUNDLES OF A1 1-N16-HT-200, A2 2-N16-A-200**

**FIGURE 7f: ALTERNATIVE METHOD**

- **A1 10-N16-HT-200, A2 2-N16-A-200**

**FIGURE 7g**
Drawings on which reinforcement is detailed shall contain a note which states the required cover to the reinforcement. Where there is a suite of drawings to depict an element within a set of drawings, the note shall be provided on one sheet only.

Example:-

"Nominal cover to reinforcement nearest to the concrete surface shall be 50mm, unless specified otherwise."

Figure 8a shows the method of detailing cover on the drawings, where such detailing is necessary.
9. **LAPS IN REINFORCEMENT**

Straight laps in reinforcement are detailed as shown in Figures 9a and 9b.

**FIGURE 9a:** First preference

**FIGURE 9b:** Alternative method

The length of lap should only appear on the drawing, as shown in Figures 8a and 8b, if not covered in the General Notes.
Laps need not be shown unless they are required in a specific location. In this case different bar marks should be shown.

a) When lap location does not matter.

```
MAXIMUM LENGTH OF BAR*
```

```
D1
```

**FIGURE 9c: Incorrect method**

```
MAXIMUM LENGTH OF BAR*
```

```
D1
```

**FIGURE 9d: Correct method**

b) Where specific location of laps is required.

```
MAXIMUM LENGTH OF BAR*
```

```
D1
```

```
GIVE DIMENSION
```

```
D2
```

**FIGURE 9e**

**OR**

```
MAXIMUM LENGTH OF BAR*
```

```
D1 ('x' LONG)
```

```
D2
```

**FIGURE 9f: Preferred**

*As shown in Clause 18.3 of the RTA Structural Drafting and Detailing Manual*
c) Where bars of different diameter lap, the required lap length shall be shown (the lap length being that required for the smaller sized bar).

![Figure 9f](image)

Lap lengths for various size bars that are lapped on a drawing should be shown in General Notes.

Acceptable minimum lap lengths are set out in Tables 1, 2 and 3 on pages 37 and 38.

Where laps in longitudinal bars are not detailed eg in deck slabs, the following notes shall appear in the General Notes.

**UNLESS SHOWN OTHERWISE ON THE DRAWINGS, LAPS ON ADJACENT BARS ON ANY FACE SHALL BE STAGGERED (OFFSET) BY NO LESS THAN THE LAP LENGTH.**

**UNLESS OTHERWISE SPECIFIED, THE MINIMUM DEVELOPMENT LENGTHS AND LAP LENGTHS SHALL BE AS FOLLOWS:**

<table>
<thead>
<tr>
<th>BAR SIZE (mm):</th>
<th>10</th>
<th>12</th>
<th>16</th>
<th>20</th>
<th>24</th>
<th>28</th>
<th>32</th>
<th>36</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) HORIZONTAL BARS WITH &gt;300mm OF CONCRETE CAST BELOW THE BAR:</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>b) OTHER BARS:</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

*DENOTES VARIABLE LENGTH BAR.

GIVE VALUES AS APPLICABLE (See AS 5100.5-Clause 13.1)
The development length of reinforcement for any bars which are anchored in concrete (as distinct from laps) shall be indicated on the drawings only if different from that shown in the table. Acceptable minimum development and lap lengths are set out in Tables 1, 2 and 3 on pages 37 and 38 of this document.
11. DETAILING REINFORCEMENT IN SECTIONS

Examples of reinforced concrete members are given in Figures 11a, 11b and 11c.

The following is to be noted:-

(i) Bars in section (shown as filled in circles) are indicated by arrows when designating the bar mark. Bars should be approximately in proportion with the scale of drawings.

(ii) Fitments and other bars shown as a line in section, are indicated by a circle when designating the bar mark.

(a) When all bars in section are of the same mark

Note: Sufficient dimensions for the spacing of the reinforcement are necessary in this section to permit dimensions of fitments to be calculated. Dimensions are necessary where bars would foul dowel locations or recesses, etc.
(b) More than one bar mark in a section

This method may be used where there are only one or two bars of the same mark.

Showing the number of equal spaces is optional.
FIGURE 11c
12. **LAYERS OF REINFORCEMENT**

Where layers of reinforcement are to be detailed, as in the faces of deck slabs or walls, the abbreviations used to denote reinforcement placement information shall be in accordance with AS/NZS 1100.501 – Table 3.2.

It is not necessary to explain the denotations NF etc. in the General Notes, as they are included in Australian Standard terminology. An example of usage is given in Figure 12a.

Note: In Figure 12a the number of bars shown in the notation “A2 11-N12-S-150EF” applies to each face. Therefore, the total number of A2 bars is 22.
Where bars such as 'LL' bars are to be placed at near and far faces at equivalent spacing, the upper bars cannot be placed directly over corresponding lower bars. This being due to side legs lapping. In this case it is generally sufficient to show one typical bar to cover both upper and lower bars, as shown in Figure 12b.

**Figure 12b**
If bars on the near face and the far face are of different length or shape, then it is necessary to detail each layer separately. Figure 12c shows the detailing of bars of different length or shape.
Sometimes it may be necessary to detail more layers of reinforcement than those on near face and far faces, eg deep pile caps. In this case layers shall be numbered as shown in Figure 12d.

**PLAN**

**SECTION 1**

- **P1** 19-N28-S-150NF1, FF1
- **P3** 10-N24-SP-300NF2, NF3, FF2

**PLAN**

**FIGURE 12d**
13  **SPACING OF BARS**

Spacing of bars shall be as required by AS 5100.5.

Minimum spacing centre to centre of parallel bars shall be 2.5 times the diameter and the clear distance shall be not less than 1.5 times the size of the aggregate.

Maximum spacing of temperature and shrinkage reinforcement shall be 200mm for φ12 bars and 300mm for φ16 bars.

Considerable thought should be given to:-
   a) Ease of placing bars
   b) Ensuring that bars can fit where they are supposed to be placed. (Large scale details may be of assistance.)
   c) Fitment type bars have a thickness of 2 diameters where ends overlap at hooks.
   d) The deformations on deformed bars, see Figure 13a.

![Deformed bar](image)

**HEIGHT RANGE (h) OF DEFORMATIONS**

<table>
<thead>
<tr>
<th>BAR SIZE</th>
<th>HEIGHT</th>
<th>BAR SIZE</th>
<th>HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.5-1.0</td>
<td>28</td>
<td>1.4-2.8</td>
</tr>
<tr>
<td>12</td>
<td>0.6-1.2</td>
<td>32</td>
<td>1.6-3.2</td>
</tr>
<tr>
<td>16</td>
<td>0.8-1.6</td>
<td>36</td>
<td>1.8-3.6</td>
</tr>
<tr>
<td>20</td>
<td>1.0-2.0</td>
<td>40</td>
<td>2.0-4.0</td>
</tr>
<tr>
<td>24</td>
<td>1.2-2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 13a - Deformed bars**

   e) Providing sufficient access between bars to place and vibrate concrete - ESPECIALLY WHERE BARS ARE LAPPED.

Concrete pump hoses require an access of 125mm x 125mm, however 200mm x 200mm is desirable to accommodate other discharge tubes etc. These access holes should be spaced at no more than 1500mm centres. Preferably these access holes should continue to the soffit. Vibrator access of 60mm x 60mm at 750mm centres should be provided.
f) The location of starter bars in columns should be clearly defined to facilitate lapping with main vertical reinforcement.

g) The arrangement of bars at connections such as piles to pile-caps, columns to headstocks etc. should be checked to ensure no clashes take place.

h) Where cast-in items, eg bolts and dowels, or formed recesses are incorporated, check that bars clear these items.

i) In post-tensioned work special attention should be paid to bars in end-block areas. Every effort should be made to ensure bars fit without clashing and sufficient room is allowed for placing and vibrating concrete.

j) Where closely spaced bars need to be spliced, thought should be given to cranking bars or double splicing so continuing bars shall have the same location. See Figure 13b.

![Diagram of Double Splice and Cranked Bar]

**FIGURE 13b – Types of bar splices**
14. **REINFORCING FABRIC**

Reinforcing fabric is detailed as shown in Figures 14a and 14b. The reference numbers and other details of the fabric are given in AS/NZS 4671.

(a) **Rectangular or square shaped fabric**

![Diagram of rectangular or square shaped fabric with reference numbers and details](image)

Note: Show cross section of the fabric for non-symmetrical shapes in the Bar Shapes Diagram.

(b) **Trapezoidal shaped fabric**

![Diagram of trapezoidal shaped fabric with reference numbers and details](image)

**FIGURE 14b**
15. LAPPED SPLICES FOR REINFORCING FABRIC IN TENSION

A lapped splice for reinforcing fabric in tension shall be made so that the two outermost transverse bars of one sheet of fabric overlap the two outermost transverse bars of the sheet being lapped as shown in Figure 15a.

![Figure 15a](image)

\[ a) \ s_1 = s_2 \quad b) \ s_1 < s_2 \]

FIGURE 15a - LAPPED SPLICES FOR REINFORCING FABRIC

16. DETAILING LARGE AREAS OF REINFORCEMENT

When detailing large areas of reinforcement and it is impractical to show the plan and/or elevation in full (e.g. continuous decks), there are several options which can be considered:

a) The drawing may be drawn not to scale. This is done in order to present a pictorial view of the reinforcement. Although the drawing is 'not to scale', thought should be given to keeping the drawing in reasonable proportion to actual dimensions.

b) The drawing may be drawn to scale but with break lines. These should be kept to a minimum (say, two or three). Where a drawing necessitates more break lines, consideration should be given as outlined in Option 'c'.

c) The use of match lines. Larger areas are drawn in full but are split into more than one part.
17. **CONCRETE DETAILING**

In more complex reinforced concrete elements such as abutments, it is preferable to show concrete dimensions on a separate view to that showing the reinforcement detail.

On simple details the concrete dimensions and reinforcement details can be shown on the same view.

18. **ARRANGEMENT OF REINFORCEMENT**

The clear arrangement of reinforcement in a view or section is important. A little thought in detailing the reinforcement will ensure a clear picture of the layout of the bars.

Reinforcement shall be numbered from the 'bottom' up in sequential order of placement i.e. the first bar placed, irrespective of shape, shall be P1 with the next bar placed being P2 etc.

Figure 17a shows an example of a badly detailed section. Figure 17b shows the same section redetailed in a more orderly fashion.
CONSTRUCTION JOINT

VARIABLE LAP
350 min

NOT ACCEPTABLE

FIGURE 17a

ACCEPTABLE

FIGURE 17b
19.1 Reinforcing Bar
Reinforcing bars are available as either deformed ribbed (D), deformed
Indented (I) or plain round bars (R) to AS/NZS 4671.
The standard bar sizes are:

Deformed bars:– 10, 12, 16, 20, 24, 28, 32, 36 and 40mm diameter

Plain round bars:– 6, 10, 12, 16, 20, 24, 28, 32 and 36 mm diameter

Small diameter bars, both deformed ribbed and plain round, may be
hard drawn into bars of smaller diameter for use in the manufacture of
reinforcing mesh. Such bars are commonly referred to as hard drawn wire.

19.2 Stocking of Reinforcing Bars

The lengths of Grade D500N deformed reinforcement bars normally
stocked by suppliers in Australia are shown in the table below.
Grade R250N plain reinforcing bars are available in 6 metre lengths only.

<table>
<thead>
<tr>
<th>BAR SIZE (mm)</th>
<th>LENGTH (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade D500N</td>
<td>6  9  10  12  15  18</td>
</tr>
<tr>
<td>Ø10</td>
<td></td>
</tr>
<tr>
<td>Ø12</td>
<td></td>
</tr>
<tr>
<td>Ø16</td>
<td></td>
</tr>
<tr>
<td>Ø20</td>
<td></td>
</tr>
<tr>
<td>Ø24</td>
<td></td>
</tr>
<tr>
<td>Ø28</td>
<td></td>
</tr>
<tr>
<td>Ø32</td>
<td></td>
</tr>
<tr>
<td>Ø36</td>
<td></td>
</tr>
<tr>
<td>Ø40</td>
<td></td>
</tr>
</tbody>
</table>
Clear Spacing at Laps

Where laps in reinforcement are staggered, the clear spacing used in calculations for required lap lengths shall be "S" as shown in Figure 20a.

![Figure 20a]

Where laps in reinforcement are not staggered, the clear spacing used in calculations for required lap lengths shall be "S" as shown in Figure 20b.

![Figure 20b]
The figures given in Table 1 on Page 37 are based on the minimum cover to the bar or fitment.
For calculation purposes, the actual cover to the bar being lapped, as shown in Figure 20a, shall be used.

**FIGURE 21.a**
DEVELOPMENT LENGTH FOR A BAR IN TENSION

The development length \( L_{sy,t} \), to develop the yield strength \( f_{sy} \) of a deformed bar in tension shall be calculated as follows:

\[
L_{sy,t} = \frac{k_7 k_8 f_{sy} A_b}{(2a + d_b) \sqrt{f'_c}}
\]

Where

- \( k_7 = 1.25 \) for a horizontal bar with more than 300mm of concrete cast below the bar
- \( k_7 = 1.0 \) for all other bars
- \( k_8 = 1.7 \) for bars in slabs and walls if the clear distance between adjacent parallel bars developing stress is not less than 150mm
- \( k_8 = 2.2 \) for longitudinal bars in beams and columns with fitments
- \( k_8 = 2.4 \) for any other longitudinal bar

\( A_b \) = cross-sectional area of the reinforcing bar

\( 2a \) = twice the minimum cover to the deformed bar or the clear distance between adjacent parallel bars developing stress, whichever is less.

Minimum cover is nominal cover minus a fixing tolerance of 5mm.

\( L_{sy,t} \) shall not be less than \( 25k_7 d_b \)

LAPPED SPLICE LENGTH FOR A BAR IN COMPRESSION

The minimum length of a lapped splice for deformed bars in compression \( L_{sy,c} \) shall be calculated as follows:

\[
L_{sy,c} = (0.125f_{sy}-22)d_b \text{ for } f_{sy} \text{ greater than 400MPa}
\]

but \( L_{sy,c} \) shall not be less than 300mm
## TABLE 1

**TENSILE DEVELOPMENT LENGTHS (L_{sy,t}) FOR DEFORMED BARS - GRADE 500N - GENERAL BARS**

<table>
<thead>
<tr>
<th>Combination of Minimum Values</th>
<th>L (mm)</th>
<th>Bar Size</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>12</td>
<td>16</td>
<td>20</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>36</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F'c MPa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 50</td>
<td>250</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td>750</td>
<td>950</td>
<td>1150</td>
<td>1400</td>
<td></td>
</tr>
<tr>
<td>40 50</td>
<td>250</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>650</td>
<td>850</td>
<td>1100</td>
<td>1300</td>
<td>1600</td>
<td></td>
</tr>
<tr>
<td>32 45</td>
<td>250</td>
<td>300</td>
<td>400</td>
<td>550</td>
<td>750</td>
<td>950</td>
<td>1200</td>
<td>1500</td>
<td>1750</td>
<td></td>
</tr>
<tr>
<td>25 35</td>
<td>250</td>
<td>300</td>
<td>550</td>
<td>800</td>
<td>950</td>
<td>1250</td>
<td>1600</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>40 25</td>
<td>300</td>
<td>400</td>
<td>650</td>
<td>900</td>
<td>1200</td>
<td>1500</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>50 25</td>
<td>300</td>
<td>400</td>
<td>650</td>
<td>900</td>
<td>1200</td>
<td>1500</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
</tbody>
</table>

NR Denotes not recommended

Values above the double line are governed by L_{sy,t} is greater than or equal to 25d_b.

Intermediate values of L_{sy,t} shall not be interpolated.

The development length L_{sy,t} given in Tables 1 and 2 shall be deemed to comply with Clause 13.1.2.1 of AS 5100.5 provided that the following conditions are met:

(i) In slabs and walls, the clear distance between adjacent parallel bars developing stress shall not be less than 150 mm.

(ii) For beams and columns, fitments are provided and the clear distance between bars shall not be less than twice the nominal cover.

(iii) The minimum bar size for fitments shall be 6 mm for bars ≤20 mm and 10 mm for bars > 20 mm.

(iv) Allowances, such as for casting against ground, shall not be included in the nominal cover for the purpose of determination of development lengths.
TABLE 2
TENSILE DEVELOPMENT LENGTHS ($L_{sy.t}$) FOR DEFORMED BARS - GRADE 500N - TOP BARS

<table>
<thead>
<tr>
<th>Combination of Minimum Values</th>
<th>L (mm) Bar Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_c$ MPa</td>
<td>10</td>
</tr>
<tr>
<td>40 50</td>
<td>350</td>
</tr>
<tr>
<td>40 50</td>
<td>350</td>
</tr>
<tr>
<td>32 40</td>
<td>350</td>
</tr>
<tr>
<td>32 50</td>
<td>350</td>
</tr>
<tr>
<td>40 50</td>
<td>400</td>
</tr>
<tr>
<td>25 50</td>
<td>400</td>
</tr>
</tbody>
</table>

NR Denotes not recommended
Values above the double line are governed by $L \geq 1.25 \times 25 \, d_b$
Intermediate values of $L_{sy.t}$ shall not be interpolated

Where a bar ends with a standard hook or cog complying with Clause 13.1.2.6 of AS5100.5, the development length at that end of the bar measured from the outside of the hook or cog shall be taken as $0.5 \, L_{sy.t}$.

TABLE 3
DEVELOPMENT AND LAP LENGTHS FOR GRADE D500N BARS IN COMPRESSION

<table>
<thead>
<tr>
<th>L (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAR SIZE</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>240</td>
</tr>
<tr>
<td>DEVELOPMENT LENGTH (20d_b)</td>
</tr>
<tr>
<td>500</td>
</tr>
</tbody>
</table>
# TABLE 4
## BAR MASSES

<table>
<thead>
<tr>
<th>BAR SIZE (mm)</th>
<th>10</th>
<th>12</th>
<th>16</th>
<th>20</th>
<th>24</th>
<th>28</th>
<th>32</th>
<th>36</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>MASS (kg/m)</td>
<td>0.617</td>
<td>0.888</td>
<td>1.58</td>
<td>2.47</td>
<td>3.55</td>
<td>4.83</td>
<td>6.31</td>
<td>7.99</td>
<td>9.86</td>
</tr>
</tbody>
</table>