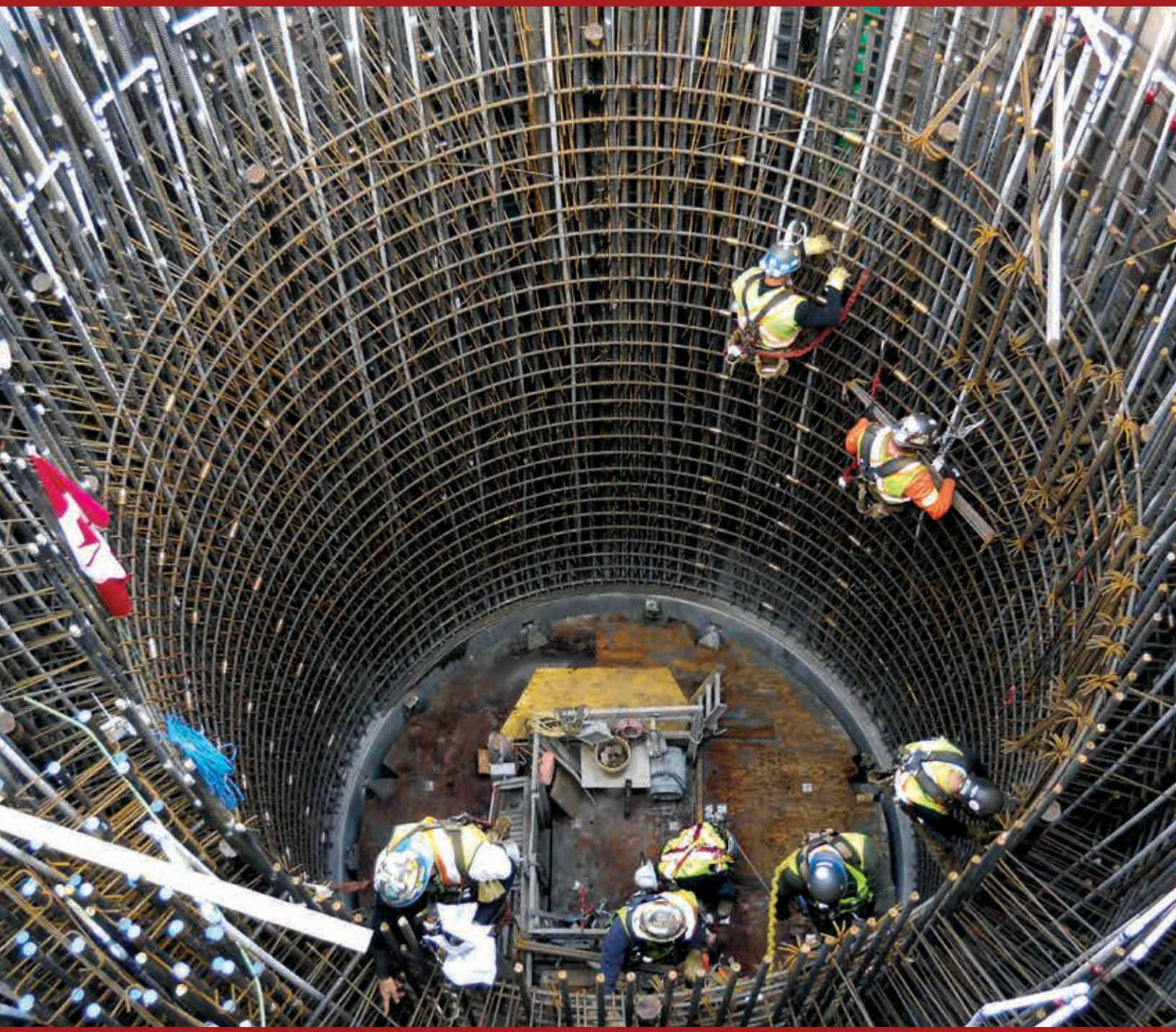
MANUAL OF STANDARD PRACTICE



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REINFORCING STEEL INSTITUTE OF CANADA
INSTITUT D'ACIER D'ARMATURE DU CANADA

Preface

REINFORCING STEEL - MANUAL OF STANDARD PRACTICE

Fifth Canadian Edition 2020 Edited and
Published by the Members of
The Reinforcing Steel Institute of Canada

The main objective for the continued development of this Reinforcing Steel Manual of Standard Practice is to ensure that methods and procedures in our industry remain consistent across Canada.

The acceptance shown by Architects, Engineers, General Contractors, Educational Institutions, Fabricators and Placers from across Canada of previous editions of this manual has been gratifying. Care has been taken with this edition to recognize and incorporate the constructive comments we have received from these people.

The intent of this manual is to provide assistance to the Designer and is not intended to substitute the experience of an Architect/Engineer as to the best way of achieving specific design requirement.

The information contained herein is accurate, up-to-date and correct at the time of publication. The R.S.I.C. assumes no responsibility for and shall not be held liable in any way for any loss, damage, injury or expense, howsoever caused, arising out of any error or omission of any form in this manual, or arising out of any misinterpretation or misuse of any information contained in this manual.

FIFTH EDITION 2020-V4

Comments From The Chairperson

Over 3,ooo hours of volunteer time by the Technical Committee has contributed to this outstanding 5th Edition of the RSIC, Manual of Standard Practice 2020.

A debt of gratitude and my thanks go to each of the members for their unwavering efforts and contribution to this document.

This Manual provides an invaluable resource for the Reinforced Concrete Industry in supplying, designing, engineering, fabricating and placing Reinforcing Steel and clearly describes and illustrates the industry's best practices.

Many thanks to the committee and those involved in making this Manual possible.

Roger Hubbard - Chair	AMJ Enterprises Ltd.
Emin Buzimkic	Rebar Enterprises Inc.
Sam Costa	Mateenbar
Rick Dozzi	Canadian BBR
Andrew Oliver	Harris Rebar
Maryam Rezaie	AGF Rebar
Peter Spatola	Harris Rebar
Sean Van Rassel	Dayton Superior

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Glossary and Abbreviations

Accessories

Miscellaneous items used to facilitate the installation of reinforcing steel.

Architect

The person or company who architecturally designs the structure and can also act as the owner's representative.

Band

Group of bars distributed in a slab or wall. (See Strips)

Bar

Abbreviated term for Reinforcing Steel Bar.

Bar List

List of bars indicating such things as: mark, quantity, size, length and bending details.

Bar Mark

Alpha-numeric code identifying bar; for reinforcing bars and bar lists to drawings.

Bar Spacing

Distance between parallel reinforcing bars measured from centre-to-centre.

Bar Supports and Bar Spacers

Devices used to support, hold and space reinforcing bars within the formwork.

Beam

Horizontal structural member carrying vertical loads.

Beam Bolster

Wire or plastic bar support used to support steel reinforcement in the formwork for a reinforced concrete beam.

Beam Schedule

Table giving the quantity, size and mark number of beams and the required reinforcing steel.

Bent Bar

A reinforcing bar bent to a prescribed shape such as a truss bar, straight bar with end hook, stirrup, or column tie.

Billet

The semi-finished piece of steel from which the reinforcing steel is rolled.

Bond

Holding or gripping force between reinforcing steel and concrete. See Development Length.

Bond Beam

A course or courses of a masonry wall grouted and reinforced in the horizontal direction with reinforcing bars.

Bundled Bars

A group of not more than four parallel bars in contact with each other.

Butt-Welded Splice

Reinforcing bar connection made by welding the butted ends of the reinforcing bars.

Buyer

The person, company, government, authority etc., who is purchasing the product and/or service.

Caisson

A cast-in-place pier, usually extending down to solid earth or rock.

Can

Is used to express possibility or capability.

Cantilever

That part of a structure extending freely beyond the support.

Chamfer

An outside bevel on the exposed edge of a concrete member.

Column

Vertical member supporting a slab, beam, girder or other member.

Column Capital

Upper flared section on columns.

Column Horses

Two or more sets of supports used to hold longitudinal reinforcement in position for placing stirrups/ties while prefabricating column, beam or pile cages.

Column Schedule

Table giving the quantity, size and mark number of columns and the required reinforcing steel.

Compression Bars

Steel used in concrete members to resist compressive forces.

Concrete Cover

The distance from the face of the concrete to the face of the reinforcing bars.

Construction Joint

The line dividing concrete pours placed at different times.

Construction Schedule

Table showing by date the progression of the project.

Continuous Beam

A beam which extends over three or more supports.

Deformed Bar

Bar having ridges in various patterns. These ridges increase the bond between steel and concrete.

Detailer

The person or company who prepares the reinforcing steel placing drawings and a list of materials from the plans and specifications.

Development Length

Length of bar embedment required to fully transfer stress from the bar to the concrete.

Dowels

Short bars connecting two pours of concrete through a construction joint.

Drop Panel

The thickening of the slab in the area adjacent to a column for deflection control, extra shear strength, or extra depth.

Embedment Length

The length of embedded reinforcement provided beyond a critical section.

Epoxy Coated Rebar

A coating applied to rebar to resist corrosion.

Estimator

The person or company who prepares a quantity takeoff and cost estimates of the project from the plans and specifications.

Expansion Joint

A joint which allows free movement between two adjacent sections of concrete.

Fabricating

Shop work on the reinforcing steel, such as cutting, bending, bundling and tagging.

Fabricator

The person or company that is responsible for the supply, cutting and bending of reinforcing steel.

Far Face

A term used by the Detailer to locate the reinforcing steel; the face of the component farthest from the viewer.

Flat Slab Floor Construction

The floor slab generally being of constant depth throughout, except for lintels or drop panels.

Flat Plate Slab

A flat slab without drop panels or column capitals.

Footings

Supporting elements of a building which rest directly on the soil or supporting earth.

Form

A mold in which the concrete is placed, and which dictates the final shape.

Glossary and Abbreviations

Foundation

Substructure through which the loads are carried to the earth, rock or piles.

Galvanized Reinforcing Bars

Reinforcing bars with a protective zinc coating.

General Contractor

The person or company selected by the owner or the project manager to construct the proposed project.

Girder

A horizontal structural member (beam) used as a main horizontal support in a building/bridge.

Grade of Steel

A designation of the strength properties of the steel which is used in the structural design.

Grout in Dowels

Bars that are placed in drilled holes and chemically anchored in existing concrete.

Haunch

Portion of a beam that increases in depth towards the support.

Headed Bar

It is a large disc attached to the end of a length of reinforcing steel, creating anchorage within the concrete.

Heavy Bending

Bar sizes 15M through 55M that are bent at not more than six points in one plane and single radius bending.

Hook

A 90°, 135° or 180° bend in rebar having a specified radius of bend, and a specified extension of a certain number of bar diameters at the free end of the bar.

Keys

Slotted joints in concrete - such as tongue and groove.

Lap Splice

The joining of two reinforcing bars by placing them side by side for a specified length.

Light Bending

All 10M bars, stirrups, hoops, supplementary ties, and ties, and all bars 15M through 55M that are bent at more than six points in one plane, or bars that are bent in more than one plane or bent with more than one radius.

Lintel

Beam over and spanning a window or door opening, to support the wall above.

Low-Density Concrete

Concrete with a 28 day compressive strength in excess of 20 MPa and an air dry density not exceeding 1858 Kg/m3.

May

Is used to express an option or that which is permissible within the limits of the standard.

Mechanical Coupler

A mechanical device for joining reinforcing bars for the purpose of providing transfer of either axial compression or axial tension or both from one bar to the other.

Mill Scale

The scale that forms on steel when cooling from rolling temperature.

Monolithic

Concrete cast in one continuous operation.

Near Face

A term used by the Detailer to locate the reinforcing steel; the face of the component nearest to the viewer.

Nominal Diameter

The diameter of a deformed reinforcing bar that has the same weight per linear metre as a plain round bar.

Glossary and Abbreviations

Normal-Density Concrete

Concrete with a 28-day compressive strength in excess of 20 MPa and an air-dry density between 2150 and 2500 kg/m3.

Parapet

Extension of the outside wall above the roof line or floor level.

Pedestal

Short pier on plinth used as a base for a column.

Pier

A column or wall used as a foundation member.

Pilaster

Column embedded in a wall.

Pile

Reinforced concrete, steel or wood column driven or placed into the ground as part of the foundation.

Pile Cap

Block of reinforced concrete on top of a pile or group of piles to distribute the load to the piles.

Pitch

Centre-to-Centre spacing between turns of a spiral.

Placing Drawings

Detailed drawings which give the size, location and spacing of bars and all other information required by the Placer.

Owner

The person, company, government, authority, etc., who owns the structure or proposed structure.

Placer

The person or company responsible for the installation of the reinforcing steel on the project.

Plinth

A base or platform on which a column, pedestal, beam or structure rests.

Positional Coupler

A mechanical device used in applications where neither bar can be moved or rotated.

Post-Tensioning

A method of pre-stressing concrete after it has reached strength.

Precast Concrete

Concrete members cast elsewhere than their final position in the structure.

Project Manager

The person or company selected by the owner to oversee the construction team.

Radius Bend

Reinforcing bars bent to a radius larger than that specified for standard hooks; a bar curved to fit into circular walls, as the horizontal bars in a silo.

Rebar

Abbreviated term for Reinforcing Steel Bar.

Reinforced Masonry

Masonry containing reinforcing steel that acts together compositely with the other masonry components in resisting forces.

Reinforcing Steel Bar

Deformed steel bars used in the reinforcing of concrete.

Retaining Wall

Structural wall to hold or retain earth, fluid or granular material.

Rodmen Collective Agreement

The current Rodmen Collective Agreement that is in effect, and under the terms of which the union Placing Contractor must hire his Rodmen to place the rebar.

Schedule

Table showing size, shape and arrangement of a number of variations of similar items. See Beam Schedule, Column Schedule.

Section

View, usually at right angles to the plan view, or through part of a structure to explain or show certain details.

Shall

Is used to express requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard.

Shear

Two equal opposed forces.

Shear Reinforcement

Reinforcement designed to resist shearing forces; usually consisting of stirrups bent and located as required.

Shear Head

Assembled unit in the top of the columns of flat slab or flat plate construction to transmit loads from slab to column.

Shear Wall

A wall in a building designed to resist horizontal forces such as wind, blast or earthquake.

Should

Is used to express recommendation or that which is advised but not required.

Simple Beam

Beam that is supported at two points and is not continuous.

Skewed

At an angle other than 90°.

Slab

Flat section of floor or roof, either on the ground, or supported by beams, walls or columns.

Slab Band

A continuous extension of a drop panel between supports or between a support and another slab band.

Slab Bolster

Wire or plastic bar support used to support bottom slab reinforcing bars.

Slab Schedule

Table showing the reinforcement for each slab.

Span

The horizontal distance between supports of a member such as a beam, girder, slab or joist.

Spandrel Beams

A beam at the exterior edge of a structure.

Special Bending

All bending to special tolerances, all radius bending in more than one plane or more than one radius, bending bars to less than recommended radius, and all bending for precast units.

Spiral

Continuously coiled reinforcing bar or wire.

Spiral Column

A column reinforced with longitudinal bars with a continuous spiral encircling them.

Spiral Spacer Bars

Bars, usually made from angle or flat bar, punched to form hooks which carry the coiled spiral loops to maintain a prescribed pitch.

Splice

Joining of one bar to another by lapping, welding, or mechanical coupling.

Staggered Splices

Joining of one bar to another by lapping it in a manner to obtain offsetting lap locations.

Stainless Steel Rebar

Stainless steel rebar contain Molybdenum (Mo) alloys which improve corrosion resistance.

Steel Mill

The company who produces reinforcing steel.

Stirrups

Reinforcing bars bent in a rectangular or U shape and placed perpendicular to the longitudinal bars in beams.

Strips

Bands of reinforcement steel in flat slab or flat plate construction.

The column strip is a quarter-panel wide each side of the column centre-line, and runs either way of the building, from column to column.

The middle strip is half a panel in width, filling in between, and running parallel to the column strips to fill in the centre part of the panel.

Structural Drawings

Design drawings showing all framing plans, sections, details and elevations required for construction. They also include the sizes and general arrangement of reinforcement from which the Fabricator prepares placing drawings.

Structural Engineer

The person or company who designs and prepares drawings for the structural elements of a project.

Subcontractor

The person or company selected by a Contractor for a specific element of the project.

Support Bars

Bars resting upon individual chairs to support bars in slabs or joists.

Temperature Bars

Bars distributed throughout the concrete to minimize cracks due to temperature changes.

Template

A device used to locate and hold dowels.

Tensile Strength

The stress at which a bar ruptures; also called ultimate tensile strength.

Tie Wire

Annealed wire used to secure intersections of reinforcing bars for the purpose of securing them in place.

Tied Column

Vertical member, reinforced with longitudinal bars and individual lateral ties.

Ties

Small-size reinforcing bars usually bent in the form of a rectangle to encircle and confine vertical bars in columns or walls.

Tolerance

Allowable variation from a given dimension or position.

Tonne

1000 kg

Transitional Coupler

A mechanical Coupler used to connect bars of different diameters.

Typical Floors

Floors with the same distribution pattern and size of reinforcing, and the same dimensions as to beam layout, slab layout, column spacing, etc.

Upturned Beam

Concrete beam which extends above the slab or structure it is supporting.

Waffle Slab

A two-way reinforced concrete joist floor, with ribs running in both directions.

Welded Splice

A means of joining two reinforcing bars by electric arc welding.

Yield Strength

The stress at which the reinforcing steel exhibits plastic, rather than elastic behavior.

Zone Reinforcing

Concentrated reinforcing bar generally located in walls to resist the splitting of concrete.

Glossary and Abbreviations

Abbreviations

ADD'L / ADD - Additional

ALT / ALTN - Alternate

B / BOT - Bottom

BEW - Bottom Each Way

BLDG - Building

BLL - Bottom Lower Layer

BLW - Bottom Long Way

BM - Beam

BML - Bottom Middle Layer

BOF - Bottom Of Footing

BS - Both Sides

BSMT - Basement

BSW - Bottom Short Way

BT - Beam Tie

BTWN - Between

BUL - Bottom Upper Layer

BW - Both Ways

C - Coated

C/C - Centre To Centre

CA - Column Above

CANT - Cantilever

CB - Column Below

CIP - Cast In Place

CJ - Construction Joint

CL - Centre Line

CLJ - Control Joint

CLR - Clearance / Clear Spacing

CMU - Concrete Masonry Unit

COL - Column

COMP - Compression

CONC - Concrete

CONC. DIM - Concrete Dimension

CONT. - Continuous

CTR'D - Centered

CTS - Cut To Suit

D - Depth

DBL - Double

DET - Detail

DIA - Diameter

DIAG - Diagonal

DIM - Dimension

DL / DEV - Development Length

DN - Down

DWG - Drawing

DWL - Dowel

EA - Each

ECR - Epoxy Coated Reinforcement

EE - Each End

EF - Each Face

EJ / EXP.JT. - Expansion Joint

EL - Elevation

EMBED - Embedment

EQ - Equal

EW - Each Way

E-W - East-West

EX / EXIST - Existing

EXT - Exterior

FDN - Foundation

FF - Far Face

Glossary and Abbreviations

FF / F. FL - Finished Floor

FL - Floor

FOC - Face of Concrete

FOW - Face of Wall

FRP - Fiber Reinforced Polymer

FS - Far Side

FTG - Footing

G / GALV - Galvanized

GA - Gauge

GB - Grade Beam

GC - General Contractor

GFRP - Glass Fiber Reinforced Polymer

GL - Grid Line

GID - Grout In Dowels

H / HK (HKS) - Hook (Standard Hook)

H / HOR - Horizontal

HDG - Hot Dipped Galvanized

HEF - Horizontal Each Face

HFF - Horizontal Far Face

HH / H2E - Hook Each End / Hook Both End

HIF - Horizontal Inside Face

HOC - Horizontal On Centre

HNF - Horizontal Near Face

HOF - Horizontal Outside Face

IF - Inside Face

IJ - Isolation Joint

INFO - Information

INT - Interior

IR - Integrity Reinforcement

JT - Joint

Ld - Tension Development Length

LE - Left End

LG - Long

LL - Lower Layer

LONG - Longitudinal

LVL - Level

LW - Long Way

MAX - Maximum

MC / MECH. - Mechanical

MEZZ - Mezzanine

MIN - Minimum

MISC - Miscellaneous

ML - Middle Layer

NA - Not Applicable

NBC - National Building Code Of Canada

NF - Near Face

NIC - Not In Contract

NO. - Number

NS - Near Side

N-S - North-South

NTS - Not To Scale

O/C - On Centre

O/O - Out To Out

OBC - Ontario Building Code

OF - Outside Face

OPNG - Opening

OPP - Opposite

PC - Precast Concrete

P/T or PT - Post Tensioning

R/W - Reinforced With

Glossary and Abbreviations

RC - Reinforced Concrete

RE - Right End

REF - Reference

REINF - Reinforcement

REQ / REQ'D - Required

REV - Revision/Revised

RSIC - Reinforcing Steel Institute Of Canada

RW / RET.W - Retaining Wall

SB - Support Bars

SC/1 - Saw Cut One End

SC/2 - Saw Cut Two Ends

SCHED - Schedule

SDF - Step Down Footing

SECT - Section

SF - Strip Footing

SIM - Similar

SL - Slab

SOG - Slab On Grade

SP - Spiral

SPEC - Specification

SQ - Square

SS / S - Stainless Steel

STAG / STAGG'D - Staggered

STD - Standard

STIRR / STIR - Stirrup

STR - Straight

SW - Short Way

SYM - Symmetrical

T - Top

T&B - Top & Bottom

T.S / TLS - Tension Splice / Tension Lap Splice

TB - Tie Beam

TBC / TBD - To Be Confirmed, Determined

TEMP - Temperature Steel

TEW - Top Each Way

THK - Thickness

THR/1 - Thread One End

THR/2 - Thread Two Ends

TLL - Top Lower Layer

TOC - Top Of Concrete

TOF - Top Of Footing

TOP - Top Of Pier

TOW - Top Of Wall

TOS - Top Of Slab

TRANSV - Transverse Bars

TUL - Top Upper Layer

V / VERT - Vertical

VEF - Vertical Each Face

VOC - Vertical On Centre

VIF - Vertical Inside Face

VOF - Vertical Outside Face

W/ - With

WWF / WWM - Welded Wire Fabric / Mesh

Glossary and Abbreviations

Codes and Department of Transportations

DSM - Designated Source Material

MTO - Ministry of Transportation Ontario

MTQ - Ministry of Transportation Quebec

ASTM - American Society for Testing and Materials

OPSS - Ontario Provincial Standard Specification

MTBC - British Columbia Ministry of Transportation and Infrastructure

ABMT - Alberta Ministry of Transportation

SKMHI - Saskatchewan Ministry of Highway and Infrastructure

MBMIT - Manitoba Ministry of Infrastructure and Transportation

NBMTI - New Brunswick Ministry of Transportation and Infrastructure

NSDTI - Nova Scotia Department of Transportation and Infrastructure Renewal

PEIDoT - Prince Edward Island Department of Transportation, Infrastructure and Energy

NLDoT - Newfoundland & Labrador Department of Transportation and Works

YUDoT - Yukon Department of Highways and Public Works

NWTDoT - North West Territories Department of Transportation

NUDoT - Nunavut Department of Economic Development and transportation

Introduction

The contents of this manual are based upon the collective experiences of members from the Reinforcing Steel Institute of Canada. These recommendations should be used as a guide to available materials and standard methods for Estimating, Detailing, Fabricating, and Placing Reinforcing Steel and related components throughout Canada.

In the absence of details and specifications from the contract drawings, the members of the Reinforcing Steel Institute of Canada will follow by the methods, tables and procedures as outlined in this manual.

In this revision you will find additional tables and charts to better assist and define applications of the code requirements. The tables will serve as a guide for Designers and Detailers.

In addition, please refer to local, municipal, regional and provincial by-laws and standards.

Suggestions for the use of this Manual

Specification Writers

This Manual refers to the Canadian Standards for reinforcing materials. Included also are recommendations for the supply and/or placing of reinforcing steel, post-tensioning, bar supports and welded wire fabric.

Contractors

Adherence to the recommendations and standards contained in this Manual will simplify the purchase of reinforcing materials and services. To avoid misunderstandings and to ensure that construction will remain on schedule, advance agreement must be reached concerning exceptions, additions, deletions and variations.

In the event of a dispute with regards to standard practices in the industry, the methods and procedures of this manual shall govern.

Estimators and Detailers

Estimators and Detailers should familiarize themselves with the standard practice as set out in this manual along with the various tables and figures in reference to hook dimensions, embedment, splices, etc.

In the event that details are missing and/or parts of a structure are not designed, the Estimator/ Detailer is not to assume any reinforcing and all information passed on thereafter will be assumed as an extra to the contract.

Inspectors

Photographic reproductions of bar deformations, mill identification marks and grade identification marks are shown in Chapter 2. Placing recommendations, given in Chapter 7, are accepted standard practice and should be adhered to. Chapter 2 shows the chemical composition of a mill test report and acceptable figures according to the code.

General

The recommendations in this Manual concerning the selection and use of reinforcing materials are not intended as a substitute for the judgment of an experienced Engineer regarding the best method of achieving specific design requirements.

It is the responsibility of the Engineer to provide all information and details necessary for the Estimator, Detailer, Fabricator and Placer to carry out their responsibilities. Unless the Engineer specifies otherwise, the standards in this Manual shall be adhered to.

It is recognized that while completed structures may differ, the application of the principle of standardization in the design and the construction methods of the component parts of the various structures will result in economies in time and cost.

Design

It is recommended that the design follow the latest issues of the applicable Canadian standards, see Chapter 2.

In supplying the reinforcing steel, as specified by the Engineer, the Fabricator assumes no liability or responsibility for the design of the structure, or the selection of the reinforcing steel specified.

Grades of Reinforcing Steel

CSA Standard G30.18-09 (R2019) specifies four grades: Grade 400R, Grade 500R, Grade 400W and Grade 500W. The W grades are intended for applications where weldability or ductility is required. Grade numbers indicate the minimum yield strength in MPa (megapascals). For grades of Stainless Steel and FRP see Chapter 9.

Engineers must specify the grade for every component on drawings and specifications.

Failure to include the Grade for bars will result in the supply of 400MPa reinforcing bars. Failure to include the chemical composition type (R or W) will result in the supply of reinforcing bars, at the discretion of the Fabricator.

Scale or Rust on Reinforcing Steel

Scale on reinforcing steel occurs at the time the bars are rolled.

- Loose scale - sloughs off when the bars are: loaded, unloaded, fabricated and handled on the job site.
- Tight scale - on the bars is normal; it does not have any harmful effect and therefore need not be removed.

Research has indicated that rust on reinforcing steel improves the bond strength. Reinforcing steel with rust shall be acceptable provided the minimum dimensions, including height of deformation and bar diameter, are not less than the requirements specified in CSA Standards. See CSA A23.1-19 Clause 6.1.6.

Sizes of Reinforcing Steel

Standard sizes are listed in the Appendix, Table 1. It is common industry practice to refer to the bar as 10M, 15M, etc.. This avoids confusion with American bar sizes, which also have number designations.

These sizes constitute a range from which the Engineer has options for satisfying the required area of steel in a component. It is suggested that the number of sizes selected for any one component be held to a minimum.

Availability of Sizes and Grades

Some of the size/grade combinations listed in CSA G30.18-09 (R2019) are not in popular demand. Fabricators cannot economically justify the stocking of these unpopular items for which there is low, or virtually no demand.

The following more popular sizes and grades will normally be available from Fabricator stockpiles:

- Grade 400W-10M, 15M, 20M, 25M, 30M, 35M.

The following low demand items will normally be available through orders placed with the mills:

- Grade 400W - 45M, 55M.
- Grade 400R - All sizes 10M through 55M.

- Grade 500R and 500W - All sizes 10M through 55M.
- All Corrosion Resistant Reinforcing

Designers should recognize the lead time and minimum order size for obtaining these items. A Engineer/client planning to use any low demand item should consult with the Fabricator on stock position and mill lead time well in advance of scheduling of concrete pour.

Length of Reinforcing Steel

Standard mill lengths are:

- 10M - 12 meters
- 15M and larger - 18 meters

Stainless steel reinforcing and FRP standard lengths depend on the mill.

Due to practical fabricating considerations, lengths of bars should be given to the nearest 20 mm. In critical situations where it is important that lengths be more exact, a note to this effect must appear opposite the item.

Where bar lengths exceeding 18 m are desired, a special arrangement with the Fabricator is necessary. Practical difficulties such as supply, transportation (length and width considerations) and handling limitations, etc., often make the alternative use of lapped splices, welding, or mechanical couplers more feasible.

For shipping limitations on radius and bend bars, refer to Table 21A.

Recommendations for Structural Drawings

- Use the terms “similar”, “standard” and “typical” only where strictly applicable. For instance, it is necessary to indicate the difference between “typical” details and “similar” details.
- When two or more grades of reinforcing steel are required, specify where each grade is to be used.
- Standard fabricating equipment bends bars in one plane. Where bends in more than one plane are required, separate bars should be spliced together to avoid costly fabrication.
- Use typical bar bends where possible, see Typical Bar Bends, Appendix Table 4.
- Where straight bars are staggered or straight bars of two lengths are to be alternated, indicate centre-to-centre spacing of adjacent bars; e.g. - 10M @ 250 mm indicates 250 mm centre-to-centre of the bars.
- Where bars of two different sizes are lap spliced, unless specified otherwise, lap length will be based on the diameter of the smaller bar, but shall not be less than the required development length of the larger bar.

- Where vertical column bars are discontinued, the Engineer must indicate the dimension to the cut-off relative to the top of the horizontal concrete member; otherwise the cut-off will be assumed to be made 80 mm below the top of the horizontal concrete member.
- When concrete cover is given for beams or columns, it should be specified whether it is to the ties or to the main steel. Unless specified otherwise, cover will be to the ties as shown in the Appendix, Table 8.
- Where bar congestion occurs, such as two beams or girders intersecting on the same plane, the Engineer must indicate the specific location of each layer of bar at the intersection.
- Truss bars should not be used unless absolutely necessary. Cut off points for reinforcement must be shown.
- All reinforcing steel to be used in concrete and masonry components must be shown on the structural drawings.
- Specialty Material Designation must be clearly identified on the contract drawings. Acceptable practice to signify specialty bars are as follows:

  Epoxy Coated - “C” C15M@300
  Stainless Steel - “S” S20M@250
  Galvanized - “G” G15M@250
  Fiber Reinforced Polymer -”F” F20M@200

- For splices, the Engineer shall indicate the type and class of splice required or the length of lapped splices.
- The Fabricator shall produce placing drawings and bar lists in accordance with the contract documents. It is suggested, however, that the Engineer and the Fabricator meet prior to the preparation of the placing drawings for the purpose of reaching a clear understanding of the intent of the Engineering drawings and the detailing standards of the Fabricator.
- Computer aided design (CAD) drawings shall be provided to the reinforcing Contractor. These should be provided to increase efficiency in preparation of detailed placing drawings. These drawings will be used strictly for concrete layout.

Footings

Where considerable variations exist in the depth to which different footings must be carried, a cap or pier on top of the footing may be used to reach the level at which the columns start. The connection of columns to the footing, cap or pier, should be made with dowels, see Appendix, Table 9.

Columns

- The cross-sectional dimensions should remain constant for as many storeys as possible. Where the required area decreases, the dimension change should be kept to a minimum. The outside surface and the width of exterior columns is best kept constant, only the inside surface being set back.
- The dimensions of all columns should change in increments of 50 mm. The dimensions of all interior columns should be constant throughout a single storey. The spacing of columns from centre-to-centre should be uniform. It is suggested that as many storeys as possible in a building be of the same height.
- Column reinforcement should generally be of bars as large as is practical. All vertical bars in square or rectangular columns should be shop offset bent to suit lap splices.
- Vertical bars in a round column, where the size of the column is unchanged, need not be offset bent for lap splices. When the column face above is offset more than 75 mm, straight bars in the column below should develop to within 75 mm of the top of the slab, and separate straight dowels should be used to lap with the vertical column bars above.

Column Splices

Column splice dimensions shall be specified by the Engineer to ensure the capacity required in his analysis. If staggered splices are necessary, the Engineer must specify the dimensions of the staggered splice arrangement.

Welding of reinforcing steel shall have a welding procedure, a data sheet and a test completed by an approved welder as per W186-M1990 (R2016). If mechanical devices are required the engineer shall specify compression or tension. If not specified, compression will be used.

Flat Slabs

Where a flat slab design is used, the dimensions of the column capital and the size of the drop panel should be uniform throughout the building. If possible, the size of the drop panel should be adjusted to allow for the slab form between drop panels to utilize standard plywood sizes. The number of bars, dimensioning and positioning of the steel for structural integrity shall be clearly indicated.

Beams

As far as it is practical, the spacing, widths and depths of beams should be uniform throughout the structure.

Where closed ties are required, costs may be reduced by using two-piece stirrups to facilitate placing.

Design beam and column widths to avoid placement of horizontal and vertical reinforcing steel in the same plane.

Slab-On-Grade Concrete Floors

No codes or standards govern the design of concrete floors cast directly on the ground despite the widespread use of slab-on-grade floors in the industry. As a result, steel reinforcement is sometimes omitted from slabs. Most Engineers however specify steel reinforcement in ground slabs as a safeguard against the problems arising from the tendency of un-reinforced concrete to crack visibly due to:

- Drying shrinkage
- Differential temperature
- Slab contraction and expansion
- Non-uniform support
- Traffic loadings

Slab-on-grade steel reinforcement in either reinforcing steel or wire fabric is generally located 50 mm below the top surface. To ensure proper placement, suitable supports should be used such as continuous high chairs, single chairs or concrete blocks.

Special Services

Certain services, such as the following, are not provided by the Fabricator unless specifically specified by the Engineer and/or the Buyer:

- Bar threading
- Bending or cutting to special tolerances
- Chair or support bars- supply only contract
- Epoxy coating
- Galvanizing
- Masonry Rebar (in certain regions only)
- Mechanical splices
- Non-typical bends, hot bends, or end preparations not otherwise defined Square, bevel-cut or sawed ends
- Supplying, painting, dipping or coating of dowels
- Water stop support bars
- Welding
- FRP
- Punching shear studs
- Stainless Steel
- Post Tensioning
- Pre-Stress Bars
- Site Inspections
- Engineered Stamp Drawings
- Additional tying of reinforcing steel.

Suggested Specifications - Reinforcing Steel

Scope

The work shall consist of the supplying and the placing of reinforcing steel.

Reinforcing Steel

All reinforcing steel, including column spirals, shall be deformed as defined in the CSA Standard G30.18-09(R2019).

Tie Wire

The tie wire used shall be 16 gauge, black annealed wire unless specified otherwise. For corrosive environments see applicable sections in this manual.

Welded Wire Fabric

Welded wire fabric shall be resistance welded in wire of size and spacing as shown on the drawings and shall conform to ASTM - A1064/A1064M-18.

Reinforcing Steel Bar Supports

Bar supports shall conform to the Bar Support Standards and Standard Nomenclature as shown in this Manual of Standard Practice, Chapter 8.

Mill Test Reports

A certified copy of a mill test report showing physical and chemical analysis on each heat of reinforcing steel shall be provided when requested, at time of shipment. This shall be in lieu of physical and chemical tests.

Placing Drawings and Bar Lists

The Fabricator shall supply placing drawings and bar lists in accordance with Chapter 5, “Submission of Placing Drawings and Bar Lists”.

Approval of Reinforcing Steel Placing Drawings

The Engineer - (unequivocally the final decision maker) - shall approve, approve with corrections, or disapprove proposed details. Only the structural Engineer has performed the analysis for all loading effects and knows the effective area of steel required at all points, and thus must provide interpretations of Building Code requirements.

Standard practice in the industry is such that the Fabricator does not provide a professional Engineer’s stamp on the placing drawings as prepared by the reinforcing steel Detailer.

The placing drawings indicate the quantity, length, mark, grade, location and spacing (where applicable) of the reinforcing steel in each component of the structure. They should be simple, clear and complete with no unnecessary lines, marks, symbols or dimensions to clutter up the information being conveyed to the workers on the site. They must, however, contain all essential notes and data necessary for quick and accurate interpretation. They are to be used for placing the reinforcing steel only.

Fabrication

- All hooks should be bent using the pin diameters and dimensions as shown in the Appendix Tables, unless specified otherwise.
- Reinforcing bars should not be bent or straightened in a manner that will damage or fracture the material.
- Reinforcing bars should conform accurately to the dimensions shown on the drawings and within the fabricating tolerances as shown in Chapter 6, Standard Practice - Fabricating.

Placing Reinforcing Steel

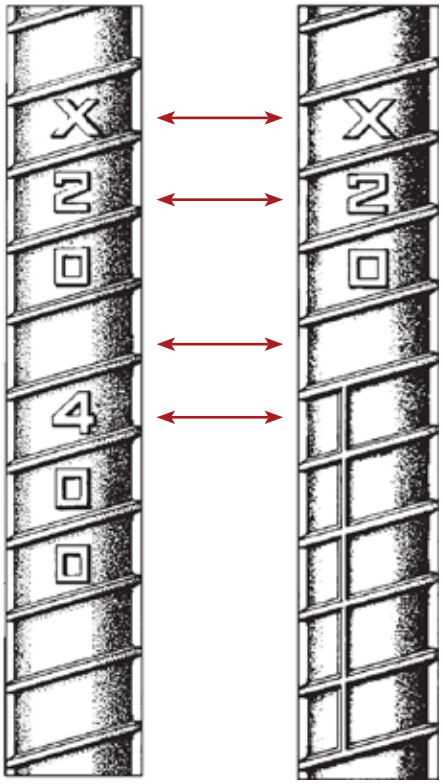
- The placement of reinforcing steel shall be as shown in Chapter 7, Standard Practice - Placing.
- Reinforcing steel shall be securely tied to prevent movement during the placement of the concrete.
- The splicing of bars, the concrete cover, and the bar spacing shall be as shown in this manual of standard practice unless otherwise specified by the Engineer.
- The welding of reinforcing bars shall be performed in accordance with the regulations and practices of the Canadian Welding Bureau and the latest edition of the CSA W186-M1990 (R2016) Standard.
- Placing of post-tensioning material takes precedence over mild reinforcing. Displacement of reinforcing steel may occur.

User Notes

User Notes

Identification Requirements

Deformed Concrete Reinforcing Bar
To comply with CSA Standard G30.18-09 (R2019)



Sequence

MILL SYMBOL - ON ALL GRADES

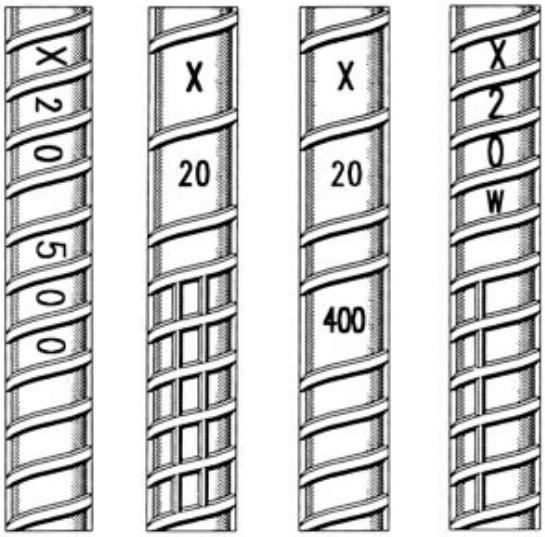
BAR SIZE - ON ALL GRADES

BLANK SPACE - IF GRADE SYMBOL IS IN NUMBERS

GRADE SYMBOL - OPTIONS ALLOWED

Grade 400R	Either the number 400 or one offset line through at least 5 spaces
Grade 500R	Either the number 500 or two offset lines through at least 5 spaces
Grade 400W & 500W	The letter W between the blank space and the grade symbol or in the blank space.

NOTE: The letter R is not rolled onto the bar.



Possible Variations

To achieve clarity of symbols on all sizes and to accommodate a variety of roll marking techniques it has been trade practice for mills to modify symbol size or orientation while still observing the prescribed sequence.

Note: Identification markings occur at intervals of 1 to 1.5 metres along the bars. If from Rod Coils markings could be at 0.5 metre intervals.

Typical Identification Patterns of Producers Supplying the Canadian Market

ALTASTEEL LTD.

ARCELORMITTAL Long Products Canada
Longueuil Mill

ARCELORMITTAL Long Products Canada
Contrecoeur West

ARCELORMITTAL Long Products Canada
Contrecoeur East

GERDAU
Cambridge Mill

GERDAU
Manitoba Mill

GERDAU
Whitby Mill

MAX AICHER - North America LTD.
(MANA)

NORTH AMERICA
STAINLESS

NUCOR AUBURN NY

NUCOR STEEL
SEATTLE INC.

VALBRUNA
CANADA LTD.

References

These Standards for reinforcing steel are generally accepted for construction in Canada. Some of these Standards are adopted by reference in the National Building Code and used as a basis for most statutory codes in Canada.

The Standards that are referred to, or that have been used in preparing this Manual of Standard Practice, are:

CSA Standard..... S413-14 (R2019)
CSA Standard..... S806-12 (R2017)
CSA Standard..... S807-19
CSA Standard..... S6-19
CSA Standard..... G30.18-09 (R2019)
CSA Standard..... A23.1-19
CSA Standard..... A23.2-19
CSA Standard..... A23.3-19
CSA Standard..... W186-M1990 (R2016)
ACI 318-19
ACI 352R-10
ASTM..... A416/A416M-18
ASTM..... D3963/D3963M-15
ASTM..... A775/A775M-19
ASTM..... A722/A722M-18
ASTM..... A1064/A1064M-18
ASTM..... A767/A767M-19
ASTM..... A995/A995M-20
ASTM..... A123/A123M-17
ASTM..... A780/A780M-20
ASTM..... A970/A970M-18

OPSS..... 905
OPSS..... 1440
OPSS..... 1442
OPSS..... 1443

Mill Test Report Properties

The reinforcing steel producers provide mill test reports for each shipment of reinforcing steel delivered. The mill test report describes the steel size, heat identification number and chemical analysis. It lists the required element, symbol and weight percentage of each.

Mechanical properties such as yield strength, tensile strength, elongation and bend test result are included.

It references the industry standard specification – CSA G30.18-09 (R2019) to which the producer certified the steel.

Test Report Symbol	Element Name	Description of Effects Elements on Steel Characteristics in Reinforcing Grades	Grades 400R and 500R Maximum Percentage	Grades 400W and 500W
C	Carbon	Present in all steels and its primary purpose is to increase hot rolled strength and hardness of steel.	Not Specified.	Must be equal to or less than 0.30 %
Si	Silicon	Steel in liquid form acts like a sponge for oxygen in the air. High oxygen concentrations in the molten steel become gas bubbles as the steel cools and becomes solid. Silicon is the most commonly used element that is used to reduce the oxygen levels so that gas bubbles do not form in the solid metal.	Not Specified.	Must be less than 0.50 %
Mn	Manganese	Helps to increase steel strength and toughness as well as reducing oxygen levels.	Not Specified.	Must be equal to or less than 1.60 %
S	Sulphur	Trace element from raw material results in reduced ductility and toughness.	Not Specified.	Must be equal to or less than 0.045 %
P	Phosphorus	Trace element from raw materials can reduce ductility and toughness.	Must be equal to or less than 0.05 of one percent.	Must be equal to or less than 0.035 %
CE	Carbon Equivalent	Calculated value that takes the following elements into consideration: C, Mn,Cu, Ni, Cr, Mo and V.	Not Specified.	Must be equal to or less than 0.55 %.
V	Vanadium	Used in weldable rebar to maintain strength levels while C levels are kept below 0.30 %	Not Specified.	Must be reported but no limit is specified.

Mill Test Report Properties

Continued

Test Report Symbol	Element Name	Description of Effects Elements on Steel Characteristics in Reinforcing Grades	Grades 400R and 500R Maximum Percentage	Grades 400W and 500W
Mo	Molybdenum	Trace element from raw materials increases hardness.	Not Specified.	Must be reported but no limit is specified.
Ni	Nickel	Trace element from raw materials increases hardness.	Not Specified.	Must be reported but no limit is specified.
Cr	Chromium	Trace element from raw materials increases hardness.	Not Specified.	Must be reported but no limit is specified.
Cu	Copper	Trace elements from raw materials increases toughness.	Not Specified.	Must be reported but no limit is specified.

Note- Based on CSA G30.18-09 (R2019)

Mechanical Properties Information

Specified Property	Definition
Yield Strength or Yield Point *	The point at which steel changes from the elastic to plastic range under an increasing load. (After this point the material will deform permanently). This is the strength level used in design criteria and in the name. Eg., 400R or 400W requires a 400 MPa minimum yield strength.
Tensile Strength or Ultimate Strength *	The load level at which steel reaches its point of failure and fractures.
Elongation	A measure of the ductility of the steel which is used as a measure of steels ability to bend or distort before breaking. Prior to performing the tensile test the center of the test piece is marked with two indications that are of 200 mm apart. After failure the test piece is fitted back together and the length between these marks is re-measured. The percent elongation is calculated by subtracting the original length from the length after failure and dividing this change by the original length.
Bend Test	All reinforcing steel must be capable of withstanding a 180° bend around a pin of a specified diameter without cracking on the outside of the bent portion.

*For bars supplied in coils, the test specimens are straightened and must achieve an additional 25MPa over the minimum requirement. G30.18-09 (R2019) Clause 10.2

Tensile Test Requirements

Requirement	Grade			
	400R	500R	400W	500W
Minimum tensile strength, MPa	540*	675*	540*	625*
Minimum yield strength, MPa	400	500	400	500
Maximum yield strength, MPa	-	-	525	625
Bar designation number	**Minimum elongation in 200 mm,%**			
10M	10	9	13	12
15M or 20M	10	9	13	12
25M	9	8	13	12
30M or 35M	8	7	12	10
45M or 55M	7	6	12	10

* And not less than 1.15 times the actual yield strength.
See G30.18-09 (R2019) clauses 10 and 12.3

General

It should be noted that contract components and standard quotations may vary from region to region and province to province. We recommend that the Buyer be aware of local practices at the time of the contract.

This chapter outlines the standard contract components for reinforcing steel. We have included two typical standard quotations which have been accepted by the Reinforcing Steel Institute of Canada. The French edition of this manual contains standard contract components and a typical standard quotation used in the province of Quebec.

Contract Types

Reinforcing materials and/or services may be covered by one of three types of contract:

- Supply Only
- Placing Only
- Supply and Placing

These three types are broken down further into Lump Sum Contracts or Unit Price Contracts.

Lump Sum Contract

A Lump Sum Contract is an agreement by the Fabricator and/or Placer to do a specific project, as outlined in the quotation terms, for a specified amount of money to be paid on a monthly progressive basis by the Buyer.

Unit Price Contract

A Unit Price Contract is an agreement by the Fabricator and/or Placer to do a specific project, as outlined in the quotation terms, for a specified amount of money per tonne to be paid on a monthly basis by the Buyer. It is based on the theoretical weight of steel supplied, as indicated on the approved bar lists. These bar lists would cover all reinforcing steel supplied and/or placed on the project.

Supply Only Contract

In a Supply Only Contract the Buyer shall be the Owner or the General Contractor or the Developer of a project.

A Supply Only Contract shall include the following:

- Acceptance of Offer
- Additions and Deletions
- Basis of Agreement
- Bonding (if required)
- Claims
- Contract Agreement
- Method for Dispute Resolution
- Hold Harmless
- Materials and/or Services
- Penalty or Bonus
- Price
- Project
- Schedules
- Seller's Clause
- Terms of Payment
- Testing and Inspection
- Title
- Transportation
- Warranty

Acceptance of Offer

By stating in each offer that "acceptance of the offer is expressly limited to the terms of the offer", the Fabricator can avoid having the Buyer return his own order form, in response to an offer, substituting the Buyer's terms for the Fabricator's terms.

Acceptance of the quotation by the Buyer should be conditional upon satisfactory arrangements being made with respect to payment to and/or security for the Fabricator.

Additions and Deletions

Unit prices for additions and deletions to contract quantities should be stipulated in the quotation form. If any changes to the contract document are made, the resulting cost may be ascertained quickly provided the proper documentation accompanies the change. The resulting extra charge or credit allowance will be made to the contract amount.

Unit prices are only applicable to changes made prior to the detailing of the part of the structure being changed. Otherwise, the change may involve additional detailing, fabricating, delivery and placing charges.

Basis of Agreement

Include a complete description of the drawings, specifications, bulletins, addenda, revisions, dates, plan numbers, etc. upon which the quotation and contract are based, and whether the contract is on a lump sum or unit price basis.

Bonding and Insurance

The cost of a Labour and Material Payment Bond and/or Performance Bond should be the responsibility of the Buyer, unless specified otherwise.

This Clause should describe the insurance to be provided by the Fabricator to protect the Buyer or Owner against liability from damages, injury or death of the Fabricator's employees, damage to property, injury or death resulting from the negligent acts of the Fabricator. This Clause usually requires the Fabricator to provide the Buyer with a certificate of insurance to assure the Buyer that adequate insurance is in effect.

Claims

Claims for shortages, improper fabrication, or for any other reason, should be made by the Buyer, in writing, to the Fabricator within seventy-two hours after the goods are delivered. Failure to make any claim in this period should constitute an irrevocable acceptance of the goods and an admission that they fully comply with the terms, conditions and specifications of the contract.

Contract Agreement

Use of the current revised issue of the Canadian Standard Form of Construction Contract between the Buyer and the Fabricator is recommended. This Contract is approved and issued by the Canadian Construction Association and is generally available at local construction association offices across Canada.

As a supplement to this section, a sample quotation form prepared by the RSIC is included see pages 38-41. It is recommended that all the "Terms and Conditions" included in this Quotation Form, as is, or revised to suit particular conditions, should form a rider to any contract entered into between the Buyer and the Fabricator.

A signature on behalf of the Buyer on the RSIC Standard Quotation Form may serve as a letter of intent until such time as a Standard Form of Construction Contract is signed.

Careful attention should be paid by the Fabricator to the Contract binding the General Contractor to the Owner, as it may be an integral part of the Sub-Contract Document.

Disputes

All contracts should clearly state the method of settling disputes under the terms of the contract.

Arbitration is the method recommended and if it is used, the criteria for selecting the arbitrators and the responsibility for the expenses incurred should be clearly stated.

The Fabricator should check the General Conditions of the Specifications in the contract binding the General Contractor with the Owner for the clarification of the foregoing.

Hold Harmless

This Clause should clearly limit the liability of the Fabricator to his own acts of omission or negligence and should not include the acts of negligence or omission by the Owner, Buyer, Contractor or other Sub-Contractors.

Materials and/or Services

A complete description of materials included in the sale (reinforcing steel, accessories, mesh, and any other materials or services sold) should be included. This description should define materials and/or services included by specifically excluding any associated materials and/or services not intended to become part of the contract.

Penalty or Bonus

When the Contract sets out specific completion dates and imposes penalties for delays in performance by the Fabricator, the Fabricator should carefully scrutinize his obligations under the contract.

A provision should be added here that if penalties are to be incurred for delays in performance by the Fabricator, so conversely, a bonus should accrue to the Fabricator for early completion of the project.

Price

Prices, both lump sum and/or unit price, must be clearly defined. Applicable taxes and amounts should be defined as to their inclusion or exclusion. Any certificates of tax exemption must be produced prior to work commencing.

Project

For legal purposes the exact description of the Project as outlined in the specifications or shown on the drawings should be indicated in the contract. Generally, a Project will be known by a common name and it would be indicated by such name on the placing drawings and bills of material.

Schedules

The contract should contain a work schedule defining the responsibility of the Buyer and the Fabricator. Should changes to this schedule be necessary during the course of the project, they should be mutually agreed to in writing.

Seller's Clause

All commitments for sales and deliveries should be made subject to delays in performance cause by: unavailability of materials; labour strife; accidents; compliance with any law; government orders; shortage of transportation; or any other cause beyond the Fabricators control.

Terms of Payment

The Fabricators terms of payment for the materials and/or services should be described exactly. **A supply only contract is not subject to holdback.**

Testing and Inspection

Cost of inspection and testing material supplies is the responsibility of the Buyer. Mill test reports may be supplied by the Fabricator on request in lieu of testing.

Title

Title to the material should remain with the Fabricator until full contract payment is made. Lump sum quotations should state that materials remaining unused at the completion of the project shall be the Fabricators property.

Transportation

This Clause should cover the following:

The point of delivery shall be stated F.O.B. Truck job site, or F.O.B. Truck at any point suitable to the conditions prevailing. Unloading equipment and operator to be provided by the Buyer.

State the maximum or minimum load provisions. Variations will be charged to the Buyer.

If, for any reason and through no fault of the Fabricator, material does not arrive at the point of delivery at the scheduled delivery time, the Fabricator shall be relieved of any back charges or penalties from such delays.

If, after acceptance of a delivery schedule, the Buyer refuses delivery for any reason, the Buyer shall be responsible for any extra costs incurred by the Fabricator, including transportation costs each way.

When the Fabricator delivers material to the point of delivery and the Buyer unduly delays unloading, the Buyer shall be responsible for any extra costs incurred by the Fabricator.

Warranty

The following provision applies: If any material is defective or does not conform to the Terms of the Contract, the liability of the Fabricator shall be limited to the replacement of such material.

Placing Only Contract

In a Placing Only Contract the Buyer could be: the Owner, the General Contractor or Fabricator.

A Placing Only Contract should include the following:

- Acceptance of Offer*
- Additions and Deletions*
- Basis of Agreement*
- Bonding and Insurance*
- Claims*
- Contract Agreement*
- Disputes*
- Hold Harmless*
- Labour and/or Services
- Labour by Others
- Overtime
- Penalty or Bonus*
- Price*
- Project*
- Schedules*
- Seller's Clause*
- Terms of Payment
- Title*

In a Placing Only Contract the clauses, as listed above and marked by asteriks (*) are the same as used in the Supply Only Contract except - the words Placing Contractor or the word Placer should be substituted for the word Fabricator wherever it is used.

Labour and/or Services

The Buyer is responsible for supplying adequate unloading equipment and the operator. The Buyer shall furnish all grades, lines, levels, elevations, templates, ramps, scaffolds and safety barriers. The Buyer shall also ensure that there is adequate truck and trailer accessibility for the delivery and/or storage of materials as close as possible to the point of use.

The Placing Contractor is responsible for providing the labour, tools, equipment and supplies necessary for placing the reinforcing steel.

When personnel lifts are required it shall be clearly stated who will be responsible for providing them and who will be responsible for the cost of this service.

Labour by Others

The Placing Contractor reserves the right to supply all labour necessary to complete his contract. If labour is supplied by the General Contractor or others, the charges shall not exceed those that would have been incurred by the Placing Contractor if he had supplied the labour.

Overtime

Where applicable, a clause shall be included indicating that the performance of the contract is based upon the current Rodmen's Collective Agreement or applicable local government regulations. The contract shall clearly state the manner in which the Placing Contractor will be compensated for overtime or shift work.

Terms of Payment

The terms of payment by which the Placing Contractor expects payment for his services shall be described exactly. In contracts pertaining to two or more structures, each structure, as far as terms of payment are concerned, can be construed as a separate contract.

Supply and Placing Contract

In a Supply and Placing Contract the Buyer could be the Owner or General Contractor.

In a Supply and Placing Contract the supply of reinforcing steel may or may not be subject to holdback.

A Supply and Placing Contract shall include all the provisions of both the Supply Only Contract and the Placing Only Contract. The two must be taken in conjunction with each other.

User Notes

Sample Quotation Form A

To:

Date:
Quotation Number:

Project:
We are pleased to submit our quotation for reinforcing steel as per the following plans and specifications:

Addenda:
Our price, subject to the following terms, conditions and scope of work is: $ _____

SCOPE OF WORK	Included	Not Included
1. Grade of Steel	☐	☐
2. Delivery, F.O.B.	☐	☐
3. G.S.T. at_____ %	☐	☐
4. Provincial Sales Tax and/or HST %	☐	☐
5. Detailing	☐	☐
6. Epoxy Coating	☐	☐
7. Galvanizing and FRP and Stainless Steel	☐	☐
8. Placing	☐	☐
9. Placing Accessories	☐	☐
10. Support Bars	☐	☐
11. Overtime Labour	☐	☐
12. Crane to Unload and Hoist (Including Prefabricated Members)	☐	☐
13. Lines, Levels, Templates	☐	☐
14. Scaffolding	☐	☐
15. Welding	☐	☐
16. Threading	☐	☐
17. Plain Round Bars	☐	☐
18. Mechanical Splices	☐	☐
19. Caisson Rebar	☐	☐
20. Masonry Rebar	☐	☐
21. Drilling and Grouting	☐	☐
22. Precast or Related Work	☐	☐
23. Inspecting and Testing	☐	☐
24. Exterior Work	☐	☐
25. Bonding	☐	☐
26. Post Tensioning Support Rebar	☐	☐
27. Bars Welded to Structural Steel	☐	☐
28. Anchor Bolts	☐	☐
29. Synthetic or Steel Fibres	☐	☐
30. Jobsite Clean Up	☐	☐

WELDED WIRE FABRIC QUOTATION
Size: _____
Prices: $ _____

	Included	Not Included
A. Delivery, F.O.B.	☐	☐
B. G.S.T. and/or HST at ____ %	☐	☐
C. Provincial Sales Tax at ____%	☐	☐
D. Placing	☐	☐
E. Support Bars or Chairs	☐	☐

Terms: - Net 30 days from date of invoice, no holdback on supply only contracts.
- 10% holdback on placing portion of supply and place contracts only, that portion is:
- holdback to be paid 45 days after substantial completion of our work

Reinforcing steel additions to contract will be charged at _____ per kg. Epoxy Coated at _____ per kg.
Reinforcing steel deletions to contract will be charged at _____ per kg. Epoxy Coated at _____ per kg.
This lump sum quotation is based on our work being completed by: _____
This unit price quotation remains firm until: _____
Notes: _____

Accepted By: Submitted By:
Per: Per:
Date:

FOR CONDITIONS PERTAINING TO THIS QUOTATION SEE REVERSE SIDE

Sample Quotation Form A (Continued)

CONDITIONS UNDER WHICH THIS QUOTATION IS MADE

1. This quotation is subject to acceptance within thirty days from the date hereof and may be withdrawn without notice before acceptance.
2. Should any or all payments not be made promptly at the time it or they respectively become due, (tender) may, without prejudice to its rights, stop further work and shipments hereunder, and at its options, all or any portion of the contract formed by acceptance of the quotation.
3. Tenderer shall not be liable for delays caused by labour disputes, accident, fire, truck, rail, air or water transportation, acts of God or other acts beyond its control.
4. No one has authority to depart from conditions hereof or to make any representations or warranties not herein contained.
5. This agreement is not subject to payment holdback unless specifically noted on the reverse side of this quotation.
6. All fixed sum contracts will be invoiced by shipment as a percentage of total contract.
7. All reinforcing steel not fixed by firm contract will be invoiced on theoretical weights.
8. Any products agreed to be sold under a fixed sum contract and which remain unused at the completion of the construction work, shall be the property of the tenderer and subject to its order.
9. Terms to be outlined on reverse side, subject to approval of credit by tenderer.
10. Any purchase order and/or contract received based on this quotation will have expressed or implied as terms and conditions of the agreement all the terms and conditions on both sides of this quotation.
11. ITEMS TO BE SUPPLIED BY THE PURCHASER WITHOUT COST TO THE TENDERER
    a. A crane of adequate size and operator, to safely hoist, load, unload, raise, lower and move reinforcing steel and wire mesh, including prefabricated cages where required throughout the construction site.
    b. All policemen or flagmen for unloading of reinforcing steel when required.
    c. All necessary layout lines, levels and templates required to place the reinforcing steel.
    d. The supply, erection and removal of scaffolding, safety rails and ladders as may be required by the applicable Occupational Health and Safety legislation to facilitate the installation of reinforcing steel.
    e. Clear access to all rebar placed on the construction site.
    f. Snow removal.
    g. The protection of reinforcing steel once installed, from the elements, harmful products, and physical displacement by others.
    h. Location with services for a site trailer.
    i. Provide protection of exposed dowels to prevent injury of workers if required by the Occupational Health and Safety Act.
12. In the event that the plans identified by date referred to on the face of this quotation are changed, the tenderer reserves the right to revise the original quotation or any contract made if the quotation is accepted, which revision shall be deemed to have been approved by the contractor if the tenderer continues to work after such revision has been submitted to the contractor or any employee, thereof, however, the tenderer reserves the right to have any revision approved in writing upon request and may cease any work if such approval in writing is not given forthwith, and shall not be liable for any damages, consequential or otherwise suffered by anyone as a result of such cessation of work and payment for all work done up to the time work ceases shall immediately become due and payable.
13. Claims for shortage of material must be made in writing within 72 hours of delivery of said material and supported by bill of lading and such additional evidence as may be deemed necessary by the tenderer.
14. If requested, the tenderer shall supply Mill Test Reports on all material being supplied to the project covered in this quotation, but is not held responsible for any costs incurred on material removed from the site for testing purposes, unless authorized by the tenderer.
15. Reinforcing bars shall be wired tied together at sufficient intersections to prevent them from being displaced during the concreting operation.
16. Bar supports shall be of the size and type called for on the placing plans, or by the R.S.I.C. Recommended Practice For Placing Reinforcing Bars and shall be arranged, spaced and tied as called for by these two requirements.
17. Bars, mesh and accessories shall be detailed according to the latest edition of the R.S.I.C. Manual of Standard Practice.
18. Tenderer shall have the sole and exclusive right to determine the number of men required to carry out its obligations hereunder.
19. Tenderer shall be required to provide workers to perform its obligations hereunder on a day shift basis, and only during the standard union work week in force at the construction site.
20. Pouring of concrete over reinforcement constitutes acceptance of the reinforcement as supplied, detailed and placed.
21. The liability of tenderer for any bars which are defective for any reason, shall be limited to the repair or replacement of these bars, or at the option of the seller, to the selling price of these bars. Tenderer shall not be liable for consequential damages. Tenderer must be advised 72 hours before any action is taken by any claimant for defective material, and such material shall be held for inspection by tenderer.

Sample Quotation Form B

We are pleased to submit our quotation for reinforcing steel as per the following plans and specifications:

Structural: _____
By: _____
Architectural: _____
Addenda: _____
Our price, subject to the following terms, conditions and scope of work is: _____$ _____ plus G.S.T.

SCOPE OF WORK (see "notes" below)

Item	Included	Not Included	Item	Included	Not Included
1. Grade of Steel G30.18-09(R2019) 400R			25. Pile or Caissons Reinforcing		
2. Provincial Sales Tax at:			26. Galvanizing FRP + SS		
3. GST at: HST at:			27. Masonry or Rebar (Supply Only)		
4. Rebar Additions to Contract ($/kg):			28. Precast or Related Work		
5. Rebar Deletions to Contract ($/kg):			29. Exterior Landscape Work		
6. Epoxy Coated Rebar Additions ($/kg):			30. Exterior Site Work		
7. Epoxy Coated Rebar Deletions ($/kg):			31. Crane Base Rebar		
8. Free Unloading Time:			32. Rebar and Mesh Shown on Mechanical Drawings		
9. Additional Unloading Time:			33. Rebar and Mesh Shown on Electrical Drawings		
10. Additional for Crane Truck:			34. Shear Reinforcing Stud Rails		
11. Placing Drawings			35. Bars Welded to Structural Steel		
12. Epoxy Coated Rebar			36. Anchor Bolts		
13. Placing			37. Welded Wire Mesh		
14. Placing Accessories			38. Post-Tensioning Supply		
15. Support Bars			39. Post-Tensioning Installation		
16. Overtime Labour			40. Post-Tensioning Support Rebar		
17. Crane to Unload and Hoist			41. Patching of P/T Anchor Pockets		
18. Lines, Levels, Layouts & Templates			42. Removal of Staples from Underside of Slab		
19. Scaffolding			43. Post-Tensioning Additions ($/kg):		
20. Welding			44. Post-Tensioning Deletions ($/kg):		
21. Threading			45. Bonding		
22. Plain Round Bars			46. Job Site Cleanup (Own Material)		
23. Mechanical Splices or Couplers			47. Dywidag Bars		
24. Drilling and/or Grouting			48. In Slab Duct Reinforcing		

Terms:

- This quotation is subject to acceptance within (30) thirty days from the date hereof and may be withdrawn without notice before acceptance.
- Net thirty (30) days from date of invoice, no holdback on supply only contracts.
- We will not enter into any contract that contains "pay when paid" payment terms.
- The New B. C. Builders' Lien Act shall apply to this quotation.
- This quotation is based on our work being completed by: _____ as per schedule.

Notes: 1. _____
2. _____
3. _____
4. _____
5. _____

Accepted By: Submitted By:
Per: Per:
Date:

FOR CONDITIONS PERTAINING TO THIS QUOTATION SEE REVERSE SIDE

Sample Quotation Form B (Continued)

CONDITIONS UNDER WHICH THIS QUOTATION IS MADE

1. It is a condition precedent to any performance obligations by (Supplier) that, prior to commencement of performance of the work and from time to time during the course of the work, the Contractor furnish to (Supplier), that financial arrangements are in place to fulfill the Owner's obligations under the Prime Contract. The failure to furnish the evidence required is a default giving (Supplier) right to terminate the contract.
2. Should any or all payments not be made promptly at the time that it or they respectively become due, (Supplier) may, without prejudice to its rights, stop further work and shipments hereunder, and at its option, all or any portion of the contract formed by acceptance of the quotation.
3. (Supplier) shall not be liable for any delays caused by labour disputes, accident, fire, truck, rail, air or water transportation, acts of God or other acts beyond its control.
4. This agreement is subject only to payment holdback as noted on this quotation.
5. All fixed sum contracts will be invoiced by shipment as a percentage of total contract.
6. All reinforcing steel not fixed by firm contract will be invoiced on theoretical weights.
7. Any products agreed to be sold under a fixed sum contract and which remain unused at the completion of the construction work, shall be the property of (Supplier) and subject to its order.
8. Payment terms as outlined on Page 1, subject to approval of credit by (Supplier)
9. Any purchase order and/or contract received based on this quotation will have expressed or implied as terms and conditions of the agreement all the terms and conditions on both sides of this quotation.
10. ITEMS TO BE SUPPLIED BY THE PURCHASER WITHOUT COST TO THE TENDERER
    a. A crane of adequate size and operation, to safely hoist, load, unload, raise, lower and move reinforcing steel and welded wire fabric, including prefabricated cages where required, throughout the construction site. The Purchaser shall provide adequate site access to facilitate unloading of fully loaded semi-trailer trucks.
    b. All policemen or flag men for unloading of reinforcing steel when required.
    c. All necessary layout lines, levels and templates required to place the reinforcing steel.
    d. The supply, erection and removal of scaffolding, safety rails and ladders as may be required by the applicable Workers' Compensation Act legislation to facilitate the installation of reinforcing steel.
    e. Protection of exposed dowels to prevent injury of workers, if required by the Workers' Compensation Act.
    f. Engineered & sufficient fall protection connection points conforming to the requirements of the Workers' Compensation Act.
    g. Clear access to all reinforcing steel placed on the construction site.
    h. Snow removal.
    i. The protection of reinforcing steel once installed, from the elements, harmful products, and physical displacement by others.
    j. Suitable location, with services, for (Supplier) site trailer.
    k. Adequate site security of all (Supplier) material and equipment.
    l. Adequate lay down and prefabrication areas to be within 7 metres of work area.
    m. Qualified first aid attendant on site, if required as per WCB Regulations.
11. In the event that the plans identified by date referred to on the face of this quotation are changed, (Supplier) reserves the right to revise the original quotation or any contract made if the quotation is accepted, which revision shall be deemed to have been approved by the Purchaser if (Supplier) continues to work after such revision has been submitted to the Purchaser or any employee, thereof. However, (Supplier) reserves the right to have any revision approved in writing upon request and may cease any work if such approval in writing is not given forthwith; (supplier) shall not be liable for any damages, consequential or otherwise, suffered by anyone as a result of such cessation of work and payment for all work done up to the time work ceases shall immediately become due and payable.
12. Claims for shortage of material must be made in writing within 24 hours of delivery of said material and supported by bill of lading and such additional evidence as may be deemed necessary by (supplier).
13. (Supplier) shall not be liable for any backcharges unless notice is given in writing within 72 hours of said occurrence.
14. If requested, (supplier) shall supply mill test reports on all material being supplied to the project covered in this quotation, but is not held responsible for any costs incurred on material removed from the site for testing purposes, unless authorized by (supplier)
15. Reinforcing bars shall be wire tied together at sufficient intersections to prevent them from being displaced during the concreting operation.
16. (Supplier) shall have the sole and exclusive right to determine the number of men required to carry out its obligations hereunder.
17. (Supplier) shall provide workers to perform its obligations herein on a day shift basis, and only during the standard 8 hour day, 5 day week (being Monday to Friday) and as per the B. C. Labour Code and Employment Standards Act, unless overtime is shown as included on the reverse side of this quotation.
18. Placement of concrete over reinforcement constitutes acceptance of the reinforcement as supplied, detailed, and placed.
19. The liability of (supplier) for any bars which are defective for any reason, shall be limited to the repair or replacement of these bars, or at the option of (supplier), to the selling price of these bars. (Supplier) shall not be liable for consequential damages. (Supplier) must be advised 72 hours before any action is taken by any claimant for defective material, and such material shall be held for inspection by (supplier).
20. Purchaser shall schedule all deliveries and installation a minimum of (3) three working days in advance. Costs incurred by (supplier) due to cancellation or re-scheduling will be the responsibility of the Purchaser.
21. No one has authority to depart from conditions hereof or to make any representations or warranties not herein contained.
22. This quotation shall be attached to, and form an integral part of, the Standard Form of Construction Contract between Prime Contractor and Sub-Contractor, B.C.C.A. Document No. 200, Article 1.
23. The New B. C. Builders' Lien Act shall apply to this quotation.

Bidder's Name: (Supplier) _____ Accepted By:_____
Project Name: _____ Date:_____
Quotation No.: _____ 0GCSTD (WRCA)

User Notes

General

An estimate is by definition an approximation of quantities only and shall not be taken as the actual final quantities which will be required. In order to make the estimate as accurate as possible, the Estimator shall be provided with a complete and accurate set of structural drawings for the project. If typical details and splice lengths are not provided then the Estimator will adhere to this manual of standard practice.

The Estimator shall use the structural drawings, and/or the architectural drawings for the take-off. The Estimator shall check all other drawings and the specifications that are provided at the time of take-off for anything that is not specifically called for on the structural drawings. A record of the drawings, specifications, bulletins, addenda, bonding, special site conditions etc., with the dates noted, which were provided to the Estimator at the time of take-off, shall be listed in the estimate. Only those items which are clearly shown on or in these documents will be included in the estimate. Any items that are shown on the above-noted documents and are not included in the estimate shall be specifically listed.

Estimators shall be aware of regional bidding practices, with regards to standard inclusions and exclusions.

Reinforcing steel is sold by the Fabricator on the basis of the theoretical mass, see Appendix, Table 1A & 1B. The Estimator shall consider various components of an estimate.

Estimate Components

Bar Length

When bar lengths are not specifically shown on the structural drawings, the following Standard Practices shall apply:

- Footings

Footing bars are estimated as straight bars extending to within 75 mm of each face of the footing.

- Construction Joints

In the case of horizontal continuous wall steel, no construction joints or dowels will be included unless specifically shown on the structural drawings. If no dowel length is specified, splices and embedment will be taken as shown in Appendix, Tables 12, 13, 14 and 15.

- Column Verticals

Bars, at least equal in area to that in the columns above, shall be extended the required length from the column below, to lap with the bars above.

If the bar arrangement changes between floors, bars may be extended to lap with bars above or be cut off 75 mm below the top of the horizontal member. In the case of terminated bars, they may be required to continue upwards a designated distance for tension or compression embedment. This last condition will only be estimated when it is specifically indicated on the structural drawings and/or typical details.

All column verticals that are to be lap spliced shall be estimated as shop offset bent with two exceptions:

- Round columns that do not change size and permit extending bars in the same circle as the bars above.
- Column offsets greater than 75 mm which are estimated with separate dowels.

- Column Ties

The out-to-out dimensions of column ties shall be 80 mm less than the outside dimensions of the column, unless specified otherwise. The lowest tie will start at no more than half the designated spacing above the top of the footing or floor, while the top tie will be the same distance below the lowest horizontal member above. Extra ties shall be required where column verticals are offset bent, usually one or two being added below the lower bend point of the offset. For recommended types of column ties, see Appendix, Table 24A & 24B.

Bar Size

The total mass for each size of bar shall be listed separately for all types of reinforcing.

Bar Supports

Estimators shall be aware of the bar supports and systems required for their own area. Bar supports shall be estimated as a separate item and according to the information contained in Chapter 8, unless specified otherwise.

Bars - Plain

Plain bars and their preparation are specialty items and shall be estimated separately.

Bars - Threaded

Threaded bars are specialty items and must be estimated separately.

Caissons and Cast-In-Place Piles

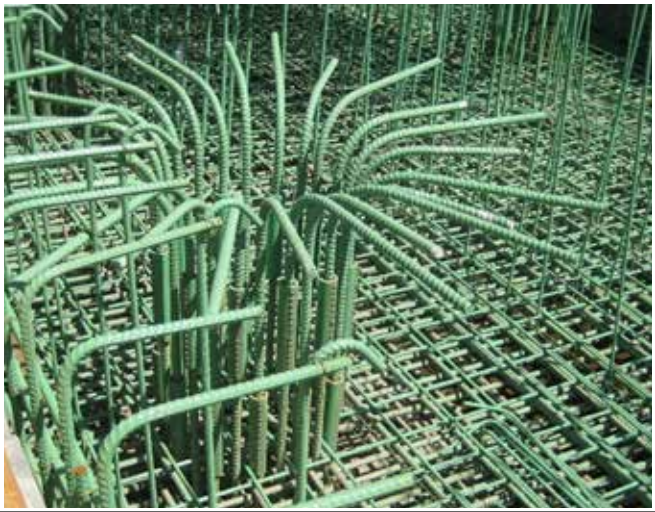
Rebar for caissons and cast-in-place piles shall be estimated as a separate item. It is usually the responsibility of the Caisson or Piling Sub-Contractor to supply and install the bar.

Architectural/Exposed Concrete

Installation of Rebar for architectural/exposed concrete elements may require extra care and/or costs. Estimators shall make mention of this requirement.

Epoxy Coated Reinforcing Steel

Epoxy coated reinforcing steel is a specialty item and shall be estimated separately.



FRP

Fiber Reinforced Polymers are specialty items and shall be estimated separately by size, total length and number of bends per size.

Galvanized Reinforcing Steel

Galvanized reinforcing steel is a specialty item and shall be estimated separately.

Stainless Steel Rebar

Stainless steel rebar is a specialty item and shall be estimated separately.

Mechanical Devices

Mechanical devices are a specialty item and shall be estimated separately by size, by type and quantity of end preparations.

Welded Wire Reinforcement

Welded Wire Reinforcement is a specialty item and shall be estimated separately by size and square area.

Fabrication

Fabrication is defined as all of the work done in the cutting and bending of reinforcing steel to specific dimensions and tolerances.

The estimator shall be aware of special fabrication requirements such as:

- Cutting

Reinforcing steel is cut to specified lengths from stock material.

- Bending

All bending has an extra charge and shall be listed separately and itemized under two headings:

Light Bending

Light bending includes the following:

- all 10M bar
- all stirrups and column ties
- all bars, 15M through 55M, which are:
  - Bent at more than six points.
  - Bent in more than one plane.
  - Radius bent with more than one radius in any one bar.
  - A combination of radius and other bending.

(Radius being defined as all bends that have a radius of 300 mm or more to the inside of the bar.)

Heavy Bending

Heavy bending includes bars 15M through 55M which are:

- Bent at not more than six points.
- Radius bent to one radius.
- Bending not otherwise defined.

Radius bending is represented by Type 9 or 10, as shown in the Appendix, Table 4, and is done by the Fabricator when the radius of a bend on the bar is less than that shown for each bar design as indicated in the Appendix, Table 21B. Bars of larger radius are shipped straight and are bent into place in the field.

For practical lengths of radius bent bars that can be shipped, see the Appendix, Table 21A.

- Field

If field fabrication is necessary it shall be noted on the estimate. This may occur when founding elevations are unknown, and in the event of maintaining the schedule or it becomes more practical to fabricate on site or due to shipping limitations.

- Special

There are a number of processes and/or items where special fabrication is required and in these cases an extra charge is levied. The quantities for each process and/or item shall be kept separate in the estimate.

Some of these processes or items are:

- Bending a bar in more than one radius, or in more than one plane.
- Bending a bar to less than recommended radius.
- Beveling the ends of bars.
- Fabrication of bars where the tolerances are to be more demanding than as mentioned in Chapter 6 - Fig. 6-1.
- Saw cutting the ends of bars in order to achieve a proper fit for compression splices.
- Spirals and spacers.
- Welding, which shall be done under the Engineer's authority and in accordance with the requirements as set out in the CSA Standard W186.
- Epoxy, galvanized & stainless reinforcing.
- Bends or end preparations not otherwise defined.

Hooks

Hooks will be estimated on the ends of bars when they are shown on the drawings, in the specifications, or in typical details. Where hooks are called for, estimate a length equal to dimensions A or G, shown in the Appendix, Table 5. If the type of hook is not specified, 90° is assumed.

Masonry Reinforcing

Reinforcing steel for masonry shall be estimated as a separate item. The estimator shall check to ascertain who is responsible for the supply of reinforcing steel for masonry reinforcement, e.g. General Contractor, Masonry Contractor. For masonry vertical bars, stock length shall be estimated at 1200mm plus lap splice unless noted otherwise.

Post-Tensioning Work

Reinforcing steel for post-tensioning shall be included in the estimate when shown on the contract drawings.

Precast Work

Reinforcing steel for precast work, including bars in joints or connections, shall be excluded from the estimate.

Slab Bar Spacing

When the main slab bars are parallel to beams or walls supporting the edge of the slab, the first slab bar is usually spaced one-half the distance of the specified spacing from the support. The remaining bars are spaced at the specified spacing across the slab.

Slabs on Steel Decks

Reinforcing steel, when shown in the contract documents for slabs on steel decks, shall be estimated.

Spirals

The grade, size of bar and the quantity of spirals shall appear in the estimate.

The diameter of a spiral shall be 80 mm less than the outside diameter of the column, unless otherwise noted.

The height of a spiral is the distance from top of the footing or floor to the level of the lowest horizontal reinforcement in the slab, drop panel or beam above. In columns with a capital, the spiral extends to a plane at which the diameter or width of the capital is twice that of the column.

The recommended Standard Practice for the minimum diameter of a spiral is 240 mm O.D. Diameters up to 1800 mm are common, however, capabilities exist to produce larger diameters.

Spirals are finished off with an extra one and one-half turns at the top and bottom unless otherwise noted.

When splices are necessary in spirals, they shall be in tension lap splices of 50 bar diameter, minimum, plus a 90^0 hook around a longitudinal bar at the free end. Welds in accordance with CSA W186 are acceptable where authorized by the Engineer.

Spacers

Where spacers are provided by the Fabricator, the total cost of spirals shall include the mass of both the bar and spacers.

For the mass of standard spirals per metre of column, see Appendix, Tables 22 and 23. The mass in these Tables does not include the spacers or the mass of the one and one-half turns top and bottom; these must be added to determine the total mass.

Spacers are used to maintain the proper pitch and alignment of the spiral and will be provided by the Fabricator, as shown below, when specified by the Engineer and shown on the structural drawings, or typical details:

SPIRALS FABRICATED FROM 10M BAR:

- Core diameter 500 mm or less - 2 spacers.
- Core diameter more than 500 mm to 800 mm - 3 spacers.
- Core diameter more than 800 mm - 4 spacers.

SPIRALS FABRICATED FROM 15M BAR:

- Core diameter 600 mm or less - 3 spacers.
- Core diameter more than 600 mm - 4 spacers.

The maximum length of a spacer is the height of a spiral plus one pitch. Angle iron spacers may range in size from 40 x 40 x 5 to 45 x 45 x 5 with masses from 2.97 kg/m to 3.34 kg/m respectively.

Splices

An Estimator shall not determine the location of a splice or length of the lap required. These will depend strictly on the Engineer's design. The structural drawings, therefore, must show the location, type and class of all splices or the length of lap required. If this information is not specifically shown, then the Estimator will allow

for Class B tension laps for horizontal and vertical bars in walls, slabs and beams; compression and embedment lengths for column dowels; and compression splices for all other vertical bars.

Lap splices of bars 45M and 55M are not allowed. Where bars are not lapped they may be joined by welding or mechanical splices, see Chapter 10 for the different types available. The estimate shall include the quantity of mechanical splices required, plus the number of special bar end preparations needed. For a welded butt splice, estimate one bar end square-cut and one bar end double-bevel cut.

Temperature or Shrinkage Reinforcement

Where temperature reinforcement is required, it shall be specified on the design drawings in bar sizes and centre-to-centre spacings.

Temperature reinforcement may serve as top support bars.

Tying

If additional tying of reinforcement is required beyond the normal (every fourth or fifth intersection), this shall be clearly indicated by the Engineer. Estimators shall make mention of this requirement.

User Notes

General

The detailing service rendered by the Detailer never replaces the function of the Architect and the Structural Engineer. The purpose of this detailing service is to facilitate the efficient fabrication and installation of the reinforcing steel. Effective detailing service can be performed only if all dimensions and related information are available. Lacking this, the Detailer must make time-consuming and possible job-delaying inquiries. Detailing without clear instructions from the Engineer invariably involves additional work for all concerned.

In addition, please refer to local, municipal, regional and provincial by-laws and standards.

Responsibility

No responsibility shall be assumed by the Fabricator for the structural design or the accuracy of the dimensions on the drawings supplied by others. The Fabricator shall not be held responsible for the coordination or accuracy of information shown on drawings or bar lists furnished by others.

Approval of Reinforcing Steel Placing Drawings

Rebar Placing drawings are prepared to properly interpret the Engineers design intent and shall be approved as such.

The Engineer - unequivocally the final decision maker - shall either approve, or approve with corrections, or disapprove proposed details. Only the structural Engineer has performed the analysis for all loading effects and knows the effective area of steel required at all locations, and thus must provide interpretations of Building Code requirements.

Standard Practice in the industry is such that the reinforcing steel Fabricator/ Detailer will not provide a professional Engineer's stamp on the placing drawings.

Detailing Services

The detailing services will consist of preparing placing drawings and bar lists from contract documents.

The placing drawings or placing sheet will provide the following:

- Element location.
- Identify the type of reinforcing i.e. black, epoxy, stainless steel, galvanized and FRP.
- Quantity.
- Bar size and grade.
- Length or bar mark.
- Necessary dimensions for placing purposes only.
- Spacing of reinforcing steel bars, where applicable.
- Splice type and location.
- Title block, contract information.

The bar list will provide the following:

- Cross reference to a specific drawing.
- Identify the type of reinforcing i.e. black, epoxy, stainless steel, galvanized and FRP.
- Total quantity required.
- Bar size and bar grade.
- Bar mark and bend dimensions.
- Contract information.

Bar lists may be incorporated into the placing drawings as a label list.

RSIC Detailer Certification Program

In order to standardize the practice of detailing, the RSIC developed a Detailer certification program.

The RSIC standards for certification of a reinforcing steel Detailer ensure a minimum of a 2 year apprenticeship period. Placing drawings are then submitted to the RSIC certification committee for review. Upon approval certification is granted.

Placing Drawings

Placing drawings indicate the quantity, length, bar mark, grade, location and spacing (where applicable) of the reinforcing steel types in each component of the structure. They shall be simple, clear and complete with no unnecessary lines, marks, symbols or dimensions to clutter up the information being conveyed to the installation personnel. They must, contain all essential notes and data necessary for quick and accurate interpretation. They are to be used for placing of the reinforcing steel only and not for other consultants, trades, or consultants coordination.

Reinforcing bars shall be shown in heavy lines, while grid lines and concrete outlines illustrating the determining conditions shall be shown in lighter lines. Make all notes brief, clear and explicit. All drawings shall be made large enough and lettered clearly for reproduction and legibility after repeated use in the field or office.

Layout

Drawings shall be laid out in a neat and legible format, with plan views in the upper left corner of the sheet. If feasible, the northerly direction shall be at the top of the sheet. Sections, details, and elevations should be grouped either below or to the right of the plan view. Key plans shall be placed at the top right of the drawing. An arrow indicating north shall be placed beside the key plan.

Scales

Drawing scales must be of reasonable size to clearly indicate details.

The scales used must be shown on all drawing title blocks. If two or more scales are used on a drawing, they shall be shown under the title of each view. All drawings not to scale shall have this clearly indicated in the appropriate title block.

Lettering

All lettering on a drawing shall be clear and legible.

Sizes - Placing Drawings and Bar Lists

The following are some sizes (in millimetres) being used at the time of the printing of this manual:

Type of Drawing	Style (Metric)	Style (Imperial)
For bar lists	210 x 297 (A4)	8.5” x 11”
For drawings	297 x 420 (A3) 420 x 594 (A2) 594 x 841 (A1)	11” x 17” 18” x 24” 24” x 36”
For computer sheets	210 x 356	8.5” x 14”

Technology is changing constantly and Fabricators are developing methods to use similar sheet sizes which:

- can be copied on a variety of standard copying machines.
- are easier to use by the field personnel.
- require much less storage space during and after construction.
- are able to place material lists on drawing.

Bar Lists

The bar list fills a dual purpose. From the information supplied, the Fabricator is able to fabricate the reinforcing steel in the length and shape required. Secondly, it acts as a means of identifying the finished material for field use.

PROJECT								Contract			Date		By		Sheet
Structure						Grade		Group/Block NO.			Revisions		Job NO.		DWG. NO.
For detail of types, see R.S.I.C. Manual of Standard Practice REINFORCING DETAILS LENGTH UNIT: M or I															
Item	Bar Mark	Per Band	Total	Size	Length	Type	A	B	C	D	E	F	G	H	Remarks
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
Approval: _____								Fabrication: _____							

FIG. 5 - 1
Eg. BAR LIST:

Beams, Girders and Slabs

In all cases, the Engineer must specify the length or cut-off locations of reinforcement. At least one third of the positive moment reinforcement in simple members, and one fourth of the positive moment reinforcement in continuous members shall extend along the same face of the member into a support. The reinforcement shall extend into the support at least 150 mm. When the length of negative moment reinforcement is not specified, it is assumed to extend into the adjacent span to a point 12 bar diameters beyond the one quarter point of the centre-to-centre dimension of the greater span.

Non-continuous ends of top bars extend to within 80 mm of the outer faces of members into which they frame and may terminate in either a 90° or 180° hook to achieve the necessary embedment.

Column Ties

The out-to-out dimensions of column ties, unless otherwise specified, shall be 80 mm less than the outside dimensions of the column. The lowest tie will start at no more than half the designated spacing above the top of the footing or floor, while the top tie will be the same distance below the lowest horizontal member above. Extra ties shall be required where column verticals are offset bent, usually one or more being added at the lower bent point of the offset.

Column Verticals

Bars, equal in number to and at least equal in area to those in the column above, must be extended to specified length from the column below to lap splice with the bars above or have mechanical splices applied. If the bar arrangement changes between floors, bars may be extended to lap splice with the bars above or be cut off 75 mm below the top of the horizontal member and add appropriate dowels.

In the case of terminated bars, they may be required to continue upwards a designated distance for tension or compression embedment. This last condition will only be detailed when it is specifically indicated on the structural drawings and/or typical details. Where no detail is shown at the top of terminating columns, the column verticals will be supplied straight and will be terminated 75 mm below the top of the slab.

All column verticals that are to be lap spliced should be detailed as shop offset bent, with two exceptions:

- Round columns that do not change size and permit the extended bars in the same circle as the bars above.
- Column offset greater than 75 mm which are detailed with separate dowels.

Concrete Cover

For concrete cover, see Appendix, Table 8.

Construction Joints

In the case of horizontal continuous wall steel, no construction joints or dowels will be detailed unless specifically shown on the structural drawings. If no dowel length is specified, embedment and splices will be taken in Appendix, Tables 12, 13, 14 and 15.

Reinforcing in Corrosive Environments

Any reinforcing requiring epoxy coating, stainless steel, galvanizing, and FRP shall be clearly marked as shown on both the placing drawings and the bar lists, see notes on page 49 about Detailing Services.

Footings

Footing bars, unless shown otherwise, are detailed as a straight bar extending to within 75 mm of face of the footing.

Footing dowels shall be the same size and spacing of the vertical elements unless otherwise noted.

Hooks

Hooks will be detailed when they are shown on drawings, or in typical details. Where hooks are called for, detail a length equal to dimensions A or G in the Appendix, Table 5. If the type of hook is not specified, 90° is assumed.

Main Reinforcement

Where bar congestion of the main reinforcement occurs, the Engineer shall have indicated the specific position of all bars at the intersection.

Typical areas where this may occur are beam/beam, column/beam intersections.

Post-Tensioning Work

Anchorage reinforcing (grillage) for Post-Tensioning work will be designed, detailed and supplied by the Post-Tensioning Supplier unless specifically shown on the contract drawings. Other mild reinforcing will be detailed and supplied by the reinforcing steel contractor.

Slab Bar Spacing

Where main slab bars are parallel to supporting beams or walls supporting the edge of the slab, the first slab bar is usually spaced one-half the distance of the specified interval from the support. The remaining bars are spaced at the specified interval across the slab.

Spirals

The grade, the size of bar, and the pitch number of turns shall appear in the detailing.

Spirals shall be turned from deformed bar of the specified grade. The diameter of a spiral is 80 mm less than the outside diameter of the column unless otherwise specified. The recommended bar sizes for spirals are 10M and 15M.

The recommended Standard Practice for the minimum diameter of a spiral is 240 mm O.D. Diameters up to 1800 mm are common, however, capabilities exist to produce larger diameters.

Spirals are finished off with an extra one and one-half turns at the top and bottom, unless otherwise specified.

When splices are necessary in spirals, they shall be tension lap splices of 50 bar diameter minimum, plus a 90^0 hook around a longitudinal bar at the free end. Welds in accordance with CSA W186-M1990 (R2016) are acceptable where authorized by the Engineer.

Spacing of Spirals

Tying of spacers can be used to maintain proper pitch and alignment. Spacers will be provided by the Fabricator as shown below when specified by the Engineer and shown on the structural drawings or typical details. See Chapter 6- Fabrication for Spacer Requirements

Spirals Fabricated from 10M Bar:

- Core diameter 500 mm or less - 2 spacers.
- Core diameter more than 500 mm to 800 mm - 3 spacers.
- Core diameter more than 800 mm - 4 spacers.

Spirals Fabricated from 15M Bar:

- Core diameter 600 mm or less - 3 spacers
- Core diameter more than 600 mm - 4 spacers.

The maximum length of a spacer is the height of a spiral plus one pitch. Angle iron spacers may range in size from 40 x 40 x 5 to 45 x 45 x 5 with masses from 2.97 kg/m to 3.34 kg/m respectively.

Stirrups

The width and height of stirrups are detailed as 80 mm less than the width and depth of beams and girders unless otherwise specified. The first and last stirrup should be spaced no further than 50mm the designated spacing from the face to the support, unless otherwise specified.

Submission of Placing Drawings and Bar Lists

The Fabricator requires fifteen (15) working days lead time from receipt of contract drawings issued for construction to prepare the placing drawings and bar lists in an order relative to the requirements of the construction schedule. Electronic submission is the preferred method.

Unless otherwise specified in the contract documents, when these (placing drawings and bar lists) are prepared, the Fabricator will forward three hard copies of each drawing or one electric files to the General Contractor for approval. In the case of any drawing and/or bar list that requires re-submission, the same procedure applies.

When final approval of the placing drawings and or bar lists have been received, the Fabricator will provide the General Contractor with one copy of each of the approved drawings and or bar lists. Additional copies will be supplied at the cost of printing.

Should the General Contractor require the shipping of fabricated material from unapproved drawings and/or bar lists, the General Contractor shall bear the responsibility of error or omission in, or from such drawings and/or bar lists.

Temperature or Shrinkage Reinforcement

Where temperature reinforcement is required, it shall be specified on the design drawings in bar sizes and centre-to-centre spacing.

Temperature reinforcement may serve as top support bars.

Typical Bar Bends

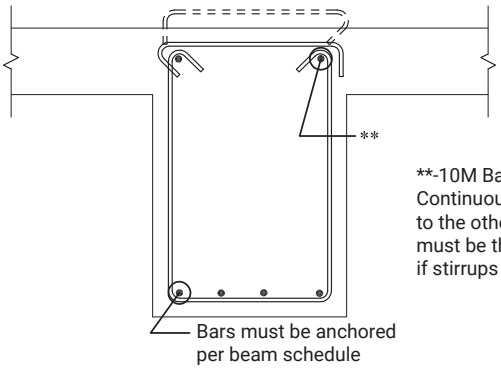
For typical bar bends, see Appendix, Table 4.

Closed Stirrup Alternate

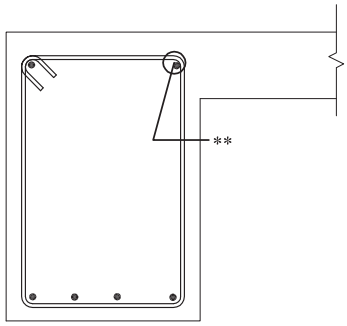
The best method for assembling closed stirrups around longitudinal bars for beams and girders is to preassemble the entire cage and drop in place into the form. This practice is impossible where the longitudinal beam bars must be interlaced through closely fitting vertical column bars and above and below longitudinal slab and/or beam bars intersecting from right angles. In such cases, out of necessity, common practice is to place stirrups loosely in the formwork, “spring” them open and drop longitudinal steel in place. This “springing” of closed stirrups may cause breakage, or worse, microscopic unnoticed cracks in the steel.

The following recommendations for two-piece assemblies to form closed stirrups avoids such difficulties: Where the Designer shows stirrups in any edge or spandrel beam, the code requires that these stirrups be closed and that at least one longitudinal bar shall be located in each corner of the beam section; the size of this bar is to be at least equal to the diameter of the stirrup but not less than 10M. These details must be indicated by the Designer. The typical details are shown below for normal and upturned edge or spandrel beams. For easier placing of the longitudinal bars in the beam, details for two-piece closed stirrups are shown. For the same reasons, the 90° stirrup hook is preferred. The Designer should show the general arrangement of all such bars and stirrups.

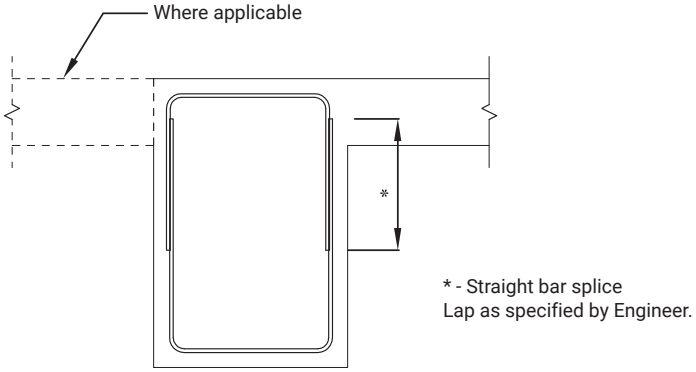
Alternate ends 90°/135° Hooks



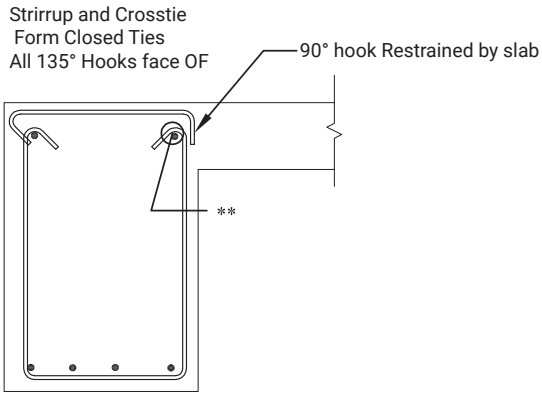
Open Stirrup + Crosstie
as Closed Tie



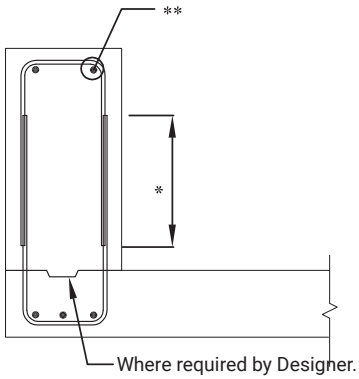
Stirrup as Closed Tie



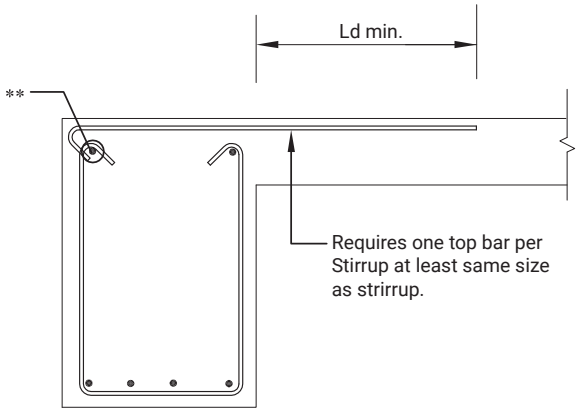
Two U-Bars Lapped
as Closed Tie



Spandrel Beam Alternate - A
as Closed Tie



Two U-Bars Lapped
as Closed Tie
at Upstand Beam



Spandrel Beam Alternate - B
as Closed Tie

CSA A23.3-19 Clause 21.3.3.4

FIG. 5 - 2

Typical Concrete Wall Details

On intersecting walls with a single mat of reinforcing, hook direction should change on alternate bars.

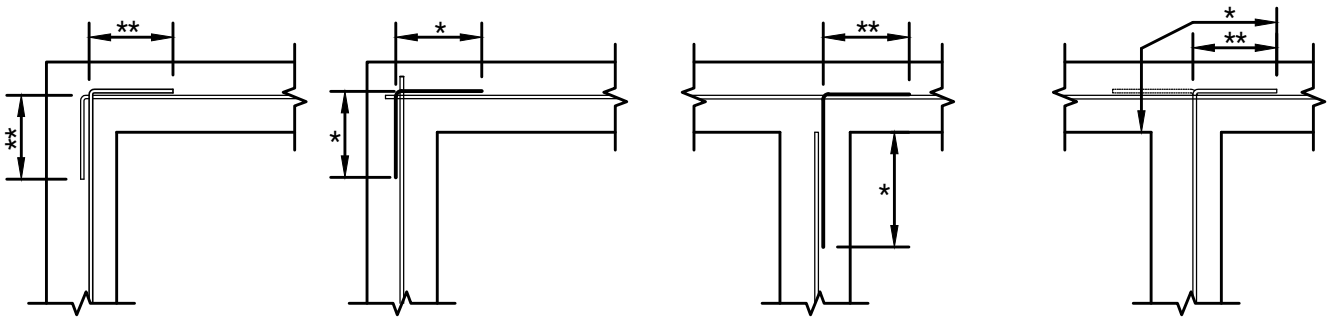
Corner and intersection splice bar method:

- "Corner bars" are the same size and spacing as the specified horizontal reinforcing.
- This method requires more material, however in many cases the extra material costs is off-set by greater ease in fabricating and erection.

Corner and intersection continuous splice bar method:

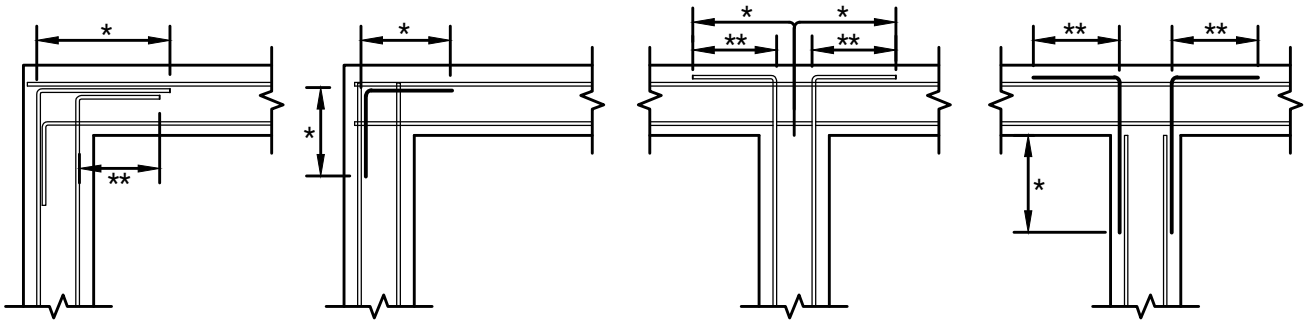
- Where continuous corner method is specified, permission must be obtained from the structural Engineer before substituting to a corner splice bar method.
- Continuous corner method or corner spliced bar method are acceptable when no details are indicated by the structural Engineer.

Single face



Corner Continous | Corner Splice Bar | Intersection Splice Bar | Intersection Continous

Double face



Corner Continous | Corner Splice Bar | Intersection Continous | Intersection Splice Bar

FIG. 5 - 3

* This dimension must be shown or specified by Engineer.
** If other than a standard 90^0 end hook, this dimension must be shown by the Engineer.

Typical One-Way Slab Details

Notes:

1. **Top bars should be minimum size 15M to avoid damage from construction traffic.**
2. **At interior supports, 50% of bottom bars may be curtailed at 0.125 X clear span from the face of the support.**

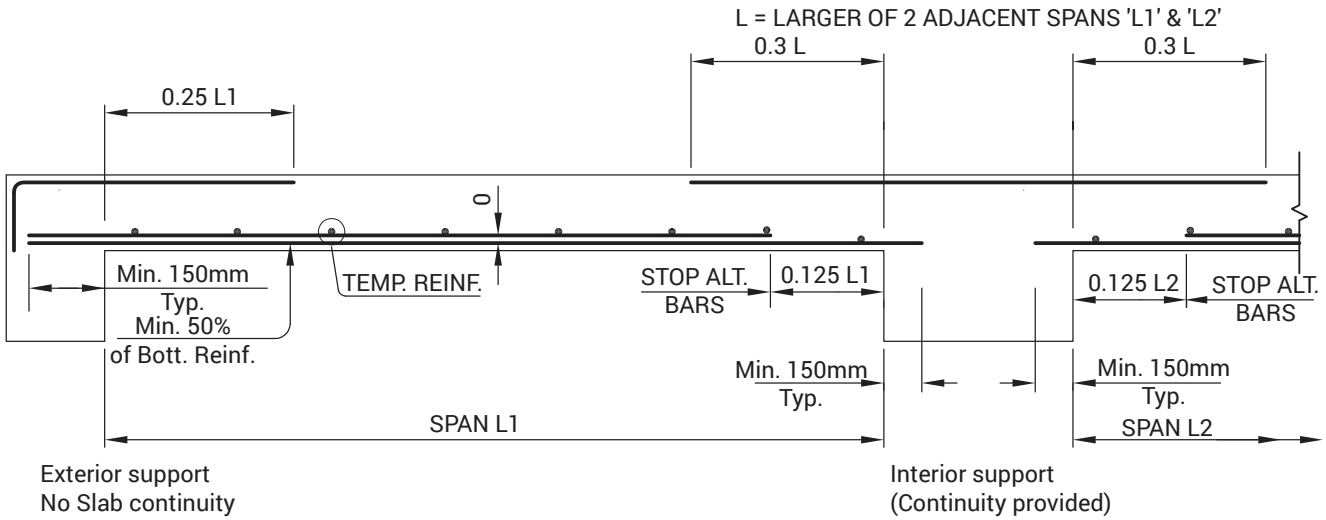


FIG. 5 - 4
Typical One - Way Slab Details

Minimum Length of Reinforcement Two-Way Flat Plates and Flat Slabs without Beams

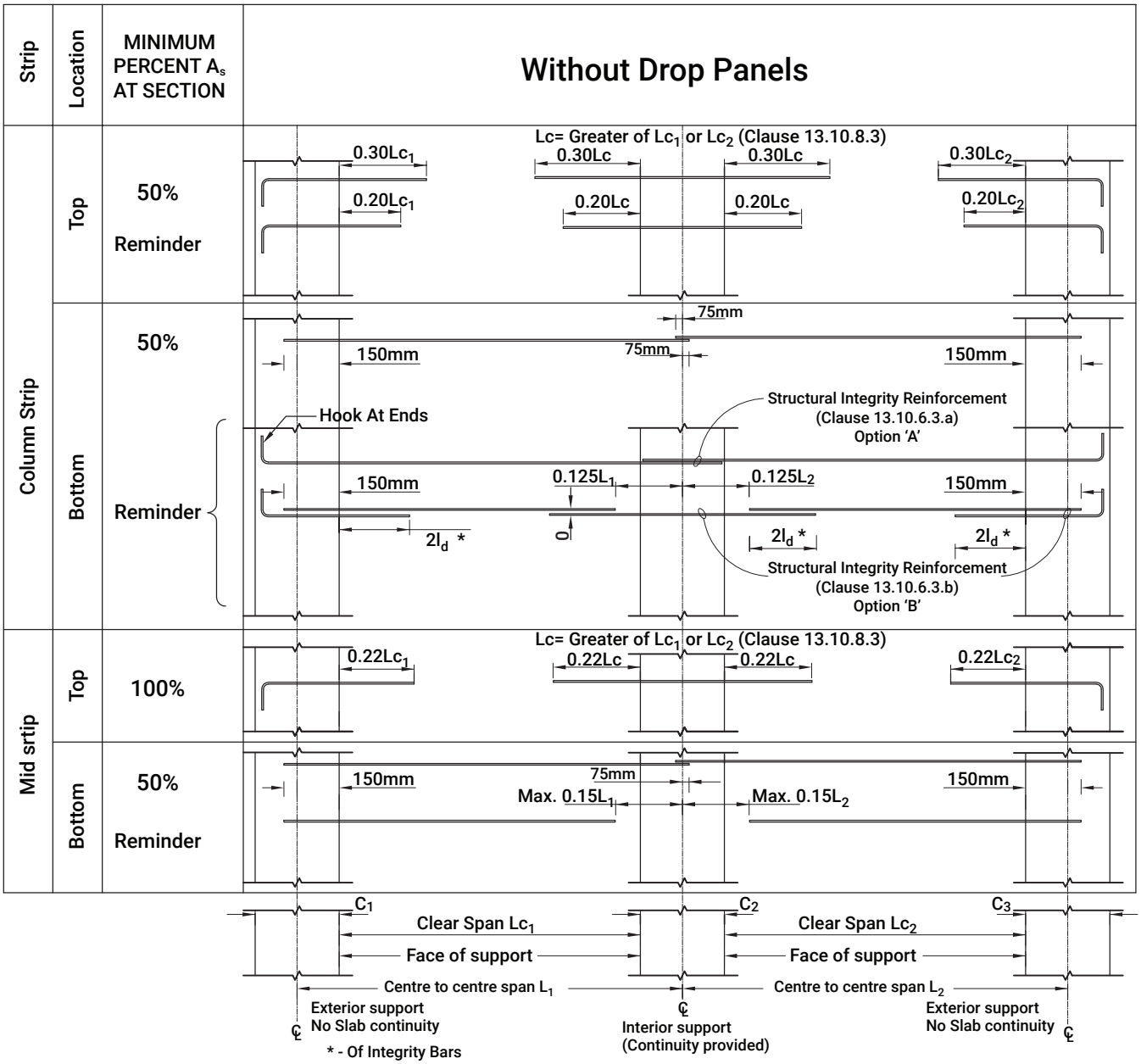


FIG. 5 - 5A

Minimum Length continued

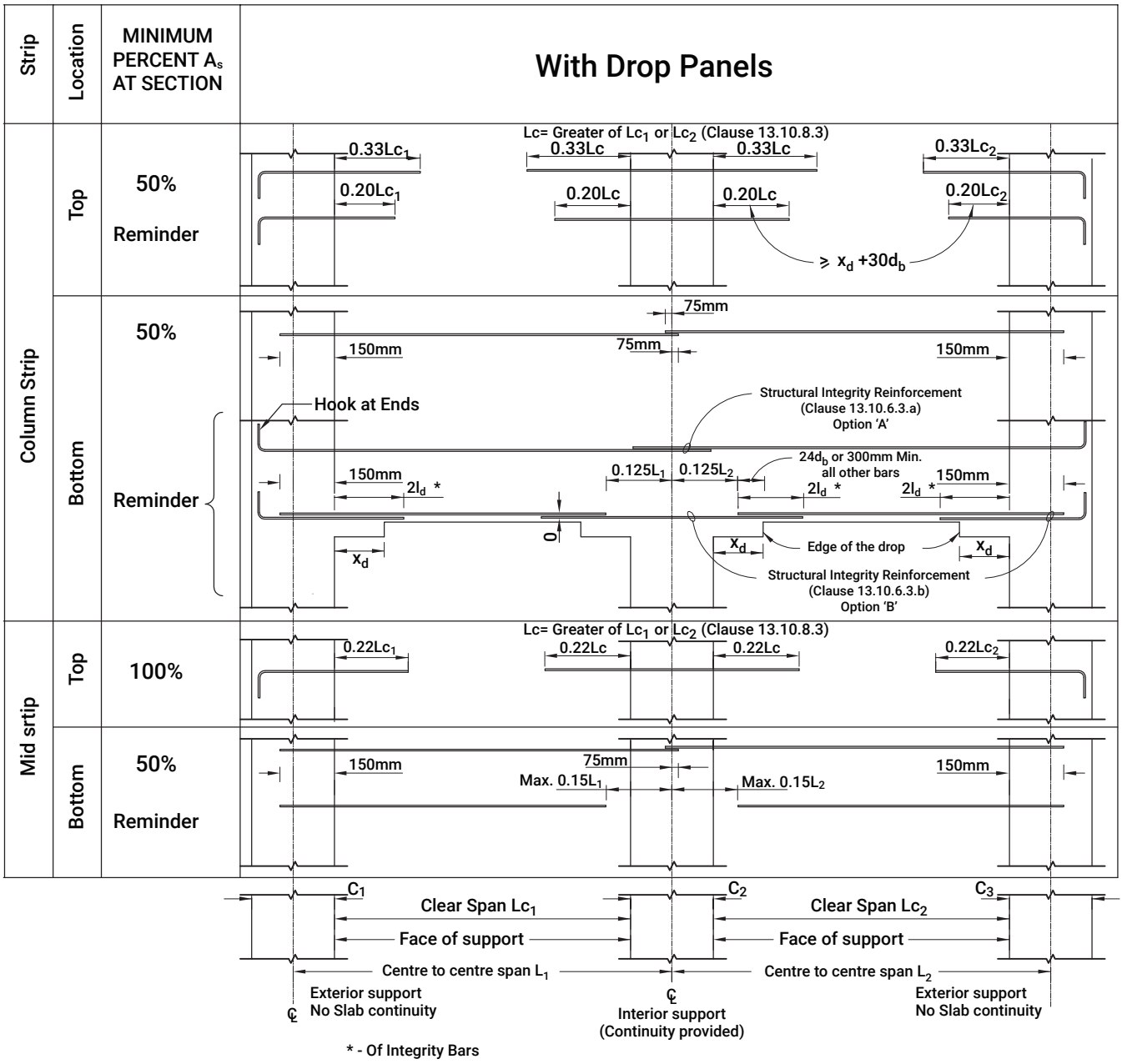


FIG. 5 - 5B

Reinforcing Steel for Masonry Construction

The use and type of concrete blocks shall be determined and specified by the Architect and Engineer. The details provided by the Architect and Engineer will determine the placement and configuration of reinforcing steel in both horizontal and vertical planes.

A standard practice will not be recommended in this section, due to the large variety and configuration in the design of masonry reinforcing. It is the sole responsibility of the Engineer to specify the location, size, spacing, lap length and required embedment of the reinforcing steel in masonry construction.

Prior to detailing reinforcing steel the Detailer shall verify the local practice used in concrete masonry construction. For example:

- Are shop drawings required?
- Is a bar list acceptable in-lieu of shop drawings?
- Maximum lengths for vertical and horizontal reinforcing steel.
- Lap locations.
- Lap lengths.

Earthquake Resistant Structures

Primary members of structures are subject to stress variations from earthquake loads. CSA Standard A23.3-19 provides greater toughness to frames by way of provisions for shear, torsion, anchorage, and joint design for beams, columns, and walls. The Engineer shall check that frames designed in accordance with the provision of the standard shall be sufficient for ordinary and tall structures constructed in seismic zones where risk of minor or moderate damage from earthquake is present.

In a seismic zone where risk of major damage from an earthquake is present, a frame of greater ductility is required. As an elasto-plastic system, such a frame is designed to accommodate the formation of plastic hinges with the accompanying large deflections. These frames may be used with or without shear walls.

The subject here is to illustrate what the Designer should convey to the Detailer, and to familiarize the Detailer with the special reinforcement details. Much of this can be done with special schematic diagrams as shown in Fig. 5-6 and 5-7. The details given are, in principle, applicable to “ductile moment resisting space frames” in the highest seismic zone in Canada, as required by the National Building Code.

Avoiding Bar Congestion

It is important for the Designer to study bar layouts carefully and give the Detailer the appropriate information. This study will help avoid congestion at beam-column joints where beam bars, column bars, and ties intersect and can create significant congestion. A large scale drawing, model or mock-up of the joint details may be worthwhile to assure that the design can be assembled and concreted.

Ductile Frames - Beam

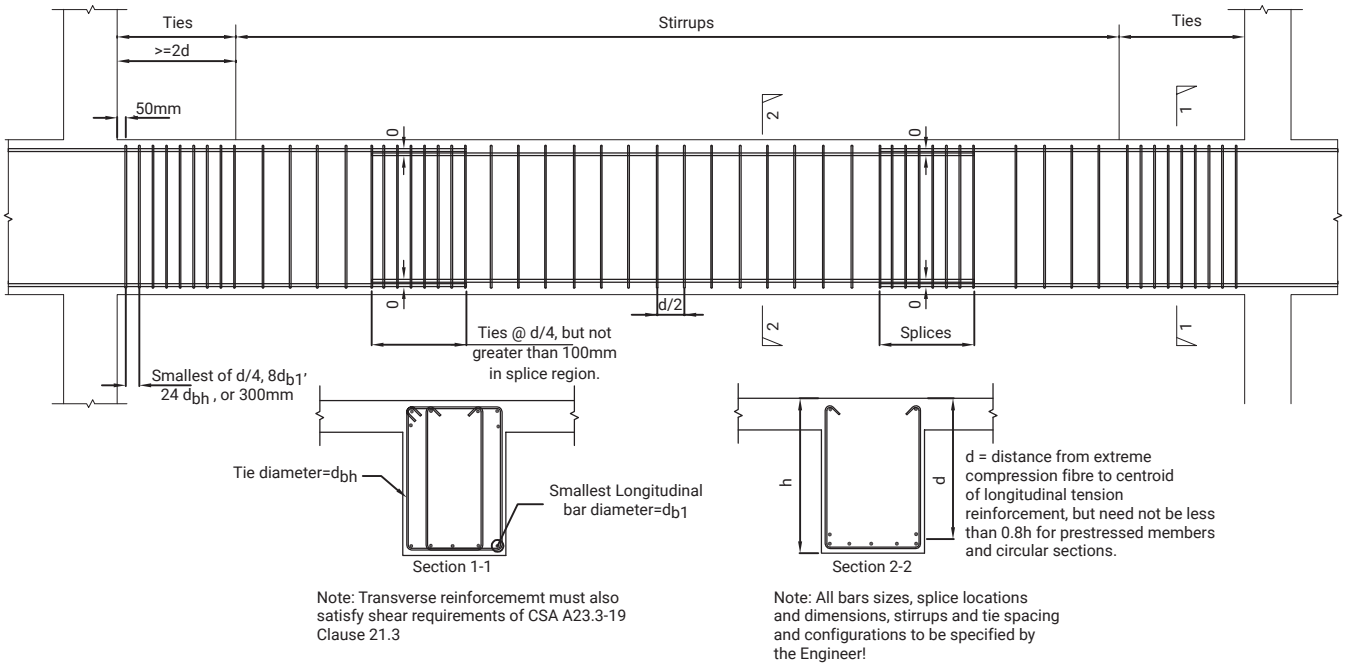
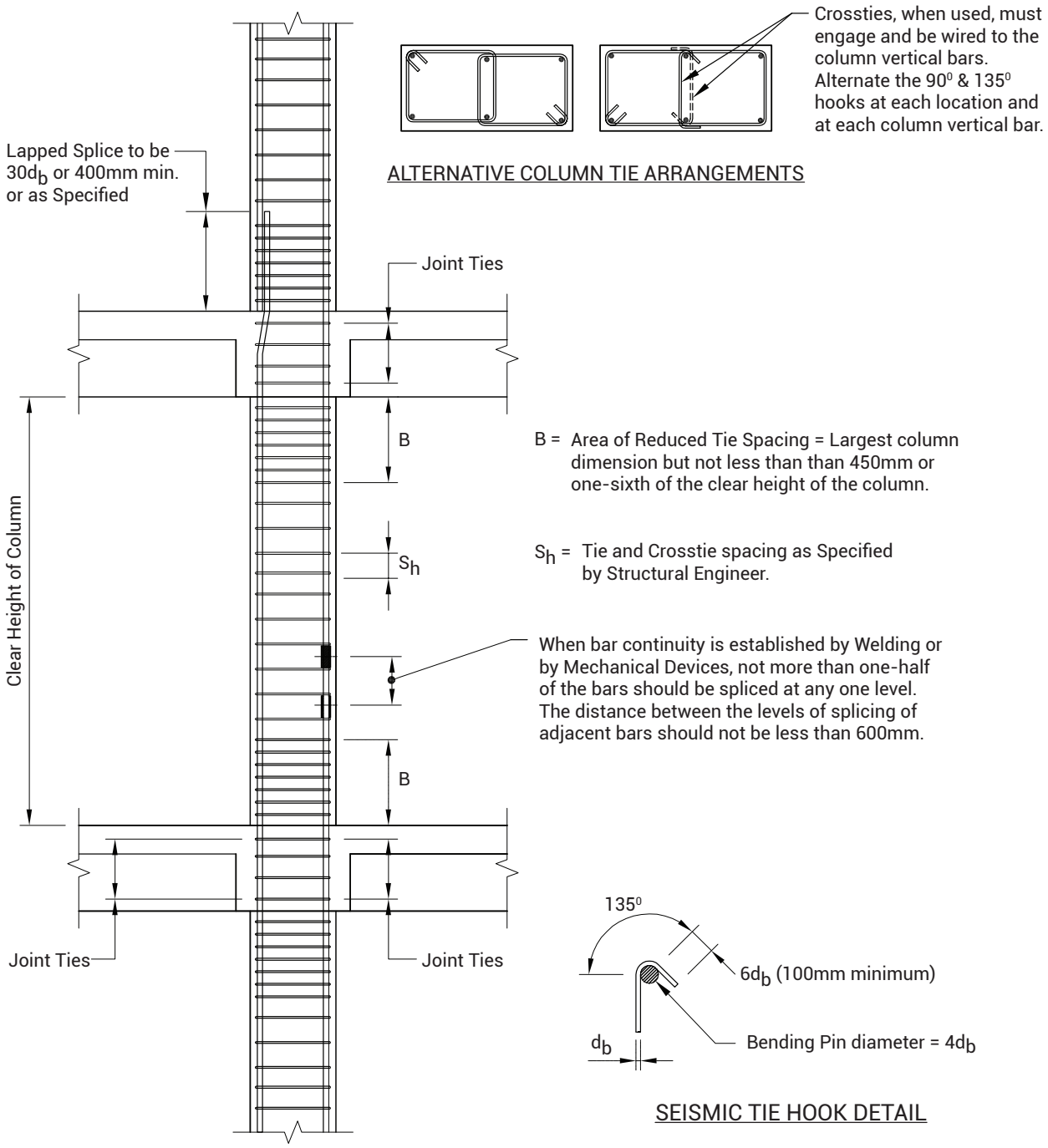


FIG. 5-6
Transverse Reinforcement Requirements for Beams in Ductile Moment Resisting Frames

Ductile Frames - Column



Splice Type, Location and Staggering Requirements are to be Determined by the Structural Engineer as per the Local Seismic Requirements

FIG. 5-7
Reinforcement Requirements for Columns in Moment Resisting Frames

General

Fabrication consists of the cutting, identification of bars, bundling, bending and loading for transport, reinforcing steel to a specified bar list. This chapter will discuss the sequence of fabrication as well as the allowable tolerances as outlined in Fig 6-1.

Manifest/Bar Identification

Before fabrication can commence a manifest of material must be provided. The manifest must show the following information:

- Project
- Contract Number
- Order Number
- Bar List
- Grade
- Bar Mark
- Number of Bars
- Size
- Length
- Part of Structure
- Required Bending

Once a manifest is available, bars get identified for fabrication and installation, using Bar Lists and Tags.

Bar Lists and Tags

Tags are usually made of weather resistant material and are commonly prepared by computers. Fabricators may use their tags in different ways, i.e. - different colour tags may be used to identify bundles for the different components of a structure.

Tags shown in Fig 6-2 and Fig 6-3 are fairly representative of the type of tags used in the industry.

Sequence of Fabrication

Cutting/Shearing

The first shop operation is to shear the bars to the proper lengths. Straight bars are bundled, tagged/painted and then delivered directly to the shipping area. Bars requiring further fabrication are moved to the appropriate process areas of the shop prior to being complete.

Bundling

A bundle shall consist of reinforcing bars of one size and similar lengths. Small quantities of bars may be bundled together for convenience. Varying bars must be bundled together. Straight bars and bent bars may be bundled separately. Bundle weights shall not exceed shop or job site lifting capacity.

Bending

Reinforcing bars shall be cold bent accurately to the dimension given within the tolerances shown on Fig. 6-1. The bend diameter shall be as per Appendix Table 5. Reinforcing steel shall not be bent or straightened in a manner that will damage the integrity of the material.

Mill Certificate Tracking

There are two methods of associating mill certificates with fabricated rebar.

1. Through automated software, parts of structures are associated with mill certificates using scanners and production software.

2. A manual system where the shear operator records heat numbers and associates them to parts of structures.

Loading for Transport

The loading and securing of bundles onto trailers should be done in a manner that evenly distributes the weight across the trailer and conforms with local transportation and safety laws. Sufficient dunnage should be used to facilitate the ease of unloading.

Quality Control

Although there is no industry standard on quality assurance, the responsibility to ensure the correct quantity, size, grade, length and shape delivered to the site rests solely on the fabricator. Methods and procedures are available to the fabricator that will help achieve the level of quality a fabricator desires.

Tolerances

Practical limitations imposed by the nature of reinforcing steel, fabrication safety, the equipment used and the speed of production, make it necessary to establish certain fabrication tolerances which can be met with standard shop equipment. Where greater accuracy is required other than Fig. 6-1, Engineers must clearly state that requirement. An extra charge is applicable for deviation from these standard tolerances.

- Straight reinforcing bars are cut to length by shearing with a tolerance of ± 25 mm.
- Tolerances of typical bent bars see Fig. 6-1.
- The tolerance for the overall length of a bent bar is ± 25 mm.
- All dimensions are out-to-out of a bar, except "A" and "G" on standard 135^0 and 180^0 hooks.
- The diameter of column spirals is measured to the outside spiral.
- The tolerance:
  ± 13 mm for diameters less than 750 mm.
  ± 25 mm for diameters 750 mm and larger.
- The tolerance for ties and stirrups:
  ± 13 mm.

When saw cutting the ends of bars in order to achieve a proper fit for compression splices, the end deviation of the cut should not exceed 1.5^0 when measured from a right angle to the axis of the bar and should be fitted within 3^0 of full bearing after assembly. See Fig. 10-1

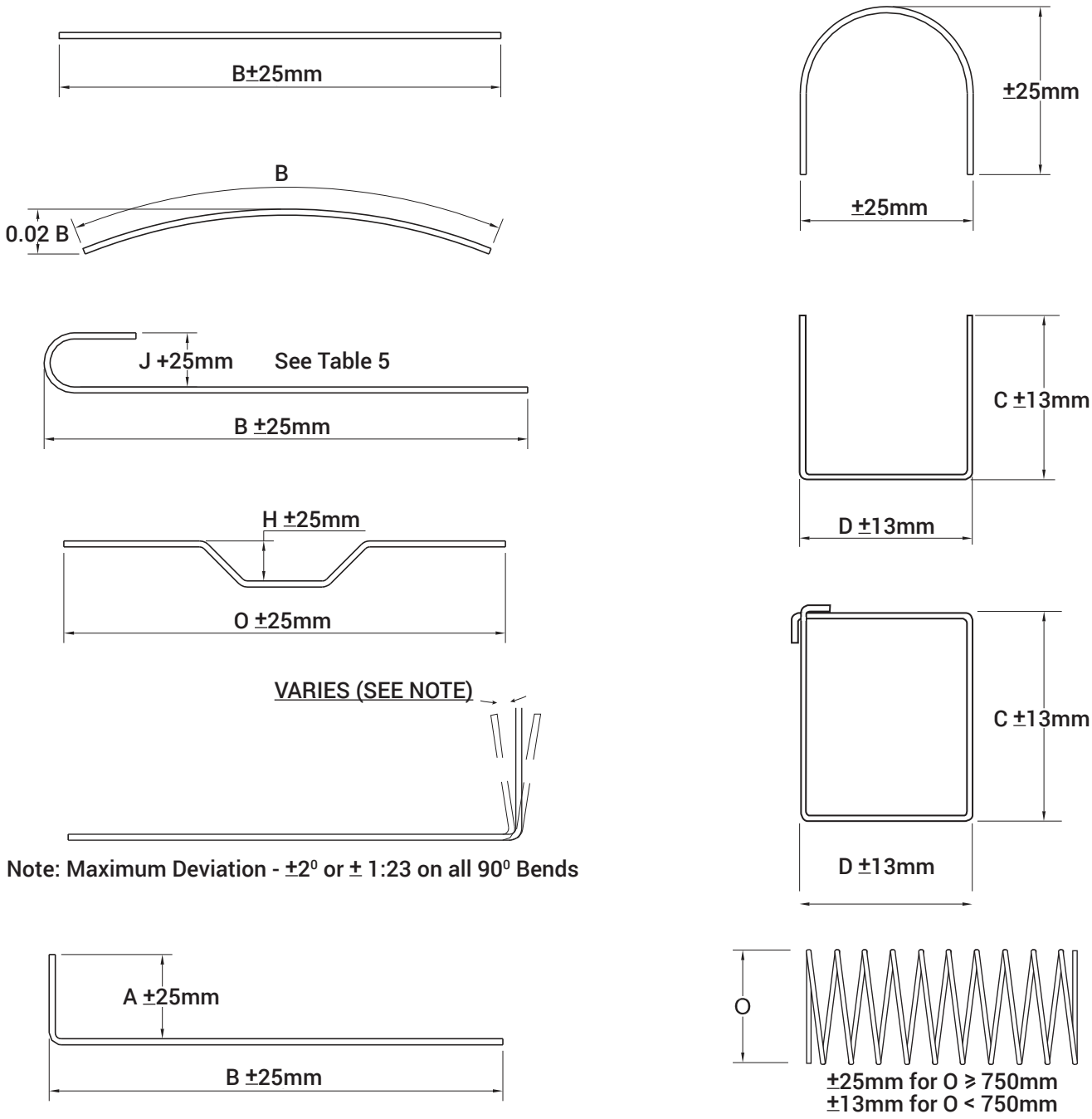


FIG. 6-1
Standard Fabricating Tolerances 10M to 55M Bars

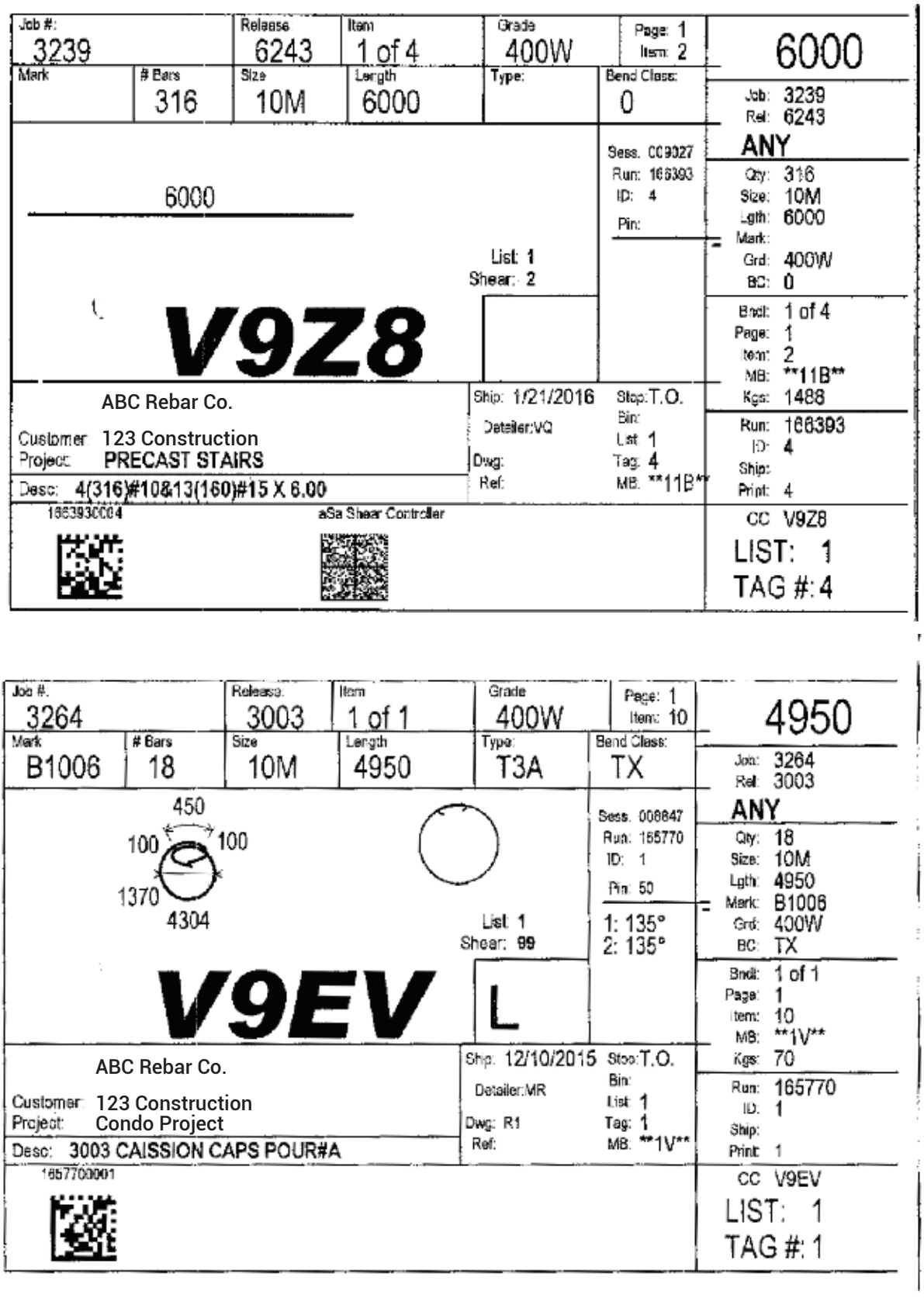
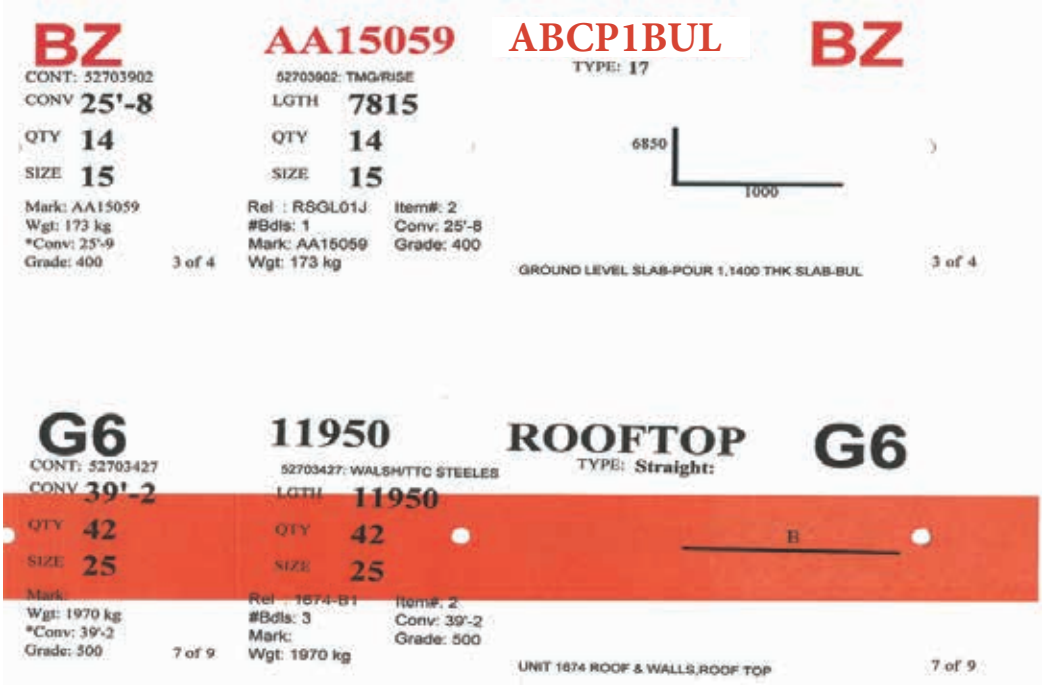
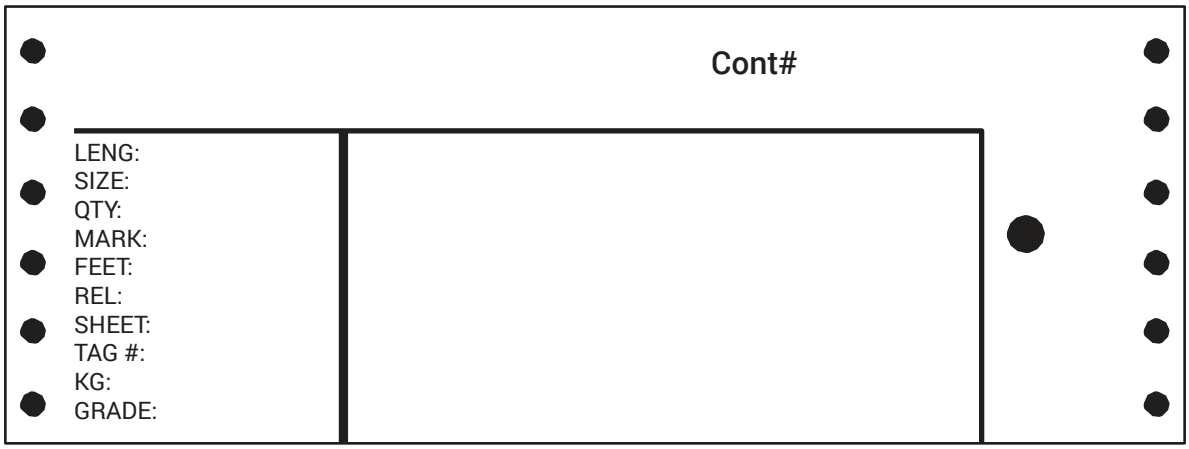


FIG. 6-2
Sample Bar Tags





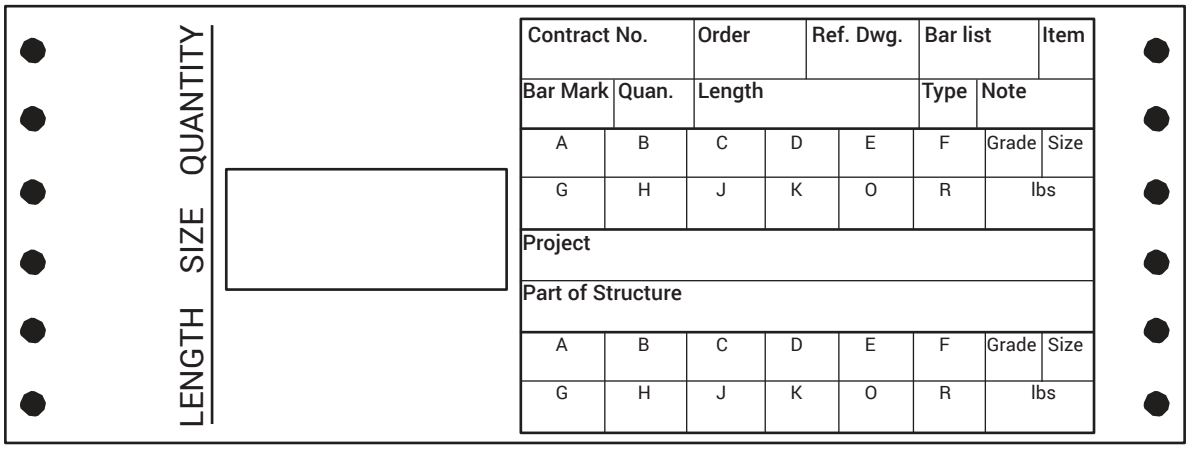


FIG. 6-3
Sample Bar Tags (Continued)

General

The correct procedure for the placement of reinforcing steel bars calls for a series of logical steps that shall be followed for safety, speed and economy. It is therefore recommended that all bars be placed in accordance with the following directions:

Before any bar is placed, the placing drawings and bar lists must be studied by competent supervisory personnel to ensure that all parties understand the work to be done.

The points to be considered include the following:

- Quantity of reinforcement required
- Grades of steel
- Additional reinforcement required
- Method of placement
- Accessories required
- Typical details
- Spacing of bars
- Special conditions

Problems that arise shall be resolved between the Placing Contractor and/or the Fabricator and the Engineer and/or the General Contractor.

Guidance for the safe handling and installation of reinforcing steel can be obtained from the RSIC's Placing Reinforcing Bars Manual or your local safety authority.

Unloading - Hoisting - Storage

Approved equipment must be used for the safe unloading, moving, hoisting and lowering of reinforcing steel and assembled components. All slings used shall be made of wire rope or approved nylon capable of handling the loads involved.

Special care and special slings MUST be used for all handling of specialty products, see Chapter 9.

Reinforcing steel shall be unloaded and stored as close as possible to the placing area. To keep bars free of mud, to prevent damage and to facilitate re-handling, store bars on wood blocks. Any mud or foreign material shall be removed from the bars before placing. Bars stored on formwork or new concrete must be spread out to distribute the weight.

Inspection

Each load of reinforcement arriving at the job site shall be checked by the Buyer, at the time of unloading, for quantity and grade. Any discrepancy must be reported to the Fabricator immediately. The Fabricator will not be responsible for any shortage that is not reported within seventy-two hours of receipt of the load, see Chapter 3, Claims.

The condition of the bars should be checked. Bars with rust or mill scale or a combination of both are considered acceptable without cleaning or brushing, provided that the minimum dimensions, including height of deformation, and mass of a cleaned sample shall not be less than as specified in CSA Standard G30.18, see Chapter 1.

Bar Supports

The Placing Contractor is responsible for the estimating, supplying, and the installation of bar supports in accordance with the standards referred to in Chapter 8 of this Manual, unless specified otherwise. Any additional supports or special supports required by the Engineer or by the Contractor will be supplied and placed by special arrangements.

Concrete Cover for Reinforing Steel Bars

CSA A23.1-19 requires that different covers be used for corrosive and non-corrosive environments. It is up to the Designer to specify the cover for a corrosive environment. Unless otherwise specified, a non-corrosive environment will be expected and the concrete covers for non-corrosive environments as detailed in Appendix Table 8 will be used.

Concrete Cover in a Non-Corrosive Environment

The specified cover for reinforcement in prestressed and non-prestressed concrete shall not be less than as follows:

EXPOSURE TO EARTH OR WEATHER	EXPOSED	NOT EXPOSED
a. When cast against and permanently exposed to earth	75 mm	75 mm
b. For		
i. Beams, girders, columns and piles: Principal reinforcement, 35M and smaller	40 mm	30 mm
ii. Slabs, walls, joists shells and folded plates: 20M and smaller	40 mm	20 mm
c. For bars with a diameter d_b larger than listed above, the cover shall be at least as shown right but not be more than 60 mm	1.5 d_b	1.0 d_b
d. The ratio of the cover to the nominal maximum aggregate size shall be at least	1.5 d_b	1.0 d_b
e. The cover for a bundle of bars shall be the same as that for a single bar with an equivalent area		

*See also Table 8 in Appendix.

Spacing of Bars

The equal spacing of each bar in a slab or wall generally is not of prime importance. It is of greater importance that in any given length or panel of slab or wall the correct number of bars be installed at a reasonably equal spacing. For example: if the placing drawing calls for 10 spaces of 150 mm each, this would require 11 bars in 1500 mm.

In slabs other than cellular or ribbed construction the principal reinforcement shall be spaced no further apart than three times slab thickness, or 500 mm as per A23.3-19 (Clause 13.10.4)

In walls and slabs, the first bar placed at the end member shall be spaced no more than the specified spacing.

Placing Tolerances

Unless specified otherwise by the Engineer, reinforcing steel is to be placed within the following allowable tolerances:

- For clear concrete protection of reinforcement: ±12 mm

Where the depth of a flexural member, thickness of a wall or smallest dimension of a column is:

- 200 mm or less: ±8 mm
- Larger than 200 mm, but less than 600 mm: ±12 mm
- 600 mm or larger : ± 20 mm

The lateral spacing of these bars shall be within ±30 mm of the specified spacing:

- For longitudinal location of bends and end of bars: ±50 mm
- For longitudinal location of bends and ends or bars at discontinuous ends of members: ±20mm.

Regardless of the tolerance requirements for placing, concrete cover shall not be reduced by more than one-third of the specified cover.

Bars shall be placed as shown on the placing drawings. They shall be tied to ensure that displacement outside the allowable tolerances will not occur. It is not necessary to tie bars at every intersection; a tie at every fourth or fifth intersection is sufficient. Additional tying beyond industry practice must be clearly specified.

There are certain conditions where greater tolerances are permitted:

- Temperature steel placement has a spacing tolerance of ±50 mm.
- In slabs and walls the main steel has a spacing tolerance of ±50 mm.
- A variation of ±25 mm in stirrup placing is permissible.

Cutting of Bars On Site

Cutting bars to clear obstructions reduces the strength of the structure at that point, and may only be done with the approval of the Engineer.

Embedment

Embedment of bars is required to develop the design strength of the structural members. The bottom reinforcing bars in beams, slabs and girders shall be embedded a minimum of 150 mm into the supports. The top reinforcing bars in continuous construction shall have an embedment length not less than the development length l_d beyond the point where bent or terminated tension reinforcement is no longer required to resist flexure, subject to requirements of CSA- A23.3-19.

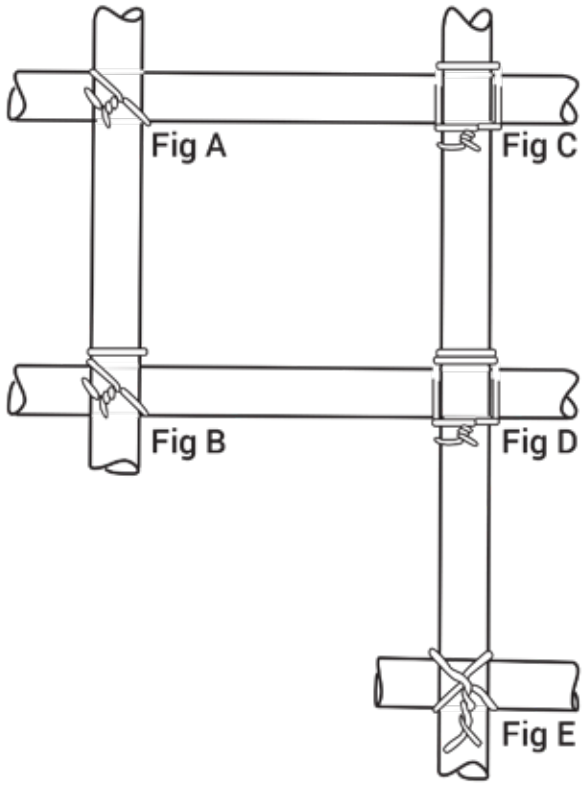
In all cases, sufficient steel shall be extended or hooked for embedment purposes, as specified in CSA-A23.3-19.

Tying of Reinforcing Bars

There are various methods of hand tying the intersection of bars. Some of the most common ones are:

- Fig. A Single tie is used normally to secure the bars in position against displacement.
- Fig. B Wrap and single tie is normally used when tying wall reinforcement, holding the bars securely in position so that the horizontal bars do not shift during the construction process or concreting.
- Fig. C Saddle tie used particularly for tying bars in footings or mats to hold bent ends of bars in position.
- Fig. D Wrap and saddle tie is used to secure heavy bars that are pre-assembled into units to be lifted by crane where there is a tendency for a great deal of strain on the ties.
- Fig. E Figure eight tie is sometimes used in walls in place of the wrap and single tie.

16-gauge wire is used for tying rebar unless specified otherwise by the Engineer.



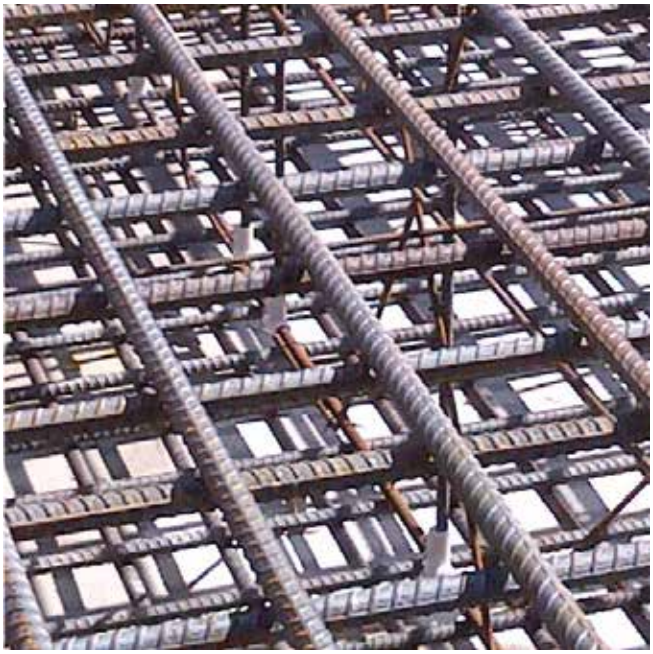
Diameter of Holes for Reinforcing Steel Bars

The overall diameter of reinforcing steel, including the height of the deformation, may be important when making holes in structural steel or form work to insert a bar. The following chart gives the approximate diameter, of the various sizes of holes:

Bar Size	Approximate Diameter of Hole Sizes (mm)
10M	15
15M	20
20M	25
25M	30
30M	40
35M	45
45M	55
55M	70

Splices

The Contract drawings will indicate the splicing details. Generally the lapped splice is the most economical. For the length of lap required on a lapped splice, refer to Appendix, Tables 10, 12, 13, 14, 15 and 16.



General

Bar supports are used to ensure that the reinforcing steel is firmly held in place before and during the placement of concrete. They must be of adequate size and strength and spaced to prevent any displacement of the reinforcing steel during the course of construction, and keep the bars at the specified distance from the formwork.

The Placing Contractors shall be responsible for the supply of all support materials, including any reinforcing steel bar that is to be used for support purposes (support bars). An exception would be where reinforcing steel is specified as support material on the structural drawings. The reinforcing steel so specified to be used as support material is then the responsibility of the Fabricator.

Manufacturer of Bar Supports

Bar supports may be made of metal, plastic, concrete or other approved materials, or a combination of these materials.

The nominal height of bar supports shall be taken as the distance from the bottom of the leg, sand-plate or runner wire to the bottom of the reinforcement. Variations of ± 3mm from the stated nominal height shall be permitted, as per A23.1-19 Clause 6.6.7.2.3 and 7.2.2.

Classes of Bar Supports

Class A - No Protection

Bar supports are manufactured from cold-drawn steel wire, and are referred to as Bright Basic. They are for use in situations where concrete surface staining can be tolerated. Class A Bar supports are available with earth-bearing bases (sand plates).

Types of wire supports manufactured in Class A are shown in Fig. 8-1 and Fig. 8-2.

Class B - Moderate Protection

Bar supports are manufactured from cold-drawn steel wire and have a plastic coating protection to use in situations of moderate exposure and to minimize surface staining. At the option of the manufacturer, the plastic coating protection may be applied either by a dipping operation, by the addition of premoulded plastic legs to the top wires, or by the addition of premoulded plastic tips to the wire legs. The plastic, at points of contact with the form, shall have a thickness of not less than 0.75mm and an average thickness of 1.5mm. The plastic shall extend upward on the wire to a point at least 15mm above the form. The plastic shall not chip, peel, crack or deform under ordinary job condition temperatures.

Class B bar supports are manufactured in types shown in Fig. 8-1 and Fig. 8-2.

Class C - Maximum Protection

Bar supports are manufactured from precast concrete blocks, with or without tie wire embedded in the block. They are designed to be used in contact with soil, in severe exposure or in footings. They can also be used for most other applications.

Class C bar supports are manufactured in types shown in Fig. 8-1 and Fig. 8-2.

Class D - Maximum Protection

Bar supports are manufactured from cold-drawn steel wire and supported by plastic bearing legs. They are for use in exposure conditions, or when sand blasting is required. Class D bar supports are available with earth-bearing bases (sand-plates).

Steel wire bar supports can be coated with a suitable material (ie; epoxy) for use as a Class D support, when supporting corrosion resistant reinforcing bar. Where sand blast is required the support must have plastic bearing legs.

Class D bar supports are manufactured in types shown in Fig. 8-1 and Fig. 8-2.

Class E - Maximum Protection

Bar supports are manufactured entirely from plastic. They are made in various shapes and sizes as shown in Fig. 8-1 and Fig. 8-2. They can be used in supporting all reinforcing bars.

Specifications

Identification of bar supports shall be noted as follows:

- Nominal Height
- Type of Support (Symbol)
- Class of support

For example:

- 200, HC-E identifies a 200 mm height, individual plastic high chair, Class E.
- 100, CHC-B identifies a 100 mm height, continuous high chair, Class B.

Recommended use and Placing of Bar Supports

Bar supports shall be sufficient in number and strength to carry the reinforcing steel. When bar supports are placed in continuous lines, the end legs on adjoining supports shall be lapped. No bar shall be placed more than 50 mm beyond the last leg at the end of a run of continuous supports.

Bar support chairs are supplied:

- For top bars in slabs up to 450 mm in thickness
- In sufficient quantities so as to not exceed a 1200 mm average spacing in each direction.

Bar supports are not supplied for temperature mesh, unless specified in the structural drawings or specifications.

Manufactured bar supports for top bars in footings and foundation mats of more than 450 mm in thickness are only supplied by special arrangement.

Bar supports are designed and installed to support the reinforcing steel only. Failure of bar supports due to abnormal load conditions, such as supporting runways for concrete buggies or other heavy loads, shall not be a cause for rejection if the support meets the requirements of this chapter. Replacement of bar supports damaged by such things as noted above shall not be the responsibility of the Placing Contractor.

Fig. 8-3 to Fig. 8-6 show the location and spacing of bar spports for various spans in slabs and beams. The quantities shown are the amounts estimated and supplied by the Supplier to provide maximum spacings shown in Fig. 8-3 to Fig. 8-6 for each type of support. For structural framing not covered by these figures, the proper types of supports will be supplied at maximum, or as close as possible to maximum spacings, unless otherwise specified.

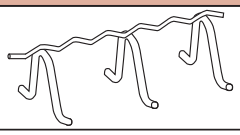
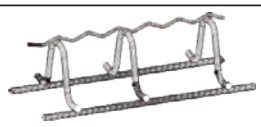
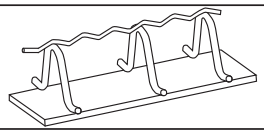
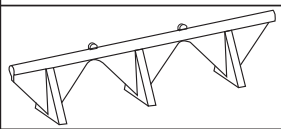
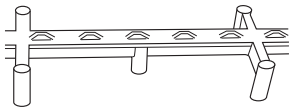
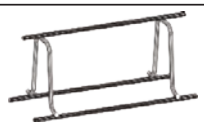
Symbol	Bar Support	Type of Support	Standard Size
SB-A		Slab Bolster Plain Wire	20, 25, 40 and 50 mm height in 1500 mm lenghts for black bar
SB-B		Slab Bolster legs dipped or tipped	same as SB-A
SB-U-A		Slab Bolster with runners	same as SB-A
SB-P-B		Slab Bolster with plates	same as SB-A
BB-A		Beam Bolster plain wire	20, 25, 40, 50 mm heights 50 to 130 mm heights in increments of 10 mm - 1500 mm lenghts of black bar
BB-B		Beam Bolster legs dipped or tipped	same as BB-A
BB-D		Beam Bolster with plastic encased top wires and legs	20, 25, 40, 50 & 65 mm in 150 mm lengths good for all rebar
BB-E		Beam Bolster made entirely from plastic.	20, 25, 40, 50, 65 &75mm heights in 1500 mm lengths. Good for all Rebar
CHC-A		Continuous High Chair plain wire	65 to 230 mm heights in increments of 10 mm, 1500 and 3000 mm lengths of black bar
CHC-B		Continuous High Chair plastic dipped or tipped	same as CHC-A
CHC-U-A		Continuous High Chair Upper	same as CHC-A

FIG. 8-1
Standard Types and Sizes of
Types of - Continuous Chairs

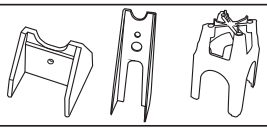
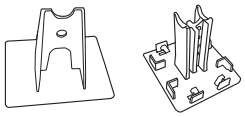
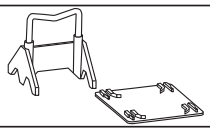
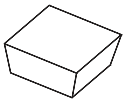
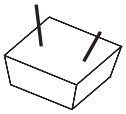
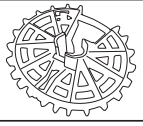
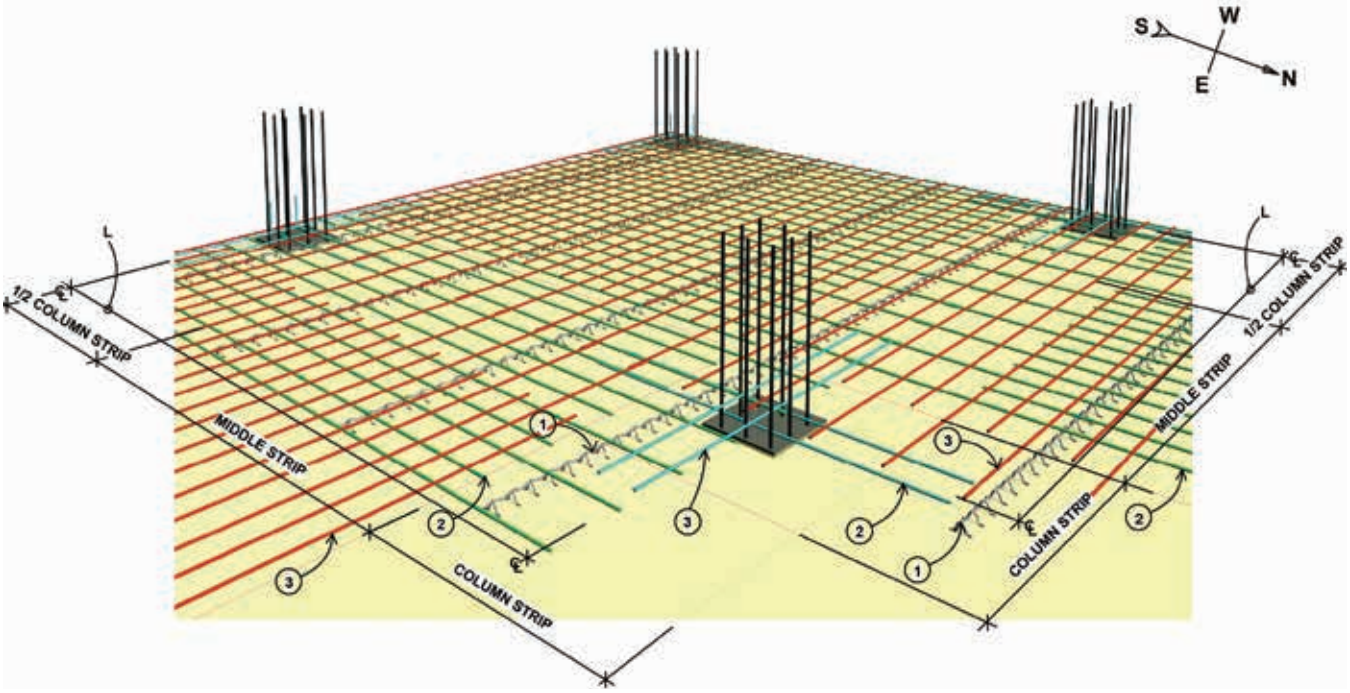
Symbol	Bar Support	Type of Support	Standard Size
HC-A		High Chair plain wire	Up to 450 mm for black bar
HC-B		High Chair plastic dipped or tipped	Up to 450 mm for black bar
HC-D		High Chair top wire mounted on plastic legs	Up to 500 mm for black bar
HC-E		High Chair entirely from plastic	Up to 300 mm for all bars
HC-P-E		High Chair made entirely from plastic with a sand plate	Standard Size - Up to 300mm for all Bars
HC-P-A		High Chair with Sand Plates	Heights to 450 mm for bearing on soil
HC-P-D		High Chair top wire mounted on plastic legs with sand plates	Up to 500 mm for bearing on soil
HC-F		High Chair with base wires	same as HCP
Standee A-A		A 10M or 15M bar bent to order over 450 mm standee rests on lower mat of bars	Up to 450 mm
CB-A		Concrete Block	Up to 250 mm
CBW-A		Concrete Block with plain or coated wire	Up to 250 mm
PC-CL-E		Clip on type chair	20, 25, 40, 50 mm
PC-W-E		Circular Spacer	Up to 75 mm cover for spacing wall or column steel

FIG. 8-2
Standard Bar Types and Sizes of Types of - Individual Chairs

Sequence of Placing Bottom Bar Supports and Bars in a Two Way Flat Plate

The N-S & E-W references in this diagram and notes are for reference purposes only. The Structural Engineer is responsible for designating the direction of placing the BLL, BUL, TLL & TUL bars in each slab.



N-S & E-W Bottom Bars

1. Place continuous lines of Slab Bolster in E -W direction at 1200 mm o/c between columns, begin spacing 300 mm from center line of columns.
2. Lay N-S Bottom Bars in column and middle strips - BLL (Bottom Lower Layer)
3. Lay E-W Bottom Bars in column and middle strips - BUL (Bottom Upper Layer)

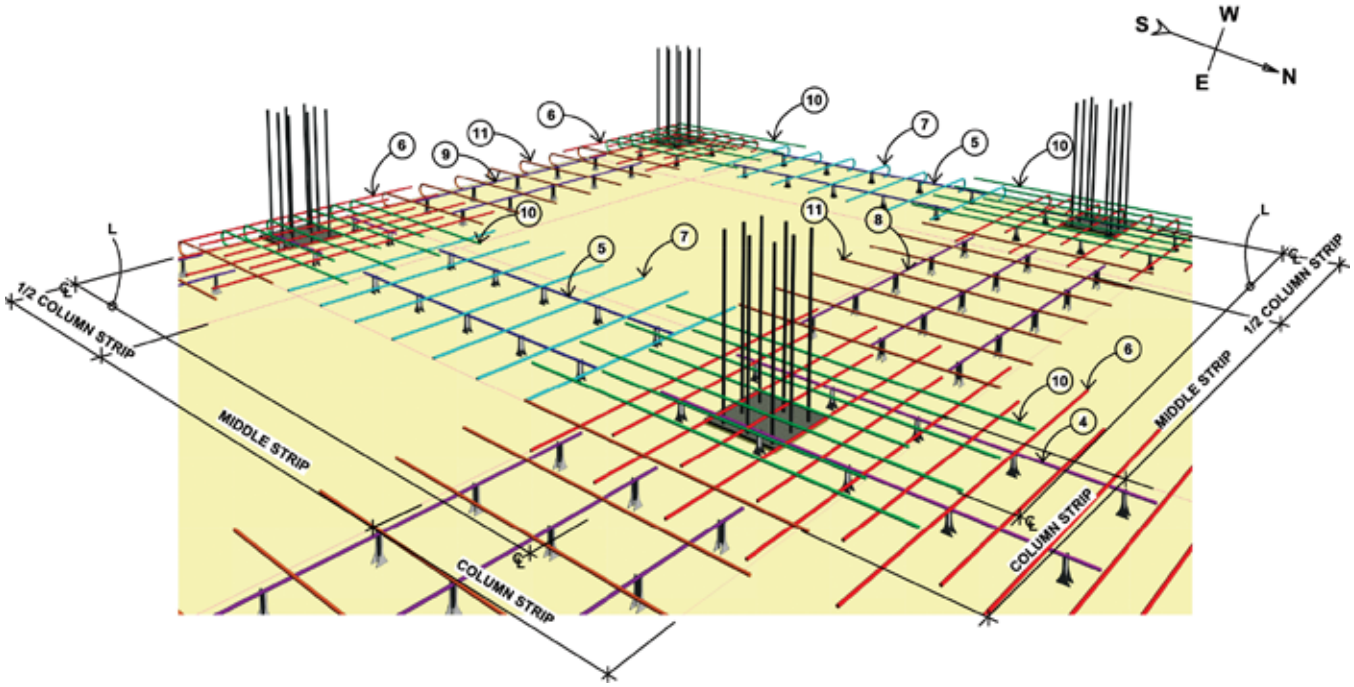
Quantities of Bars Supports Required					
Spans Center to Center of Columns	Bottom Bar Slab Bolsters N.S. and E.W.	Column Heads E.W. Directions		Middle Strip N.S. & E.W. Directions	
		Top Bar Support Bars	High Chairs	Top Bar Support Bars	High Chairs
0 to 4 Meters	4	3	9	3	9
4 m to 5 m	5	3	12	3	12
5 m to 7 m	6	4	20	4	16
7 m to 8 m	7	4	20	4	20
8 m to 9 m	8	5	30	5	25
9 m to 10 m	9	5	30	5	25

Bar support quantities in the adjacent table are for interior panels only. As conditions in exterior panels vary quantities must be adjusted accordingy.

FIG. 8-3

Sequence of Placing Top Bar Supports and Bars in a Two Way Flat Plate

The N-S & E-W references in this diagram and notes are for reference purposes only. The Structural Engineer is responsible for designating the direction of placing the BLL, BUL, TLL & TUL bars in each slab.



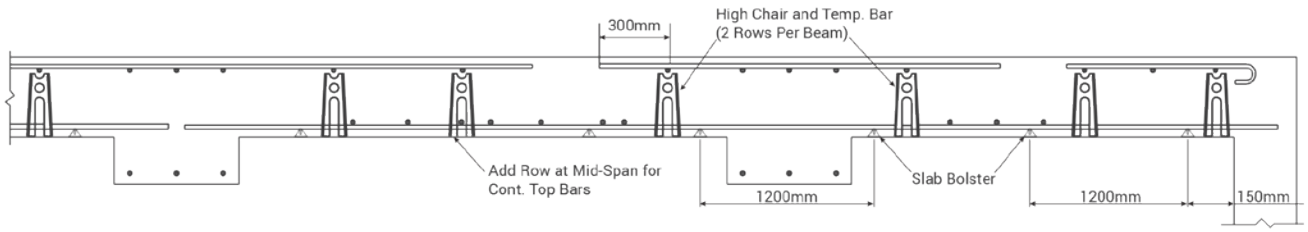
N-S & E-W Top Bars

4. Place 3 or more rows of 15M Supports Bars, on High Chairs, in N-S direction at each column head. (Bar lenght = 0.5L, maximum spacing 1200 mm o/c, high chairs spaced at 800 mm (maximum).
5. Place 2 rows of 15M Support Bars, on High Chairs, between columns at slab edge in N-S direction.
6. Lay E-W Bars in column strips - TLL (Top Lower Layer).
7. Lay E-W Bars in middle strips - TLL
8. Place 3 or more rows of 15M Support Bars, on High Chairs, between colunms in E-W directions. (Bar length = 0.5L maximum spacing 1200 mm o/c, high chairs spaced at 800 mm maximum).
9. Place 2 rows of 15M Support Bars, on High Chairs, between columns at slab edges in E-W direction.
   (Bar length = 0.4L, maximum spacing 1200 mm o/c, high chairs spaced at 800 mm maximum).
10. Lay N-S Bars in column strips - TUL (Top Upper Layer).
11. Lay N-S Bars in middle strips - TUL.

For Quantities of Support Bars and High Chairs see table on Fig. 8-3

FIG. 8-4

Bar Supports for One-Way Solid Slabs

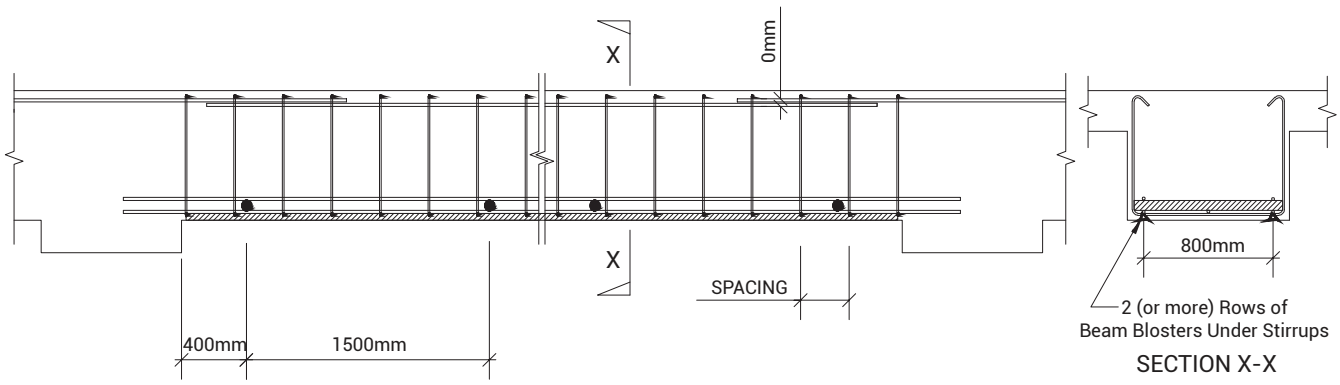


Notes:

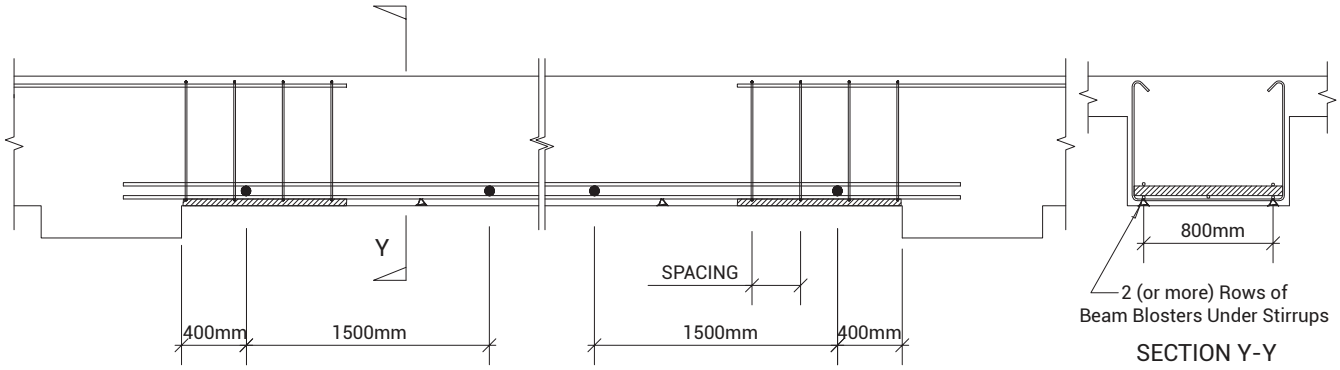
1. Temperature bars to be used for support bars for:
   - 15M temp. bars - HC @ 1200mm Max.
   - 10M temp. bars - HC @ 800mm Max.
2. Continuous high chairs (CHC) may be used in lieu of high chairs and temp. bar.
3. With 10M continuous top bars provide rows of support @ 800mm c.c.
4. Temperature bars to be used as support bars usually require Class A splice.

FIG. 8-5

Bar Supports for Beams and Girders



STIRRUPS FULL LENGTH OF BEAM



STIRRUPS PARTIAL LENGTH OF BEAM

FIG. 8-6

General

This chapter is intended to discuss the materials available for corrosive environments. This chapter will deal with Epoxy Coated Reinforcing Steel, Stainless Steel, Galvanized Reinforcing Steel and Fiber Reinforced Polymers Bar(FRP). These various types of materials are used to deter concrete spalling. Spalling is a premature deterioration of reinforced concrete due to corrosion of reinforcing steel. This corrosion takes place when solutions containing materials such as; salt, potash or sulphur, penetrate the surface of concrete structures and attack the reinforcing steel. The specifications in this chapter should follow all local, regional, municipal and provincial standards and specifications.

Application

Many types of concrete structures are subjected to a corrosive environment where Epoxy Coated Reinforcing Steel, Stainless Steel, Galvanized Reinforcing Steel or FRP would be beneficial. Primary applications include: bridges, parking garages, seawater structures, water and sewage treatment facilities, mining projects, chemical plants, and processing plants where chemicals are used.

Epoxy Coating Reinforcing

Definition

Epoxy coated reinforcing bars are specially coated with an organic coating, known as fusion bonded powder epoxy, which is applied by electrostatic spray.

Material

- Steel

Steel reinforcing bars to be coated shall meet CSA G30.18-09 (R2019) specifications and be free of contaminants such as oil, grease, paint or scale.

- Primer

Some specifiers and designers in Canada require primers to enhance the adhesion of the coating. The application of a primer, together with the advances in coatings and a quality assurance program, significantly slows the rate of water penetration and the progress of corrosion at the steel surface.

- Coating

Coating and patching materials shall comply with the requirements of OPSS 1443, or ASTM A775/A775M-19 and D3963/D3963M-15 and local, regional, municipal and provincial guidelines and specifications.

These specifications cover such requirements as coating integrity, thickness, chemical resistance, resistance to applied voltage, chloride permeability, flexibility, bond strength to concrete, abrasion resistance, impact resistance and hardness.

Quality Assurance

There are specified standards for the application of epoxy coating found in the OPSS 1442, ASTM A775/A775M-19 and D3963/D3963M-15. These standards describe steel surface preparation, coating application, thickness of coating, continuity of coating, adhesion of coating and quality control requirements.

The quality control procedures required are:

- Visual inspection of steel surface
- Visual and chemical monitoring of primer applications (where applicable)
- Monitoring of steel temperature
- Maintaining production samples of the epoxy resin
- Electronic holiday detection
- Monitoring of coating thickness
- Bend test to check flexibility
- Sampling and testing bars for adhesion
- Documenting and maintaining test results.

The R.S.I.C. recognizes the epoxy coating plant certification program, developed by the Concrete Reinforcing Steel Institute (C.R.S.I.), as an effective tool in maintaining a uniformly high level of excellence in plant facilities, production procedures and quality assurance operations. This program addresses the specifics of the epoxy coating process which is monitored by a third party inspection firm, and in doing so, maintains the consistent level of high quality epoxy coated reinforcing steel that is expected by owners, specifiers and designers.

Fabrication

The fabrication, handling and shipping procedures concerning epoxy coated reinforcing steel are contained in the OPSS 905, and ASTM D3963/D3963M-15. Systems used to fabricate, handle and ship regular reinforcing bars must be altered for epoxy coated bar to facilitate protection from damaging the coating. All contact areas shall be padded when shearing, bending, banding, bundling, hoisting and shipping epoxy coated bar. There are also special requirements for the coating of sheared ends and fabrication damage with an approved patching material.

See Appendix Table 5B for the recommended minimum bending pin diameters and hook dimensions for epoxy coated steel.

Detailing

Detailing epoxy coated rebar shall follow the same standard practices and procedures as black bar, bends, embedments and laps shall conform to tables 5B, 13, 15 and 18.

Placing

The OPSS 905 and ASTM D3963/D3963M-15 detail special provisions for the placing of epoxy coated bar. All tie wire, chairs and bar supports used for the installation of epoxy coated bar shall be non-metallic materials, or materials with an acceptable protective coating. Epoxy coated bars should not be dragged, and should be stored on non-metallic supports until ready for placing. Hoisting bars on site shall be done in a way to prevent excessive sagging of the bundles. Patching of all visible damage with an approved patch compound according to the patch manufacturer's instruction is required. The maximum amount of repaired damage must be less than two percent of the surface area per metre of each coated bar. Studies have shown that the most damage to epoxy coated steel occurs as a result of vibration of concrete with uncoated vibrator tips. Most specifiers require plastic tipped ends for the vibration of concrete.

Storage and Handling

Epoxy coated reinforcing shall be stored under cover and protected from the elements. Ultra violet rays will reduce the effectiveness of the coating.

Epoxy coated reinforcing shall be handled with care to ensure the coating does not get scratched or damaged. Nylon slings shall be used when lifting epoxy coated reinforcing.

Stainless Steel Reinforcing

Definition

Stainless steel is a reinforcing steel product used in highly corrosive areas and non-magnetic applications. Its resistance to corrosion is due to its chemical composition. It is mainly produced in an electric arc furnace from recycled stainless steel.

Material

Stainless steel reinforcing commonly used in Canada follows OPSS 1440 and the ASTM A995M/A995M-20 specification for yield, tensile strength and elongation. Stainless steel manufacturers shall meet the ASTM, ASME, QQS standards and local, municipal, regional and provincial standards and specifications.

Quality Assurance

Care shall be taken in the handling, shipping, fabrication and placing of stainless reinforcing steel.

Recommended quality assurance is a visual inspection that includes the following considerations:

- Surface area, free of contaminants such as deposits of iron and non- stainless steel metals, mud, dirt, grease and oil.
- Damage due to straightening from coil.
- Inconsistency of surface colour.

Fabrication

To avoid contaminants of iron and non- stainless steel metals, fabrication shall be done in a similar manner as epoxy coated reinforcing. Non-corrosive materials must be used and special care taken when handling, bundling, tagging, hoisting and transporting stainless steel reinforcing. For bending of SS reinforcing, Table 5A grade 500W shall be followed.

Detailing

Detailing stainless steel reinforcing shall follow the same standard practices and procedures as black reinforcing. Bends and lap lengths to be used in stainless steel reinforcing shall be the same as black reinforcing due to their equivalent bond strength to concrete.

Placing

Stainless steel reinforcing steel shall be supported using non-corrosive chairs and spacers. Stainless steel wire must be used when tying bars together.

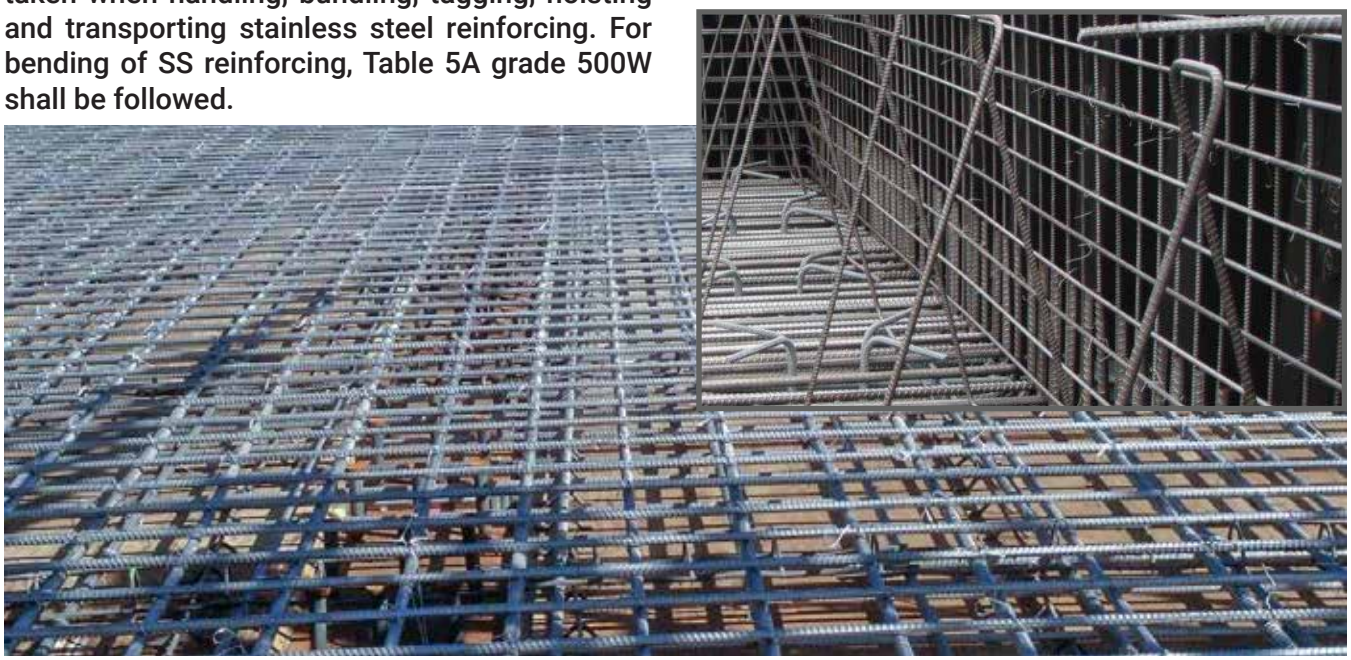
The same precaution as in fabrication shall be maintained on the job site. All handling, hoisting and storage shall be done with non-corrosive materials and be contaminate free.

Tying stainless steel reinforcing to regular reinforcing is an acceptable practice.

Storage and Handling

Stainless steel shall be stored separate from black reinforcing due to the possibility of mill scale or other ferrous metal filings landing on the surface causing localized rusting.

The handling of stainless steel in the fabrication shop and sites is similar to that of epoxy coated reinforcing steel.



Fibre Reinforced Polymer

Definition

FRP is fibre reinforced polymer material, manufactured with polymeric matrix and continuous fibre that is non-corrosive a non-conductive, light weight and high strength.

Material

Concrete reinforcing designs are according to CSA S6-19 (CHBDC) or CSA S806-12 (R2017) building code. All production and reporting is according to CSA S807-19 FRP specification.

Fibers must be ECR glass (Boron Free Glass) and thermoset polymers must be 100% vinylester. All mechanical/physical properties must be in accordance with tables in CSA S807-19. Suppliers must provide full qualification testing for all bar diameters and bends.

Bar Classification

Minimum Tensile strengths are noted in Table 1, tensile modulus of elasticity in Table 2 and durability properties in Table 4 in CSA S807-19. Individual bars are classified by their minimum modulus of elasticity: Grade I (40 GPa), Grade II (50 GPa) and Grade III (60 GPa).

Quality Assurance

Manufacturers shall provide a formal quality control plan along with quality control test reports that verify the conformity of the bars to CSA S807-19. This includes the properties labelled as “Manufacturer’s QC” in Tables 3 and 4 of CSA S807-19.

Fabrication

Pultrusion is the platform for producing FRP bars. The minimum bend diameter shall be at least three times the diameter of the bar. Bending shall be done by the manufacturer before curing the polymer. Field bending is not permitted.

The manufacturer’s name, production lot number, and bar designation shall be printed on each individual straight bar at a frequency allowing for the proper identification and traceability of the bars. Weatherproof labels shall be used to identify bundles of bent bars.

Detailing

Detailing straight FRP reinforcing shall follow the same standard practices and procedures as Black Bar. Detailing Bent Bars shall follow the FRP Manufacturers limitations.

Splicing

Lap splices shall be as per Black Bar or as per Contract Drawings.

Placing

FRP bars shall be secured in place with non-corrosive material.

Storage and Handling

- FRP bars shall not be dragged, dropped or impacted. Bars that have been subjected to any of those actions or that show obvious signs of damage shall be removed and replaced.
- FRP bars shall be stored clear of the ground on suitable protective cribbing. If storing outside for longer than 8 months, cover with tarp to protect from UV.
- For long lengths, a spreader bar shall be used to prevent excessive bending
- Field cutting shall be done with a high speed cutter. Shear cutting is not permitted. Proper PPE should be worn during any cutting.

Galvanized Reinforcing

Definition

Hot dipped Zinc galvanizing is a molten metal emergian process which creates a metallurgically bonded protective coating to steel.

Material

Reinforcing steel is galvanized in accordance with ASTM A767/A767M-19 and wire ASTM A123/A123M-17.

These standards cover such areas as minimum coating thickness, finish, adherence and handling.

Fig 9-1 in this chapter, refers to the minimum coating thicknesses for class I and class II as outlined in ASTM A767/A767M-19.

Quality Assurance

The quality control procedures required are:

- Visual inspection of steel surface prior to galvanizing.
- Visual and chemical monitoring of surface preparation steps which include degreasing, acid pickling and fluxing.
- Monitoring of galvanizing bath temperature.
- Maintaining bath spelter samples.
- Monitoring of coating thickness.
- Sampling and testing bars for adhesion.
- Documenting and maintaining test results.
- Visual inspection for uncoated areas.

Dissimilar Metals in Concrete

When using dissimilar metals in concrete, electrolytic action can occur. Some form of separation shall be used in order to electrically separate galvanized bars from dissimilar metals.

Fabrication

Fabrication can be done before or after the Galvanizing process. Standards used in fabricating regular reinforcing steel shall apply. Approved touch up paint must be used if flaking occurs as per ASTM A780/A780M-20.

The fabricator must work in conjunction with the galvanizer to develop a system to re-tag the reinforcing steel due to the fact that paper tags dissolve in the acid pickling process. As per ASTM A767/A767M-19 Clause 6.4

Detailing

Detailing galvanized reinforcing shall follow the same standard practices and procedures as black reinforcing. Bends and lap lengths to be used in galvanized reinforcing shall be the same as black reinforcing due to their equivalent bond strength to concrete.

Placing

Hot dipped galvanized reinforcing steel shall be supported using non-corrosive chairs and spacers. Zinc coated or dielectric material wire must be used when tying bars together.

Although galvanized reinforcing is abrasion resistant, care must still be taken to avoid damage.

All coating damage due to fabrication or handling shall be repaired with a zinc-rich formulation in accordance with A780/A780M-20.

Storage and Handling

Galvanized reinforcing can be stored outdoors without affecting its corrosion protection properties.

Galvanized reinforcing can be handled in the same manner as black reinforcing. Care shall be taken to avoid damage or flaking of the zinc coating.

Coating Class	Mass of Zinc Coating min, g/m^2 (oz/ft^2) of surface
Class I Bar Designation Size 10M Bar Designation Size 15M & Larger	 915 (3.00) 1070 (3.50)
Class II Bar Designation Size 10M & Larger	 610 (2.00)

FIG. 9-1 Minimum Coating Thickness

Coating Weight		Coating Thickness	
oz/ft^2	gm/m^2	mils	microns
1.00	305.2	1.70	43
1.50	457.8	2.55	65
2.00	610.3	3.40	86
2.50	762.9	4.25	108
3.00	915.5	5.10	130
3.50	1068.1	5.95	153

FIG. 9-2 Conversion from Zinc Coating Weight to Thickness

General

Limitations on the length of reinforcing steel bars due to manufacturing, fabrication, transportation and constructability restraints make it impossible to place continuous bars in one piece throughout the structure. Such conditions may necessitate splicing of reinforcing bars. Other conditions may require the use of splices such as, but not limited to rehabilitation work, future expansion and connecting to existing structures. Properly designed splices are key elements in design.

The recommendations and examples in this chapter concerning the type of splice, method of splicing, welding processes and splicing devices are merely illustrative. Proper engineering must be followed to achieve the specific design requirements. Some proprietary splicing devices are shown in this chapter for information purposes only.

Splices are designed for Tension and Compression or Compression only. There are three methods of splicing:

- Lapped
- Mechanical
- Welded

Each method can be used for either compression splices or tension splices.

Lap Splice

Lapped splicing is the most commonly used method. It involves the overlapping of the ends of two bars by a prescribed distance. The lapped portion of the bars may be fastened together or left spaced apart. Lap splices shall not be used for bars larger than 35M.

CSA A23.3-19 requires that reinforcing bars be spliced to resist the design stresses in the bar at that section.

Only the design Engineer can determine the approximate stress level in a bar or whether a splice can go through a stress reversal.

The Engineer shall clearly show on the structural drawings the type and method of splice required.

If this information is not specifically shown, the Fabricator will supply:

- A lapped tension splice, Class B, for horizontal and vertical bars in walls, slabs and beams.
- Compression embedment lengths for column dowels see Appendix Table 9.
- Compression splices for all other vertical bars.

Where column faces are offset more than 75 mm, separate dowel bars will be embedded into the column below by the amount of the compression development length, and lapped with the bars above by the amount of a compression splice.

When lap-splicing column bars of different sizes, the length of the lap is determined by the diameter of the smaller bar (except as noted in the paragraph above), but may not be less than the required embedment length of the larger bar.

Lapped Tension Splices

Lapped tension splices fall into two classes, “A” and “B”, and may be used for rebar sizes 10M through to 35M. Lapped splices may be contact or spaced. Contact lapped splices shall be securely fastened together. Spaced lapped splices shall be spaced not more than 1/5 of the lapped length of the bar and to a maximum of 150 mm. For development and lap lengths see Appendix, Tables 12, 13, 14, 15 & 16.

Definition of Class of Splice

According to CSA A23.3-19 Clause 12.

Class A Splice 1.0 l_d
Class B Splice 1.3 l_d

Note that l_d is the development length of the bar. The Engineer must determine the required class of splice.

Lapped Compression Splices

For all strengths of concrete 20 MPa and greater, and for Grade 400 rebar, sizes 10M through to 35M, the compression laps shall be as per Appendix Table 10. However, bars sizes 45M and 55M may be spliced in compression only to 35M bars or smaller.

Mechanical Connections

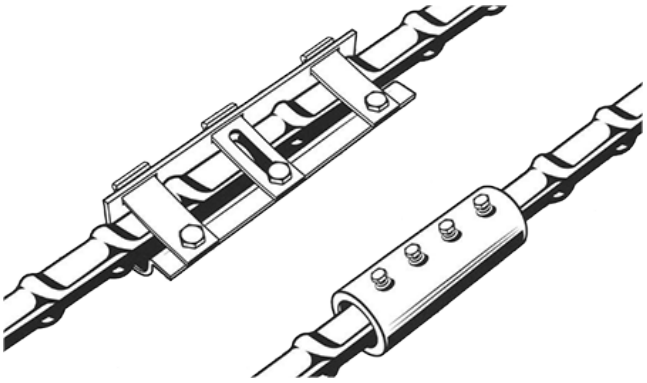
Mechanical connections are used where it is difficult to lap splice bars or where the lapping of bars is prohibited. These situations may occur at:

- Pour breaks.
- Where new bars are being connected to existing embedded bars.
- Where 45M and 55M bars are restricted from being lap spliced by the concrete design code.
- Bar congestion.
- Where area of steel exceeds code limits.

Two basic forms of devices are used to make mechanical connections, those being Compression Only End-bearing and Tension/ Compression.

Coupler Installation procedures may vary from manufacturer to manufacturer. Installation specifications must always be followed.

Compresson Only End Bearing Connections



In applications such as walls and columns where bars are required to carry compressive stress only, compression only end-bearing devices are used. As shown in the diagram, a suitable device consists of a steel cylindrical shell that keeps the bar ends aligned during installation. The capacity of the connection is therefore the capacity of the bars in compression.

To achieve design specifications for an end-bearing connection, See Figure 10-1 maximum angle of deviation and CSA A23.3-19 Clause 12.16.4.2

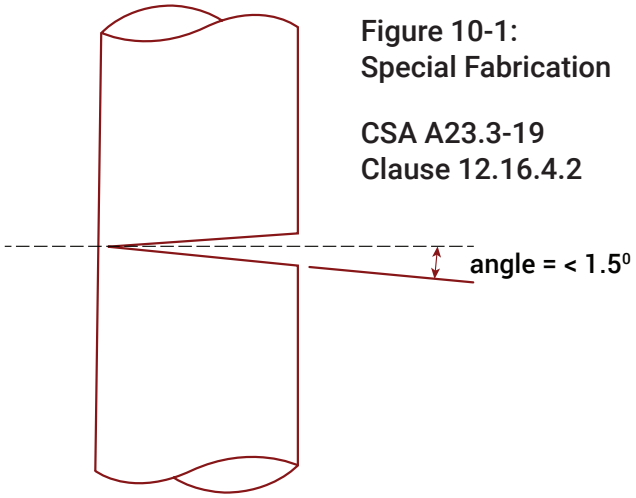


Figure 10-1:
Special Fabrication

CSA A23.3-19
Clause 12.16.4.2

Tension Compression Devices

There are three different CSA design -categories for Tension-Compression Mechanical Connections.

1. General - CSA A23.3-19 Clause 12.14.3.4

A full mechanical connection shall develop, in tension or compression as required, at least 120% of the specified yield strength, fy, of the bar, but not less than 110% of the actual yield strength of the bar used in the test of the mechanical connection.

2. Seismic - CSA A23.3-19 Clause 21.2.7.3

Mechanical splices shall be classified as either Type 1 or Type 2, as follows:

a. Type 1 mechanical splices shall comply with Clause 12.14.3.4 – see above.

b. Type 2 mechanical splices shall comply with Clause 12.14.3.4 and shall develop the minimum tensile strength of the spliced bar. Note: See CSA G30.18 for determining the minimum tensile strength

3. Bridge - CSA S6-19 Section 8.4.4.4

Mechanical connections for reinforcing bars shall develop, in tension or compression (as required), the greater of 120% of the specified yield strength of the bars or 110% of the mean yield strength of the actual bars used to test the mechanical connection. The total slip of the reinforcing bars within the splice sleeve of the connector after loading in tension to 0.5fy and relaxing to 0.05fy shall not exceed the following measured displacements between gauge points straddling the splice sleeve:

a. for bars sizes up to and including 45M: 0.25 mm; and

b. for 55M bars: 0.75mm

Mechanical devices are used in a variety of situations where it is necessary to meet these design categories. The coupler device used in a mechanical connection is designed to transmit the tensile and/or compressive forces between the bars. These couplers can be made in a variety of ways.

Hot-Rolled Threaded Bar Couplers

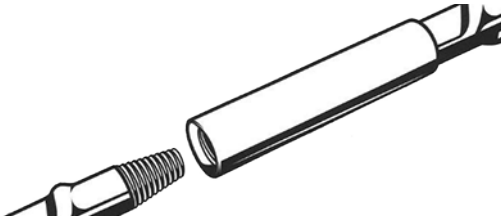
Special reinforcing bars that are rolled with thread-like deformations use couplers with matching threads for splicing. The thread is rolled directly onto the bar, there is no loss of bar strength. The diagram illustrates the splice which must utilize jam nuts to ensure a secure connection. This splice can be used in any situation where splices are required, but requires enough clearance to tighten the jam nut with a wrench.

Threaded Coupler

Depending on manufacturer, there are many thread type couplers available.

Some of these are;

a. Tapered threads;
A taper-threaded coupler joins reinforcing bars with matching taper threads. The coupler is tightened by turning the bar or coupler to the manufacture's specified torque.



b. Upsized straight threads;
A coupler with threads at each end that joins two reinforcing bars with matching upsized threads.

c. Non-upsized straight threads;
A coupler with threads that joins reinforcing bars with matching threads.
NOTE: The cutting of straight threads reduces the net cross-sectional area of the bar, some manufactures use larger bars, while others may use higher strength bars, in order to compensate the net loss.

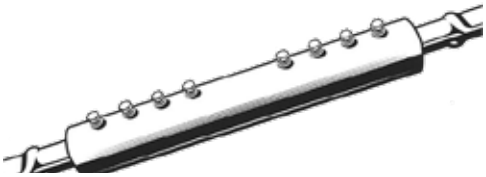
Most of these couplers are also available in transitional, positional and weld-on coupler designs. These couplers can be used in a variety of situations requiring only sufficient clearance for tightening with a wrench.

Cold-Forged/Swaged Steel Coupler

With forged steel sleeve couplings, the transmission of stress is achieved through bearing

between the deformed steel coupling and the bar deformations. The sleeves are squeezed onto the bars while hot or cold with hydraulic jacks. The hydraulic equipment necessary for these splices can restrict their application.

Bolted Steel Coupler



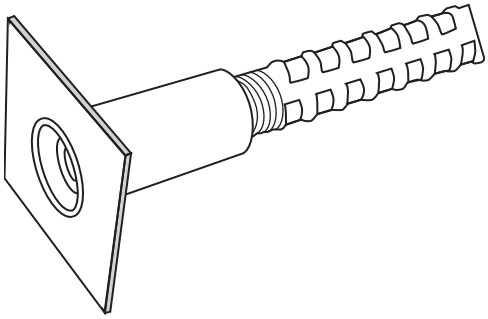
The bolted steel sleeve couplers transmit the stresses developed in one bar to the other bar through high strength, threaded bolts on the side of the sleeve. These bolts have a pointed end, which engages the bar against the sleeve. They are tightened until the bolt heads snap off or to the manufacture's specifications.

Dowel Bar Substitutes and Formwork Savers

Formwork savers are used in situations where it would not be economical to cut holes in forms or where protruding dowels would interfere with continuing work. Crane openings or vertical pour joints in walls are examples of these conditions. The connection typically consists of a threaded coupler that can be attached to the formwork with one of the bars connected. After the concrete is poured and the form is stripped, the remaining threaded bar can be threaded into the exposed coupler when required to complete the connection.

There are primarily two types of formwork saver devices; Threaded bar Formwork Saver and the Threaded Forged bar Formwork Saver.

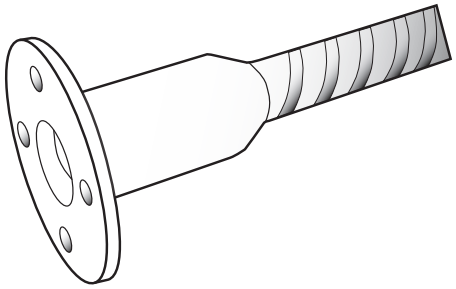
Threaded Bar Formwork Saver



The reinforcing steel bar is threaded to fit a flanged steel coupler that can be bolted or nailed to the formwork.

Threaded Forged Bar Formwork Saver

These splices are typically made up of a bar with

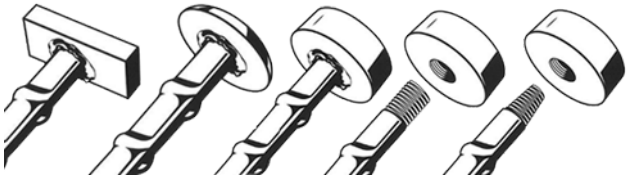


a flanged coupler forged on its end. The bar and coupler are secured to the inside of the formwork. After stripping, another bar with matching threads is screwed into the exposed coupler when required to complete the connection.

Positional Coupler

A positional coupler is used when either bar cannot be rotated to complete the connection. There are many types of positional couplers available, see manufacturer specifications to determine the type to use for the specific condition.

Headed Bar Devices



An alternate way to fully anchor or develop reinforcing bars in tension within relatively short embedment lengths is to use headed reinforcing bars rather than bars with standard end hooks. Headed bars consist of a disc or plate, having either a round, elliptical or rectangular shape, attached to the end(s) of the bar. Attachment of the head to the bar is accomplished by either integrally-forging, threading, welding, cold swaging or shear screw.

CSA A23.3-19 Clause 7.1.4 covers requirements of Headed Bars and Studs. -"Headed bars and studs with a head of an area equal to ten times the bar area shall be deemed capable of developing the tensile strength of the bar without crushing of the concrete under the head provided that the specified concrete strength is equal to or greater than 25MPa and the yield strength of the bar used in the design does not exceed 500MPa."

NOTE: Additional resources. ASTM A970/A970M-18 and ACI 352R-10 are industry publications that focus on the use of Headed Reinforcing Bars.

Welded Splices

Reinforcing steel may be spliced by welding which is governed by CSA W186-M1990- R2016 and can be done in the shop or in the field. However, welding of reinforcing steel requires close control and qualified personnel because of the critical effects of bar chemistry, welding technique, bar preparation, and site conditions on the strength of welded bar. These splices will resist both tensile and compressive stresses and can be used in a variety of situations, especially where existing embedded bars are to be spliced or where bars must be secured to structural steel. The use of this type of splice is limited only by the requirement of qualified personnel and time required per connection.

General

Welded Wire Fabric (WWF) is a prefabricated reinforcement consisting of parallel series of high strength, cold-drawn or cold-rolled wire welded together in square or rectangular grids. Each wire intersection is electrically resistance-welded by a continuous automatic welder. Pressure and heat fuse the intersecting wires into a homogeneous section and fix all wires in their proper position. Plain wire, deformed wire or a combination of both may be used in WWF.

Welded Construction and Structural mesh specifications in Canada and USA as per ASTM A1064/A1064M-18, "Standard Specifications for Carbon Steel Wire and Welded Wire Reinforcement, Plain and Deformed for Concrete".

Welded smooth wire reinforcement in standard sheets or rolls, referred to as "construction mesh", is commonly specified as temperature and shrinkage reinforcement in slabs. It bonds to concrete by the positive mechanical anchorage at each welded wire intersection. Standard styles are listed in Fig. 11-2 and 11-3.

Nomenclature

Style Designation

The spacings and sizes of wires in welded wire fabric are identified by "style". A typical style designation is:

- 102 x 152 – MW18.7x MW25.8

This denotes a fabric in which:

- Spacing of longitudinal wires: 102 mm
- Spacing of transverse wire: 152 mm
- Area of longitudinal wires: 18.7 mm2
- Area of transverse wires: 25.8 mm2

A welded deformed wire fabric style would be noted in the same manner by substituting MD-number wire sizes for the MW-numbers shown.

Standard styles of construction fabric are listed in Fig. 11-2 with a notation for those commonly stocked.

Dimensions

Widths are based on the distance centre-to-centre of the outside longitudinal wires, exclusive of the overhangs, when the total of both overhangs does not exceed 50 mm. When the total of both overhangs exceeds 50 mm, the tip-to-tip dimension of the transverse wire is considered as the "overall" width, see Fig.11-2.

If not specifically ordered otherwise, the overhang of the transverse wire beyond the outside longitudinal wire is normally furnished no greater than 25 mm on each side.

Rolls

Welded wire fabric in rolls can usually be manufactured to any length, but within the individual manufacturing limitations of different producers. Rolls of 30 metres and 60 metres are commonly accepted standard lengths; other lengths are available to order.

Sheets

The tip-to-tip measurement of the longitudinal wires in a sheet may be of any length, but should be a multiple of transverse wire spacing. Welded wire fabric in sheets is furnished on order.

Maximum sheet size often depends on railroad or truck restrictions rather than manufacturing limits. In general, sheets 2.44 metres (8') wide represent the standard width with other sizes available on request.

Finish

Fabric can be supplied bright or galvanized. When both longitudinal and transverse wires have a size designation of MW7.7 or smaller, only galvanized can be furnished. When the finish is not specifically designated, bright wire shall be supplied.

Detailing Welded Wire Fabric

Availability

Limitations of wire size and spacing for both rolls and sheets of welded wire fabric vary within the industry due to differences in equipment used. Specifiers shall consult their local Fabricator to ensure the style they are considering can be readily produced and shipped.

Welded wire fabric can be furnished either in rolls or flat sheets, except that fabric having longitudinal wires with a cross-sectional area larger than 50 mm2, i.e. size designation greater than MW50; shall always be furnished in flat sheets. Where the material must lie substantially flat when placed in the work, fabric furnished in rolls shall be limited to those styles having longitudinal wires not greater than MW35. The availability of sheets or rolls of non-standard sizes shall be determined by contacting a Fabricator.

Quantity

To determine the total quantity of welded wire fabric required to cover a specific area, take the area in square metres and add a varying percentage for the lapping of rolls or sheets as required by the specification. Typically at least 10% to the total area to be covered to allow for laps in rolls and 15% if using sheets.

Laps

Rigidly connected cross-members provide mechanical anchorage. Therefore, adequate lapping may often be accomplished with a short lap when cross wires occur within the lap. The requirements for lapped splices are outlined in the National Building Code and CSA A23.3-19 Clause 12.

Typically, structural laps for WWF are a minimum length of 150 mm plus overhangs for plain wire and 200 mm including overhangs for deformed wires. The design standard requires that 1 or 2 cross wires, depending on type of wire, occur in structural laps of WWF.

Deformed wire structural laps, when no cross wires are included in the splice region, are a minimum of 300 mm.

Placing

In the absence of engineers' specifications, the following will apply. For slab on grade construction; with slab thickness less than 150mm, a single layer of welded wire is placed in the middle of the slab.

For slabs 150 mm and greater, the top cover is 1/3 the depth of the slab. When two layers are specified (usually over 200 mm thick), the top cover will be 25 to 50 mm depending on saw cuts (WWF is placed below the saw cuts). The bottom cover will be 40 mm minimum on earth or 25 mm on vapor barriers.

Support manufacturers produce concrete blocks or steel (coated and uncoated) and plastic chairs, bolsters, and WWF support accessories made specifically for either single layer or double layer reinforcing applications.

Placing WWF on appropriately spaced concrete blocks, steel or plastic supports with base plates and tying the WWF at laps is adequate to maintain its position during concrete placement. WWF shall not be placed on the sub grade and pulled up during concrete placement.

Type of WWF	DIAMETER/SIZE	SPACING
Heavy	MW 58.1 and larger	1.2 to 2.0m
Medium	MW 32.3 to 51.6	0.9 to 1.2m
Light	MW 25.8 or less	0.8m or less

FIG. 11-1: **Spacing for Support Accessories**
See Chapter 7 and 8 in this manual

Metric Designation	Imperial Designation	Steel Area		Weight		Standard Size	
		mm^2/ln m	in^2/ln ft	kg/m^2	lb/100 ft^2	Mesh Sheets	Roll*
152x152 MW9.1 x MW9.1	6x6 10x10	59.9	0.029	1.02	21	4x8 5x10	5x150 6x100x6x201
152x152 MW11.1 x MW11.1	6x6 9x9	74.3	0.035	1.22	25	4x8 8x12 8x20	6x100 6x200
152x152 MW13.3 x MW13.3	6x6 8x8	88.7	0.042	1.46	30	8x20	
152x152 MW18.7 x MW18.7	6x6 6x6 ***	124.5	0.059	2.05	42	4x8 5x10 8x12 8x20	5x150 6x100 6x200
152x152 MW25.7 x MW25.7	6x6 4x4 ***	171.5	0.081	2.83	58	8x12 8x20	
152x152 MW34.9 x MW34.9	6x6 2x2	232.8	0.11	3.81	78	8x12 8x20	
152x152 MW47.6 x MW47.6	6x6 0x0	317.3	0.15	5.22	107	8x12 8x20	
102x102 MW18.7 x MW18.7	4x4 6x6 ***	186.8	0.088	3.02	62	8x12 8x20	
102x102 MW25.7 x MW25.7	4x4 4x4 ***	257.2	0.122	4.14	85	8x12 8x20	
203x203 MD51.6 x MD51.6	8x8 D8xD8	257.2	0.112	4.14	85	8x12 8x20	
305x305 MW22.2 x MW22.2	12x12 W3.4xW3.4	73.0	0.035	1.22	25	8x12 8x20	
305x305 MW37.4 x MW37.4	12x12 W5.8xW5.8	123.0	0.059	2.05	42	8x12 8x20	
305x305 MW51.5 x MW51.5	12x12 W8xW8	170.0	0.081	2.83	58	8x12 8x20	
102x102 MW43.9 x MW39.4 Road Mesh	4x6 W6.1xW6.1	430.1 / 259.2	0.204 / 0.122	5.9	121	8x12 8x20	

* Upon Request *** Also Available in Galvanized sheet 8x20 Available in Grades Fy 485Mpa, 550 Mpa

FIG. 11-2: **Standard Construction Fabric Metric / Imperial Designations**

Wire Size*	Nominal Diam.	Nominal Area	Nominal Mass	CENTRE TO CENTRE SPACING (in.) CENTRE TO CENTRE SPACING (mm)						
W/D MW/MD	in. mm	$in.^2$ mm^2	lb/ft kg/m	2 in. 51 mm	3 in. 76 mm	4 in. 102 mm	6 in. 152 mm	8 in. 203 mm	10 in. 254 mm	12 in. 305 mm
W/D31 MW/WD200	0.628 (#5) 15.96 (15M)	0.310 200.00	1.054 1.568	1.86 3937	1.24 2625	0.93 1969	0.62 1312	0.465 984	0.372 787	0.310 656
W/D30 MW/MD193.5	0.618 15.70	0.300 193.55	1.020 1.517	1.80 3810	1.20 2540	0.90 1905	0.60 1270	0.45 953	0.36 762	0.30 635
W/D28 MW/MD180.6	0.597 15.17	0.280 180.64	0.952 1.416	1.68 3556	1.12 2371	0.84 1778	0.56 1185	0.42 889	0.336 711	0.28 593
W/D26 MW/MD167.7	0.575 14.61	0.260 167.74	0.884 1.315	1.56 3302	1.04 2201	0.78 1651	0.52 1101	0.39 826	0.312 660	0.26 550
W/D24 MW/MD154.8	0.553 14.04	0.240 154.84	0.816 1.214	1.44 3048	0.96 2032	0.72 1524	0.48 1016	0.36 762	0.288 610	0.24 508
W/D22 MW/MD141.9	0.529 13.44	0.220 141.94	0.748 1.112	1.32 2749	0.88 1863	0.66 1397	0.44 931	0.33 699	0.264 559	0.220 466
W/D20 MW/MD129.0	0.505 (#4) 12.82	0.200 129.03	0.680 1.011	1.20 2540	0.80 1693	0.60 1270	0.40 847	0.30 635	0.24 508	0.20 423
W/D18 MW/MD116.1	0.479 12.16	0.180 116.13	0.612 0.910	1.08 2286	0.72 1542	0.54 1143	0.36 762	0.27 572	0.216 457	0.18 381
W/D16 MW/MD103.2	0.451 11.46	0.160 103.23	0.544 0.809	0.96 2032	0.64 1355	0.48 1016	0.32 677	0.24 508	0.192 406	0.16 339
W/D15.5 MW/MD100	0.444 11.26 (10M)	0.155 100.00	0.527 0.784	0.93 1960	0.62 1316	0.465 980	0.31 658	0.233 490	0.186 394	0.155 328
W/D14 MW/MD90.3	0.422 10.72	0.140 90.32	0.476 0.708	0.84 1778	0.56 1185	0.42 889	0.28 593	0.21 445	0.168 356	0.14 296
W/D12 MW/MD77.4	0.391 9.93	0.120 77.42	0.408 0.607	0.72 1524	0.48 1016	0.36 762	0.24 508	0.18 381	0.144 305	0.12 254
W/D11 MW/MD71.0	0.374 (#3) 9.51	0.110 70.97	0.374 0.556	0.66 1397	0.44 931	0.33 699	0.22 466	0.165 349	0.132 279	0.11 233
W/D10.5 MW/MD67.7	0.366 9.29	0.105 67.47	0.357 0.531	0.63 1334	0.42 889	0.315 667	0.21 445	0.157 332	0.126 267	0.105 222
W/D10 MW/MD64.5	0.357 9.06	0.100 64.52	0.340 0.506	0.60 1270	0.40 847	0.30 635	0.20 423	0.15 318	0.12 254	0.10 212
W/D9.5 MW/MD61.3	0.348 8.83	0.095 61.29	0.323 0.480	0.57 1207	0.38 804	0.285 603	0.19 402	0.142 301	0.114 241	0.095 201
W/D9 MW/MD58.1	0.339 8.60	0.090 58.06	0.306 0.455	0.54 1143	0.36 762	0.27 572	0.18 381	0.135 286	0.108 229	0.09 191
W/D8.5 MW/MD54.8	0.329 8.36	0.085 54.84	0.289 0.430	0.51 1080	0.34 720	0.255 540	0.17 360	0.127 269	0.102 216	0.085 180
W/D8 MW/MD51.6	0.319 8.11	0.080 51.61	0.272 0.405	0.48 1016	0.32 677	0.24 508	0.16 339	0.12 254	0.096 203	0.08 169
W/D7.5 MW/MD48.4	0.309 7.85	0.075 48.39	0.255 0.379	0.45 953	0.30 635	0.225 476	0.15 318	0.112 237	0.09 191	0.075 159
W/D7 MW/MD45.2	0.299 7.58	0.070 45.16	0.238 0.354	0.42 889	0.28 593	0.21 445	0.14 296	0.105 222	0.084 178	0.07 148
W/D6.5 MW/MD41.9	0.288 7.31	0.065 41.94	0.221 0.329	0.39 826	0.26 550	0.195 413	0.13 275	0.097 205	0.078 165	0.065 138
W/D6 MW/MD38.7	0.276 7.02	0.060 38.71	0.204 0.304	0.36 762	0.24 508	0.18 381	0.12 254	0.09 191	0.072 152	0.06 127
W/D5.5 MW/MD35.5	0.265 6.72	0.055 35.48	0.187 0.278	0.33 699	0.22 466	0.165 349	0.11 233	0.082 174	0.066 140	0.055 116
W/D5 MW/MD32.3	0.252 6.41	0.050 32.26	0.170 0.253	0.30 635	0.20 423	0.15 318	0.10 212	0.075 159	0.06 127	0.05 106
W/D4.5 MW/MD29.0	0.239 6.08	0.045 29.03	0.153 0.228	0.27 572	0.18 381	0.135 286	0.09 191	0.067 142	0.054 114	0.045 95.3
W/D4 (4ga) MW/MD25.8	0.226 5.73	0.040 25.81	0.136 0.203	0.24 508	0.16 339	0.12 254	0.08 169	0.06 127	0.048 102	0.04 84.7
W/D3.5 MW/MD22.6	0.211 5.36	0.035 22.58	0.119 0.177	0.21 445	0.14 296	0.105 222	0.07 148	0.052 110	0.042 88.9	0.035 74.1
W/D3 MW/MD19.2	0.195 4.95	0.030 19.35	0.102 0.152	0.18 381	0.12 254	0.09 191	0.06 127	0.045 95.3	0.036 76.2	0.03 63.5
W/D2.9 (6ga) MW/MD18.7	0.192 4.88	0.029 18.68	0.098 0.146	0.174 368	0.116 245	0.087 184	0.058 123	0.043 91	0.035 74.1	0.029 61.4
W/D2.5 (7ga) MW/MD15.9	0.177 4.50	0.025 15.87	0.084 0.124	0.15 315	0.10 212	0.075 159	0.05 106	0.037 78.3	0.03 63.5	0.025 52.9
W/D2.1 (8ga) MW/MD13.5	0.162 4.11	0.021 13.30	0.070 0.104	0.124 262	0.082 175	0.062 131	0.041 87	0.031 65.6	0.025 52.4	0.021 43.6
W/D1.7 (9ga) MW/MD11.0	0.148 3.77	0.017 11.14	0.059 0.087	0.104 219	0.069 146	0.052 110	0.035 73	0.026 54.8	0.021 43.9	0.017 36.6
W/D1.4 (10ga) MW/MD9.2	0.135 3.43	0.014 9.23	0.049 0.072	0.086 182	0.057 121	0.043 91	0.029 61	0.021 45.4	0.017 36.3	0.014 30.3

FIG. 11-3: **Sectional Areas of Engineered Structural Welded Mesh (ESWM)**

Imperial Units/Metric Units Area – $in.^2$ Per Linear Foot/Area – mm^2 Per Linear Metre

FIG. 11-3: Continued

Wire sizes are designated by their sectional area in hundredths of a square inch. E.G. W8 Area = 0.08 sq2
W denotes smooth wire, E.G. W18
D denotes deformed wire, E.G. D18

Mesh Conversion:
Rebar fy = 400 Mpa: Deformed WWM Fy 485 Mpa available up to 550 Mpa Area reduction when converting Rebar Steel Area to Deformed Mesh Multiply by x 400/485 = 0.825

Rebar Sizes:		Conversion Factors:	
#3: A = 0.11 in^2 = 71 mm^2	10m : A = 100mm^2 = 0.155 in^2	1 in = 25.4 mm	1 lb = .04536 kg
#4: A = 0.20 in^2 = 129 mm^2	15m : A = 200mm^2 = 0.310 in^2	1ft. = 0.3048 m	1000 psi = 6.895 Mpa
#5: A = 0.31 in^2 = 199 mm^2	20m : A = 300mm^2 = 0.465 in^2	1 in^2 = 645.2 mm^2	Diam. In^2x2.673 + weight lbs/ft
#6: A = 0.44 in^2 = 284 mm^2	25m : A = 500mm^2 = 0.775 in^2	1 in^2/ft = 2116.7 mm^2	A = 0.7854 d^2
#7: A = 0.60 in^2 = 387 mm^2	30m : A = 700mm^2 = 1.085 in^2	1 lb/100 ft^2 = 0.0488 kg/m^2	
#8: A = 0.79 in^2 = 510 mm^2		Area inches 2 x 3.4 = weight lbs/ft	

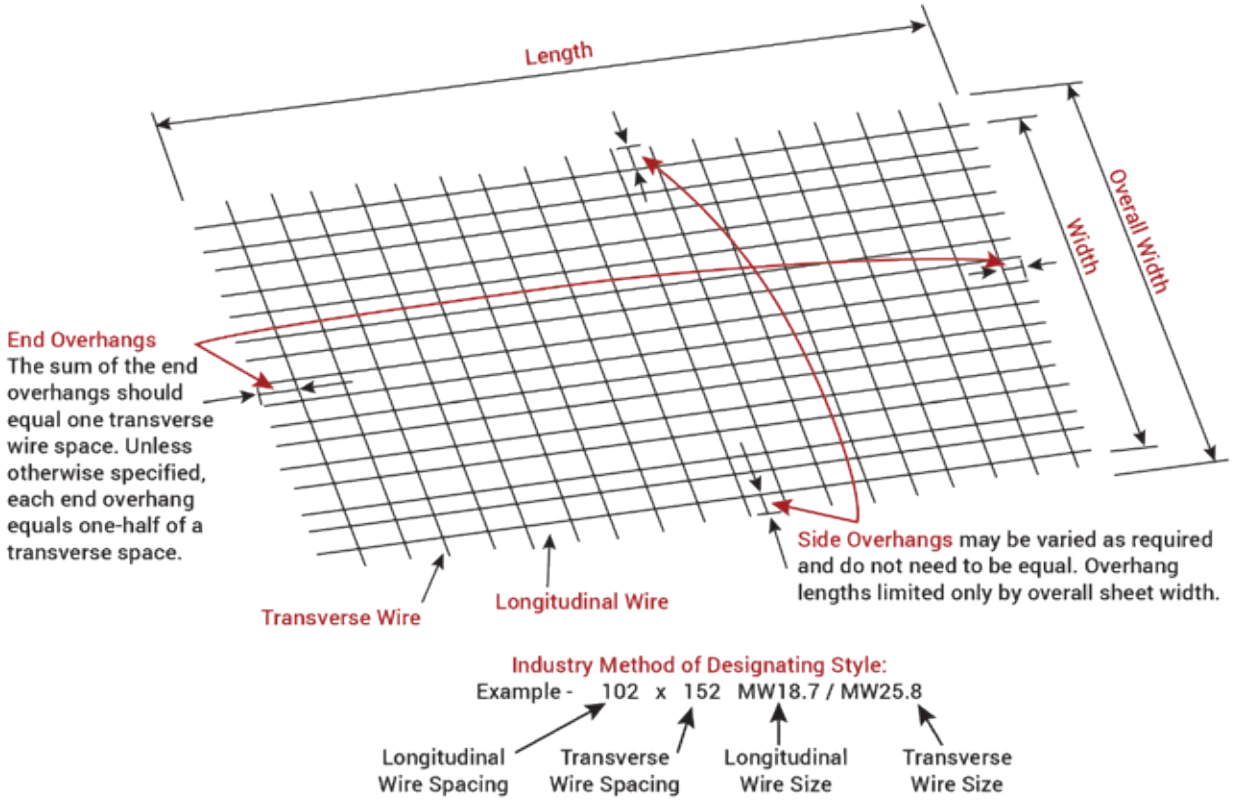


FIG. 11-4: Nomenclature

Minimum Mechanical Properties for WWF

Type of WWF	Minimum Yield Strength Fy	Minimum Tensile Strength Fu	Minimum Weld Shear Strength
Smooth Wire Fabric	450 MPa (65 000 psi)	515 MPa (75 000 psi)	241 x area * mm^2 =Newtons (35 000 x area * $in.^2$ = lb. force
Deformed Structural Wire Fabric	485 MPa (70 000 psi)	550 MPa (80 000 psi)	241 x area * mm^2 =Newtons (35 000 x area * $in.^2$ = lb. force)

*Area of the biggest wire. The smallest wire must have 40% x area of the biggest wire.

According to ASTM A1064/A1064M-18

General

Post-tensioning is a method of reinforcing a structural element using high strength materials such as prestressing strand and/or bars. Prestressing of concrete is the application of internal forces that bend and compress a structural element in order to actively counteract bending from applied loading.

A post-tensioning tendon is prestressing strand and/or bar, complete with anchorages, protective plastic or metal sheath, corrosion inhibiting coating and/or cementitious grout. Two types of post-tensioning tendons exist, a bonded system and an unbonded system. Designers can utilize either system individually or in combination.

Bonded Post-Tensioning

A bonded tendon consists of having one or more prestressing strands and/or a bar placed inside a plastic or metal duct within the concrete structural element. Once the concrete has achieved the desired strength, the tendon is stressed to a predetermined force using calibrated hydraulic jacking equipment. The area inside the plastic or metal duct and surrounding the prestressing strands and/or bar is then filled with a cementitious grout bonding the tendon to the cast-in-place concrete.

Unbonded Post-Tensioning

An unbonded tendon consists of having a single prestressing strand, coated with a rust inhibiting grease and encased in an extruded plastic sheath, placed within the structural concrete element. Once the concrete has achieved the desired strength, the tendon is stressed to a predetermined force using calibrated hydraulic jacking equipment. The prestressing strand is not bonded to the concrete and the prestressing force is transferred to the structural element through the anchor assembly.

Anchor Components

Bonded and unbonded post-tensioning use similar anchor components. The bonded anchor consists of a wedge plate or anchor head, a bearing plate or iron casting, and permanent conical wedges.

The unbonded anchor consists of a single ductile iron casting and conical wedge. Many manufacturers exist and for the purpose of clarity, only a few types of anchors have been shown.

For bar post-tensioning systems, an anchor plate and nut is commonly used. The bar post-tensioning system is primarily used for grouted construction.

The Designer/Engineer may specify size and type of prestressing tendon and/or bar. Familiarization with post-tensioning systems and local post-tensioning Contractors are essential.

Responsibility

No responsibility can or will be assumed by the Post-Tensioning Contractors for the structural design or the correctness of the dimensions on the drawings supplied to them by others. The Post-Tensioning Contractor is responsible for providing sufficient prestress post-tensioning to comply with forces and eccentricities shown on the contract documents.

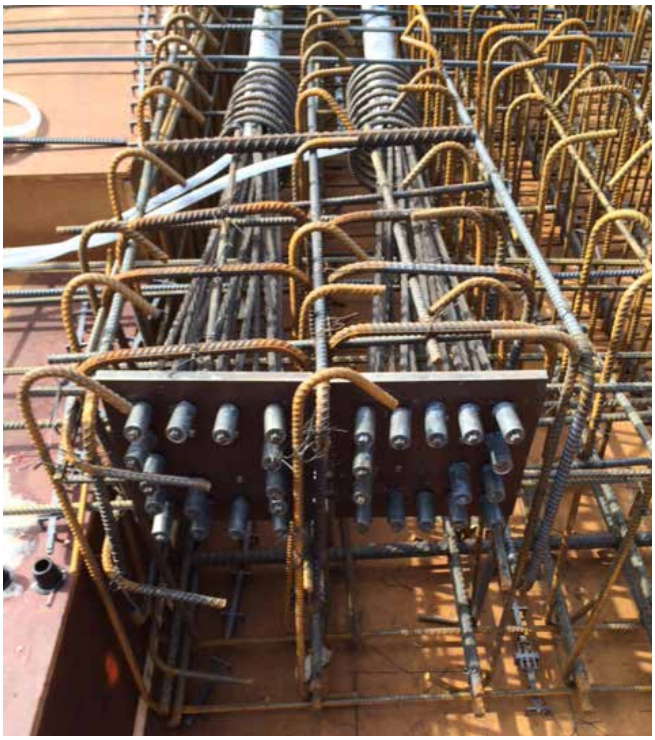
The Engineer - unequivocally the final decision maker - shall approve, approve with comments, or disapprove proposed details. Only the structural Engineer has performed the analysis for all load combinations and knows the required prestress force at all locations. The Post-Tensioning Contractor is responsible for local bursting/spalling reinforcement in the anchorage zone and tendon support bars unless noted otherwise. All other reinforcement requirement is to be designed by the Engineer and supplied & placed by the reinforcing steel Contractor.

Placing Drawings

For placing purposes, the drawings shall indicate tendon size, length, identification mark, location, spacing and ordinates. Tendon ordinates are shown from the soffit of the structural member to the underside of tendon sheath. The ordinates are calculated with respect to tendon centre of gravity. Spacing and location of support bars must correspond to the spacing of stirrup reinforcing. Where reinforcing steel and post-tensioning conflict, post-tensioning is to take precedence.

Coordination between reinforcing steel and post-tensioning Detailers is required to minimize congestion and/or conflict between materials.

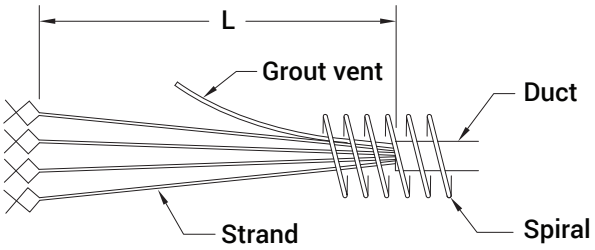
Drawings must also include a stressing and construction sequence. Along with recess box dimensions, it is recommended to include space and clearance requirements for hydraulic jacking equipment. The drawings should be simple, clear and complete with no unnecessary lines, marks, symbols or dimensions to clutter up the information being conveyed to workers on site. They must contain all essential notes and data necessary for quick and accurate interpretation. They are to be used for post-tensioning placing purposes only.



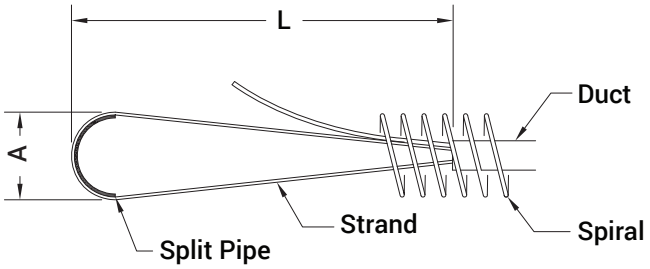
Layout, Scales and Lettering

The layout, scales and lettering of post-tensioning drawings shall follow the same criteria as the reinforcing steel sections.

Typical Dead-End Multi-Strand Fixed Post-Tensioning Anchorage Details

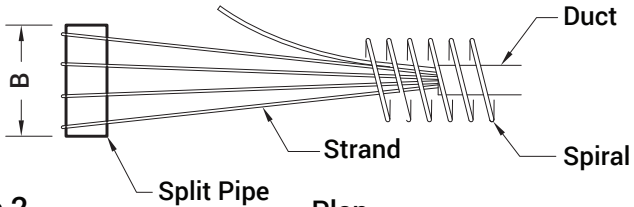


Type 1

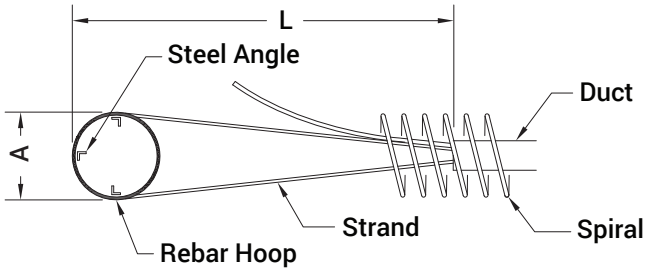


Elevation

Type 2

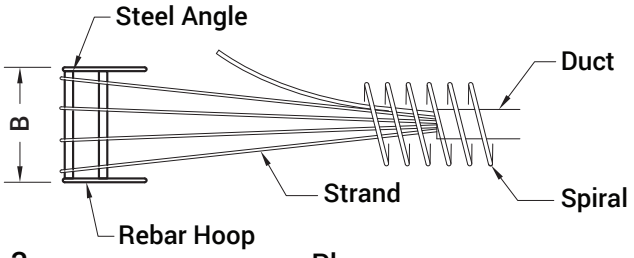


Plan



Elevation

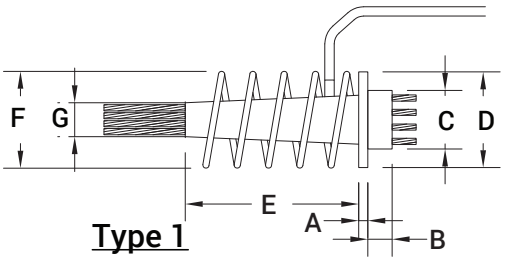
Type 3



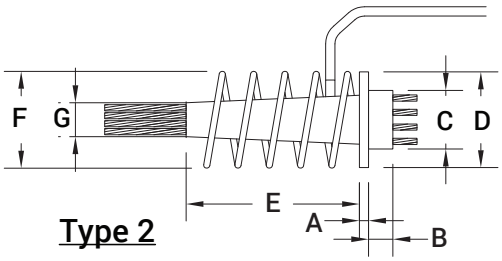
Plan

No. of Strands	Strand Dia. (mm)	TYPE 1		TYPE 2			TYPE 3		
		A	L	A	B	L	A	B	L
7	13	230	900						
12	13	300	1070	250	200	710	250	200	1070
19	13	380	1200	250	250	810	250	300	1070
31	13	460	1200	400	400	1070	250	450	1070
4	15	150	900						
7	15	230	1070	350	200	710	300	200	1070
12	15	300	1200	350	250	810	300	300	1070
19	15	380	1200	350	400	1070	300	450	1070

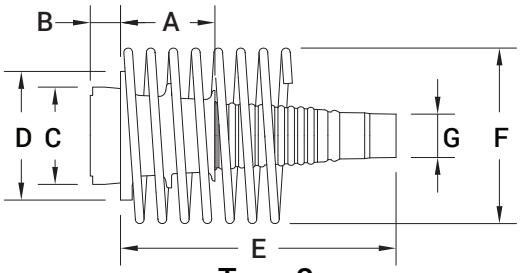
Typical Live End Multi-Strand Post-Tensioning Anchorage Details



Type 1



Type 2



Type 3

Type	No. of Strands	Strand Dia. (mm)	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Sheath ID G (mm)	SPIRAL (mm)	No. of Turns
1	4		20	50	115	200	140	175	55	10	5
	7		25	50	150	250	270	210	65	10	5
	12		30	63	185	330	360	300	81	10	5
	19		45	76	230	420	560	390	100	15	7
	22		50	76	260	445	560	420	106	15	7
	27		60	95	292	470	560	440	112	15	8
	31		64	95	292	500	560	470	124	15	8
2	4		20	60	95	180	330	150	55	10	5
	7		25	70	132	235	380	215	60	10	6
	12		35	80	170	280	600	240	70	15	6
	15		40	100	200	350	600	270	94	15	7
	19		45	100	220	375	760	300	105	15	7
	22		45	100	230	400	760	400	115	15	7
3	7		90	75	84	130 Dia.	315	195	50	15	5
	12		125	75	140	191 Dia.	400	240	75	15	5
	15		180	75	160	221 Dia.	510	285	85	15	6
	20		200	75	179	250 Dia.	560	320	95	15	6
	27		220	75	201	279 Dia.	640	370	100	15	7
	37		240	75	241	314 Dia.	700	430	115	20	7
	5		90	75	84	130 Dia.	315	195	50	15	5
	9		125	75	140	191 Dia.	400	240	75	15	5
	12		180	75	160	221 Dia.	510	285	85	15	6
	15		200	75	179	250 Dia.	560	320	95	15	6
	19		220	75	201	279 Dia.	640	370	100	15	7
	27		240	75	241	314 Dia.	700	430	115	20	7

Typical Monostrand Casting Details

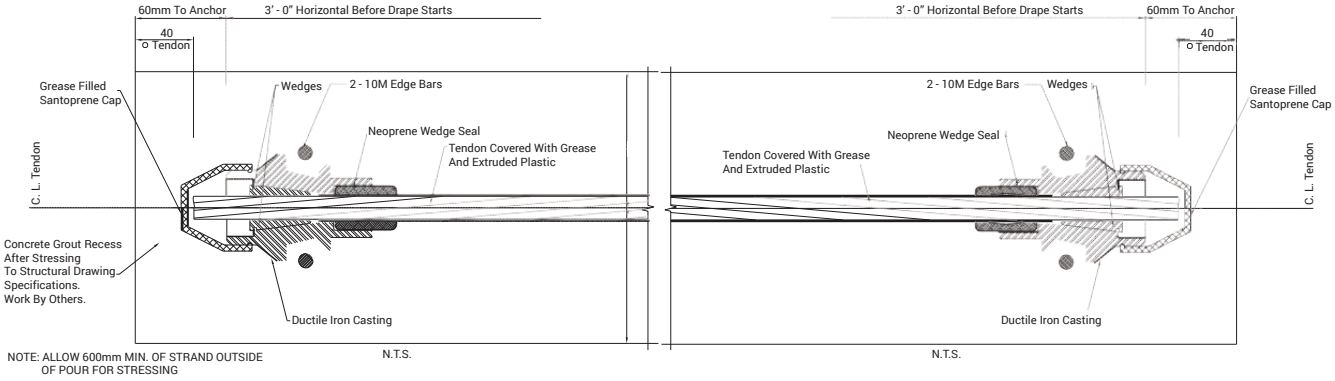


Figure 12.1:
Post-Tensioning Anchor
(Stress End Shown)
(View of Casting after Tendon Stressed)

Figure 12.2:
Post-Tensioning Anchor
(Dead End Shown)

User Notes

Table 1A.
Reinforcing Steel Bars

Bar Designation Number (Bar Size)	Mass (kg/m)	Nominal Dimensions		
		Diameter (mm)	Cross Sectional Area (mm^2)	Perimeter (mm)
10M	0.785	11.3	100	35.5
15M	1.570	16.0	200	50.1
20M	2.355	19.5	300	61.3
25M	3.925	25.2	500	79.2
30M	5.495	29.9	700	93.9
35M	7.850	35.7	1000	112.2
45M	11.775	43.7	1500	137.3
55M	19.625	56.4	2500	177.2

The nominal diameter, d_b, of metric reinforcing may be taken as the bar designation number.

Table 1B.
Metric/Imperial Comparison

Bar Designation Number (Bar Size)	Area (in^2)	MASS		
		(lb/m)	(lb/ft)	(kg/ft)
10M	0.16	1.731	0.528	0.239
15M	0.31	3.461	1.055	0.479
20M	0.47	5.192	1.583	0.718
25M	0.78	8.653	2.638	1.196
30M	1.09	12.144	3.693	1.675
35M	1.55	17.306	5.275	2.393
45M	2.33	25.959	7.912	3.589
55M	3.88	43.265	13.188	5.982

1/8 inch = 3.175 mm
1 inch = 25.4 mm
1 foot = 0.3048 m
1 Pound = 0.4536 kg
Short Ton (2000 lbs) = 907.18 kg
Long Ton (2240 lbs) = 1016 kg
1 psi = 6.895 kPa

1 millimetre = 0.0394 inch
1 metre = 3.2808 ft
1 kilogram = 2.2046 lbs
0.90718 tonne = 2000 lbs
1 tonne = 2204.6 lbs
1 megapascal = 145.04 psi
1 in^2 = 645 mm^2

GRADE 400 = 58,015 psi
GRADE 500 = 72,519 psi

Table 2.
Area of Bars for Various Spacings

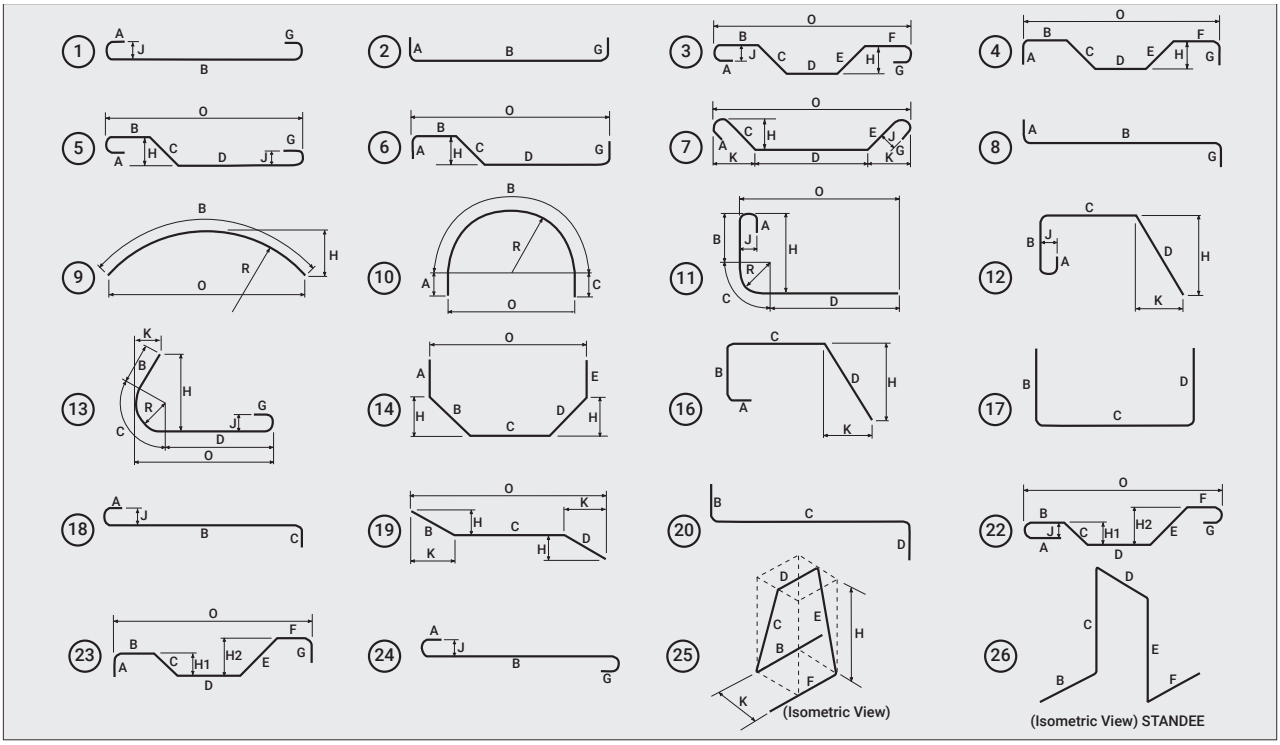
Sectional Area Per Metre Width (mm^2)											
Spacing / size	60	80	100	120	150	180	200	250	300	400	500
10M	1667	1250	1000	833	667	556	500	400	333	250	200
15M	3333	2500	2000	1667	1333	1111	1000	800	667	500	400
20M	5000	3750	3000	2500	2000	1667	1500	1200	1000	750	600
25M	8333	6250	5000	4167	3333	2778	2500	2000	1667	1250	1000
30M	11666	8750	7000	5833	4667	3889	3500	2800	2333	1750	1400
35M		12500	10000	8333	6667	5556	5000	4000	3333	2500	2000
45M			15000	12500	10000	8333	7500	6000	5000	3750	3000
55M				20833	16667	13889	12500	10000	8333	6250	5000

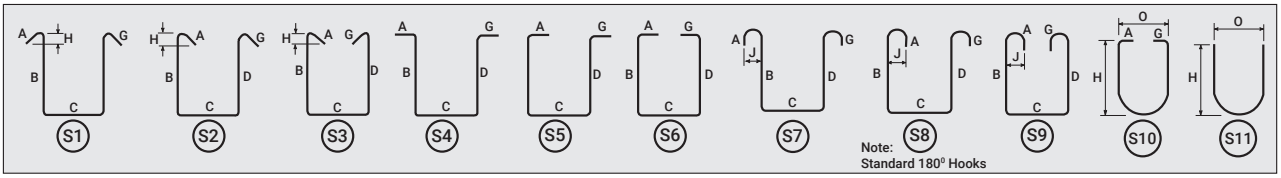
Spacing of reinforcing steel shall be in accordance with CSA-A23.3-19 Clause 13.10.4.

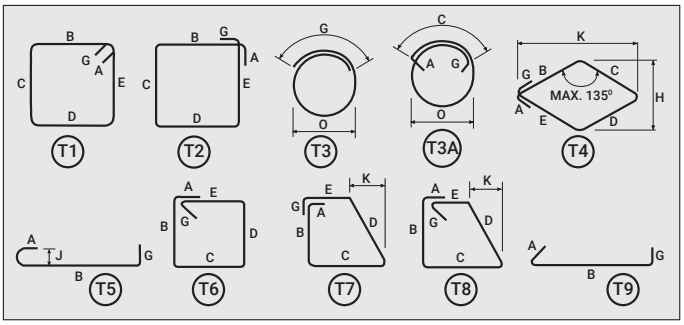
Table 3.
Area of Bars for Number of Bars

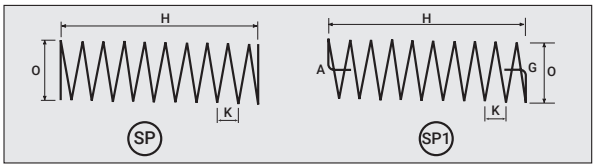
	Area (mm^2)									
Number of Bars/Size	1	2	3	4	5	6	7	8	9	10
10M	100	200	300	400	500	600	700	800	900	1000
15M	200	400	600	800	1000	1200	1400	1600	1800	2000
20M	300	600	900	1200	1500	1800	2100	2400	2700	3000
25M	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
30M	700	1400	2100	2800	3500	4200	4900	5600	6300	7000
35M	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
45M	1500	3000	4500	6000	7500	9000	10500	12000	13500	15000
55M	2500	5000	7500	10000	12500	15000	17500	20000	22500	25000

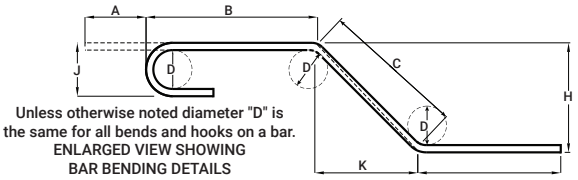
Table 4.
Typical Bar Bends





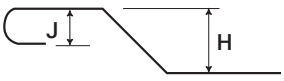






NOTES:

1. All dimensions are out-to-out of a bar except "A" and "G" on standard 180^0 and 135^0 hooks.
2. "J" dimensions on 180^0 hooks to be shown only where necessary to restrict hook size, otherwise standard hooks are to be used.
3. On Truss bars "J" will be kept equal to or less than "H". Where "J" can exceed "H" it should be shown.



4. On stirrups "H" dimension should be shown only where necessary to fit within concrete.
5. Critical dimensions are to be identified where bars are to be bent more accurately than standard bending tolerance.
6. Type T3 "G" dimensions are equal to Class B splice.
7. Type T3A Lap "C" shall be minimum 150mm or distance to hook ties around two adjacent longitudinal bars whichever is greater.
8. Figures shown in circles show types.
9. All bar bends other than the types shown above must be designated as type "X".
10. Spirals SP1- A and G shall be at least $24d_b$ (CSA S6-19 CL 8.14.4.2)

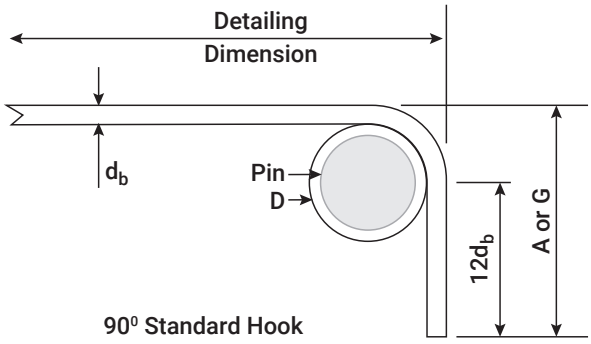
Standard Hook Dimensions

Table 5A.

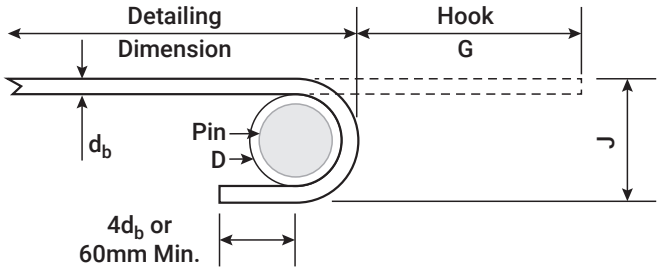
Standard Hook Dimensions for Black/Stainless Steel Reinforcing									
		400R or 500R				400W or 500W			
Bar Size	Bar Dia d_b(mm)	D (mm)	J (mm)	90° Hook A or G (mm)	180° Hook A or G (mm)	D (mm)	J (mm)	90° Hook A or G (mm)	180° Hook A or G (mm)
10M	11.3	70	90	180	140	60	80	180	130
15M	16.0	100	130	260	180	90	120	250	170
20M	19.5	120	160	310	220	100	140	300	200
25M	25.2	150	200	400	280	150	200	400	280
30M	29.9	250	310	510	400	200	260	490	350
35M	35.7	300	370	610	480	250	320	590	430
45M	43.7	450	540	790	680	400	490	770	630
55M	56.4	600	710	1030	900	550	660	1010	850

- D= FINISHED BEND DIAMETER
- The dimensions provided use the minimum bend diameters (D= Finished Bend Diameter) permitted in (CSA A23.1-19 CL.6.6.2.3 and Table 16).
- Standard hooks are defined in (CSA A23.1-19 CL.6.6.2.4).
- To achieve "J" dimension the pin diameter is less than the standard bend diameter.
- Bend diameter shall not be reduced by more than 10% from those listed unless specified by the Engineer and/or Owners Representative.

* Add the additional hook dimension G to the detailing dimension to estimate the total bar length.
For 180° hooks: $G= (4d_b >- 60\ mm)+ \pi\ (ID+d_b)/2-D/2-d_b$
For 90° hooks: $G= A= 12d_b + D/2 + d_b$



90⁰ Standard Hook



180⁰ Standard Hook

Table 5B.

Minimum Hook Dimensions for Epoxy Coated Reinforcing Bars				
Bar Size	Finished Bend Diameter D (mm)	90° Hooks A or G (mm)	180° Hooks A or G (mm)	J (mm)
10M	80	190	150	100
15M	120	270	200	150
20M	160	330	260	200
25M	200	430	330	250
30M	250	510	400	310
35M	350	640	530	420
45M	450	800	670	540
55M	600	1030	880	710

Table 5C.

Standard Hook Dimensions for Galvanized Reinforcing Bars				
Bar Size	Finished Bend Diameter D (mm)	90° Hooks A or G (mm)	180° Hooks A or G (mm)	J (mm)
10M	60	160	130	80
15M	90	240	170	120
20M	120	320	220	160
25M	200	430	330	250
30M	240	510	400	300
35M	280	600	460	350
45M	450	810	690	540
55M	550	990	850	660

1. Values are calculated based on ASTM A767/A767M-19 Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement. Clause 7.3.1.1
2. Calculations are based on the bar designation number, d_b in accordance with CSA A23.3-19 Clause 3.3.3.
3. Minimum Finished Bend Diameters for 90° and 180° hooks.

   $6d_b$ for 10M to 20M
   $8d_b$ for 25M to 35M
   $10d_b$ for 45M to 55M

Table 5D.

Stirrup and Tie Hook Dimensions							
Bar Size	Bar Dia d_b (mm)	Finished Bend Diameter D (mm)	90° Hook A or G (mm)	135° Standard Hook		135° Seismic Hook	
				A or G (mm)	H (appox.) (mm)	A or G (mm)	H (appox.) (mm)
10M	11.3	45	100	100	70	140	90
15M	16.0	65	140	140	100	150	120
20M and larger	Same as 180° Hook						

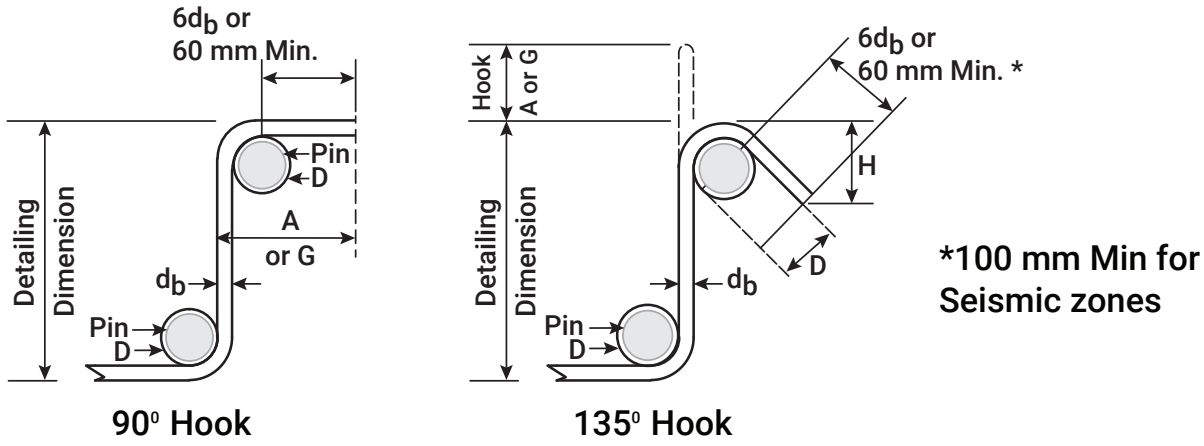


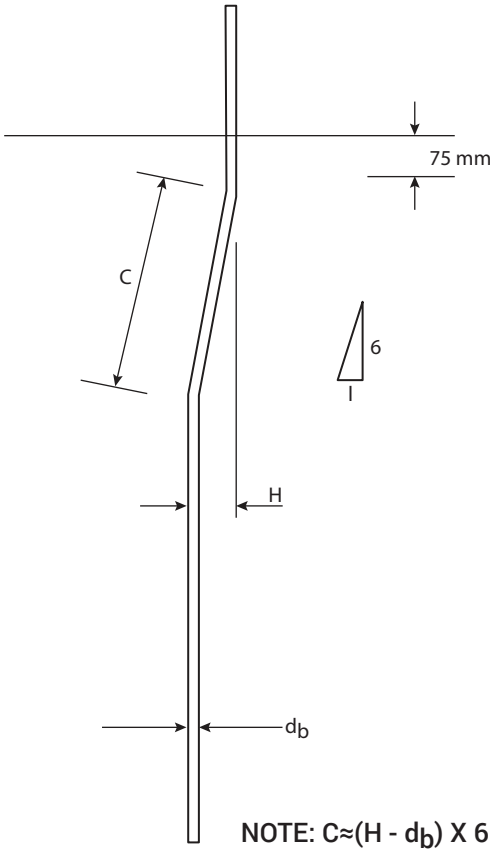
Table 6.
Millimeters of Lap Related to Number of Bar Diameters

Bar Size		Number of Bar Diameters (Using Bar Size)							
	Bar Dia	12	20	24	30	36	40	48	54
10M	11.3	120	200	240	300	360	400	480	540
15M	16.0	180	300	360	450	540	600	720	810
20M	19.5	240	400	480	600	720	800	960	1080
25M	25.2	300	500	600	750	900	1000	1200	1350
30M	29.9	360	600	720	900	1080	1200	1440	1620
35M	35.7	420	700	840	1050	1260	1400	1680	1890
45M	43.7	Lap Not Permitted							
55M	56.4	Lap Not Permitted							

Table 7.
Cranked Vertical Bars in Columns

Minimum Offset (Using Bar Size)			
Bar Size	Bar Dia (mm) (d_b)	H (mm)	C (mm)
20M	19.5	60	240
25M	25.2	70	270
30M	29.9	80	300
35M	35.7	90	330
45M	43.7	Lap Splices Not Permitted	
55M	56.4		

Maximum Offset		
Bar Size	Bar Dia (mm) (d_b)	H (mm)
20 to 35M	—	75mm Plus Dia of Bar and Bar Above



NOTE: $C \approx (H - d_b) \times 6$

Table 8.
Concrete Cover for Reinforcing Steel Bars

In accordance with CSA A23.1-19:

- Clause 4.3.2.2.1 - Table 17 Concrete Cover and Tables 1, 2 Exposure Classes.
- Clause 6.6.6.2.3 - Tolerances for Location of Reinforcement.

Concrete Cover			
Exposure Condition	Not Exposed	Exposed	Exposed to Chlorides/Manure
(a) Cast against and permanently exposed to earth	75 mm	75 mm	75 mm
(b) (i) Beams, girders, columns and piles (ii) Slabs, walls, joists, shells and folded plates	30 mm 20 mm	40 mm 40 mm	60 mm 60 mm
(c) Ratio of cover to nominal bar diameter	1.0	1.5	2.0
(d) Ratio of cover to nominal maximum aggregate size	1.0	1.5	2.0

Tolerances for Placing Reinforcement

Unless otherwise specified by the Owner, reinforcement, prestressing steel, and post-tensioning ducts shall be placed within the following tolerances:

(a) Concrete Cover.....±12 mm
(but the concrete cover shall in no case be reduced more than one-third of the specified cover);
(b) Where the depth of a flexural member, the thickness of a wall, or the smallest dimension of a column is:
(i) 200 mm or less.....±8 mm;
(ii) larger than 200 mm but less than 600 mm.....±12 mm;
(iii) 600 mm or larger .....±20 mm;
(c) Lateral spacing of bars .....±30 mm;
(d) Longitudinal location of bends and ends of bars.....±50 mm;
(e) As item (d) at discontinuous ends of members .....±20 mm.

NOTE: Where reinforcement is added to help provide a more rigid reinforcing mat or cage, as for instance in prefabricated reinforcing cages, such additional reinforcement is not subject to the tolerances of Clause 6.6.6.2.3 except for the minimum cover requirements. Bar fabrication tolerances are given in Figure 6-1.
* For parking garages see CSA S413-14 (R2019).

Table 9.
Compression Development Lengths l_d (mm)
(Minimum Straight Compression Embedment Lengths)

1. In accordance with CSA A23.3-19 - Clause 12.3.2 Compression development length is calculated as $0.24\ f_y\ d_b / \sqrt{(f'c)}$ but not less than $0.044\ f_y\ d_b$ or 200 mm.
2. In accordance with CSA A23.3-19 - Clause 12.3.3 for embedments enclosed in spirals use 0.75 l_d but not less than 200 mm.
3. For normal weight concrete only.

Bar Size	Grade fy (MPa)	f'c=25MPa	f'c=30MPa	f'c=35MPa	f'c=40MPa	f'c=45MPa	f'c=50MPa
10M	400	220	200	200	200	200	200
	500	270	250	250	250	250	250
15M	400	310	280	280	280	280	280
	500	380	350	350	350	350	350
20M	400	370	340	340	340	340	340
	500	470	430	430	430	430	430
25M	400	480	440	440	440	440	440
	500	600	550	550	550	550	550
30M	400	570	530	530	530	530	530
	500	720	660	660	660	660	660
35M	400	690	630	630	630	630	630
	500	860	790	790	790	790	790
45M	400	840	770	770	770	770	770
	500	1050	960	960	960	960	960
55M	400	1080	990	990	990	990	990
	500	1350	1240	1240	1240	1240	1240

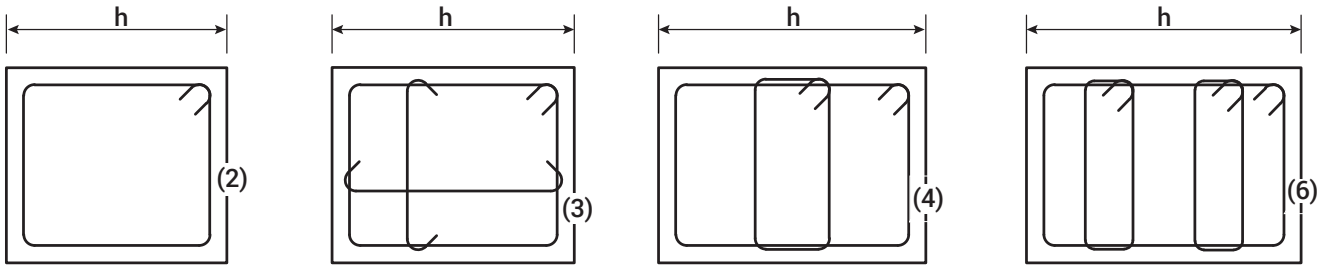
Table 10.
Compression Lap Splices (mm)

1. Calculated according to CSA A23.3-19 - Clause 12.14 and 12.16. The minimum length for compression lap splices shall be $0.073f_y d_b$ for f_y less than or equal to 400 MPa or $(0.133fy - 24) d_b$ for f_y greater than 400MPa, but shall not be taken less than 300mm.
2. When bars of different sizes are to be lap spliced in compression, the splice length shall be the larger of the compression development length of the larger bar or the splice length of the smaller bar. 45M and 55M bars may be lap spliced to 35M and smaller bars.
3. In compression members where ties have an effective area $A_v \geq 0.0015hs$, 0.83 times the standard lap length may be used, but not less than 300 mm. See Table 11 for size and spacing of ties to meet this requirement. See – CSA A23.3-19 Clause 12.17.3.4
4. Within spirals of spiral tied columns, 0.75 times the standard lap but not less than 300mm may be used. See – CSA A23.3-19 Clause 12.17.3.5

Bar Size	Bar Grade (MPa)	Standard Lap (mm)	Within Ties (Note 3) (mm)	Within Spirals (Note 4) (mm)
10M	400	300	300	300
10M	500	430	360	320
15M	400	440	370	330
15M	500	640	530	480
20M	400	590	490	440
20M	500	850	710	640
25M	400	730	610	550
25M	500	1070	890	800
30M	400	880	730	660
30M	500	1280	1060	960
35M	400	1030	850	770
35M	500	1490	1240	1120
45M	All	Lap Splices Not Permitted		
55M	All			

Table 11.
Maximum Spacing of Ties Enclosing Reduced Length Compression Lap Splices

1. In accordance with CSA A23.3-19 Clause 7.1.2.
2. Values in table are for Av≥0.0015hs.
3. Tie legs perpendicular to dimension h are used in calculating effective area Av.



Column or Beam Width h (mm)	Maximum Tie Spacing(s) for Minimum Av (mm^2)							
	10M Ties				15M Ties			
	No. of Legs				No. of Legs			
	(2)	(3)	(4)	(6)	(2)	(3)	(4)	(6)
300	440				890			
350	380				760			
400	330	500			670	1000		
450	300	440			590	890		
500	270	400	530		530	800	1070	
550	240	360	480		480	730	970	
600	220	330	440	670	440	670	890	1340
650	210	310	410	620	410	620	820	1230
700	190	290	380	570	380	570	760	1140
750		270	360	530	360	530	710	1070
800		250	330	500	330	500	670	1000
850		240	310	470		470	630	940
900			300	440		440	590	890
950			280	420			560	840
1000			270	400			530	800

Modification Factors	Notes:
bar location factor, k_1 k_1 = 1.3 for horizontal reinforcement placed in such a way that more than 300mm of fresh concrete is cast in the below the development length or splice k_1 = 1.0 for all other cases Concrete segregation can occur when 300mm or more of fresh concrete is cast below the bar.	
coating factor, k_2 k_2 = 1.5 for epoxy coated reinforcement with clear cover less than $3d_b$ or with clear spacing between bars being developed less than $6d_b$ k_2 = 1.2 for all other epoxy coated reinforcement k_2 = 1.0 for uncoated bars	$k_1 \times k_2$ need not be greater than 1.7
concrete density factor, k_3 k_3 = 1.3 for structural low-density concrete k_3 = 1.2 for structural semi low-density concrete k_3 = 1.0 for normal-density concrete	
bar size factor, k_4 k_4 = 0.8 for 20M and smaller bars and deformed wires k_4 = 1.0 for 25M and larger bars	
confining/congestion factor, k_c k_c = 1.0 for bars with minimum ties or stirrups (columns and beams Slabs, walls, shells, or folded plates having clear spacing of not less than $2d_b$ between bars being developed or lapped to be used for Tables 12-15. k_c = 1.33 for all other cases	Case-1 Case-2
bundling factor, k_b k_b = 1.10 where 2-bars are bundled k_b = 1.20 where 3-bars are bundled k_b = 1.33 where 4-bars are bundled	CSA A23.3-19 Clause 12.4
Notes regarding confining/congestion factors: Case -2 factor typically applies at: -One way slab top bars -Slab band bottom bars -Bars (Excluding The Splice) spaced closer than 2 bar diameter -Stirrups in Beams, Girders and Transfer slabs	

Refer to CSA A23.3-19 Table 12.1 and Clause 12.4

Table 12. Tension Development Length l_d (mm) - Class A Tension Lap Splice Black Bars (10M-35M)

1. Values are calculated based on CSA Standard A23.3-19, Clause 12.2 and Table 12.1 for bars with clear cover greater than 1.0 d_b and clear spacing not less than 1.4 d_b for members containing minimum stirrups or ties in accordance with Clause 11.2.8.2 or 7.6.5 or for slabs, walls, shells, or folded plates having clear spacing between bars being developed not less than 2.0 d_b.
2. The size factor, k_4, has been included for bars 20M and smaller.
3. Calculations are based on the bar designation number as the nominal bar diameter d_b in accordance with Clause 3.3.3.
4. For Stainless Steel, Galvanized and Regular Reinforcing steel refer to Black Bars Tables unless otherwise noted.

Table 12A. Black Bars - Normal Density Concrete

(k_1 = 1.0)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	330	300	300	300	300	300	300	300	300	300
10M	500	410	360	330	310	300	300	300	300	300	300
15M	400	490	440	400	370	350	330	310	300	300	300
15M	500	610	540	500	460	430	410	390	370	350	340
20M	400	650	580	530	490	460	430	410	390	380	360
20M	500	810	720	660	610	570	540	510	490	470	450
25M	400	1010	900	830	770	720	680	640	610	590	570
25M	500	1260	1130	1030	960	890	840	800	760	730	710
30M	400	1210	1080	990	920	860	810	770	730	700	680
30M	500	1510	1350	1240	1150	1070	1010	960	920	880	850
35M	400	1410	1260	1160	1070	1000	940	900	850	820	790
35M	500	1770	1580	1440	1340	1250	1180	1120	1070	1020	990
45M	400	1820	1620	1480	1370	1290	1210	1150	1100	1050	1020
45M	500	2270	2030	1850	1720	1610	1510	1440	1370	1310	1270
55M	400	2220	1980	1810	1680	1570	1480	1410	1340	1280	1240
55M	500	2770	2480	2260	2100	1960	1850	1760	1670	1600	1550

Table 12B. Black Bars - Normal Density Concrete

(k_1 = 1.3; All horizontal bars with more than 300 mm of fresh concrete cast below the bar in question.)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	420	380	350	320	300	300	300	300	300	300
10M	500	530	470	430	400	370	350	340	320	310	300
15M	400	630	570	520	480	450	420	400	380	370	360
15M	500	790	710	650	600	560	530	500	480	460	440
20M	400	840	750	690	640	600	560	530	510	490	470
20M	500	1050	940	860	800	740	700	670	640	610	590
25M	400	1310	1170	1070	990	930	880	830	790	760	740
25M	500	1640	1470	1340	1240	1160	1100	1040	990	950	920
30M	400	1570	1410	1290	1190	1110	1050	1000	950	910	880
30M	500	1970	1760	1610	1490	1390	1310	1250	1190	1140	1100
35M	400	1840	1640	1500	1390	1300	1230	1160	1110	1060	1030
35M	500	2290	2050	1870	1740	1620	1530	1450	1390	1330	1280
45M	400	2360	2110	1930	1780	1670	1570	1490	1420	1360	1320
45M	500	2950	2640	2410	2230	2090	1970	1870	1780	1700	1650
55M	400	2880	2580	2350	2180	2040	1920	1830	1740	1670	1610
55M	500	3600	3220	2940	2720	2550	2400	2280	2170	2080	2020

Table 13. Tension Development Length l_d (mm) - Class A Lap Splice Epoxy Coated Bars (10M-35M)

1. Values are calculated based on CSA Standard A23.3-19, Clause 12.2 and Table 12.1 for bars with clear cover greater than 1.0 d_b and clear spacing not less than 1.4 d_b for members containing minimum stirrups or ties in accordance with Clause 11.2.8.2 or 7.6.5 or for slabs, walls, shells, or folded plates having clear spacing between bars being developed not less than 2 d_b (minimum cover and clear spacing for epoxy shown).
2. The size factor, k_4, has been included for bars 20M and smaller.
3. Calculations are based on the bar designation number as the nominal bar diameter d_b in accordance with Clause 3.3.3.
4. k_2 = 1.5 for Epoxy-Coated Reinforcement with clear cover less than $3d_b$ or with clear spacing between bars being developed less than $6d_b$ as per A23.3-19 Clause 12.2.4.

Table 13A. Epoxy Bars - Normal Density Concrete

(k_1 = 1.0) (k_2 = 1.2; cover > $3d_b$; clear spacing > $6d_b$)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	390	350	320	300	300	300	300	300	300	300
10M	500	490	440	400	370	350	330	310	300	300	300
15M	400	580	520	480	440	410	390	370	350	340	330
15M	500	730	650	600	550	520	490	460	440	420	410
20M	400	780	700	640	590	550	520	490	470	450	440
20M	500	970	870	790	740	690	650	620	590	560	540
25M	400	1210	1090	990	920	860	810	770	730	700	680
25M	500	1510	1350	1240	1150	1070	1010	960	920	880	850
30M	400	1450	1300	1190	1100	1030	970	920	880	840	820
30M	500	1820	1620	1480	1370	1290	1210	1150	1100	1050	1020
35M	400	1700	1520	1390	1280	1200	1130	1070	1020	980	950
35M	500	2120	1890	1730	1600	1500	1410	1340	1280	1220	1190
45M	400	2180	1950	1780	1650	1540	1450	1380	1320	1260	1220
45M	500	2720	2430	2220	2060	1930	1820	1720	1640	1570	1520
55M	400	2660	2380	2170	2010	1880	1780	1690	1610	1540	1490
55M	500	3330	2970	2720	2520	2350	2220	2110	2010	1920	1860

Table 13B. Epoxy Bars - Normal Density Concrete

(k_1 = 1.3; All horizontal bars with more than 300 mm of fresh concrete cast below the bar in question.)
(k_2 = 1.2; cover > $3d_b$; clear spacing > $6d_b$)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	510	450	420	380	360	340	320	310	300	300
10M	500	630	570	520	480	450	420	400	380	370	360
15M	400	760	680	620	570	540	510	480	460	440	430
15M	500	950	850	770	720	670	630	600	570	550	530
20M	400	1010	900	830	760	720	670	640	610	590	570
20M	500	1260	1130	1030	950	890	840	800	760	730	710
25M	400	1570	1410	1290	1190	1110	1050	1000	950	910	880
25M	500	1970	1760	1610	1490	1390	1310	1250	1190	1140	1100
30M	400	1890	1690	1540	1430	1340	1260	1200	1140	1090	1060
30M	500	2360	2110	1930	1780	1670	1570	1490	1420	1360	1320
35M	400	2200	1970	1800	1670	1560	1470	1390	1330	1270	1230
35M	500	2750	2460	2250	2080	1950	1840	1740	1660	1590	1540
45M	400	2830	2530	2310	2140	2000	1890	1790	1710	1640	1580
45M	500	3540	3160	2890	2670	2500	2360	2240	2130	2040	1980
55M	400	3460	3090	2820	2620	2450	2310	2190	2090	2000	1940
55M	500	4320	3870	3530	3270	3060	2880	2740	2610	2500	2420

Table 13C. Epoxy Bars - Normal Density Concrete

(k_1 = 1.0; cover < $3d_b$; clear spacing < $6d_b$)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	490	440	400	370	300	300	300	300	300	300
10M	500	610	540	500	460	430	410	390	370	300	300
15M	400	730	650	600	550	520	490	460	440	420	410
15M	500	910	810	740	690	650	610	580	550	530	510
20M	400	970	870	790	740	690	650	620	590	560	540
20M	500	1210	1080	990	920	860	810	770	730	700	680
25M	400	1510	1350	1240	1150	1070	1010	960	920	880	850
25M	500	1890	1690	1550	1430	1340	1260	1200	1140	1090	1060
30M	400	1820	1620	1480	1370	1290	1210	1150	1100	1050	1020
30M	500	2270	2030	1850	1720	1610	1510	1440	1370	1310	1270
35M	400	2120	1890	1730	1600	1500	1410	1340	1280	1220	1190
35M	500	2650	2370	2160	2000	1870	1770	1680	1600	1530	1480
45M	400	2720	2430	2220	2060	1930	1820	1720	1640	1570	1520
45M	500	3400	3040	2780	2570	2410	2270	2150	2050	1970	1900
55M	400	3330	2970	2720	2520	2350	2220	2110	2010	1920	1860
55M	500	4160	3720	3390	3140	2940	2770	2630	2510	2400	2330

Table 13D. Epoxy Bars - Normal Density Concrete

(k_1 = 1.3; All horizontal bars with more than 300 mm of fresh concrete cast below the bar in question.)
(k_2 = 1.5; cover < $3d_b$; clear spacing < $6d_b$)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	580	520	480	440	410	390	370	350	340	330
10M	500	730	650	600	550	520	490	460	440	420	410
15M	400	870	780	710	660	620	580	550	530	510	490
15M	500	1090	980	890	830	770	730	690	660	630	610
20M	400	1160	1040	950	880	820	780	740	700	670	650
20M	500	1450	1300	1190	1100	1030	970	920	880	840	810
25M	400	1820	1620	1480	1370	1290	1210	1150	1100	1050	1020
25M	500	2270	2030	1850	1720	1610	1510	1440	1370	1310	1270
30M	400	2180	1950	1780	1650	1540	1450	1380	1320	1260	1220
30M	500	2720	2430	2220	2060	1930	1820	1720	1640	1570	1520
35M	400	2540	2270	2080	1920	1800	1700	1610	1530	1470	1420
35M	500	3170	2840	2590	2400	2250	2120	2010	1920	1830	1780
45M	400	3270	2920	2670	2470	2310	2180	2070	1970	1890	1830
45M	500	3400	3040	2780	2570	2410	2270	2150	2050	1970	1900
55M	400	3990	3570	3260	3020	2820	2660	2530	2410	2310	2230
55M	500	4990	4460	4070	3770	3530	3330	3160	3010	2880	2790

Table 14. Class B Tension Lap Splice Black Bars (mm)

1. Values are calculated based on CSA Standard A23.3-19, Clause 12.2 and Table 12.1 for bars with clear cover greater than 1.0 d_b and clear spacing not less than 1.4 d_b for members containing minimum stirrups or ties in accordance with Clause 11.2.8.2 or 7.6.5 or for slabs, walls, shells, or folded plates having clear spacing between bars being developed not less than 2.0 d_b.
2. The size factor, k_4, has been included for bars 20M and smaller.
3. Calculations are based on the bar designation number as the nominal bar diameter d_b in accordance with Clause 3.3.3.

Table 14A. Class B Tension Lap Splices Black Bars - Normal Density Concrete

(k_1 = 1.0)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	420	380	350	320	300	300	300	300	300	300
10M	500	530	470	430	400	370	350	340	320	310	300
15M	400	630	570	520	480	450	420	400	380	370	360
15M	500	790	710	650	600	560	530	500	480	460	440
20M	400	840	750	690	640	600	560	530	510	490	470
20M	500	1050	940	860	800	740	700	670	640	610	590
25M	400	1310	1170	1070	990	930	880	830	790	760	740
25M	500	1640	1470	1340	1240	1160	1100	1040	990	950	920
30M	400	1570	1410	1290	1190	1110	1050	1000	950	910	880
30M	500	1970	1760	1610	1490	1390	1310	1250	1190	1140	1100
35M	400	1840	1640	1500	1390	1300	1230	1160	1110	1060	1030
35M	500	2290	2050	1870	1740	1620	1530	1450	1390	1330	1280
45M	All	Lap Splices Not Permitted									
55M	All										

Table 14B. Class B Tension Lap Splices Black Bars - Normal Density Concrete

(k_1 = 1.3; All horizontal bars with more than 300 mm of fresh concrete cast below the bar in question.)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	550	490	450	420	390	370	350	330	320	310
10M	500	690	610	560	520	490	460	440	420	400	390
15M	400	820	740	670	620	580	550	520	500	480	460
15M	500	1030	920	840	780	730	690	650	620	590	580
20M	400	1090	980	890	830	770	730	690	660	630	610
20M	500	1370	1220	1120	1030	970	910	870	830	790	770
25M	400	1710	1530	1390	1290	1210	1140	1080	1030	990	960
25M	500	2130	1910	1740	1610	1510	1420	1350	1290	1230	1190
30M	400	2050	1830	1670	1550	1450	1370	1300	1240	1180	1150
30M	500	2560	2290	2090	1930	1810	1710	1620	1540	1480	1430
35M	400	2390	2130	1950	1800	1690	1590	1510	1440	1380	1340
35M	500	2980	2670	2430	2250	2110	1990	1890	1800	1720	1670
45M	All	Lap Splices Not Permitted									
55M	All										

Table 15. Class B Tension Lap Splice - Epoxy Coated Reinforcing Bars (mm)

1. Values are calculated based on CSA Standard A23.3-19, Clause 12.2 and Table 12.1 for bars with clear cover greater than 1.0 d_b and clear spacing not less than 1.4 d_b for members containing minimum stirrups or ties in accordance with Clause 11.2.8.4 or 7.6.5 or for slabs, walls, shells, or folded plates having clear spacing between bars being developed not less than 2.0 d_b. (minimum cover and clear spacing for epoxy shown).
2. The size factor, k_4, has been included for bars 20M and smaller.
3. Calculations are based on the bar designation number as the nominal bar diameter d_b in accordance with Clause 3.3.3.

Table 15A. Class B Tension Lap Splices - Epoxy Bars - Normal Density Concrete

(k_1 = 1.0) (k_2 = 1.2; cover > 3 d_b ; clear spacing > 6 d_b)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	510	450	420	380	360	340	320	310	300	300
10M	500	630	570	520	480	450	420	400	380	370	360
15M	400	760	680	620	570	540	510	480	460	440	430
15M	500	950	850	770	720	670	630	600	570	550	530
20M	400	1010	900	830	760	720	670	640	610	590	570
20M	500	1260	1130	1030	950	890	840	800	760	730	710
25M	400	1570	1410	1290	1190	1110	1050	1000	950	910	880
25M	500	1970	1760	1610	1490	1390	1310	1250	1190	1140	1100
30M	400	1890	1690	1540	1430	1340	1260	1200	1140	1090	1060
30M	500	2360	2110	1930	1780	1670	1570	1490	1420	1360	1320
35M	400	2200	1970	1800	1670	1560	1470	1390	1330	1270	1230
35M	500	2750	2460	2250	2080	1950	1840	1740	1660	1590	1540
45M	All	Lap Splices Not Permitted									
55M	All										

Table 15B. Class B Tension Lap Splices - Epoxy Bars - Normal Density Concrete

(k_1 = 1.3; All horizontal bars with more than 300 mm of fresh concrete cast below the bar in question.)
(k_2 = 1.2; cover > 3 d_b ; clear spacing > 6 d_b)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	660	590	540	500	470	440	420	400	380	370
10M	500	820	740	670	620	580	550	520	500	480	460
15M	400	980	880	800	750	700	660	620	600	570	550
15M	500	1230	1100	1000	930	870	820	780	740	710	690
20M	400	1310	1170	1070	990	930	880	830	790	760	740
20M	500	1640	1470	1340	1240	1160	1090	1040	990	950	920
25M	400	2050	1830	1670	1550	1450	1370	1300	1240	1180	1150
25M	500	2560	2290	2090	1930	1810	1710	1620	1540	1480	1430
30M	400	2450	2200	2000	1860	1740	1640	1550	1480	1420	1370
30M	500	3070	2740	2500	2320	2170	2050	1940	1850	1770	1720
35M	400	2860	2560	2340	2160	2030	1910	1810	1730	1650	1600
35M	500	3580	3200	2920	2700	2530	2390	2260	2160	2070	2000
45M	All	Lap Splices Not Permitted									
55M	All										

Table 15C. Class B Tension Lap Splices - Epoxy Bars - Normal Density Concrete

(k_1 = 1.0) (k2 = 1.5; cover > 3 d_b ; clear spacing > 6 d_b)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	630	570	520	480	450	420	400	380	370	300
10M	500	790	710	650	600	560	530	500	480	460	440
15M	400	950	850	770	720	670	630	600	570	550	530
15M	500	1180	1060	970	890	840	790	750	710	680	660
20M	400	1260	1130	1030	950	890	840	800	760	730	710
20M	500	1570	1410	1290	1190	1110	1050	1000	950	910	880
25M	400	1970	1760	1610	1490	1390	1310	1250	1190	1140	1100
25M	500	2460	2200	2010	1860	1740	1640	1560	1480	1420	1380
30M	400	2360	2110	1930	1780	1670	1570	1490	1420	1360	1320
30M	500	2950	2640	2410	2230	2090	1970	1870	1780	1700	1650
35M	400	2750	2460	2250	2080	1950	1840	1740	1660	1590	1540
35M	500	3440	3080	2810	2600	2430	2290	2180	2080	1990	1920
45M	All	Lap Splices Not Permitted									
55M	All										

Table 15D. Class B Tension Lap Splices - Epoxy Bars - Normal Density Concrete

(k_1 = 1.3; all horizontal bars with more than 300 mm of fresh concrete cast below the bar in question.)
(k_2 = 1.5; cover > 3 d_b ; clear spacing > 6 d_b)

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	820	740	670	620	580	550	520	500	480	460
10M	500	1030	920	840	780	730	690	650	620	590	580
15M	400	1230	1100	1000	930	870	820	780	740	710	690
15M	500	1540	1370	1250	1160	1090	1030	970	930	890	860
20M	400	1640	1470	1340	1240	1160	1090	1040	990	950	920
20M	500	2050	1830	1670	1550	1450	1370	1300	1240	1180	1150
25M	400	2560	2290	2090	1930	1810	1710	1620	1540	1480	1430
25M	500	3190	2860	2610	2420	2260	2130	2020	1930	1850	1790
30M	400	3070	2740	2500	2320	2170	2050	1940	1850	1770	1720
30M	500	3830	3430	3130	2900	2710	2560	2420	2310	2210	2140
35M	400	3580	3200	2920	2700	2530	2390	2260	2160	2070	2000
35M	500	4470	4000	3650	3380	3160	2980	2830	2700	2580	2500
45M	All	Lap Splices Not Permitted									
55M	All										

Table 16. Tension Development Lengths ld Expressed in Bar Diameters d_b

1. For slabs, walls, shells or folded plates having a clear spacing between bars being developed not less than 2.0 d_b and clear cover of 1.0 d_b.
2. Bars with minimum clear cover of 1.0 d_b and minimum clear spacing of 1.4 d_b and confinement in the form of minimum ties or stirrups is provided.
3. For normal density concrete, black bars, bottom bars, (k_1 = 1.0), 400MPa.
4. The actual bar size can be used to calculate l_d.
5. Bar size factor, k_4, included and l_d not less than 300 mm.

Bar Size	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=64
20M & smaller	32	29	26	24	23	22	20	19	18
25M & larger	40	36	33	30	29	27	26	24	23

User Notes

Table 17. Minimum Tension Embedment E with Standard End Hooks (mm)

1. In accordance with CSA A23.3-19 Clause 12.5, the minimum tension development length is calculated as:
   a. 0.7 (fy/400) 100 d_b/ ($\sqrt{f'c}$)) but not less than 8 d_b or 150 mm, (whichever is greater), for bars 10M to 35M, where side cover (perpendicular to the plane of the hook) and top or bottom cover is greater than 60 mm and, for 90° hooks, where the cover on the bar extension beyond the hook is not less than 50 mm.

   b. (fy/400) 100 d_b/ ($\sqrt{f'c}$)) but not less than 8 d_b or 150 mm, (whichever is greater), for bars 45M and 55M where cover requirements are as in a., above.

2. For 35M and smaller bars, where cover requirements in 1. a) are met, and at least three ties or stirrup ties spaced along a length at least equal to the inside diameter of the hook at a spacing of not more than 3.0 d_b, the above values may be multiplied by a further factor of 0.8.
3. Where cover conditions given in 1.a and 1.b are not met, or where both side cover and top (or bottom) cover are less than 60 mm, the values shall be divided by 0.7, and ties or stirrup ties as described in Note 2, shall be provided. The factor of 0.8 shall not apply.
4. The above values shall be multiplied by the applicable Modification Factors on **Page 115**.
5. Standard hooks in accordance with Table 5A.

Table 17.
Black Bars - Normal Density Concrete

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	160	150	150	150	150	150	150	150	150	150
10M	500	200	180	160	150	150	150	150	150	150	150
15M	400	240	210	200	180	170	160	150	150	150	150
15M	500	300	270	240	230	210	200	190	180	170	170
20M	400	320	280	260	240	230	210	200	190	190	180
20M	500	400	350	320	300	280	270	250	240	230	220
25M	400	400	350	320	300	280	270	250	240	230	220
25M	500	490	440	400	370	350	330	310	300	290	280
30M	400	470	420	390	360	340	320	300	290	280	270
30M	500	590	530	480	450	420	400	380	360	340	330
35M	400	550	490	450	420	390	370	350	340	320	310
35M	500	690	620	560	520	490	460	440	420	400	390
45M	400	1010	900	830	770	720	680	640	610	590	570
45M	500	1260	1130	1030	960	890	840	800	760	730	710
55M	400	1230	1100	1010	930	870	820	780	750	720	690
55M	500	1540	1380	1260	1170	1090	1030	980	930	890	860

Table 18. Minimum Tension Embedment E with Standard End Hook - Epoxy Coated Bars (mm)

1. In accordance with CSA A23.3-19 Clause 12.5, the minimum tension development length is calculated as:
   a. 1.2 x 0.7 (f_y/400) 100 d_b/ ($\sqrt{f'c}$)) but not less than 8 d_b or 150 mm, (whichever is greater), for bars 10M to 35M, where side cover (perpendicular to the plane of the hook) and top or bottom cover is greater than 60 mm and, for 90° hooks, where the cover on the bar extension beyond the hook is not less than 50 mm.

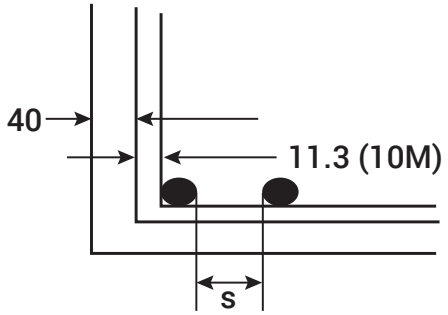
   b. 1.2 (f_y/400) 100 d_b/ ($\sqrt{f'c}$)) but not less than 8 d_b or 150 mm, (whichever is greater), for bars 45M and 55M where cover requirements are as in a., above.

2. For 35M and smaller bars, where cover requirements in 1. a) are met, and at least three ties or stirrup ties spaced along a length at least equal to the inside diameter of the hook at a spacing of not more than 3.0 d_b, the above values may be multiplied by a further factor of 0.8.
3. Where cover conditions given in 1.a and 1.b are not met, or where both side cover and top (or bottom) cover are less than 60 mm, the values shall be divided by 0.7, and ties or stirrup ties as described in Note 2, shall be provided. The factor of 0.8 shall not apply.
4. The above values shall be multiplied by the applicable Modification Factors on **Page 115**.
5. Standard hooks in accordance with Table 5B.

Table 18.
Epoxy Coated Bars - Normal Density Concrete

Bar Size	Bar Grade (MPa)	f'c=20	f'c=25	f'c=30	f'c=35	f'c=40	f'c=45	f'c=50	f'c=55	f'c=60	f'c=64
10M	400	190	170	160	150	150	150	150	150	150	150
10M	500	240	210	200	180	170	160	150	150	150	150
15M	400	290	260	240	220	200	190	180	170	170	160
15M	500	360	320	290	270	250	240	230	220	210	200
20M	400	380	340	310	290	270	260	240	230	220	210
20M	500	470	420	390	360	340	320	300	290	280	270
25M	400	470	420	390	360	340	320	300	290	280	270
25M	500	590	530	480	450	420	400	380	360	340	330
30M	400	570	510	470	430	400	380	360	340	330	320
30M	500	710	630	580	540	500	470	450	430	410	400
35M	400	660	590	540	500	470	440	420	400	380	370
35M	500	830	740	680	630	590	550	520	500	480	460
45M	400	1210	1080	990	920	860	710	770	730	700	680
45M	500	1510	1360	1240	1150	1070	1010	960	920	880	850
55M	400	1480	1330	1210	1120	1050	990	940	890	860	830
55	500	1850	1650	1510	1400	1310	1230	1170	1120	1070	1040

Table 19A.
Minimum Web Width for Various Combinations of Bars 10M Stirrups



The clear distance between parallel bars or parallel bundles of bars shall be not less than 1.4 times the bar diameter, not less than 1.4 times the nominal maximum size of the coarse aggregate, and not less than 30mm. This clear distance shall apply to the distance between a contact lap splice and adjacent splices of bars.

As per A23.1-19 Clause 6.6.5.2

		0	5												
	1	-	300												
	2	150	330												
10M	3	190	370												
	4	220	400												
	5	260	440		1	2	3	4	5						
	1	-	320		150	190	230	160	300						
	2	160	360		200	230	270	310	340						
15M	3	200	410	10M	240	270	310	350	380						
	4	240	450		280	310	350	390	420						
	5	280	490		320	360	390	430	460		1	2	3	4	5
	1	-	340		160	200	250	290	330		160	190	230	270	300
	2	170	390		210	250	290	330	370		200	240	280	310	350
20M	3	210	430	15M	250	290	330	380	420	10M	250	280	320	360	390
	4	260	480		300	340	380	420	460		290	330	360	400	440
	5	300	520		340	380	420	460	510		340	390	410	450	480
	1	-	380		170	220	260	310	350		170	210	250	290	330
	2	180	430		220	270	310	360	400		220	260	300	340	380
25M	3	230	480	20M	270	320	360	410	450	15M	270	310	350	390	430
	4	280	530		320	370	410	460	500		320	360	400	440	480
	5	330	580		370	420	460	510	550		370	410	450	490	530
	1	-	430		190	240	290	340	390		180	230	270	320	360
	2	190	490		250	300	350	400	450		240	290	330	380	420
30M	3	250	550	25M	310	360	410	460	510	20M	300	350	390	440	480
	4	310	610		370	420	470	520	570		360	410	450	490	540
	5	370	670		430	480	530	580	620		420	470	510	550	600
	1	-	500		200	260	320	380	440		200	250	300	350	400
	2	210	570		280	340	390	450	510		270	320	370	420	470
35M	3	280	640	30M	350	410	470	530	590	25M	340	390	440	490	540
	4	350	710		420	480	540	600	660		410	460	510	560	620
	5	420	780		490	550	610	670	730		480	530	590	640	690

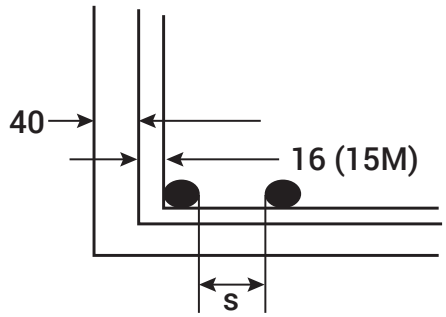
Columns headed contain data for bars of one size in groups of one to ten.

0	5

Columns headed contain data for bars of two sizes with from one to five of each group.

1	2	3	4	5

Table 19B.
Minimum Web Width for Various Combinations of Bars 15M Stirrups



The clear distance between parallel bars or parallel bundles of bars shall be not less than 1.4 times the bar diameter, not less than 1.4 times the nominal maximum size of the coarse aggregate, and not less than 30mm. This clear distance shall apply to the distance between a contact lap splice and adjacent splices of bars.

As per A23.1-19 Clause 6.6.5.2

		0	5												
	1		310												
	2	160	340												
10M	3	200	380												
	4	230	410												
	5	270	450		1	2	3	4	5						
	1		330		160	200	240	170	310						
	2	210	370		210	240	280	320	350						
15M	3	210	420	10M	250	280	320	360	390						
	4	250	460		290	320	360	400	430						
	5	290	500		330	370	400	440	470		1	2	3	4	5
	1		370		180	220	260	300	340		170	210	250	280	320
	2	180	410		220	260	310	350	390		220	260	300	330	370
20M	3	230	460	15M	270	310	360	400	440	10M	270	300	340	370	410
	4	280	510		320	360	400	450	490		310	350	390	420	460
	5	320	560		370	410	450	490	530		360	400	440	470	510
	1		440		190	240	290	330	380		190	230	270	310	350
	2	200	500		250	300	350	390	440		250	290	330	370	410
25M	3	260	560	20M	310	360	410	450	500	15M	310	350	390	430	470
	4	320	620		370	420	470	520	560		370	410	450	490	530
	5	380	680		430	480	530	580	620		430	470	510	550	590
	1		500		210	270	330	390	450		200	250	300	350	394
	2	210	570		280	340	400	460	520		280	320	370	420	466
30M	3	290	650	25M	350	410	470	530	600	20M	350	400	440	490	540
	4	360	720		430	490	550	610	670		420	470	510	560	610
	5	430	790		500	560	620	680	740		490	540	590	630	680
	1		570		230	300	370	440	520		220	280	340	400	460
	2	230	660		310	390	460	530	600		310	370	430	490	550
35M	3	320	740	30M	400	470	540	610	690	25M	400	460	510	580	640
	4	400	830		490	560	630	700	780		480	540	600	660	720
	5	490	910		570	640	720	790	860		570	630	690	750	810

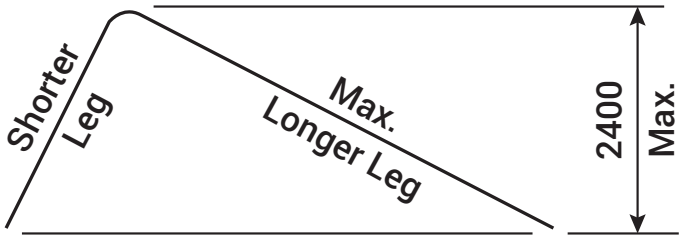
Columns headed contain data for bars of one size in groups of one to ten.

0	5

Columns headed contain data for bars of two sizes with from one to five of each group.

1	2	3	4	5

Table 20.
Maximum Right Angle Leg for Shipping



Shorter Leg	Max. Long Leg
3350	3450
3300	3500
3250	3560
3200	3630
3150	3710
3100	3790
3050	3890
3000	4000
2950	4130
2900	4280
2850	4450
2800	4660
2750	4920
2700	5240
2650	5660
2600	6240
2550	7100
2500	8570
2450	11940

N.B. All dimensions rounded to the nearest 10mm.

Table 21A.
Maximum Dimensions of Curved Bars within Loading Limits

Radius (mm)	Maximum Bar Length (mm)	Radius (mm)	Maximum Bar Length (mm)	Radius (mm)	Maximum Bar Length (mm)
1200	Full Circle	4650	9910	9750	13980
1250	6720	4800	10050	10000	14150
1350	6650	4950	10190	10250	14320
1500	6640	5100	10330	10500	14480
1650	6740	5250	10470	10750	14650
1800	6880	5400	10600	11000	14810
1950	7030	5550	10740	11250	14970
2100	7200	5700	10870	11500	15130
2250	7370	5850	11000	11750	15290
2400	7540	6000	11130	12000	15440
2550	7710	6250	11340	12250	15600
2700	7880	6500	11550	12500	15750
2850	8050	6750	11750	12750	15900
3000	8220	7000	11950	13000	16050
3150	8380	7250	12150	13250	16200
3300	8540	7500	12340	13500	16350
3450	8700	7750	12540	13750	16490
3600	8860	8000	12730	14000	16640
3750	9020	8250	12910	14250	16780
3900	9170	8500	13100	14500	16920
4050	9320	8750	13280	14750	17060
4200	9470	9000	13460	15000	17200
4650	9620	9250	13630	15250	17340
4500	9770	9500	13810	15500	17480

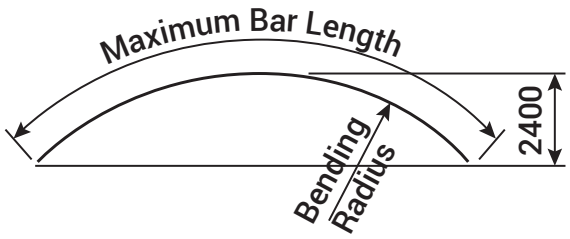


Table 21B. Maximum Radii Fabricated

10M - 4000 mm	25M - 25000 mm
15M - 8000 mm	30M - 36000 mm
20M - 14000 mm	35M - 46000 mm
45M & 55M - All Bending Prefabricated	

Table showing, for various radii of bending, the maximum length of bars not exceeding a 2400 mm limit for loading dimension.

Table 22.
Mass Table for Spiral Designation 10M
in Kilograms Per Meter (1000 mm) Exclusive of Spacers

Cage Diameter (mm)	Pitch in Millimeters							Mass for Three Extra Turns (1-1/2 Top & Bottom
	30	40	50	60	70	80	90	
240	19.7	14.8	11.8	9.9	8.5	7.4	6.6	1.8
260	21.4	16.0	12.8	10.7	9.2	8.0	7.1	1.9
280	23.0	17.3	13.8	11.5	9.9	8.6	7.7	2.1
300	24.7	18.5	14.8	12.3	10.6	9.5	8.2	2.2
320	26.3	19.7	15.8	13.2	11.3	9.9	8.8	2.4
340	27.9	21.0	16.8	14.0	12.0	10.5	9.3	2.5
360	29.6	22.2	17.8	14.8	12.7	11.1	9.9	2.7
380	31.2	23.4	18.7	15.6	13.4	11.7	10.4	2.8
400	32.9	24.7	19.7	16.4	14.1	12.3	11.0	3.0
420	34.5	25.9	20.7	17.3	14.8	12.9	11.5	3.1
440	36.2	27.1	21.7	18.1	15.5	13.6	12.1	3.3
460	37.8	28.4	22.7	18.9	16.2	14.2	12.6	3.4
480	39.5	29.6	23.7	19.7	16.9	14.8	13.2	3.6
500	41.1	30.8	24.7	20.6	17.6	15.4	13.7	3.7
520	42.7	32.1	25.6	21.4	18.3	16.0	14.2	3.8
540	44.4	33.3	26.6	22.2	19.0	16.6	14.8	4.0
560	46.0	34.5	27.6	23.0	19.7	17.3	15.3	4.1
580	47.7	35.8	28.6	23.8	20.4	17.9	15.9	4.3
600	49.3	37.0	29.6	24.7	21.1	18.5	16.4	4.4
620	51.0	38.2	30.6	25.5	21.8	19.1	17.0	4.6
640	52.6	39.5	31.6	26.3	22.5	19.7	17.5	4.7
660	54.3	40.7	32.6	27.1	23.3	20.3	18.1	4.9
680	55.9	41.9	33.5	27.9	24.0	21.0	18.6	5.0
700	57.5	43.2	34.5	28.8	24.7	21.6	19.2	5.2
720	59.2	44.4	35.5	29.6	25.4	22.2	19.7	5.3
740	60.8	45.6	36.5	30.4	26.1	22.8	20.3	5.5
760	62.5	46.9	37.5	31.2	26.8	23.4	20.8	5.6
780	64.1	48.1	38.5	32.1	27.5	24.0	21.4	5.8
800	65.8	49.3	39.5	32.9	28.2	24.7	21.9	5.9
820	67.4	50.6	40.4	33.7	28.9	25.3	22.5	6.1
840	69.1	51.8	41.1	34.5	29.6	25.9	23.0	6.2
860	70.7	53.0	42.4	35.3	30.3	26.5	23.6	6.4
880	72.3	54.3	43.4	36.2	31.0	27.1	24.1	6.5
900	74.0	55.5	44.4	37.0	31.7	27.7	24.7	6.7
920	75.6	56.7	45.4	37.8	32.4	28.4	25.2	6.8
940	77.3	58.0	46.4	38.6	33.1	29.0	25.8	7.0
960	78.9	59.2	47.4	39.5	33.8	29.6	26.3	7.1
980	80.6	60.4	48.3	40.3	34.5	30.2	26.9	7.3
1000	82.2	61.7	49.3	41.1	35.2	30.8	27.4	7.4
1020	83.8	62.9	50.3	41.9	35.9	31.4	27.9	7.5
1040	85.5	64.1	51.3	42.7	36.6	32.1	28.5	7.7
1060	87.1	65.4	52.3	43.6	37.3	32.7	29.0	7.8
1080	88.8	66.6	53.3	44.4	38.0	33.3	29.6	8.0
1100	90.4	67.8	54.3	45.2	38.8	33.9	30.1	8.1
1120	92.1	69.1	55.2	46.0	39.5	34.5	30.7	8.3
1140	93.7	70.3	56.2	46.9	40.2	35.1	31.2	8.4
1160	95.4	71.5	57.2	47.7	40.9	35.8	31.8	8.6
1180	97.0	72.8	58.2	45.5	41.6	36.4	32.3	8.7
1200	98.6	74.0	59.2	49.3	42.3	37.0	32.9	8.9

Spacer Requirements
Cage Diameter 500 mm or Less - 2/spiral
Cage Diameter 520 mm to 800 mm - 3/spiral
Cage Diameter more than 800 mm - 4/spiral

Mass of spacers which may range from 2.67 Kg/m to 3.34 Kg/m, must be added to the mass of the spiral shown above to give the mass of the complete spiral assembly.

Table 23.
Mass Table for Spiral Designation 15M
in Kilograms Per Meter (1000 mm) Exclusive of Spacers

Cage Diameter (mm)	Pitch in Millimeters							Mass for Three Extra Turns (1-1/2 Top & Bottom
	30	40	50	60	70	80	90	
240	39.5	29.6	23.7	19.7	16.9	14.8	13.2	3.6
260	42.7	32.1	25.6	21.4	18.3	16.0	14.2	3.8
280	46.0	34.5	27.6	23.0	19.7	17.3	15.3	4.1
300	49.3	37.0	29.6	24.7	21.1	18.5	16.4	4.4
320	52.6	39.5	31.6	26.3	252.5	19.7	17.5	4.7
340	55.9	41.9	33.5	27.9	24.0	21.0	18.6	5.0
360	59.2	44.4	35.5	29.6	25.4	22.2	19.7	5.3
380	62.5	46.9	37.5	31.2	26.8	23.4	20.8	5.6
400	65.8	49.3	39.5	32.9	28.2	24.7	21.9	5.9
420	69.1	51.8	41.4	34.5	29.6	25.9	23.0	6.2
440	72.3	54.3	43.4	36.2	31.0	27.1	24.1	6.5
460	75.6	56.7	45.4	37.8	32.4	28.4	25.2	6.8
480	78.9	59.2	47.4	39.5	33.8	29.6	26.3	7.1
500	82.2	61.7	49.3	41.1	35.2	30.8	27.4	7.4
520	85.5	64.1	51.3	42.7	36.6	32.1	28.5	7.7
540	88.8	66.6	53.3	44.4	38.0	33.3	29.6	8.0
560	92.1	69.1	55.2	46.0	39.5	34.5	30.7	8.3
580	95.4	71.5	57.2	47.7	40.9	35.8	31.8	8.6
600	98.6	74.0	59.2	49.3	42.3	37.0	32.9	8.9
620	101.9	76.5	61.2	51.0	43.7	38.2	34.0	9.2
640	105.2	78.9	63.1	52.6	45.1	39.5	35.1	9.5
660	108.5	81.4	65.1	54.3	46.5	40.7	36.2	9.8
680	111.8	83.8	67.1	55.9	47.9	41.9	37.3	10.1
700	115.1	86.3	69.1	57.5	49.3	46.2	38.4	10.4
720	118.4	88.8	71.0	59.2	50.7	44.4	39.5	10.7
740	121.7	91.2	73.0	60.8	52.1	45.6	40.6	10.9
760	125.0	93.7	75.0	62.5	53.6	46.9	41.7	11.2
780	128.2	96.2	76.9	64.1	55.0	48.1	42.7	11.5
800	131.5	98.6	78.9	65.8	56.4	49.3	43.8	11.8
820	134.8	101.1	80.9	67.4	57.8	50.6	44.9	12.1
840	138.1	103.6	82.9	69.1	59.2	51.8	46.0	12.4
860	141.4	106.0	84.8	70.7	60.6	53.0	47.1	12.7
880	144.7	108.5	86.8	72.3	62.0	54.3	48.2	13.0
900	148.0	111.0	88.8	74.0	63.4	55.5	49.3	13.3
920	151.3	113.4	90.8	75.6	64.8	56.7	50.4	13.6
940	154.5	115.9	92.7	77.3	66.2	58.0	51.5	13.9
960	157.8	118.4	94.7	78.9	67.6	59.2	52.6	14.2
980	161.1	120.8	96.7	80.6	69.1	60.4	53.7	14.5
1000	164.4	123.3	98.6	82.2	70.5	61.7	54.8	14.8
1020	167.7	125.8	100.6	8.8	71.9	62.9	55.9	15.1
1040	171.0	128.2	102.6	85.5	73.3	64.1	57.0	15.4
1060	174.3	130.7	104.6	87.1	74.7	65.4	58.1	15.7
1080	177.6	133.2	106.5	88.8	76.1	66.6	59.2	16.0
1100	180.9	135.6	108.5	90.4	77.5	67.8	60.3	16.3
1120	184.1	138.1	110.5	92.1	78.9	69.1	61.4	16.6
1140	187.4	140.6	112.5	93.7	80.3	70.3	62.5	16.9
1160	190.7	143.0	114.4	95.4	81.7	71.5	63.6	17.2
1180	194.0	145.5	116.4	97.0	83.1	72.8	64.7	17.5
1200	197.3	148.0	118.4	98.6	84.6	74.0	65.8	17.8

Spacer Requirements
Cage Diameter 500 mm or Less - 2/spiral
Cage Diameter 520 mm to 800 mm - 3/spiral
Cage Diameter more than 800 mm - 4/spiral

Mass of spacers which may range from 2.67 Kg/m to 3.34 Kg/m, must be added to the mass of the spiral shown above to give the mass of the complete spiral assembly.

Table 24A.
Universal Standard Column Ties

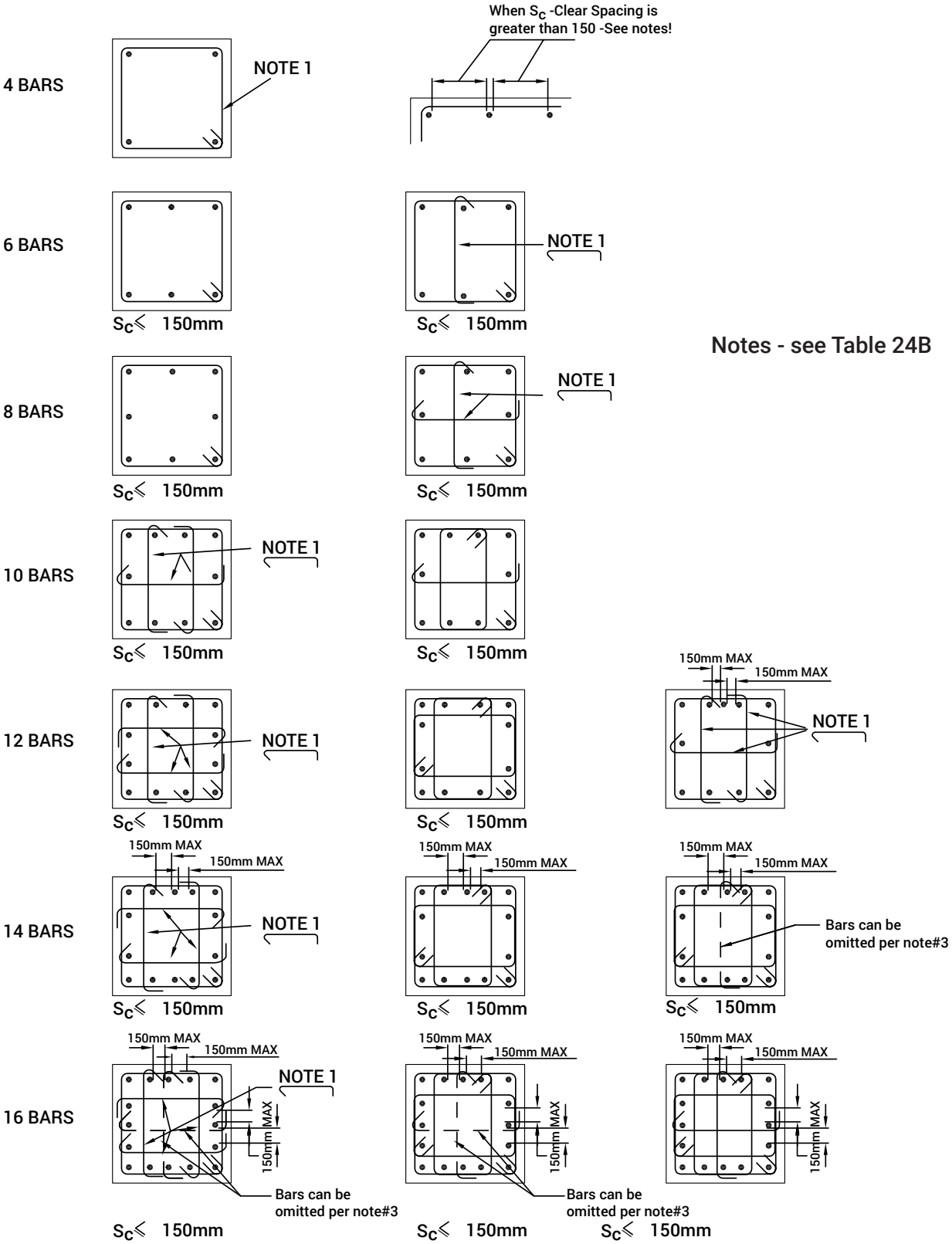
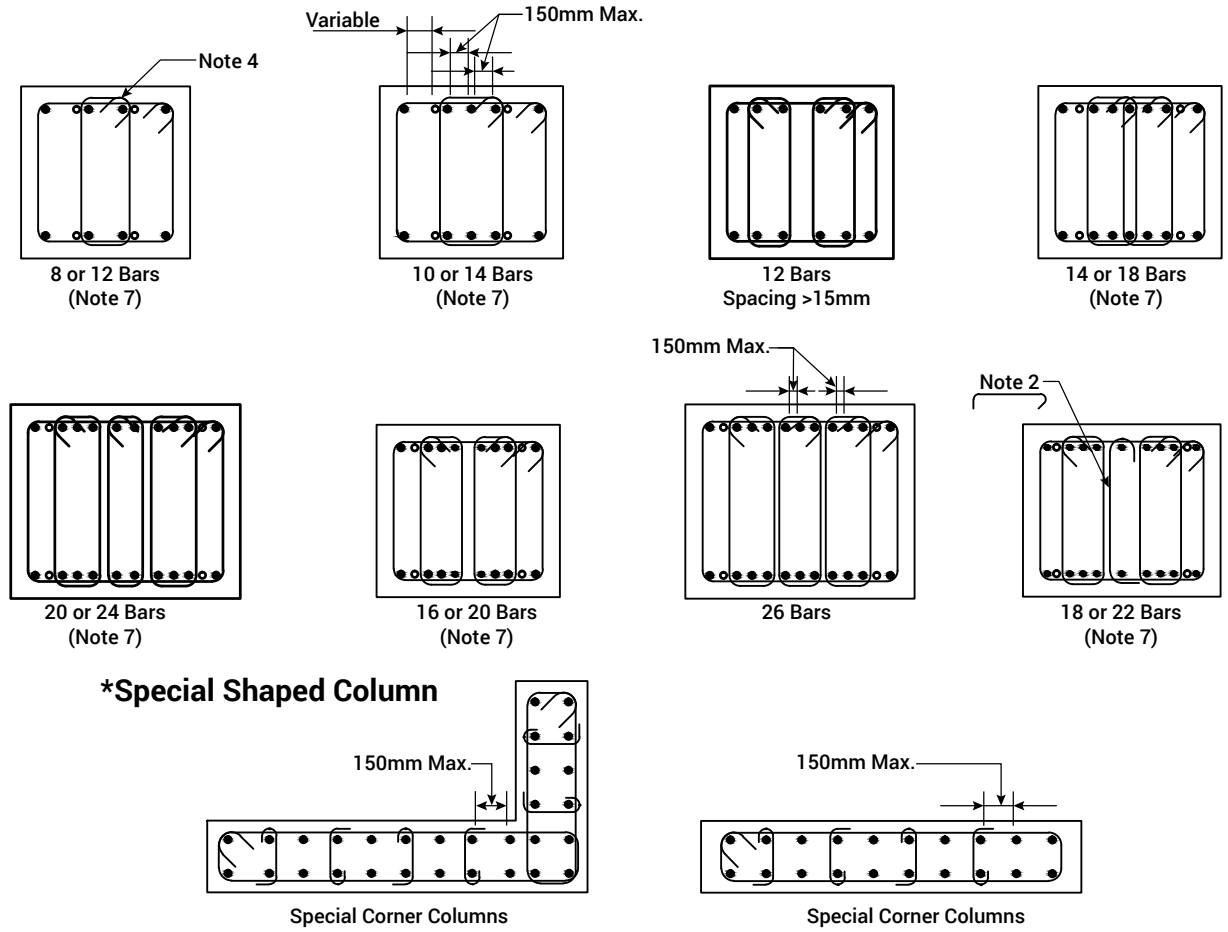


Table 24B.
Standard Column Ties
Columns with Vertical Bars in Two Faces



1. Alternate position of hooks in placing successive sets of ties.
2. Type T5 or T9 cross ties (TABLE 4) may be used in place of interior closed T1 ties.
3. Elimination of tie for center bar in groups of three limits clear spacings to be 150 mm maximum. Unless otherwise specified, bars shall be so grouped.
4. Note to Designers: Accepted practice requires that design drawings show all requirements for splicing column verticals; ie. type of splice, lap length if lapped, location in elevation, and layout in cross section.
5. Note to Detailers: Dowel erection details are required for any design employing special large vertical bars, bundled vertical bars, staggered splices, or specially grouped vertical bars as shown.
6. Bars shown as open circles may be accommodated provided clear spaces between bars do not exceed 150 mm.
7. Tie patterns shown may accommodate additional single bars between tied groups provided clear spaces between bars do not exceed 150 mm.
8. Spaces between corner bars and interior groups of three and between interior groups may vary to accommodate average spacing >150mm.
9. For average spacing <150mm, one untied interior bar may be located between each tied group of three and between a tied group and corner bar.
10. For alternate Ties that can be omitted - See Table 25

Table 25.
Maximum Column Dimension at which Alternate Ties can be Omitted

(with 40mm Cover to Ties)

Bars on One Face	20M	25M	30M	35M	45M	55M
3	470	485	500	515	545	575
4	640	660	680	700	740	780
5	810	860	860	885	935	985
6	980	1040	1040	1070	1130	1190
7	1150	1220	1220	1255	1325	1395
8	1320	1400	1400	1440	1520	1600
9	1490	1580	1580	1625	1715	1805
10	1660	1760	1760	1810	1910	2010
11	1830	1940	1940	1995	2105	2215
12	2000	2120	2120	2180	2300	2420
13	2170	2300	2300	2365	2495	2625
14	2340	2480	2480	2550	2690	2830
15	2510	2660	2660	2735	2885	3035
16	2680	2840	2840	2920	3080	3240
17	2850	3020	3020	3105	3275	3445
18	3020	3200	3200	3290	3470	3650
19	3190	3380	3380	3475	3665	3855
20	3360	3560	3560	3660	3860	4060

Applies Where Clear Spacing Between Bars is ≤ than 150 mm.