

CONCRETE CULVERT DESIGN AND DETAILING MANUAL



Ontario

Ministry
of
Transportation

QUALITY AND STANDARDS
TRANSPORTATION ENGINEERING BRANCH
BRIDGE OFFICE
ST. CATHARINES, ONTARIO

August, 2003

ISBN 0-7729-4279-X

© The Queen's Printer of Ontario, 2000.
Reproduced with permission.

ISBN 0-7794-5308-5
© The Queen's Printer for Ontario.
Reproduced with permission.

Although the contents of this manual have been checked no warranty, expressed or implied, is made by the Ministry of Transportation as to the accuracy of the contents of this manual, nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the Ministry of Transportation in any connection therewith. It is the responsibility of the user to verify its currency and appropriateness for the use intended, to obtain the revisions, and to disregard obsolete or inapplicable information.

CONTINUING RECORD OF REVISIONS MADE
to the
CONCRETE CULVERT DESIGN AND DETAILING MANUAL

This sheet should be retained permanently in this page sequence in the Manual.

All revised material should be inserted as soon as received and the relevant entries made by hand in the spaces provided to show who incorporated the Revision and the date this was done. If this practice is followed faithfully it will be a simple matter to tell whether or not this copy of the Manual is up to date since all future Revisions will be dated.

[illegible]

To all users of the:

**CONCRETE CULVERT DESIGN AND DETAILING
MANUAL**

Enquiries regarding the purchase and distribution of this manual should be directed to:

Publications Ontario
880 Bay Street
Toronto, Ontario
Canada, M7A 1N8

www.publications.gov.on.ca

Phone: 416 326 5300
800 668 9938
TTY: 800 268 7095
Fax: 613 566 2234

Enquires regarding amendments, suggestions or comments should be directed to:

Ministry of Transportation
Policy, Planning and Standards Division
Engineering Standards Branch
Bridge Office
2nd Floor, 301 St. Paul Street
St. Catharines, Ontario
L2R 7R4

or

Phone: 905 704 2406
Fax: 905 704 2060

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

TABLE OF CONTENTS

Page i

1	INTRODUCTION	1
1.1	General	1
1.2	Divisions	1
1.3	Numbering System	1
1.4	Existing Handbook and Drawings	1
1.5	Distribution	2
1.6	Revisions	2
1.7	Standard Drawings	2
2	DEFINITIONS	3
3	NOTATION	5
4	GENERAL INFORMATION	7
4.1	Introduction	7
4.1.1	Scope	7
4.1.2	Design Criteria	7
4.1.3	Limitations	7
4.2	Standard Concrete Culverts	8
4.2.1	Rigid Frame Concrete Culverts	8
4.2.2	Non-Rigid Frame Concrete Culverts	8
4.2.3	Fill Heights for Standard Culverts	9
4.2.4	Culvert Extensions	9
4.2.5	Skewed End Culverts	9
4.2.6	Use of Culvert Header Walls	10
4.2.7	Use of Culvert Apron Walls	10
4.2.8	Use of Retaining Walls	10
4.2.9	Use of Traversable Safety Grating	10
4.3	Standard Drawings	12
4.3.1	Professional Engineers Stamping	12
4.3.2	Information to be Added to Standard Drawings	12
4.3.3	Scales for Added Details	13
4.4	Designation of Reinforcing Steel	13
4.4.1	Reinforcing Steel Schedule	15
4.5	Contract Preparation System	15
5	RIGID FRAME OPEN FOOTING CULVERTS	16
5.1	Culvert Dimensions and Reinforcement	16
5.2	Footing Design	19
5.2.1	General Information	19
5.2.2	Calculation of Bearing Pressure	20
5.2.3	Determination of Lateral Sliding Resistance	20
5.2.4	Modification of Footing Concrete Quantities	21
5.2.5	Modification of Footing Steel Quantities	21

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

TABLE OF CONTENTS

Page ii

5.3	Detailing of Open Footing Culvert Drawings	23
5.3.1	Details for Standard Drawings	23
5.3.2	Steel Table for Culvert	25
5.3.3	Steel Table for Header Wall	25
5.3.4	Adjustment of Concrete Quantities	25
5.3.5	Quantity Tables	26
5.4	Detailing Tables	27
6	RIGID FRAME BOX CULVERTS	73
6.1	Culvert Dimensions and Reinforcement	73
6.2	Foundation Investigation	73
6.3	Detailing of Box Culvert Drawings	76
6.3.1	Details for Standard Drawings	76
6.3.2	Steel Table for Culvert	77
6.3.3	Steel Table for Apron Wall and Header Wall	78
6.3.4	Adjustment of Concrete Quantities	78
6.3.5	Quantity Tables	78
6.4	Detailing Tables	79
7	NON-RIGID FRAME BOX CULVERTS	125
7.1	General	125
7.2	Culvert Dimensions and Reinforcement	125
7.3	Detailing of Box Culvert Drawings	128
7.3.1	Details for Standard Drawings	128
7.3.2	Steel Table for Culvert	129
7.3.3	Steel Table for Apron Wall	129
7.3.4	Adjustment of Concrete Quantities	129
7.3.5	Quantity Table	129
7.4	Detailing Table	130
8	CULVERT DETAILS	131
8.1	Reinforcing Steel Details	131
8.1.1	Vertical and Transverse Bars	131
8.1.2	Longitudinal Bars	131
8.1.3	Reinforcing Steel Quantity Adjustment for R and W Bars	132
8.2	Apron Walls	133
8.2.1	Details of Apron Walls	133
8.2.2	Concrete Quantity for Apron Wall	133
8.2.3	Reinforcing Steel Quantity for Apron Wall	134
8.3	Header Walls	135
8.3.1	Details of Header Walls	135
8.3.2	Concrete Quantity for Header Wall	135
8.3.3	Reinforcing Steel Quantity for Header Wall	136

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

TABLE OF CONTENTS

Page iii

8.4	Skewed End Culverts	139
8.4.1	Details of Skewed End Culverts	139
8.4.2	Concrete Quantity Adjustment for Skewed End Culverts	139
8.4.3	Reinforcing Steel Quantity Adjustment for Skewed End Culverts	139
8.4.4	Extension of Culverts	142
8.5	Intersecting Drains, Catch Basins or Manholes	143
8.5.1	Hole Diameter or Side Dimension Not Exceeding 300mm	144
8.5.2	Holes 301mm to 760mm Diameter or Rectangular Holes with 301mm to 600mm Side Dimension	145
8.6	Retaining Walls for Culverts	147
8.6.1	General	147
8.6.2	Plan View of Culvert with Retaining Wall	148
8.6.3	Modification of Culvert to Suit Retaining Walls	149
8.6.4	Retaining Wall Details	153
8.7	Special Treatment of Culvert Ends	158
9	APPENDIX	161
9.1	Appendix A: Half-Size Prints of Standard Drawings	162
9.2	Appendix B: Reduced Print of Design Data Form for Concrete Culverts	166
9.3	Appendix C: Deviations From CHBDC	168
9.4	Appendix D: Material and Construction Specifications for Precast Reinforced Concrete Box Culverts and Box Sewers	169
9.5	Appendix E: Methodology Used for Rigid Frame Culvert Design	170
	INDEX	175

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 1 - INTRODUCTION

August 2003

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

INTRODUCTION

Page 1

1 INTRODUCTION

1.1 GENERAL

The Concrete Culvert Design and Detailing Manual have been prepared to facilitate the design and detailing of standard rectangular concrete culverts.

1.2 DIVISIONS

This Manual is divided up into the following divisions:

Division 1 Introduction

Division 2 Definitions

Division 3 Notation

Division 4 General Information

Division 5 Rigid Frame Open Footing Culverts

Division 6 Rigid Frame Box Culverts

Division 7 Non-Rigid Frame Box Culverts

Division 8 Culvert Details

Division 9 Appendix

1.3 NUMBERING SYSTEM

Within each of the above-described divisions, the material is subdivided into sections and subsections. The standard drawings corresponding to the various divisions are numbered independently of the Manual's numbering system.

1.4 EXISTING HANDBOOK AND DRAWINGS

This Manual supersedes the 1988 edition of the Concrete Culvert Design and Detailing Manual.

1.5 DISTRIBUTION

Copies of the Manual and revisions may be obtained from:

Ronen Publishing House, Inc.
505 Consumers Road, Suite 910
Toronto, Ontario
M2J 4V8
Tel: 1-800-856-2196
Fax: 1-800-870-7239

1.6 REVISIONS

When additions or revisions are necessary, they will be made available through Ronen Publishing House, Inc., as detailed in Section 1.5. The date shown at top left corner of each page indicates the date of (re)issue.

1.7 STANDARD DRAWINGS

Electronic CAD files containing standard drawings in AutoCAD may be obtained from Ronen Publishing House Inc. The latest revision date will be that available from Ronen House.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 2 - DEFINITIONS

August 2003

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

DEFINITIONS

Page 3

2 DEFINITIONS

Apron Wall - Also known as a cutoff wall; a vertical non-structural concrete wall built across the full width of the ends of box culverts and extending below the level of the bottom slab.

Bar Mass - The mass of a reinforcing bar per unit length (kg/m).

Bearing Capacity - The maximum load that can be applied to a soil at the respective limit state.

Box Culvert - A culvert in the shape of an enclosed rectangle and consisting of a bottom slab, two wall elements and a top slab.

Culvert Extension - A portion of a culvert built beyond the limits of a previously existing culvert.

Designer - Individual(s) designated by the Structural Engineer to use this manual to design and detail culverts.

Fill Height - The vertical distance from the top of the top slab of a culvert to the riding surface of the roadway above it.

Geotechnical Engineer - A licensed professional engineer designated a specialist in the soils or geotechnical field.

Haunch - The increase in thickness of a culvert's walls or slabs at the corners.

Header Wall - A vertical concrete wall across the full width of the ends of a culvert and extending upwards from the level of the top slab.

Height - For box culverts this is the vertical distance measured from the top of the bottom slab to the bottom of the top slab at mid-span. For open footing culverts this is the vertical distance measured from the level of the top of the footings to the bottom of the top slab at mid-span.

Length - The length of a culvert is the distance between the ends, along the longitudinal axis of the culvert.

Longitudinal Axis - The longitudinal axis of a culvert is located at the geometric centroid of the culvert cross-section and is parallel to the walls of the culvert.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

DEFINITIONS

Page 4

Non-Rigid Frame Culvert - A non-rigid frame culvert is one detailed so that there is no intended transfer of bending moment between wall and slab elements.

Open Footing Culvert - A culvert in the shape of an open rectangle, consisting of two wall elements supported on footings and a top slab. Note that there is no bottom slab.

Retaining Wall - A retaining wall for the purpose of this Manual is an earth retaining structure consisting of a vertical stem element supported by a horizontal footing element and built of reinforced concrete.

Rigid Frame Culvert - A rigid frame culvert is one detailed so that full continuity of bending moment is assured between the wall and slab elements.

Set - A set of longitudinal reinforcing bars refers to the placement of a reinforcing bar in a specific location on a cross-section.

Skew Angle - The skew angle is the angle between the centreline of the highway and a line perpendicular to the longitudinal axis of the culvert.

Skew Number - The skew number is the angle between the centreline of the highway and the longitudinal axis of the culvert, measured clockwise.

Skewed End Culvert - A skewed end culvert is one with ends not at a right angle to the longitudinal axis of the culvert. Usually the ends are built at right angles to the longitudinal axis of the culvert.

Span - The span of a culvert is the minimum horizontal distance measured between the inside faces of the walls.

Standard Culvert - A culvert detailed in accordance with this Manual.

Structural Engineer - A licensed professional engineer of Ontario specializing in structural design.

Strut - A member placed between the footings of an open footing culvert.

Traversable Grate - A safety grating over the open tapered ends of concrete culverts that do not have traffic protection.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 3 - NOTATION

August 2003

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

NOTATION

Page 5

3 NOTATION

A'	the effective contact area of a footing, square metres
a	a detailing dimension for culverts with skewed ends, mm
B	thickness of the bottom slab of a box culvert, mm
b	spacing between adjacent bars as per detailing tables, mm
C	a coefficient used in the determination of reinforcing bar quantities.
CANBAS	Canadian Bridge Analysis System
c'	the effective cohesion between the base of the footing and the soil at the ULS, as per CHBDC. kPa
CHBDC	Canadian Highway Bridge Design Code, 2000 Edition
CGSB	Canadian General Standards Board
F	width of footing for open footing culverts, mm
F_1	a reinforcing bar spacing factor, mm^{-1}
H_{ULS}	maximum factored horizontal reaction at the level of the base of the footing at the ULS, kN
L_c	culvert length measured along the longitudinal axis, m
OCPA	Ontario Concrete Pipe Association
OMBAS	Ontario Modular Bridge Analysis System
OPSS	Ontario Provincial Standard Specifications
S	culvert span measured perpendicular to the longitudinal axis of the culvert, mm
SLS	serviceability limit states, as per CHBDC
T	thickness of top slab of culvert, mm

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

NOTATION

Page 6

$\tan \phi'$	effective friction coefficient for concrete cast against soil.
ULS	ultimate limit states, as per CHBDC
V	unfactored vertical reaction due to the dead load of cast-in-place concrete and soil fill, at the level of the base of the footing, kN
V_{SLS}	maximum vertical reaction at the level of the base of the footing at SLS, kN
V_{ULS}	maximum factored vertical reaction at the level of the base of the footing at ULS, kN
W	thickness of wall of culvert, mm
γ	the acute angle between the normal to the longitudinal axis and the end of the same culvert, degrees
ϕ'	the effective angle of internal friction, as per CHBDC, degrees
θ	skew angle of culvert, degrees

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

GENERAL INFORMATION

Page 7

4 GENERAL INFORMATION

4.1 INTRODUCTION

4.1.1 SCOPE

This Manual contains all data necessary to complete the standard drawings and quantities for concrete box and open footing culverts that fall within the size range of "Standard Concrete Culverts" specified in Sections 4.2.1 and 4.2.2. Data is also provided to permit the detailing of:

- i. Simple retaining walls for use with these culverts.
- ii. Intersecting drains, catch basins and manholes.
- iii. Culverts with skewed ends.

The Manual provides quantities per unit length of culvert but no data is provided for the calculation of extra quantities for footings, apron and header walls or for retaining walls. Concrete quantities are in cubic metres and steel quantities are in kilograms. Provision is made on the drawings for inserting a breakdown of quantities for progress payment purposes. The Designer must compute these quantities.

4.1.2 DESIGN CRITERIA

Design and detailing data contained in this Manual conforms to the requirements of the 2000 edition of the Canadian Highway Bridge Design Code with the exception of the criteria listed in the Appendix. Calculations are based on 30 MPa concrete and grade 400 reinforcing steel.

4.1.3 LIMITATIONS

The following topics are considered to be beyond the scope of this Manual:

- i. Selection of culvert type and size, and all information usually shown on form PH-D-353, or DB-RD-77 or "Design Data Form for Concrete Culverts".
- ii. Culverts with less than 0.6 m fill (require special attention).
- iii. Culverts with skew angle exceeding 25°.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 4 - GENERAL INFORMATION

August 2003

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

GENERAL INFORMATION

Page 8

- iv. Hydrological considerations and selection of type and extent of end treatment.
- v. Granular backfill requirements.
- vi. Bedding requirements for box culverts.
- vii. Future deepening of municipal drains.
- viii. Precast concrete box culverts (See Appendix D).
- ix. Pipe culverts.

4.2 **STANDARD CONCRETE CULVERTS**

4.2.1 **RIGID FRAME CONCRETE CULVERTS**

Standard rigid frame culverts are rectangular single cell cast-in-place concrete culverts (open footing or box) which conform to the dimensions specified in Table 4-2, have fill heights as specified in Section 4.2.3, and have skew angles not exceeding 25 degrees.

Note that the spans are in increments of 0.5 metres and the heights are in increments of 0.25 and 0.5 metres. Spans and heights which fall between these increments are not standard and should be rounded up to the nearest standard value.

4.2.2 **NON-RIGID FRAME CONCRETE CULVERTS**

Details for smaller box culverts of the non-rigid frame type are included in this package. These culverts comprise the following sizes (in metres):

<u>Span</u>		<u>Height</u>
1.25	x	1.25
1.50	x	1.25
1.50	x	1.50

Concrete culverts with spans less than 1.25 metres or heights less than 1.25 metres are impracticable due to the difficulty in removing interior forms and falsework.

4.2.3 FILL HEIGHTS FOR STANDARD CULVERTS

Rigid frame culverts described in this Manual are designed for fill heights ranging from 0.6 to 6.0 metres. Non-rigid frame culverts are designed for fill heights ranging from 0.6 to 5.0 metres.

Culverts with fill heights between 0.6 and 1.0 metre shall be designed for 0.6 metres of fill. With this exception, all culverts for which the fill height does not correspond to the listed fill heights shall be designed for the next highest listed fill height.

Culverts with less than 0.6 or more than 6.0 metres of fill are not covered by this Manual.

For cast-in-place culverts with less than 0.6 m fill, the use of a distribution slab is not mandatory. However, if no distribution slab is provided, the culvert will have to be structurally designed for the effect of direct wheel load, and the required concrete cover will have to reflect the applicable environmental exposure from Section 8 of the CHBDC.

For precast culverts with less than 0.6 m of fill, a reinforced distribution slab is required to provide an improved live load shear transfer between the units, as well as an enhanced live load distribution.

Detailing tables are provided for each type of culvert, giving all necessary design and detailing information for the listed height of fill.

4.2.4 CULVERT EXTENSIONS

Culvert extensions may be detailed using this Manual provided modifications are made to the standard drawings and to the detailing procedures described in Divisions 5, 6, 7 and 8 and as specified in Section 8.4.4.

4.2.5 SKEWED END CULVERTS

Ends of culverts may be skewed to permit a reduction in total length; for extensions, to accommodate existing skewed end culverts; or to suit geometric constraints or other reasons.

4.2.6 USE OF CULVERT HEADER WALLS

Header walls shall be provided only when one or more of the following criteria apply:

- i. When the culvert has retaining walls, header walls are recommended to allow a further reduction in culvert length. (Note, where recovery distance requirements dictate the culvert length, this further reduction in length may not be desirable).
- ii. When a skewed end culvert has a skew angle greater than 15°.
- iii. When the skew angle of an existing culvert is greater than 15° a header wall may be provided on top of the top slab and below the bottom slab of the extension at the end abutting the existing culvert, as prescribed in Section 8.4.4.

Header wall details are described in Division 8.

4.2.7 USE OF CULVERT APRON WALLS

Apron walls are to be added at the ends of all box culverts and shall be detailed as shown in Division 8.

4.2.8 USE OF RETAINING WALLS

Retaining walls may be built at the ends of culverts to reduce the total length of culvert, for hydraulic considerations, or for other reasons. Retaining wall details are described in Division 8.

4.2.9 USE OF TRAVERSABLE SAFETY GRATING

Concrete culverts that have tapered ends that match the slope of the roadway fill, and have no traffic protection around them shall be equipped with the traversable safety grating. Contact the Ministry for the relevant Special Provision and standard drawing on the requirement of such grating. Refer to further details in Section 8.7.

TABLE 4-2
STANDARD RIGID FRAME BOX AND OPEN FOOTING CULVERT SIZES

		CULVERT SPAN (m)										
			2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	
CULVERT HEIGHT (m)	1.25											
	1.50											
	1.75											
	2.00											
	2.50											
	3.00											
	3.50											
	4.00											

NOTE: Range of fill heights are 0.6, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0 and 6.0 metres.

4.3 STANDARD DRAWINGS

The following standard drawings are used for detailing standard culverts:

SS114-1 Rigid Frame Open Footing Culvert.

SS114-2 Rigid Frame Box Culvert.

SS114-3 Non-Rigid Frame Box Culvert.

4.3.1 PROFESSIONAL ENGINEERS STAMPING

Standard drawings shall be reviewed together with the corresponding text in the Manual to determine what information, if any, needs to be added to them.

Where information in tables and dimensions are added to standard drawings for their completion, the drawings shall bear the seal, date and signature of a Professional Engineer. This Engineer accepts full responsibility for the accuracy of the added information only.

Where engineering design changes are made on standard drawings that affect the original design, these drawings shall be identified as "Modified" and bear the seals, dates and signatures of two Professional Engineers. These Engineers accept full responsibility for the design that results from these changes.

4.3.2 INFORMATION TO BE ADDED TO STANDARD DRAWINGS

When the culvert is without skewed ends, retaining walls, or openings in walls or slabs, all information necessary to complete the drawings is available directly from the detailing tables and from "Design Data Form for Concrete Culverts".

The following special information must be added to the drawings when a culvert has skewed ends, retaining walls or openings in walls or slabs:

- Plan view of the culvert showing location of applicable features.
- Details of steel arrangement at skewed ends.
- Header wall length and steel arrangement at skewed ends.
- Apron wall length and steel arrangement for box culverts with skewed ends.

- Retaining wall dimensions and reinforcing steel.
- Steel table for retaining walls.
- Details of reinforcement at openings.
- Steel table for such reinforcement.

4.3.3 SCALES FOR ADDED DETAILS

The selection of scales for details to be added to drawings (as specified in Section 4.3.1 above) is important, since the drawings will be reduced for inclusion in the contract documents.

The plan view of the culvert should normally be drawn at 1:50 scale when many additional details are required (e.g. for skewed end culvert with retaining walls).

All details should be drawn to a sufficiently large scale to ensure legibility after reduction to contract size.

4.4 DESIGNATION OF REINFORCING STEEL

The standard notation for designating reinforcing steel bars has been adopted to maintain a degree of uniformity with bridges or other concrete structures that may be included in the same contract as concrete culverts.

The system uses one alphabetical character followed by five numerical characters e.g. P15001.

The alphabetical character indicates the part of the culvert where the bar is located as follows:

- H - transverse bar, outside face, top and bottom slab.
- J - vertical/transverse bar, outside face, walls and slabs, alternating with K bar.
- K - vertical/transverse bar, outside face, walls and slabs, alternating with J bar.
- P - transverse bar, inside face, top slab.
- Q – transverse bar, inside face, bottom slab.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

GENERAL INFORMATION

Page 14

- R - longitudinal bar, walls and slabs.
- S - vertical/transverse bar, inside face, bottom haunch (rigid frame box culvert), or,
- S - transverse bar, footing (rigid frame open footing culvert).
- T - vertical bar, inside face, walls
- U - vertical/transverse bar, inside face, top haunch
- V - vertical bar, footing
- W - longitudinal bar, footing
- L - apron wall
- M - apron wall
- Y - header wall
- Z - header wall

The first two numerical characters denote the size of the bar.

e.g. P 15001 is a size 15 bar
Q 20001 is a size 20 bar

The remaining three numerical characters are for use as bar mark numbers so that up to 999 different bars could be used with the same alphabetical character.

The culverts in this book are detailed so that there is generally only one bar type for each alphabetical character with the final three characters 001; however bars in retaining wall systems or around apertures may have several mark numbers.

The character N is used for bars specifically added to reinforce apertures in culvert walls or slabs.

The letters A to G should be used for designating steel for retaining walls.

The letters I, O and X shall not be used for designating reinforcing bars.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

GENERAL INFORMATION

Page 15

4.4.1 REINFORCING STEEL SCHEDULE

Section 12.2.1 of the Structural Manual describes when separate computerized reinforcing steel schedules are required for culverts.

4.5 CONTRACT PREPARATION SYSTEM

Capital construction contract tender documents are produced for the ministry by using the Contract Preparation System (CPS). This is an integrated application facility for the preparation of tender item documents, item quantity sheets, modified and fill-in special provisions, etc., for road design, structural and electrical work.

The designer should be aware of the main tender items and associated specifications shown in Table 4.5 that are to be used, where applicable, in conjunction with concrete culverts.

OPSS SPEC. No.	CPS ITEM	UNIT
902	Earth Excavation for Structure	cubic metre
902	Rock Excavation for Structure	cubic metre
902	Unwatering Structure Excavation	lump sum
902	Clay Seal	lump sum
904	Concrete in Culverts	cubic metre
905	Reinforcing Steel Bar	lump sum
314	Granular B, Type I	tonne
314	Granular B, Type II	tonne
539	Roadway Protection	lump sum
539	Track Protection	lump sum

TABLE 4.5 – CPS ITEMS FOR CONCRETE CULVERTS

Guidance on estimating quantities and other information on the above tender items may be found in the ministry's manuals "Contract Design, Estimating and Documentation" (CDED) Volumes I and II.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 5 - RIGID FRAME OPEN FOOTING CULVERTS

August 2003

5 RIGID FRAME OPEN FOOTING CULVERTS**5.1 CULVERT DIMENSIONS AND REINFORCEMENT**

Dimensions and detailing information for standard rigid frame open footing culverts is given in Figure 5.1(a). Construction joints indicated are optional and are provided for the contractor's convenience. Note that both the height and width of the haunches are equal to the thickness of the top slab of the culvert. The standard footing depth is shown as 1.2 metres, the minimum for frost protection in Ontario. Culverts to be founded on piles are beyond the scope of this Manual.

Figure 5.1(b) details the layout of the reinforcing steel for standard rigid frame open footing culverts. Table 5-1 identifies the various bar sizes and shapes used for this type of culvert.

The detailing tables at the end of the division should be read in conjunction with Figures 5.1(a) and (b) and Table 5-1.

Details of header walls and retaining walls are provided in Division 8.

The design assumption and parameters, as well as the load cases and combinations, as per CHBDC are summarized in Appendix E (Section 9.5).

FIGURE 5.1(a) RIGID FRAME OPEN FOOTING CULVERT DIMENSIONS

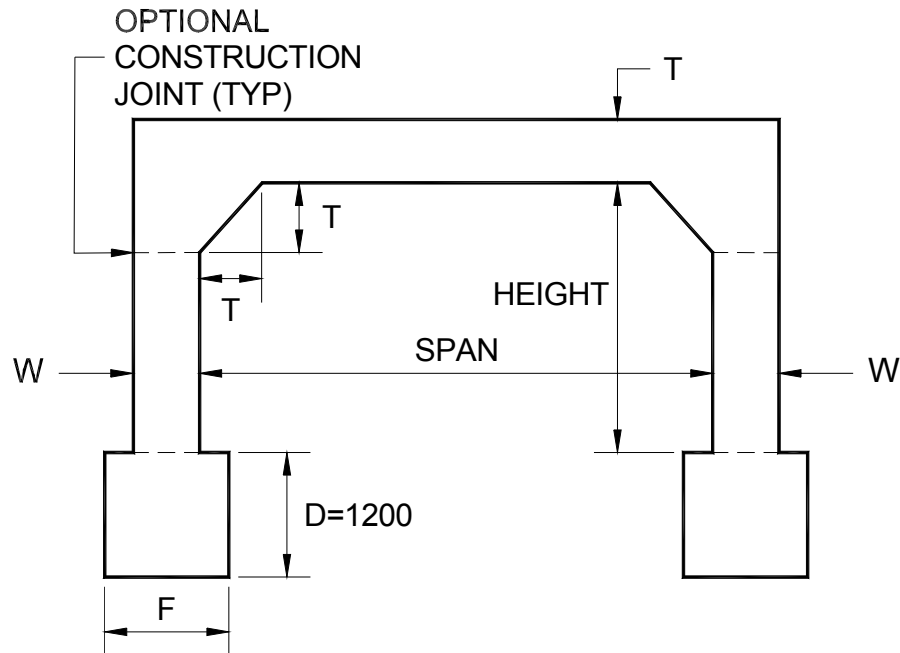
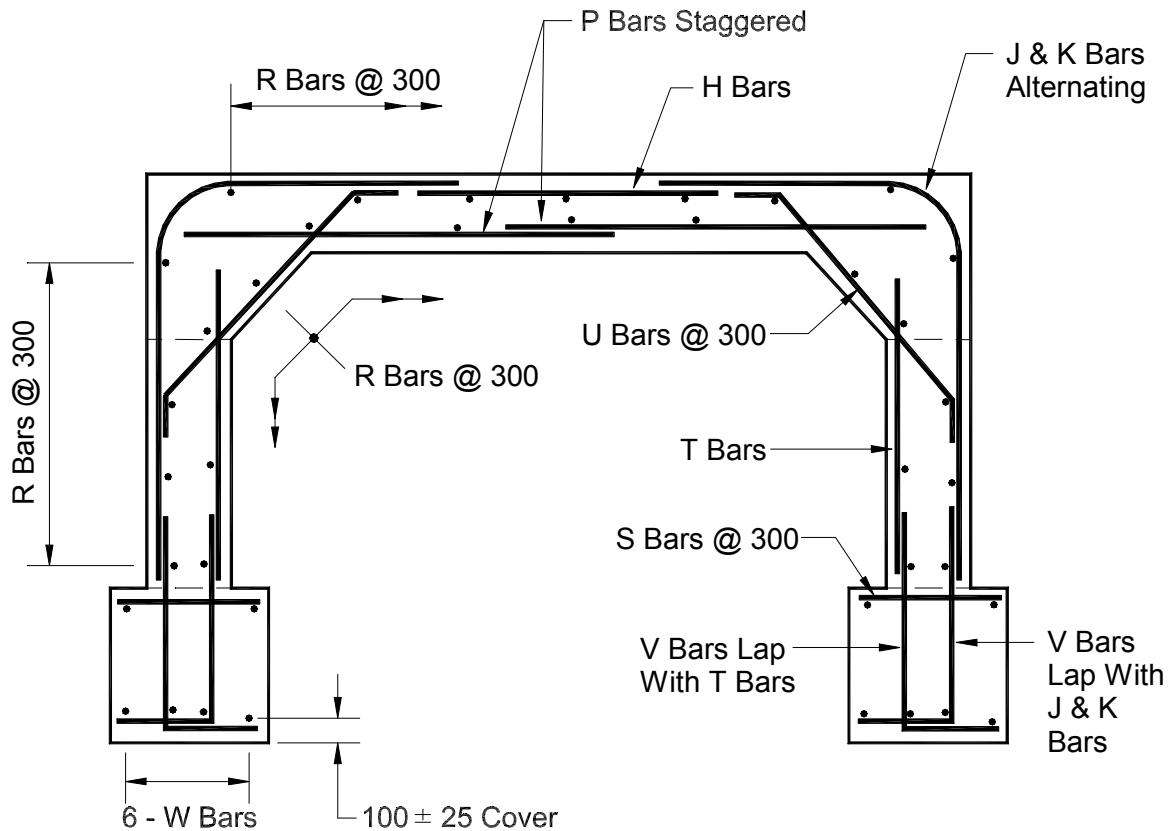


FIGURE 5.1(b) RIGID FRAME OPEN FOOTING CULVERT REINFORCEMENT



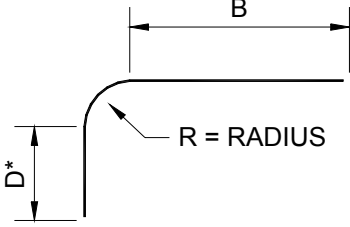
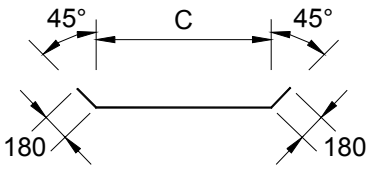
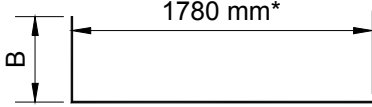
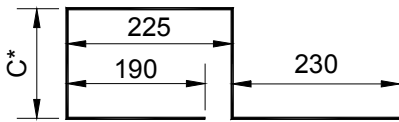
CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 18

TABLE 5-1 REINFORCING STEEL IDENTIFICATION

MARK	DETAILS	REMARKS
P BARS	STRAIGHT	BOTTOM OF TOP SLAB STAGGERED
H BARS	STRAIGHT	15M BARS TOP OF TOP SLAB
J & K BARS		J BARS ALTERNATE WITH K BARS
T BARS	STRAIGHT	INSIDE FACE OF WALLS
U BARS		15M BARS HAUNCH
R BARS	STRAIGHT	15M BARS LONGITUDINAL
V BARS		20M BARS FOOTING DOWELS
S BARS	STRAIGHT	15M BARS TOP OF FOOTING
W BARS	STRAIGHT	20M BARS LONGITUDINAL IN FOOTING
Y BARS	STRAIGHT	HEADER WALL
Z BARS		15M BARS HEADER WALL

NOTE: -All dimensions shown to centreline of bar.
 -* represents vertical dimension

5.2 FOOTING DESIGN**5.2.1 GENERAL INFORMATION**

A foundation investigation is generally necessary for culvert design and documentation in the contract for culvert construction purposes. Foundation information such as subsurface conditions, soil strength parameters, settlement limitations, and any dewatering and shoring requirements will be needed. In addition, information will be useful for the contractor to plan his work and as a baseline in the event of any construction disputes. The need and the level of detail required for the foundation investigation shall be determined by the designer and should be based on:

- (a) the complexity and the importance of the culvert, and
- (b) the data currently available for the foundation material.

It is important to realize that the footing width shown on the detailing tables is the minimum width compatible with the wall thickness of the culvert. It does not take into account any geotechnical considerations.

The detailing tables also list four values of footing reactions per metre of culvert: maximum factored vertical reactions at the footing level for the ultimate limit state and serviceability limit state, (V_{ULS} and V_{SLS}); maximum factored horizontal reaction at the footing level for the ultimate limit state (H_{ULS}) and the unfactored vertical reaction due to the dead load of cast-in-place concrete and soil fill at the footing level (V). The maximum vertical reactions are intended for use in calculating the maximum bearing pressures for the relevant limit states. The maximum factored horizontal reaction and unfactored vertical reaction are provided in order that the lateral sliding resistance of the footing can be checked.

If the bearing capacity of the founding soil is not exceeded by using the footing widths shown on the detailing tables and if the lateral sliding stability of the footing has been checked, then the geotechnical considerations are deemed to have been satisfied and the tabulated footing width is adequate.

If the bearing capacities are exceeded or lateral sliding stability is not assured, then the Geotechnical Engineer and the Structural Engineer shall be consulted.

IN ANY CASE, rigid frame open footing culverts should only be used when the foundation conditions are such so as to permit the use of the minimum footing width, or very close to it.

5.2.2 CALCULATION OF BEARING PRESSURE

The maximum applied factored pressure at the ultimate limit state is:

$$\frac{\text{MAXIMUM FACTORED VERTICAL REACTION @ULS, kN}}{\text{FOOTING AREA, square metres}}$$

and must not exceed the factored bearing capacity at the ultimate limit state.

The maximum applied bearing pressure at the serviceability limit state, is:

$$\frac{\text{MAXIMUM VERTICAL REACTION @ SLS, kN}}{\text{FOOTING AREA, square metres}}$$

and must not exceed the bearing capacity at this limit state.

5.2.3 DETERMINATION OF LATERAL SLIDING RESISTANCE

For cast-in-place rigid frame open footing culverts, the designer must check for the possibility of a sliding failure in the soil. The following expression may be used:

$$0.8 A' c' + 0.8 V \tan \phi' \geq H_{ULS}$$

Values of the parameters c' and $\tan \phi'$ for the culvert site can be found in the foundation report or from the Geotechnical Engineer.

For those cases where a check of the lateral sliding stability of the footings is not satisfied, several options are available. Depending on the structure's characteristics and site conditions, one of the following options may be utilized:

- i. The open footing culvert may be replaced with a box culvert or bridge.
- ii. The designer may design and detail reinforced concrete "struts" to be placed at regular intervals along the full length of the culvert and spanning the full distance between its footings.

- iii. Given that it has been determined that the footings will slide, analyze the structure to see how much horizontal movement takes place at the base of the footing. From this, calculate the additional moments induced into the culvert, and provide reinforcement sufficient for the Total moment in each member of the culvert structure.

5.2.4 MODIFICATION OF FOOTING CONCRETE QUANTITIES

The concrete quantities given in the detailing tables are based on the minimum footing dimensions. If the minimum footing width and depth is used, then these quantities are correct. If the footing must be enlarged, then the quantities given in the tables must be adjusted in proportion to the new footing dimensions.

The additional volume of concrete required to construct the four 100 mm lips at the ends of the footings of an open footing culvert must be determined and added to the total volume of footing concrete. This volume must be based on the actual footing dimensions.

5.2.5 MODIFICATION OF FOOTING STEEL QUANTITIES

The steel quantities given in the detailing tables are based on the minimum footing dimensions. If the minimum footing width and depth is used, then these quantities are correct. If the footings are made larger, then the quantities must be increased. In the following expressions, footing dimensions and bar spacing are in millimeters. The resulting quantities are in kilograms per metre of culvert length.

(a) Additional Steel for Widened Footings

The horizontal leg of each V bar must be lengthened by an amount equal to half the increase in footing width. Therefore, the total additional quantity of V type bars for widened footings is:

$$1.570 \times (\text{INCREASE IN FOOTING WIDTH}) \times F_1$$

where,

$$F_1 = \frac{1}{\text{EXTERIOR V BAR SPACING}} + \frac{1}{\text{INTERIOR V BAR SPACING}}$$

The length of the S bar must be increased by an amount equal to the increase in footing width, hence the total additional quantity of S bars is:

$$0.011 \times (\text{INCREASE IN FOOTING WIDTH})$$

(b) Additional Steel for Deepened Footings

When a footing is deepened, the vertical leg of each V bar must be lengthened by an amount equal to the increase in footing depth. In this case the total additional quantity of V type reinforcement for a deepened footing is:

$$3.140 \times (\text{INCREASE IN FOOTING DEPTH}) \times F_1$$

5.3 DETAILING OF OPEN FOOTING CULVERT DRAWINGS**5.3.1 DETAILS FOR STANDARD DRAWINGS**

The following is a suggested procedure for completing the drawing for standard rigid frame open footing culverts, SS114-1, with no skewed end, retaining walls or other special features:

- Obtain culvert size, length, and height of fill from "Design Data Form for Concrete Culverts".
- Select appropriate standard drawing for rigid frame open footing culvert.
- Determine from "Design Data Form for Concrete Culverts" whether culvert is an extension or not:

If culvert is an extension, change vertical centreline on left side of section detail 1 to a solid line and label - "END OF EXISTING CULVERT".

Insert length of culvert extension on the horizontal dimension line:

e.g. 16 m EXTN RT
 17 m EXTN LT

If culvert is not an extension, label centreline "Centre-Line Highway" and add culvert length each side of Centre-Line Highway.

e.g. 16 m RT
 17 m LT

- Select from Division 5 appropriate detailing table for required size of culvert.
- Insert span and height of culvert and dimensions of top slab, haunch and wall on "Typical Culvert Section" detail.
- Determine maximum soil bearing pressure as per Section 5.2.
- Determine footing width required and insert footing dimensions on "Typical Culvert Section" detail. The dimension showing the footing projection may be found from the following expression:

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 24

FOOTING WIDTH - WALL THICKNESS

2

- Insert bar size and/or spacing for H, J, K and P bars where required on all details. Note that P bar spacing is at mid-span. Insert spacing for V bars. Insert Y bar size on Detail B.
- Insert bar size and spacing for T bars.
- Insert dimensions on Detail 2 for layout of P bars, noting that smaller dimension is half of the wall thickness and larger dimension is P bar length.
- Add additional P bar at each end of culvert where no header wall is required.
- Add header walls where required as specified in Sections 4.2.6.

WARNING NOTE: a dimension is required on Detail 1 to show the actual distance between any J bar and the adjacent K bar. This is necessary to avoid confusion about the spacing of alternating bars, since the space between adjacent bars is 1/2 of the J spacing.

i.e., if J bar spacing is 300 mm and
K bar spacing is 300 mm

then distance between adjacent bars is 150 mm.

THIS IS AN EXTREMELY IMPORTANT POINT.

- Complete steel bar table for culvert and for header wall.
- Multiply unit quantities by culvert length.
- Calculate modifications to steel and concrete quantities required if actual footing size exceeds minimum footing size and modify unit quantities given.
- Add adjustment to steel quantity for R and W bar laps.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 25

- Add adjustment to footing concrete quantity for 100 mm lip at each end of footings.
- Add header wall quantities where applicable.
- Insert total quantities in "Culvert Quantities" table on standard drawings.
- **The Standard Drawing shall be sealed, dated and signed according to 4.3.1.**

5.3.2 STEEL TABLE FOR CULVERT

Spacing, bar length, and bar bending dimensions are available from the culvert detailing tables located at the end of this division.

Numbers of H, J, K, P, S, T, U and V bars required can be calculated as per Division 8. This procedure considers only one bar per cross-section; therefore for J, K, S, T, U and V bars, numbers given must be multiplied by 2.

Exterior face V bars lap with J bars. For culverts less than or equal to 2 metres high and, if J bar spacing exceeds 400 mm, then exterior face V bars lap with both J and K bars. Interior face V bars lap with T bars.

For R bars the number of sets of bars is available from the detail tables; the number of bars per set and bar length are as given in Division 8.

For W bars the number of sets are always 12 (6 per footing) regardless of the footing width. The bar length and number of bars per set are found as described in Division 8.

5.3.3 STEEL TABLE FOR HEADER WALL

Length and number of Y bars required and number of Z bars required are as given in Division 8.

Modification of these quantities is required for skewed end culverts.

5.3.4 ADJUSTMENT OF CONCRETE QUANTITIES

The additional volume of concrete required for header walls is described in Division 8.

Modification of these quantities is required for skewed end culverts.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 26

5.3.5 QUANTITY TABLE

Complete the quantity table. Concrete and steel quantities should be total quantities for complete length of culvert including header wall, where applicable.

5.4 DETAILING TABLES

The following pages contain the detailing tables. These tables list various culvert dimensions; concrete and reinforcing steel quantities, and reinforcing steel detailing information.

All dimensions, spacings and lengths given are in millimetres.

Steel quantities given are in kilograms, per metre length of culvert.

Concrete quantities given are in cubic metres, per metre length of culvert.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 28

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.00

HEIGHT: 1.25

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	210	220	220
	T	210	210	210	210	210	210	210	220	220
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	211.4	196.8	195.4	197.6	204.4	216.6	237.8	254.9	276.8
	CONC.	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
FOOTING REACTION *	V ULS	137.7	122.7	120.1	127.9	138.3	152.3	184.6	222.4	258
	V SLS	86.1	82.2	85.8	94.9	105.4	117.8	144.9	175.7	204.7
	H ULS	46.1	46.6	50.2	54.7	59.7	65	75.8	86.9	98.1
	V	46	57	72	86	101	115	145	175	204
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	300	400	425	425	425	375	300	275	225
	LENGTH	2210	2210	2210	2210	2210	2210	2210	2220	2220
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	550	630	630	625	575	525	425	375	325
	LENGTH	3080	2950	2890	2890	2890	2890	2890	2910	2910
	B	1610	1480	1420	1420	1420	1420	1420	1420	1420
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	140	140	140	140	140	140	140	150	150
K BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	550	630	630	625	575	525	425	375	325
	LENGTH	2650	2520	2420	2360	2310	2280	2250	2260	2240
	B	1180	1050	950	890	840	810	780	770	750
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	140	140	140	140	140	140	140	150	150
U BARS	LENGTH	910	910	910	910	910	910	910	960	960
	C	550	550	550	550	550	550	550	600	600
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	400	425	425	400	375	325	300	275	250
	LENGTH	1250	1250	1250	1250	1250	1250	1250	1250	1250
R BARS	# SETS	37	37	37	37	37	37	37	37	37
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	1995	2000	2000
	B	215	215	215	215	215	215	215	220	220
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 29

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.00

HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	210	210	230
	T	210	210	210	210	210	210	210	210	230
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	229.1	214.5	217.6	222.9	236.6	250.2	274.4	308.4	315.1
	CONC.	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.5
FOOTING REACTION *	V ULS	139.2	124.2	121.6	129.4	139.9	153.8	186.2	221.1	259.6
	V SLS	87.4	83.4	87.1	96.2	106.7	119.1	146.2	174.7	208.6
	H ULS	53	53.8	58	63.2	68.9	74.9	87.2	99.8	112.5
	V	47	58	73	88	102	117	146	175	208
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	300	400	450	450	425	400	325	275	250
	LENGTH	2210	2210	2210	2210	2210	2210	2210	2210	2230
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	550	625	600	575	500	450	375	300	300
	LENGTH	3370	3370	3310	3210	3140	3140	3140	3140	3170
	B	1650	1650	1590	1490	1420	1420	1420	1420	1420
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	140	140	140	140	140	140	140	140	160
K BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	550	625	600	575	500	450	375	300	300
	LENGTH	3140	3140	2870	2780	2710	2670	2610	2580	2610
	B	1420	1420	1150	1060	990	950	890	860	860
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	140	140	140	140	140	140	140	140	160
U BARS	LENGTH	910	910	910	910	910	910	910	910	1000
	C	550	550	550	550	550	550	550	550	640
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	325	350	325	300	275	250	225	200	200
	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
R BARS	# SETS	39	39	39	39	39	39	39	39	41
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	1995	1995	2005
	B	215	215	215	215	215	215	215	215	225
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 30

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.00

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	210	220	240
	T	210	210	210	210	210	210	210	220	230
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	256.4	242.9	245.1	257.9	272.1	290.9	324.4	350.8	350.6
	CONC.	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.6	2.7
FOOTING REACTION *	V ULS	140.7	125.8	123.2	131	141.4	155.4	187.7	225.6	267.1
	V SLS	88.7	84.7	88.3	97.5	108	120.4	147.5	178.4	212.2
	H ULS	60.2	61.4	66.1	72	78.4	85	98.8	112.8	127.8
	V	48	60	74	89	103	118	147	178	212
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	300	400	450	450	450	425	350	300	275
	LENGTH	2210	2210	2210	2210	2210	2210	2210	2220	2240
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	500	575	550	500	450	400	325	300	400
	LENGTH	3620	3620	3620	3620	3610	3540	3450	3430	3600
	B	1650	1650	1650	1650	1640	1570	1480	1440	1600
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	140	140	140	140	140	140	140	150	160
K BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	500	575	550	500	450	400	325	300	400
	LENGTH	3390	3390	3390	3390	3180	3110	3020	3010	2980
	B	1420	1420	1420	1420	1210	1140	1050	1020	980
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	140	140	140	140	140	140	140	150	160
U BARS	LENGTH	910	910	910	910	910	910	910	960	1010
	C	550	550	550	550	550	550	550	600	650
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	275	275	275	250	225	200	175	150	150
	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
R BARS	# SETS	43	43	43	43	43	43	43	43	45
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	1995	2000	2010
	B	215	215	215	215	215	215	215	220	230
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 31

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.00
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	220	230	250
	T	210	210	210	210	210	210	210	220	240
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	284.9	273.9	281.9	301.1	325.6	357.9	369.2	367.9	369.9
	CONC.	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.7	2.9
FOOTING REACTION *	V ULS	142.3	127.3	124.7	132.5	143	156.9	189.2	229.6	272.3
	V SLS	89.9	86	89.6	98.8	109.3	121.7	150.5	181.7	216.4
	H ULS	67.9	69.3	74.6	81.1	88.1	95.5	110.5	126.9	142.5
	V	49	61	76	90	105	119	149	181	216
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	325	425	450	450	450	450	375	325	325
	LENGTH	2210	2210	2210	2210	2210	2210	2220	2230	2250
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	475	525	475	425	375	325	400	375	375
	LENGTH	3870	3870	3870	3870	3870	3870	4080	4020	4050
	B	1650	1650	1650	1650	1650	1650	1860	1780	1780
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	140	140	140	140	140	140	140	150	170
K BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	475	525	475	425	375	325	400	375	375
	LENGTH	3640	3640	3640	3640	3640	3640	3780	3410	3430
	B	1420	1420	1420	1420	1420	1420	1560	1170	1160
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	140	140	140	140	140	140	140	150	170
U BARS	LENGTH	910	910	910	910	910	910	930	970	1050
	C	550	550	550	550	550	550	570	610	690
T BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	225	225	225	200	175	150	150	200	200
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	47	47	47	47	47	47	47	49	49
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	2000	2005	2015
	B	215	215	215	215	215	215	220	225	235
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 32

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.50

HEIGHT: 1.25

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	210	220	240
	T	210	210	210	210	210	210	220	230	250
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	255.9	229.8	229.4	233.4	241.8	258.3	280.4	279.5	288.9
	CONC.	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.6
FOOTING REACTION *	V ULS	162.7	139	141.7	150.9	164.3	180.6	219.6	264.2	314.2
	V SLS	101.1	93.3	100.8	111.7	124.8	139.5	172.7	208.8	249.2
	H ULS	46	46	49	53	57.5	62.2	72	81.9	92
	V	51	65	82	100	117	135	170	207	247
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	275	275	275	250	225	200	175	150
	LENGTH	2710	2710	2710	2710	2710	2710	2710	2720	2740
H BARS	C/C	-	-	-	425	400	350	300	400	375
	LENGTH	-	-	-	1540	1560	1580	1600	1160	1320
J BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	375	450	450	425	400	350	300	400	375
	LENGTH	3140	3140	3140	2400	2390	2380	2380	2610	2560
	B	1670	1670	1670	930	920	910	890	1110	1030
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	140	140	140	140	140	140	150	160	180
K BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	375	450	450	425	400	350	300	400	375
	LENGTH	2460	2390	2330	1970	1950	1940	1960	1990	1960
	B	990	920	860	500	480	470	470	490	430
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	140	140	140	140	140	140	150	160	180
U BARS	LENGTH	910	910	910	910	910	910	940	980	1070
	C	550	550	550	550	550	550	580	620	710
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	400	450	450	425	400	375	350	325	350
	LENGTH	1250	1250	1250	1250	1250	1250	1250	1250	1250
R BARS	# SETS	40	40	40	40	40	40	40	42	42
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	1995	2000	2010
	B	215	215	215	215	215	215	215	220	230
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 33

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.50

HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	210	230	250
	T	210	210	210	210	210	210	220	240	260
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	274.4	247.9	247.2	254.9	271.6	283.1	299.0	305.8	308.0
	CONC.	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.7	2.8
FOOTING REACTION *	V ULS	164.2	140.5	143.2	152.5	165.8	182.2	221.8	268.8	319.3
	V SLS	102.4	94.6	102.1	113	126.1	140.7	174	212.6	253.4
	H ULS	53.2	53.5	57.2	62	67.3	72.8	84	95.8	107.6
	V	52	66	83	101	119	136	171	211	251
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	275	275	275	250	225	200	175	175
	LENGTH	2710	2710	2710	2710	2710	2710	2710	2730	2750
H BARS	C/C	-	-	-	-	-	350	400	400	400
	LENGTH	-	-	-	-	-	1300	900	1100	1120
J BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	375	450	450	425	375	350	400	400	400
	LENGTH	3390	3390	3390	3390	3390	2770	2980	2910	2930
	B	1670	1670	1670	1670	1670	1050	1240	1140	1130
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	140	140	140	140	140	140	150	170	190
K BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	375	450	450	425	375	350	400	400	400
	LENGTH	2830	2750	2660	2610	2570	2340	2370	2290	2330
	B	1110	1030	940	890	850	620	630	520	530
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	140	140	140	140	140	140	150	170	190
U BARS	LENGTH	910	910	910	910	910	910	940	1030	1110
	C	550	550	550	550	550	550	580	670	750
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	325	350	350	325	300	275	250	250	250
	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
R BARS	# SETS	42	42	42	42	42	42	42	44	44
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	1995	2005	2015
	B	215	215	215	215	215	215	215	225	235
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 34

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.50

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	220	220	240	260
	T	210	210	210	210	210	210	230	250	270
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	302.9	277.8	276.9	287.6	308.0	326.4	342.8	342.0	344.2
	CONC.	2.6	2.6	2.6	2.6	2.6	2.6	2.7	2.8	3.0
FOOTING REACTION *	V ULS	165.8	142	144.8	154	167.4	185.5	225.4	272.9	323.8
	V SLS	103.6	95.9	103.3	114.3	127.3	143.5	177.5	216.5	257.7
	H ULS	60.7	61.4	65.7	71.2	77.3	84	96.6	110	123.5
	V	53	67	85	102	120	138	174	213	254
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	275	275	275	275	250	225	200	200
	LENGTH	2710	2710	2710	2710	2710	2720	2720	2740	2760
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	375	425	425	400	350	325	300	400	400
	LENGTH	3690	3640	3640	3640	3640	3640	3670	3840	3870
	B	1720	1670	1670	1670	1670	1670	1670	1810	1810
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	140	140	140	140	140	140	160	180	200
K BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	375	425	425	400	350	325	300	400	400
	LENGTH	3260	3150	3030	2960	2920	2860	2900	2930	2970
	B	1290	1180	1060	990	950	890	900	900	910
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	140	140	140	140	140	140	160	180	200
U BARS	LENGTH	910	910	910	910	910	930	980	1070	1150
	C	550	550	550	550	550	570	620	710	790
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	250	275	275	250	225	200	200	200	200
	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
R BARS	# SETS	46	46	46	46	46	46	48	48	48
V BARS	LENGTH	1995	1995	1995	1995	1995	2000	2000	2010	2020
	B	215	215	215	215	215	220	220	230	240
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 35

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.50
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	230	250	280
	T	210	210	210	210	210	210	230	260	280
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	345.3	312.4	308.5	331.4	352.3	364.0	366.4	366.3	380.6
	CONC.	2.7	2.7	2.7	2.7	2.7	2.7	2.9	3.0	3.3
FOOTING REACTION *	V ULS	167.3	143.6	146.3	155.6	168.9	185.3	229.9	277.8	332.7
	V SLS	104.9	97.2	104.6	115.6	128.6	143.3	180.6	220.5	264.3
	H ULS	68.6	69.6	74.5	80.7	87.5	94.5	109.2	124.1	139.1
	V	54	68	86	103	121	138	178	217	261
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	275	300	300	275	250	225	225	200
	LENGTH	2710	2710	2710	2710	2710	2710	2730	2750	2780
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	350	400	400	350	325	300	400	400	375
	LENGTH	4120	4050	3890	3890	3890	3890	4060	4110	4140
	B	1900	1830	1670	1670	1670	1670	1810	1810	1810
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	140	140	140	140	140	140	160	190	210
K BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	350	400	400	350	325	300	400	400	375
	LENGTH	3890	3620	3450	3360	3290	3250	3260	3310	3350
	B	1670	1400	1230	1140	1070	1030	1010	1010	1020
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	140	140	140	140	140	140	160	190	210
U BARS	LENGTH	910	910	910	910	910	910	1000	1110	1210
	C	550	550	550	550	550	550	640	750	850
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	225	225	200	175	175	175	175	175
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	50	50	50	50	50	50	52	50	50
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	2005	2015	2030
	B	215	215	215	215	215	215	225	235	250
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 36

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.00
HEIGHT: 1.25

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	220	220	230	260
	T	220	210	210	210	210	220	240	260	290
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	293.1	275.5	274.0	282.9	273.9	290.2	319.7	326.0	324.5
	CONC.	2.5	2.5	2.5	2.5	2.5	2.6	2.6	2.7	3.0
FOOTING REACTION *	V ULS	185.7	155.5	162.5	173.7	189.8	212.2	258.1	311	371.8
	V SLS	115.2	104.7	115.4	128.3	143.9	163.4	202.3	245.6	294.9
	H ULS	45.2	44.7	46.9	50.2	54	57.9	66.5	75.3	83.8
	V	56	72	93	113	134	156	197	241	291
P BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	150	200	200	200	175	175	150	200	175
	LENGTH	3210	3210	3210	3210	3210	3220	3220	3230	3260
H BARS	C/C	-	325	325	300	400	350	300	300	325
	LENGTH	-	1620	2000	2040	1760	1780	1760	1740	1760
J BARS	SIZE	20	15	15	15	20	20	20	20	20
	C/C	400	325	325	300	400	350	300	300	325
	LENGTH	3550	2610	2420	2400	2540	2550	2570	2600	2640
	B	2060	1140	950	930	1070	1060	1050	1050	1040
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	150	140	140	140	140	150	170	190	220
K BARS	SIZE	20	15	15	15	20	20	20	20	20
	C/C	400	325	325	300	400	350	300	300	325
	LENGTH	2550	2150	1990	1970	1920	1930	1960	2000	2080
	B	1060	680	520	500	450	440	440	450	480
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	150	140	140	140	140	150	170	190	220
U BARS	LENGTH	940	910	910	910	910	960	1010	1080	1210
	C	580	550	550	550	550	600	650	720	850
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	425	450	450	450	450	450	450	450	450
	LENGTH	1250	1250	1250	1250	1250	1250	1250	1250	1250
R BARS	# SETS	43	43	43	43	43	43	45	45	45
V BARS	LENGTH	1995	1995	1995	1995	1995	2000	2000	2005	2020
	B	215	215	215	215	215	220	220	225	240
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 37

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.00
HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	220	240	270
	T	230	210	210	210	210	220	250	270	290
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	313.9	294.3	290.3	302.3	295.1	306.4	334.0	337.7	338.3
	CONC.	2.7	2.6	2.6	2.6	2.6	2.6	2.8	2.9	3.1
FOOTING REACTION *	V ULS	187.3	157.1	164	175.2	191.4	212.1	259.7	315.8	376.3
	V SLS	117	105.9	116.7	129.6	145.2	163.4	204.3	249.5	298.6
	H ULS	52.5	52.6	55.6	59.8	64.4	69.3	79.6	90	100.5
	V	58	73	94	114	135	155	200	245	293
P BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	175	200	200	200	175	175	150	200	200
	LENGTH	3210	3210	3210	3210	3210	3210	3220	3240	3270
H BARS	C/C	-	-	325	300	400	375	325	325	325
	LENGTH	-	-	1920	1980	1580	1560	1700	1700	1740
J BARS	SIZE	20	15	15	15	20	20	20	20	20
	C/C	400	325	325	300	400	375	325	325	325
	LENGTH	3810	3640	2710	2680	2880	2900	2850	2880	2910
	B	2060	1920	990	960	1160	1160	1070	1070	1060
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	160	140	140	140	140	150	180	200	220
K BARS	SIZE	20	15	15	15	20	20	20	20	20
	C/C	400	325	325	300	400	375	325	325	325
	LENGTH	2880	2720	2280	2250	2270	2280	2250	2290	2340
	B	1130	1000	560	530	550	540	470	480	490
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	160	140	140	140	140	150	180	200	220
U BARS	LENGTH	970	910	910	910	910	940	1040	1130	1220
	C	610	550	550	550	550	580	680	770	860
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	325	375	375	350	350	325	325	350	375
	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
R BARS	# SETS	47	45	45	45	45	45	47	47	47
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	2000	2010	2025
	B	215	215	215	215	215	215	220	230	245
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 38

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.00

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	230	260	280
	T	230	210	210	210	220	230	250	280	300
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	342.9	326.3	321.9	329.3	332.2	348.6	355.7	350.9	359.3
	CONC.	2.8	2.7	2.7	2.7	2.7	2.8	2.9	3.2	3.3
FOOTING REACTION *	V ULS	188.8	158.6	165.6	176.8	192.9	213.6	264.2	323	381.8
	V SLS	118.3	107.2	117.9	130.9	147	165.3	207.3	255.5	303.1
	H ULS	60.2	60.8	64.5	69.5	75	80.6	92.5	104.8	117.1
	V	59	74	95	116	136	158	202	251	297
P BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	150	175	200	200	200	175	150	150	200
	LENGTH	3210	3210	3210	3210	3210	3210	3230	3260	3280
H BARS	C/C	-	-	-	300	375	350	350	350	350
	LENGTH	-	-	-	1580	1480	1480	1500	1520	1540
J BARS	SIZE	20	15	15	15	20	20	20	20	20
	C/C	400	325	325	300	375	350	350	350	350
	LENGTH	4060	3890	3890	3130	3190	3190	3210	3250	3270
	B	2060	1920	1920	1160	1200	1190	1180	1170	1160
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	160	140	140	140	150	160	180	210	230
K BARS	SIZE	20	15	15	15	20	20	20	20	20
	C/C	400	325	325	300	375	350	350	350	350
	LENGTH	3240	3050	2970	2660	2570	2580	2610	2670	2720
	B	1240	1080	1000	690	580	580	580	590	610
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	160	140	140	140	150	160	180	210	230
U BARS	LENGTH	970	910	910	910	940	970	1050	1180	1270
	C	610	550	550	550	580	610	690	820	910
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	275	275	275	275	250	250	250	275	275
	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
R BARS	# SETS	51	49	49	49	49	51	51	49	50
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	2005	2020	2030
	B	215	215	215	215	215	215	225	240	250
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 39

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.00
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	210	210	250	270	290
	T	240	210	210	210	220	230	260	280	310
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	374.7	364.9	360.3	364.2	377.5	414.6	365.3	380.6	390.0
	CONC.	2.9	2.8	2.8	2.8	2.8	2.9	3.2	3.3	3.6
FOOTING REACTION *	V ULS	191	160.2	167.1	178.3	195.1	215.9	268	327.4	387.4
	V SLS	120.2	108.5	119.2	132.2	148.3	166.6	212.9	259	307.7
	H ULS	67.7	69.2	73.7	79.4	85.4	91.7	105.8	119.8	133.6
	V	61	76	96	117	137	159	208	253	302
P BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	150	175	200	200	175	175	175	150	200
	LENGTH	3210	3210	3210	3210	3210	3210	3250	3270	3290
H BARS	C/C	-	-	-	-	-	-	375	350	350
	LENGTH	-	-	-	-	-	-	1260	1500	1480
J BARS	SIZE	20	15	15	20	20	20	20	20	20
	C/C	400	300	300	400	375	325	375	350	350
	LENGTH	4370	4140	4140	4280	4300	4310	3610	3520	3570
	B	2100	1920	1920	2060	2060	2060	1310	1190	1190
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	170	140	140	140	150	160	190	210	240
K BARS	SIZE	20	15	15	20	20	20	20	20	20
	C/C	400	300	300	400	375	325	375	350	350
	LENGTH	3750	3410	3310	3270	3270	3270	3020	2950	3030
	B	1480	1190	1090	1050	1030	1020	720	620	650
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	170	140	140	140	150	160	190	210	240
U BARS	LENGTH	1000	910	910	910	940	970	1110	1200	1310
	C	640	550	550	550	580	610	750	840	950
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	225	225	225	200	200	175	225	225	225
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	55	53	53	53	53	55	53	53	54
V BARS	LENGTH	1995	1995	1995	1995	1995	1995	2015	2025	2035
	B	215	215	215	215	215	215	235	245	255
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 40

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50
HEIGHT: 1.25

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	220	220	220	220	220	260	290
	T	240	220	220	230	230	240	270	300	330
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	344.6	311.2	296.1	307.7	322.6	339.2	348.9	336.1	353.4
	CONC.	2.7	2.6	2.7	2.7	2.7	2.8	2.9	3.1	3.4
FOOTING REACTION *	V ULS	207.4	172.6	181.3	199.1	218.3	242.5	294.8	359.8	431.8
	V SLS	128.8	116.5	129.4	147.6	165.4	186.6	231.7	286.8	343.2
	H ULS	43.7	42.8	44.1	46.5	49.5	52.9	60.3	66.9	72.7
	V	62	80	105	128	152	177	225	280	336
P BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	200	150	175	175	150	200	175	175	175
	LENGTH	3710	3710	3720	3720	3720	3720	3720	3760	3790
H BARS	C/C	-	350	375	350	325	300	400	450	425
	LENGTH	-	1940	2140	2160	2200	2200	1740	1800	1780
J BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	325	350	375	350	325	300	400	450	425
	LENGTH	3830	2710	2620	2610	2590	2600	2840	2870	2930
	B	2310	1220	1130	1110	1090	1080	1280	1260	1270
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	170	150	150	160	160	170	200	230	260
K BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	325	350	375	350	325	300	400	450	425
	LENGTH	2660	2100	2000	1990	1980	1980	2070	2100	2190
	B	1140	610	510	490	480	460	510	490	530
	D	1250	1250	1250	1250	1250	1250	1250	1250	1250
	R	170	150	150	160	160	170	200	230	260
U BARS	LENGTH	1000	940	960	980	980	1010	1100	1240	1370
	C	640	580	600	620	620	650	740	880	1010
T BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	450	450	450	450	450	450	450	450	450
	LENGTH	1250	1250	1250	1250	1250	1250	1250	1250	1250
R BARS	# SETS	49	47	47	49	49	49	48	48	48
V BARS	LENGTH	1995	1995	2000	2000	2000	2000	2000	2020	2035
	B	215	215	220	220	220	220	220	240	255
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 41

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50

HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	220	220	230	260	290
	T	250	220	220	230	240	250	270	300	340
	F	500	500	500	500	500	500	500	500	500
QUANTITIES	STEEL	352.0	316.9	314.2	326.2	335.8	351.4	346.6	355.8	360.7
	CONC.	2.9	2.8	2.8	2.8	2.9	2.9	3.0	3.3	3.6
FOOTING REACTION *	V ULS	210.3	175.2	182.9	200.7	219.9	244.1	297.2	364.9	434.8
	V SLS	131.4	118.6	130.8	149	167.4	188.6	234.6	288.4	345.8
	H ULS	51.4	51.2	53.3	56.7	60.6	64.9	74.3	82.9	91.6
	V	65	82	106	129	154	178	227	282	338
P BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	200	150	150	150	150	200	175	150	175
	LENGTH	3720	3720	3720	3720	3720	3720	3730	3760	3790
H BARS	C/C	-	375	375	350	325	300	450	450	450
	LENGTH	-	1880	1980	2020	2160	2160	1740	1740	1740
J BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	350	375	375	350	325	300	450	450	450
	LENGTH	4090	3000	2950	2930	2870	2870	3100	3150	3200
	B	2310	1260	1210	1180	1100	1090	1290	1290	1280
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	180	150	150	160	170	180	200	230	270
K BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	350	375	375	350	325	300	450	450	450
	LENGTH	2990	2380	2330	2320	2260	2270	2330	2380	2470
	B	1210	640	590	570	490	490	520	520	550
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	180	150	150	160	170	180	200	230	270
U BARS	LENGTH	1040	960	960	980	1010	1040	1110	1240	1390
	C	680	600	600	620	650	680	750	880	1030
T BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	375	425	450	450	450	450	450	450	450
	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
R BARS	# SETS	50	49	49	51	51	50	50	48	50
V BARS	LENGTH	2000	2000	2000	2000	2000	2000	2005	2020	2035
	B	220	220	220	220	220	220	225	240	255
S BARS	LENGTH	360	360	360	360	360	360	360	360	360
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 42

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	220	220	220	220	220	240	280	310
	T	250	220	220	230	240	250	280	310	340
	F	500	500	500	500	500	500	500	500	600
QUANTITIES	STEEL	394.4	345.2	341.9	354.4	365.9	382.4	387.2	388.8	397.7
	CONC.	3.0	2.9	2.9	2.9	3.0	3.0	3.2	3.5	4.0
FOOTING REACTION *	V ULS	210.5	176.8	184.5	203.1	222.3	246.5	303.8	370	442.3
	V SLS	132	120	132.1	150.3	168.8	189.9	238.4	294.6	351.9
	H ULS	59	59.7	62.7	66.9	71.7	76.8	87.6	98.5	109
	V	65	83	107	131	155	179	231	287	346
P BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	200	150	150	150	150	200	175	175	175
	LENGTH	3710	3720	3720	3720	3720	3720	3740	3780	3810
H BARS	C/C	-	375	375	350	325	300	300	300	300
	LENGTH	-	1520	1920	1940	1940	1920	2120	2180	2180
J BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	325	375	375	350	325	300	300	300	300
	LENGTH	4340	3430	3230	3220	3230	3240	3180	3210	3250
	B	2310	1440	1240	1220	1210	1210	1100	1080	1080
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	180	150	150	160	170	180	210	240	270
K BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	325	375	375	350	325	300	300	300	300
	LENGTH	3330	2820	2620	2610	2620	2630	2610	2670	2730
	B	1300	830	630	610	600	600	530	540	560
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	180	150	150	160	170	180	210	240	270
U BARS	LENGTH	1030	960	960	980	1010	1040	1150	1290	1420
	C	670	600	600	620	650	680	790	930	1060
T BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	275	325	325	325	325	325	325	375	425
	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
R BARS	# SETS	54	53	53	55	55	54	52	54	54
V BARS	LENGTH	1995	2000	2000	2000	2000	2000	2010	2030	2095
	B	215	220	220	220	220	220	230	250	315
S BARS	LENGTH	360	360	360	360	360	360	360	360	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 43

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	220	220	260	290	320
	T	260	230	230	230	240	250	290	320	340
	F	500	500	500	500	500	500	500	500	600
QUANTITIES	STEEL	403.8	387.4	372.3	385.1	410.3	417.9	410.6	422.2	424.1
	CONC.	3.2	3.0	3.0	3.0	3.1	3.1	3.5	3.8	4.2
FOOTING REACTION *	V ULS	213.5	178.5	186.1	204.7	223.9	248.1	309.9	377.8	448.2
	V SLS	134.7	121.9	134.1	151.6	170.1	191.3	244.1	299	356
	H ULS	67.3	68.4	72.2	77.2	82.8	88.7	101.4	114	126.8
	V	68	85	108	132	157	180	236	292	350
P BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	200	150	175	150	150	200	200	175	175
	LENGTH	3720	3720	3720	3720	3720	3720	3760	3790	3820
H BARS	C/C	-	-	375	350	300	300	300	300	300
	LENGTH	-	-	1540	1860	1860	1860	1920	2120	2180
J BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	350	375	375	350	300	300	300	300	300
	LENGTH	4610	4560	3670	3510	3520	3520	3560	3500	3510
	B	2310	2310	1420	1260	1250	1240	1210	1110	1090
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	190	160	160	160	170	180	220	250	270
K BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	350	375	375	350	300	300	300	300	300
	LENGTH	3730	3440	3060	2900	2900	2910	2990	2960	3000
	B	1430	1190	810	650	630	630	640	570	580
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	190	160	160	160	170	180	220	250	270
U BARS	LENGTH	1070	980	980	980	1010	1040	1210	1340	1440
	C	710	620	620	620	650	680	850	980	1080
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	250	250	250	250	250	225	275	275	300
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	56	59	59	59	59	56	56	58	58
V BARS	LENGTH	2000	2000	2000	2000	2000	2000	2020	2035	2100
	B	220	220	220	220	220	220	240	255	320
S BARS	LENGTH	360	360	360	360	360	360	360	360	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 44

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50
HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	230	250	290	320	350
	T	280	230	230	240	260	270	300	330	360
	F	500	500	500	500	500	500	500	600	600
QUANTITIES	STEEL	478.2	460.4	475.0	504.4	504.3	473.2	458.1	468.0	475.5
	CONC.	3.5	3.3	3.3	3.3	3.4	3.6	4.0	4.5	4.8
FOOTING REACTION *	V ULS	218.3	182.4	190.1	208.7	229.8	259	320	390.7	463.5
	V SLS	138.6	124.6	136.8	155	175.6	200.2	253.6	309.6	368.5
	H ULS	83.4	86.4	91.7	98	105.5	113.4	129.5	146	162.2
	V	71	88	112	135	161	188	245	304	361
P BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	150	150	150	150	150	150	150	200	175
	LENGTH	3720	3720	3720	3720	3730	3750	3790	3820	3850
H BARS	C/C	-	-	-	-	-	-	350	325	325
	LENGTH	-	-	-	-	-	-	1480	1880	1900
J BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	350	350	350	300	300	325	350	325	325
	LENGTH	5440	5060	5060	5080	5110	5120	4310	4160	4200
	B	2610	2310	2310	2310	2310	2310	1450	1250	1240
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	210	160	160	170	190	200	230	260	290
K BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	350	350	350	300	300	325	350	325	325
	LENGTH	5140	4200	4060	4020	4010	3990	3740	3630	3700
	B	2310	1450	1310	1250	1210	1180	880	720	740
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	210	160	160	170	190	200	230	260	290
U BARS	LENGTH	1130	980	980	1010	1080	1140	1280	1410	1540
	C	770	620	620	650	720	780	920	1050	1180
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	175	175	150	150	150	175	175	200	200
	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
R BARS	# SETS	64	65	65	65	64	64	66	66	64
V BARS	LENGTH	2000	2000	2000	2000	2005	2015	2035	2100	2115
	B	220	220	220	220	225	235	255	320	335
S BARS	LENGTH	360	360	360	360	360	360	360	460	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 45

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	220	220	250	290	330
	T	260	240	240	250	260	270	300	330	370
	F	500	500	500	500	500	500	500	500	600
QUANTITIES	STEEL	399.6	357.0	367.0	374.2	379.8	400.2	401.1	403.3	422.2
	CONC.	3.1	3.0	3.0	3.0	3.1	3.1	3.4	3.7	4.3
FOOTING REACTION *	V ULS	220.6	192.6	201.6	224.9	247.4	274.3	341.3	413.8	497.5
	V SLS	138.9	130.9	144.7	166.5	188.2	211.4	267.6	329.2	395.9
	H ULS	50.1	49	50.4	53.1	56.3	60.2	67.1	73.9	79
	V	70	90	117	144	172	198	258	321	389
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	175	200	200	175	175	150	150	150	150
	LENGTH	4220	4220	4220	4220	4220	4220	4250	4290	4330
H BARS	C/C	-	325	300	300	400	375	375	400	375
	LENGTH	-	2300	2520	2560	2140	2160	2180	2240	2240
J BARS	SIZE	20	20	20	20	25	25	25	25	25
	C/C	300	325	300	300	400	375	375	400	375
	LENGTH	4360	3050	2940	2920	3140	3130	3170	3200	3260
	B	2560	1280	1170	1140	1340	1320	1310	1290	1290
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	190	170	170	180	190	200	230	260	300
K BARS	SIZE	20	20	20	20	25	25	25	25	25
	C/C	300	325	300	300	400	375	375	400	375
	LENGTH	3070	2430	2320	2310	2370	2360	2400	2460	2560
	B	1270	660	550	530	570	550	540	550	590
	D	1500	1500	1500	1500	1500	1500	1500	1500	1500
	R	190	170	170	180	190	200	230	260	300
U BARS	LENGTH	1070	1010	1010	1040	1070	1100	1220	1370	1540
	C	710	650	650	680	710	740	860	1010	1180
T BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	400	450	450	450	450	450	450	450	450
	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
R BARS	# SETS	54	54	54	54	54	54	52	54	53
V BARS	LENGTH	2000	2000	2000	2000	2000	2000	2015	2035	2105
	B	220	220	220	220	220	220	235	255	325
S BARS	LENGTH	360	360	360	360	360	360	360	360	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 46

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	220	220	260	300	340
	T	260	240	240	250	260	270	310	340	380
	F	500	500	500	500	500	500	500	500	600
QUANTITIES	STEEL	434.8	382.6	391.6	382.4	402.1	423.5	413.2	424.0	434.6
	CONC.	3.2	3.1	3.1	3.1	3.2	3.2	3.6	3.9	4.6
FOOTING REACTION *	V ULS	222.2	194.2	203.2	226.5	249.9	275.9	346.2	421.6	503.6
	V SLS	140.2	132.2	146.1	167.8	189.6	212.7	271.6	333.7	400.9
	H ULS	58.1	57.7	60.1	63.7	68	72.6	81.7	90.3	98.6
	V	72	92	119	145	173	200	262	324	394
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	200	200	175	175	150	150	150	150
	LENGTH	4220	4220	4220	4220	4220	4220	4260	4300	4340
H BARS	C/C	-	325	300	450	400	375	400	400	400
	LENGTH	-	2220	2340	2100	2120	2120	2160	2200	2220
J BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	325	300	450	400	375	400	400	400
	LENGTH	4610	3340	3280	3400	3400	3400	3450	3480	3540
	B	2560	1320	1260	1370	1350	1340	1320	1310	1300
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	190	170	170	180	190	200	240	270	310
K BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	325	300	450	400	375	400	400	400
	LENGTH	3390	2730	2670	2630	2630	2630	2690	2750	2850
	B	1340	710	650	600	580	570	560	580	610
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	190	170	170	180	190	200	240	270	310
U BARS	LENGTH	1070	1010	1010	1040	1070	1100	1270	1410	1580
	C	710	650	650	680	710	740	910	1050	1220
T BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	325	350	375	400	400	400	450	450	450
	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
R BARS	# SETS	58	58	58	58	58	58	58	58	59
V BARS	LENGTH	2000	2000	2000	2000	2000	2000	2020	2040	2110
	B	220	220	220	220	220	220	240	260	330
S BARS	LENGTH	360	360	360	360	360	360	360	360	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 47

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	220	230	270	310	350
	T	260	240	240	250	260	280	310	350	380
	F	500	500	500	500	500	500	500	600	600
QUANTITIES	STEEL	464.1	436.1	423.9	417.4	438.8	432.6	430.9	432.4	442.9
	CONC.	3.3	3.2	3.2	3.3	3.3	3.4	3.8	4.4	4.8
FOOTING REACTION *	V ULS	223.9	195.8	204.8	228.1	251.5	280.3	348.1	427.3	509.9
	V SLS	141.6	133.6	147.4	169.2	190.9	216.3	275	338.4	405.2
	H ULS	66.4	66.6	69.8	74.3	79.4	84.9	96.1	107	117.7
	V	73	93	120	148	174	203	265	331	397
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	175	200	175	175	175	150	150	150
	LENGTH	4220	4220	4220	4220	4220	4230	4270	4310	4350
H BARS	C/C	-	300	300	450	400	400	425	425	425
	LENGTH	-	1680	2260	1860	1880	2080	2160	2160	2220
J BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	300	300	450	400	400	425	425	425
	LENGTH	4860	3860	3570	3770	3770	3690	3710	3770	3800
	B	2560	1590	1300	1490	1470	1360	1330	1330	1310
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	190	170	170	180	190	210	240	280	310
K BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	300	300	450	400	400	425	425	425
	LENGTH	3730	3190	2960	3000	3010	2920	2950	3050	3120
	B	1430	920	690	720	710	590	570	610	630
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	190	170	170	180	190	210	240	280	310
U BARS	LENGTH	1070	1010	1010	1040	1070	1140	1280	1450	1590
	C	710	650	650	680	710	780	920	1090	1230
T BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	250	275	275	275	275	300	350	400	450
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	60	62	62	60	60	60	62	61	63
V BARS	LENGTH	2000	2000	2000	2000	2000	2005	2025	2095	2115
	B	220	220	220	220	220	225	245	315	335
S BARS	LENGTH	360	360	360	360	360	360	360	460	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 48

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	240	260	300	340	370
	T	280	250	250	260	270	300	330	360	390
	F	500	500	500	500	500	500	500	600	600
QUANTITIES	STEEL	526.7	510.8	509.1	514.1	504.2	476.6	491.1	486.8	490.6
	CONC.	3.6	3.5	3.5	3.5	3.7	3.9	4.3	5.0	5.3
FOOTING REACTION *	V ULS	227.9	199.1	208.9	231.4	259.3	290.5	362.9	440.6	521.9
	V SLS	145.7	137	150.8	172.6	197.4	225.5	285.4	349.3	415.1
	H ULS	83.5	85.3	89.7	96	103.1	110.4	125.2	140.3	155.1
	V	77	96	123	150	180	211	274	342	406
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	175	200	200	200	175	200	175	175	150
	LENGTH	4220	4220	4220	4220	4240	4260	4300	4340	4370
H BARS	C/C	-	-	-	400	425	450	300	300	450
	LENGTH	-	-	-	1320	1760	1780	2280	2360	2160
J BARS	SIZE	20	20	20	25	25	25	20	20	25
	C/C	300	300	300	400	425	450	300	300	450
	LENGTH	5390	5340	5340	4550	4350	4380	4190	4210	4350
	B	2560	2560	2560	1750	1540	1520	1280	1250	1350
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	210	180	180	190	200	230	260	290	320
K BARS	SIZE	20	20	20	25	25	25	20	20	25
	C/C	300	300	300	400	425	450	300	300	450
	LENGTH	4660	4210	4100	3780	3580	3610	3660	3720	3670
	B	1830	1430	1320	980	770	750	750	760	670
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	210	180	180	190	200	230	260	290	320
U BARS	LENGTH	1130	1040	1040	1070	1130	1240	1380	1520	1650
	C	770	680	680	710	770	880	1020	1160	1290
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	175	175	175	175	175	200	225	250	250
	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
R BARS	# SETS	68	68	68	68	68	68	70	67	69
V BARS	LENGTH	2000	2000	2000	2000	2010	2020	2040	2110	2125
	B	220	220	220	220	230	240	260	330	345
S BARS	LENGTH	360	360	360	360	360	360	360	460	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 49

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	220	230	250	270	290	330	370	400
	T	300	260	270	280	290	310	350	380	410
	F	500	500	500	500	500	500	600	600	600
QUANTITIES	STEEL	586.0	593.9	555.0	553.8	562.8	570.7	566.7	559.3	573.3
	CONC.	4.0	3.7	3.9	4.0	4.2	4.5	5.2	5.6	6.0
FOOTING REACTION *	V ULS	232.9	203.1	214.6	241.8	270.6	302.5	375.6	455.9	538.6
	V SLS	150.8	140.3	156.3	181.2	206.6	234.7	296.7	361.9	428.7
	H ULS	101	104.7	111.1	119.6	128.3	137.3	155.9	174.3	192.8
	V	82	100	128	157	188	220	288	353	419
P BARS	SIZE	20	20	15	15	15	20	20	20	20
	C/C	175	200	150	150	150	200	200	175	150
	LENGTH	4230	4220	4230	4250	4270	4290	4330	4370	4400
H BARS	C/C	-	-	-	-	-	-	300	300	300
	LENGTH	-	-	-	-	-	-	1600	2280	2300
J BARS	SIZE	20	25	25	20	20	20	20	20	20
	C/C	300	425	450	300	300	300	300	300	300
	LENGTH	6220	6000	6010	5890	5910	5940	5070	4790	4820
	B	2860	2700	2700	2560	2560	2560	1630	1300	1290
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	230	190	200	210	220	240	280	310	340
K BARS	SIZE	20	25	25	20	20	20	20	20	20
	C/C	300	425	450	300	300	300	300	300	300
	LENGTH	5920	5150	4940	4780	4740	4740	4430	4320	4380
	B	2560	1850	1630	1450	1390	1360	990	830	850
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	230	190	200	210	220	240	280	310	340
U BARS	LENGTH	1200	1070	1110	1170	1220	1310	1480	1620	1750
	C	840	710	750	810	860	950	1120	1260	1390
T BARS	SIZE	20	20	20	20	15	15	15	15	15
	C/C	200	175	200	200	150	150	150	175	175
	LENGTH	3000	3000	3000	3000	3000	3000	3000	3000	3000
R BARS	# SETS	72	74	74	74	74	74	73	75	75
V BARS	LENGTH	2005	2000	2005	2015	2025	2035	2105	2125	2140
	B	225	220	225	235	245	255	325	345	360
S BARS	LENGTH	360	360	360	360	360	360	460	460	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 50

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	250	260	280	300	320	360	400	430
	T	320	270	280	290	310	330	370	400	430
	F	500	500	500	500	500	600	600	600	700
QUANTITIES	STEEL	643.2	648.8	635.4	609.4	620.2	626.2	613.0	620.0	636.2
	CONC.	4.5	4.2	4.4	4.6	4.8	5.3	5.8	6.3	7.0
FOOTING REACTION *	V ULS	240.4	213	225.2	253.1	282.7	315.5	390.1	472	556.1
	V SLS	157.3	147.9	164.3	189.8	216.7	245.4	308.6	375.2	443.2
	H ULS	121.8	127.4	135	145	155.2	165.8	187.7	209.5	231.2
	V	88	106	136	166	197	232	298	365	435
P BARS	SIZE	20	15	15	15	15	15	15	20	20
	C/C	200	150	175	175	150	150	150	200	175
	LENGTH	4250	4250	4260	4280	4300	4320	4360	4400	4430
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	20	20	20	20	20	20	20	20	25
	C/C	300	300	300	300	300	300	300	300	450
	LENGTH	6750	6610	6390	6410	6440	6470	6530	6580	6770
	B	2860	2800	2560	2560	2560	2560	2560	2560	2700
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	250	200	210	220	240	260	300	330	360
K BARS	SIZE	20	20	20	20	20	20	20	20	25
	C/C	300	300	300	300	300	300	300	300	450
	LENGTH	6450	6020	5740	5550	5500	5490	5480	5520	5580
	B	2560	2210	1910	1700	1620	1580	1510	1500	1510
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	250	200	210	220	240	260	300	330	360
U BARS	LENGTH	1280	1140	1180	1240	1320	1410	1580	1720	1850
	C	920	780	820	880	960	1050	1220	1360	1490
T BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	175	150	150	175	175	175	200	200	200
	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
R BARS	# SETS	82	80	80	80	82	82	83	81	81
V BARS	LENGTH	2015	2015	2020	2030	2040	2100	2120	2140	2205
	B	235	235	240	250	260	320	340	360	425
S BARS	LENGTH	360	360	360	360	360	460	460	460	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 51

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	290	310	330	350	390	420	460
	T	340	290	290	300	310	330	380	410	450
	F	500	500	500	600	600	600	600	700	700
QUANTITIES	STEEL	687.9	674.9	678.1	686.6	694.3	696.2	700.4	731.4	746.4
	CONC.	5.2	4.9	4.9	5.4	5.6	5.9	6.5	7.2	7.8
FOOTING REACTION *	V ULS	251.2	223.8	235.7	264.3	293.9	327.5	404.5	485	574.6
	V SLS	166.8	158.3	173.1	199.2	226	255.3	320.5	385.9	458.4
	H ULS	146.7	151.9	161.4	172.9	185.1	197.1	221.7	245.8	270.8
	V	97	116	143	177	208	241	309	378	449
P BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	150	175	200	200	175	175	175	150	200
	LENGTH	4290	4290	4290	4310	4330	4350	4390	4420	4460
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	20	20	20	20	25	25	25	25	25
	C/C	325	325	300	300	450	450	450	425	425
	LENGTH	7280	7210	7130	6920	7080	7110	7190	7230	7300
	B	2860	2860	2780	2560	2700	2700	2700	2700	2700
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	270	220	220	230	240	260	310	340	380
K BARS	SIZE	20	20	20	20	25	25	25	25	25
	C/C	325	325	300	300	450	450	450	425	425
	LENGTH	6980	6910	6570	6300	6160	6150	6200	6260	6340
	B	2560	2560	2220	1940	1780	1740	1710	1730	1740
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	270	220	220	230	240	260	310	340	380
U BARS	LENGTH	1390	1250	1250	1310	1370	1450	1650	1780	1950
	C	1030	890	890	950	1010	1090	1290	1420	1590
T BARS	SIZE	20	20	25	20	20	20	20	20	20
	C/C	150	150	225	150	150	150	150	150	150
	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
R BARS	# SETS	90	88	88	90	90	90	89	89	91
V BARS	LENGTH	2035	2035	2035	2095	2105	2115	2135	2200	2220
	B	255	255	255	315	325	335	355	420	440
S BARS	LENGTH	360	360	360	460	460	460	460	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 52

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	220	240	280	330	380
	T	280	260	260	270	280	300	340	380	410
	F	500	500	500	500	500	500	500	600	600
QUANTITIES	STEEL	476.3	411.1	425.4	449.0	462.0	447.0	469.1	470.7	501.3
	CONC.	3.4	3.3	3.3	3.4	3.4	3.6	4.0	4.7	5.1
FOOTING REACTION *	V ULS	233	211.4	222.7	248.5	276.9	311.1	387.8	475.6	568.2
	V SLS	148.3	144.5	161.1	184.7	210.6	240	305.2	376.6	451.7
	H ULS	56.6	55.6	57.2	60.2	63.7	67.4	74	80.3	85.2
	V	78	101	130	161	191	224	292	368	442
P BARS	SIZE	25	20	20	20	20	20	25	25	25
	C/C	225	175	175	150	150	150	225	225	225
	LENGTH	4720	4720	4720	4720	4720	4740	4780	4830	4880
H BARS	C/C	-	425	375	350	325	350	350	375	350
	LENGTH	-	2220	2480	2540	2540	2580	2600	2660	2720
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	375	350	325	350	350	375	350
	LENGTH	5030	3600	3470	3440	3450	3460	3510	3560	3590
	B	2950	1550	1420	1380	1370	1350	1340	1320	1310
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	210	190	190	200	210	230	270	310	340
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	375	350	325	350	350	375	350
	LENGTH	3520	2830	2700	2680	2680	2690	2780	2880	2940
	B	1440	780	650	620	600	580	610	640	660
	D	1750	1750	1750	1750	1750	1750	1750	1750	1750
	R	210	190	190	200	210	230	270	310	340
U BARS	LENGTH	1130	1070	1070	1100	1130	1210	1380	1560	1720
	C	770	710	710	740	770	850	1020	1200	1360
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	350	400	450	450	450	450	400	350	300
	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
R BARS	# SETS	59	61	61	61	59	58	60	60	62
V BARS	LENGTH	2000	2000	2000	2000	2000	2010	2030	2105	2130
	B	220	220	220	220	220	230	250	325	350
S BARS	LENGTH	360	360	360	360	360	360	360	460	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 53

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	220	250	290	340	390
	T	280	260	260	270	280	310	350	380	410
	F	500	500	500	500	500	500	500	600	600
QUANTITIES	STEEL	508.7	450.6	455.7	475.8	500.7	464.8	470.3	490.5	492.6
	CONC.	3.5	3.4	3.4	3.5	3.5	3.8	4.3	4.9	5.3
FOOTING REACTION *	V ULS	234.6	213	225.3	250.1	279.4	315.7	393.1	480.5	573.8
	V SLS	149.7	145.8	162.4	186	212	243.8	309.5	380.6	456.2
	H ULS	65	64.7	67.3	71.2	75.8	80.4	89.5	98	105.7
	V	80	102	131	162	192	227	297	371	445
P BARS	SIZE	25	20	20	20	25	25	20	25	25
	C/C	225	150	150	150	225	225	150	225	225
	LENGTH	4720	4720	4720	4720	4720	4750	4790	4840	4890
H BARS	C/C	-	425	400	350	325	375	375	375	375
	LENGTH	-	2120	2260	2500	2520	2540	2580	2660	2720
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	400	350	325	375	375	375	375
	LENGTH	5280	3900	3830	3710	3710	3750	3790	3820	3850
	B	2950	1600	1530	1400	1380	1370	1350	1330	1320
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	210	190	190	200	210	240	280	310	340
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	400	350	325	375	375	375	375
	LENGTH	3860	3130	3060	2950	2940	2990	3070	3140	3190
	B	1530	830	760	640	610	610	630	650	660
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	210	190	190	200	210	240	280	310	340
U BARS	LENGTH	1130	1070	1070	1100	1130	1250	1420	1580	1730
	C	770	710	710	740	770	890	1060	1220	1370
T BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	275	300	325	350	350	425	450	450	450
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	63	63	63	63	63	62	64	66	64
V BARS	LENGTH	2000	2000	2000	2000	2000	2015	2035	2110	2135
	B	220	220	220	220	220	235	255	330	355
S BARS	LENGTH	360	360	360	360	360	360	360	460	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 54

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	250	270	320	360	400
	T	290	260	260	270	290	320	360	400	430
	F	500	500	500	500	500	500	600	600	600
QUANTITIES	STEEL	580.3	572.0	549.1	577.5	535.4	518.5	496.6	509.5	534.6
	CONC.	3.8	3.7	3.7	3.7	4.0	4.3	5.0	5.5	5.9
FOOTING REACTION *	V ULS	237.8	216.3	228.5	253.4	287.3	324.4	406.3	492.8	584.7
	V SLS	153.1	148.5	165.1	188.7	220	250.9	319.6	390.8	465.2
	H ULS	82.7	83.6	87.9	93.4	99.9	106.6	120	133.3	146.4
	V	83	105	135	165	200	235	308	381	454
P BARS	SIZE	20	20	20	20	20	20	20	25	25
	C/C	150	150	150	150	150	150	150	225	225
	LENGTH	4720	4720	4720	4720	4750	4770	4820	4860	4900
H BARS	C/C	-	-	375	325	375	400	425	425	400
	LENGTH	-	-	1720	2140	2240	2240	2560	2580	2640
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	400	375	325	375	400	425	425	400
	LENGTH	5800	5750	4600	4390	4390	4420	4340	4390	4420
	B	2950	2950	1800	1580	1540	1530	1380	1370	1350
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	220	190	190	200	220	250	290	330	360
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	400	375	325	375	400	425	425	400
	LENGTH	4640	4310	3830	3630	3620	3670	3630	3720	3780
	B	1790	1510	1030	820	770	780	670	700	710
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	220	190	190	200	220	250	290	330	360
U BARS	LENGTH	1150	1070	1070	1100	1200	1310	1490	1660	1800
	C	790	710	710	740	840	950	1130	1300	1440
T BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	175	175	200	200	225	250	300	325	350
	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
R BARS	# SETS	71	71	71	71	71	72	70	72	72
V BARS	LENGTH	2000	2000	2000	2000	2015	2025	2100	2120	2140
	B	220	220	220	220	235	245	320	340	360
S BARS	LENGTH	360	360	360	360	360	360	460	460	460
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 55

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	220	240	260	280	310	350	390	420
	T	300	270	270	290	310	340	370	410	450
	F	500	500	500	500	500	600	600	600	700
QUANTITIES	STEEL	640.7	645.2	620.4	605.8	566.1	555.4	556.6	565.3	590.8
	CONC.	4.2	3.9	4.1	4.3	4.5	5.2	5.6	6.1	6.8
FOOTING REACTION *	V ULS	242	220.4	234.3	264	300.7	338.9	419.4	507.3	599
	V SLS	157.6	152	171.4	199	229.5	262.9	330.3	402.7	477
	H ULS	101.2	103.2	109.6	117.2	125.8	134.3	151.5	168.6	185.6
	V	87	108	140	174	207	248	318	392	468
P BARS	SIZE	20	20	20	20	20	20	20	20	25
	C/C	150	150	175	175	175	175	150	150	225
	LENGTH	4730	4720	4740	4760	4780	4810	4850	4890	4920
H BARS	C/C	-	-	-	-	425	450	450	450	425
	LENGTH	-	-	-	-	1760	2180	2280	2320	2560
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	375	400	425	425	450	450	450	425
	LENGTH	6510	6260	6260	6300	5170	5000	5010	5050	4990
	B	3150	2950	2950	2950	1790	1580	1540	1520	1390
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	230	200	200	220	240	270	300	340	380
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	375	400	425	425	450	450	450	425
	LENGTH	5750	5140	4880	4810	4410	4270	4310	4390	4380
	B	2390	1830	1570	1460	1030	850	840	860	780
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	230	200	200	220	240	270	300	340	380
U BARS	LENGTH	1200	1100	1130	1210	1290	1420	1560	1730	1890
	C	840	740	770	850	930	1060	1200	1370	1530
T BARS	SIZE	20	20	15	15	15	15	15	15	15
	C/C	200	200	150	150	175	175	200	200	200
	LENGTH	3000	3000	3000	3000	3000	3000	3000	3000	3000
R BARS	# SETS	74	77	77	77	76	76	76	78	77
V BARS	LENGTH	2005	2000	2010	2020	2030	2095	2115	2135	2200
	B	225	220	230	240	250	315	335	355	420
S BARS	LENGTH	360	360	360	360	360	460	460	460	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 56

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	260	270	290	310	340	380	420	460
	T	320	290	300	310	330	360	390	430	460
	F	500	500	500	500	600	600	600	700	700
QUANTITIES	STEEL	687.6	641.7	638.8	638.6	625.4	636.4	639.4	633.5	664.6
	CONC.	4.7	4.6	4.7	4.9	5.4	5.8	6.3	7.1	7.6
FOOTING REACTION *	V ULS	249.7	230.5	247.8	277.4	313.1	352.3	434.5	523.9	619
	V SLS	164.2	161.7	181.1	208.6	239.8	274	342.7	416.4	493.4
	H ULS	122.3	126	134	143.5	153.2	163.4	184.1	204.8	225.7
	V	93	117	149	182	220	258	330	407	483
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	200	200	200	200	200	175	175	150
	LENGTH	4750	4760	4770	4790	4810	4840	4880	4920	4960
H BARS	C/C	-	-	-	-	-	-	300	450	425
	LENGTH	-	-	-	-	-	-	1660	2220	2300
J BARS	SIZE	25	20	25	20	20	20	20	25	25
	C/C	450	300	450	300	300	300	300	450	425
	LENGTH	7210	6660	6810	6690	6720	6770	5860	5650	5660
	B	3320	2810	2950	2810	2810	2810	1860	1580	1550
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	250	220	230	240	260	290	320	360	390
K BARS	SIZE	25	20	25	20	20	20	20	25	25
	C/C	450	300	450	300	300	300	300	450	425
	LENGTH	6840	5990	5670	5520	5490	5510	5130	5010	5050
	B	2950	2140	1810	1640	1580	1550	1130	940	940
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	250	220	230	240	260	290	320	360	390
U BARS	LENGTH	1280	1210	1250	1310	1390	1520	1660	1830	1970
	C	920	850	890	950	1030	1160	1300	1470	1610
T BARS	SIZE	20	20	20	20	20	15	15	15	15
	C/C	175	175	175	175	200	150	150	150	150
	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
R BARS	# SETS	84	83	82	84	84	84	86	84	85
V BARS	LENGTH	2015	2020	2025	2035	2095	2110	2130	2200	2220
	B	235	240	245	255	315	330	350	420	440
S BARS	LENGTH	360	360	360	360	460	460	460	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 57

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	300	320	340	370	410	450	500
	T	350	310	310	330	350	370	410	450	480
	F	500	500	500	600	600	600	700	700	700
QUANTITIES	STEEL	730.4	724.2	708.1	712.6	710.8	719.5	705.9	738.8	762.4
	CONC.	5.4	5.2	5.3	5.8	6.1	6.5	7.3	7.9	8.6
FOOTING REACTION *	V ULS	262.3	241.5	258.6	290	326.5	365.6	449.3	541.4	641.4
	V SLS	175	171	190.1	219	250.9	285	355.9	430.8	511.9
	H ULS	146.6	150.7	160.5	171	182.2	194.5	218.6	242.1	267.1
	V	103	125	157	195	230	268	345	421	501
P BARS	SIZE	20	15	15	15	15	15	20	20	20
	C/C	200	150	150	150	150	150	200	175	175
	LENGTH	4790	4790	4800	4820	4840	4870	4910	4950	5000
H BARS	C/C	-	-	-	-	-	-	-	-	-
	LENGTH	-	-	-	-	-	-	-	-	-
J BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	300	300	300	300	300	450	450	425	400
	LENGTH	7550	7490	7190	7220	7250	7420	7480	7550	7590
	B	3110	3110	2810	2810	2810	2950	2950	2950	2950
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	280	240	240	260	280	300	340	380	410
K BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	300	300	300	300	300	450	450	425	400
	LENGTH	7250	7190	6430	6310	6260	6200	6190	6280	6290
	B	2810	2810	2050	1900	1820	1730	1660	1680	1650
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	280	240	240	260	280	300	340	380	410
U BARS	LENGTH	1420	1310	1320	1410	1490	1590	1760	1930	2090
	C	1060	950	960	1050	1130	1230	1400	1570	1730
T BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	150	150	150	150	150	175	175	175
	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
R BARS	# SETS	90	92	92	92	90	92	92	93	93
V BARS	LENGTH	2035	2035	2040	2100	2110	2125	2195	2215	2240
	B	255	255	260	320	330	345	415	435	460
S BARS	LENGTH	360	360	360	460	460	460	560	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 58

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	240	270	330	380	420
	T	300	270	270	290	310	330	380	410	450
	F	500	500	500	500	500	500	600	600	700
QUANTITIES	STEEL	569.7	501.0	515.5	530.9	543.0	536.9	519.4	541.7	566.9
	CONC.	3.8	3.6	3.6	3.7	4.0	4.2	5.1	5.5	6.2
FOOTING REACTION *	V ULS	249.5	228.6	244	271.4	308.9	350.8	437.2	536.7	636.8
	V SLS	159.7	157.6	176.4	203.1	235.8	270.9	346.5	425.2	506.5
	H ULS	63.5	62.8	64.5	67.8	71.3	74.7	81	86.1	92.1
	V	87	110	143	177	214	252	335	413	497
P BARS	SIZE	25	20	25	25	25	25	25	25	25
	C/C	200	150	225	225	200	200	225	225	200
	LENGTH	5220	5220	5220	5220	5240	5270	5330	5380	5420
H BARS	C/C	-	350	325	300	300	325	350	325	325
	LENGTH	-	2600	2880	2920	2960	3020	3100	3140	3160
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	350	350	325	300	300	325	350	325	325
	LENGTH	5560	3910	3770	3770	3780	3790	3840	3880	3940
	B	3200	1600	1460	1420	1400	1380	1350	1350	1340
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	230	200	200	220	240	260	310	340	380
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	350	350	325	300	300	325	350	325	325
	LENGTH	3940	3140	3000	3000	3020	3050	3150	3220	3320
	B	1580	830	690	650	640	640	660	690	720
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	230	200	200	220	240	260	310	340	380
U BARS	LENGTH	1180	1100	1100	1150	1240	1340	1560	1720	1890
	C	820	740	740	790	880	980	1200	1360	1530
T BARS	SIZE	15	15	15	15	15	20	20	20	20
	C/C	300	325	375	425	450	450	450	450	450
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	66	66	66	66	66	68	68	67	69
V BARS	LENGTH	2000	2000	2000	2000	2010	2025	2105	2130	2200
	B	220	220	220	220	230	245	325	350	420
S BARS	LENGTH	360	360	360	360	360	360	460	460	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 59

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00
HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	220	240	260	290	320	360	410	450
	T	310	280	290	310	330	350	390	430	460
	F	500	500	500	500	500	600	600	700	700
QUANTITIES	STEEL	658.0	597.3	577.8	565.9	536.6	531.2	537.5	572.3	592.3
	CONC.	4.1	3.9	4.1	4.3	4.6	5.1	5.6	6.4	6.9
FOOTING REACTION *	V ULS	255.3	233.8	252.3	284.4	324.7	366.9	452.3	552.4	652.9
	V SLS	164.4	161.1	183.2	213.1	248	284.1	357.1	438.2	519.7
	H ULS	81.6	81.8	85.9	90.9	96.4	101.8	112.9	123.9	134.4
	V	91	114	150	186	224	266	344	428	509
P BARS	SIZE	25	25	25	20	20	20	20	25	25
	C/C	200	225	225	150	150	150	150	225	200
	LENGTH	5230	5220	5240	5260	5290	5320	5360	5410	5450
H BARS	C/C	-	350	350	350	375	375	375	350	350
	LENGTH	-	1740	2560	2640	2960	3020	3080	3120	3180
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	350	350	350	350	375	375	375	350	350
	LENGTH	6080	4850	4470	4460	4340	4350	4380	4440	4460
	B	3200	2020	1620	1580	1430	1410	1380	1370	1350
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	240	210	220	240	260	280	320	360	390
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	350	350	350	350	375	375	375	350	350
	LENGTH	4690	3990	3700	3700	3600	3630	3710	3800	3860
	B	1810	1160	850	820	690	690	710	730	750
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	240	210	220	240	260	280	320	360	390
U BARS	LENGTH	1220	1130	1180	1270	1370	1460	1630	1820	1960
	C	860	770	820	910	1010	1100	1270	1460	1600
T BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	175	200	225	250	300	350	450	450	450
	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
R BARS	# SETS	74	74	74	76	76	74	76	75	77
V BARS	LENGTH	2005	2000	2010	2020	2035	2100	2120	2195	2215
	B	225	220	230	240	255	320	340	415	435
S BARS	LENGTH	360	360	360	360	360	460	460	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 60

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	230	240	260	300	330	370	420	460
	T	320	280	290	310	340	360	400	450	480
	F	500	500	500	500	500	600	600	700	700
QUANTITIES	STEEL	704.2	701.6	689.1	645.4	592.1	573.7	592.0	612.1	626.6
	CONC.	4.4	4.2	4.3	4.6	5.0	5.6	6.1	7.0	7.5
FOOTING REACTION *	V ULS	257.1	237.1	255.8	288.2	332.1	374.8	462.3	563.6	665.1
	V SLS	168.1	165	186.2	216.3	254.1	290.7	364.5	447.4	529.8
	H ULS	100	102.1	108	115	122.9	130.7	146.1	161.6	176.9
	V	94	117	152	189	230	273	351	436	518
P BARS	SIZE	25	25	20	25	20	20	25	25	25
	C/C	200	225	150	225	150	150	225	225	225
	LENGTH	5230	5230	5240	5260	5300	5330	5370	5420	5460
H BARS	C/C	-	-	-	350	400	425	400	375	375
	LENGTH	-	-	-	2480	2600	2680	3000	3040	3080
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	350	350	350	400	425	400	375	375
	LENGTH	6590	6530	6550	5040	5030	5040	4940	5000	5030
	B	3200	3200	3200	1660	1610	1580	1420	1400	1390
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	250	210	220	240	270	290	330	380	410
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	350	350	350	400	425	400	375	375
	LENGTH	5730	5110	4900	4280	4300	4330	4280	4390	4440
	B	2340	1780	1550	900	880	870	760	790	800
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	250	210	220	240	270	290	330	380	410
U BARS	LENGTH	1250	1140	1180	1270	1410	1510	1680	1890	2030
	C	890	780	820	910	1050	1150	1320	1530	1670
T BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	150	150	150	175	200	225	250	275	300
	LENGTH	3000	3000	3000	3000	3000	3000	3000	3000	3000
R BARS	# SETS	78	80	80	80	80	80	81	81	81
V BARS	LENGTH	2005	2005	2010	2020	2040	2105	2125	2200	2220
	B	225	225	230	240	260	325	345	420	440
S BARS	LENGTH	360	360	360	360	360	460	460	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 61

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	260	280	300	330	350	410	450	490
	T	340	300	310	340	350	380	420	460	500
	F	500	500	500	500	600	600	700	700	700
QUANTITIES	STEEL	758.4	713.1	676.8	666.5	654.5	666.6	651.2	660.1	672.7
	CONC.	4.9	4.8	5.0	5.3	5.9	6.2	7.2	7.8	8.4
FOOTING REACTION *	V ULS	266.1	247.3	266.8	303.1	343.9	386.4	480.4	576.7	680.7
	V SLS	175.5	173.7	196.8	228.5	263.9	300.3	379.4	460.6	545.3
	H ULS	121.3	125.1	132.4	141.2	151.1	160.2	179.9	199	218.3
	V	101	125	162	200	242	281	368	449	533
P BARS	SIZE	25	20	20	20	20	20	20	20	25
	C/C	225	150	150	175	175	150	150	150	225
	LENGTH	5250	5260	5280	5300	5330	5350	5410	5450	5490
H BARS	C/C	-	-	-	-	425	425	425	425	400
	LENGTH	-	-	-	-	1960	2540	2700	2740	3040
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	400	425	425	425	425	425	425	400
	LENGTH	7490	7060	7080	7120	5890	5640	5640	5680	5600
	B	3570	3200	3200	3200	1950	1650	1590	1570	1420
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	270	230	240	270	280	310	350	390	430
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	400	425	425	425	425	425	425	400
	LENGTH	7120	5900	5640	5580	5090	4950	4990	5070	5030
	B	3200	2040	1760	1660	1150	960	940	960	850
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	270	230	240	270	280	310	350	390	430
U BARS	LENGTH	1340	1240	1290	1410	1480	1590	1790	1960	2130
	C	980	880	930	1050	1120	1230	1430	1600	1770
T BARS	SIZE	20	20	20	20	15	15	15	15	15
	C/C	175	175	200	200	150	150	175	175	200
	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
R BARS	# SETS	88	86	88	88	88	90	87	89	89
V BARS	LENGTH	2015	2020	2030	2040	2105	2115	2195	2215	2235
	B	235	240	250	260	325	335	415	435	455
S BARS	LENGTH	360	360	360	360	460	460	560	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 62

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	300	310	330	360	380	440	480	520
	T	360	330	330	350	370	400	440	480	520
	F	500	500	600	600	600	600	700	700	800
QUANTITIES	STEEL	783.6	746.4	740.2	719.1	723.7	725.8	711.4	738.1	747.8
	CONC.	5.7	5.6	5.9	6.2	6.6	6.9	8.0	8.6	9.5
FOOTING REACTION *	V ULS	279.5	261.3	280.6	314.9	357.8	401.1	497	597.7	703.6
	V SLS	186.4	185.4	206.8	238.3	275.3	312.4	393	475.5	561.5
	H ULS	146.3	150.2	159.4	169.4	180.7	191.4	214.9	237.7	260.6
	V	110	136	174	212	253	292	380	463	551
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	175	200	175	175	175	175	150	150
	LENGTH	5290	5300	5310	5330	5360	5380	5440	5480	5520
H BARS	C/C	-	-	-	-	-	-	425	400	400
	LENGTH	-	-	-	-	-	-	1800	2640	2680
J BARS	SIZE	25	20	25	25	25	25	25	25	25
	C/C	450	300	450	450	450	450	425	400	400
	LENGTH	8030	7470	7610	7640	7670	7720	6630	6270	6320
	B	3570	3060	3200	3200	3200	3200	2050	1630	1610
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	290	260	260	280	300	330	370	410	450
K BARS	SIZE	25	20	25	25	25	25	25	25	25
	C/C	450	300	450	450	450	450	425	400	400
	LENGTH	7660	6810	6380	6280	6210	6260	5830	5680	5770
	B	3200	2400	1970	1840	1740	1740	1250	1040	1060
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	290	260	260	280	300	330	370	410	450
U BARS	LENGTH	1450	1380	1390	1480	1580	1690	1890	2060	2230
	C	1090	1020	1030	1120	1220	1330	1530	1700	1870
T BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	150	150	175	175	175	200	200	200
	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
R BARS	# SETS	94	96	96	94	96	95	97	97	97
V BARS	LENGTH	2035	2040	2095	2105	2120	2130	2210	2230	2300
	B	255	260	315	325	340	350	430	450	520
S BARS	LENGTH	360	360	460	460	460	460	560	560	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 63

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	260	260	280	310	360	410	480
	T	320	280	300	320	350	370	410	450	490
	F	500	500	500	500	500	600	600	700	700
QUANTITIES	STEEL	606.6	571.3	581.5	586.8	556.3	596.4	583.3	618.9	639.5
	CONC.	4.1	3.8	4.1	4.3	4.6	5.1	5.6	6.4	7.0
FOOTING REACTION *	V ULS	267.2	246.4	265.8	303.4	343.6	392.3	486.4	592.3	710.6
	V SLS	171.6	169.4	196.3	227.1	263.4	303.3	382.8	469.4	564.3
	H ULS	61.9	60.5	61.5	63	65.2	67.1	70.5	73.3	93.4
	V	94	119	159	198	239	283	368	458	551
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	175	200	200	200	225	200	200	200	200
	LENGTH	5720	5720	5760	5760	5780	5810	5860	5910	5980
H BARS	C/C	300	300	300	300	325	300	325	300	300
	LENGTH	2660	3040	3440	3400	3420	3480	3520	3580	3660
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	300	325	300	325	300	300
	LENGTH	4160	3950	3800	3830	3860	3870	3920	3970	4020
	B	1770	1620	1440	1440	1420	1400	1390	1370	1360
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	250	210	230	250	280	300	340	380	420
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	300	325	300	325	300	300
	LENGTH	3420	3210	3060	3100	3140	3170	3260	3350	3440
	B	1030	880	700	710	700	700	730	750	780
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	250	210	230	250	280	300	340	380	420
U BARS	LENGTH	1240	1130	1240	1290	1410	1510	1690	1870	2090
	C	880	770	880	930	1050	1150	1330	1510	1730
T BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	325	400	300	300	300	300	300	300	250
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	70	70	70	72	71	71	71	73	73
V BARS	LENGTH	2000	2000	2020	2020	2030	2095	2120	2195	2230
	B	220	220	240	240	250	315	340	415	450
S BARS	LENGTH	360	360	360	360	360	460	460	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 64

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50
HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	230	230	260	300	320	370	430	480
	T	320	290	300	330	360	380	420	460	500
	F	500	500	500	500	500	600	600	700	700
QUANTITIES	STEEL	734.9	653.2	643.4	606.2	584.4	587.2	616.6	630.7	664.0
	CONC.	4.4	4.2	4.2	4.6	5.0	5.5	6.1	7.0	7.6
FOOTING REACTION *	V ULS	271.9	252.1	269.1	307.3	352.6	400	495.2	606	717.6
	V SLS	175.5	174.2	195.7	231.2	270.7	309.7	390.1	479.7	571.3
	H ULS	80.6	80.4	83.2	87.5	91.9	96.7	105.7	114	121.5
	V	97	123	160	202	245	289	375	468	558
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	175	200	200	200	225	200	200	200	200
	LENGTH	5730	5730	5730	5760	5800	5820	5870	5930	5980
H BARS	C/C	-	300	300	325	325	350	325	325	300
	LENGTH	-	2860	2980	3320	3380	3420	3500	3580	3620
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	325	325	350	325	325	300
	LENGTH	6340	4560	4500	4380	4410	4420	4450	4490	4550
	B	3450	1710	1640	1470	1450	1430	1400	1380	1370
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	250	220	230	260	290	310	350	390	430
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	325	325	350	325	325	300
	LENGTH	4720	3820	3760	3640	3700	3730	3800	3890	3980
	B	1830	970	900	730	740	740	750	780	800
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	250	220	230	260	290	310	350	390	430
U BARS	LENGTH	1250	1170	1200	1320	1460	1550	1730	1930	2120
	C	890	810	840	960	1100	1190	1370	1570	1760
T BARS	SIZE	15	15	15	15	15	20	20	20	20
	C/C	200	225	250	325	400	450	450	450	400
	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
R BARS	# SETS	78	78	78	80	77	77	79	81	78
V BARS	LENGTH	2005	2005	2005	2020	2040	2100	2125	2205	2230
	B	225	225	225	240	260	320	345	425	450
S BARS	LENGTH	360	360	360	360	360	460	460	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 65

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50
HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	230	260	290	320	350	400	440	500
	T	340	290	320	340	370	390	440	480	520
	F	500	500	500	500	600	600	600	700	700
QUANTITIES	STEEL	776.1	789.0	699.9	653.8	640.9	616.8	613.1	663.7	686.9
	CONC.	4.7	4.4	4.8	5.1	5.8	6.1	6.8	7.6	8.3
FOOTING REACTION *	V ULS	276.5	255.5	279.7	318.9	363.2	412.3	506.8	616.4	733.4
	V SLS	180.1	177	204.5	239.9	278.6	319.8	402.6	489.3	584.4
	H ULS	99.6	101.3	106.3	112.7	119.3	126.1	139.8	153.4	166.1
	V	101	126	168	209	256	298	386	476	570
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	200	200	225	225	225	225	200	200
	LENGTH	5730	5730	5760	5790	5820	5850	5900	5940	6000
H BARS	C/C	-	-	325	350	350	375	375	350	325
	LENGTH	-	-	2840	3000	3060	3400	3480	3500	3580
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	325	300	325	350	350	375	375	350	325
	LENGTH	6870	6800	5110	5070	5090	4960	5000	5050	5100
	B	3450	3450	1720	1650	1620	1460	1420	1410	1390
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	270	220	250	270	300	320	370	410	450
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	325	300	325	350	350	375	375	350	325
	LENGTH	5640	5110	4370	4340	4390	4280	4370	4460	4550
	B	2220	1760	980	920	920	780	790	820	840
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	270	220	250	270	300	320	370	410	450
U BARS	LENGTH	1310	1170	1290	1390	1520	1620	1830	2000	2200
	C	950	810	930	1030	1160	1260	1470	1640	1840
T BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	150	150	175	200	250	275	325	350	400
	LENGTH	3000	3000	3000	3000	3000	3000	3000	3000	3000
R BARS	# SETS	84	84	84	84	83	85	85	85	86
V BARS	LENGTH	2005	2005	2020	2035	2100	2115	2140	2210	2240
	B	225	225	240	255	320	335	360	430	460
S BARS	LENGTH	360	360	360	360	460	460	460	560	560
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 66

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50
HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	260	280	310	340	370	430	470	530
	T	360	310	330	360	380	400	450	500	540
	F	500	500	500	600	600	600	700	700	800
QUANTITIES	STEEL	785.5	788.6	735.1	709.9	677.2	676.9	700.3	707.2	732.5
	CONC.	5.2	5.0	5.3	5.9	6.3	6.7	7.8	8.4	9.5
FOOTING REACTION *	V ULS	284	265.9	288.2	329.4	373.4	423.2	525.3	634.1	753
	V SLS	187.7	185.7	211.6	248.6	287	328.8	414.9	503.9	600.5
	H ULS	120.2	124.6	130.8	138.9	147.8	156.7	174.5	192.2	209.6
	V	108	134	175	220	263	307	401	489	588
P BARS	SIZE	25	25	20	20	20	20	25	25	25
	C/C	200	225	150	150	150	150	225	200	200
	LENGTH	5750	5760	5780	5810	5840	5870	5930	5970	6030
H BARS	C/C	-	-	-	375	400	400	375	375	350
	LENGTH	-	-	-	2820	2960	3060	3420	3440	3540
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	350	375	375	400	400	375	375	350
	LENGTH	7580	7330	7360	5700	5670	5660	5570	5630	5660
	B	3620	3450	3450	1740	1680	1640	1470	1450	1420
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	290	240	260	290	310	330	380	430	470
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	350	375	375	400	400	375	375	350
	LENGTH	6880	5840	5660	4990	4980	5000	4950	5060	5130
	B	2920	1960	1750	1030	990	980	850	880	890
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	290	240	260	290	310	330	380	430	470
U BARS	LENGTH	1390	1270	1350	1480	1580	1680	1900	2100	2300
	C	1030	910	990	1120	1220	1320	1540	1740	1940
T BARS	SIZE	20	20	20	15	15	15	15	15	15
	C/C	200	175	200	150	175	175	200	225	250
	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
R BARS	# SETS	91	92	92	91	93	91	93	92	94
V BARS	LENGTH	2015	2020	2030	2095	2110	2125	2205	2225	2305
	B	235	240	250	315	330	345	425	445	525
S BARS	LENGTH	360	360	360	460	460	460	560	560	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 67

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	300	320	350	370	400	460	510	560
	T	380	340	350	370	390	420	470	510	550
	F	500	500	600	600	600	600	700	800	800
QUANTITIES	STEEL	798.7	771.9	767.1	746.5	745.8	728.2	760.0	799.4	792.2
	CONC.	6.0	5.8	6.3	6.7	7.0	7.5	8.6	9.6	10.3
FOOTING REACTION *	V ULS	297.8	277.9	300.4	343.6	386.4	438.3	542.4	655.7	773.5
	V SLS	198.9	197.3	223.3	260.4	297.8	341.3	428.9	520.6	616.2
	H ULS	145.3	149.2	157.4	167.9	178	188.6	210.3	231.9	253.4
	V	117	145	188	231	273	319	413	508	602
P BARS	SIZE	20	20	20	20	20	20	20	25	25
	C/C	150	150	150	150	150	150	150	225	200
	LENGTH	5790	5800	5820	5850	5870	5900	5960	6010	6060
H BARS	C/C	-	-	-	-	400	425	400	375	375
	LENGTH	-	-	-	-	1900	2940	3060	3140	3500
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	425	425	425	425	400	425	400	375	375
	LENGTH	8310	7870	7890	7920	6730	6260	6290	6320	6210
	B	3820	3450	3450	3450	2230	1710	1660	1630	1460
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	310	270	280	300	320	350	400	440	480
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	425	425	425	425	400	425	400	375	375
	LENGTH	7940	6710	6420	6270	5810	5610	5690	5760	5690
	B	3450	2290	1980	1800	1310	1060	1060	1070	940
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	310	270	280	300	320	350	400	440	480
U BARS	LENGTH	1510	1410	1460	1560	1650	1780	2000	2190	2370
	C	1150	1050	1100	1200	1290	1420	1640	1830	2010
T BARS	SIZE	20	20	20	20	20	15	15	15	15
	C/C	175	175	175	200	200	150	150	150	175
	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
R BARS	# SETS	97	100	97	97	99	99	101	100	100
V BARS	LENGTH	2035	2040	2100	2115	2125	2140	2220	2295	2320
	B	255	260	320	335	345	360	440	515	540
S BARS	LENGTH	360	360	460	460	460	460	560	660	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 68

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	310	310	310	320	310	340	400	470	550
	T	360	320	340	360	380	400	450	490	540
	F	600	600	600	600	600	600	600	700	800
QUANTITIES	STEEL	600.0	589.7	590.3	592.2	606.2	610.1	618.2	638.9	663.3
	CONC.	5.2	4.9	5.0	5.2	5.3	5.6	6.3	7.2	8.2
FOOTING REACTION *	V ULS	299.1	272.3	298.8	340.3	377.8	429.1	536.5	655.3	786.7
	V SLS	195.6	190.5	218.9	255.6	289.3	332.4	422.4	519.8	626.2
	H ULS	61	57.1	55.8	56	58.3	58.3	74	102.5	135.2
	V	112	140	181	224	264	310	404	505	612
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	225	225	225	225	200	200	200	200	200
	LENGTH	6310	6310	6310	6320	6310	6340	6400	6470	6550
H BARS	C/C	300	300	300	300	300	300	300	300	300
	LENGTH	3420	3780	3800	3840	3860	3900	3960	4060	4160
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	300	300	300	300	300	300
	LENGTH	4150	3940	3940	3950	3940	3960	4020	4060	4120
	B	1690	1550	1520	1490	1450	1440	1420	1400	1380
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	290	250	270	290	310	330	380	420	470
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	300	300	300	300	300	300
	LENGTH	3440	3230	3230	3240	3250	3290	3400	3490	3590
	B	980	840	810	780	760	770	800	830	850
	D	2000	2000	2000	2000	2000	2000	2000	2000	2000
	R	290	250	270	290	310	330	380	420	470
U BARS	LENGTH	1480	1370	1420	1490	1540	1630	1860	2070	2330
	C	1120	1010	1060	1130	1180	1270	1500	1710	1970
T BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	450	450	450	450	450	450	450	400	350
	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
R BARS	# SETS	74	74	74	74	74	74	73	75	77
V BARS	LENGTH	2095	2095	2095	2100	2095	2110	2140	2225	2315
	B	315	315	315	320	315	330	360	445	535
S BARS	LENGTH	460	460	460	460	460	460	460	560	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 69

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	310	310	310	280	310	340	410	460	530
	T	360	320	330	350	380	410	460	500	540
	F	600	600	600	500	600	600	700	700	800
QUANTITIES	STEEL	665.9	637.8	634.4	642.6	624.3	672.9	646.1	699.4	722.9
	CONC.	5.5	5.2	5.3	5.0	5.7	6.0	7.1	7.7	8.7
FOOTING REACTION *	V ULS	305	276.7	302.2	337	382.4	435.3	546	661	789
	V SLS	199.4	194.3	221.7	252.9	293.1	337.6	430.2	524.6	628.3
	H ULS	81.3	78.9	79.9	83.6	87	90.4	95.9	101.6	104.9
	V	116	144	185	220	269	315	415	510	615
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	225	225	200	200	175	200	175	175
	LENGTH	6310	6310	6310	6280	6310	6340	6410	6460	6530
H BARS	C/C	300	300	300	300	325	300	325	300	300
	LENGTH	3160	3540	3780	3780	3840	3880	3960	4020	4100
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	300	325	300	325	300	300
	LENGTH	4780	4560	4450	4430	4450	4470	4530	4580	4630
	B	1820	1670	1540	1490	1460	1440	1420	1400	1390
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	290	250	260	280	310	340	390	430	470
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	300	300	300	300	325	300	325	300	300
	LENGTH	4050	3850	3740	3720	3760	3810	3920	4020	4100
	B	1090	960	830	780	770	780	810	840	860
	D	2500	2500	2500	2500	2500	2500	2500	2500	2500
	R	290	250	260	280	310	340	390	430	470
U BARS	LENGTH	1480	1370	1390	1410	1540	1660	1900	2090	2300
	C	1120	1010	1030	1050	1180	1300	1540	1730	1940
T BARS	SIZE	15	15	20	20	20	20	20	20	20
	C/C	325	375	450	425	450	450	450	400	350
	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
R BARS	# SETS	80	82	82	80	80	82	83	81	83
V BARS	LENGTH	2095	2095	2095	2030	2095	2110	2195	2220	2305
	B	315	315	315	250	315	330	415	440	525
S BARS	LENGTH	460	460	460	360	460	460	560	560	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 70

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	240	240	260	300	330	360	420	480	530
	T	360	310	330	360	390	420	470	510	560
	F	500	500	500	500	600	600	700	700	800
QUANTITIES	STEEL	815.3	772.2	746.6	688.1	680.9	654.4	684.7	717.3	768.6
	CONC.	5.1	4.7	5.0	5.5	6.2	6.6	7.6	8.4	9.4
FOOTING REACTION *	V ULS	297.9	270.5	298.4	346	392.2	445.9	555.8	674.7	799.7
	V SLS	194	188.8	218.6	260.4	301.2	346.4	438.4	535.8	637.2
	H ULS	98.6	99.8	103.9	109.4	115.1	121	132.4	142.9	153.9
	V	110	137	179	226	276	323	422	521	623
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	175	175	175	200	200	200	200	175	175
	LENGTH	6240	6240	6260	6300	6330	6360	6420	6480	6530
H BARS	C/C	-	300	300	325	325	350	325	325	300
	LENGTH	-	2080	3320	3460	3780	3840	3920	4000	4020
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	325	300	300	325	325	350	325	325	300
	LENGTH	7160	5720	5130	5120	5000	5020	5070	5110	5180
	B	3700	2340	1720	1660	1500	1470	1440	1420	1410
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	290	240	260	290	320	350	400	440	490
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	325	300	300	325	325	350	325	325	300
	LENGTH	5660	4730	4420	4410	4320	4370	4470	4550	4670
	B	2200	1350	1010	950	820	820	840	860	900
	D	3000	3000	3000	3000	3000	3000	3000	3000	3000
	R	290	240	260	290	320	350	400	440	490
U BARS	LENGTH	1380	1240	1320	1460	1590	1720	1950	2140	2360
	C	1020	880	960	1100	1230	1360	1590	1780	2000
T BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	150	175	200	250	300	350	450	400	350
	LENGTH	3000	3000	3000	3000	3000	3000	3000	3000	3000
R BARS	# SETS	86	84	86	86	88	88	87	87	89
V BARS	LENGTH	2010	2010	2020	2040	2105	2120	2200	2230	2305
	B	230	230	240	260	325	340	420	450	525
S BARS	LENGTH	360	360	360	360	460	460	560	560	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 71

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	260	270	290	340	370	400	470	510	570
	T	380	340	350	380	410	430	480	530	580
	F	500	500	500	600	600	600	700	800	800
QUANTITIES	STEEL	869.3	805.3	766.3	743.0	728.6	715.5	725.6	776.5	778.4
	CONC.	5.6	5.4	5.7	6.5	7.0	7.3	8.5	9.5	10.4
FOOTING REACTION *	V ULS	306.4	282.1	310.1	360.8	408.1	461.6	576.2	697.5	823.2
	V SLS	201.8	198.6	228.2	272.6	314.4	359.3	455.2	551.1	656.5
	H ULS	120.7	123	128.9	136.7	144.4	152.2	167.8	183.7	198.9
	V	117	146	189	240	288	335	437	537	641
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	200	200	225	225	225	200	200	200
	LENGTH	6260	6270	6290	6340	6370	6400	6470	6510	6570
H BARS	C/C	-	-	350	350	350	350	350	325	325
	LENGTH	-	-	3120	3400	3460	3820	3940	3940	4020
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	325	350	350	350	350	350	350	325	325
	LENGTH	7690	7620	5770	5700	5710	5580	5610	5680	5730
	B	3700	3700	1830	1710	1680	1510	1470	1460	1430
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	310	270	280	310	340	360	410	460	510
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	325	350	350	350	350	350	350	325	325
	LENGTH	6570	5920	5040	5020	5050	4940	5020	5140	5240
	B	2580	2000	1100	1030	1020	870	880	920	940
	D	3500	3500	3500	3500	3500	3500	3500	3500	3500
	R	310	270	280	310	340	360	410	460	510
U BARS	LENGTH	1460	1370	1420	1580	1700	1800	2040	2240	2470
	C	1100	1010	1060	1220	1340	1440	1680	1880	2110
T BARS	SIZE	20	20	15	15	15	15	15	20	20
	C/C	175	200	150	175	200	225	275	300	325
	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
R BARS	# SETS	94	94	94	96	94	94	95	97	97
V BARS	LENGTH	2020	2025	2035	2110	2125	2140	2225	2295	2325
	B	240	245	255	330	345	360	445	515	545
S BARS	LENGTH	360	360	360	460	460	460	560	660	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME OPEN FOOTING CULVERTS

Page 72

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	300	300	320	360	390	420	480	540	600
	T	400	360	370	390	420	440	500	550	590
	F	500	500	600	600	600	700	700	800	800
QUANTITIES	STEEL	845.0	828.1	827.8	787.5	791.9	798.0	784.3	814.5	853.0
	CONC.	6.4	6.1	6.6	7.1	7.6	8.2	9.3	10.4	11.3
FOOTING REACTION *	V ULS	316.7	290.6	322.6	371.3	419.3	473.6	588.5	712.6	844.4
	V SLS	213.3	208.2	238.7	281.3	323.7	369.3	465.4	567.1	672.8
	H ULS	144.1	148	155.8	165.5	175	185	205	224.9	244.5
	V	126	155	201	249	297	347	448	552	656
P BARS	SIZE	25	20	20	20	25	25	25	25	25
	C/C	225	150	150	150	225	225	225	200	200
	LENGTH	6300	6300	6320	6360	6390	6420	6480	6540	6600
H BARS	C/C	-	-	-	375	375	375	375	350	325
	LENGTH	-	-	-	2260	3300	3460	3500	3920	4000
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	375	375	375	375	375	375	350	325
	LENGTH	8380	8160	8170	6790	6320	6280	6360	6230	6280
	B	3860	3700	3700	2290	1770	1700	1680	1480	1460
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	330	290	300	320	350	370	430	480	520
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	375	375	375	375	375	375	350	325
	LENGTH	7710	6700	6430	5840	5650	5650	5770	5710	5800
	B	3190	2240	1960	1340	1100	1070	1090	960	980
	D	4000	4000	4000	4000	4000	4000	4000	4000	4000
	R	330	290	300	320	350	370	430	480	520
U BARS	LENGTH	1580	1460	1520	1630	1760	1860	2120	2340	2540
	C	1220	1100	1160	1270	1400	1500	1760	1980	2180
T BARS	SIZE	20	20	20	15	15	15	15	15	15
	C/C	175	175	175	150	150	150	175	200	200
	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
R BARS	# SETS	102	100	100	102	102	102	101	103	105
V BARS	LENGTH	2040	2040	2100	2120	2135	2200	2230	2310	2340
	B	260	260	320	340	355	420	450	530	560
S BARS	LENGTH	360	360	460	460	460	560	560	660	660
W BARS	# SETS	12	12	12	12	12	12	12	12	12

* - The designer must check the resistance to SLIDING, according to Section 5.2.3 of this Manual.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 6 - RIGID FRAME BOX CULVERTS

August 2003

6 RIGID FRAME BOX CULVERTS**6.1 CULVERT DIMENSIONS AND REINFORCEMENT**

Dimensions and detailing information for standard rigid frame box culverts are given in Figure 6.1(a). Construction joints indicated are optional and are provided for the contractor's convenience. Note that both the horizontal and vertical dimensions of all haunches are equal to the thickness of the top slab of the culvert.

Reinforcing details for standard rigid frame box culverts are shown in Figure 6.1(b). Table 6-1 identifies the bar sizes and shapes used for these culverts.

The detailing tables should be read in conjunction with Figures 6.1(a) and (b) and Table 6-1.

Details of apron walls, header walls and retaining walls are provided in Division 8.

The design assumption and parameters, as well as the load cases and combinations, as per CHBDC are summarized in Appendix E (Section 9.5).

6.2 FOUNDATION INVESTIGATION

For foundation investigation requirements of rigid frame box culverts, refer to Section 5.2.1.

FIGURE 6.1(a) RIGID FRAME BOX CULVERT DIMENSIONS

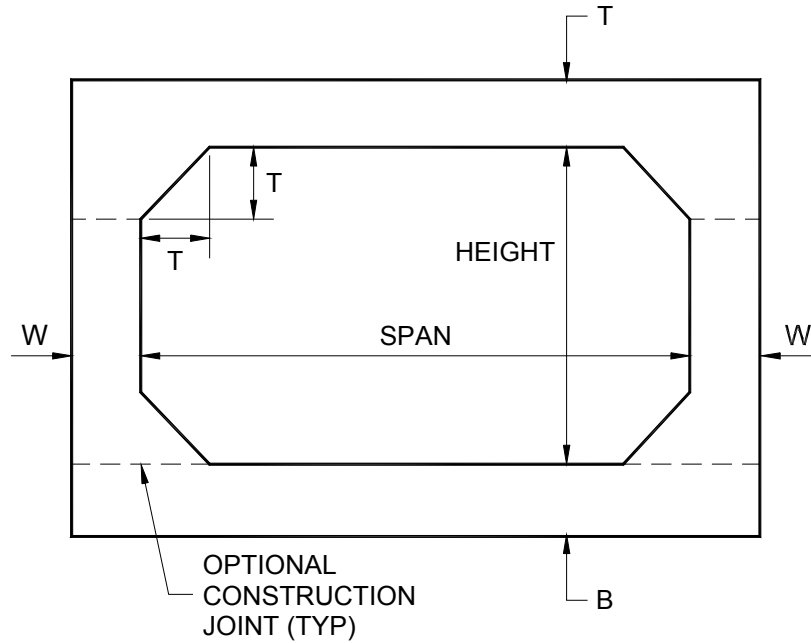
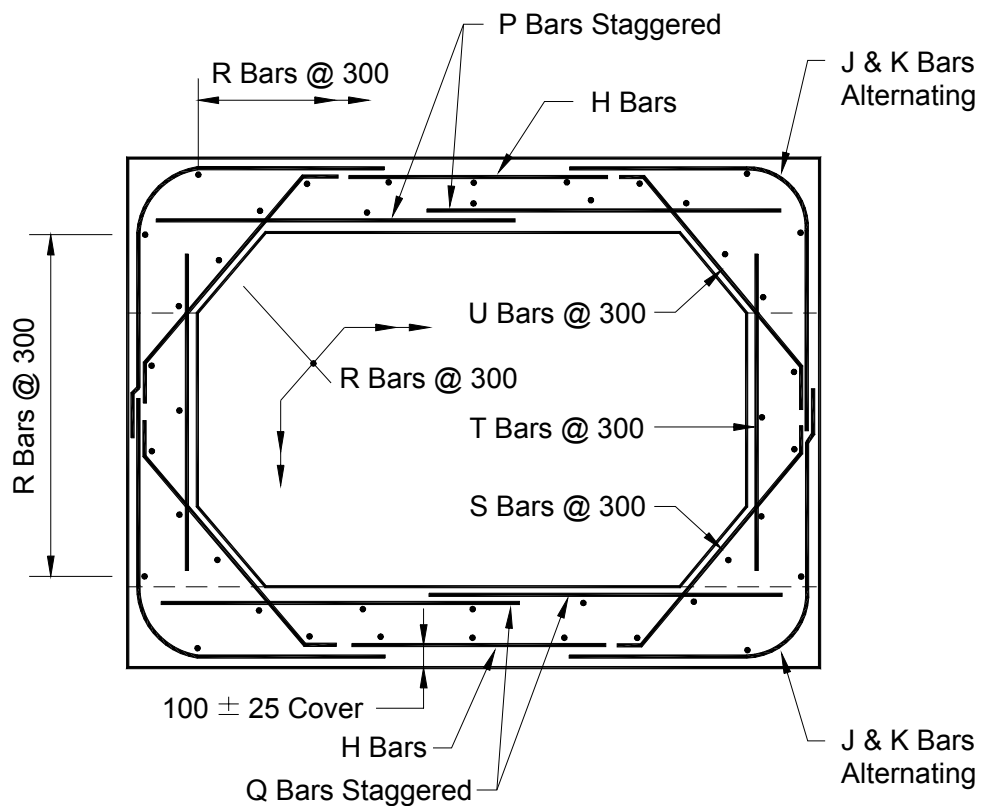


FIGURE 6.1(b) RIGID FRAME BOX CULVERT REINFORCEMENT



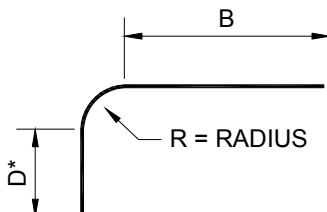
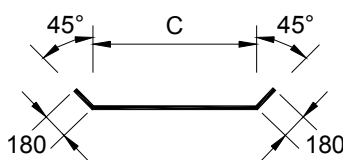
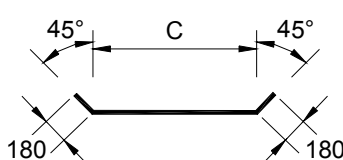
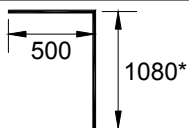
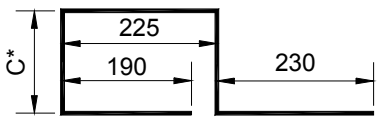
CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 75

TABLE 6-1 REINFORCING STEEL IDENTIFICATION

MARK	DETAILS	REMARKS
P BARS	STRAIGHT	BOTTOM OF TOP SLAB STAGGERED
Q BARS	STRAIGHT	TOP OF BOTTOM SLAB STAGGERED
H BARS	STRAIGHT	15M BARS TOP OF TOP SLAB & BOTTOM OF BOTTOM SLAB
J & K BARS		J BARS ALTERNATE WITH K BARS
S BARS		15M BARS HAUNCH (AT BOTTOM)
T BARS	STRAIGHT	15M BARS INSIDE FACE OF WALLS
U BARS		15M BARS HAUNCH (AT TOP)
R BARS	STRAIGHT	15M BARS LONGITUDINAL
L BARS		15M BARS DOWELS TO APRON WALL
M BARS	STRAIGHT	15M BARS, APRON WALL
Y BARS	STRAIGHT	15M BARS, HEADER WALL
Z BARS		15M BARS HEADER WALL

NOTE: -All dimensions shown to centreline of bar.
-represents vertical dimension

6.3 DETAILING OF BOX CULVERT DRAWINGS

6.3.1 DETAILS FOR STANDARD DRAWINGS

The following is the procedure used for completing the structural standard drawing for standard rigid frame box culverts, SS114-2, with no skewed ends, retaining walls or other special features:

- Obtain culvert size, length, and height of fill from "Design Data Form for Concrete Culverts".
- Select appropriate standard drawing for rigid frame box culvert.
- Determine from "Design Data Form for Concrete Culverts" whether culvert is extension or not:

If culvert is an extension, change vertical centreline on left side of section 1 to a solid line and label - "END OF EXISTING CULVERT" Insert length of culvert extension on the horizontal dimension line:

e.g. 9 m EXTN RT
11 m EXTN LT

If culvert is not an extension, label centreline "Centre-line Highway" and add culvert length each side of Centre-line Highway

e.g. 16 m RT
13 m LT

- Select from Division 6 appropriate detailing table for required size of culvert.
- Insert span and height of culvert and dimensions of top slab, haunch, bottom slab and wall on "Typical Culvert Section" detail.
- Insert bar size and/or spacing for H, J, K, P, and Q bars where required on all details. Note that P and Q bar spacing is specified at mid-span. Insert Y bar size on Detail B.
- Insert dimensions on Section 2 for layout of P and Q bars, noting that the smaller dimension is half the wall thickness and that the larger dimension is the P bar or Q bar length.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

RIGID FRAME BOX CULVERTS

Page 77

WARNING NOTE: a dimension is required on Section 1 to show the actual distance between any J bar and the adjacent K bar. This is necessary to avoid confusion about the spacing of alternating bars, since the space between adjacent bars is $\frac{1}{2}$ of the J spacing.

i.e., if J bar spacing is 300 mm and
K bar spacing is 300 mm

then distance between adjacent bars is 150 mm.

THIS IS AN EXTREMELY IMPORTANT POINT.

- Complete steel bar table for culvert, apron wall and header wall, where applicable.
- Multiply unit quantities by culvert length.
- Add additional P Bar at each end of culvert if no header wall is required.
- Add header walls where required as specified in Sections 4.2.6.
- Add adjustment to steel quantity for R bar laps.
- Add apron wall quantities.
- Add header wall quantities, where applicable.
- Insert total quantities in "Culvert Quantities" table on standard drawing.
- **The Standard Drawing shall be sealed, dated and signed according to 4.3.1.**

6.3.2 STEEL TABLE FOR CULVERT

Spacing, bar length, and bar bending dimensions are available from the individual culvert detailing tables at the end of this division.

The number of H, J, K, P, Q, S, T and U bars required can be calculated using the expression given in Division 8. This procedure considers only one bar per cross-section, therefore, the number of S, T and U bars must be doubled, and the number of J and K bars must be quadrupled.

For R bars the number of sets of bars is available on the detailing tables; the number of bars per set and bar length in Division 8.

For H bars the spacing and length of bar are given in the detailing tables, when these bars are required.

6.3.3 STEEL TABLE FOR APRON WALL AND HEADER WALL

The length and number of L, M, Y and Z bars required for apron and header walls are as given in Division 8.

Modification of these quantities is required for culverts with skewed ends.

6.3.4 ADJUSTMENT OF CONCRETE QUANTITIES

The additional volume of concrete required for apron and header walls is discussed in Division 8.

Modification of these quantities is required for culverts with skewed ends.

6.3.5 QUANTITY TABLE

Complete the quantity table. Concrete and steel quantities should be the total quantity for the complete length of culvert including apron wall and header wall, where applicable.

6.4 DETAILING TABLES

The following pages contain the detailing tables. These tables list various culvert dimensions, concrete and reinforcing steel quantities, and reinforcing steel detailing information.

All dimensions, spacings and lengths given are in millimetres.

Steel quantities given are in kilograms, per metre length of culvert.

Concrete quantities given are in cubic metres, per metre length of culvert.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 80

DETAILING TABLE	SPAN:	2.00
DIMENSIONS & QUANTITIES	HEIGHT:	1.25

SPAN: 2.00
HEIGHT: 1.25

HEIGHT: 1.25

[illegible]

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 81

DETAILING TABLE		SPAN:	2.00
DIMENSIONS & QUANTITIES		HEIGHT:	1.50

HEIGHT: 1.50

[illegible]

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 85

DETAILING TABLE	SPAN:	2.50
DIMENSIONS & QUANTITIES	HEIGHT:	1.50

SPAN: 2.50
HEIGHT: 1.50

HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	210	210	210	210	220	220	230	240	280
	T	220	220	220	220	220	220	230	240	290
	B	220	220	240	240	240	240	260	280	330
QUANTITIES	STEEL	265.2	237.7	236.1	241.6	249.2	259.1	286.4	314.3	308.8
	CONC.	2	2	2.1	2.1	2.1	2.1	2.2	2.4	2.9
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	250	275	250	250	225	200	175	175
	LENGTH	2710	2710	2710	2710	2720	2720	2730	2740	2780
H BARS	C/C	350	450	450	425	400	375	325	400	300
	LENGTH	1450	1590	1650	1670	1690	1690	1710	1290	1690
J BARS	SIZE	15	15	15	15	15	15	15	20	15
	C/C	350	450	450	425	400	375	325	400	300
	LENGTH	2370	2300	2270	2260	2260	2260	2260	2630	2360
	B	970	900	870	860	860	860	850	1060	850
	D	1170	1170	1170	1170	1170	1170	1170	1310	1170
	R	145	145	145	145	145	145	155	165	215
K BARS	SIZE	15	15	15	15	15	15	15	20	15
	C/C	350	450	450	425	400	375	325	400	300
	LENGTH	1940	1880	1860	1850	1850	1840	1860	2030	2020
	B	540	480	460	450	450	440	450	460	510
	D	1170	1170	1170	1170	1170	1170	1170	1310	1170
	R	145	145	145	145	145	145	155	165	215
S BARS	LENGTH	900	900	930	930	940	940	1000	1050	1250
	C	540	540	570	570	580	580	640	690	890
T BARS	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
U BARS	LENGTH	940	940	940	940	960	960	1000	1040	1240
	C	580	580	580	580	600	600	640	680	880
Q BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	225	225	225	200	175	150	150	150
	LENGTH	2710	2710	2710	2710	2720	2720	2730	2740	2780
R BARS	# SETS	62	62	62	62	62	62	66	66	66

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 86

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.50

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	230	230	240	260	280
	T	220	220	220	220	230	230	240	260	290
	B	220	220	240	240	240	240	270	320	340
QUANTITIES	STEEL	272	247.4	244	249.6	260.9	274.9	295.4	310.2	314.9
	CONC.	2.2	2.2	2.2	2.2	2.3	2.3	2.5	2.8	3.1
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	250	250	250	250	225	200	175	175
	LENGTH	2720	2720	2720	2720	2730	2730	2740	2760	2780
H BARS	C/C	400	475	500	475	450	400	350	325	325
	LENGTH	1310	1530	1610	1650	1650	1670	1690	1690	1670
J BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	400	475	500	475	450	400	350	325	325
	LENGTH	2580	2470	2430	2410	2420	2410	2420	2450	2500
	B	1050	940	900	880	880	870	860	860	860
	D	1300	1300	1300	1300	1300	1300	1300	1300	1300
	R	145	145	145	145	155	155	165	185	215
K BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	400	475	500	475	450	400	350	325	325
	LENGTH	2160	2050	2030	2010	2020	2010	2040	2100	2170
	B	630	520	500	480	480	470	480	510	530
	D	1300	1300	1300	1300	1300	1300	1300	1300	1300
	R	145	145	145	145	155	155	165	185	215
S BARS	LENGTH	910	910	940	940	970	970	1040	1170	1270
	C	550	550	580	580	610	610	680	810	910
T BARS	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
U BARS	LENGTH	960	960	960	960	1000	1000	1040	1130	1240
	C	600	600	600	600	640	640	680	770	880
Q BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	175	225	225	200	200	175	150	150	150
	LENGTH	2720	2720	2720	2720	2730	2730	2740	2760	2780
R BARS	# SETS	66	66	66	66	70	70	70	70	70

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 87

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 2.50

HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	220	230	230	240	260	270
	T	220	220	220	220	230	230	240	260	290
	B	220	220	240	240	240	250	270	330	350
QUANTITIES	STEEL	279.8	257.8	253.1	260.4	271.4	281	305.3	313.6	336.4
	CONC.	2.3	2.3	2.3	2.3	2.4	2.4	2.6	3	3.2
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	200	225	250	225	225	200	175	175	150
	LENGTH	2720	2720	2720	2720	2730	2730	2740	2760	2770
H BARS	C/C	-	525	525	500	475	450	375	350	325
	LENGTH	-	1370	1530	1570	1590	1610	1630	1630	1630
J BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	425	525	525	500	475	450	375	350	325
	LENGTH	3320	2670	2590	2570	2570	2560	2570	2600	2630
	B	1670	1020	940	920	910	900	890	890	870
	D	1420	1420	1420	1420	1420	1420	1420	1420	1420
	R	145	145	145	145	155	155	165	185	215
K BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	425	525	525	500	475	450	375	350	325
	LENGTH	2340	2250	2190	2170	2170	2170	2180	2260	2330
	B	690	600	540	520	510	510	500	550	570
	D	1420	1420	1420	1420	1420	1420	1420	1420	1420
	R	145	145	145	145	155	155	165	185	215
S BARS	LENGTH	910	910	940	940	970	980	1040	1180	1270
	C	550	550	580	580	610	620	680	820	910
T BARS	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
U BARS	LENGTH	960	960	960	960	1000	1000	1040	1130	1220
	C	600	600	600	600	640	640	680	770	860
Q BARS	SIZE	15	15	15	15	15	15	15	15	20
	C/C	175	200	225	200	200	175	150	150	200
	LENGTH	2720	2720	2720	2720	2730	2730	2740	2760	2770
R BARS	# SETS	70	70	70	70	74	74	74	72	74

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 89

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.00
HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	230	230	230	240	240	260	280	320
	T	230	230	230	240	250	250	260	280	340
	B	230	230	250	250	260	260	310	370	390
QUANTITIES	STEEL	331.9	299.7	299.5	306.8	317	339.2	361.2	390	398.7
	CONC.	2.4	2.4	2.5	2.5	2.6	2.6	2.9	3.3	3.8
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	175	200	225	200	200	175	175	150	150
	LENGTH	3230	3230	3230	3230	3240	3240	3260	3280	3320
H BARS	C/C	400	325	325	325	300	400	350	325	325
	LENGTH	1430	1990	2050	2090	2090	1670	1670	1690	1650
J BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	400	325	325	325	300	400	350	325	325
	LENGTH	2790	2370	2340	2330	2340	2690	2720	2740	2840
	B	1240	960	930	900	900	1110	1120	1110	1110
	D	1310	1170	1170	1170	1170	1310	1310	1310	1310
	R	155	155	155	165	175	175	185	205	265
K BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	400	325	325	325	300	400	350	325	325
	LENGTH	2160	1960	1920	1930	1950	2080	2120	2180	2330
	B	610	550	510	500	510	500	520	550	600
	D	1310	1170	1170	1170	1170	1310	1310	1310	1310
	R	155	155	155	165	175	175	185	205	265
S BARS	LENGTH	960	960	980	1000	1040	1040	1150	1300	1460
	C	600	600	620	640	680	680	790	940	1100
T BARS	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
U BARS	LENGTH	1000	1000	1000	1030	1070	1070	1130	1210	1440
	C	640	640	640	670	710	710	770	850	1080
Q BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	175	200	200	175	175	150	150	200	200
	LENGTH	3230	3230	3230	3230	3240	3240	3260	3280	3320
R BARS	# SETS	70	70	72	72	72	72	72	74	72

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 90

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.00
HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	230	230	240	240	260	290
	T	220	220	230	230	240	250	250	280	330
	B	220	220	240	240	250	260	310	360	410
QUANTITIES	STEEL	352.2	316.2	308.3	319.7	329.2	339.8	388.6	396	409.1
	CONC.	2.4	2.4	2.5	2.5	2.6	2.7	2.9	3.3	3.9
P BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	150	175	200	200	175	175	150	200	200
	LENGTH	3220	3220	3220	3230	3230	3240	3240	3260	3290
H BARS	C/C	400	325	350	325	325	300	350	350	350
	LENGTH	1390	1970	2070	2090	2110	2110	1670	1670	1650
J BARS	SIZE	20	15	15	15	15	15	20	20	20
	C/C	400	325	350	325	325	300	350	350	350
	LENGTH	2930	2500	2450	2450	2450	2460	2820	2860	2930
	B	1260	970	910	910	890	890	1110	1100	1090
	D	1440	1300	1300	1300	1300	1300	1440	1440	1440
	R	145	145	155	155	165	175	175	205	255
K BARS	SIZE	20	15	15	15	15	15	20	20	20
	C/C	400	325	350	325	325	300	350	350	350
	LENGTH	2290	2080	2050	2050	2060	2080	2220	2300	2430
	B	620	550	510	510	500	510	510	540	590
	D	1440	1300	1300	1300	1300	1300	1440	1440	1440
	R	145	145	155	155	165	175	175	205	255
S BARS	LENGTH	910	910	960	970	1000	1040	1110	1250	1440
	C	550	550	600	610	640	680	750	890	1080
T BARS	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
U BARS	LENGTH	960	960	980	1000	1030	1070	1070	1180	1370
	C	600	600	620	640	670	710	710	820	1010
Q BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	150	175	175	175	150	150	175	175	175
	LENGTH	3220	3220	3220	3230	3230	3240	3240	3260	3290
R BARS	# SETS	72	72	74	76	76	76	76	74	76

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 91

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.00
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	220	220	220	230	230	240	240	270	300
	T	220	230	230	230	240	250	250	280	330
	B	220	230	240	240	250	260	320	360	430
QUANTITIES	STEEL	355.5	323.8	323.5	334.1	343.1	350.7	395.4	405.5	415.6
	CONC.	2.5	2.6	2.6	2.7	2.7	2.9	3.1	3.5	4.2
P BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	150	175	175	175	175	150	200	200	200
	LENGTH	3220	3220	3220	3230	3230	3240	3240	3270	3300
H BARS	C/C	300	375	375	350	325	325	375	375	375
	LENGTH	1690	1910	2010	2050	2070	2070	1650	1670	1630
J BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	300	375	375	350	325	325	375	375	375
	LENGTH	2760	2650	2600	2590	2590	2600	2950	2990	3070
	B	1110	990	940	930	910	910	1120	1110	1110
	D	1420	1420	1420	1420	1420	1420	1560	1560	1560
	R	145	155	155	155	165	175	175	205	255
K BARS	SIZE	15	15	15	15	15	15	20	20	20
	C/C	300	375	375	350	325	325	375	375	375
	LENGTH	2320	2230	2200	2190	2200	2220	2360	2450	2590
	B	670	570	540	530	520	530	530	570	630
	D	1420	1420	1420	1420	1420	1420	1560	1560	1560
	R	145	155	155	155	165	175	175	205	255
S BARS	LENGTH	910	940	960	970	1000	1040	1130	1270	1480
	C	550	580	600	610	640	680	770	910	1120
T BARS	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
U BARS	LENGTH	960	980	980	1000	1030	1070	1070	1200	1380
	C	600	620	620	640	670	710	710	840	1020
Q BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	200	150	150	150	150	200	175	175	175
	LENGTH	3220	3220	3220	3230	3230	3240	3240	3270	3300
R BARS	# SETS	76	78	78	80	80	78	78	80	80

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 92

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50

HEIGHT: 1.25

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	230	230	240	250	260	300	330	370
	T	250	250	240	240	250	260	300	340	380
	B	250	250	270	270	270	290	320	400	460
QUANTITIES	STEEL	397.8	362.1	375	379.5	396.3	399.1	437.5	463.4	495.3
	CONC.	2.7	2.7	2.7	2.7	2.8	3	3.5	4.1	4.8
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	150	200	200	175	175	175	175	150	150
	LENGTH	3730	3730	3730	3740	3750	3760	3800	3830	3870
H BARS	C/C	300	350	325	325	300	300	450	425	400
	LENGTH	1850	1930	1990	2010	2030	2050	1630	1610	1590
J BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	300	350	325	325	300	300	450	425	400
	LENGTH	2720	2680	2650	2650	2650	2660	3060	3130	3200
	B	1260	1220	1200	1200	1190	1180	1390	1390	1400
	D	1190	1190	1190	1190	1190	1190	1320	1320	1320
	R	175	175	165	165	175	185	225	265	305
K BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	300	350	325	325	300	300	450	425	400
	LENGTH	2120	2080	2040	2030	2040	2070	2290	2420	2540
	B	660	620	590	580	580	590	620	680	740
	D	1190	1190	1190	1190	1190	1190	1320	1320	1320
	R	175	175	165	165	175	185	225	265	305
S BARS	LENGTH	1010	1010	1030	1040	1070	1130	1280	1490	1690
	C	650	650	670	680	710	770	920	1130	1330
T BARS	LENGTH	1250	1250	1250	1250	1250	1250	1250	1250	1250
U BARS	LENGTH	1050	1050	1030	1040	1080	1130	1290	1450	1620
	C	690	690	670	680	720	770	930	1090	1260
Q BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	175	175	175	175	150	150	150	150	150
	LENGTH	3730	3730	3730	3740	3750	3760	3800	3830	3870
R BARS	# SETS	76	76	78	78	76	76	80	78	82

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 93

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50
HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	230	230	240	250	260	300	330	370
	T	250	240	240	240	250	260	300	340	380
	B	250	250	270	270	270	290	330	400	480
QUANTITIES	STEEL	416.3	380.4	385.3	385.8	395.3	422.2	434.6	469.7	500.8
	CONC.	2.8	2.7	2.8	2.9	3	3.1	3.7	4.3	5
P BARS	SIZE	15	15	15	15	15	15	15	15	15
	C/C	150	175	175	175	175	150	150	150	150
	LENGTH	3730	3730	3730	3740	3750	3760	3800	3830	3870
H BARS	C/C	300	350	350	350	325	300	300	450	425
	LENGTH	1870	1970	2010	2050	2070	2070	2090	1650	1630
J BARS	SIZE	20	20	20	20	20	20	20	25	25
	C/C	300	350	350	350	325	300	300	450	425
	LENGTH	2830	2780	2760	2750	2750	2770	2820	3240	3310
	B	1250	1210	1190	1180	1170	1170	1160	1370	1380
	D	1310	1310	1310	1310	1310	1310	1310	1450	1450
	R	175	165	165	165	175	185	225	265	305
K BARS	SIZE	20	20	20	20	20	20	20	25	25
	C/C	300	350	350	350	325	300	300	450	425
	LENGTH	2230	2170	2140	2140	2140	2170	2270	2520	2650
	B	650	600	570	570	560	570	610	650	720
	D	1310	1310	1310	1310	1310	1310	1310	1450	1450
	R	175	165	165	165	175	185	225	265	305
S BARS	LENGTH	1010	1000	1030	1040	1070	1130	1300	1490	1720
	C	650	640	670	680	710	770	940	1130	1360
T BARS	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
U BARS	LENGTH	1050	1030	1030	1040	1080	1130	1290	1450	1620
	C	690	670	670	680	720	770	930	1090	1260
Q BARS	SIZE	15	15	15	15	15	20	20	20	20
	C/C	150	175	150	150	150	200	200	200	200
	LENGTH	3730	3730	3730	3740	3750	3760	3800	3830	3870
R BARS	# SETS	78	80	80	80	78	78	80	80	84

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 94

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 3.50

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	230	230	230	240	250	260	300	330	370
	T	250	240	240	240	250	260	300	340	380
	B	250	250	270	270	270	290	320	400	480
QUANTITIES	STEEL	423.8	396.6	390.6	411.8	409.8	431	442.9	472.5	490
	CONC.	2.9	2.9	2.9	3	3.1	3.3	3.8	4.5	5.2
P BARS	SIZE	20	15	15	15	15	15	15	20	20
	C/C	200	150	175	150	150	150	150	200	200
	LENGTH	3730	3730	3730	3740	3750	3760	3800	3830	3870
H BARS	C/C	325	375	375	350	350	325	325	300	300
	LENGTH	1870	1970	2030	2070	2090	2090	2110	2090	2070
J BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	325	375	375	350	350	325	325	300	300
	LENGTH	2960	2910	2880	2870	2870	2890	2940	3010	3080
	B	1250	1210	1180	1170	1160	1160	1150	1150	1160
	D	1440	1440	1440	1440	1440	1440	1440	1440	1440
	R	175	165	165	165	175	185	225	265	305
K BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	325	375	375	350	350	325	325	300	300
	LENGTH	2360	2290	2270	2260	2260	2290	2390	2500	2630
	B	650	590	570	560	550	560	600	640	710
	D	1440	1440	1440	1440	1440	1440	1440	1440	1440
	R	175	165	165	165	175	185	225	265	305
S BARS	LENGTH	1010	1000	1030	1040	1070	1130	1280	1490	1720
	C	650	640	670	680	710	770	920	1130	1360
T BARS	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
U BARS	LENGTH	1050	1030	1030	1040	1080	1130	1290	1450	1620
	C	690	670	670	680	720	770	930	1090	1260
Q BARS	SIZE	15	15	15	20	20	20	20	20	20
	C/C	150	150	150	200	200	175	175	175	175
	LENGTH	3730	3730	3730	3740	3750	3760	3800	3830	3870
R BARS	# SETS	82	84	84	84	82	82	84	84	88

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 95

DETAILING TABLE	SPAN:	3.50
DIMENSIONS & QUANTITIES	HEIGHT:	2.00

SPAN: 3.50
HEIGHT: 2.00

HEIGHT: 2.00

[illegible]

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 96

DETAILING TABLE DIMENSIONS & QUANTITIES		SPAN: 3.50 HEIGHT: 2.50
---	--	---

HEIGHT: 2.50

[illegible]

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 97

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 1.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	240	240	240	240	270	280	300	360	390
	T	260	250	250	260	280	300	320	410	410
	B	260	260	270	280	310	330	360	440	550
QUANTITIES	STEEL	494.3	446.3	450.7	496.5	481.8	507.3	555.5	570.2	614.8
	CONC.	3.2	3.1	3.2	3.3	3.6	3.9	4.2	5.4	6.1
P BARS	SIZE	20	15	15	15	15	15	20	15	20
	C/C	200	150	150	150	150	150	175	150	200
	LENGTH	4240	4240	4240	4240	4270	4280	4300	4360	4390
H BARS	C/C	425	300	300	425	450	425	375	375	350
	LENGTH	1750	2350	2410	1930	1990	2030	2050	1970	2010
J BARS	SIZE	25	20	20	25	25	25	25	25	25
	C/C	425	300	300	425	450	425	375	375	350
	LENGTH	3300	2850	2820	3210	3220	3220	3240	3400	3410
	B	1560	1270	1240	1470	1450	1420	1410	1420	1430
	D	1450	1310	1310	1450	1450	1450	1450	1450	1450
	R	185	175	175	185	205	225	245	335	335
K BARS	SIZE	25	20	20	25	25	25	25	25	25
	C/C	425	300	300	425	450	425	375	375	350
	LENGTH	2490	2250	2220	2400	2430	2450	2500	2740	2790
	B	750	670	640	660	660	650	670	760	810
	D	1450	1310	1310	1450	1450	1450	1450	1450	1450
	R	185	175	175	185	205	225	245	335	335
S BARS	LENGTH	1050	1040	1050	1080	1200	1270	1370	1690	1890
	C	690	680	690	720	840	910	1010	1330	1530
T BARS	LENGTH	1500	1500	1500	1500	1500	1500	1500	1500	1500
U BARS	LENGTH	1100	1070	1070	1100	1200	1270	1350	1690	1730
	C	740	710	710	740	840	910	990	1330	1370
Q BARS	SIZE	15	15	20	20	20	20	20	20	20
	C/C	150	150	200	175	200	175	175	175	150
	LENGTH	4240	4240	4240	4240	4270	4280	4300	4360	4390
R BARS	# SETS	86	86	86	86	86	88	88	90	92

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 98

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	240	240	250	260	280	310	350	400
	T	270	250	250	260	280	300	330	370	440
	B	270	270	270	280	310	330	400	450	560
QUANTITIES	STEEL	487.5	474.2	472.9	481.9	482.1	516.6	555.7	581.6	604.4
	CONC.	3.5	3.3	3.3	3.4	3.7	4	4.7	5.4	6.6
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	175	200	200	200	200	200	175	175	175
	LENGTH	4250	4240	4240	4250	4260	4280	4310	4350	4400
H BARS	C/C	300	300	300	300	300	450	425	400	400
	LENGTH	2250	2350	2430	2470	2490	2070	2050	2050	2010
J BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	300	300	300	300	300	450	425	400	400
	LENGTH	3060	2980	2940	2940	2950	3320	3380	3440	3550
	B	1310	1270	1230	1210	1190	1400	1410	1410	1410
	D	1440	1440	1440	1440	1440	1570	1570	1570	1570
	R	195	175	175	185	205	225	255	295	365
K BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	300	300	300	300	300	450	425	400	400
	LENGTH	2470	2370	2340	2350	2380	2550	2640	2740	2940
	B	720	660	630	620	620	630	670	710	800
	D	1440	1440	1440	1440	1440	1570	1570	1570	1570
	R	195	175	175	185	205	225	255	295	365
S BARS	LENGTH	1100	1050	1050	1100	1180	1270	1450	1630	1960
	C	740	690	690	740	820	910	1090	1270	1600
T BARS	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
U BARS	LENGTH	1140	1070	1070	1110	1180	1270	1390	1560	1830
	C	780	710	710	750	820	910	1030	1200	1470
Q BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	200	200	200	175	175	175	150	150	150
	LENGTH	4250	4240	4240	4250	4260	4280	4310	4350	4400
R BARS	# SETS	90	90	90	90	88	92	92	92	94

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 99

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	250	250	250	250	280	310	340	400
	T	260	260	260	260	270	300	330	380	450
	B	260	260	270	300	320	360	430	480	570
QUANTITIES	STEEL	506.3	460.8	480.1	495.5	513.5	519.4	560.9	599.3	626.1
	CONC.	3.5	3.5	3.5	3.7	3.8	4.3	5	5.7	6.9
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	175	200	200	200	175	200	175	150	175
	LENGTH	4250	4250	4250	4250	4250	4280	4310	4340	4400
H BARS	C/C	300	350	325	300	300	300	450	425	425
	LENGTH	2270	2370	2450	2470	2490	2490	2050	2050	2030
J BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	300	350	325	300	300	300	450	425	425
	LENGTH	3160	3110	3070	3060	3060	3100	3510	3570	3680
	B	1310	1260	1220	1210	1190	1190	1410	1390	1390
	D	1560	1560	1560	1560	1560	1560	1700	1700	1700
	R	185	185	185	185	195	225	255	305	375
K BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	300	350	325	300	300	300	450	425	425
	LENGTH	2570	2510	2480	2470	2480	2540	2770	2900	3100
	B	720	660	630	620	610	630	670	720	810
	D	1560	1560	1560	1560	1560	1560	1700	1700	1700
	R	185	185	185	185	195	225	255	305	375
S BARS	LENGTH	1070	1070	1080	1130	1170	1310	1490	1680	1990
	C	710	710	720	770	810	950	1130	1320	1630
T BARS	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
U BARS	LENGTH	1110	1110	1110	1110	1140	1270	1390	1580	1860
	C	750	750	750	750	780	910	1030	1220	1500
Q BARS	SIZE	20	20	20	20	20	20	20	20	25
	C/C	175	200	175	175	150	150	150	150	200
	LENGTH	4250	4250	4250	4250	4250	4280	4310	4340	4400
R BARS	# SETS	92	92	92	92	92	96	96	98	98

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 100

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	250	250	260	280	310	310	370	430
	T	270	250	250	260	280	310	320	410	480
	B	270	260	270	300	330	340	440	500	580
QUANTITIES	STEEL	522.3	493.3	504.7	516.8	521	533.7	585.3	579.5	638.5
	CONC.	3.8	3.7	3.7	4	4.3	4.7	5.3	6.5	7.8
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	175	175	175	175	175	150	150	175
	LENGTH	4250	4250	4250	4260	4280	4310	4310	4370	4430
H BARS	C/C	350	375	350	350	350	350	300	325	325
	LENGTH	2090	2350	2430	2450	2470	2490	2470	2470	2450
J BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	350	375	350	350	350	350	300	325	325
	LENGTH	3510	3360	3320	3330	3350	3390	3400	3520	3630
	B	1390	1280	1240	1230	1220	1210	1210	1180	1180
	D	1810	1810	1810	1810	1810	1810	1810	1810	1810
	R	195	175	175	185	205	235	245	335	405
K BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	350	375	350	350	350	350	300	325	325
	LENGTH	2920	2760	2730	2750	2790	2860	2880	3120	3300
	B	800	680	650	650	660	680	690	780	850
	D	1810	1810	1810	1810	1810	1810	1810	1810	1810
	R	195	175	175	185	205	235	245	335	405
S BARS	LENGTH	1100	1050	1070	1140	1240	1340	1490	1790	2090
	C	740	690	710	780	880	980	1130	1430	1730
T BARS	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
U BARS	LENGTH	1140	1080	1080	1130	1210	1340	1370	1700	1990
	C	780	720	720	770	850	980	1010	1340	1630
Q BARS	SIZE	20	20	20	20	20	20	25	20	25
	C/C	175	175	175	150	150	150	225	150	150
	LENGTH	4250	4250	4250	4260	4280	4310	4310	4370	4430
R BARS	# SETS	100	100	100	100	100	104	104	104	108

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 101

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	250	250	250	270	280	290	320	380	430
	T	280	280	280	280	280	290	340	410	460
	B	280	280	280	300	360	370	450	500	590
QUANTITIES	STEEL	587.4	519.4	526.8	546	562.8	585.8	621.8	602.5	657.7
	CONC.	4.2	4.2	4.2	4.4	4.8	4.9	5.8	6.9	8.1
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	175	175	175	175	175	150	150	150
	LENGTH	4250	4250	4250	4270	4280	4290	4320	4380	4430
H BARS	C/C	-	300	300	400	375	350	325	350	325
	LENGTH	-	2050	2470	2330	2410	2410	2390	2430	2370
J BARS	SIZE	20	15	15	20	20	20	20	20	20
	C/C	375	300	300	400	375	350	325	350	325
	LENGTH	4940	3640	3430	3660	3630	3650	3720	3800	3900
	B	2560	1400	1190	1280	1250	1250	1240	1210	1240
	D	2060	1920	1920	2060	2060	2060	2060	2060	2060
	R	205	205	205	205	205	215	265	335	385
K BARS	SIZE	20	15	15	20	20	20	20	20	20
	C/C	375	300	300	400	375	350	325	350	325
	LENGTH	3460	3080	2980	3110	3130	3140	3260	3430	3580
	B	1080	840	740	730	750	740	780	840	920
	D	2060	1920	1920	2060	2060	2060	2060	2060	2060
	R	205	205	205	205	205	215	265	335	385
S BARS	LENGTH	1130	1130	1130	1180	1280	1320	1550	1800	2070
	C	770	770	770	820	920	960	1190	1440	1710
T BARS*	LENGTH	3000*	3000*	3000*	3000*	3000*	3000*	3000	3000	3000
U BARS	LENGTH	1170	1170	1170	1200	1210	1250	1440	1720	1930
	C	810	810	810	840	850	890	1080	1360	1570
Q BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	150	175	150	150	150	225	225	225	175
	LENGTH	4250	4250	4250	4270	4280	4290	4320	4380	4430
R BARS	# SETS	106	106	106	106	108	108	108	110	112

*T BARS to be Size 20M. Modify drawing SS114-2 accordingly.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 102

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	260	260	270	280	290	300	330	380	450
	T	280	260	270	280	310	330	350	410	460
	B	280	280	300	340	370	400	470	510	610
QUANTITIES	STEEL	582.9	537.3	536.2	537.9	547.6	588.7	608.4	629.7	666.2
	CONC.	4.5	4.4	4.6	4.9	5.3	5.7	6.4	7.4	8.8
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	150	175	175	175	150	150	150	150
	LENGTH	4260	4260	4270	4280	4290	4300	4330	4380	4450
H BARS	C/C	-	300	300	300	300	400	375	375	350
	LENGTH	-	1070	1810	1910	2070	2050	2070	2050	2010
J BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	400	300	300	300	300	400	375	375	350
	LENGTH	5190	4380	4030	3990	3940	4110	4140	4240	4350
	B	2560	1920	1550	1500	1400	1400	1400	1400	1440
	D	2310	2170	2170	2170	2170	2310	2310	2310	2310
	R	205	185	195	205	235	255	275	335	385
K BARS	SIZE	20	15	15	15	15	20	20	20	20
	C/C	400	300	300	300	300	400	375	375	350
	LENGTH	3830	3550	3410	3410	3430	3610	3680	3800	3940
	B	1200	1090	930	920	890	900	940	960	1030
	D	2310	2170	2170	2170	2170	2310	2310	2310	2310
	R	205	185	195	205	235	255	275	335	385
S BARS	LENGTH	1140	1110	1170	1250	1350	1440	1610	1820	2130
	C	780	750	810	890	990	1080	1250	1460	1770
T BARS	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
U BARS	LENGTH	1180	1130	1170	1210	1310	1380	1480	1720	1960
	C	820	770	810	850	950	1020	1120	1360	1600
Q BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	150	175	150	150	150	225	225	200	200
	LENGTH	4260	4260	4270	4280	4290	4300	4330	4380	4450
R BARS	# SETS	112	112	112	112	116	116	116	116	120

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 103

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.00

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	280	280	280	300	320	320	360	420	480
	T	290	280	280	300	340	350	380	430	490
	B	310	310	330	350	390	410	480	570	660
QUANTITIES	STEEL	587.6	556.4	568.9	567	573.4	599.9	612.5	653	673.8
	CONC.	5.1	5.1	5.2	5.6	6.2	6.3	7.2	8.6	10
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	175	175	175	175	150	150	150	150
	LENGTH	4280	4280	4280	4300	4320	4320	4360	4420	4480
H BARS	C/C	-	-	-	-	325	300	300	400	400
	LENGTH	-	-	-	-	750	850	1190	1350	1210
J BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	300	325	300	325	325	300	300	400	400
	LENGTH	5180	5160	5160	5190	4900	4850	4740	4890	5050
	B	2420	2420	2420	2420	2060	2000	1840	1770	1840
	D	2420	2420	2420	2420	2420	2420	2420	2560	2560
	R	215	205	205	225	265	275	305	355	415
K BARS	SIZE	15	15	15	15	15	15	15	20	20
	C/C	300	325	300	325	325	300	300	400	400
	LENGTH	4240	3950	3830	4010	4070	4060	4060	4290	4460
	B	1480	1210	1090	1240	1230	1210	1160	1170	1250
	D	2420	2420	2420	2420	2420	2420	2420	2560	2560
	R	215	205	205	225	265	275	305	355	415
S BARS	LENGTH	1220	1210	1240	1320	1460	1510	1710	1990	2290
	C	860	850	880	960	1100	1150	1350	1630	1930
T BARS	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
U BARS	LENGTH	1240	1210	1210	1290	1440	1460	1610	1830	2090
	C	880	850	850	930	1080	1100	1250	1470	1730
Q BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	150	150	150	150	150	225	225	225	225
	LENGTH	4280	4280	4280	4300	4320	4320	4360	4420	4480
R BARS	# SETS	120	120	120	124	124	120	124	126	130

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 104

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 1.75

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	290	290	290	320	330	420	470
	T	310	310	310	310	320	340	350	440	490
	B	300	320	320	350	380	400	470	550	660
QUANTITIES	STEEL	517.7	488.3	502.6	546.4	583.7	590.7	656.3	655.5	698.6
	CONC.	4.3	4.4	4.4	4.6	4.8	5.2	5.6	7.1	8.4
P BARS	SIZE	20	15	15	20	20	20	20	20	20
	C/C	175	150	150	200	175	175	150	175	175
	LENGTH	4790	4790	4790	4790	4790	4820	4830	4920	4970
H BARS	C/C	300	325	300	450	400	400	350	375	350
	LENGTH	2610	2730	2810	2410	2430	2450	2450	2430	2410
J BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	325	300	450	400	400	350	375	350
	LENGTH	3190	3130	3090	3420	3410	3450	3460	3610	3700
	B	1380	1320	1280	1480	1460	1460	1460	1470	1480
	D	1440	1440	1440	1570	1570	1570	1570	1570	1570
	R	235	235	235	235	245	265	275	365	415
K BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	325	300	450	400	400	350	375	350
	LENGTH	2640	2580	2540	2660	2660	2720	2740	2990	3170
	B	830	770	730	720	710	730	740	850	950
	D	1440	1440	1440	1570	1570	1570	1570	1570	1570
	R	235	235	235	235	245	265	275	365	415
S BARS	LENGTH	1250	1280	1280	1320	1380	1480	1610	1970	2270
	C	890	920	920	960	1020	1120	1250	1610	1910
T BARS	LENGTH	1750	1750	1750	1750	1750	1750	1750	1750	1750
U BARS	LENGTH	1310	1310	1310	1310	1340	1440	1480	1860	2070
	C	950	950	950	950	980	1080	1120	1500	1710
Q BARS	SIZE	15	15	15	20	20	20	20	20	20
	C/C	150	150	150	175	175	175	150	150	150
	LENGTH	4790	4790	4790	4790	4790	4820	4830	4920	4970
R BARS	# SETS	94	96	96	96	96	96	98	100	102

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 105

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	280	280	280	280	300	310	320	400	470
	T	310	300	300	300	320	340	350	440	490
	B	310	320	320	350	380	400	470	550	660
QUANTITIES	STEEL	538.8	504.5	533.5	569.2	584.5	602.6	683.6	671.9	713.1
	CONC.	4.4	4.4	4.4	4.6	5	5.3	5.7	7.2	8.6
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	175	200	200	175	175	175	150	175	175
	LENGTH	4780	4780	4780	4780	4800	4810	4820	4900	4970
H BARS	C/C	300	325	300	450	450	425	350	375	375
	LENGTH	2650	2750	2830	2430	2450	2470	2450	2450	2430
J BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	325	300	450	450	425	350	375	375
	LENGTH	3280	3220	3180	3520	3540	3560	3580	3710	3820
	B	1350	1310	1270	1470	1460	1440	1450	1440	1470
	D	1560	1560	1560	1700	1700	1700	1700	1700	1700
	R	235	225	225	225	245	265	275	365	415
K BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	325	300	450	450	425	350	375	375
	LENGTH	2740	2660	2620	2750	2790	2830	2860	3090	3240
	B	810	750	710	700	710	710	730	820	890
	D	1560	1560	1560	1700	1700	1700	1700	1700	1700
	R	235	225	225	225	245	265	275	365	415
S BARS	LENGTH	1250	1250	1250	1300	1390	1460	1590	1950	2270
	C	890	890	890	940	1030	1100	1230	1590	1910
T BARS	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
U BARS	LENGTH	1290	1270	1270	1270	1350	1420	1460	1830	2070
	C	930	910	910	910	990	1060	1100	1470	1710
Q BARS	SIZE	20	15	20	20	20	20	25	20	25
	C/C	200	150	175	175	150	150	225	150	200
	LENGTH	4780	4780	4780	4780	4800	4810	4820	4900	4970
R BARS	# SETS	98	98	98	100	100	100	102	104	106

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 106

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50
HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	280	280	280	280	300	310	330	400	490
	T	310	290	290	300	320	340	350	440	520
	B	320	300	300	330	380	400	470	600	660
QUANTITIES	STEEL	577.2	543	567.2	588.6	604.1	616.5	699.3	693.6	731.4
	CONC.	4.8	4.6	4.6	4.8	5.3	5.6	6.1	7.9	9.5
P BARS	SIZE	20	20	20	20	20	20	25	20	20
	C/C	150	175	175	175	150	150	225	150	150
	LENGTH	4780	4780	4780	4780	4800	4810	4830	4900	4990
H BARS	C/C	325	350	325	300	300	300	400	425	425
	LENGTH	2610	2750	2850	2870	2890	2890	2470	2450	2450
J BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	325	350	325	300	300	300	400	425	425
	LENGTH	3550	3470	3420	3410	3430	3460	3830	3960	4100
	B	1370	1320	1270	1250	1240	1230	1450	1440	1450
	D	1810	1810	1810	1810	1810	1810	1950	1950	1950
	R	235	215	215	225	245	265	275	365	445
K BARS	SIZE	20	20	20	20	20	20	25	25	25
	C/C	325	350	325	300	300	300	400	425	425
	LENGTH	3010	2900	2860	2860	2900	2940	3120	3370	3600
	B	830	750	710	700	710	710	740	850	950
	D	1810	1810	1810	1810	1810	1810	1950	1950	1950
	R	235	215	215	225	245	265	275	365	445
S BARS	LENGTH	1270	1210	1210	1270	1390	1460	1610	2020	2340
	C	910	850	850	910	1030	1100	1250	1660	1980
T BARS	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
U BARS	LENGTH	1290	1240	1240	1270	1350	1420	1480	1830	2190
	C	930	880	880	910	990	1060	1120	1470	1830
Q BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	175	175	150	150	150	225	200	225	200
	LENGTH	4780	4780	4780	4780	4800	4810	4830	4900	4990
R BARS	# SETS	108	106	106	108	108	108	108	112	114

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 107

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	280	280	280	290	300	320	330	410	490
	T	310	310	310	310	320	340	360	440	520
	B	310	310	320	350	390	400	470	590	660
QUANTITIES	STEEL	622.1	577.3	590.2	596.4	623.1	627.7	716.3	693	750.3
	CONC.	5	5	5.1	5.3	5.6	6	6.5	8.3	9.9
P BARS	SIZE	20	20	20	20	20	20	25	20	20
	C/C	150	150	150	150	150	150	225	150	150
	LENGTH	4780	4780	4780	4790	4800	4820	4830	4910	4990
H BARS	C/C	350	400	400	350	325	325	450	300	300
	LENGTH	2030	2630	2730	2810	2830	2850	2410	2870	2730
J BARS	SIZE	20	20	20	20	20	20	25	20	20
	C/C	350	400	400	350	325	325	450	300	300
	LENGTH	4090	3790	3740	3710	3710	3740	4120	3870	4070
	B	1660	1360	1310	1280	1270	1260	1470	1240	1310
	D	2060	2060	2060	2060	2060	2060	2200	2060	2060
	R	235	235	235	235	245	265	285	365	445
K BARS	SIZE	20	20	20	20	20	20	25	20	20
	C/C	350	400	400	350	325	325	450	300	300
	LENGTH	3420	3240	3210	3200	3210	3250	3440	3530	3750
	B	990	810	780	770	770	770	790	900	990
	D	2060	2060	2060	2060	2060	2060	2200	2060	2060
	R	235	235	235	235	245	265	285	365	445
S BARS	LENGTH	1250	1250	1270	1320	1410	1480	1620	2020	2340
	C	890	890	910	960	1050	1120	1260	1660	1980
T BARS*	LENGTH	3000*	3000*	3000*	3000	3000	3000	3000	3000	3000
U BARS	LENGTH	1290	1290	1290	1310	1350	1440	1510	1850	2190
	C	930	930	930	950	990	1080	1150	1490	1830
Q BARS	SIZE	20	20	20	20	25	25	25	25	25
	C/C	150	175	150	150	225	225	175	200	150
	LENGTH	4780	4780	4780	4790	4800	4820	4830	4910	4990
R BARS	# SETS	110	110	112	112	112	112	114	118	120

*T BARS to be Size 20M. Modify drawing SS114-2 accordingly.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 108

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	280	280	290	290	300	310	320	420	480
	T	310	310	310	310	320	340	360	450	520
	B	310	320	320	360	400	400	480	580	670
QUANTITIES	STEEL	643.3	585.2	603.4	624.5	652.4	681.1	734.5	730	795.2
	CONC.	5.3	5.3	5.4	5.6	6	6.2	6.8	8.8	10.4
P BARS	SIZE	25	20	20	20	20	25	25	25	25
	C/C	225	150	150	150	150	225	200	225	225
	LENGTH	4780	4780	4790	4790	4800	4810	4820	4920	4980
H BARS	C/C	-	300	400	375	350	325	300	325	300
	LENGTH	-	1990	2450	2630	2670	2710	2710	2610	2450
J BARS	SIZE	20	15	20	20	20	20	20	20	20
	C/C	375	300	400	375	350	325	300	325	300
	LENGTH	5490	4220	4140	4050	4040	4050	4070	4270	4450
	B	2810	1680	1460	1370	1350	1320	1310	1370	1440
	D	2310	2170	2310	2310	2310	2310	2310	2310	2310
	R	235	235	235	235	245	265	285	375	445
K BARS	SIZE	20	15	20	20	20	20	20	20	20
	C/C	375	300	400	375	350	325	300	325	300
	LENGTH	3920	3540	3570	3550	3570	3590	3660	3880	4070
	B	1240	1000	890	870	880	860	900	980	1060
	D	2310	2170	2310	2310	2310	2310	2310	2310	2310
	R	235	235	235	235	245	265	285	375	445
S BARS	LENGTH	1250	1270	1280	1340	1420	1460	1620	2030	2340
	C	890	910	920	980	1060	1100	1260	1670	1980
T BARS	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
U BARS	LENGTH	1290	1290	1310	1310	1350	1420	1490	1890	2170
	C	930	930	950	950	990	1060	1130	1530	1810
Q BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	150	150	150	225	200	200	175	175	150
	LENGTH	4780	4780	4790	4790	4800	4810	4820	4920	4980
R BARS	# SETS	118	120	120	120	120	120	122	124	128

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 109

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 4.50

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	300	310	340	340	370	460	490
	T	300	300	300	310	340	350	400	480	520
	B	340	330	330	370	410	460	500	630	700
QUANTITIES	STEEL	687.6	616.6	647.9	664.8	655.3	698.5	718.9	752.4	809.3
	CONC.	5.8	5.7	5.8	6.2	6.8	7.2	8	10.2	11.1
P BARS	SIZE	25	20	20	20	20	20	25	20	25
	C/C	225	150	150	150	150	150	225	150	225
	LENGTH	4790	4790	4800	4810	4840	4840	4870	4960	4990
H BARS	C/C	-	-	400	375	400	350	350	350	325
	LENGTH	-	-	1810	1890	2030	2110	2130	2010	1990
J BARS	SIZE	20	15	20	20	20	20	20	20	20
	C/C	375	300	400	375	400	350	350	350	325
	LENGTH	5720	5440	4710	4690	4670	4630	4680	4880	4940
	B	2810	2670	1800	1760	1690	1640	1610	1680	1680
	D	2560	2420	2560	2560	2560	2560	2560	2560	2560
	R	225	225	225	235	265	275	325	405	445
K BARS	SIZE	20	15	20	20	20	20	20	20	20
	C/C	375	300	400	375	400	350	350	350	325
	LENGTH	4260	3950	3980	4000	4030	4040	4130	4360	4450
	B	1350	1180	1070	1070	1050	1050	1060	1160	1190
	D	2560	2420	2560	2560	2560	2560	2560	2560	2560
	R	225	225	225	235	265	275	325	405	445
S BARS	LENGTH	1300	1280	1300	1380	1520	1610	1780	2200	2400
	C	940	920	940	1020	1160	1250	1420	1840	2040
T BARS	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
U BARS	LENGTH	1280	1280	1290	1340	1460	1490	1680	2030	2190
	C	920	920	930	980	1100	1130	1320	1670	1830
Q BARS	SIZE	25	20	25	25	25	25	25	25	25
	C/C	225	150	225	225	225	200	200	175	150
	LENGTH	4790	4790	4800	4810	4840	4840	4870	4960	4990
R BARS	# SETS	128	128	128	128	128	128	130	134	134

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 110

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	290	300	310	310	360	440	510
	T	310	300	310	320	340	350	390	480	540
	B	310	300	320	340	380	440	520	630	700
QUANTITIES	STEEL	652.2	616	619.2	678.6	683.6	715.8	761	785.7	847.7
	CONC.	4.8	4.7	4.9	5.1	5.5	5.9	6.9	8.7	10.1
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	175	175	150	150	150	150	150	150
	LENGTH	5290	5290	5290	5300	5310	5310	5360	5440	5510
H BARS	C/C	400	425	425	375	375	350	325	325	325
	LENGTH	2630	2730	2790	2850	2850	2850	2870	2830	2810
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	425	375	375	350	325	325	325
	LENGTH	3690	3630	3610	3590	3620	3620	3680	3840	3950
	B	1620	1580	1540	1510	1500	1490	1490	1500	1520
	D	1700	1700	1700	1700	1700	1700	1700	1700	1700
	R	235	225	235	245	265	275	315	405	465
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	425	375	375	350	325	325	325
	LENGTH	2930	2860	2850	2850	2890	2900	3010	3280	3460
	B	860	810	780	770	770	770	820	940	1030
	D	1700	1700	1700	1700	1700	1700	1700	1700	1700
	R	235	225	235	245	265	275	315	405	465
S BARS	LENGTH	1270	1240	1280	1340	1440	1540	1780	2170	2450
	C	910	880	920	980	1080	1180	1420	1810	2090
T BARS	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
U BARS	LENGTH	1310	1280	1310	1350	1420	1450	1630	2000	2270
	C	950	920	950	990	1060	1090	1270	1640	1910
Q BARS	SIZE	20	20	20	20	20	25	25	20	25
	C/C	175	175	175	150	150	225	225	150	175
	LENGTH	5290	5290	5290	5300	5310	5310	5360	5440	5510
R BARS	# SETS	108	106	108	108	108	108	112	114	116

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 111

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	280	280	290	290	310	320	390	450	520
	T	310	300	320	320	340	350	420	470	560
	B	310	310	330	350	430	450	560	650	700
QUANTITIES	STEEL	689	633.5	638.4	687.4	712.5	751.9	771.1	794.8	880.8
	CONC.	5	5	5.3	5.4	6.1	6.4	8	9.3	10.8
P BARS	SIZE	25	20	20	20	20	25	20	20	20
	C/C	225	150	150	150	150	225	150	150	150
	LENGTH	5280	5280	5290	5290	5310	5320	5390	5450	5520
H BARS	C/C	425	300	300	425	400	375	375	375	350
	LENGTH	2610	3170	3250	2870	2850	2870	2850	2890	2850
J BARS	SIZE	25	20	20	25	25	25	25	25	25
	C/C	425	300	300	425	400	375	375	375	350
	LENGTH	3940	3510	3490	3820	3870	3870	3990	4060	4200
	B	1620	1350	1300	1490	1500	1490	1500	1490	1490
	D	1950	1810	1810	1950	1950	1950	1950	1950	1950
	R	235	225	245	245	265	275	345	395	485
K BARS	SIZE	25	20	20	25	25	25	25	25	25
	C/C	425	300	300	425	400	375	375	375	350
	LENGTH	3180	2960	2950	3070	3140	3150	3340	3500	3730
	B	860	800	760	740	770	770	850	930	1020
	D	1950	1810	1810	1950	1950	1950	1950	1950	1950
	R	235	225	245	245	265	275	345	395	485
S BARS	LENGTH	1250	1240	1310	1340	1510	1560	1920	2200	2500
	C	890	880	950	980	1150	1200	1560	1840	2140
T BARS	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
U BARS	LENGTH	1290	1270	1340	1340	1420	1460	1760	1990	2340
	C	930	910	980	980	1060	1100	1400	1630	1980
Q BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	150	150	150	225	225	200	200	200	150
	LENGTH	5280	5280	5290	5290	5310	5320	5390	5450	5520
R BARS	# SETS	114	114	116	116	116	114	118	122	122

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 112

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	290	300	310	320	380	450	540
	T	320	320	320	320	340	350	410	480	580
	B	320	320	320	370	430	460	560	660	740
QUANTITIES	STEEL	705	653	656.5	698	729.8	797.2	808.3	833	884.7
	CONC.	5.5	5.5	5.5	5.9	6.4	6.7	8.2	9.9	11.9
P BARS	SIZE	25	20	20	25	25	25	25	25	25
	C/C	225	150	150	225	225	200	225	225	225
	LENGTH	5290	5290	5290	5300	5310	5320	5380	5450	5540
H BARS	C/C	300	350	325	300	450	400	400	400	400
	LENGTH	2670	3110	3190	3250	2830	2850	2830	2870	2850
J BARS	SIZE	20	20	20	20	25	25	25	25	25
	C/C	300	350	325	300	450	400	400	400	400
	LENGTH	4030	3810	3770	3750	4130	4130	4240	4330	4480
	B	1590	1370	1330	1310	1510	1500	1510	1490	1490
	D	2060	2060	2060	2060	2200	2200	2200	2200	2200
	R	245	245	245	245	265	275	335	405	505
K BARS	SIZE	20	20	20	20	25	25	25	25	25
	C/C	300	350	325	300	450	400	400	400	400
	LENGTH	3400	3270	3230	3230	3400	3420	3600	3810	4070
	B	960	830	790	790	780	790	870	970	1080
	D	2060	2060	2060	2060	2200	2200	2200	2200	2200
	R	245	245	245	245	265	275	335	405	505
S BARS	LENGTH	1300	1300	1300	1380	1510	1580	1890	2230	2610
	C	940	940	940	1020	1150	1220	1530	1870	2250
T BARS*	LENGTH	3000*	3000*	3000	3000	3000	3000	3000	3000	3000
U BARS	LENGTH	1340	1340	1340	1350	1420	1460	1720	2020	2430
	C	980	980	980	990	1060	1100	1360	1660	2070
Q BARS	SIZE	20	20	25	25	25	25	25	25	25
	C/C	150	150	225	200	200	175	175	175	150
	LENGTH	5290	5290	5290	5300	5310	5320	5380	5450	5540
R BARS	# SETS	120	120	120	120	120	122	124	126	128

*T BARS to be Size 20M. Modify drawing SS114-2 accordingly.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 113

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00
HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	290	290	310	330	390	460	540
	T	310	310	320	320	340	360	420	490	580
	B	320	320	350	410	450	480	560	660	770
QUANTITIES	STEEL	724.4	676.7	683.8	735	740.4	804.6	820.2	887.1	928.8
	CONC.	5.7	5.7	6	6.3	6.8	7.3	8.7	10.5	12.7
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	225	225	225	225	200	200	200	225
	LENGTH	5290	5290	5290	5290	5310	5330	5390	5460	5540
H BARS	C/C	325	350	350	300	300	450	450	425	425
	LENGTH	1990	2710	3030	3110	3170	2770	2790	2770	2810
J BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	325	350	350	300	300	450	450	425	425
	LENGTH	4620	4260	4100	4060	4070	4440	4520	4640	4750
	B	1940	1580	1410	1370	1340	1540	1530	1540	1510
	D	2310	2310	2310	2310	2310	2450	2450	2450	2450
	R	235	235	245	245	265	285	345	415	505
K BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	325	350	350	300	300	450	450	425	425
	LENGTH	3810	3630	3570	3580	3630	3800	3930	4140	4380
	B	1130	950	880	890	900	900	940	1040	1140
	D	2310	2310	2310	2310	2310	2450	2450	2450	2450
	R	235	235	245	245	265	285	345	415	505
S BARS	LENGTH	1280	1280	1340	1420	1540	1630	1920	2260	2650
	C	920	920	980	1060	1180	1270	1560	1900	2290
T BARS	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
U BARS	LENGTH	1310	1310	1340	1340	1420	1510	1760	2060	2430
	C	950	950	980	980	1060	1150	1400	1700	2070
Q BARS	SIZE	25	20	25	25	25	25	25	25	25
	C/C	225	150	225	200	200	175	175	150	125
	LENGTH	5290	5290	5290	5290	5310	5330	5390	5460	5540
R BARS	# SETS	128	128	128	128	128	130	130	134	134

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 114

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.00

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	290	290	290	310	330	350	400	480	550
	T	320	310	310	340	360	380	430	510	580
	B	350	340	380	440	480	510	580	720	800
QUANTITIES	STEEL	778.9	726.6	756	759.1	763.3	808.8	833.1	867.1	931
	CONC.	6.3	6.1	6.4	7.1	7.7	8.2	9.4	11.7	13.5
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	225	225	225	225	225	200	225	200
	LENGTH	5290	5290	5290	5310	5330	5350	5400	5480	5550
H BARS	C/C	-	350	325	325	325	300	300	300	300
	LENGTH	-	1930	2190	2510	2590	2650	2670	2570	2430
J BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	325	350	325	325	325	300	300	300	300
	LENGTH	6000	4900	4770	4650	4640	4640	4710	4880	5060
	B	3060	1970	1840	1670	1630	1600	1590	1640	1710
	D	2560	2560	2560	2560	2560	2560	2560	2560	2560
	R	245	235	235	265	285	305	355	435	505
K BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	325	350	325	325	325	300	300	300	300
	LENGTH	4330	4090	4040	4040	4070	4100	4210	4420	4610
	B	1390	1160	1110	1060	1060	1060	1090	1180	1260
	D	2560	2560	2560	2560	2560	2560	2560	2560	2560
	R	245	235	235	265	285	305	355	435	505
S BARS	LENGTH	1340	1310	1370	1520	1630	1730	1970	2400	2710
	C	980	950	1010	1160	1270	1370	1610	2040	2350
T BARS	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
U BARS	LENGTH	1340	1310	1310	1420	1510	1590	1800	2140	2440
	C	980	950	950	1060	1150	1230	1440	1780	2080
Q BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	225	225	200	200	200	175	175	150	125
	LENGTH	5290	5290	5290	5310	5330	5350	5400	5480	5550
R BARS	# SETS	136	136	136	136	136	138	138	140	142

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 115

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50
HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	320	290	300	320	350	390	440	540	620
	T	350	320	330	350	380	420	470	570	640
	B	320	330	360	390	450	460	550	640	730
QUANTITIES	STEEL	713.2	704.5	740.1	741.9	756.4	791.2	856.4	869.1	949.6
	CONC.	5.6	5.3	5.6	6.1	6.8	7.4	8.7	10.8	12.5
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	150	150	150	150	150	150	175	175
	LENGTH	5820	5790	5800	5820	5850	5890	5940	6040	6120
H BARS	C/C	375	375	350	350	350	325	300	300	300
	LENGTH	2990	3110	3190	3210	3270	3250	3250	3210	2990
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	375	350	350	350	325	300	300	300
	LENGTH	3810	3700	3680	3700	3720	3790	3870	4050	4280
	B	1680	1620	1580	1570	1540	1550	1550	1570	1690
	D	1700	1700	1700	1700	1700	1700	1700	1700	1700
	R	275	245	255	275	305	345	395	495	565
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	375	350	350	350	325	300	300	300
	LENGTH	3090	2960	2950	2980	3040	3140	3280	3580	3790
	B	960	880	850	850	860	900	960	1100	1200
	D	1700	1700	1700	1700	1700	1700	1700	1700	1700
	R	275	245	255	275	305	345	395	495	565
S BARS	LENGTH	1380	1310	1380	1480	1650	1780	2040	2450	2790
	C	1020	950	1020	1120	1290	1420	1680	2090	2430
T BARS	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
U BARS	LENGTH	1460	1340	1380	1460	1590	1760	1970	2400	2710
	C	1100	980	1020	1100	1230	1400	1610	2040	2350
Q BARS	SIZE	20	20	20	20	20	20	25	20	25
	C/C	175	175	150	150	150	150	225	150	175
	LENGTH	5820	5790	5800	5820	5850	5890	5940	6040	6120
R BARS	# SETS	114	116	116	114	118	116	120	120	126

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 116

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50
HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	320	290	300	320	350	390	440	530	610
	T	350	320	330	350	380	420	470	570	640
	B	320	330	360	400	450	460	550	650	730
QUANTITIES	STEEL	709.4	716.9	756	774.4	789.8	790.1	859.7	950.1	986.5
	CONC.	6	5.6	5.9	6.5	7.2	7.8	9.1	11.3	13.1
P BARS	SIZE	20	20	25	25	25	20	25	20	20
	C/C	150	150	225	225	225	150	225	150	150
	LENGTH	5820	5790	5800	5820	5850	5890	5940	6030	6110
H BARS	C/C	425	425	400	375	375	375	350	325	325
	LENGTH	2990	3130	3210	3270	3270	3290	3290	3270	3170
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	425	425	400	375	375	375	350	325	325
	LENGTH	4060	3940	3920	3920	3970	4020	4100	4260	4430
	B	1680	1610	1570	1540	1540	1530	1530	1530	1590
	D	1950	1950	1950	1950	1950	1950	1950	1950	1950
	R	275	245	255	275	305	345	395	495	565
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	425	425	400	375	375	375	350	325	325
	LENGTH	3340	3190	3180	3210	3280	3370	3500	3780	3980
	B	960	860	830	830	850	880	930	1050	1140
	D	1950	1950	1950	1950	1950	1950	1950	1950	1950
	R	275	245	255	275	305	345	395	495	565
S BARS	LENGTH	1380	1310	1380	1490	1650	1780	2040	2450	2780
	C	1020	950	1020	1130	1290	1420	1680	2090	2420
T BARS	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
U BARS	LENGTH	1460	1340	1380	1460	1590	1760	1970	2380	2690
	C	1100	980	1020	1100	1230	1400	1610	2020	2330
Q BARS	SIZE	20	20	25	25	25	25	25	25	25
	C/C	175	150	225	225	225	225	200	150	150
	LENGTH	5820	5790	5800	5820	5850	5890	5940	6030	6110
R BARS	# SETS	120	124	124	120	124	124	128	128	134

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 117

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	320	300	300	330	360	390	430	530	610
	T	350	320	330	360	390	420	470	570	640
	B	320	330	360	420	490	500	570	690	770
QUANTITIES	STEEL	771.4	715	780.7	785.5	800	827.3	896.6	945	1033
	CONC.	6.3	6	6.2	7	7.9	8.5	9.6	12.1	14
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	225	225	225	225	225	225	200	225	225
	LENGTH	5820	5800	5800	5830	5860	5890	5930	6030	6110
H BARS	C/C	450	300	425	425	425	400	375	375	350
	LENGTH	2930	3510	3210	3250	3250	3290	3270	3290	3230
J BARS	SIZE	25	20	25	25	25	25	25	25	25
	C/C	450	300	425	425	425	400	375	375	350
	LENGTH	4340	3870	4170	4200	4240	4270	4350	4500	4650
	B	1710	1430	1570	1550	1550	1530	1530	1520	1560
	D	2200	2060	2200	2200	2200	2200	2200	2200	2200
	R	275	245	255	285	315	345	395	495	565
K BARS	SIZE	25	20	25	25	25	25	25	25	25
	C/C	450	300	425	425	425	400	375	375	350
	LENGTH	3630	3320	3430	3490	3560	3630	3750	4060	4260
	B	1000	880	830	840	870	890	930	1080	1170
	D	2200	2060	2200	2200	2200	2200	2200	2200	2200
	R	275	245	255	285	315	345	395	495	565
S BARS	LENGTH	1380	1320	1380	1550	1730	1830	2060	2510	2840
	C	1020	960	1020	1190	1370	1470	1700	2150	2480
T BARS*	LENGTH	3000*	3000	3000	3000	3000	3000	3000	3000	3000
U BARS	LENGTH	1460	1350	1380	1510	1630	1760	1960	2380	2690
	C	1100	990	1020	1150	1270	1400	1600	2020	2330
Q BARS	SIZE	20	20	25	25	25	25	25	25	25
	C/C	150	150	200	200	200	200	175	150	125
	LENGTH	5820	5800	5800	5830	5860	5890	5930	6030	6110
R BARS	# SETS	126	128	128	126	130	130	132	136	138

*T BARS to be Size 20M. Modify drawing SS114-2 accordingly.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 118

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	320	290	300	330	360	380	430	530	610
	T	350	320	330	360	390	420	470	570	640
	B	340	350	390	450	490	500	580	690	770
QUANTITIES	STEEL	788.4	786.3	787.2	810.8	836.9	870.8	935.8	1000.7	1106.6
	CONC.	6.7	6.3	6.7	7.6	8.3	8.8	10.1	12.6	14.6
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	200	200	225	225	200	200	200	200
	LENGTH	5820	5790	5800	5830	5860	5880	5930	6030	6110
H BARS	C/C	300	300	300	450	450	425	400	400	375
	LENGTH	2410	3310	3510	3170	3210	3230	3230	3290	3130
J BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	300	300	450	450	425	400	400	375
	LENGTH	4710	4210	4130	4490	4510	4540	4620	4750	4950
	B	1970	1520	1420	1590	1570	1550	1550	1520	1610
	D	2310	2310	2310	2450	2450	2450	2450	2450	2450
	R	275	245	255	285	315	345	395	495	565
K BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	300	300	450	450	425	400	400	375
	LENGTH	3900	3630	3620	3820	3870	3910	4050	4330	4530
	B	1160	940	910	920	930	920	980	1100	1190
	D	2310	2310	2310	2450	2450	2450	2450	2450	2450
	R	275	245	255	285	315	345	395	495	565
S BARS	LENGTH	1410	1340	1420	1590	1730	1820	2070	2510	2840
	C	1050	980	1060	1230	1370	1460	1710	2150	2480
T BARS	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
U BARS	LENGTH	1460	1340	1380	1510	1630	1750	1960	2380	2690
	C	1100	980	1020	1150	1270	1390	1600	2020	2330
Q BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	225	200	200	200	175	175	150	125	100
	LENGTH	5820	5790	5800	5830	5860	5880	5930	6030	6110
R BARS	# SETS	134	136	136	136	138	136	140	142	146

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 119

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 5.50

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	300	300	320	340	370	370	450	520	610
	T	340	330	350	370	400	410	490	560	650
	B	350	360	420	470	530	550	650	690	790
QUANTITIES	STEEL	879.9	808.5	802.5	849.9	848.2	892.1	922.4	1015.6	1093.1
	CONC.	6.8	6.8	7.5	8.2	9.1	9.3	11.4	13	15.4
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	175	200	200	200	225	200	200	200	200
	LENGTH	5800	5800	5820	5840	5870	5870	5950	6020	6110
H BARS	C/C	-	325	325	300	300	450	450	425	425
	LENGTH	-	2550	3010	3110	3150	3130	3130	3110	2890
J BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	300	325	325	300	300	450	450	425	425
	LENGTH	6290	4860	4660	4640	4670	4830	4950	5070	5320
	B	3310	1900	1670	1620	1600	1600	1600	1610	1720
	D	2560	2560	2560	2560	2560	2700	2700	2700	2700
	R	265	255	275	295	325	335	415	485	575
K BARS	SIZE	20	20	20	20	20	25	25	25	25
	C/C	300	325	325	300	300	450	450	425	425
	LENGTH	4500	4090	4040	4070	4140	4290	4460	4610	4860
	B	1520	1130	1050	1050	1070	1060	1110	1150	1260
	D	2560	2560	2560	2560	2560	2700	2700	2700	2700
	R	265	255	275	295	325	335	415	485	575
S BARS	LENGTH	1380	1380	1520	1650	1820	1860	2230	2480	2880
	C	1020	1020	1160	1290	1460	1500	1870	2120	2520
T BARS	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
U BARS	LENGTH	1410	1380	1460	1550	1680	1700	2040	2340	2720
	C	1050	1020	1100	1190	1320	1340	1680	1980	2360
Q BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	200	200	175	175	175	175	125	100
	LENGTH	5800	5800	5820	5840	5870	5870	5950	6020	6110
R BARS	# SETS	144	144	140	142	144	144	150	150	150

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 120

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 2.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	330	310	330	360	410	420	510	630	780
	T	370	340	360	390	440	450	510	580	660
	B	350	350	370	450	480	490	610	700	810
QUANTITIES	STEEL	773.1	777.1	805.8	819.3	832.9	881.8	903.5	939.4	1041.1
	CONC.	6.4	6	6.4	7.4	8.3	8.5	10.4	12.5	15.1
P BARS	SIZE	20	20	20	20	20	20	20	20	20
	C/C	150	150	150	150	150	150	150	150	175
	LENGTH	6330	6310	6330	6360	6410	6420	6510	6630	6780
H BARS	C/C	350	350	325	325	325	300	300	300	300
	LENGTH	3370	3470	3570	3630	3610	3630	3610	3530	3450
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	350	350	325	325	325	300	300	300	300
	LENGTH	3890	3810	3790	3800	3890	3900	4030	4230	4470
	B	1730	1690	1640	1610	1620	1610	1650	1740	1850
	D	1700	1700	1700	1700	1700	1700	1700	1700	1700
	R	295	265	285	315	365	375	435	505	585
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	350	350	325	325	325	300	300	300	300
	LENGTH	3190	3080	3080	3120	3260	3280	3470	3690	3950
	B	1030	960	930	930	990	990	1090	1200	1330
	D	1700	1700	1700	1700	1700	1700	1700	1700	1700
	R	295	265	285	315	365	375	435	505	585
S BARS	LENGTH	1460	1390	1480	1680	1860	1900	2290	2680	3160
	C	1100	1030	1120	1320	1500	1540	1930	2320	2800
T BARS	LENGTH	2000	2000	2000	2000	2000	2000	2000	2000	2000
U BARS	LENGTH	1540	1420	1510	1630	1850	1890	2190	2550	2990
	C	1180	1060	1150	1270	1490	1530	1830	2190	2630
Q BARS	SIZE	20	20	20	20	20	25	20	20	25
	C/C	175	150	150	150	150	225	150	150	150
	LENGTH	6330	6310	6330	6360	6410	6420	6510	6630	6780
R BARS	# SETS	120	120	120	124	122	124	128	130	134

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 121

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 2.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	330	310	330	360	400	410	480	580	700
	T	380	340	360	390	440	450	510	620	680
	B	350	350	390	450	510	530	610	750	850
QUANTITIES	STEEL	812.4	802.8	813.6	851.5	857	914.3	969.4	1061.7	1090.5
	CONC.	6.8	6.3	6.9	7.7	8.8	9.1	10.7	13.5	15.7
P BARS	SIZE	25	25	25	25	20	25	25	25	20
	C/C	225	225	225	225	150	225	225	225	150
	LENGTH	6330	6310	6330	6360	6400	6410	6480	6580	6700
H BARS	C/C	375	375	375	350	350	325	300	300	300
	LENGTH	3370	3510	3610	3650	3670	3690	3690	3530	3370
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	375	375	350	350	325	300	300	300
	LENGTH	4150	4040	4020	4040	4100	4110	4210	4460	4690
	B	1720	1670	1620	1600	1580	1570	1580	1650	1790
	D	1950	1950	1950	1950	1950	1950	1950	1950	1950
	R	305	265	285	315	365	375	435	545	605
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	375	375	375	350	350	325	300	300	300
	LENGTH	3460	3310	3310	3360	3470	3500	3650	3990	4200
	B	1030	940	910	920	950	960	1020	1180	1300
	D	1950	1950	1950	1950	1950	1950	1950	1950	1950
	R	305	265	285	315	365	375	435	545	605
S BARS	LENGTH	1480	1390	1510	1680	1890	1950	2240	2740	3130
	C	1120	1030	1150	1320	1530	1590	1880	2380	2770
T BARS	LENGTH	2500	2500	2500	2500	2500	2500	2500	2500	2500
U BARS	LENGTH	1560	1420	1510	1630	1830	1870	2140	2600	2940
	C	1200	1060	1150	1270	1470	1510	1780	2240	2580
Q BARS	SIZE	20	20	25	25	25	25	25	25	25
	C/C	150	150	225	225	225	200	200	150	150
	LENGTH	6330	6310	6330	6360	6400	6410	6480	6580	6700
R BARS	# SETS	126	128	126	130	132	132	132	136	140

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 122

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 3.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	320	320	330	350	400	410	470	560	700
	T	360	350	360	380	440	450	510	600	700
	B	350	350	420	450	520	550	650	750	880
QUANTITIES	STEEL	846.6	805.7	841	887.9	892.9	951.1	1005.4	1065	1140.5
	CONC.	6.9	6.8	7.4	7.9	9.3	9.7	11.4	13.7	16.9
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	225	225	200	225	200	200	200	225
	LENGTH	6320	6320	6330	6350	6400	6410	6470	6560	6700
H BARS	C/C	400	425	400	375	375	350	325	325	325
	LENGTH	3350	3530	3610	3670	3670	3690	3690	3670	3390
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	400	375	375	350	325	325	325
	LENGTH	4390	4290	4270	4270	4350	4360	4450	4600	4940
	B	1740	1660	1620	1590	1580	1570	1570	1580	1760
	D	2200	2200	2200	2200	2200	2200	2200	2200	2200
	R	285	275	285	305	365	375	435	525	625
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	400	425	400	375	375	350	325	325	325
	LENGTH	3680	3570	3560	3590	3720	3740	3900	4170	4480
	B	1030	940	910	910	950	950	1020	1150	1300
	D	2200	2200	2200	2200	2200	2200	2200	2200	2200
	R	285	275	285	305	365	375	435	525	625
S BARS	LENGTH	1440	1420	1550	1650	1900	1970	2290	2680	3200
	C	1080	1060	1190	1290	1540	1610	1930	2320	2840
T BARS	LENGTH	3000	3000	3000	3000	3000	3000	3000	3000	3000
U BARS	LENGTH	1490	1460	1510	1590	1830	1870	2130	2510	2990
	C	1130	1100	1150	1230	1470	1510	1770	2150	2630
Q BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	225	225	200	200	200	175	175	150	125
	LENGTH	6320	6320	6330	6350	6400	6410	6470	6560	6700
R BARS	# SETS	132	132	132	136	138	136	138	140	146

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 123

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 3.50

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	320	310	330	360	390	410	450	530	650
	T	360	340	360	390	430	450	490	580	700
	B	360	360	410	470	520	570	680	780	900
QUANTITIES	STEEL	879.9	851.2	872.8	924.9	934.9	965.5	1053.7	1170.8	1202.9
	CONC.	7.3	7	7.7	8.6	9.5	10.2	11.7	14	17.2
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	175	200	200	200	200	200	175	175	200
	LENGTH	6320	6310	6330	6360	6390	6410	6450	6530	6650
H BARS	C/C	450	450	425	400	400	375	350	350	350
	LENGTH	3150	3450	3570	3630	3650	3650	3650	3670	3410
J BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	450	450	425	400	400	375	350	350	350
	LENGTH	4740	4570	4540	4550	4600	4630	4690	4810	5130
	B	1840	1700	1640	1610	1590	1590	1590	1570	1700
	D	2450	2450	2450	2450	2450	2450	2450	2450	2450
	R	285	265	285	315	355	375	415	505	625
K BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	450	450	425	400	400	375	350	350	350
	LENGTH	4000	3840	3840	3890	3970	4020	4150	4400	4720
	B	1100	970	940	950	960	980	1050	1160	1290
	D	2450	2450	2450	2450	2450	2450	2450	2450	2450
	R	285	265	285	315	355	375	415	505	625
S BARS	LENGTH	1450	1410	1540	1710	1880	2000	2270	2650	3160
	C	1090	1050	1180	1350	1520	1640	1910	2290	2800
T BARS	LENGTH	3500	3500	3500	3500	3500	3500	3500	3500	3500
U BARS	LENGTH	1490	1420	1510	1630	1790	1870	2040	2410	2920
	C	1130	1060	1150	1270	1430	1510	1680	2050	2560
Q BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	200	200	175	175	175	150	100	100
	LENGTH	6320	6310	6330	6360	6390	6410	6450	6530	6650
R BARS	# SETS	140	140	140	144	144	144	146	148	152

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

RIGID FRAME BOX CULVERTS

Page 124

DETAILING TABLE DIMENSIONS & QUANTITIES

SPAN: 6.00

HEIGHT: 4.00

		FILL HEIGHT								
		0.6	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
DIMENSIONS	W	340	320	340	360	400	410	480	590	670
	T	370	350	370	390	440	460	530	630	720
	B	370	390	440	490	560	590	690	820	930
QUANTITIES	STEEL	894.7	863.1	885.5	941.6	937	1025.5	1050.5	1136	1240.6
	CONC.	7.9	7.7	8.4	9.1	10.4	10.9	12.9	15.9	18.5
P BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	175	200	200	200	200	175	175	200	175
	LENGTH	6340	6320	6340	6360	6400	6410	6480	6590	6670
H BARS	C/C	300	300	300	425	450	400	400	375	375
	LENGTH	2430	3190	3550	3550	3570	3570	3570	3410	3190
J BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	300	300	425	450	400	400	375	375
	LENGTH	5230	4820	4670	4840	4900	4920	5030	5280	5520
	B	2210	1830	1650	1650	1630	1620	1620	1710	1810
	D	2560	2560	2560	2700	2700	2700	2700	2700	2700
	R	295	275	295	315	365	385	455	555	645
K BARS	SIZE	20	20	20	25	25	25	25	25	25
	C/C	300	300	300	425	450	400	400	375	375
	LENGTH	4310	4090	4070	4240	4350	4360	4550	4840	5080
	B	1290	1100	1050	1050	1080	1060	1140	1270	1370
	D	2560	2560	2560	2700	2700	2700	2700	2700	2700
	R	295	275	295	315	365	385	455	555	645
S BARS	LENGTH	1510	1480	1610	1730	1960	2040	2380	2860	3260
	C	1150	1120	1250	1370	1600	1680	2020	2500	2900
T BARS	LENGTH	4000	4000	4000	4000	4000	4000	4000	4000	4000
U BARS	LENGTH	1550	1460	1550	1630	1830	1900	2200	2640	3010
	C	1190	1100	1190	1270	1470	1540	1840	2280	2650
Q BARS	SIZE	25	25	25	25	25	25	25	25	25
	C/C	200	200	175	175	175	150	150	125	100
	LENGTH	6340	6320	6340	6360	6400	6410	6480	6590	6670
R BARS	# SETS	146	146	148	150	152	152	154	158	160

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 7 - NON-RIGID FRAME BOX CULVERTS

August 2003

7 NON-RIGID FRAME BOX CULVERTS**7.1 GENERAL**

These culverts differ from standard rigid frame box culverts as there are no haunches at the corners, slabs and walls have only one layer of steel in each direction and all steel is straight (except for apron dowels). Note that these culverts are designed to accommodate fill heights of up to 5 .0 metres.

7.2 CULVERT DIMENSIONS AND REINFORCEMENT

Dimensions and detailing information for standard non-rigid frame box culverts are given in Figure 7.2(a). Construction joints indicated are optional and are provided for the contractor's convenience.

Reinforcing details for standard non-rigid frame box culverts are shown in Figure 7.2(b). Table 7-2 identifies the various bar types used in these culverts.

Detailing information listed in the detailing table at the end of this division should be read in conjunction with Figure 7.2(a) and (b) and Table 7-2.

Details of apron walls are provided in Division 8.

FIGURE 7.2(a) NON-RIGID FRAME BOX CULVERT DIMENSIONS

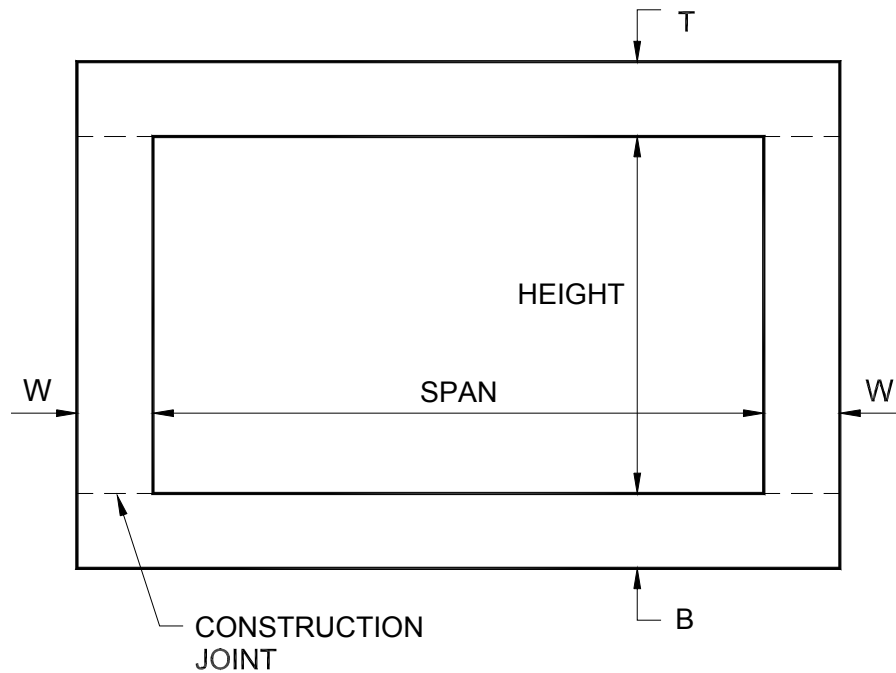
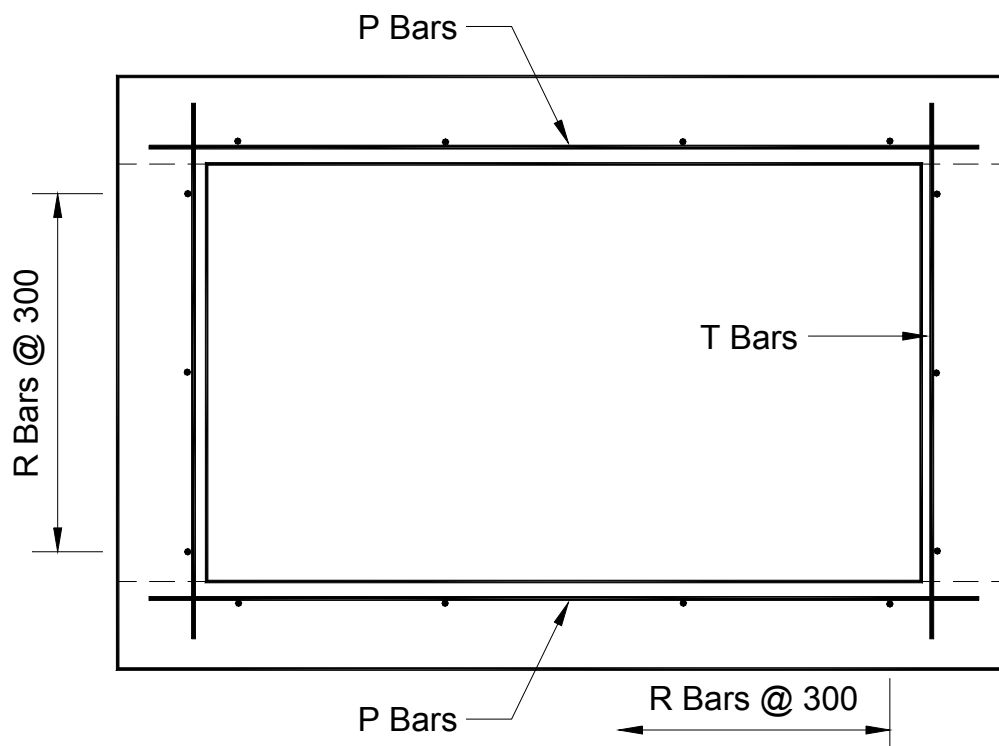


FIGURE 7.2(b) NON-RIGID FRAME BOX CULVERT REINFORCEMENT



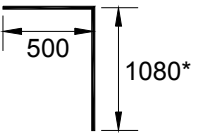
CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

NON-RIGID FRAME BOX CULVERTS

Page 127

TABLE 7-2 REINFORCING STEEL IDENTIFICATION

MARK	DETAILS	REMARKS
P BARS	STRAIGHT	BOTTOM AND TOP SLAB INSIDE FACE
T BARS	STRAIGHT	INSIDE FACE OF WALLS
R BARS	STRAIGHT	15M BARS LONGITUDINAL
L BARS		15M BARS DOWELS TO APRON WALL
M BARS	STRAIGHT	15M BARS, APRON WALL

*NOTE: -All dimensions shown to centreline of bar.
-* represents vertical dimension*

7.3 DETAILING OF BOX CULVERT DRAWINGS

7.3.1 DETAILS FOR STANDARD DRAWINGS

The following is a suggested procedure for completing the structural standard drawings for standard non-rigid frame box culvert, SS114-3, without skewed ends, retaining walls or other special features.

- Obtain culvert size, length, and height of fill from Culvert Data Sheet.
- Select appropriate structural standard drawing.
- Determine from Culvert Data Sheet whether culvert is extension or not:

If culvert is an extension, change vertical centreline on left side of section Detail 1 to a solid line and label - "END OF EXISTING CULVERT". Insert length of culvert extension on the horizontal dimension line:

e.g. 9 m RT
11 m LT

If culvert is not an extension, label centreline "Centre-Line Highway" and add culvert length each side of Centre-Line Highway

e.g. 16 m RT
17 m LT

- Select from Division 7 appropriate detailing table for required size of culvert.
- Insert span and height of culvert and dimensions of top slab, bottom slab and walls on "Typical Culvert Section" detail.
- Insert bar size and /or spacing for P and T bars where required on
- all details.
- Multiply unit quantities by culvert length.
- Add apron wall quantities

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

NON-RIGID FRAME BOX CULVERTS

Page 129

- Complete steel bar table.
- Add adjustment to steel quantity for R bar laps.
- Insert total quantities in "Culvert Quantities" table on drawing.
- **The Standard Drawing shall be sealed, dated and signed according to 4.3.1.**

7.3.2 STEEL TABLE FOR CULVERT

Spacing and bar lengths are available from the culvert detailing table located at the end of this division.

Number of P and T bars required is available from Division 8. This procedure considers only one bar per cross-section; therefore the numbers given must be multiplied by 2 for P and T bars.

For R bars the number of sets of bars is available on the detailing tables; the number of bars per set and bar lengths in Division 8.

7.3.3 STEEL TABLE FOR APRON WALL

Length and number of L and M bars are available as given in Division 8.

7.3.4 ADJUSTMENT OF CONCRETE QUANTITIES

The additional volume of concrete required for apron walls is described in Division 8.

7.3.5 QUANTITY TABLE

Complete the quantity table. Concrete and steel quantities should be the total quantity for the complete length of culvert including apron walls.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

NON-RIGID FRAME BOX CULVERTS

Page 130

7.4 DETAILING TABLE

This table lists non-rigid frame culvert dimensions, concrete and steel quantities, and reinforcing steel detailing information.

		SPAN x HEIGHT		
		1.25x1.25	1.50x1.25	1.50x1.50
DIMENSIONS	T	190	220	220
	B	230	250	250
	W	190	220	220
QUANTITIES	CONC.	1.2	1.5	1.6
	STEEL	79.9	91.0	100.5
P BARS	SIZE	20	20	20
	C/C	300	250	250
	LENGTH	1490	1800	1800
T BARS	SIZE	15	15	15
	C/C	250	300	250
	LENGTH	1500	1550	1800
R BARS	#SETS	24	26	28

Fill Height $\leq$ 5.0 m

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 8 - CULVERT DETAILS

August 2003

8 CULVERT DETAILS

8.1 REINFORCING STEEL DETAILS

8.1.1 VERTICAL AND TRANSVERSE BARS

The number of vertical and transverse bars, as designated in Section 4.4, required for a given length of culvert may be determined from the following expression:

$$\frac{1000 \times C \times L_c}{b}$$

where,

- C equals 1 for H (open footing culverts)
- C equals 4 for J and K (both, box culverts) and V (open footing culverts)
- C equals 2 for the remainder

Round up decimal numbers up to the nearest whole number.

8.1.2 LONGITUDINAL BARS

The number and length of longitudinal bars, as designated in Section 4.4, required for a given length of culvert may be obtained from the following table:

TABLE 8-1 LONGITUDINAL REINFORCING BAR DETAILS

Lc (m)	NO. OF BARS PER SET	LENGTH OF EACH R BAR	LENGTH OF EACH W BAR
up to 6	1	Lc - 150 mm	Lc - 150 mm
over 6 up to 12	2	Lc/2 + 150 mm	Lc/2 + 200 mm
over 12 up to 18	3	Lc/3 + 250 mm	Lc/3 + 320 mm
over 18 up to 24	4	Lc/4 + 300 mm	Lc/4 + 375 mm
over 24 up to 30	5	Lc/5 + 330 mm	Lc/5 + 410 mm
over 30 up to 36	6	Lc/6 + 350 mm	Lc/6 + 435 mm

The length of each bar includes an allowance for lap lengths.

For longer culverts, determine the number of bars required per set for one-half the actual length and then multiply this number by two. The length of each bar may be taken as the entry corresponding to one-half the actual culvert length.

8.1.3 REINFORCING STEEL QUANTITY ADJUSTMENT FOR R AND W BARS

The quantities given in the detailing tables are based on a one-metre long section of standard culvert. These quantities require adjustment to account for the lapping of the R and W bars.

The additional steel quantity (in kilograms) to account for the lapping of the R bars is:

$$(\text{No. OF SETS OF R BARS}) \times (\text{No. OF BARS PER SET} - 1) \times 0.707$$

The additional steel quantity (in kilograms) to account for the lapping of W bar is:

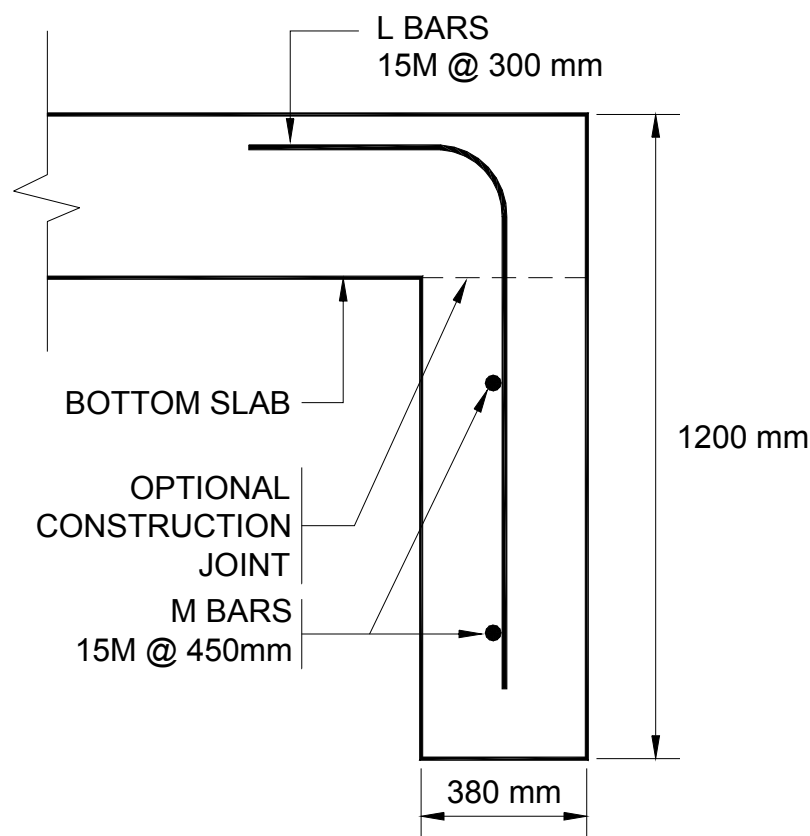
$$(\text{No. OF SETS OF W BARS}) \times (\text{No. OF BARS PER SET} - 1) \times 1.295$$

8.2 APRON WALLS

8.2.1 DETAILS OF APRON WALLS

All box culverts must have a 1.2 metre deep apron wall at each end. A cross-sectional view of a typical apron wall is shown in Figure 8.2.1.

FIGURE 8.2.1 SECTION AT APRON WALL



8.2.2 CONCRETE QUANTITY FOR APRON WALL

The additional volume of concrete (cubic metres) required for each apron wall may be determined from the following expression:

$$380 \times (S + 2 \times W) \times (1200 - B) \times 10^{-9}$$

Modification of this quantity is required for culverts with skewed ends.

8.2.3 REINFORCING STEEL QUANTITY FOR APRON WALL

The quantities shown on the standard drawings must be adjusted to include reinforcement for the apron walls.

The length of L bars for apron walls is the same for all culverts. The required number of L bars varies and may be determined from the following expression:

$$\frac{S + 2 \times W}{300} + 1$$

This expression provides the number of L bars for one apron wall.

The length of each M bar (in mm) may be determined from the following expression:

$$(S + 2 \times W) - 100$$

Modification of this quantity is required for culverts with skewed ends.

8.3 HEADER WALLS**8.3.1 DETAILS OF HEADER WALLS**

Header wall details are shown in Figures 8.3.1(a) and (b).

8.3.2 CONCRETE QUANTITY FOR HEADER WALL

The additional volume of concrete required for one header wall (in cubic metres) may be determined from the following expression:

$$0.114 \times (S + 2 \times W) / 1000$$

Modification of this quantity is required for culverts with skewed ends.

8.3.3 REINFORCING STEEL QUANTITY FOR HEADER WALL

The quantities shown on the structural standard drawings must be adjusted to include reinforcement for the header walls, where applicable.

The area of Y bars needed in the header walls may be determined from Table 8-3(a), for culvert ends skewed up to 25 degrees. The area of steel indicated is the total area required for both the top and bottom reinforcing bars of the header wall. The same area of steel should be placed in both locations.

TABLE 8-3(a) AREA OF STEEL FOR Y BARS FOR VARIOUS SKEWED END ANGLES

SPAN (m)	REINFORCING AREA (mm ²)					
	0°	5°	10°	15°	20°	25°
up to 2	1001	1004	1011	1025	1047	1076
2 - 3	1417	1421	1441	1472	1513	1578
3 - 4	2005	2019	2047	2105	2195	2312
4 - 5	2838	2858	2918	3022	3172	3400
5 - 6	4018	4046	4145	4322	4601	4983

Using the total area of reinforcing given in Table 8-3(a), the size and number of Y bars can be obtained from Table 8-3(b).

TABLE 8-3(b) REINFORCING BAR DETAILS

BAR SIZE	MASS (kg/m)	AREA (mm ²)
15M	1.570	200
20M	2.355	300
25M	3.925	500
30M	5.495	700
35M	7.850	1000

The additional quantity of steel required (in kilograms) for the Y bars in one header wall is:

$$(Y \text{ BAR LENGTH}) \times (Y \text{ BAR MASS}) \times (\text{No. OF Y BARS REQ'D})$$

The length of Z bars remains constant for all culverts. However, the required number of Z bars may be determined from the formula:

$$(S + 2 \times W) / 300 + 1$$

This expression provides the number of bars for one header wall only.

The additional quantity of steel required (in kilograms) for the Z bars in one header wall is:

$$1.57 \times ((2T + 930) / 1000) \times (\text{No. of Z BARS REQ'd})$$

Modification of the Z bar quantity is required for culverts with skewed ends.

FIGURE 8.3.1(a) ELEVATION AT END OF CULVERT

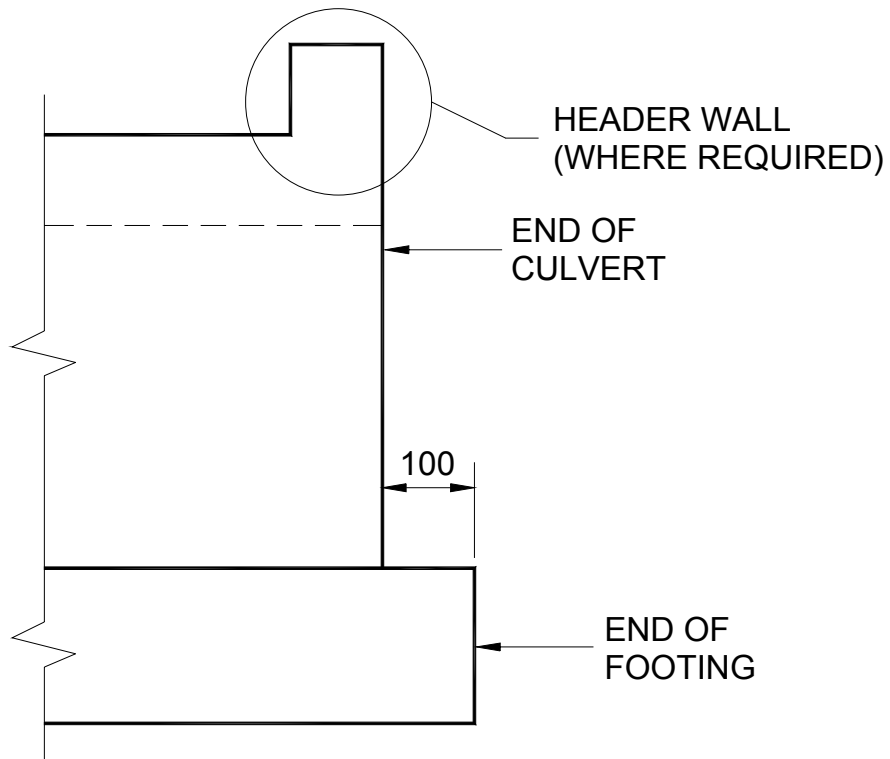
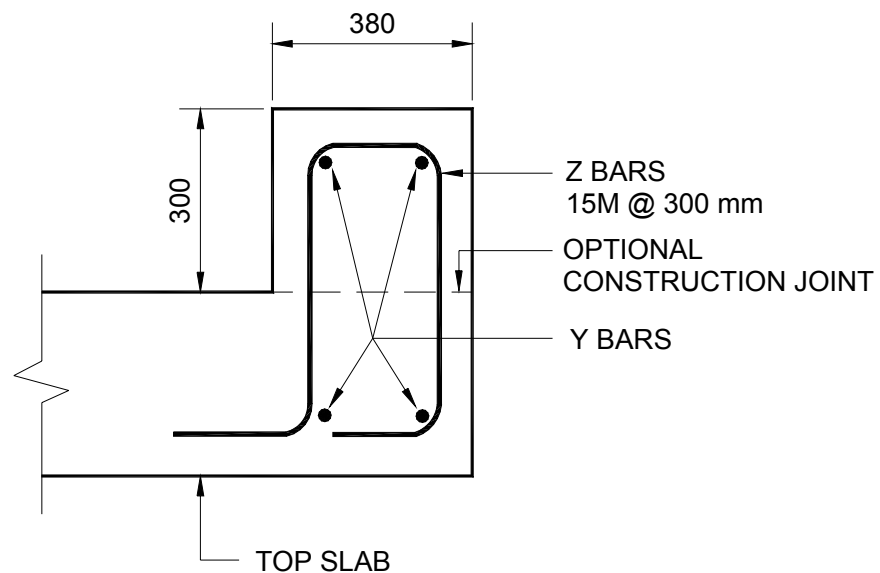


FIGURE 8.3.1(b) SECTION AT HEADER WALL



8.4 SKEWED END CULVERTS

8.4.1 DETAILS OF SKEWED END CULVERTS

A plan view of the culvert shall be added to the standard drawing, showing the skew angle and skewed end or ends.

In most cases the ends of a culvert are skewed at the same angle γ as the skew angle of the culvert θ .

A detail showing steel layout at skewed ends shall be added to the standard drawing with the modified bar spacing and necessary dimensions shown in the appropriate places.

A plan view of header wall and apron (where applicable) shall be added.

8.4.2 CONCRETE QUANTITY ADJUSTMENT FOR SKEWED END CULVERTS

Concrete quantities for the apron walls and header walls must be adjusted to account for the skewed ends. The increase is proportional to secant γ .

8.4.3 REINFORCING STEEL QUANTITY ADJUSTMENT FOR SKEWED END CULVERTS

In computing the quantity of reinforcing bars required for skewed end culverts the quantities described in Section 8.1 must be modified as follows.

The total number of additional vertical or transverse bars required for each bar type of a culvert skewed at both ends is as follows:

$$\frac{C(S + 2 \times W)}{b} \tan \gamma$$

where C is defined in Section 8.1.1.

Note that if the culvert has only one skewed end, then half the value derived from the above formula should be used.

Figure 8.4.3(a) details how P and Q bars are to be fanned.
H bars are to be similarly treated.

Figure 8.4.3(b) details how J and K bars are to be fanned.
S (box culverts), T, and U bars are to be similarly treated.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

CULVERT DETAILS

Page 140

The additional steel quantity for each bar type is the product of the number of additional bars, the length of each bar type and the bar mass per metre.

The lengths of the L and Z bars remain unchanged but the number required must be increased by a factor equal to secant γ .

The number of rows of M and Y bars required remains unchanged. However the lengths need to be increased. The length of the M bars shall be increased by a factor equaling secant γ . The treatment of the Y bars is described in Section 8.3.

FIGURE 8.4.3(a) FANNING OF P AND Q BARS

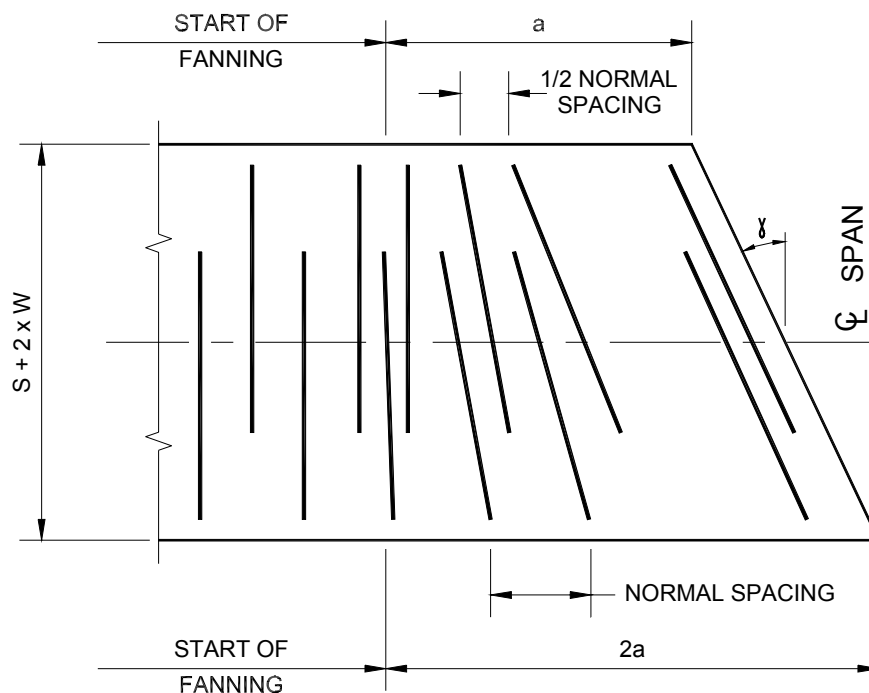
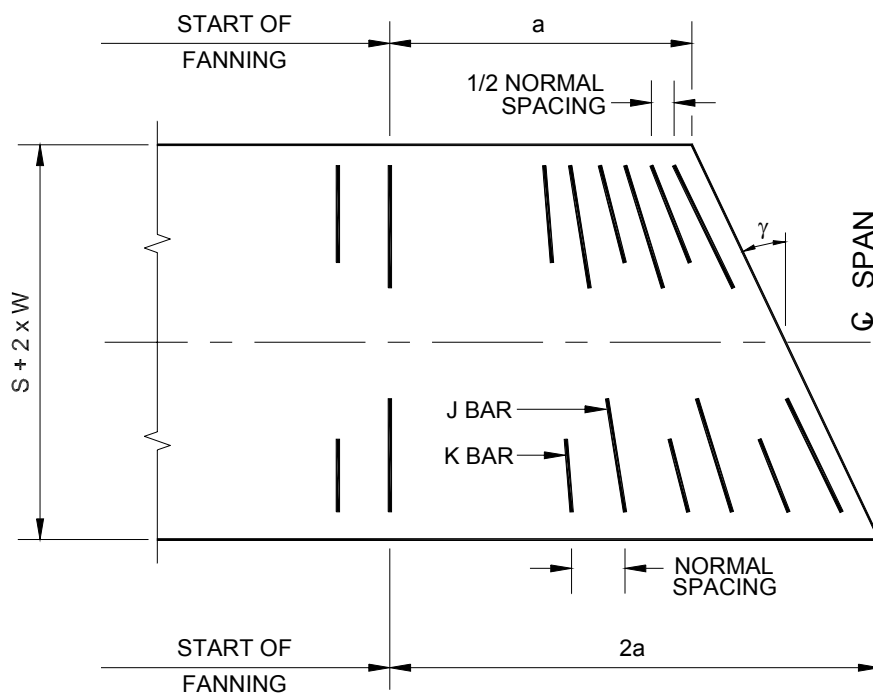


FIGURE 8.4.3(b) FANNING OF J AND K BARS



where $a = (S + 2 \times W) \tan \theta$

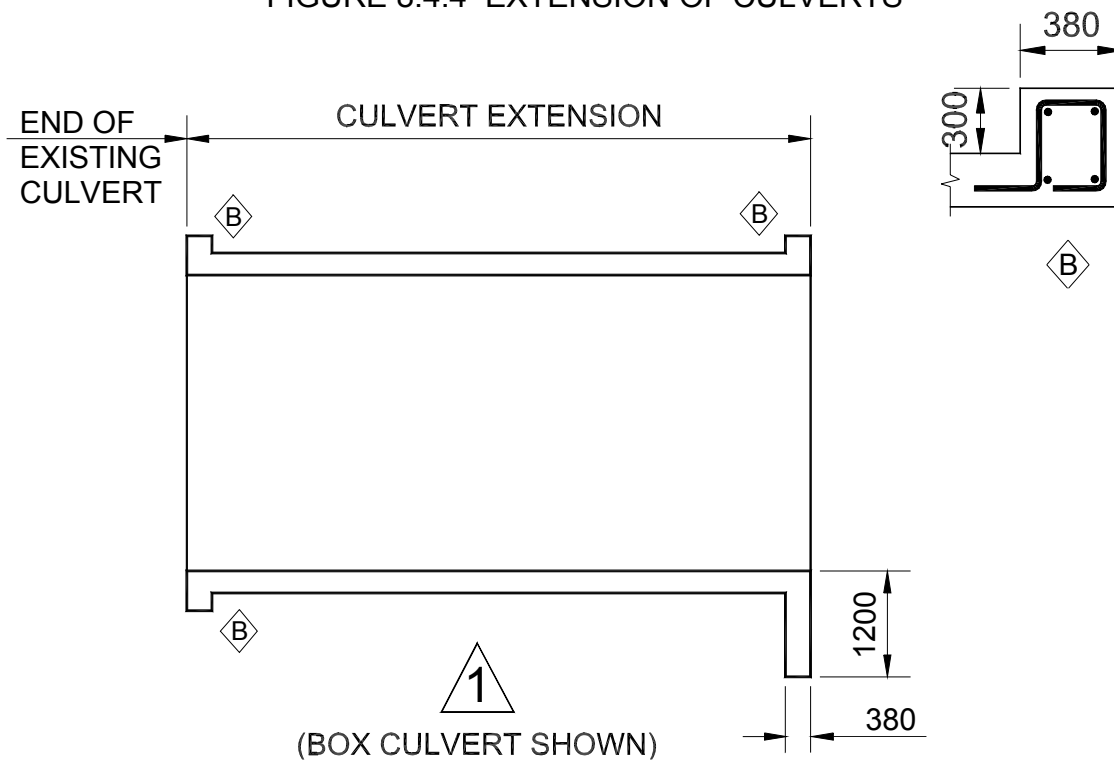
8.4.4 EXTENSION OF CULVERTS

When an existing culvert is being extended, at least one of the following requirements shall be met.

- i. Header walls shall be constructed as specified in Section 4.2.6; and/or
- ii. Dowels shall be embedded into the existing culvert and cross the joint between the existing and extension culverts; and/or
- iii. A reinforced concrete slab shall be placed over the full length of the joint between the existing and extension culverts.

Figure 8.4.4 illustrates the details that would be shown on Detail 1 if header walls were to be constructed. The other requirements, if specified, must be similarly detailed.

FIGURE 8.4.4 EXTENSION OF CULVERTS



8.5 INTERSECTING DRAINS, CATCH BASINS OR MANHOLES

Where drains or other features intersect a culvert, modifications must be made to the structural standard drawings to provide an opening in the wall or top slab of the culvert, and details of the additional steel required to reinforce the perimeter of such openings must be added. A plan view detailing the location and dimensions of the opening shall be shown.

The maximum diameter for circular openings is 760 mm. The maximum side dimension of square or rectangular openings is 600 mm.

Details in Sections 8.5.1 and 8.5.2 apply where a hole interferes with P bars in the top slab. Similar details apply where a hole interferes with H, J, K, S, T or U bars in slabs or walls.

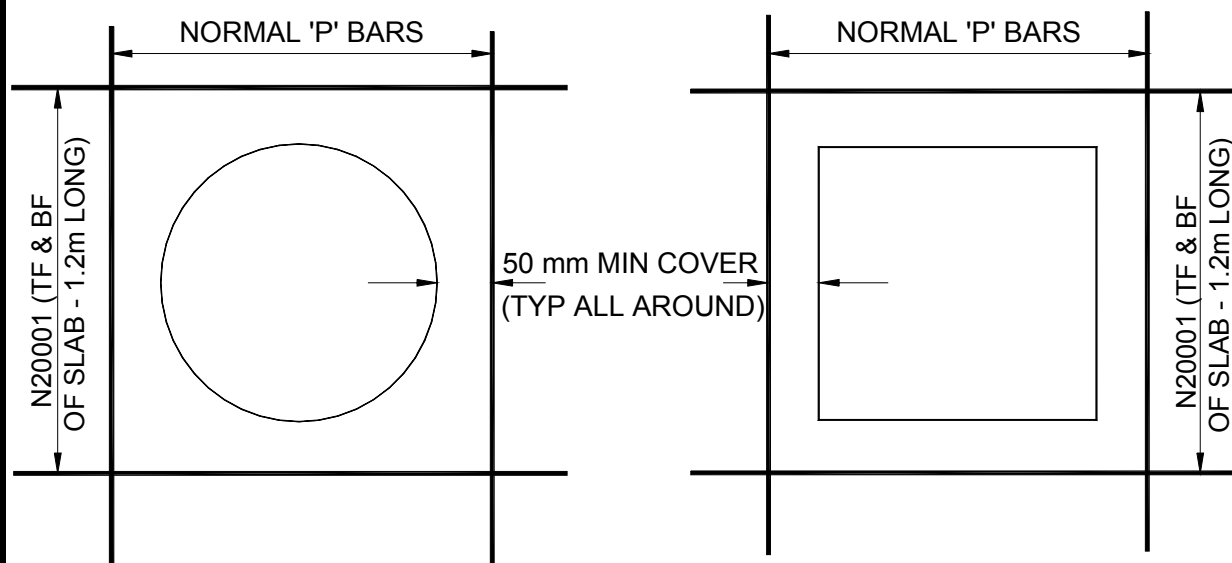
R bars may be cut for any hole where required.

Culverts requiring holes located within 300 mm of any haunch or with a dimension exceeding the above limits shall be referred to the Structural Engineer for special design consideration and advice.

8.5.1 HOLE DIAMETER OR SIDE DIMENSION NOT EXCEEDING 300 mm

- Adjust bar space at hole to provide 50 mm of concrete cover to P bars.
- Provide 1 - 20M bar 1.2 metres long, each side, as shown in Figure 8.5.1.

FIGURE 8.5.1 REINFORCING DETAILS FOR SMALL OPENINGS



8.5.2 HOLES 301 mm TO 760 mm DIAMETER OR RECTANGULAR HOLES WITH 301 mm TO 600 mm SIDE DIMENSION

- Adjustments must be made to steel arrangements as detailed in Figures 8.5.2(a) and (b).
- Move one P bar from hole location to each edge of hole providing 50 mm cover to each.
- Cut other P bars at hole and place the cut piece at other side of hole in line with original bar.
- Place one longitudinal bar in bottom face at each side of hole (perpendicular to P, same diameter as P).
- Place 4 - 20M diagonal bars (top and bottom).

FIGURE 8.5.2(a) REINFORCING DETAILS FOR LARGE ROUND OPENINGS

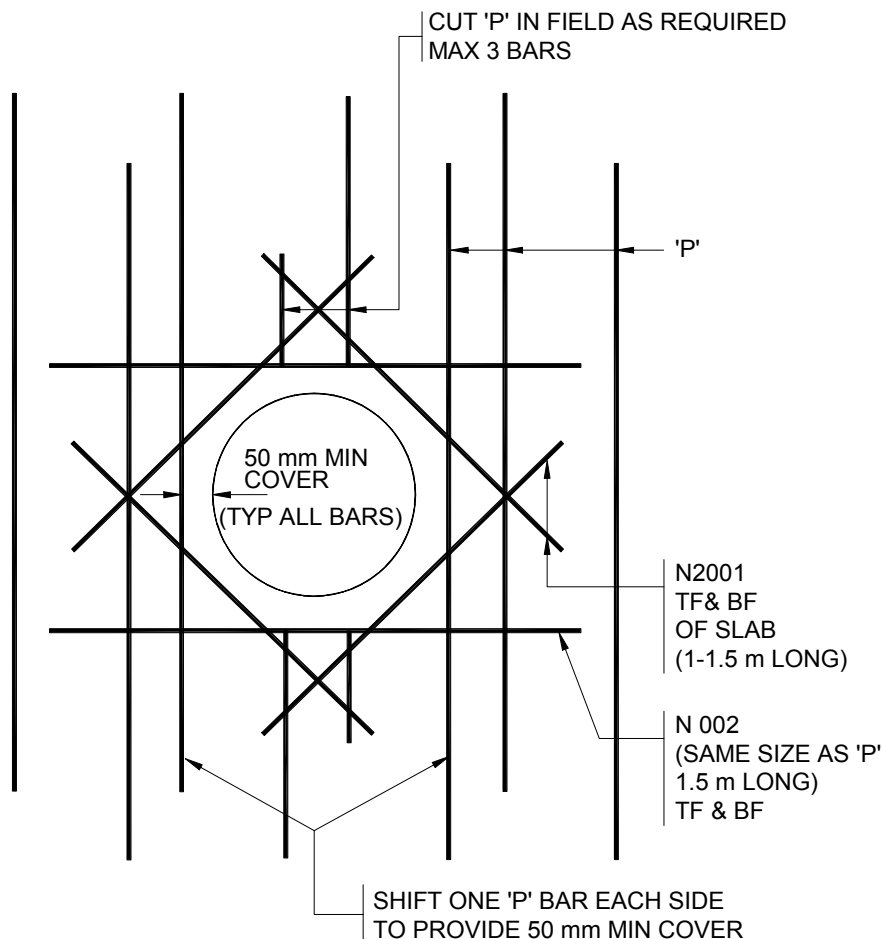
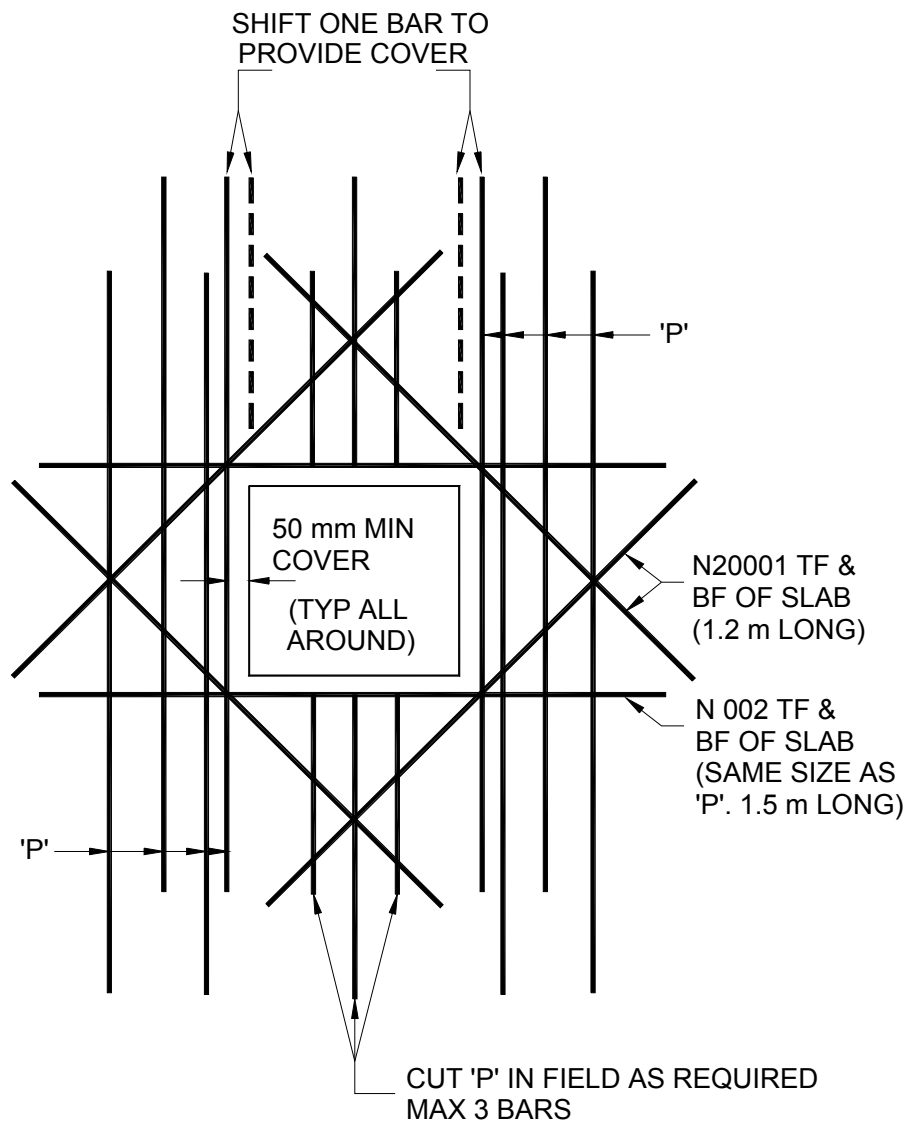


FIGURE 8.5.2(b) REINFORCING DETAILS FOR LARGE RECTANGULAR OPENINGS



8.6 RETAINING WALLS FOR CULVERTS**8.6.1 GENERAL**

Table 8-6 provides the dimensions and reinforcement details for retaining walls up to 3 metres high. Retaining walls more than 3 metres high shall be designed by an Engineer.

The retaining walls listed in Table 8-6 are designed for situations where the factored bearing capacity of the foundation material at the ultimate limit state is not less than 300 kPa; the bearing capacity at serviceability limit state is not less than 180 kPa; and, the factored coefficient of friction between the underside of the footings and foundation material, used for checking lateral sliding stability at the ultimate limit state, is not less than 0.4. Should the soil parameters at the site of the proposed construction differ significantly from the above-described values, then the design of the retaining wall should be referred to the Structural Engineer.

When retaining walls are required for a culvert, the structural standard drawings may be used provided that the following information is added in the space provided:

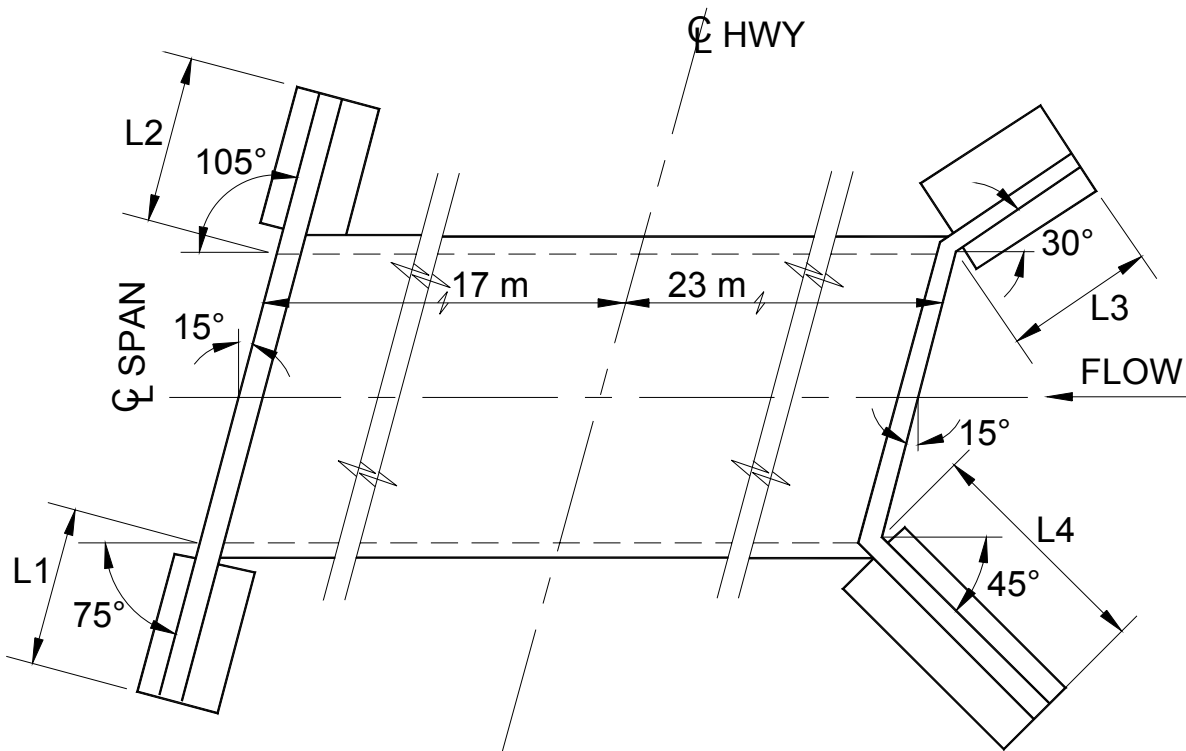
- A plan view of the culvert showing the layout and lengths of the retaining walls.
- Modification of culvert walls to suit adjacent retaining walls.
- Retaining Wall Details - A plan, elevation and cross-sectional view of each retaining wall showing dimensions and bar details for walls.
- A steel bar list table for retaining wall reinforcement. (Note: this may be combined with bar list for other special features).

8.6.2 PLAN VIEW OF CULVERT WITH RETAINING WALL

This detail should be drawn to a scale small enough to leave space available for the other details mentioned above plus details of skewed end treatments and special openings (holes) where applicable. The entire length of culvert need not be shown; the barrel of the culvert may be shown broken to conserve space.

The plan should include all dimensions shown in Figure 8.6.2, plus layout dimensions for other special features.

FIGURE 8.6.2 PLAN VIEW OF TYPICAL CULVERT



8.6.3 MODIFICATION OF CULVERT TO SUIT RETAINING WALLS

The modifications described in this section are required to permit some independent relative movement between the culvert and retaining wall.

Modifications to the header wall shall be made as shown in Figures 8.6.3(a), (b), and (c). For box culverts the apron wall shall be modified so that it has the same configuration in plan view as the header wall. No modification is required for box culverts with retaining walls perpendicular to the longitudinal axis.

Figures 8.6.3(a), (b), and (c) indicate square-ended culverts. Details for most skew-ended culverts are similar. In certain unusual circumstances (such as when the skew angle of the culvert is greater than the angle between retaining wall face and centre-line of culvert span) the location of the construction joint must be adjusted to ensure that the wall can move independently of the culvert.

The front face of the retaining wall shall meet the inside face of the culvert wall at the end of the culvert. The construction joint between the retaining wall and culvert shall be perpendicular to the front face of the retaining wall and shall touch the outside corner of the culvert wall (for box culverts) or the outside corner of the culvert footing (for open footing culverts).

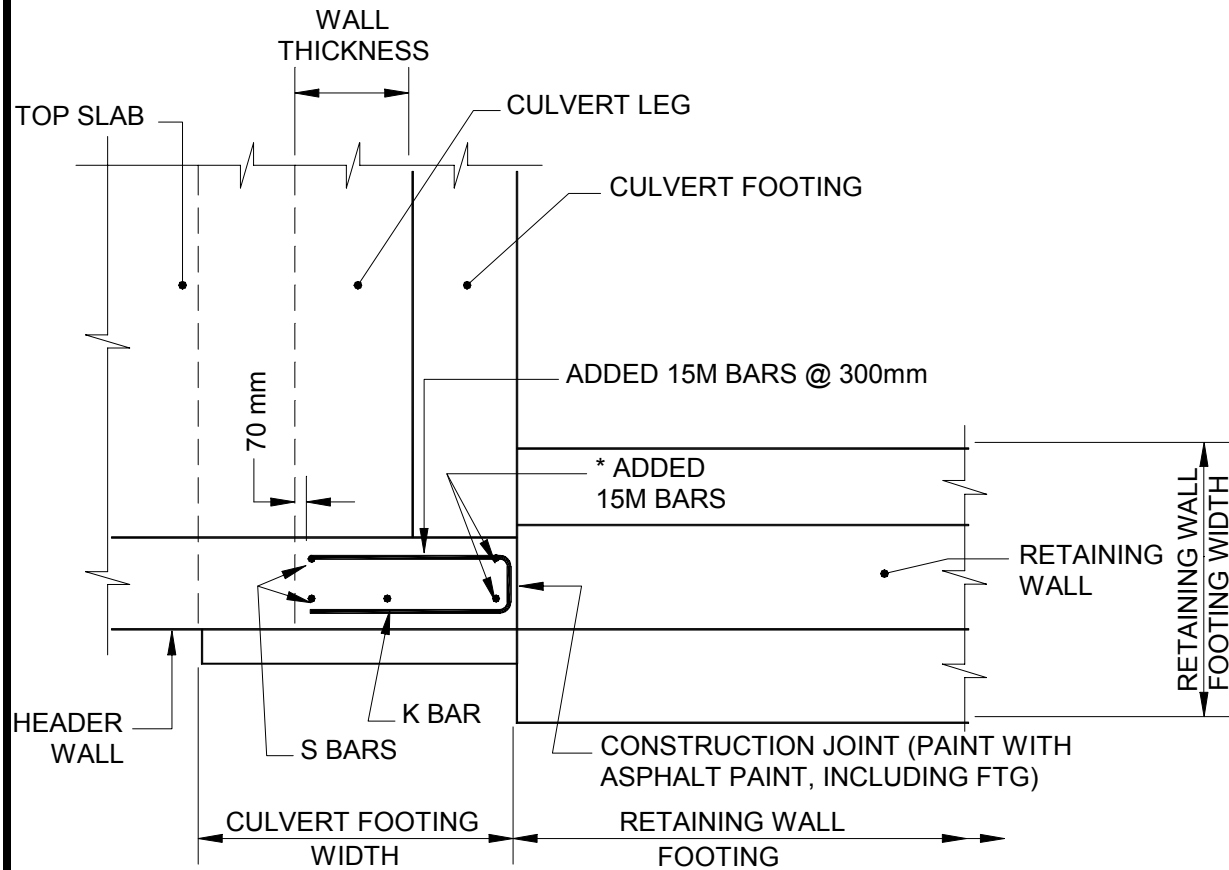
In order to achieve the minimum depth of footing for frost protection, the top of the retaining wall footing shall be set:

- i. 300 mm below the elevation of the top of the bottom slab for box culverts, or
- ii. 600 mm below the elevation of the top of the footing of open footing culverts.

The slope of the retaining wall top (where applicable) starts at the construction joint adjacent to the header wall.

A note should be added to the drawings stating: "Asphalt paint shall be supplied in accordance with CAN/CGSB-37.2-M88, coverage 2 square metres per litre".

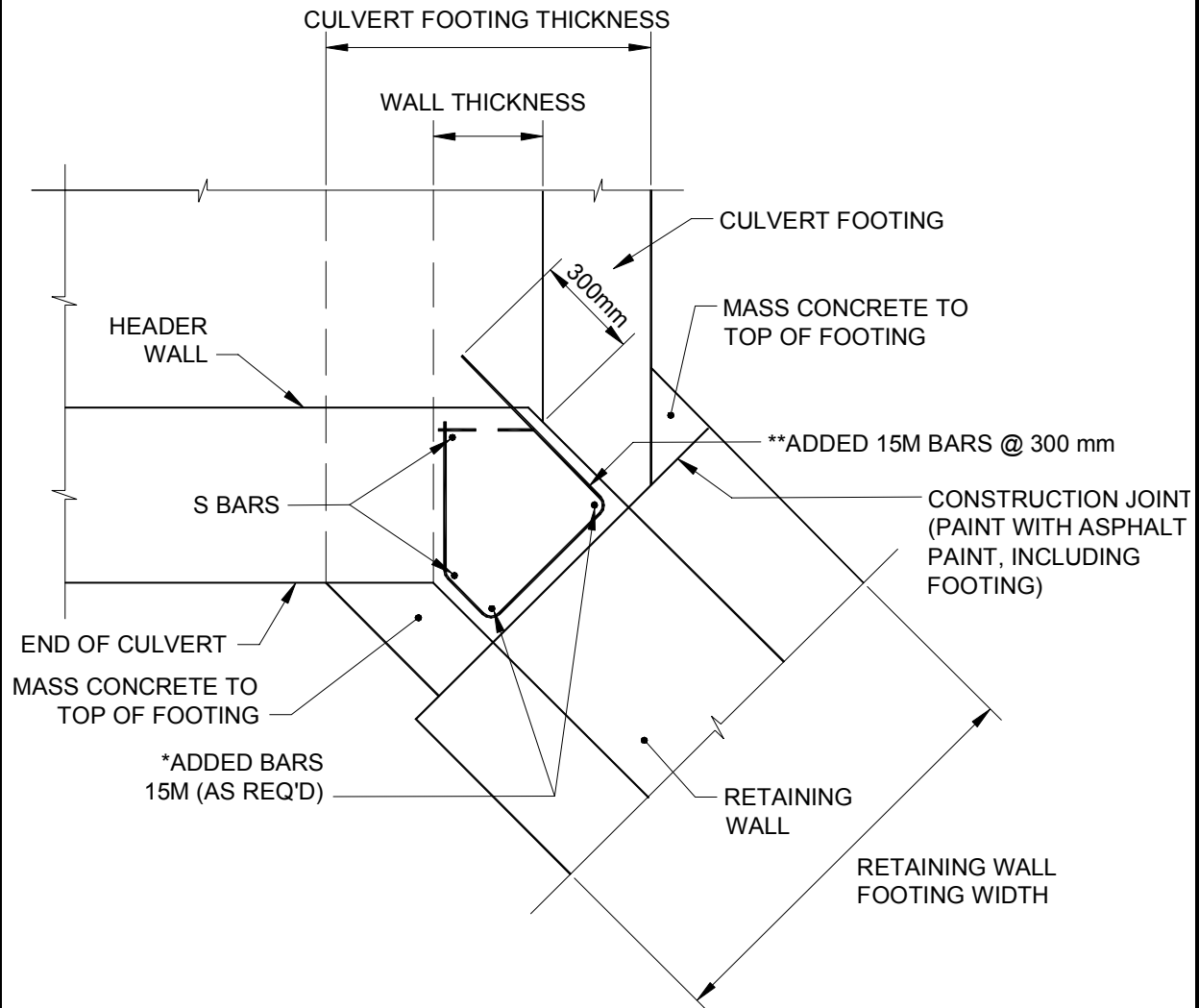
FIGURE 8.6.3(a) RETAINING WALLS PERPENDICULAR TO LONGITUDINAL AXIS (open footing culverts)



* Length of bar is the dimension from top of footing to top of header wall minus 75 mm.

NOTE: Add bars to bar list of culvert. See Section 8.6.3 for note on asphalt paint.

FIGURE 8.6.3(b) RETAINING WALLS NOT PERPENDICULAR TO LONGITUDINAL AXIS (open footing culvert)

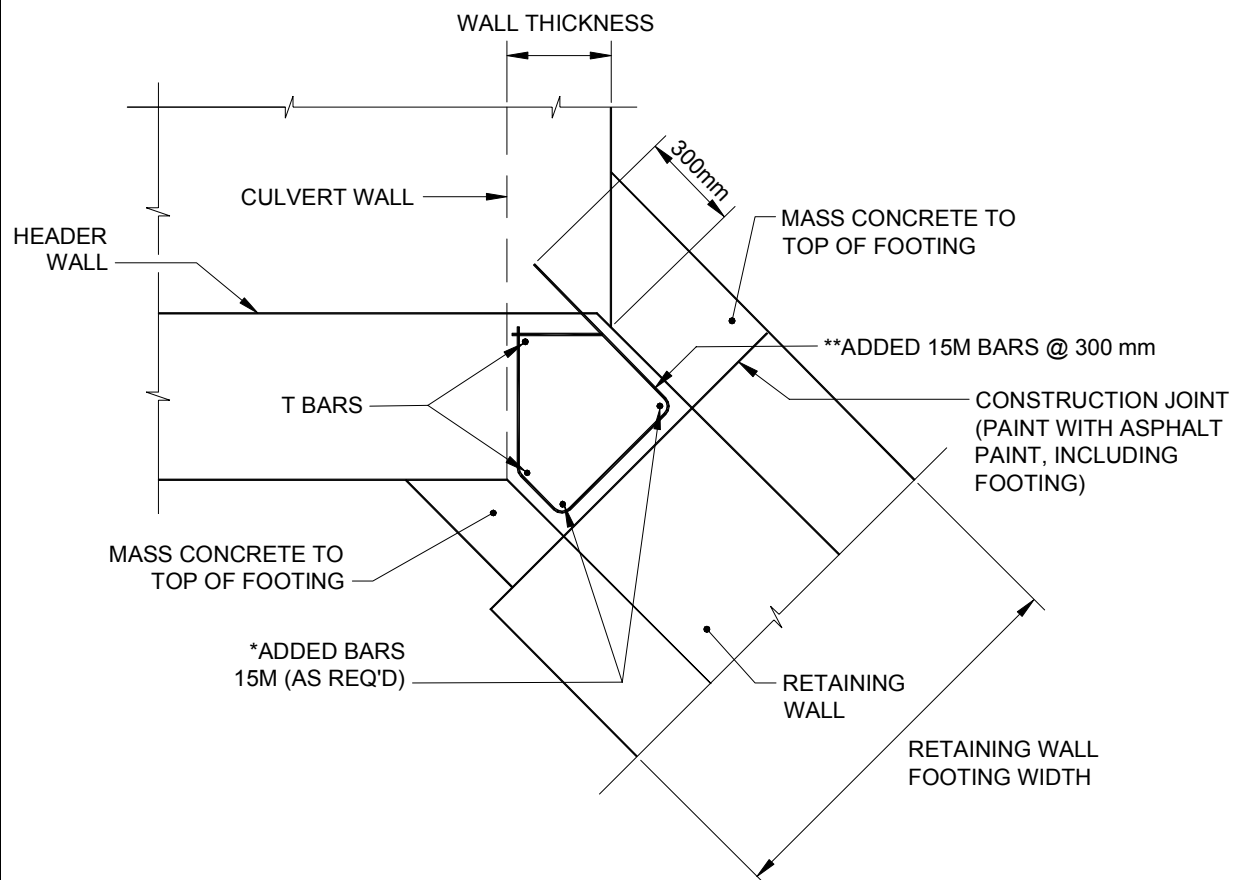


* Length of bar is the dimension from top of footing to top of header wall minus 75 mm.

** Bend top bar in field to suit as shown.

NOTE: See Section 8.6.3 for note on asphalt paint.

FIGURE 8.6.3(c) RETAINING WALLS NOT PERPENDICULAR TO LONGITUDINAL AXIS (box culvert)



* Length of bar is the dimension from bottom of culvert bottom slab to top of header wall minus 75 mm.

** Bend top bar in field to suit as shown.

NOTE: See Section 8.6.3 for note on asphalt paint.

8.6.4 RETAINING WALL DETAILS

The following formulae provide the actual wall height of a full height retaining wall (the distance from the top of the retaining wall footing to the top of the header wall) immediately adjacent to a culvert with standard header walls:

i. Open Footing Culverts

$$\text{Actual Wall Height} = \text{Culvert Height} + \text{Top Slab Thickness} + 900 \text{ mm}$$

ii. Box Culverts

$$\text{Actual Wall Height} = \text{Culvert Height} + \text{Top Slab Thickness} + 600 \text{ mm}$$

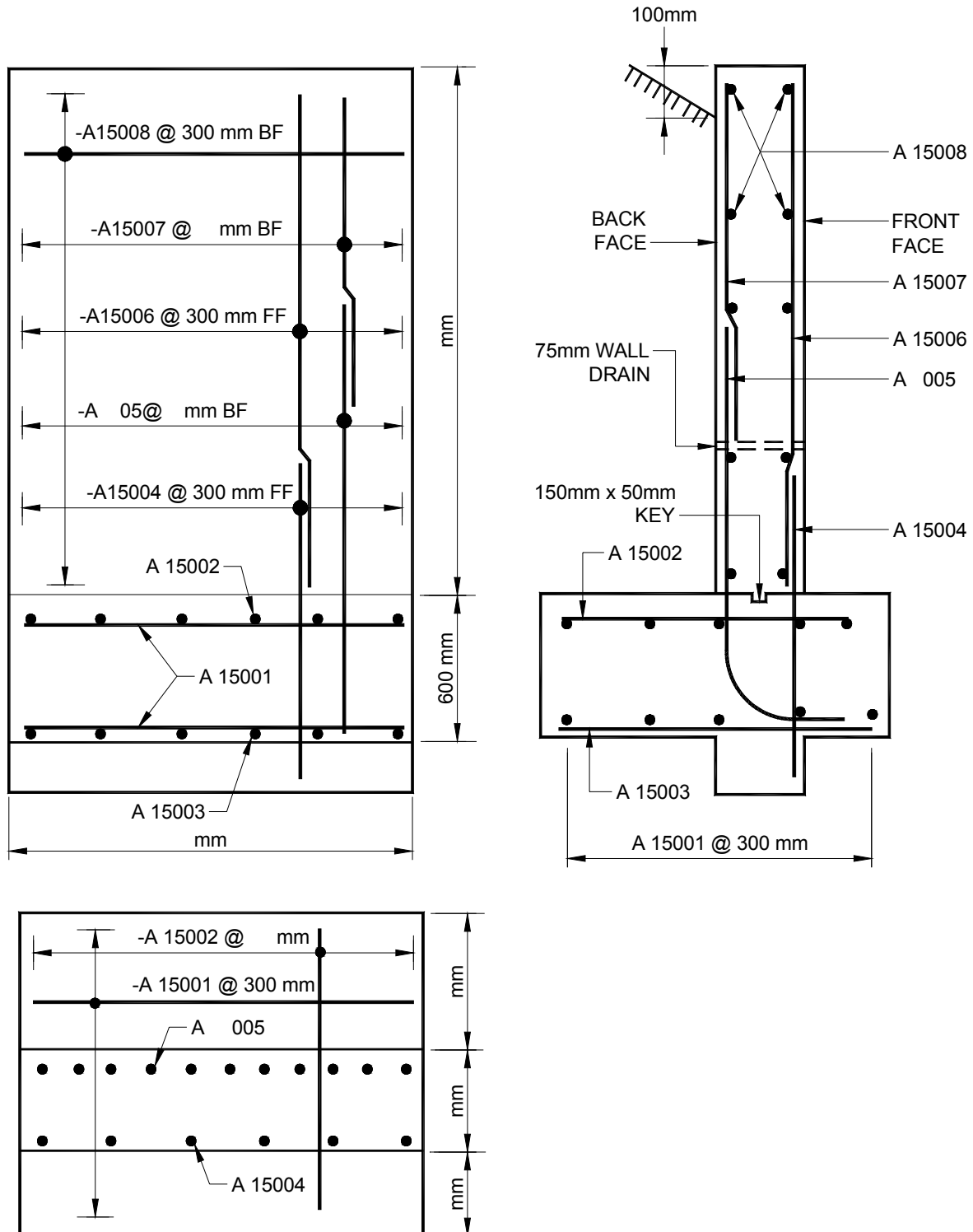
These formulations are correct for locations where the minimum depth of frost cover is required.

Design tables for retaining walls of various heights are given in Table 8-6.

(a) Retaining Walls with Constant Height

The dimensions and bar details shown in Figure 8.6.4(a) should be included for each applicable retaining wall. Where there is more than one retaining wall of this type, each wall shall be designated by a letter of the alphabet, e.g. Wall "A", Wall "B" etc. and the alphabetic symbol in the bar designation shall be that of the wall, e.g. for "Wall B" use B 001 etc. Section 8.6.4(b) explains how to adjust bars A15006 and A 007 for varying height retaining walls.

FIGURE 8.6.4(a) TYPICAL RETAINING WALL DETAILS



Where two or more walls have identical dimensions (i.e. same height and same length) they may be given the same alphabetic symbol but each must be designated by that symbol on the plan view and the title of the detail must show the number of walls required.

e.g. DETAILS OF WALL 'A'
[(2 REQUIRED)]

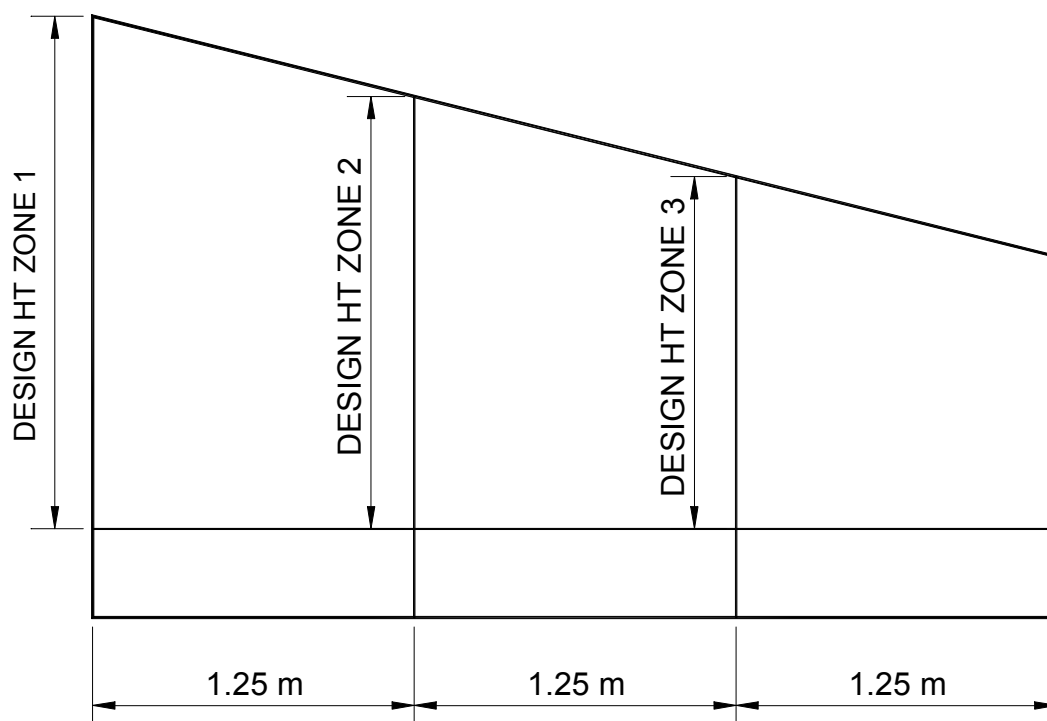
(b) Retaining Walls With Varying Height

For the purposes of design and detailing, retaining walls of this type are divided into THEORETICAL zones each approximately 1.25 metres long, as shown in Figure 8.6.4(b).

Note that this theoretical division will not appear on the final drawings since there is NO joint of any kind between the zones.

Each 1.25 metre long zone is then designed using the data given on Table 8-6 for the highest portion of the wall in that zone.

FIGURE 8.6.4(b) DETAILING OF RETAINING WALL PANELS



CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

CULVERT DETAILS

Page 156

Because the actual retaining wall height at the culvert usually depends on the thickness of the culvert top slab, the retaining wall height adjacent to the culvert will seldom correspond to the increments listed in Table 8-6.

For cases where the actual retaining wall height corresponds to an increment listed in Table 8-6, the design wall height shall be the same. When the actual wall height is not listed in Table 8-6, the design wall height shall be the actual wall height rounded up to the next higher entry on Table 8-6.

e.g. Actual Wall Height = 2.81 metres, use 3 metre design height from Table 8-6

Actual Wall Height = 2.4 metres, use 2.4 metre design height from Table 8-6

(c) Detailing of Steel Reinforcement

Front Face

- Dowels from footing (A15004) are always 15M @ 300
- For a design height of up to and including 1200 mm, A15004 bar extends to the top of the retaining wall; A15006 bars are omitted.
- A15006 bars are always 15M @ 300 but vary in length. Longest A15006 bar length for design height over 1200 mm is highest actual wall height minus 50 mm. Shortest A15006 bar length for design height over 1200 mm is lowest actual wall height minus 50 mm. Intermediately placed A15006 bars vary linearly in length between these values.
- Length of sloping A15008 bars is dimension of sloping top of wall minus 100 mm (front and back faces). If this length is within 100 mm of horizontal bar length, make sloping bars same as horizontal bars.

Back Face

- Size, spacing and lengths of vertical bars are given in Table 8-6 for the selected design height.
- For design height up to and including 2400 mm, A 005 bar extends to top of retaining wall; A15007 bar is omitted.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

CULVERT DETAILS

Page 157

- Number of vertical bars for each type in first panel is

$$\frac{1175}{\text{BAR SPACING (mm)}} + 1$$

(round up decimal numbers to nearest whole number).

- Place first bar in 2nd panel so that distance from last bar in 1st panel is not greater than spacing of bars in 2nd panel.
- Number of vertical bars for each type in 2nd panel is

$$\frac{1250}{\text{BAR SPACING (mm)}}$$

Treat subsequent panels in similar manner.

- Add or subtract one bar in last panel if required to complete reinforcing steel.

NOTE: *If the design height of any panel is obtained by rounding up the actual wall height to the next increment, then the top vertical bars in each face must be shortened by the same amount as the height is rounded up. (e.g. If actual wall height is 2.81 metres, design height is 3 metres, length of vertical bars must be shortened by 190 mm.).*

(d) Adjustment of Steel

The size or spacing of individual bars may be adjusted for convenience, where necessary, provided that at least as much steel is provided at each location as is called for in Table 8-6.

For instance, the bar arrangements in any panel may be continued into a lower panel, partially or completely, in order to provide a more satisfactory overall arrangement.

8.7 SPECIAL TREATMENT OF CULVERT ENDS

For aesthetic, economic or other reasons the designer may choose to detail the end faces of the culvert with slopes matching the side slopes of the adjacent roadway fill.

This treatment would improve the appearance of the culvert, reduce the quantity of concrete required, and where formerly wingwalls might have been necessary, none would be needed now.

The concrete culverts that have the ends tapered to match the roadway fill slope, and have no traffic protection around them may be equipped with the traversable safety grating. Figure 8.7 shows the schematic plan and elevation of such grating. The criteria for this is given in 4.2.9.

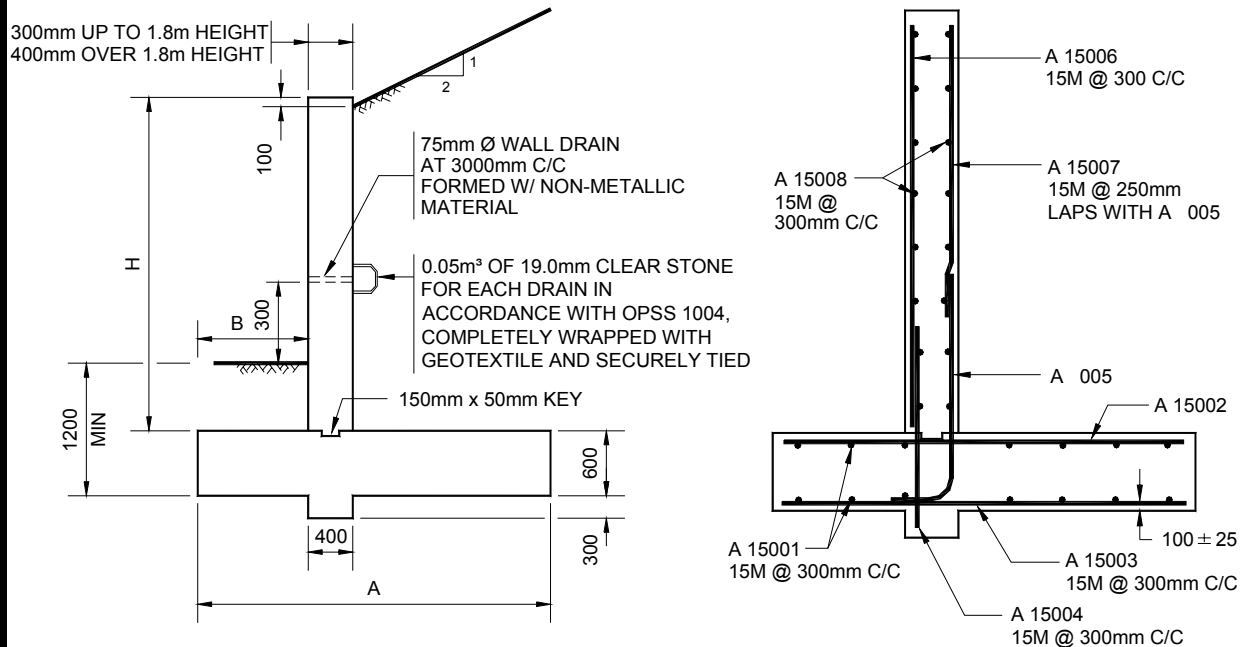
CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

CULVERT DETAILS

Page 159

TABLE 8-6 RETAINING WALL DETAILS



H (m)	DIMENSIONS		REINFORCING BAR DETAILS										
			A15002		A15003	A15004	A 005					A15006	A15007
	A	B	C/C	LGTH	LGTH	LGTH	SIZE	C/C	B	C	D	LGTH	LGTH
1.2	1200	400	250	1100	1100	2000	15	250	1340	470	300	-	-
1.8	1600	400	250	1500	1500	1290	15	250	1940	470	300	1750	-
2.4	2100	700	250	2000	2000	1290	20	250	2540	470	300	2350	-
3.0	2600	800	200	2500	2500	1290	15	125	1690	470	300	2950	1990

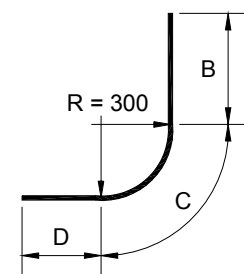
NOTES: Footing dimensions are based on an allowable soil capacity of 180 kPa @ SLS and 300 kPa @ ULS.

Reinforcing steel shall be grade 400 unless otherwise noted.

Clear cover to reinforcing steel is 70 ± 20mm unless otherwise noted.

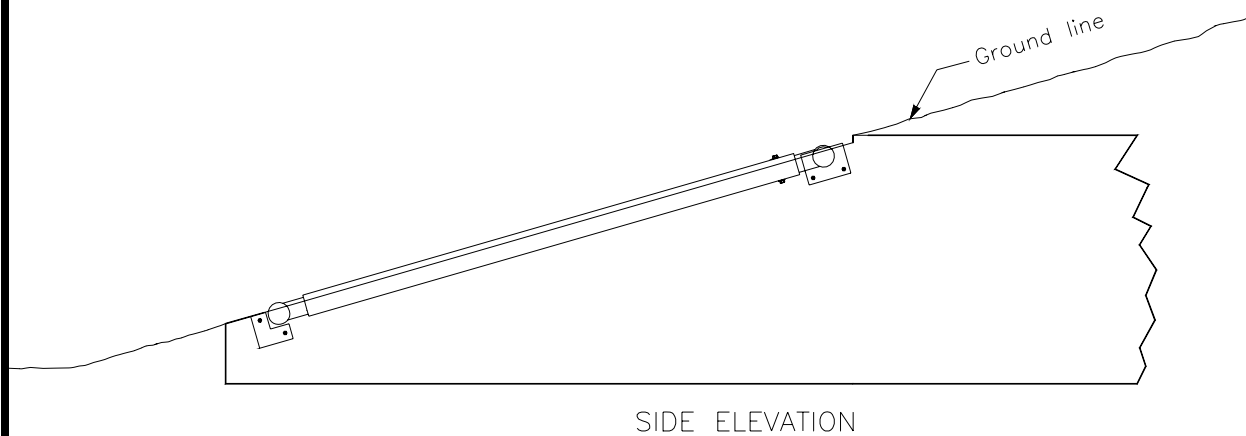
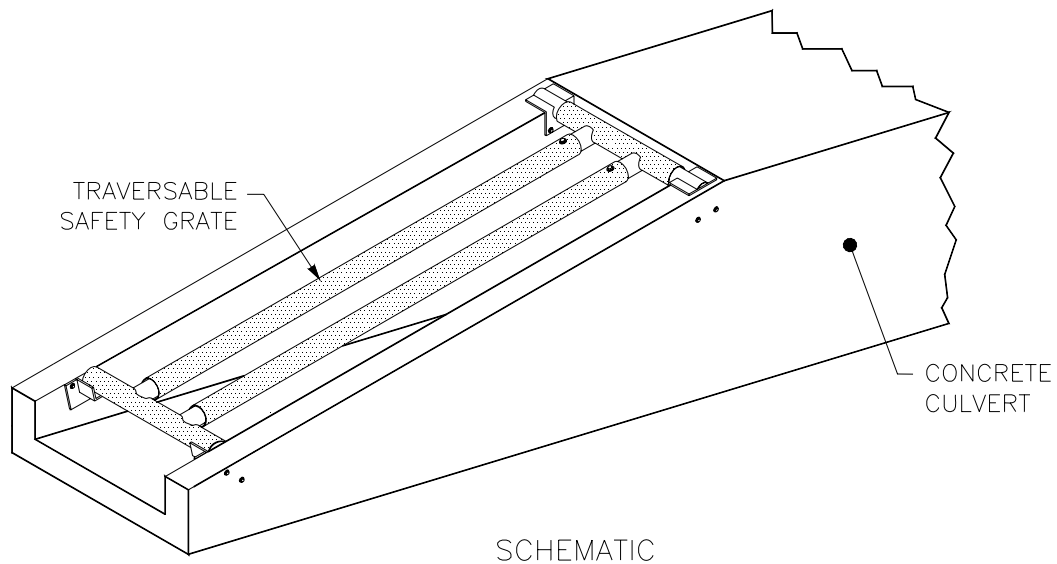
Dimensions in millimeters, unless otherwise noted.

Designed according to 2000 CHBDC



DETAIL OF BAR TYPE A 005

FIGURE 8.7 TRAVERSABLE SAFETY GRATING FOR CONCRETE CULVERT
(ASSEMBLY DETAIL)



CONCRETE CULVERT DESIGN AND DETAILING MANUAL

DIVISION 9 - APPENDIX

August 2003

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

APPENDIX

Page 161

9

APPENDIX

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

APPENDIX

Page 162

9.1 APPENDIX A: HALF-SIZE PRINTS OF STANDARD DRAWINGS

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No WP No	
RIGID FRAME BOX CULVERT	SHEET

GENERAL NOTES

- 1 CLASS OF CONCRETE TO BE 30MPa
2 CLEAR COVER TO REINFORCING STEEL
3 BOTTOM OF TOP SLAB 40 ± 10 FOR SLABS ≤ 300 THICK
50 ± 10 FOR SLABS > 300 THICK
6 BOTTOM OF BOTTOM SLAB 100 ± 25
7 REMAINDER 60 ± 20 UNLESS OTHERWISE NOTED
8 REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED.
9 LEGEND
10 AT DENOTES ALTERNATE
11 IF DENOTES INSIDE FACE
12 OF DENOTES OUTSIDE FACE
13 EF DENOTES EXTERIOR FACE
- CONSTRUCTION NOTES
- 1 BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF
2 CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME.
3 AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
4 NO CONCRETE SHALL BE PLACED UNTIL THE DEPTH OF THE EXCAVATION AND
5 THE EXISTING GROUND SURFACE ARE PROTECTED BY A MINIMUM OF 100mm OF
6 3 SUPPORTS FOR REINFORCING STEEL SHALL BE AS PER OPSD-3922/400 AND
7 OPSD-3922/100 ON FORMED SURFACES. ON NON-FORMED SURFACES, CONCRETE
8 BLOCKS (MIN. 200MPa) SHALL BE USED.

MARK	BAR SIZE	C/C	DETAILS	REMARKS
(H)	15M	----	STRAIGHT	TOP OF TOP SLAB & BOTTOM OF BOTTOM SLAB
(I)	—M	----		J BARS ALTERNATE WITH K BARS
(K)	—M	----		K BARS ALTERNATE WITH J BARS
(P)	—M	----	STRAIGHT	BOTTOM OF TOP SLAB STAGGERED
(Q)	—M	----	STRAIGHT	TOP OF BOTTOM SLAB STAGGERED
(R)	15M	300	STRAIGHT	LONGITUDINAL MIN. LAP SPICE = 500
(S)	15M	300		HAUNCH
(T)	15M	300	STRAIGHT	INSIDE FACE OF WALLS
(U)	15M	300		HAUNCH
(L)	15M	300		DOWELS TO APRON WALLS
(M)	15M	----	STRAIGHT	APRON WALL
(V)	—M	----	STRAIGHT	HEADER WALL
(Z)	15M	300		HEADER WALL

NOTES:

- All dimensions shown to centre line of bar
- $\bullet$ represents vertical dimension
- $\bullet\bullet$ c/c spacing given at midspan

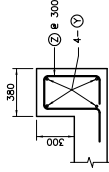
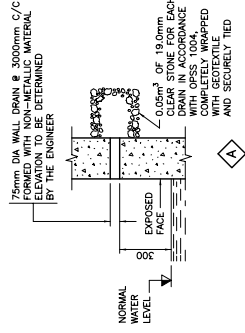
APPLICABLE STANDARD DRAWINGS

OPSD-4601.000	LOCATION OF SITE NUMBER AND DATE FIGURES
OPSD-803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS

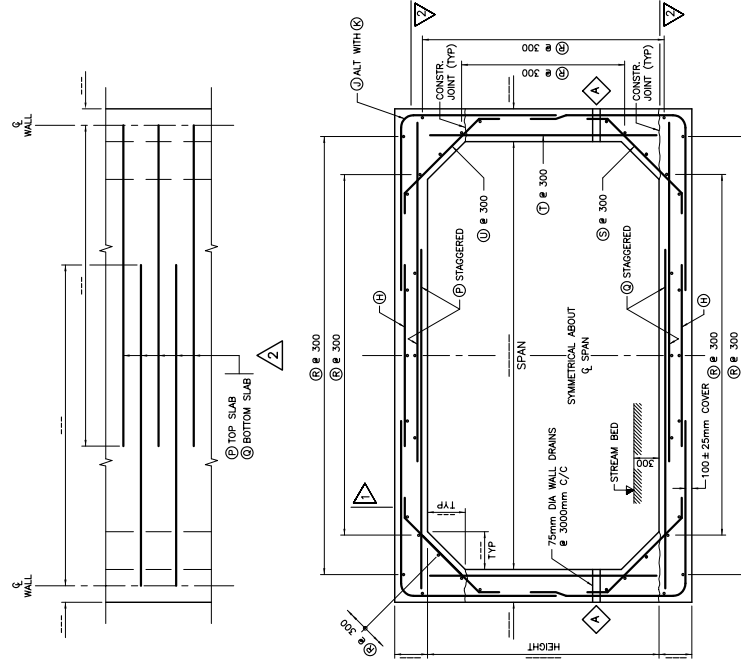
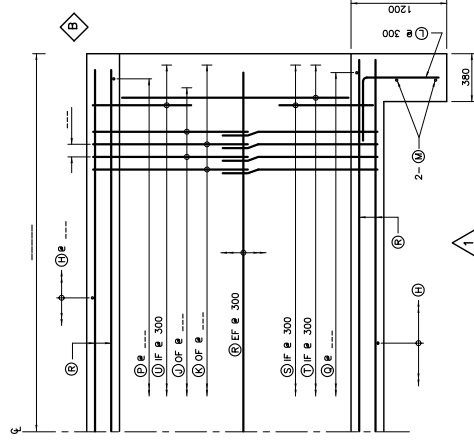
STANDARD DRAWING JANUARY 2004	SS114-2
RIGID FRAME BOX CULVERT	

QUANTITIES			
ITEM	WALLS & SLABS	RETAINING WALL	TOTAL
VOLUME OF CONCRETE cubic metres	1000.0000000000	1000.0000000000	2000.0000000000

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

[illegible]

HEADER WALL
(WHERE REQUIRED)



TYPICAL CULVERT SECTION

(APRON DETAILS SHOWN IN 
(HEADER WALL DETAILS SHOWN IN )

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 03 14

APPENDIX

Page 166

9.2 APPENDIX B: REDUCED PRINT OF DESIGN DATA FORM FOR CONCRETE CULVERTS



Date _____

Township _____ County or District _____

Notes:

Diagram of a rectangular specimen with a central hole. The width of the specimen is labeled S , and the height is labeled H . The distance from the center of the hole to the nearest edge is labeled 300mm MIN.

Prepared by ----- Approved by -----

Rev. July 2000

9.3 APPENDIX C: DEVIATIONS FROM CHBDC

The following items represent the design criteria used in the preparation of this manual that deviates from the 2000 edition of the Canadian Highway Bridge Design Code.

- 1) The minimum inside height of Concrete Box Culverts shall be 1.25 metres in order to facilitate formwork removal.

- 2) The minimum fill height considered in the culvert design tables is 0.6 meters.

- 3) Soil arching factors are based only on Type B1 installation.

- 4) The Frost Penetration requirements of clause 7.8.3.4 are ignored, as OPSD 803.010 requires cover material to be specified granular, i.e. non-frost-susceptible.

- 5) Load combination (d) in CHBDC Clause 7.8.4.1, pertaining to earthquake has been excluded from this Manual.

- 6) Wheel Load Distribution Through Fill (Clause 6.9.6.) is revised as follows: "When several distribution loads overlap, the total load shall be considered as uniformly distributed over the area defined by the outside limits of the individual areas. When the dimensions of the composite distributed load area exceeds the roof area, only that portion of the distributed load on the roof area shall be considered in the design." The wording given in the code is at least unclear, or even incorrect.

- 7) Load combination in CHBDC clause 7.8.7.1 has been excluded from this Manual.

- 8) The shear checks within 2d of the face of the support using CHBDC clause 7.8.8.2.2, which refers to clause 8.10, have been excluded from this Manual.

- 9) Temperature and shrinkage requirements for maximum spacing of CHBDC Table 7.8.11.2 of 250 mm have been ignored.

9.4 APPENDIX D: MATERIAL AND CONSTRUCTION SPECIFICATIONS FOR PRECAST REINFORCED CONCRETE BOX CULVERTS AND BOX SEWERS

For single-cell culverts not exceeding 3 metres in span and for placement under a minimum fill depth of 600 mm, the use of precast reinforced concrete structure can be considered as an alternative.

Currently, the specification OPSS 1821 “Material Specification for Precast Reinforced Concrete Box Culverts and Box Sewers” covers the requirements for materials, design and fabrication of the single-cell precast reinforced concrete box culverts with inside spans of 1.8 to 3.0 metres, and with inside rise from 0.9 to 2.4 metres. This specification is based on the current bridge code as well as the “Prequalification Requirements for Precast Concrete Drainage Products” published by the OCPA. OPSS 422 “Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers” covers the requirements for the installation of precast reinforced concrete box culverts and box storm sewers in open cut.

The member companies of the Ontario Concrete Pipe Association (OCPA) can however produce single-cell precast box culverts ranging in span from 900 mm to 4.2 metres and rise inside from 900 mm to 4.8 metres. Further details can be obtained from OCPA Office.

For precast culverts with less than 0.6 m of fill, a reinforced distribution slab is required to provide an improved live load shear transfer between the units, as well as an enhanced live load distribution.

9.5 APPENDIX E: METHODOLOGY USED FOR RIGID FRAME CULVERT DESIGN

9.5.1 GENERAL INFORMATION

The following design philosophy and method was the approach used to produce the Detailing Tables and Standard Drawings given in this Culvert Manual. The analysis was based on CHBDC Section 7 on Buried Structures, and the relevant clauses of Sections 3, 6 and 8.

The Assumptions, Design Criteria, Dead and Live Load Distributions, and Method of Design used are detailed in the following sections.

9.5.2 ASSUMPTIONS

Unit Weight of Soil20.0 kN/m³
 Concrete.....24.0 kN/m³
 Asphalt.....23.5 kN/m³
 Water.....10.0 kN/m³

Class of Concrete30 MPa

Reinforcing Steel400 MPa

Clear Cover to Reinforcing Steel as given on the Standard Drawings

Design Code CHBDC-2000

9.5.3 DESIGN CRITERIA

LOADING considered: Load Factors for ULS

1. Dead Load of Concrete Self-Weight.....[$\alpha_{max}=1.20$, $\alpha_{min}=0.90$]
2. Dead Load of Earth Fill + asphalt ($M_v=1.2$).....[$\alpha_{max}=1.25$, $\alpha_{min}=0.80$]
 (only installation Type B1 considered)
3. Lateral Earth Pressure ($M_h=0.5$ or 0.3).....[$\alpha_{max}=1.25$, $\alpha_{min}=0.80$]
 (only installation Type B1 considered)
4. Water Load (inside or outside of culvert).....[$\alpha_{max}=1.10$, $\alpha_{min}=0.90$]
5. Live Load (incl. DLA) – Vertical wheel load.....[$\alpha_{max}=1.70$, $\alpha_{min}=0.00$]
 – Approaching wheel load..[$\alpha_{max}=1.70$, $\alpha_{min}=0.00$]

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

APPENDIX

Page 171

Note:

- Dead Load is always present.
- Culverts in Ontario are designed only for Type B1 installation.
- Due to vertical negative arching, the load due to earth fill is 120% of the soil weight.
- Due to horizontal arching, earth pressure coefficients are in the range between values of 0.3 and 0.5.
- Water Load can be applied
 - (a) inside the culvert (loads the walls and the bottom slab)
 - (b) inside & outside of the culvert
 - (c) outside the culvert (loads only the walls)

When Water load is applied on the outside of the culvert, the affected earth pressure height uses the submerged unit weight of soil, in addition to water pressure.

- Live Load is applied either as the wheel loads of a truck(s) acting Vertically and distributed to the top of the culvert through the soil, or as Approaching wheel loads applied through the soil to one or both sides of the culvert as lateral earth pressure. Vertical and Approaching wheel loads are not applied at the same time.

LOADING COMBINATIONS:

According to Section 7 of the CHBDC, and without consideration of Earthquake loading, the following 3 Load Combinations at ULS were considered:

L.C.#1 = Dead Load^(concrete + earth fill) + E.P.^(min) + Water + Live Load^(vertical)

L.C.#2 = Dead Load^(concrete + earth fill) + E.P.^(max) + Water + Live Load^(vertical)

L.C.#3 = Dead Load^(concrete + earth fill) + E.P.^(min) + Water + Live Load^(approaching)

where E.P. = Lateral Earth Pressure

With each of the Loading Combinations, the Load Factors are chosen for each individual load and combined in such a way as to produce maximum load effects such as Moments, Shears, Axial Forces and Reactions.

In general, one loading will maximise the vertical and minimise the horizontal loading, while another loading will maximise the horizontal and

minimise the vertical loading. Operating between these two extremes are as many other load combinations as are required to consider every possible case. If a computer program such as OMBAS or CANBAS does the analysis, the extreme (governing) values can be selected from the envelope of results. If the analysis were done manually or by a computer program that needs additional manual input, a preliminary analysis in addition to an accurate prediction of deflected shapes and moment diagrams due to relative loadings would be an asset.

The load combination of CHBDC clause 7.8.7.1 has been excluded from this Manual.

9.5.4 DEAD AND LIVE LOAD DISTRIBUTIONS

DEAD LOAD DISTRIBUTION:

According to CHBDC, and documented by considerable research results, arching takes place in the soil in both the vertical as well as the horizontal directions.

Unless special construction techniques are utilised, the soil weight transfer from above the culvert to the top of the culvert (vertical loading) exhibits negative arching, resulting in a 20% increase in effective soil weight loading applied. This Culvert Manual does not consider any special construction techniques whereby the applied loading could be reduced. Numerous research papers discuss the possible methods (such as using some depth of compressible material directly on top of the culvert) whereby a portion of the settling fill above the culvert transfers a portion of its weight away from the culvert to the adjacent fill, reducing the actual soil weight that gets applied to the culvert.

In the horizontal direction, the effect of arching is such that it can be described in the traditional equivalent fluid pressure approach as having minimum and maximum coefficients of 0.3 and 0.5, for Type B1 installation.

LIVE LOAD DISTRIBUTION:

With respect to the direction of the Truck travel, the Live Load (wheel loads) is distributed in both the Transverse and Longitudinal directions. This distribution starts from the footprint dimensions of the truck wheel load(s), 600 mm (transverse) x 250 mm (longitudinal).

For distribution in the Transverse direction, 2 trucks in adjacent 3.0 m lanes, reduced to 90% because of multi-lane loading, represents the

governing (maximum) loading. The DLA varies according to the depth of fill. The width of distribution, at any depth H , is equal to the maximum extent of all 4 wheel loads distributed according to $[0.6 \text{ m} + 1.75H]$.

For distribution in the Longitudinal direction, the *nominal* width of distribution, at any depth H , is equal to the maximum extent of the wheels from axles 2 and 3 of the CHBDC truck, distributed according to $[0.25 \text{ m} + 1.75H]$. However, deviating from CHBDC, when the Live Load distribution overlaps and goes beyond the width of the culvert, for the *actual* width of distribution, apply to the culvert only the portion of the loading that is directly above the culvert.

9.5.5 METHOD OF ANALYSIS / DESIGN

1. With the aid of OMBAS modified for CHBDC, and based on the governing load combinations, the Bending Moment envelope, Shear, Axial Force and Reactions were calculated.
2. Based on assumed concrete thickness, reinforcing area and length of bars, the capacity of the relevant section was calculated, (as PxM interaction) and compared to the applied Moment and Axial Load.
3. Shear was checked, by comparing applied force to shear capacity in accordance with CHBDC section 8, clauses 8.9.3 and 8.9.4. The shear within $2d$ of the face of the support was not checked using clause CHBDC clause 8.10.
4. Sliding was checked, for open-footing culverts, using factored horizontal reaction and unfactored vertical reaction.
5. The assumed reinforcing, lap and embedment length required, was checked.
6. If any criteria was not satisfied, the relevant detail was modified and calculations repeated until all code requirements were met.

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

INDEX

August 2003

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

INDEX

Page 175

Aesthetics	158
Apron Wall	3, 7, 10, 12, 14, 73, 75, 77, 78, 125, 127, 128, 129, 133-134, 139, 149
Bearing Capacity	3, 19, 20, 147
Bearing Pressure	19, 20, 23
Box Culvert	1, 3, 5, 7, 8, 10, 11, 12, 14, 20, 73-79, 125-130, 131, 133, 139, 149, 152, 153, 168, 169
Cast-in-Place Culverts	6, 8, 9, 20
Catch Basins	7, 143-146
CHBDC	5, 6, 7, 9, 16, 73, 159, 168, 169, 170, 171, 172, 173, 174
Construction Joints	16, 17, 73, 74, 125, 126, 133, 138, 149, 150, 151, 152
Culvert Extensions	3, 9, 23, 76, 128, 142
Detailing Table	5, 9, 12, 16, 19, 21, 23, 25, 27, 28-72, 73, 76, 77, 78, 79, 80-124, 125, 128, 129, 130, 132, 170
Drain	7, 8, 143-146
End Treatment	8, 148, 158
Fanned Bars	139-141
Fill Height	3, 8, 9, 11, 23, 28-72, 76, 80-124, 125, 128, 130, 168, 169, 172, 173
Footing Reaction	19
Friction Coefficient	6, 147
Frost Protection	16, 149, 153, 168
Geotechnical Engineer	3, 19, 20

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

INDEX

Page 176

Haunch	3, 14, 16, 23, 73, 75, 76, 125, 143
Header Wall	3, 7, 10, 12, 14, 16, 18, 24, 25, 26, 73, 75, 77, 78, 135-138, 139, 142, 149-153
Height	3, 8, 11, 16, 17, 23, 28-72, 74, 76, 80-124, 126, 128, 130, 153, 155, 156, 157, 168, 171
Lateral Sliding	19, 20, 147
Length(Culvert)	3, 5, 9, 10, 23, 24, 76, 77, 78, 128, 131, 132, 155
Longitudinal Axis	3, 4, 5, 6, 149, 150, 151, 152
Manhole	7, 143-146
Non-Rigid Frame Culvert	1, 4, 8, 9, 12, 125-130
Open Footing Culvert	1, 3, 4, 5, 7, 8, 11, 12, 14, 16-27, 131, 149, 150, 151, 153, 173
Precast Concrete Box Culvert	8, 9, 169
Reinforcing Steel	7, 13, 14, 15, 16, 17, 18, 25, 26, 27, 28-72, 73, 74, 75, 77, 78, 79, 80-124, 125, 126, 127, 129, 130, 131-132, 134, 136-137, 139-140, 143, 144, 145, 146, 147, 156-157, 159, 173
Retaining Wall	4, 7, 9, 10, 12, 13, 14, 16, 23, 73, 76, 128, 147-159
Rigid Frame Culvert	1, 4, 8, 9, 11, 12, 14, 16-27, 73-79, 170-173
Scales	13
Set	4, 25, 78, 129, 131, 132
Skew Angle	4, 6, 7, 8, 10, 139-140, 149
Skew Number	4
Skewed End Culvert	4, 5, 7, 9, 10, 12, 13, 23, 25, 76, 78, 133, 134, 135, 136, 137, 139-141, 148, 149

CONCRETE CULVERT DESIGN AND DETAILING MANUAL

2003 08 08

INDEX

Page 177

Span	4, 5, 8, 11, 17, 23, 28-72, 74, 76, 80-124, 126, 128, 130, 149, 169
Standard Concrete Culvert	4, 7, 8, 9, 11, 12, 16, 73, 125, 132
Standard Drawing	1, 2, 7, 9, 10, 12-13, 23-25, 76-77, 128-129, 134, 136, 139, 143, 147, 162-165, 170
Steel Schedule	15
Structural Engineer	3, 4, 19, 143, 147
Strut	4, 20
Traversable Safety Grating	4, 10, 158, 160
Wingwalls	158