CHAPTER C
CROSS-SECTION ELEMENTS

TABLE OF CONTENTS

Table of Contents Continued...

Table of contents continued....

CHAPTER C
CROSS-SECTION ELEMENTS

LIST OF FIGURES

Figures continued...

Figures continued...

CHAPTER C
CROSS-SECTION ELEMENTS

LIST OF TABLES

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CHAPTER C
CROSS-SECTION ELEMENTS

C.1 CROSS-SLOPE REQUIREMENTS

C.1.1 Minimum Cross-Slope for Various Surface Types

The selection of surface type has some influence on the geometric design of roadways and is worthy of consideration. Criteria for selection includes: traffic volume and composition, availability of materials, initial cost and the extent and cost of maintenance. In selecting a surface type, the following factors are to be considered:

- The ability of the surface to retain its shape for the anticipated volumes and traffic loads
- The ability of the surface to drain storm water
- The effect the surface will have on driver behavior.

Table C.1.1 below shows minimum cross-slope requirements for the three most common surface types used in roadway construction.

Table C.1.1 Normal Cross-Slope Requirements for Various Surface Types

Surface Type	Minimum Cross Slope (m/m)
Portland Cement Concrete	0.015
Asphalt Concrete Pavement (ACP)	0.02
Asphalt Surface Treatment	0.02
Double Seal coat (Asphalt)	0.02
Gravel or Crushed Stone Surface	0.03

The maximum algebraic differences in cross-slope rates between adjacent pavements (that is, cross over crown line) are given in Table D.6.4.2.

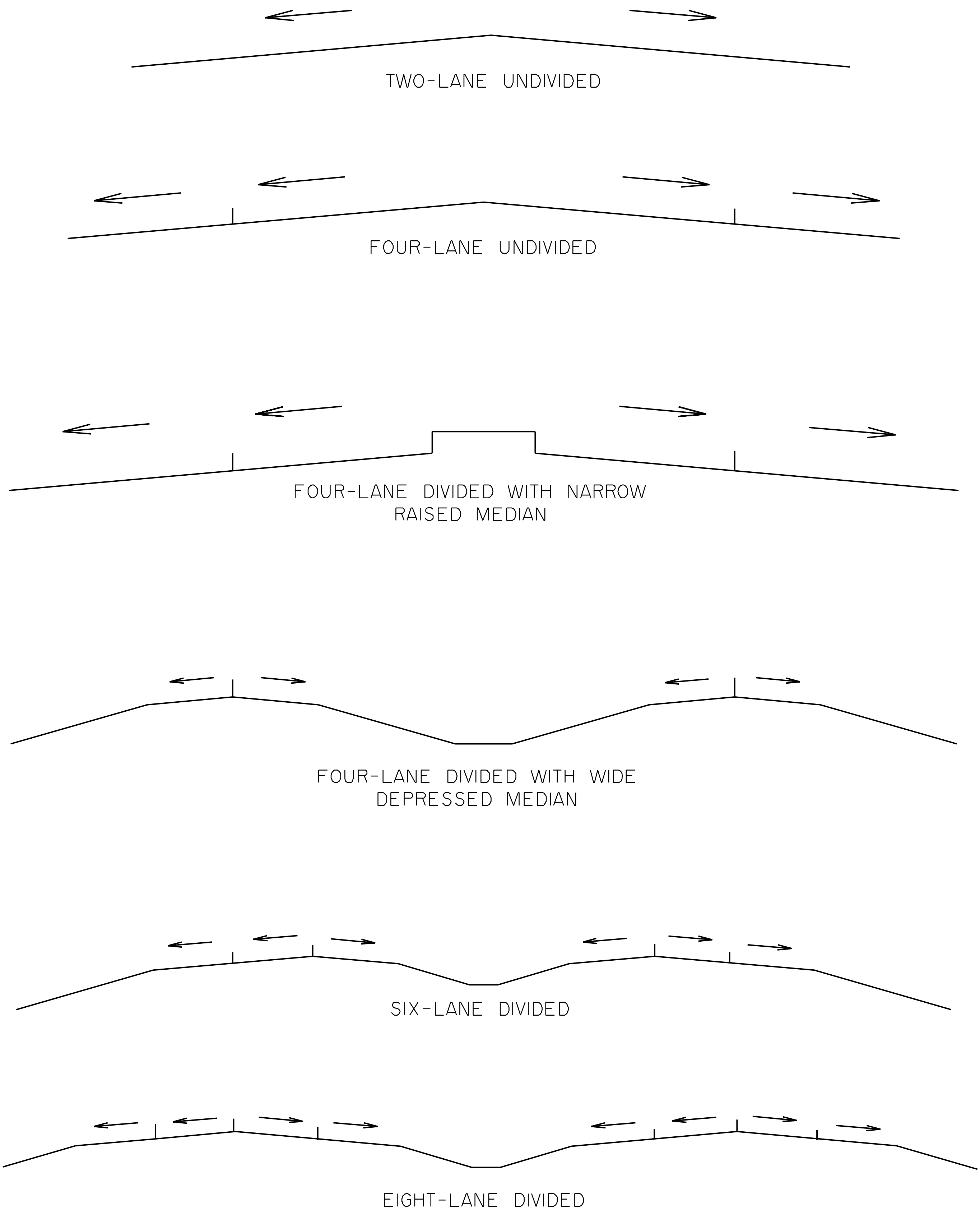
C.1.2 Normal Cross-Slope

The following discussion assumes an asphalt concrete pavement surface on tangent roadway sections:

- On two-lane highways, the pavement is normally crowned at the centreline and the pavement slopes down to the shoulder edge at a rate of 0.02 m/m.
- On four-lane undivided highways and four-lane divided highways that utilize narrow medians, the crown is normally located in the centre of the pavement or median and cross-slope proceeds to the pavement edge at 0.02m/m.
- On four-lane divided highways with wide depressed medians, the crown is normally located at the centreline of each roadway with a cross-slope of 0.02m/m to each pavement edge. If such a roadway eventually requires expansion to six lanes, the two additional lanes may be added to the median side or the outside depending on the median width, the presence (or absence) of at-grade crossings or other factors. The additional lanes will slope away from the crown.
- On six-lane divided highways, the crown for each roadway is normally located at the common edge of the centre and median lanes. The two outside lanes will have a 0.02m/m cross-slope towards the outside pavement edge, and the median lane will have the same cross-slope draining towards the median. If this roadway requires further expansion to eight lanes, the additional lanes are accommodated in the median and adopt the same 0.02m/m cross-slope towards the median.

These applications of normal cross-slope are illustrated in Figure C-1.

FIGURE C-I NORMAL CROSS-SECTION ELEMENTS



C.2 LANE WIDTHS

Through-traffic lane widths have a significant impact on capacity, safety and driver comfort. The standard width for through-lanes on all divided highways, and higher standard undivided highways, is 3.7m. This standard lane width was adopted primarily to accommodate large trucks which are allowed to be 2.6m wide. Wider loads are allowed to use the highway systems under special permit only. Log haul trucks hauling tree length logs are allowed a load width of 3.2m. However, the haul routes and times for log haul are controlled by permit.

On lower designation undivided highways, that is, for RAU-210-110 and lower designations, the standard width for the through-lane is 3.5m. On existing highways which are less than 7.0m wide, and would not conform to any of the standard design designations used for new construction, the lane width may be less than 3.5m. Typically on very narrow highways (less than 7.0m), the lane widths may be considered to be half of the pavement width; that is, no allowance is made for shoulders. On narrower roads, especially those with less than 7.0 m width, shoulder lines are often not painted. Centrelines are generally painted on all primary highways which have a permanent driving surface, e.g. asphalt concrete pavement.

Auxiliary lane widths depend on the function of the lane and the standard design designation. Climbing and passing lanes are built the same width as the through-lane in recognition of the higher operating speeds typically experienced in those lanes. All other auxiliary lanes (for left turns, right turns, acceleration, deceleration and so forth) are 3.5m wide.

A summary of all of the standard lane widths is shown in Table C.2 below. Lane widths are also illustrated on the schematic and standard cross-sections (see Figures C-8a through C-8p).

Table C.2 Standard Lane Widths

Design Designation	Through-lane (m)	Climbing/Passing Lane (m)	Turning, Acceleration, Deceleration Lane (m)
All divided highways	3.7	3.7	3.5
RAU-213.4-120 / 110	3.7	3.7	3.5
RAU-211.8-110	3.7	3.7	3.5
RAU-210-110	3.5	3.5	3.5
RAU-209-110	3.5	3.5	3.5
RAU-208-110	3.5	3.5	3.5

C.3 SHOULDERS

A shoulder is the portion of roadway running adjacent to the travel lanes. The shoulder performs a variety of functions, the more important of which are as follows:

- Provides lateral support for the roadway structure
- Provides an area that may be used to avoid a potential collision or to minimize collision severity
- Contributes to driving ease through a sense of openness created by shoulders of adequate width
- Maintains the intended capacity of the highway
- Provides a safety zone for vehicle parking that is clear of the travelled surface. Reasons for using this zone may include: motor trouble, flat tires, rest periods for drivers and parking space for maintenance vehicles
- Improves sight distance in cut sections
- Provides lateral clearance for the erecting of sign posts
- Used by cyclists.

On all paved primary and secondary highways in the province, the shoulder is fully paved and of the same material as the travel lane. Cross-slope and superelevation requirements on the shoulder are the same as the travel lanes.

Shoulder widths for all classes of rural highways are listed in Table C.3 and illustrated on the standard cross-sections (see Figures C-8a through C-8p).

The rationale for selecting the various shoulder widths shown in Table C.3 is as follows:

A 3.0m shoulder is considered to be a full width shoulder. Three metres is wide enough to serve all of the functions of a shoulder while still not being so wide that it might be confused with a lane by the road user. Although it would be desirable to provide a 3.0m shoulder on each side of all roadways, the additional cost for construction and maintenance could not be justified. Therefore, to minimize costs and optimize benefits, a set of standards has been developed which provides a reasonable shoulder width based on safety needs, design consistency and consideration of all road users (including cyclists).

On four-lane divided highways, a full shoulder should be provided on the right side. However, the shoulder on the left is not intended to serve the same purpose and does not need to be as wide. It is still desirable to have a reasonably wide shoulder on both sides of divided highways due to the high percentage of heavier (larger) vehicles and to allow for the reduction in width that normally occurs at the time of future overlays.

On six-lane divided highways, a full shoulder should be provided on the right side and a 2.5m shoulder on the left side to allow for occasional use by disabled vehicles.

Table C.3 Standard Shoulder Widths

Design Designation	Standard Shoulder Width (m)	Shoulder Width Adjacent to Auxiliary Lane* (m)
RFD-820.8-130 / 120	3.0 (left), 3.0 (right)	0.5 (left), 1.5 (right)
RFD-616.6-130 / 120	2.5 (left), 3.0 (right)	0.5 (left), 1.5 (right)
RFD / RAD-412.4-130	2.0 (left), 3.0 (right)	0.5 (left), 1.5 (right)
RAU-213.4-130 / 120	3.0	1.5
RAU-211.8-110	2.2	1.5
RAU-210-110	1.5	1.5
RAU-209-110	1.0	1.0
RAU-208-110	0.5	0.5

* Auxiliary lane included climbing, passing, turning, acceleration and deceleration lanes.

On eight-lane divided highways, a full shoulder should be provided on both sides otherwise it may not be possible for a vehicle that is having mechanical problems in the left lane to make it all the way to the right shoulder before stopping.

On undivided highways, a range of shoulder widths are available from 3.0m full width, down to 0.5m, which may be considered the practical minimum to provide lateral support to the pavement structure. The 2.2m shoulder provided on an RAU-211.8-110 roadway is intended to ensure that 1.8m shoulder will be available after the first overlay.

The minimum shoulder width adjacent to auxiliary lanes is designed to ensure that cyclists will not be forced to use the travel lane at climbing/passing lanes or at intersections. In the case of roadways where the standard shoulder width is less than 1.5m, the standard shoulder width is maintained adjacent to auxiliary lanes.

C.3.1 Grooved Rumble Strips on Shoulders

The purpose of shoulder grooving is to alert errant drivers when they inadvertently leave the travel lanes. The grooves are designed to produce a humming noise, which can be heard inside most passenger vehicles without producing any noticeable vibration, which may hinder vehicle control. Experience has found that the humming noise is sometimes not heard in larger truck cabs due to the presence of other noises. Shoulder grooving has been used by many U.S. State Transportation Departments with impressive results. Many states have reported reductions in the number of run-off-road collisions after shoulder grooves were installed. This reduction in collision numbers, coupled with the relatively low cost of installation, has resulted in shoulder grooving improvements being considered highly cost-effective based on the overall benefits to society that accrue over the life of the improvement .

Generally grooved rumble strips are recommended on first stage paving projects whenever the shoulder width is 2 m or more and on the left shoulder of divided highways where the shoulder width is 1.2 m or more. Grooved rumble strips are appropriate in this application because the roadway surface will normally be re-paved within a short time due to final paving.

However, on shoulders adjacent to climbing lanes, rumble strips may be installed on a 1.5m shoulder rather than the usual 2m minimum. This exception to the normal practice is made because the shoulder adjacent to a climbing lane rarely exceeds 1.5m, an additional lane is available for slow moving vehicles and the roadside area is generally not very forgiving for errant vehicles due to high embankment, relatively steep slopes and/or traffic barriers.

Grooved rumble strips are not carried through intersections where the shoulder width is reduced due to the existence of a turning lane. They are also not required on sections of highway adjacent to developed land within urban centres. Grooved rumble strips, which are constructed by indenting the hot asphalt surface at the time of paving, are applied to the top lift only, after final rolling has been completed, and while the surface temperature is above 65°C, approximately.

With this installation method, extra care is required to maintain good quality control over alignment of lateral placement and to minimize surface cracking (cracks) around rumble strips. Various factors such as the type of roller, the guiding device of the roller, temperature and top aggregate size of the hot mix and the weather can contribute to the quality of the final product.

The layout and dimensions of grooved shoulder rumble strips are shown in Figure C-3.1.

C.3.2 Milled Rumble Strips on Shoulders

The department began installing milled rumble strips on selected projects in 1995 to gain more experience with this method. Milled rumble strips have been found to be more expensive than the grooved type however they have several advantages including accuracy of placement, compaction of surface, no cracking etc. Because of the above advantages, designers and project sponsors have been choosing the milling method of installation more often in the recent years.

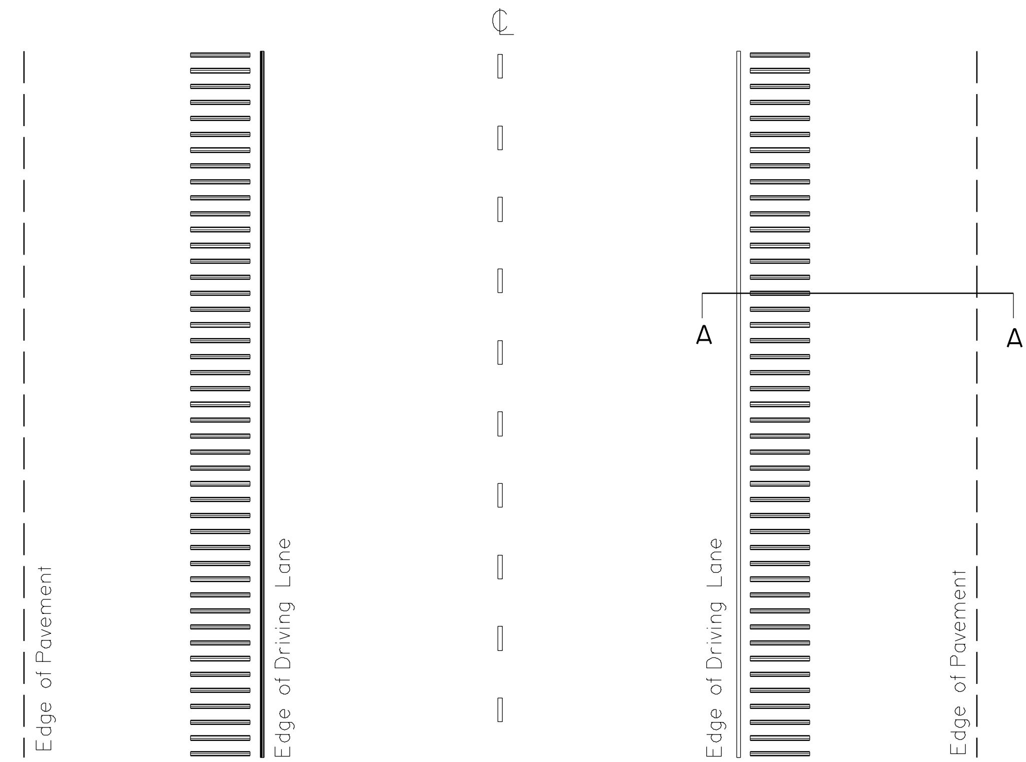
Milled rumble strips are installed with a milling machine or a bobcat equipped with a milling head. The maximum width of rumble strips is limited by the overall width of the milling head. However, the width may be reduced by removing some milling teeth from the milling head. The length (in the direction of travel) and the depth are dependent of the radius and the downward travelling distance of the milling head.

Milled rumble strips may be installed using a continuous or intermittent pattern as shown in Figure C-3.2a and Figure C-3.2b. In February 1999, the standard width of milled rumble strips was reduced from 500 mm to 300 mm to provide more shoulder space for cycling traffic, to minimize annoyance to drivers of vehicles partially encroaching on the shoulder to allow other vehicles to pass, and to reduce the noise that is generated as a result of the encroaching movements.

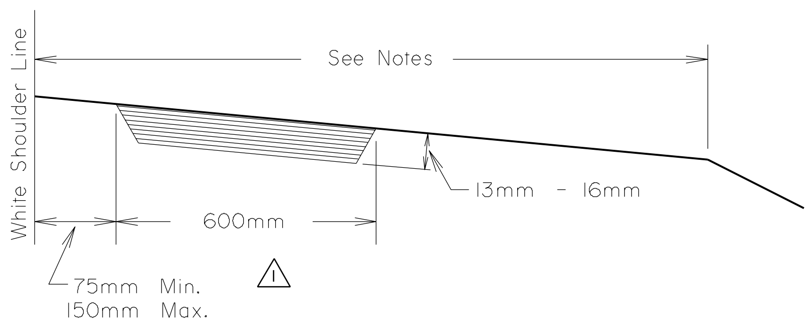
Milling-in method of installation is suggested on divided highways that are part of the National Highway System to provide a consistent high quality product on these highly visible routes.

As the cost of milled rumble strip installation has been gradually coming down since 1995, this installation method is becoming more common. It provides flexibility in timing of installation as the rumble strips may be installed at time of construction or anytime afterwards. It also provides better quality control than the grooved method in terms of accuracy in lateral placement and dimensions of the rumble strips.

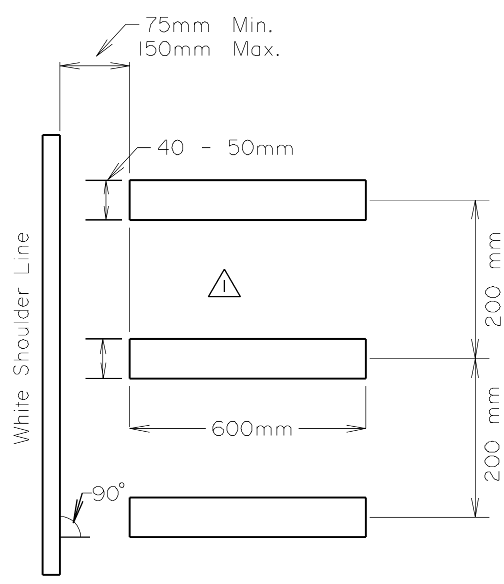
FIGURE C-3.1 GROOVED RUMBLE STRIPS ON SHOULDERS (LAYOUTS AND DIMENSIONS)



PLAN VIEW



CROSS-SECTION VIEW
A-A



DETAIL

Note:

1. Grooved rumble strips are to be included on new and overlay pavement projects on:
   - undivided highways with minimum 2m shoulders
   - divided highways with minimum 2m outside shoulders
   - divided highways with minimum 1.2m median shoulders.
2. Grooved rumble strips may be installed on interchange ramps:
   - if the outside shoulder has a minimum of 2m width
   - if the inside shoulder has a minimum of 1.2m width.
3. Grooved rumble strips are not to be placed through urban areas or where shoulder widths are reduced due to the presence of turning lanes.
4. Grooved rumble strips are to be discontinued where minimum dimensions do not exist.

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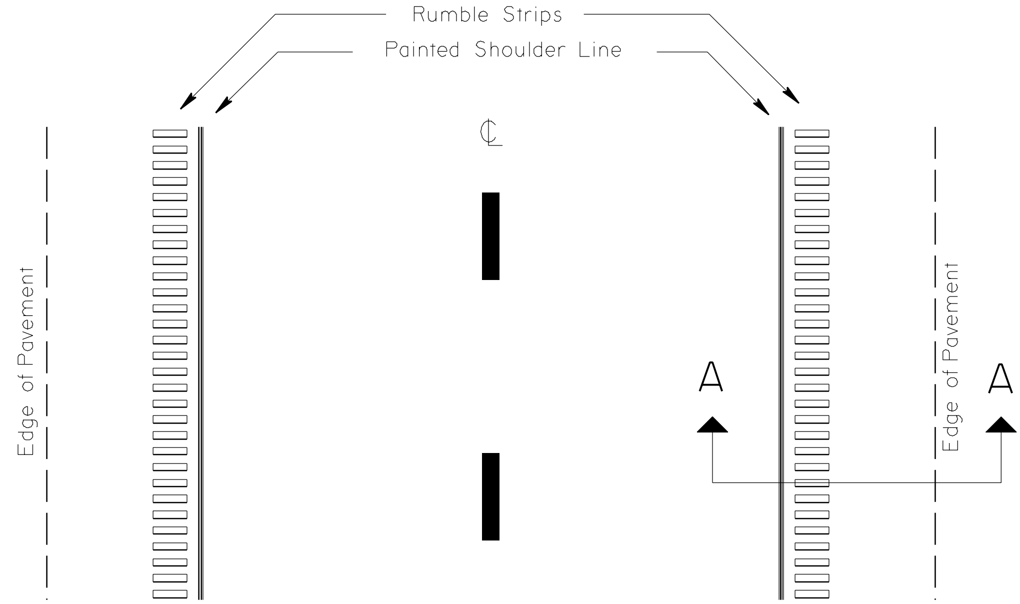
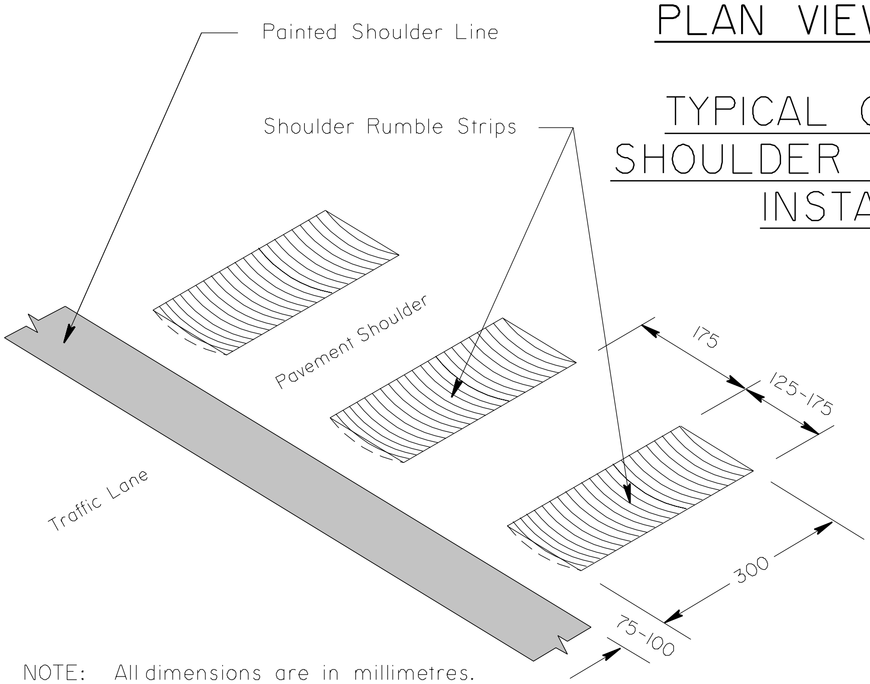
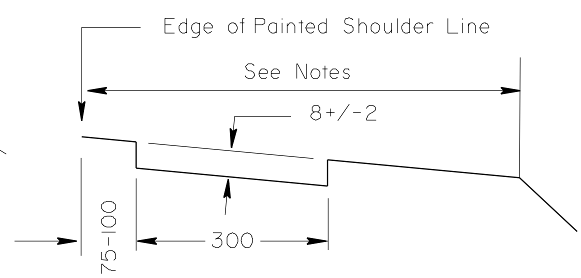
FIGURE C-3.2a CONTINUOUS MILLED RUMBLE STRIPS ON SHOULDERS (LAYOUTS AND DIMENSIONS)



PLAN VIEW



TYPICAL CONTINUOUS SHOULDER RUMBLE STRIP INSTALLATION



SECTION 'A-A'

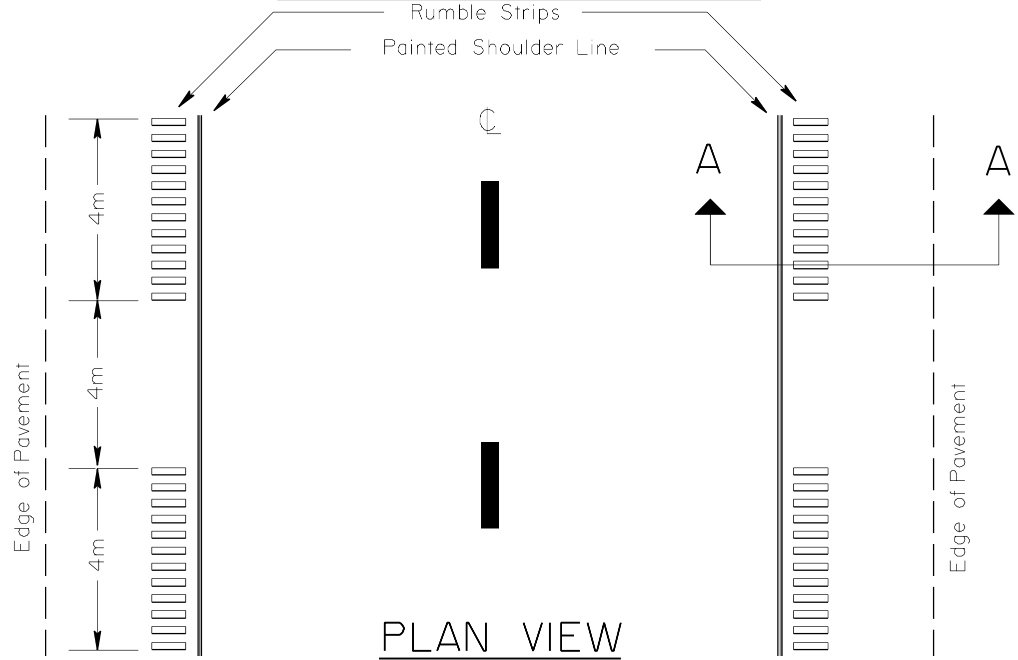
NOTE: All dimensions are in millimetres.

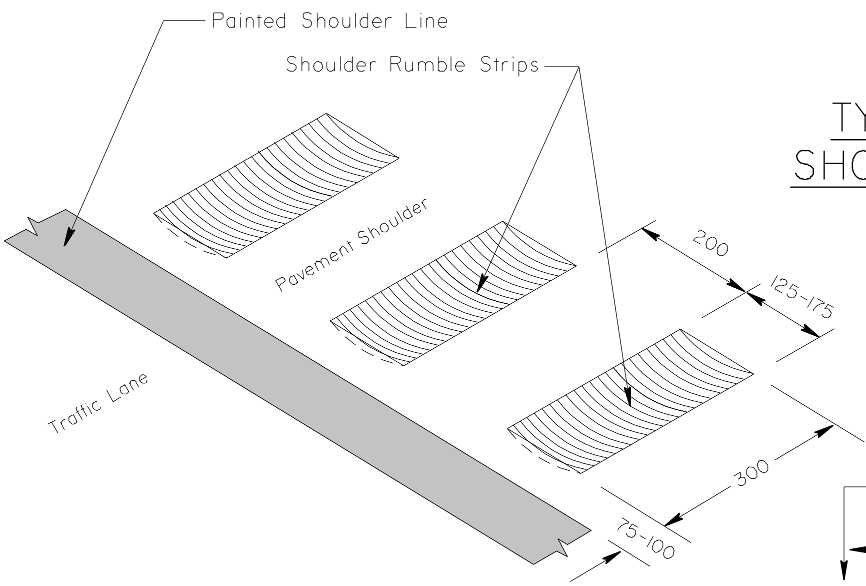
Notes:

1. Milled-in rumble strips are to be placed on existing paved projects on:
   - two-lane highways with minimum 2m shoulders
   - multi-lane highways with minimum 2m outside shoulders
   - multi-lane highways with minimum 1.2m median shoulders.
2. Milled-in rumble strips should only be installed on interchange ramps when directed by the Consultant. △2
3. Milled-in rumble strips are not to be placed through urban areas or where shoulder widths are reduced to the presence of turning lanes.
4. Milled-in rumble strips are to be discontinued where minimum dimensions do not exist.

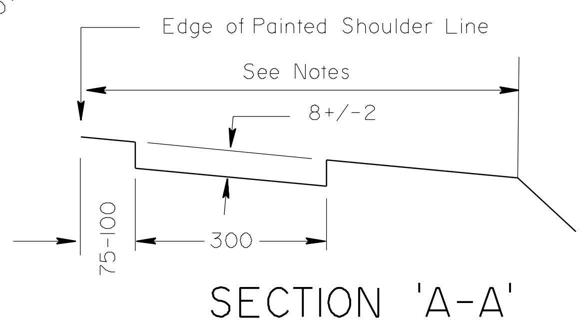
REVISIONS	No.	BY		DATE	
	△2	TDN	REVISED "ENGINEER" TO "CONSULTANT"	DATE	JULY/98
	△1	SL	REVISED PLATE & RENUMBERED FROM TEB 5.19	DATE	MAR / 98

FIGURE C-3.2b INTERMITTENT RUMBLE STRIPS ON SHOULDERS (LAYOUTS AND DIMENSIONS)





TYPICAL INTERMITTENT SHOULDER RUMBLE STRIP INSTALLATION



SECTION 'A-A'

NOTE: All dimensions are in millimetres unless otherwise specified.

Notes:

1. Milled rumble strips are to be placed on existing paved projects on:
   - two-lane highways with minimum 2m shoulders
   - multi-lane highways with minimum 2m outside shoulders
   - multi-lane highways with minimum 1.2m median shoulders.
2. Milled rumble strips should only be installed on interchange ramps when directed by the Consultant. (2)
3. Milled rumble strips are not to be placed through urban areas or where shoulder widths are reduced to the presence of turning lanes.
4. Milled rumble strips are to be discontinued where minimum dimensions do not exist.

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	1	SL	REVISED PLATE & RENUMBERED FROM TEB 5.19	DATE	MAR / 98

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C.4 DRAINAGE

C.4.1 General

Drainage design should provide the most effective and economical methods through which runoff water can be passed through and removed from the roadway. The primary objectives should be to provide culvert openings for natural drainage channels, prevent undue accumulation and retention of water upon and adjacent to the roadway, and to protect the roadway against storm and subsurface water damage. The installation of drainage facilities must not create hazardous conditions for traffic or have any adverse affect on adjoining property.

- Designers should note that highway drainage systems are not permitted to alter the natural drainage pattern of adjacent land without obtaining a permit from Alberta Environmental Protection.

C.4.2 Drainage Requirements

In determining drainage requirements, a critical factor is the expected intensity of rainfall during a storm. Predicting rainfall intensity is difficult, unless it is based on actual statistics recorded over a considerable length of time. In most cases this information is not available, therefore, it is the responsibility of field staff to provide information essential for drainage design. Observations of drainage patterns during spring time, when surface water runoff is considerable, gives a good indication of drainage requirements. Staff from Regional Services of Alberta Infrastructure or local municipalities can usually provide valuable drainage requirement information where existing highways or local roads are to be reconstructed. The department has established minimum sizes of culverts for particular installations even though these sizes may have capacity exceeding the discharge requirements. The minimum diameter for circular section pipes serving as cross drains is 800mm on the main alignment, 600mm at minor road accesses and 400mm at field approaches. The purpose of the minimum size is to facilitate pipe cleaning maintenance operations and to minimize freeze-up problems. Culverts of 600mm diameter are commonly used to drain medians on divided highways.

On a typical highway design project, it is not necessary to undertake a detailed drainage design calculation for smaller culverts because these culverts are generally, oversized for ease of maintenance. Larger bridge sized culverts or structure require a more extensive investigation as per bridge guidelines.

Where a detailed design is required for a culvert, the following guidelines should be used:

- Provide a capacity based on a return period of 100 years for primary highways, 50 years for secondary highways and 25 years for low volume local roads.
- Overall drainage system should be considered including ditches, outfalls, ponds, etc.
- Culverts may be designed to allow water to back-up to height of subgrade (not to top of surfacing material).
- If the depth of water is going to exceed 1 m in a ditch or retention pond, the duration of such high water should be very limited unless the water hazard is outside the clear zone or protected by traffic barriers.
- Storm water velocities and erosion control measures should be considered as required based on gradients, soil types, and previous experience with erosion in the local vicinity.
- Designers may refer to AASHTO "Guidelines for Storm Drain Systems" for additional information.

C.4.3 Drainage Channels

Drainage channels perform the function of removing surface water from the highway right of way. They should be designed to have sufficient capacity to keep water velocities below the scour limits where possible.

Basically, there are five types of drainage channels:

- Roadside channels or ditches are used in cut sections to remove water from the highway cross-section. The desirable minimum ditch slope is 0.2 percent and the absolute minimum is 0.1 percent. The minimum slopes are intended to eliminate ponding in ditches. The desirable maximum slope for ditch is three percent. Ditches which exceed three percent grade for long sections may require special erosion control measures. Highly erosdible soils (for example, silty soils) may experience some scouring even at relatively low grades.

- Toe-of-slope channels convey water from the cut section and from adjacent slopes to the natural water course.
- Catch water ditches are placed at the top of cut slopes to intercept surface water where required.
- Chutes carry collected water down steep cut or fill slopes.
- Swales or shallow depressions are generally used to drain medians or islands.

All channels should be streamlined in cross-section for safety, ease of maintenance and to minimize the effect of drifting snow. Design standards for the various drainage channels are shown on the typical cross-sections (see Figures C-8a through C-8p).

C.4.3.1 Ditch Configuration

The trapazoidal ditch configuration shown in all of Alberta's standard cross-sections has been adopted primarily based on safety. Studies[4] have shown that of the common ditch configurations (Vee ditch, round ditch, narrow trapazoided ditch or wide trapazoidal ditch) the latter is the safest for errant vehicles which must leave the road and traverse the roadside area including sideslope, ditch and backslope. The same study found that sideslopes of 4:1 or flatter are desirable to reduce collision severity in the roadside area (particularly by reducing the occurrence of rollovers), and to permit vehicle recovery onto the road surface; especially where embankment surfaces are firm and smooth. Based on this and other studies, it is recommended that sideslopes of 3:1 or steeper only be used where site conditions do not permit the use of flatter slopes. Depending on design speed, traffic volume and height of embankment, it may be necessary to provide guardrail or other mitigative measures where 3:1 or steeper slopes are constructed near the travel lanes. Section C.5 contains a discussion on treatment or roadside hazards, including embankment slopes.

C.4.3.2 Standard Height of Fill (Depth of Ditch)

The standard height of fill (sometimes called the depth of ditch) used in general for all design designations is one metre. This is the difference in elevation between the graded shoulder and the toe-of-fill slope. Where the height of fill exceeds one metre, ditches are frequently not required. However, if the elevation of shoulder is less than one metre above natural ground, a ditch is normally excavated as per the standard cross-section plan. This is termed a cut section.

The principal reason for using a one metre standard height of fill is to ensure that the roadway embankment will be essentially free of differential, frost-heave problems[5]. This is achieved through excavating wet or unsuitable frost susceptible soil and replacing it with selected clay or granular fill from common or borrowed excavations. The fill material is placed in layers in the embankment at optimum moisture content and a high degree of compaction as required by the construction specification. The embankment material is selected based on suitability for road construction; that is, materials with the lowest degree of frost susceptibility are preferred. By building a one-metre embankment, there is an opportunity to ensure that at least one metre of the clay material underlying a road surface is less frost susceptible, of optimum moisture content and of high density. Although this action does not eliminate the occurrence of frost heave, it does provide consistency and reduces the occurrence of localized bumps due to severe heaves. The construction of the embankment above natural ground also helps to keep the subgrade relatively dry as the natural water table generally will not rise above the natural ground line.

Additional benefits of a one-metre standard height of fill are listed below:

- Provision of adequate snow storage capacity in the ditches
- Reduction of snow-drifting on the road surface as wind will clear lighter accumulations
- Better lines of sight for drivers
- Adequate cover over most culverts
- Standard highway right of ways are wide, which contributes generally to a safer roadside area and less severe run-off-the-road collisions.

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[4] Weaver, Graeme D., Marguis, Eugene L., and Olson, Robert M., "The Relationship of Side Slope Design to Highway Safety", Texas Transportation Institute, Texas A&M University, 1975.

[5] Dacyszyn, J.M., Materials Engineer, Alberta Department of Highways, in unpublished paper, "Frost Design Practices in Alberta".

C.4.4 Culvert Types

Pipe culverts are manufactured in various sizes and shapes and from various types of materials. Types of pipes available for use include:

- Corrugated steel pipe (round and arched)
- Perforated corrugated steel pipe
- Reinforced concrete pipe
- Corrugated plastic pipe

Large size multi-plate pipe culverts* and anti-corrosive pipe are also available.

The standard corrugated steel pipe is galvanized. However, if the culvert is to be installed in a corrosive soil (for example, an alkali soil), an aluminized steel pipe may be used to provide a longer life. The additional cost for aluminized steel is about 10 percent compared with standard galvanized steel.

Concrete culverts are generally only used in special circumstances where long life is a major consideration. Examples are high embankments or high traffic volumes, interchange ramps, etc. where the replacement of an existing culvert would be very inconvenient. With improvements in the methods available for coring or pushing of pipes through existing embankments that have become common in recent years, the need to use concrete culverts around interchange areas is less critical. Special materials may be used in the rehabilitation, for example lining of, existing culverts. Please refer to Section C.4.6. for more information.

***Note**: Culverts over 1400mm in diameter are considered bridge structures.

C.4.5 Culvert Strength Requirements

Pipe culverts are manufactured to several different strength requirements. The principal factors that influence the strength requirements for pipe culverts are the height of fill, and in the case of reinforced concrete culverts, the type of backfill.

Figure C-4.5a identifies the strength requirements for round, arched and five percent vertically elongated Corrugated Steel Pipe (CSP). Maximum permissible cover is shown for various combinations of pipe diameter, pipe shape and thickness of metal. Maximum cover is based on the distance from the top of the culvert to the elevation of the finished roadway surface.

In the case of the vertically elongated CSP, the culvert must be installed with the long axis of the pipe standing vertically to obtain the benefit of the increased strength.

Figure C-4.5b shows the allowable height of fill over corrugated aluminum pipe for various gauge thickness and diameters. This information is based on standard highway loadings (as used in the other figures). However, the load carrying capacity of aluminum culverts is much less than that of steel culverts due to lower pipe stiffness and lower yield strengths.

Figure C-4.5c gives strength requirements for reinforced concrete pipe in terms of maximum permissible cover for various combinations of the five classes of pipe.

FIGURE C-4.5a THICKNESS OF CORRUGATED STEEL PIPE
(Related to Diameter and Depth of Cover)

TABLE A

THICKNESS OF CORRUGATED STEEL PIPE
METRIC CIRCULAR (CORRUGATION PROFILE 68mm x 13mm)

DIA. in mm	AREA in m²	* HEIGHT OF COVER ABOVE TOP OF CULVERT - IN m																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
400	0.126	1.6														2.0						2.8									
500	0.196	1.6										2.0							2.8												
600	0.283	1.6					2.0									2.8							3.5								
700	0.385	2.0											2.8						3.5								4.2				
800	0.503	2.0								2.8				3.5								4.2									
900	0.636	2.0					2.8					3.5				4.2															
1000	0.786	2.8								3.5				4.2																	
1200	1.131	2.8						3.5		4.2			FOR FILLS OVER 11m - USE TABLE B																		
1400	1.540	3.5						4.2			FOR FILLS OVER 9m - USE TABLE B																				

* THE IMPERFECT TRENCH CONDITION METHOD OF INSTALLATION IS TO BE USED WHEN HEIGHT OF COVER OVER A 800mm DIA. C.S.P. EXCEEDS 21m AND WHEN HEIGHT OF COVER OVER A 900mm DIA. C.S.P. EXCEEDS 19m. THE IMPERFECT TRENCH CONDITION IS SHOWN IN FIGURE C-4.6e.

TABLE B

METRIC 5% VERTICALLY ELONGATED C.S.P.
(CORRUGATION PROFILE 68mm x 13mm)

DIA. in mm	AREA in m²	* HEIGHT OF COVER ABOVE TOP OF CULVERT - IN m																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1200	1.131	2.8								3.5														4.2							
1400	1.540	3.5																4.2													

TABLE C

METRIC ARCH C.S.P.
NOTE: AN EQUIVALENT SIZE OF ROUND PIPE IS PREFERRED

SPAN in mm	RISE in mm	AREA in m²	EQUIV. DIA. mm	* HEIGHT OF COVER ABOVE TOP OF CULVERT - IN m					
				1	2	3	4	5	6
450	340	0.112	400	1.6					
560	420	0.175	500	1.6					
680	500	0.255	600	2.0					
800	580	0.342	700	2.0					
910	660	0.443	800	2.0				2.8	
1030	740	0.564	900	2.8					
1150	820	0.701	1000	2.8					3.5
1390	970	1.022	1200	3.5	2.8		3.5		
1630	1120	1.401	1400	4.2	3.5			4.2	

* HEIGHT OF COVER SHOWN IS FOR FINISHED CONSTRUCTION, DURING CONSTRUCTION, SUFFICIENT COVER SHOULD BE PROVIDED TO PROTECT THE STRUCTURE FROM DAMAGE.

NOTE: CULVERT STRENGTH FOR ALL TABLES BASED ON DESIGN SPECIFICATION CAN-CSA-S6-88 DESIGN LIVE LOAD CS750.

NOTE: GREATER HEIGHT OF COVER MAY BE ACCEPTABLE FOR CERTAIN SIZES. CONTACT DESIGN ENGINEERING BRANCH FOR CONFIRMATION.

GRAPHICS FILE: TIGSFS01\REB\MANUAL\CHAPTERS\CHAP-C\DEBC45A.MAN

FIGURE C-4.5b THICKNESS OF CORRUGATED ALUMINUM PIPE
(Related to Diameter and Depth of Cover)
METRIC CIRCULAR

<table>
<tr><th rowspan="2">DIA. in mm</th><th rowspan="2">AREA in m^2</th><th colspan="30">* HEIGHT OF COVER ABOVE TOP OF CULVERT - IN m</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th><th>28</th><th>29</th><th>30</th></tr>
<tr><td>400</td><td>0.126</td><td colspan="7">1.6</td><td colspan="4">2.0</td><td colspan="5">2.8</td><td colspan="14"></td></tr>
<tr><td>500</td><td>0.196</td><td colspan="5">1.6</td><td colspan="3">2.0</td><td colspan="4">2.8</td><td colspan="18"></td></tr>
<tr><td>600</td><td>0.283</td><td colspan="3">1.6</td><td colspan="4">2.0</td><td colspan="3">2.8</td><td colspan="3">3.5</td><td colspan="17"></td></tr>
<tr><td>700</td><td>0.385</td><td colspan="6">2.0</td><td colspan="3">2.8</td><td colspan="2">3.5</td><td colspan="19"></td></tr>
<tr><td>800</td><td>0.503</td><td colspan="5">2.0</td><td colspan="2">2.8</td><td colspan="2">3.5</td><td colspan="21"></td></tr>
<tr><td>900</td><td>0.636</td><td colspan="3">2.0</td><td colspan="2">2.8</td><td colspan="2">3.5</td><td colspan="23">THIS ZONE NOT RECOMMENDED</td></tr>
<tr><td>1000</td><td>0.786</td><td colspan="4">2.8</td><td colspan="2">3.5</td><td colspan="24"></td></tr>
<tr><td>1200</td><td>1.131</td><td colspan="3">2.8</td><td>3.5</td><td colspan="2">4.2</td><td colspan="24"></td></tr>
<tr><td>1400</td><td>1.540</td><td colspan="4">3.5</td><td>4.2</td><td colspan="25"></td></tr>
</table>

* HEIGHT OF COVER IS FOR FINISHED CONSTRUCTION. SUFFICIENT COVER SHOULD BE PROVIDED TO PROTECT THE STRUCTURE FROM DAMAGE.

NOTE: CULVERT STRENGTH FOR ALL TABLES BASED ON H-20 LIVE LOADING.

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FIGURE C-4.5c CLASS OF REINFORCED CONCRETE PIPE

STRENGTH REQUIREMENTS FOR REINFORCED CONCRETE PIPE

CLASS OF REINFORCED CONCRETE PIPE
BASED ON LIVE LOAD CS750 IN DESIGN SPECIFICATION CAN-CSA-S6-88. △1

DIAM. IN mm	AREA IN m^2	HEIGHT OF COVER ABOVE TOP OF CULVERT - IN m		
		1 - 4	4 - 6	6 - 8
375	0.110	III	IV	V
450	0.159	III	IV	V
600	0.283	III	IV	V
750	0.442	III	IV	V
900	0.636	III	IV	V
1200	1.131	III	IV	V *

1. FOR CULVERTS UP TO 900mm IN DIAMETER NEGATIVE PROJECTION EMBANKMENT METHODS TO BE USED WHEN THE HEIGHT OF COVER EXCEEDS 8 METRES. (See Figure C-4.6f)

*2. FOR 1200mm DIAMETER CULVERTS, NEGATIVE PROJECTION EMBANKMENT METHODS TO BE USED WHEN HEIGHT OF COVER EXCEEDS 6 METRES. (See Figure C-4.6f)

3. IF FULL HEIGHT EXCEEDS 8m, A DETAILED LOAD CALCULATION IS REQUIRED TOGETHER WITH AN ASSESSMENT OF THE FACTOR OF SAFETY FOR CONCRETE PIPE STRENGTH. CONTACT ROADWAY ENGINEERING BRANCH FOR INFORMATION.

REINFORCED CONCRETE PIPE MANUFACTURED IN ACCORDANCE WITH REQUIREMENTS OF CAN-CSA SPECIFICATION S6-88 ARE CLASSIFIED ACCORDING TO SUPPORTING STRENGTH CAPACITY VALUES. CONSISTENT WITH THE SUPPORTING STRENGTH CAPACITY SPECIFIED, THE VARIOUS CLASSES OF PIPE CAN GENERALLY BE GROUPED AND DESCRIBED AS TO INTENDED USE AS FOLLOWS:

CLASS I AND CLASS II:	ARE PRIMARILY INTENDED TO CARRY WATER OR SEWAGE BY GRAVITY UNDER MODERATELY LOW HEIGHTS OF COVER AND LIGHT TRAFFIC LOADS.
CLASS III AND CLASS IV:	ARE INTENDED FOR NORMAL HIGHWAY DRAINAGE USE AND FOR SEWERS IN DEEP TRENCHES AND UNDER ABOVE NORMAL LOADING CONDITIONS.
CLASS V:	IS A HIGH STRENGTH CLASSIFICATION FOR HIGHWAY DRAINAGE CULVERTS UNDER HIGH FILLS AND FOR SEWERS IN DEEP TRENCHES AND UNDER SEVERE LOADING CONDITIONS.

REVISIONS	No.	BY		DATE
	No. △2	BY		DATE
	No. △1	BY: TDN	CORRECTED LIVE LOAD SPECIFICATION	DATE JULY/ 98

GRAPHICS FILE: DEBC45C.MAN

C.4.6 Culvert Installation

A typical corrugated metal pipe culvert installation is shown in Figure C-4.6a. This drawing illustrates excavation, culvert base construction, backfilling and compaction. The excavation must be wide enough to allow pipe assembly and to accommodate the operation of compaction equipment on either side of the culvert. The culvert bed is constructed using select native or granular material and select material is also placed under the haunches prior to backfilling. A clay seal is placed at both ends of the culvert to cut-off seepage along the pipe.

Sloped end sections are specified for most pipe installations since they provide better entrance and exit flow characteristics, fit closely to the subgrade slope, and are less of an obstruction to a vehicle leaving the roadway surface. Figures C-4.6b, C-4.6c and C-4.6d are to be used in determining culvert installation lengths and the appropriate sloped end treatment for round and arched corrugated steel and plastic culverts, respectively.

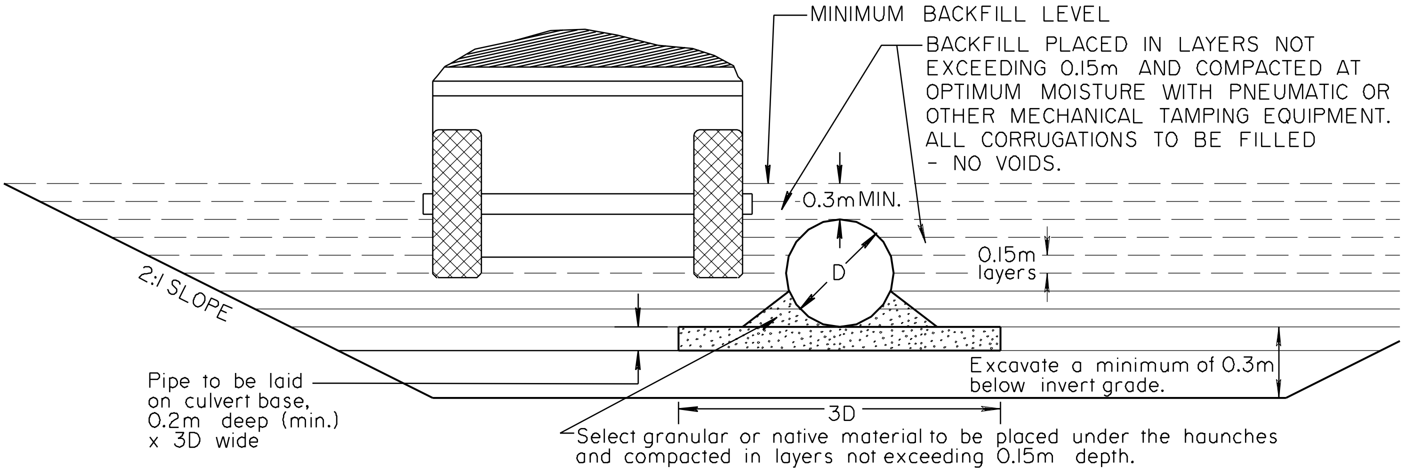
When culverts are installed on skew, the degree of skew is measured as the angle between the pipe installation and a line perpendicular to the highway centreline. A culvert angle is described in terms of which end is forward, that is, left-hand forward or right-hand forward. For example, if the left-hand end of the culvert, while looking along the highway alignment in the direction of increasing chainage, is ahead of the line perpendicular to the centreline, and the angle is 15 degrees, the installation would be described as 15 degrees left-hand forward.

Two special methods of culvert installation, the imperfect trench condition and the negative projecting embankment, are illustrated in Figure C-4.6e and C-4.6f, respectively. Both of these installation types reduce the loading due to backfill and thus increase the safe height of fill that can be carried.

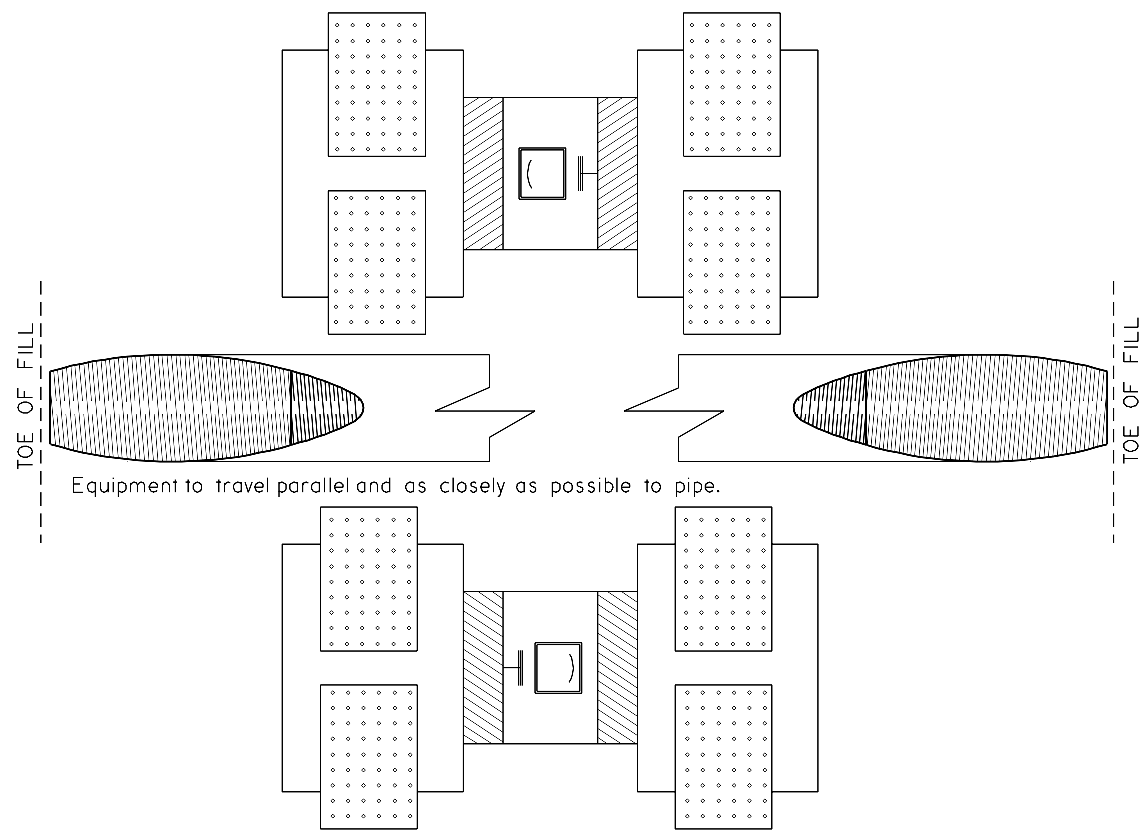
Where existing culverts need to be replaced or rehabilitated due to corrosion or extended due to roadway widening or sideslope improvement a variety of methods are available. Those methods include conventional open-cut excavation, trenching, or coring and pushing smooth wall steel or concrete pipe for culvert replacement.

Rehabilitation methods may be used if the existing culvert has retained its correct form. Rehabilitation may entail lining with plastic pipe and extending the ends using steel pipe.

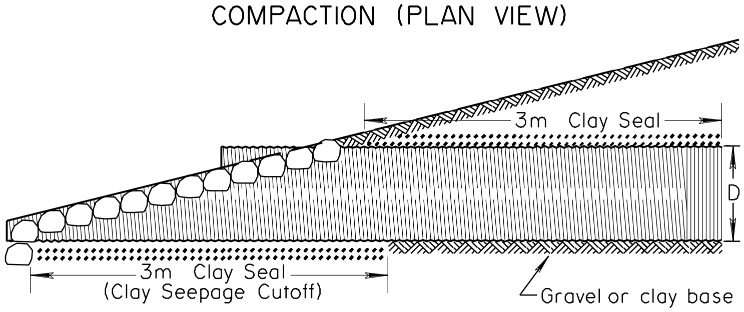
FIGURE C-4.6a CORRUGATED METAL PIPE CULVERT INSTALLATION



EXCAVATION, CULVERT BASE AND BACKFILLING



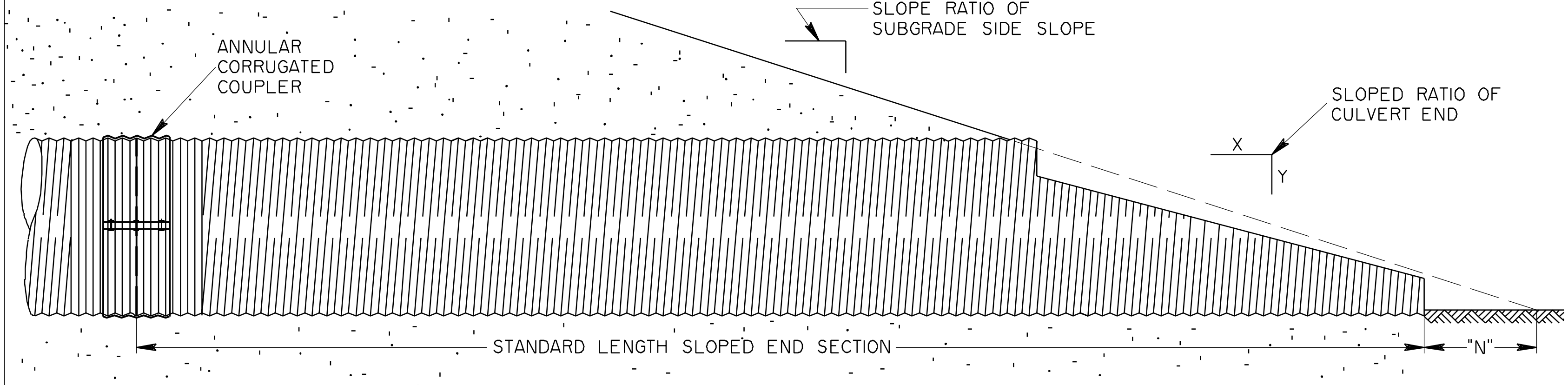
COMPACTION (PLAN VIEW)



Clay seal for seepage to be placed at both ends, for a length of 3m, and to the top of the pipe.

CLAY SEAL DETAIL

FIGURE C-4.6b SLOPED END INSTALLATIONS FOR ROUND SECTION CORRUGATED METAL PIPE



SELECTION OF SLOPE RATIO FOR SLOPED END SECTION:

A 4 : 1 SLOPED END SECTION SHALL BE USED IN CONJUNCTION WITH ALL SUBGRADE SIDE SLOPES WITH THE EXCEPTION OF 1200mm DIA. AND LARGER WHERE APPLICABLE.

C.S.P. DIAMETER - D mm	SLOPE RATIO OF CULVERT END X:Y	"N" - m				INVERT LENGTH OF SLOPE END SEC. METRE
		WITH 3:1 SUBGRADE SLOPE RATIO	WITH 4:1 SUBGRADE SLOPE RATIO	WITH 5:1 SUBGRADE SLOPE RATIO	WITH 6:1 SUBGRADE SLOPE RATIO	
400	4 : 1	0.3	0.5	0.8	1.2	6.0
500	4 : 1	0.3	0.6	0.9	1.5	6.0
600	4 : 1	0.3	0.6	1.0	1.6	6.0
700	4 : 1	0.3	0.8	1.2	2.0	6.0
800	4 : 1	0.4	0.9	1.4	2.3	6.0
900	4 : 1	0.5	1.0	1.6	2.5	6.0
1000	4 : 1	0.5	1.2	1.8	2.8	6.0
1200	3 : 1 4 : 1	0.9 0.6	1.7 1.4	2.4 2.2	3.7 3.5	6.0
1400	3 : 1 4 : 1	1.0 0.6	1.9 1.6	2.8 2.5	4.3 3.9	6.0

DETERMINING INSTALLATION LENGTH

THE LENGTH OF PIPE CULVERT TO BE INSTALLED SHALL BE DETERMINED AS FOLLOWS:

1) ESTABLISH THE THEORETICAL LENGTH BASED ON SLOPE STAKE REQUIREMENTS. WHERE NO SPECIAL TREATMENT IS REQUIRED, CULVERT INVERT ELEVATIONS ARE TYPICALLY SET ABOUT 0.15 X DIAMETER BELOW THE DRAINAGE COURSE ELEVATION.
2) ADJUST THE THEORETICAL LENGTH BY APPLYING THE END CORRECTION N AS DETERMINED FROM THE TABLE TO EACH END OF THE CULVERT.
3) INSTALLATION LENGTH SHALL BE THE LENGTH DETERMINED IN "2" ABOVE, ROUNDED OFF TO THE NEAREST METRE.

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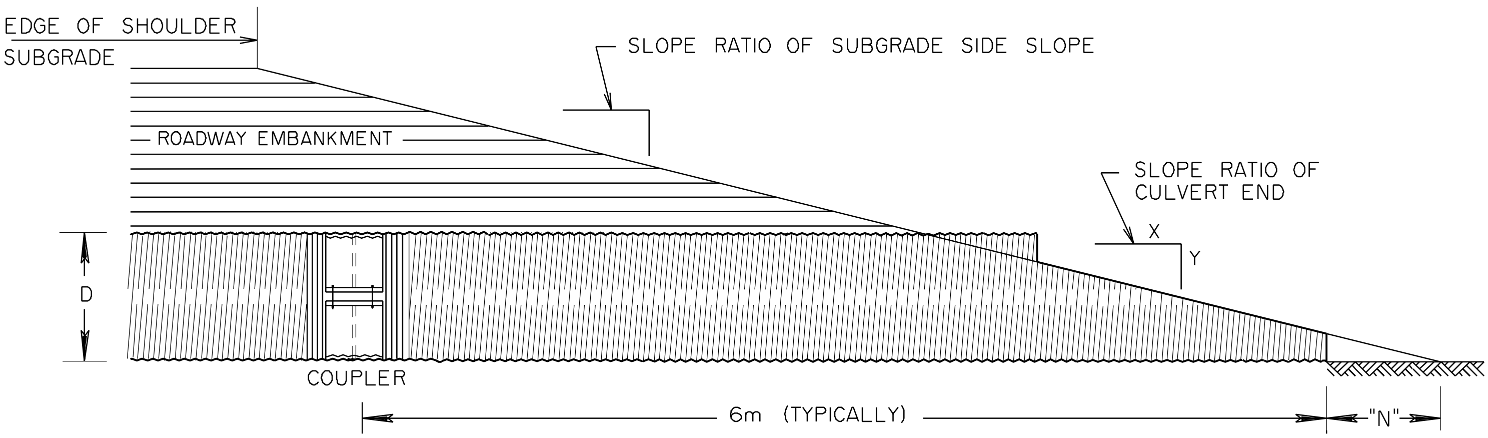
FIGURE C-4.6c ARCH CMP SLOPED END INSTALLATIONS



SECTION

ARCH DIMENSIONS		SLOPE RATIO OF CULVERT END X :Y	"N" - METRE					INVERT LENGTH OF SLOPE END SEC. METRE
SPAN mm	RISE mm		WITH 3 : 1 SUBGRADE SLOPE RATIO	WITH 4 : 1 SUBGRADE SLOPE RATIO	WITH 5 : 1 SUBGRADE SLOPE RATIO	WITH 6 : 1 SUBGRADE SLOPE RATIO	WITH 8 : 1 SUBGRADE SLOPE RATIO	
450	340	4 : 1	0.0	0.3	0.6	-	-	6.0
		5 : 1	-	0.1	0.4	0.6	1.2	6.0
560	420	4 : 1	0.0	0.4	0.7	-	-	6.0
		5 : 1	-	0.1	0.5	0.9	1.6	6.0
680	500	4 : 1	0.0	0.4	0.9	-	-	6.0
		5 : 1	-	0.2	0.6	1.1	2.0	6.0
800	580	4 : 1	0.0	0.5	1.0	-	-	6.0
		5 : 1	-	0.2	0.6	1.2	2.1	6.0
910	660	4 : 1	0.0	0.5	1.2	-	-	6.0
		5 : 1	-	0.2	0.8	1.5	2.3	6.0
1030	740	4 : 1	0.0	0.5	1.3	-	-	6.0
		5 : 1	-	0.2	0.8	1.5	2.5	6.0
1150	820	4 : 1	0.0	0.6	1.4	-	-	6.0
		5 : 1	-	0.3	0.8	1.5	3.0	6.0
1390	970	4 : 1	0.0	0.6	1.5	-	-	6.0
		5 : 1	-	0.1	0.8	1.6	3.0	6.0
1630	1120	4 : 1	0.0	0.7	1.5	-	-	6.0
		5 : 1	-	0.1	1.1	2.2	3.7	6.0

DETERMINING INSTALLATION LENGTH

THE LENGTH OF PIPE CULVERT TO BE INSTALLED SHALL BE DETERMINED AS FOLLOWS:

1.) ESTABLISH THE THEORETICAL LENGTH BASED ON SLOPE STAKE REQUIREMENTS. WHERE NO SPECIAL TREATMENT IS REQUIRED, CULVERT INVERT ELEVATIONS ARE TYPCIALLY SET AT 0.15 X DIAMETER BELOW THE DRAINAGE COURSE LEVEL.

2.) ADJUST THE THEORETICAL LENGTH BY APPLYING THE END CORRECTION "N" AS DETERMINED FROM THE TABLE TO EACH END OF THE CULVERT.

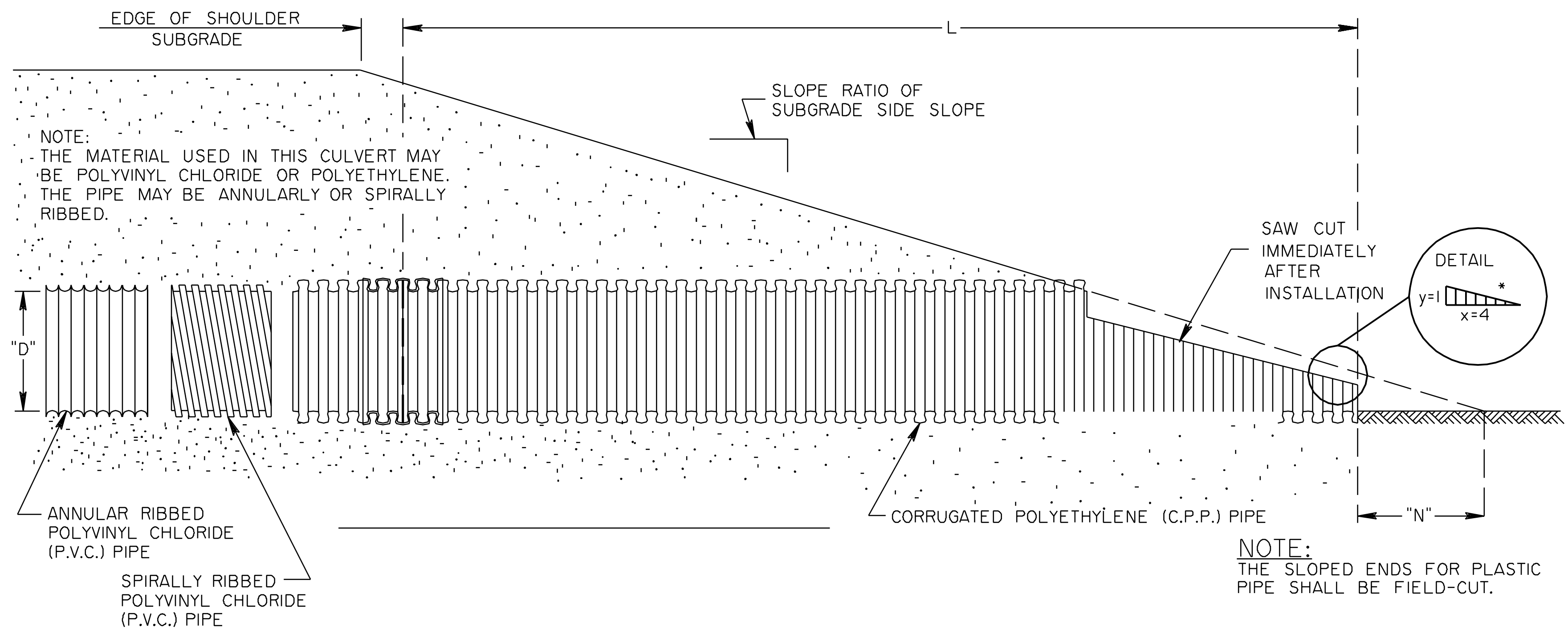
3.) INSTALLATION LENGTH SHALL BE THE LENGTH DETERMINED IN "2" ABOVE, ROUNDED OFF TO THE NEAREST METRE.

SELECTION OF SLOPE RATIO FOR SLOPED END SECTION:

1.) A 4 : 1 SLOPED END SECTION SHALL BE USED IN CONJUNCTION WITH SUBGRADE SIDE SLOPES OF 3 : 1 TO 5 : 1.

2.) A 5 : 1 SLOPED END SECTION SHALL BE USED IN CONJUNCTION WITH SUBGRADE SIDE SLOPES OF 5 : 1 TO 8 : 1.

FIGURE C-4.6d SLOPED END INSTALLATIONS FOR PLASTIC CULVERTS



INSIDE DIAMETER - "D" mm	SLOPE RATIO OF CULVERT END X:Y *	"N" - m				MINIMUM LENGTH OF SECTION FOR SLOPED END "L" - M
		WITH 3:1 SUBGRADE SLOPE RATIO	WITH 4:1 SUBGRADE SLOPE RATIO	WITH 5:1 SUBGRADE SLOPE RATIO	WITH 6:1 SUBGRADE SLOPE RATIO	
400	4 : 1	0.3	0.5	0.8	1.2	FOR PVC PIPE L=4.0
500	4 : 1	0.3	0.6	0.9	1.5	
600	4 : 1	0.3	0.6	1.0	1.6	FOR CPP PIPE L=6.0
750	4 : 1	0.4	0.8	1.3	2.1	
900	4 : 1	0.5	1.0	1.6	2.5	

DETERMINING INSTALLATION LENGTH

THE LENGTH OF PIPE CULVERT TO BE INSTALLED SHALL BE DETERMINED AS FOLLOWS:

1) ESTABLISH THE THEORETICAL LENGTH BASED ON SLOPE STAKE REQUIREMENTS. WHERE NO SPECIAL TREATMENT IS REQUIRED, CULVERT INVERT ELEVATIONS ARE TYPICALLY SET ABOUT 0.15 X DIAMETER BELOW THE DRAINAGE COURSE ELEVATION.
2) ADJUST THE THEORETICAL LENGTH BY APPLYING THE END CORRECTION "N" AS DETERMINED FROM THE TABLE TO EACH END OF THE CULVERT.
3) INSTALLATION LENGTH SHALL BE THE LENGTH NEAREST METRE.

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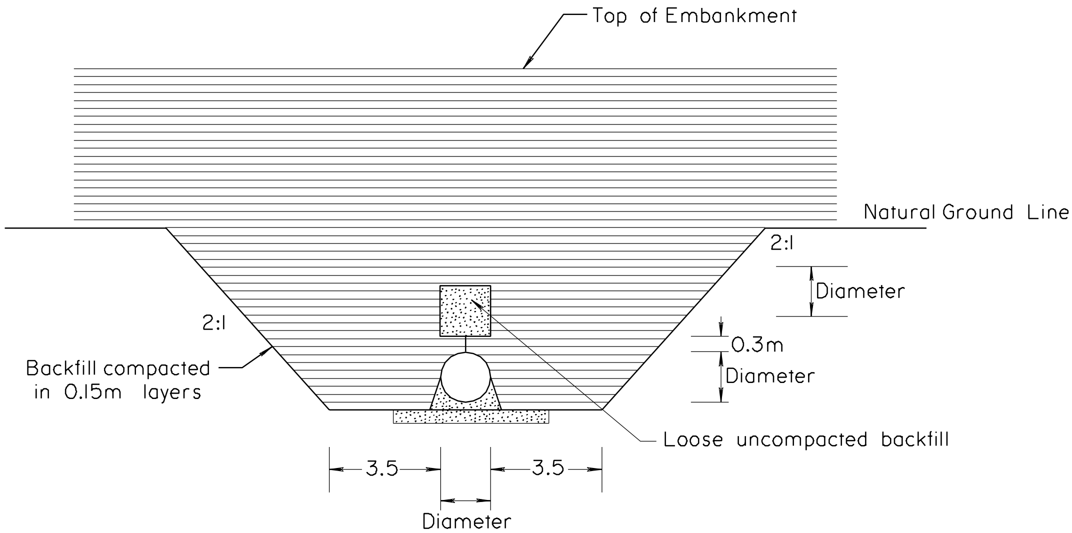
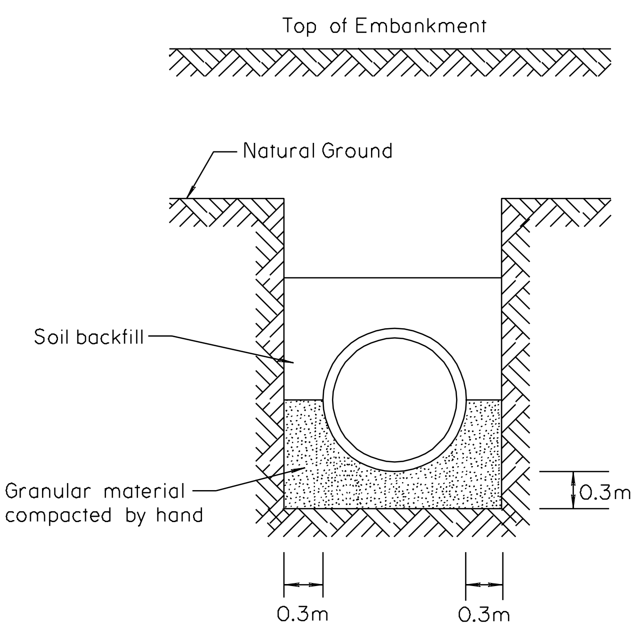
FIGURE C-4.6e SPECIAL CULVERT INSTALLATION METHOD
- Imperfect Trench Condition



NOTE:
The imperfect trench method of construction decreases the backfill or embankment load on the culvert, thus increasing the safe height of fill that can be carried. This method involves thorough compaction of the bed and material around and over the culvert in the normal way up to a height of diameter plus 0.3m above the culvert. A trench of width equal to the diameter of the culvert is then dug down to within 0.3m of the top of the culvert and refilled with loose uncompacted material after which the remainder of the fill is completed in the normal manner.

FIGURE C-4.6f SPECIAL CULVERT INSTALLATION METHOD
- Negative Projecting Embankment



NOTE:
A negative projecting culvert is one that is installed in undisturbed natural soil in a narrow ditch extending upward some distance from the top of the culvert. This type of construction results in much less loading from the same fill than would result from a conventional installation method as shown in Figure C-4.6a.

C.4.6.1 Culvert Invert Level, Slope and Camber

In areas that are generally flat, the culvert invert elevations should be set as low as, or lower, than the lowest area adjacent to the right of way without changing the existing drainage pattern. Invert elevations are generally set approximately 0.15 x diameter below the drainage course or ditch elevation.

When setting the slope for culverts, that is, the average slope between the inlet and outlet, it is desirable to ensure that the slope is steep enough to prevent sedimentation or ponding. The slope must still be flat enough to prevent high speed flow, which can cause scouring at joints or erosion at the outlet. For this purpose, Table C.4.6.1 has been prepared to show suggested minimum and maximum slopes for culverts based on diameter.

As shown in the table, a slope of one percent to two percent is advisable to give a culvert its critical slope which maximizes the capacity while still keeping the water velocity within permissible limits. In general, a minimum slope of 0.5 percent will avoid sedimentation.

For smooth wall culverts such as concrete, smooth steel or smooth plastic, the water velocity for any given slope will be higher than it would be on a corrugated metal pipe. Therefore, this fact should be taken into account when setting the slope.

Where it is necessary to have an elevation difference between inlet and outlet that is greater than what would result from using the maximum gradient, a special hydraulic design is required. Based on that design a drop inlet, downdrain, baffles inside the culvert, or an energy dissipating pond may be necessary to allow for a change in elevation without erosion. A detailed drawing showing a typical downdrain on a highway embankment is shown in Figure C-4.6.1a.

<u>Camber</u>

All culvert beds (with the exception of those founded on rock) undergo settlement and/or consolidation after construction if they were not previously loaded. Some camber is generally desirable to counteract the differential settlement along the pipe that often occurs, especially in high fills and/or in yielding ground. Figure C-4.6.1b illustrates a typical camber. The main problem that results from sagging of culverts in the centre is ponding, which reduces the flow capacity, will cause icing, and may accelerate the corrosion of the metal.

The Technical Standards Branch has developed a chart for estimating the design camber to be used for culvert installations based on height of fill and soil type. The chart has been developed based on over 500 laboratory tests on Alberta soils. The chart is reproduced here in Figure C-4.6.1c.

It should be noted that the camber should be less than or equal to half of the difference between the upstream invert elevation and the downstream invert elevation. This culvert camber estimate chart should only be used where site-specific consolidation tests are not available.

Table C.4.6.1 Suggested Gradients for Culverts (Corrugated Metal Pipe)

Culvert Diameter	Minimum Gradient	Maximum Gradient
600mm	1%	2%
800mm	1%	2%
900mm	1%	2%
1000mm	1%	2%
1200mm	1%	2%
2400mm	0.5%	1%

$$\text{Culvert Gradient} = \frac{\text{Inlet Invert Elevation (m)} - \text{Outlet Invert Elevation (m)}}{\text{Culvert Length (m)}}$$

Source: Handbook of Steel Drainage & Highway Construction Products

FIGURE C-4.6.1a DETAIL OF CORRUGATED STEEL DOWNDRAIN PIPE

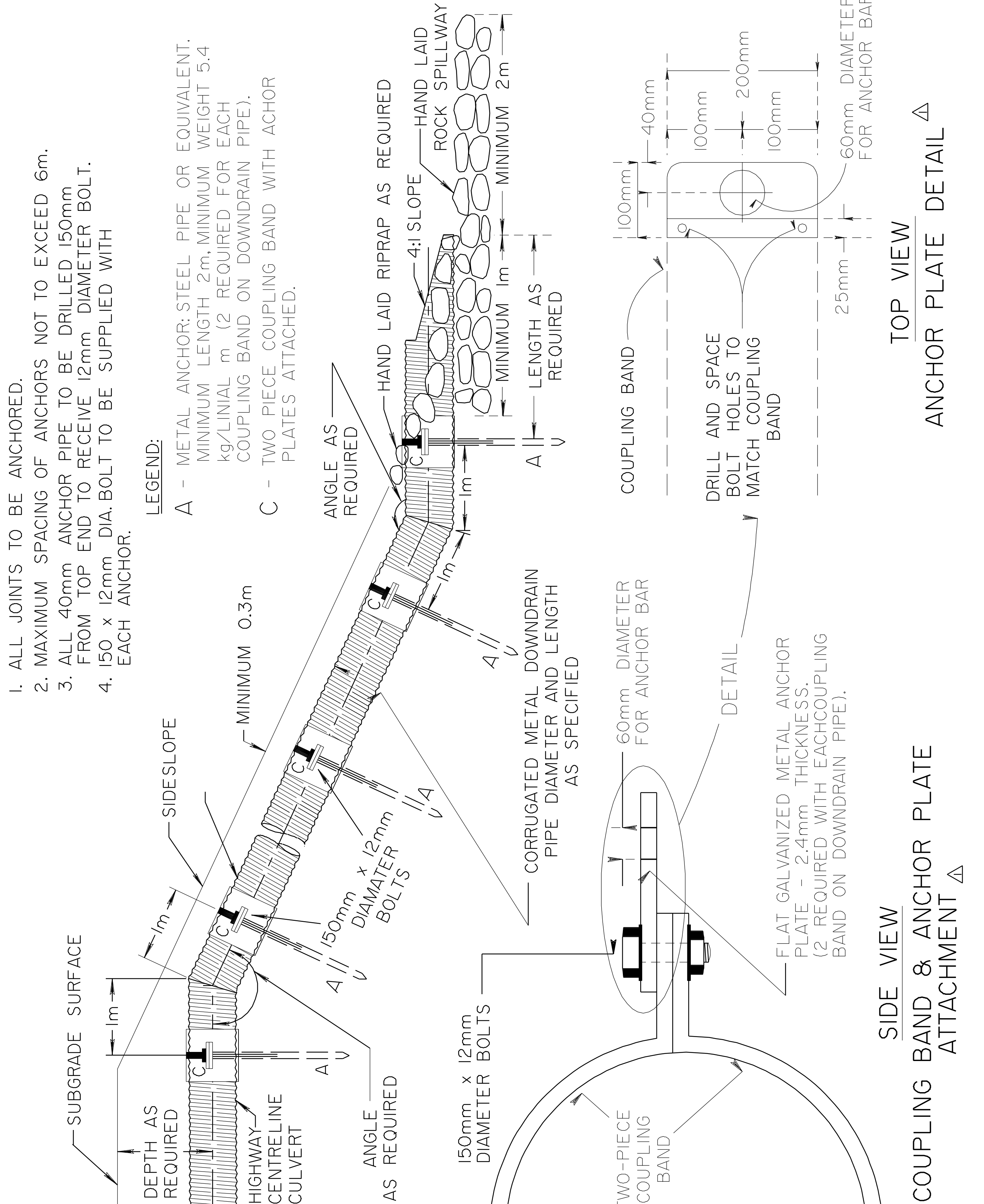


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FIGURE C-4.6.1b CULVERT CAMBER

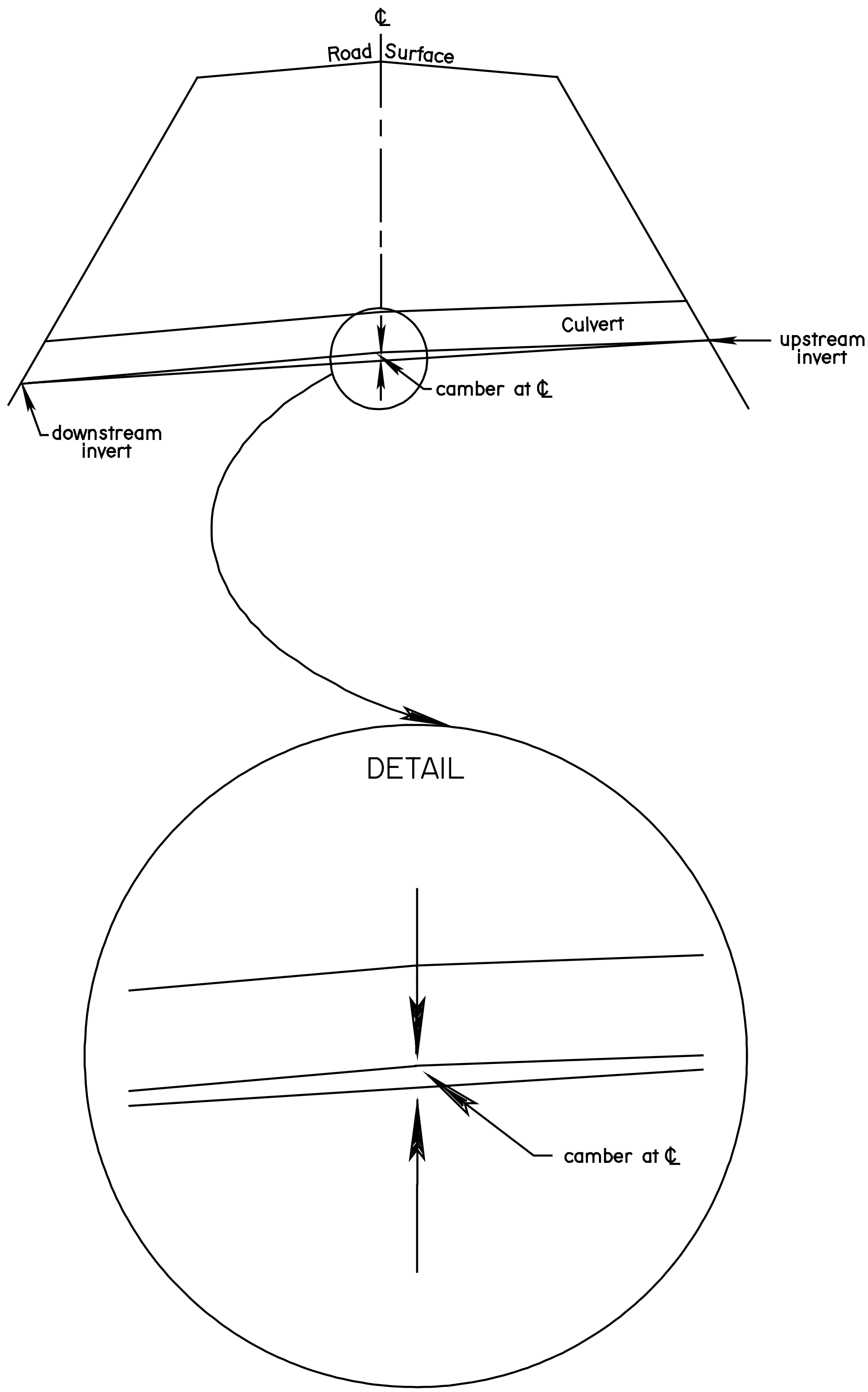
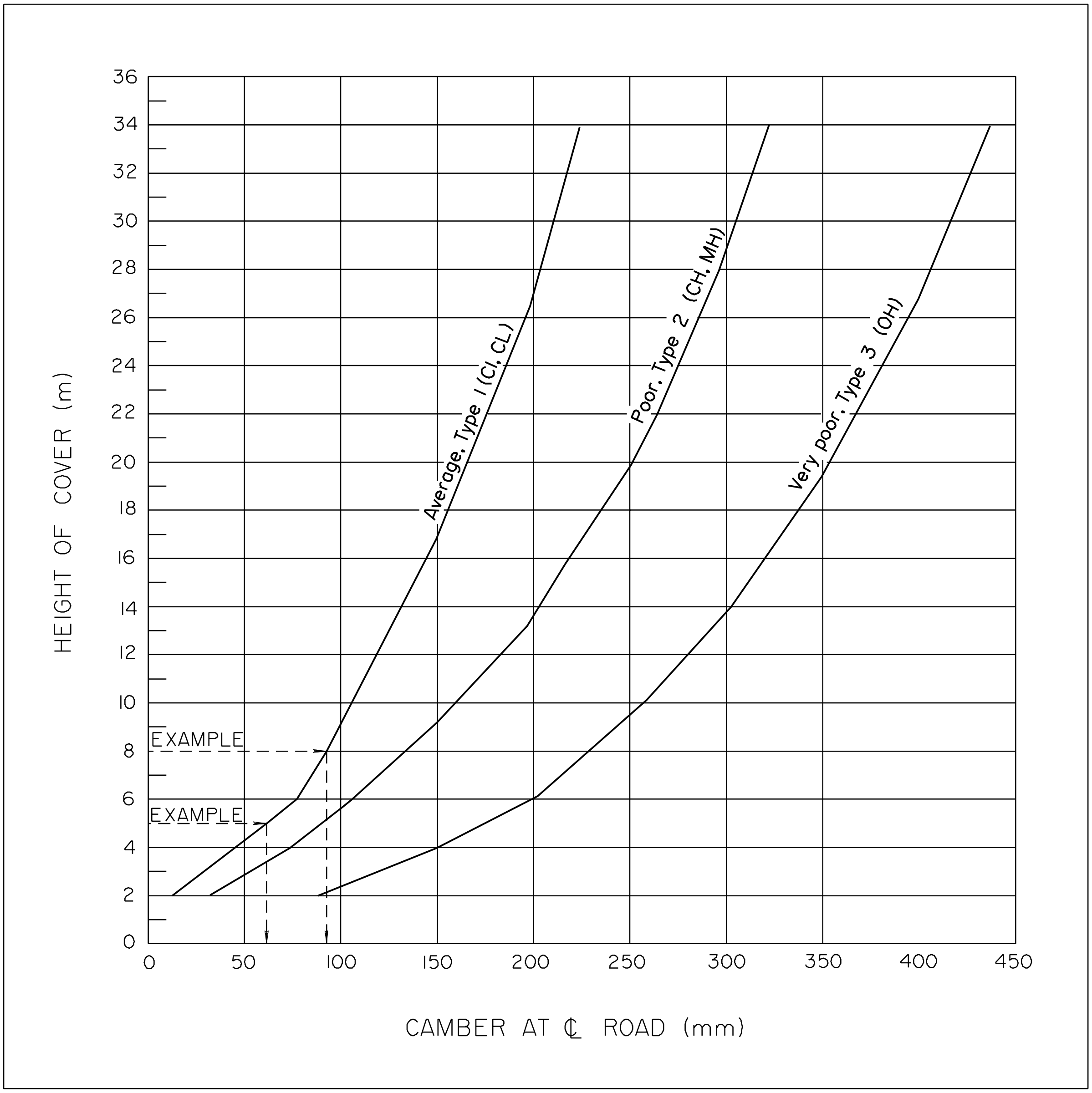


FIGURE C-4.6.lc CULVERT CAMBER ESTIMATE
Normally Consolidated Fine-Grained Foundation Material

Source: "Guidelines for Bridge Structures, Standards, Approvals and Design, Bridge Engineering Branch, A.T.&U."



CAUTION:

Use only when site-specific consolidation tests are not available.
Do not use if culvert span is > 6.0m.

$$\text{Camber} \le \frac{\text{Upstream INVERT EL.} - \text{Downstream INVERT EL.}}{2}$$

EXAMPLE:

Foundation is Type (I)
Height of Cover = 5m
Culvert diameter or rise = 3m
Adjacent fill is 5 + 3 = 8m
Camber = 60mm
Transverse differential settlement = 95mm - 60mm = 35mm

ASSUMPTIONS:

- $e_o = G_s \frac{\gamma_w}{\gamma_d} - 1$
- $3.8 < \frac{e_o}{C_c} < 4.6$ (based on over 500 lab tests on Alberta soils)

- Settlement for first 2.0m of cover is negligible
- Immediate elastic settlement will occur during foundation preparation
- Stress influence beyond 4.0m below culvert invert is ignored
- Natural moisture content of foundation material is > optimum moisture content.

C.4.7 Riprap

Riprap consists of a protective covering of hand-laid rock, randomly deposited rock, sacked concrete or sacked soil cement, that is placed around culvert inlets and outlets, along slopes and embankments, ditches, gutters or spillways, or at other places as required. The chief purpose of riprap is to prevent erosion of constructed fills and channels by water action. A secondary purpose, in the case of culvert ends (especially plastic pipe) is to provide some weight through downward force which will counteract the upward forces that can cause culvert ends to rise above the channel bed.

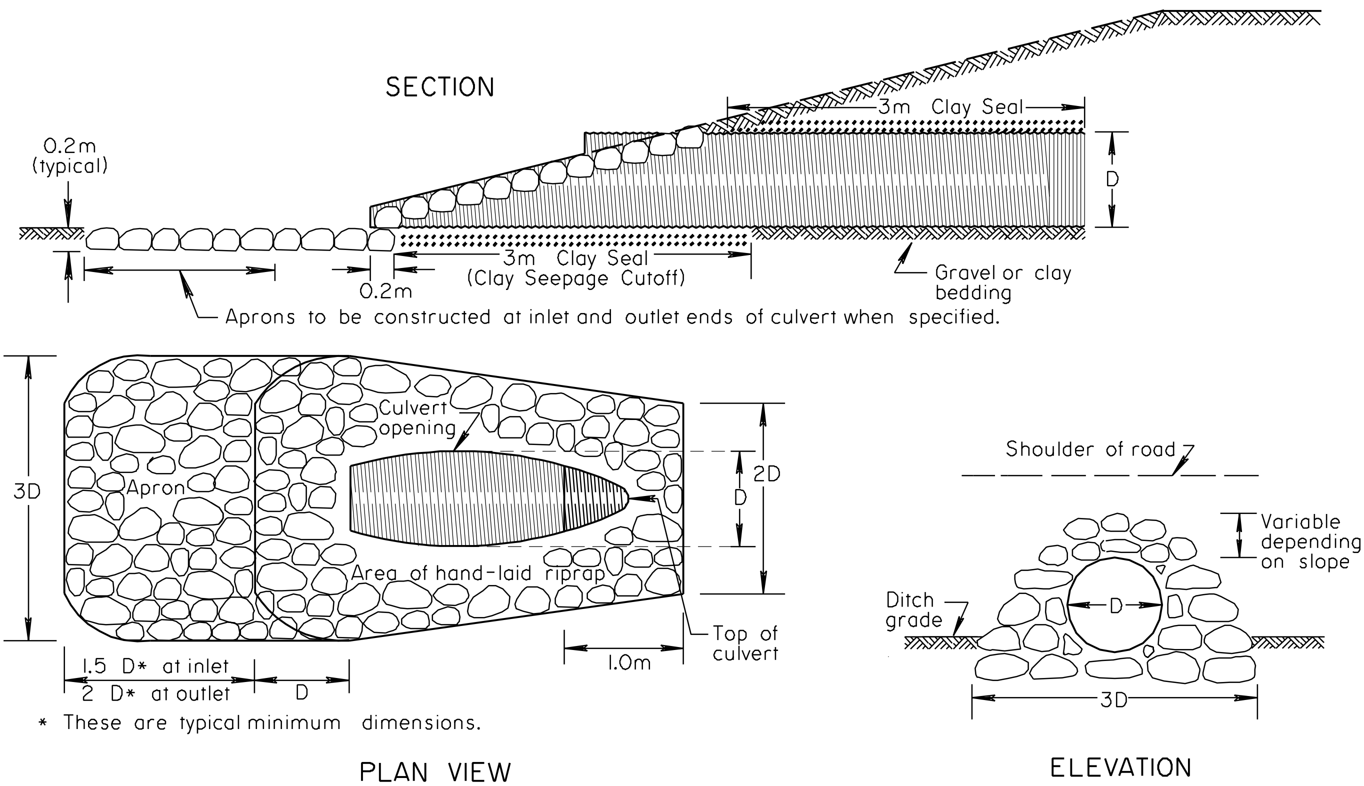
Riprap is generally called for at the inlet and outlet of all culvert installations on Alberta's highways. The typical layout of riprap installations at culvert ends is shown in Figures C-4.7a and C-4.7b. Aprons may be required at some installations. Generally, designers should select the locations which will require aprons based on the volume and speed of the flow of water through the culvert and the type of soil. On projects which have highly erodible soil, aprons may be required at most culvert installations.

Where aprons are used, the typical minimum length is 1.5 times the diameter at the inlet and two times the diameter at the outlet. These minimum lengths may be exceeded if required at a particular site. Where a watercourse is required to change direction at the inlet to a culvert, an apron is generally required. Similarly, if a culvert outlet occurs above the natural ground elevation, that is, where there will be a drop at the outlet, or where the slope of the culvert exceeds the desirable rate (generally about three percent) the use of an apron at the outlet is recommended to prevent scouring. For design and construction purposes aprons are generally only built when specified or directed by the Engineer. Riprap of culvert inlet and outlet only is assumed unless otherwise noted in the design/construction documents.

In cases where culvert outlets are constructed above the toe of embankment, as may be necessary to control water velocity in the culvert through high embankments built on sidehills, some erosion control measures are suggested. A corrugated steel pipe downdrain as shown in drawing CB6-2.4M4 (standard drawings manual) is suggested for large differences in elevation. Riprap aprons may be used for smaller drops.

Rock riprap is generally preferred where rock is available, due to its longer life. Where rock is not readily available, sacked concrete or sacked cement stabilized material may be used as a substitute.

FIGURE C-4.7a HAND LAID ROCK RIPRAP



NOTES:

1. ROCKS AND BOULDERS SHALL BE SELECTED AS NEARLY CUBICAL IN FORM AS PRACTICAL AND SHALL HAVE A LEAST MINIMUM DIMENSION OF 200mm. THE STONES SHALL BE PLACED WITH THEIR BEDS AT RIGHT ANGLES TO THE SLOPE, THE LARGER STONES BEING USED IN THE BOTTOM COURSES AND THE SMALLER STONES AT TOP. THEY SHALL BE LAID IN CLOSE CONTACT SO AS TO BREAK JOINTS AND IN SUCH MANNER THAT THE WEIGHT OF THE STONE IS CARRIED BY THE EARTH AND NOT BY THE ADJACENT STONES. THE FINISHED WORK SHALL PRESENT AN EVEN, TIGHT, AND REASONABLY PLANE SURFACE, VARYING NOT MORE THAN 75mm FROM THE REQUIRED CONTOUR.
2. WHERE NO SPECIAL TREATMENT IS REQUIRED, CULVERT INVERT ELEVATIONS ARE TYPICALLY SET ABOUT 0.15 x DIAMETER BELOW THE DRAINAGE COURSE ELEVATION.
3. A CLAY SEAL IS TO BE PLACED AT BOTH ENDS OF THE CULVERT FOR A LENGTH OF 3m TO CUT OFF SEEPAGE. THE CLAY SEAL SHALL EXTEND FROM THE BOTTOM OF THE EXCAVATION TO 300mm ABOVE THE CROWN OF THE PIPE, AND FOR THE FULL WIDTH OF THE EXCAVATION.
4. WHERE APRONS ARE REQUIRED DUE TO HIGH VELOCITY FLOW OR EROSION PRONE SOIL, TYPICALLY THE MINIMUM INLET APRON IS 1.5x DIAMETER LONG WHILE THE MINIMUM OUTLET APRON (WHERE WATER VELOCITY IS HIGHER) IS TWO DIAMETRES LONG.

ESTIMATED RIPRAP SURFACE AREAS*

PIPE DIAMETER (mm)	AREA OF ONE END EXCLUDING APRON (m^2)	AREA OF ONE END INCLUDING INLET APRON (m^2)	AREA OF ONE END INCLUDING OUTLET APRON (m^2)
500	2	3	4
600	3	5	6
700	4	6	7
800	5	8	9
900	6	10	11
1000	7	12	13
1100	9	14	16
1200	10	16	19
1400	13	22	25

* THE ESTIMATED RIPRAP SURFACE AREAS SHOWN IN THIS TABLE ARE BASED ON A 4:1 SIDESLOPE.

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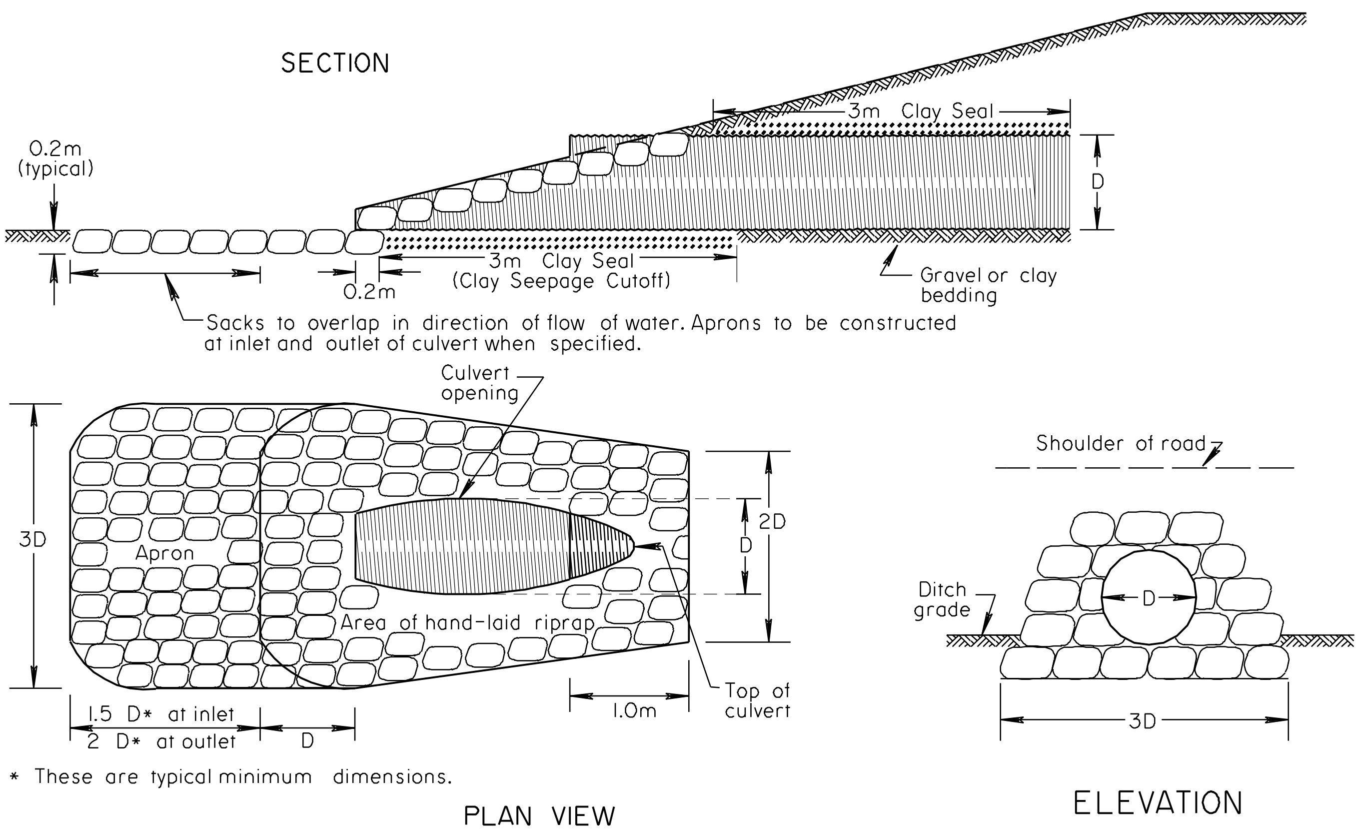
FIGURE C-4.7b SACKED CONCRETE OR SACKED CEMENT STABILIZED RIPRAP



NOTES:

1. ROCKS AND BOULDERS SHALL BE SELECTED AS NEARLY CUBICAL IN FORM AS PRACTICAL AND SHALL HAVE A LEAST MINIMUM DIMENSION OF 200mm. THE STONES SHALL BE PLACED WITH THEIR BEDS AT RIGHT ANGLES TO THE SLOPE, THE LARGER STONES BEING USED IN THE BOTTOM COURSES AND THE SMALLER STONES AT TOP. THEY SHALL BE LAID IN CLOSE CONTACT SO AS TO BREAK JOINTS AND IN SUCH MANNER THAT THE WEIGHT OF THE STONE IS CARRIED BY THE EARTH AND NOT BY THE ADJACENT STONES. THE FINISHED WORK SHALL PRESENT AN EVEN, TIGHT, AND REASONABLY PLANE SURFACE, VARYING NOT MORE THAN 75mm FROM THE REQUIRED CONTOUR.
2. WHERE NO SPECIAL TREATMENT IS REQUIRED, CULVERT INVERT ELEVATIONS ARE TYPICALLY SET ABOUT 0.15 x DIAMETER BELOW THE DRAINAGE COURSE ELEVATION.
3. A CLAY SEAL IS TO BE PLACED AT BOTH ENDS OF THE CULVERT FOR A LENGTH OF 3m TO CUT OFF SEEPAGE. THE CLAY SEAL SHALL EXTEND FROM THE BOTTOM OF THE EXCAVATION TO 300mm ABOVE THE CROWN OF THE PIPE, AND FOR THE FULL WIDTH OF THE EXCAVATION.
4. WHERE APRONS ARE REQUIRED DUE TO HIGH VELOCITY FLOW OR EROSION PRONE SOIL, TYPICALLY THE MINIMUM INLET APRON IS 1.5x DIAMETER LONG WHILE THE MINIMUM OUTLET APRON (WHERE WATER VELOCITY IS HIGHER) IS TWO DIAMETRES LONG.

ESTIMATED RIPRAP SURFACE AREAS*

PIPE DIAMETER (mm)	AREA OF ONE END EXCLUDING APRON (m^2)	AREA OF ONE END INCLUDING INLET APRON (m^2)	AREA OF ONE END INCLUDING OUTLET APRON (m^2)
500	2	3	4
600	3	5	6
700	4	6	7
800	5	8	9
900	6	10	11
1000	7	12	13
1100	9	14	16
1200	10	16	19
1400	13	22	25

* THE ESTIMATED RIPRAP SURFACE AREAS SHOWN IN THIS TABLE ARE BASED ON A 4:1 SIDESLOPE.

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C.5 ROADSIDE DESIGN

C.5.1 Introduction

Motor vehicle accidents inflict a tremendous toll on Alberta society. In recent years, there have typically been 350-400 fatal collisions annually resulting in between 400 and 500 deaths. In addition to the number of persons killed, there are typically 20,000 casualties involving personal injuries. (Source: Alberta Traffic Collision Statistics.) The total annual societal cost of motor vehicle accidents in Alberta is conservatively estimated at $2,600 million using AI's collision cost model contained in the Benefit-Cost Analysis guide.

Although a detailed breakdown for Alberta was not available, data from the United States indicates that about 60 percent of fatal collisions involved only one vehicle. In about 70 percent of these accidents, the vehicles left the road surface and either overturned or collided with a fixed object. Some of these fixed objects were man-made, including sign supports, utility poles, traffic barriers, culvert ends, approaches and other roadside elements that are usually under the direct control of the highway agency.

While every reasonable effort must be made to keep a driver on the roadway, the highway design engineer must acknowledge the fact that this goal will never be fully realized. Drivers will continue to run off the road for many reasons, including driver error in the form of excessive speed, falling asleep, reckless or inattentive driving, or driving under the influence of alcohol or other drugs. A driver may also leave the road deliberately to avoid a collision with another motor vehicle, animals or objects on the road. Roadway conditions are a factor in some cases. Poor alignment, poor visibility due to weather conditions, low pavement friction, inadequate drainage, or substandard signing, marking or delineation may play a contributory role. Finally, vehicle component failures may sometimes cause a driver to run off the road. Failures in steering or braking systems or tire blow-outs are typical vehicle-related causes.

Once a vehicle leaves the roadway, the probability of an accident occurring depends primarily on the speed, the trajectory of the vehicle, and what lies in its path. If an accident occurs, its severity is dependent upon several factors, including the use of restraint systems by vehicle occupants, the type of vehicle, and the nature of the roadside environment.

Of these factors, the highway engineer generally has a significant measure of control over only one - the roadside environment.

The forgiving roadside concept has been developed due to a recognition that drivers do run off the roadway and that serious accidents and injuries can be lessened if a traversable recovery area is provided. A current reference document on this topic is AASHTO's Roadside Design Guide (1996). Ideally, this recovery area or clear zone should be free of obstacles such as unyielding sign and luminaire supports, non-traversable drainage structures, utility poles and steep slopes. Design options for the treatment of these features have generally been considered in the following order:

- Removal of the obstacle or redesign it so it can be safely traversed
- Relocation of the obstacle to a point where it is less likely to be struck
- Reduction in impact severity by using an appropriate breakaway device
- Delineation of the obstacle if the above alternatives are not appropriate.

This forgiving roadside concept has been accepted and applied by highway agencies for almost two decades. Within that time, there have been significant advances in our knowledge of roadside safety hardware performance limits, the average severity of collisions resulting from contact with barriers and other obstacles, and the expected frequency of encroachments based on traffic volume, speed and shoulder width. In some cases — for example when considering construction of flat traversable slopes on high embankments — these factors can be combined to permit a rational examination of the design options available to the design engineer. In other cases, design decisions will continue to be made based on past experience and state-of-the-art practices. Selecting the best alternative from a range of acceptable choices is the continuing challenge that the highway design engineer must face.

The following sections describe the clear zone concept and hazards that should be considered for mitigation. Detailed information on design of traffic barriers should be obtained from the Alberta Infrastructure's Traffic Control Standards Manual.

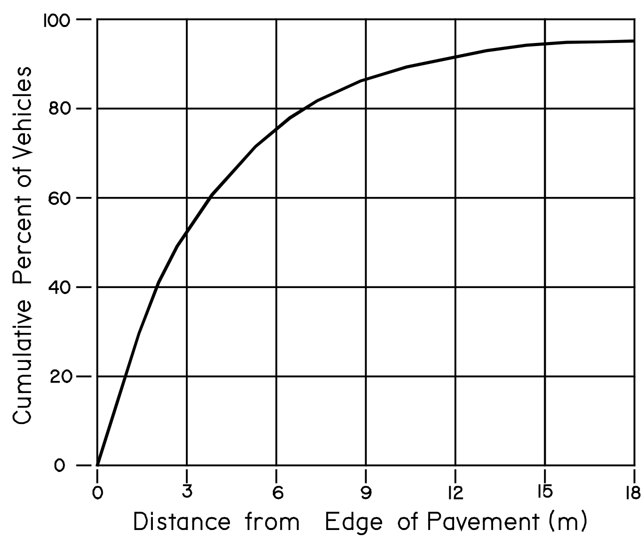
C.5.2 Clear Zone

The clear zone is defined as the border area starting at the edge of the travel lane that should be clear of hazards and available for use by errant vehicles.

The movement of an out-of-control vehicle is difficult to predict. It depends largely on the nature of the roadside, the circumstances that cause the vehicle to go out-of-control and the type of vehicle. Tests have shown that on moderate sideslopes, approximately 50 percent of errant vehicles leaving the road on tangent alignments are able to recover within 3.0m from the edge of travel lane and a full 85 percent will recover within 9.0m (see Figure C-5.2a). Beyond 9.0m, the return on investment in keeping the roadside clear is obviously less since the number of vehicles exceeding that lateral encroachment distance is small and the additional roadside clearance required to eliminate a significant number of crashes could be very costly.

The ideal time to consider elimination of hazards is at the grading design stage. When analyzing hazards, the clear zone is a primary consideration. The clear zone distance, which is a function of the design speed, design AADT, sideslope and traffic volume, may be determined from Table C.5.2a. Generally, any hazards located in the clear zone should be mitigated.

FIGURE C-5.2a COLLISION STUDY



Source: General Motors Proving Ground Collision Study.

FIGURE C-5.2b EXAMPLE OF A PARALLEL EMBANKMENT SLOPE DESIGN

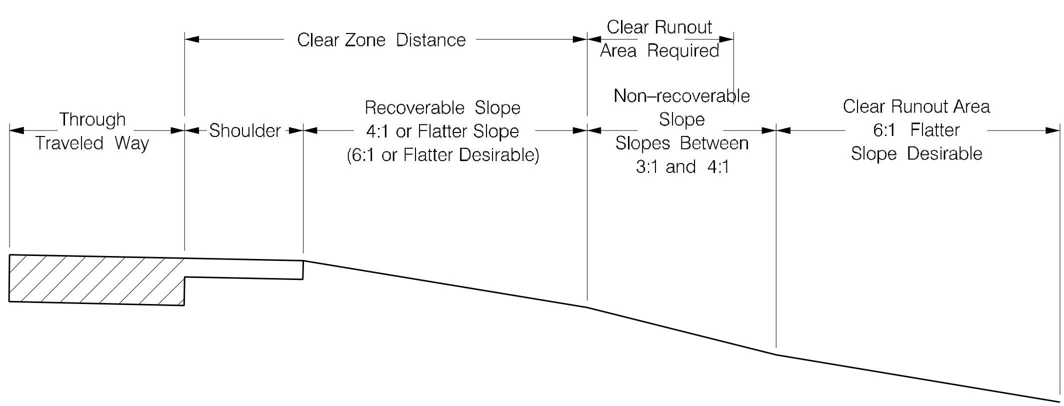


Table C.5.2a Clear Zone Distances (in meters from edge of driving lane)

Design Speed (Km/h)	Design AADT +	Fill Slopes			Cut Slopes		
		6:1 Or Flatter	5:1 To 4:1	3:1	3:1	5:1 To 4:1	6:1 Or Flatter
60 or less with barrier curb	All	0.5	0.5	0.5	0.5	0.5	0.5
60 or Less	Under 750	2.0 – 3.0	2.0 – 3.0	**	2.0 – 3.0	2.0 – 3.0	2.0 – 3.0
	750 – 1500	3.0 – 3.5	3.5 – 4.5	**	3.0 – 3.5	3.0 – 3.5	3.0 – 3.5
	1500 – 6000	3.5 – 4.5	4.5 – 5.0	**	3.5 – 4.5	3.5 – 4.5	3.5 – 4.5
	Over 6000	4.5 – 5.0	4.5 – 5.0	**	4.5 – 5.0	4.5 – 5.0	4.5 – 5.0
70 –80	Under 750	3.0 – 3.5	3.5 – 4.5	**	2.5 – 3.0	2.5 – 3.0	3.0 – 3.5
	750 – 1500	4.5 –5.0	5.0 – 6.0	**	3.0 – 3.5	3.5 – 4.5	4.5 –5.0
	1500 – 6000	5.0 – 5.5	6.0 – 8.0	**	3.5 – 4.5	4.5 – 5.0	5.0 – 5.5
	Over 6000	6.0 – 6.5	7.5 – 8.5	**	4.5 – 5.0	5.5 – 6.0	6.0 – 6.5
90	Under 750	3.5 – 4.5	4.5 – 5.5	**	2.5 – 3.0	3.0 – 3.5	3.0 - 3.5
	750 – 1500	5.0 – 5.5	6.0 – 7.5	**	3.0 – 3.5	4.5 – 5.0	5.0 – 5.5
	1500 – 6000	6.0 – 6.5	7.5 – 9.0	**	4.5 – 5.0	5.0 – 5.5	6.0 – 6.5
	Over 6000	6.5 – 7.5	8.0 – 10.0 *	**	5.0 – 5.5	6.0 – 6.5	6.5 – 7.5
100	Under 750	5.0 – 5.5	6.0 – 7.5	**	3.0 – 3.5	3.5 – 4.5	4.5 – 5.0
	750 – 1500	6.0 – 7.5	8.0 – 10.0 *	**	3.5 – 4.5	5.0 – 5.5	6.0 – 6.5
	1500 – 6000	8.0 – 9.0	10.0 – 12.0 *	**	4.5 – 5.5	5.5 – 6.5	7.5 – 8.0
	Over 6000	9.0 – 10.0 *	11.0 – 13.5 *	**	6.0 – 6.5	7.5 – 8.0	8.0 – 8.5
110	Under 750	5.5 - 6.0	6.0 – 8.0	**	3.0 – 3.5	4.5 – 5.0	4.5 – 4.9
	750 – 1500	7.5 – 8.0	8.5 – 11.0 *	**	3.5 – 5.0	5.5 – 6.0	6.0 – 6.5
	1500 – 6000	8.5 – 10.0 *	10.0 – 13.0 *	**	5.0 – 6.0	6.5 – 7.5	8.0 – 8.5
	Over 6000	9.0 – 10.5 *	11.0 – 14.0 *	**	6.5 – 7.5	8.0 – 9.0	8.5 – 9.0
120 or More	750 – 1500 +	8.0 – 9.0	9.0 – 12.0	**	3.5 – 5.0	6.0 – 6.5	7.0 – 7.5
	1500 – 6000 +	9.0 – 10.0	10.0 – 14.0	**	5.5 – 6.5	7.0 – 8.0	8.0 – 9.0
	Over 6000 +	10.0 – 11.0 *	11.0 – 15.0	**	7.0 – 8.0	8.5 – 9.5	9.0 – 10.0

* Where a site specific investigation indicates a high probability of continuing accidents, or such occurrences are indicated by accident history, the designer may provide clear zone distances greater than 9 meters as indicated. Clear zones may be limited to 9 meters for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 3:1 slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery area at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and accident histories. Also, the distance between the edge of the travel lane and the beginning of the 3:1 slope should influence the recovery area provided at the toe of slope. While the application may be limited by several factors, the fill slope parameters which may enter into determining a maximum desirable recovery area as illustrated in Figure C-5.2b.

\+ On undivided highways AADT is a total volume for two directions of travel. For divided highways the traffic volume to be used to establish the clear zone distance is for one direction only.

The designer should use judgment when applying the clear zone offsets. Where the cross section or slope of the terrain or horizontal curvature tends to channel errant vehicles towards a hazard outside the clear zone, or for critical isolated hazards, such as bodies of water, cliffs and bridge piers, just beyond the clear zone where the consequences of a collision may be extremely severe, consideration should be given to providing protection. Similarly, if isolated objects, such as trees, are found to be just within the clear zone, while other trees in the immediate vicinity are outside the clear zone, removal of the trees inside the clear zone may not significantly reduce the risk to drivers. Protection or removal may not be necessary in this case.

The designer may choose to modify the clear zone distance obtained from Table C.5.2a for horizontal curvature by using Table C.5.2b. These modifications are normally only considered where accident histories indicate a need, or a specific site investigation shows a definitive accident potential which could be significantly lessened by increasing the clear zone width, and such increases are cost-effective.

Within unprotected clear zones, cut and fill slopes should be constructed as flat as economically possible in keeping with the topography, height of cut or fill, type of soil and general appearance. On freeways and arterial roads with reasonably wide right of ways, sideslopes on embankments and in cuts should be designed to provide a reasonable opportunity for recovery of an out-of-control vehicle. Where the roadside at the point of departure is reasonably flat, smooth and clear of fixed objects, many potential collisions can be avoided. Embankment slopes 6:1 or flatter can be negotiated by a vehicle with a good chance of recovery and should be provided where practical. Figures C-5.2c and C-5.2d illustrate appropriate ditch rounding procedure for 1.0m and 0.6m ditches, respectively. Slopes at 4:1 may be negotiable, providing that the embankment height is moderate and rounding at the slope break points is sufficient.

Slope criteria for all classes of rural highways are shown on the typical cross-sections (see Figures C-8.2a through C-8.2p).

Table C.5.2b Horizontal Curve Adjustments
K_{CZ} (Curve Correction Factor)

Radius (m)	Design Speed (Km/h)					
	60	70	80	90	100	110
900	1.1	1.1	1.1	1.2	1.2	1.2
700	1.1	1.1	1.2	1.2	1.2	1.3
600	1.1	1.2	1.2	1.2	1.3	1.4
500	1.1	1.2	1.2	1.3	1.3	1.4
450	1.2	1.2	1.3	1.3	1.4	1.5
400	1.2	1.2	1.3	1.3	1.4	-
350	1.2	1.2	1.3	1.4	1.5	-
300	1.2	1.3	1.4	1.5	1.5	-
250	1.3	1.3	1.4	1.5	-	-
200	1.3	1.4	1.5	-	-	-
150	1.4	1.5	-	-	-	-
100	1.5	-	-	-	-	-

$CZ_C = (L_C)(K_{CZ})$

Where CZ_C = clear zone on outside of curvature (m)
L_C = clear zone distance (m) Table C.5.2a
Kcz = curve correction factor

Note: Clear zone correction factor is applied to outside of curves only. Curves flatter than 900 m do not require an adjusted clear zone.

FIGURE C-5.2c ROUNDED DITCH (1.0m DEPTH)
Approximation for Design Plotting and Work Stakes

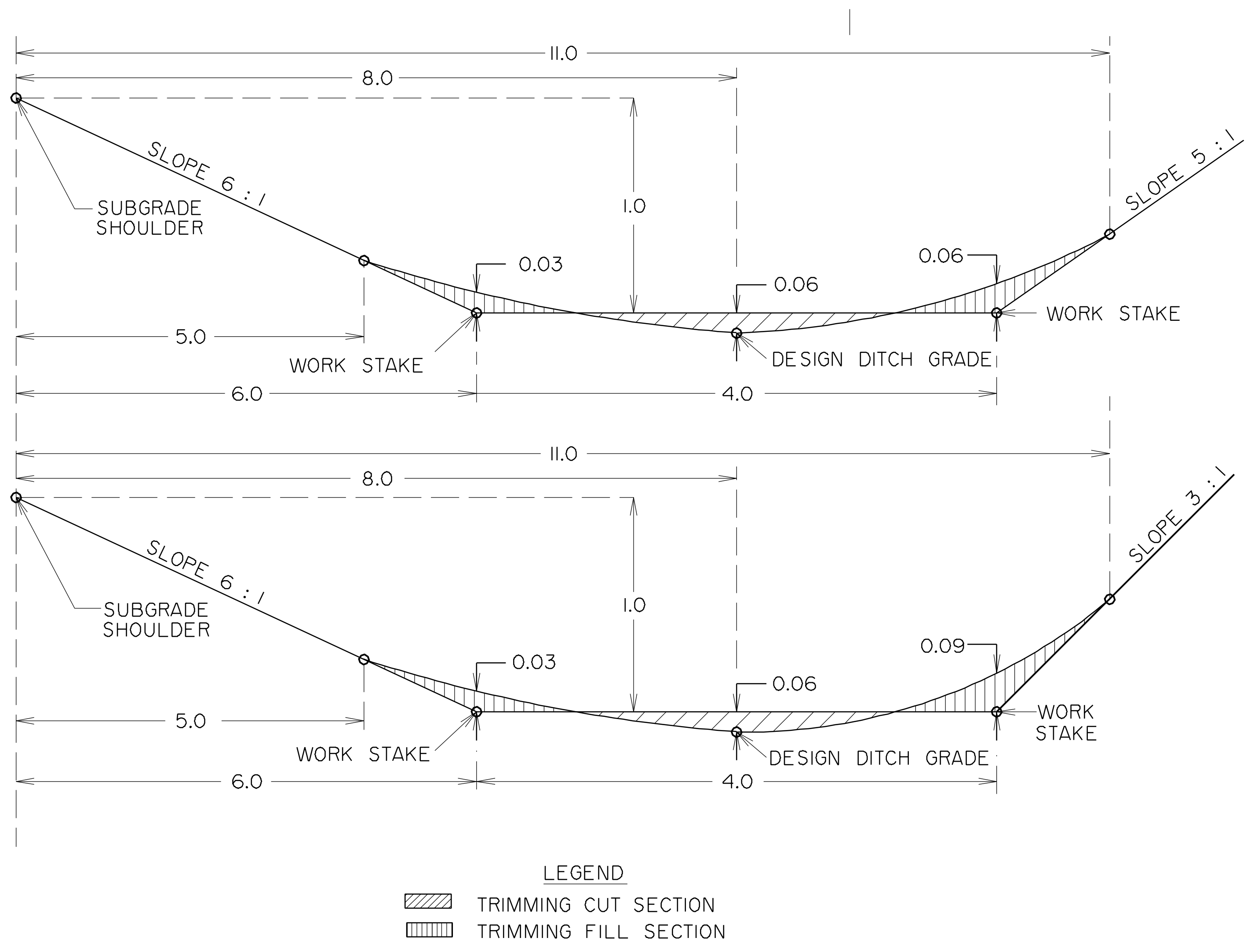


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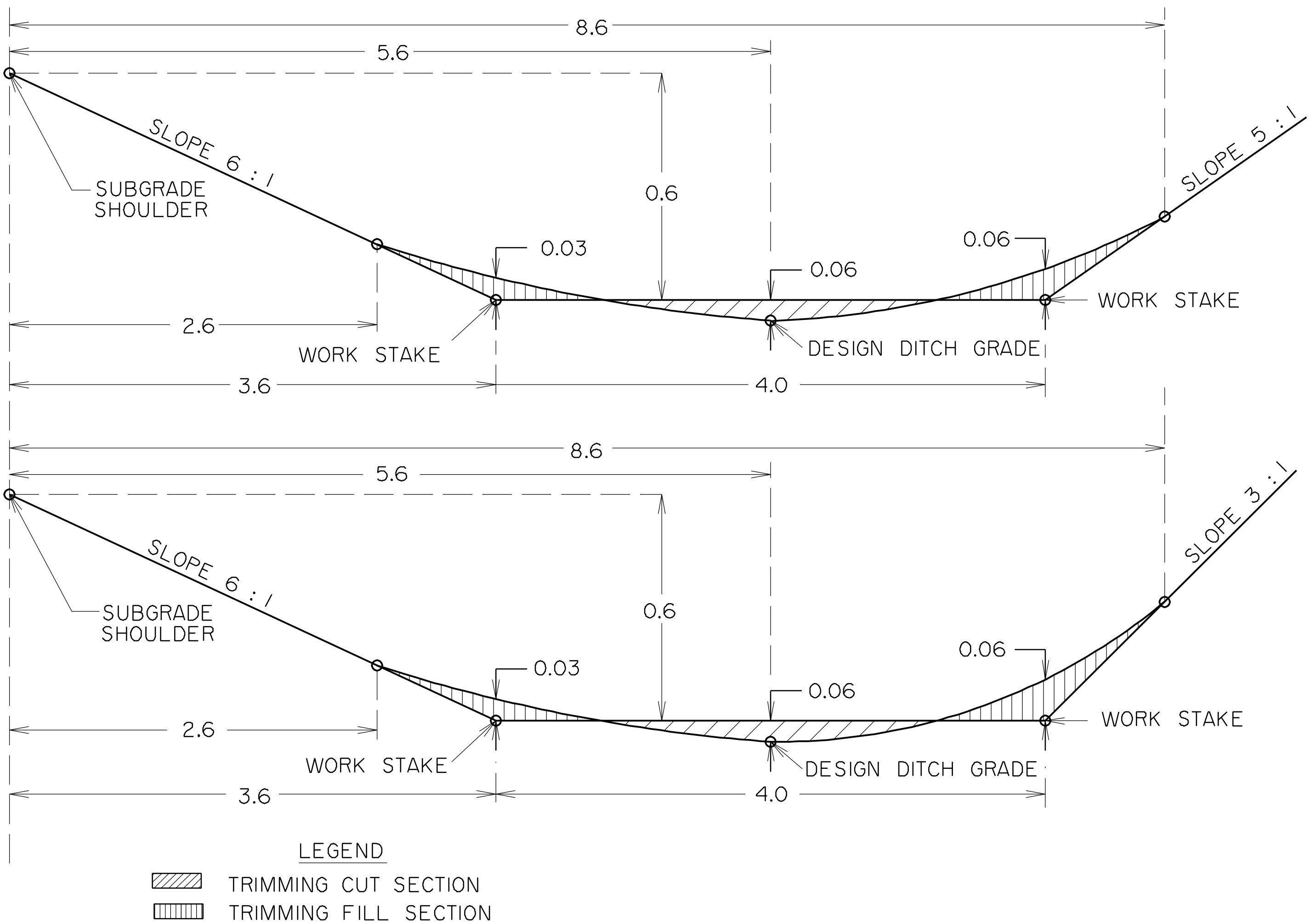
FIGURE C-5.2d ROUNDED DITCH (0.6m DEPTH)
FOR SEMI-URBAN AREAS
Approximation for Design Plotting and Work Stakes



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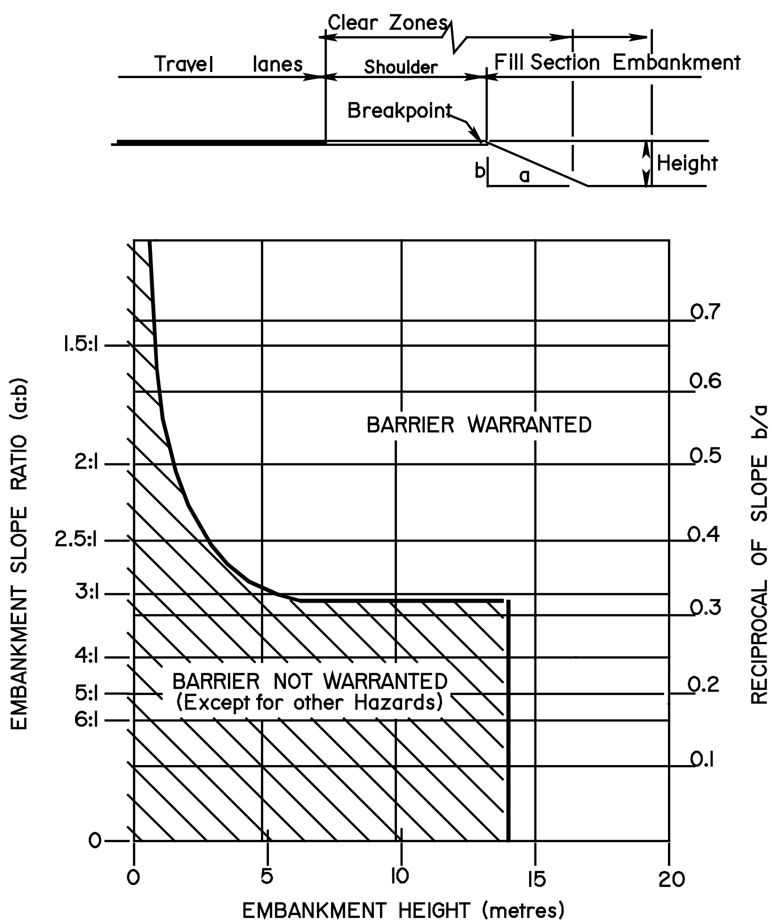
C.5.3 Hazards to be Considered for Mitigation

There are three general categories of hazards: sideslopes, roadside obstacles and permanent bodies of water.

C.5.3.1 High Embankments/Steep Slopes

Guardrail protection should be considered on high embankments, because of the hazard posed to errant vehicles that may leave the roadway and go down the slope. The installation of guardrail on embankments is warranted only when the combination of height and slope of the embankment is considered to be a more severe hazard than the barrier system. The department's guardrail embankment warrant (Figure C-5.3.1a) indicates when an embankment should be considered a hazard worthy of protection. Slope and height combinations on or below the curve do not warrant shielding unless they contain obstacles within or immediately outside the clear zone that present a serious hazard to errant vehicles. If the sideslope and height of fill intersect in the barrier-warranted zone, the sideslope should be mitigated by either flattening out the slope or shielding it with a barrier. The preferred mitigation over the installation of a traffic barrier is the flattening of the sideslope. However, all slopes that are not shielded by a barrier should be free of obstacles and water hazards based on the clear zone criteria.

FIGURE C-5.3.1a BARRIER WARRANTS FOR FILL SLOPES WHERE AADT >400



Source: Alberta Infrastructure "Design Guide for Traffic Barriers"

Where sideslope flattening is used to eliminate the need for guardrail on high embankments, a 4:1 sideslope is generally used. A 4:1 sideslope is generally considered to be safe for embankment heights up to 14 m provided that the slope itself, and the area at the base of the embankment, is free of obstacles and water hazards. If the embankment height is greater than 14 m, barrier protection is suggested regardless of sideslope rate.

For embankments up to 14m in height, if the AADT exceeds 600 on an eight metre road or exceeds 1000 on a 13.4m road, it is generally more cost effective to build flatter sideslopes than it is to install guardrail. This was shown in a 1991 study (updated in 1993) by the former Roadway Engineering Branch. For lower embankments and/or lower AADT, designers should refer to the results of the study, which are summarized in Figure C-5.3.1b. If the barrier system chosen is more expensive than the conventional W-beam weak post system; for example, strong post or concrete barrier, then a special economic analysis can also be undertaken to determine the cost effectiveness. A Lotus 1-2-3 spreadsheet customized for this purpose is available from Technical Standards Branch.

For low volume roads (AADT less than 400), Table C.5.3.1 can also be used to determine if barrier is warranted.

Table C.5.3.1 Suggested Barrier Embankment Warrants for Low Volume Roads (AADT <400)

Side Slope	Suggested Maximum Unprotected Embankment Height (m)
1.5:1	3
2:1	5
2.5:1	7.5
3:1	9
4:1	14

C.5.3.2 Roadside Obstacles

Roadside obstacles may be nontraversable hazards or fixed objects and may be either man-made such as culvert inlets, or natural such as trees. Barrier warrants for roadside obstacles are a function of the obstacle itself and the likelihood that it will be hit. However, a barrier should be installed only if it is clear that the result of a vehicle striking the barrier will be less severe than the collision resulting from hitting the unshielded object.

Object hazards which normally should be considered for mitigation are as follows:

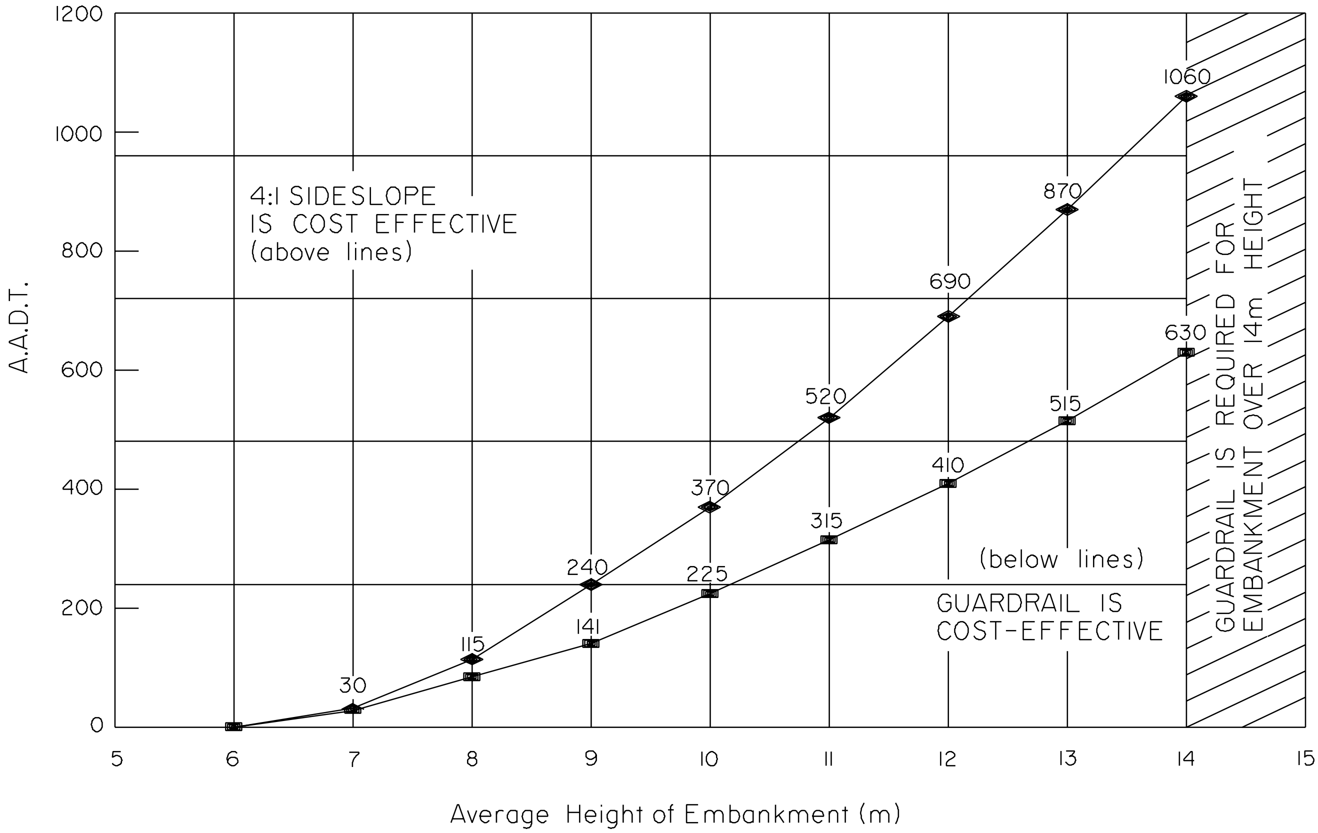
- Wood poles or posts with a cross sectional area greater than 230 square cm (150x150mm) which do not have breakaway features
- Trees having a diameter of 230mm or more
- Fixed objects extending above the ground surface by more than 200mm, such as boulders, concrete bridge rails, piers, and retaining walls
- Non-breakaway steel sign supports
- Non-breakaway luminaire supports
- Drainage structures, such as culvert and pipe ends. Decision on the use of barrier should be based on size, shape and location of the hazard.

When feasible, object hazards should be removed. This practice should focus on the area within the clear zone but should not exclude consideration of objects outside this area. Other mitigative measures include relocating an object outside the clear zone, reducing the hazard using an appropriate breakaway feature, and installing a longitudinal barrier such as the standard W-beam guardrail and/or impact attenuator.

Within the clear zone, complete removal of stumps is preferred. In some cases, the smaller stumps should be removed and the larger ones cut flush to the ground. Minor grading work should be performed to mitigate the effect of those stumps that are left.

FIGURE C-5.3.Ib SIDESLOPE IMPROVEMENT VERSUS GUARDRAIL INSTALLATION

- A Design Guide Based on Life-Cycle Cost-Effectivness



NOTE 1: Guardrail is required if there are any non-traversable hazards or fixed objects on the embankment or at the base of the embankment

NOTE 2: Additional maintenance cost associated with snow clearing at guardrail installations is not included in the analysis (due to the difficulty in estimating the annual cost)

ASSUMPTIONS:

1. Shoulder Encroachment Rate as per AASHTO (Roadside Design Guide).
2. Severity Index of Collisions as per T.A.C.
3. Collision costs as per Alberta information.
4. Guardrail and Sideslope construction costs based on 1992 and 1993 average unit prices.
5. Traffic volume increases 2% annually for first ten years and 1% thereafter.
6. Internal Rate of Return of 4% on investment at 20 years is satisfactory.
7. Embankment sideslope is 3:1 with guardrail installation.

UNIT PRICES (AVERAGE 1992 AND 1993)

1. Borrow excavation	- $1.52/cu m
2. Overhaul	- $0.57/cu m/km
3. Guardrail installation (including material cost)	- $ 37/m (1993 unit price)
4. Guardrail re-installation	- $ 43/m (1993 unit price)
5. Guardrail maintenance	- $ 500/km/yr

C.5.3.3 Permanent Bodies of Water

Bodies of water with depth of one metre or more located within the clear zone should be considered for mitigation. Longitudinal barrier is typically used to mitigate this type of hazard.

C.5.4 Traffic Barriers

A traffic barrier is defined as a device to shield a hazard that is located on the roadside or in the median, or a device used to prevent cross-over median collisions.

Traffic barriers are classified into two basic types: longitudinal barriers and crash cushions. Longitudinal barriers function primarily by redirecting errant vehicles. Crash cushions function primarily by decelerating errant vehicles to a stop. Where traffic barriers are required, designers should refer to Alberta Infrastructure's Design Guide for Traffic Barriers.

Standard plans showing installation of conventional W-beam guardrail (weak post system) are included in the construction specification. Other systems such as the three-strand steel cable guardrail, steel box beam or blocked-out W-beam guardrail (strong post generally used on multi-lane highways) may also be used if required. Standard drawings for concrete barriers are in the Standard Drawings Manual (CB-6).

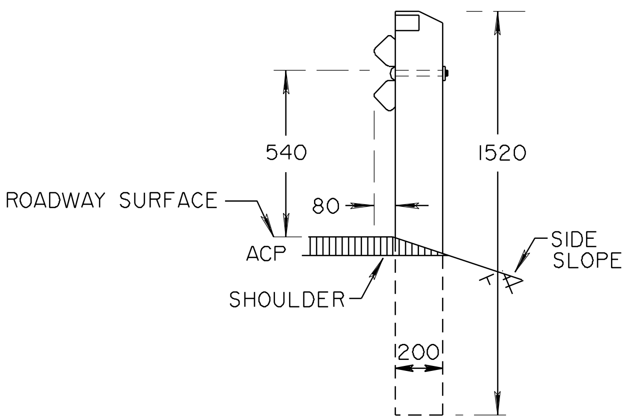
For rural highway applications, the W-beam guardrail barrier is generally preferred over the concrete barrier due to lower capital cost, less severe damage to vehicles and occupants as a result of collisions with the barrier, and less snowdrifting problems. A current reference document on this topic is AASHTO's Roadside Design Guide (1996).

Concrete barriers are generally only used where deflection is undesirable such as in narrow medians, at bridge piers or overhead sign structures. The face of the standard concrete barrier is the F-shape. Where concrete barrier is used, the designer must choose between cast-in-place or extruded type construction or installation of precast units. Generally, cast-in-place is preferred due to the superior aesthetics and smoother line, especially for longer installations. Precast units are more suitable at locations where barrier removal may be required.

C.5.4.1 Installation of Guardrail on Base Course Projects

The normal standard for installation of W-beam guardrail is shown in the relevant construction specification. Where guardrail is required on stage-construction projects, for example, where base course is to be constructed in anticipation that final paving will be delayed for between two and 10 years, an alternative installation method (as shown in Figure C-5.4.1) may be used. The advantage of using this installation method is that it may avoid removing and reinstalling guardrail at the time of final paving.

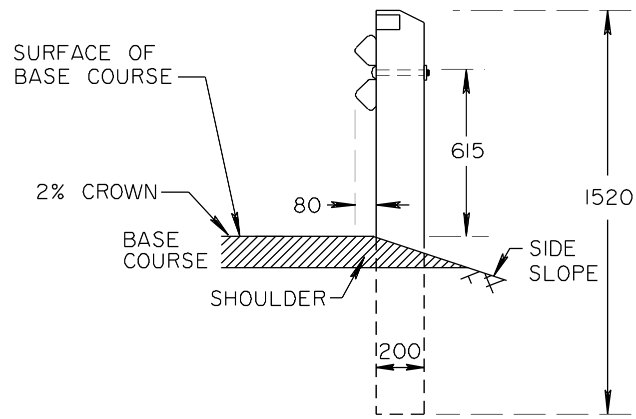
FIGURE C-5.4.1 INSTALLATION OF GUARDRAIL ON BASE-COURSE PROJECTS
(that are proposed to be paved in less than 10 years)



SECTION A-A

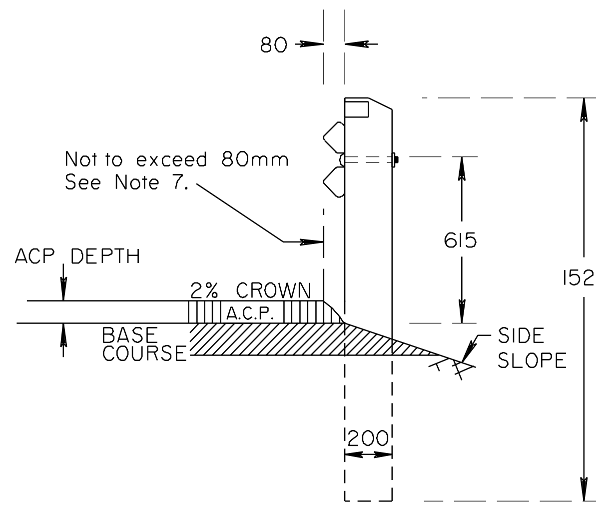
STANDARD GUARDRAIL INSTALLATION

(W beam, no blocks).



SECTION B-B

STAGE 1: BASE COURSE STAGE

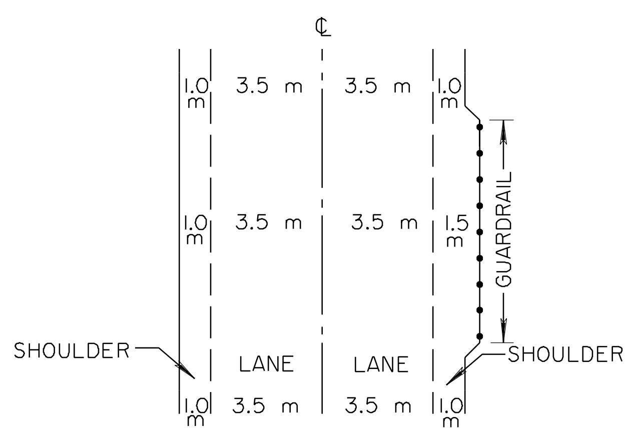


SECTION C-C

STAGE 2: ACP STAGE ON STAGED PAVING PROJECT

NOTES:

1. Sections B-B, C-C and the plan view show the special installation of guardrail that is suggested on projects where final paving is anticipated within 10 years.
2. The standard height of guardrail to the centre bolt is 540mm (Section A-A).
3. The acceptable tolerance for height of guardrail is +/-75mm.
4. By installing guardrail at the highest tolerable level (Section B-B), the final pavement can be placed without the guardrail being removed or adjusted (Section C-C).
5. All dimensions are in millimetres unless otherwise noted.
6. Drawing is not to scale.
7. Pavement drop-off line must not be inside the guardrail line, that is, no more than 80mm from guardrail post line.



PLAN VIEW

EXAMPLE SHOWING GUARDRAIL INSTALLATION ON A TYPICAL RAU-209 ROADWAY AT STAGE 2

C.6. MEDIANS

Medians are provided on multi-lane divided highways to separate opposing flows of traffic. Apart from the obvious safety benefits, medians also provide space for left turn lanes, snow storage, collecting surface water, addition of future lanes and refuge for pedestrians at cross-walks. The width of a median is measured from the inside edges of travel lanes of opposing directions of traffic.

C.6.1 Depressed Median

Depressed medians normally have rural application but may be used as an interim stage in urban design where additional lanes may be added later. In such cases, the median width is determined by those future requirements.

For rural divided highways a very wide median has many advantages over a narrow median, and for this reason a 38m centreline to centreline spacing has been adopted for many of the divided highways built in recent years. A 38m centreline to centreline spacing provides a 30.6m median at the four lane and six lane stages. The principle advantage of a wide median is that it allows for refuge of one large vehicle or several smaller vehicles while crossing the highway at at-grade intersections. A 30.6m median is not sufficiently wide to provide refuge for the Long Combination Vehicles (LCVs) however these vehicles are generally not permitted to cross a divided highway at at-grade intersections. The 25m long WB-23 (Super B-train truck-trailer combination), which is allowed to travel unrestricted on all the highways unrestricted is able to take refuge in a 30.6 m median. Additional advantages of a wide median are greater separation of opposing lanes of traffic, reduced headlight glare, more flexibility in setting gradelines and more space to build rounded flat sideslopes. Right of way costs are generally not a factor in selection of median width in rural Alberta. The cost of interchange construction, due to the longer structure required, is impacted by the choice of median width. However, a 30.6m median is generally supported because of the safer operation of at-grade intersections at the expressway stage.

Where longer vehicles such as log haul trucks (30.5 m) or Long Combination Vehicles (up to 38 m) are expected to be crossing the highway at at-grade intersections it is a good practice to provide sufficient median width to allow refuge for those vehicles plus a 3 m buffer (offset from travel lanes) at the front and back of the vehicle. This may be achieved through the use of a wide median throughout or the use of median widening at selected intersections only.

The wider medians provide for desirable 6:1 sideslopes. As a result, vehicles accidentally leaving the highway have a good chance of recovery with minimum vehicle damage or occupant injury. A minimum depressed median width in an urban-rural situation is normally 13.4m.

On existing paved divided highways where retrofitting of the existing cross-section is required to provide flatter slope or greater median width and/or roadway width, a 14.6m median width is acceptable for high speed rural conditions (design speed = 130 or 120 Km/h). The 14.6m median is needed to allow construction of flat (6:1) sideslopes on the median.

When four-lane divided highways need to be upgraded to six or eight lanes to increase capacity or level-of-service, the first set of additional lanes are generally added to the outside. This practice preserves the median width which is beneficial especially at the expressway stage. When eight lanes are required, the final two lanes are generally added on the median side. Generally eight-lane divided facilities have very strict access control and therefore the operational difficulties at at-grade intersections are minimized. Figure C-6.1 illustrates this staging procedure.

C.6.2 Raised Median

Raised medians are most commonly used on lower speed urban arterials. The desirable raised median width is 6.0m since this allows for either a parallel left turn lane or a bridge pier protected by concrete or flex beam barrier. Further information on raised medians for an urban application is found in Alberta Urban Geometric Design Standards (Supplement to the Manual of Geometric Design Standards for Canadian Roads, RTAC 1986).

Figures C-6.2a through C-6.2e illustrate various typical cross-sections used in urban-rural areas, which are designed to allow conversion to six or eight lanes in the future by widening to the inside only.

FIGURE C-6.1 RURAL MULTI-LANE DIVIDED HIGHWAY STAGING

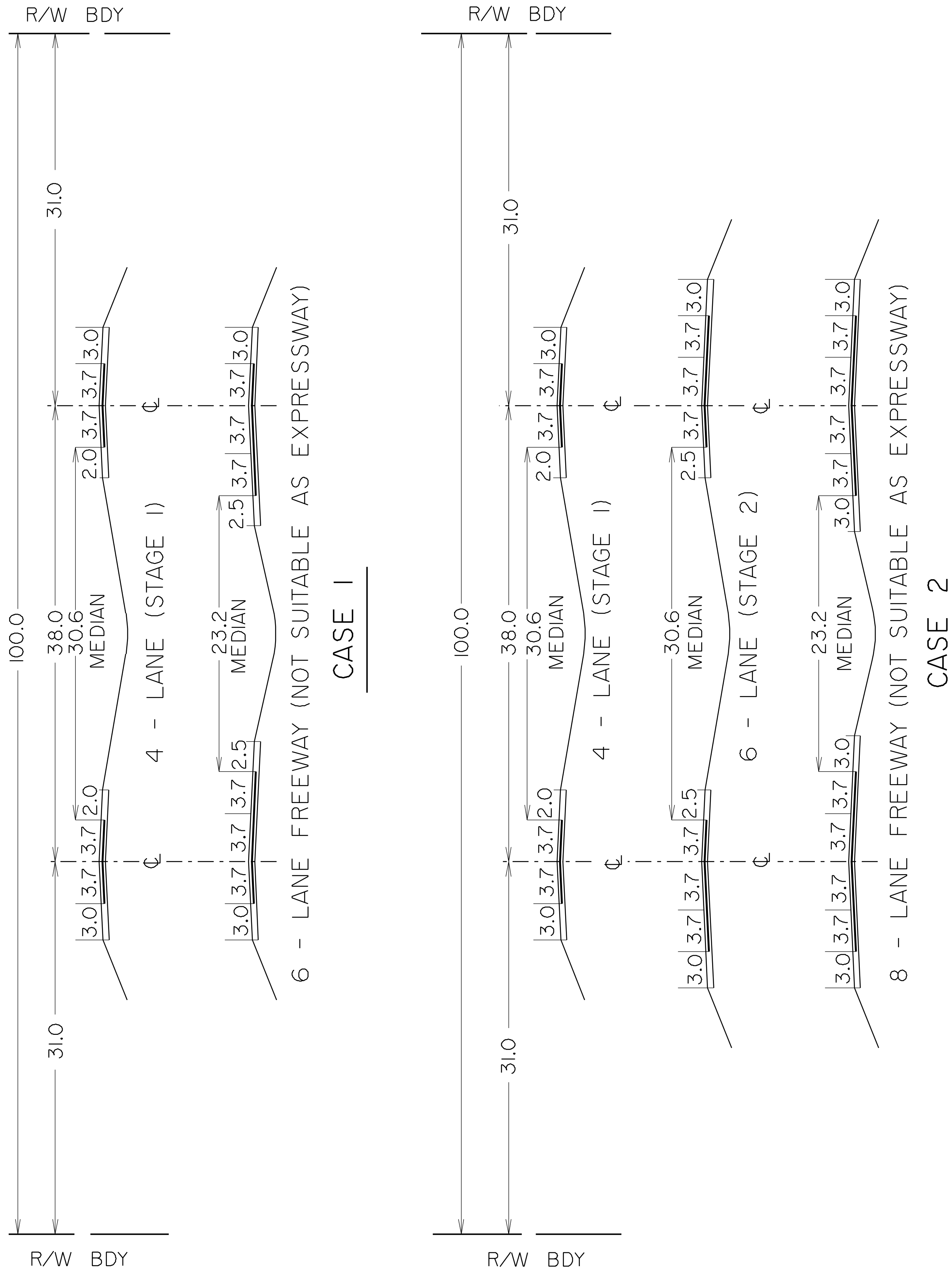
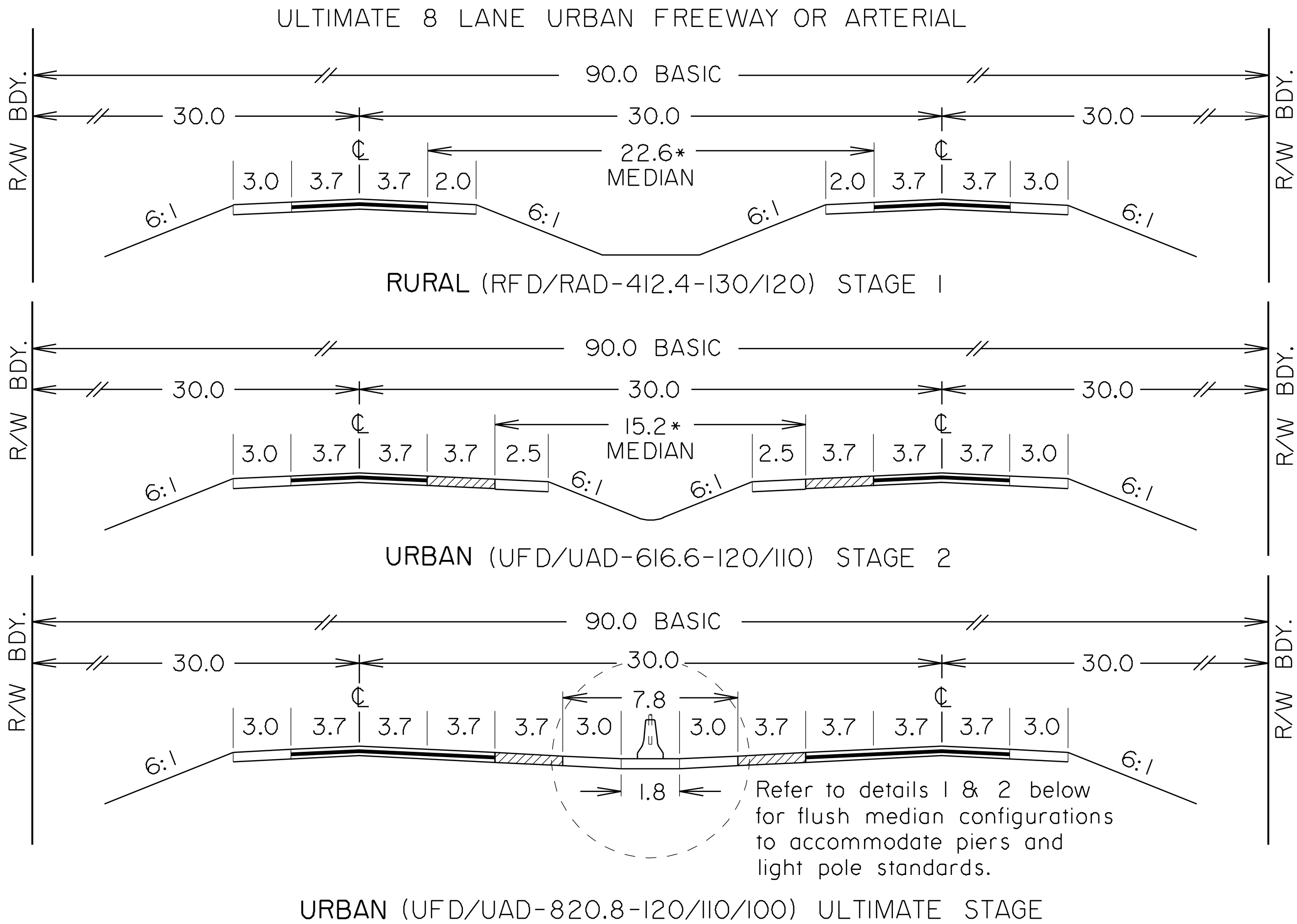
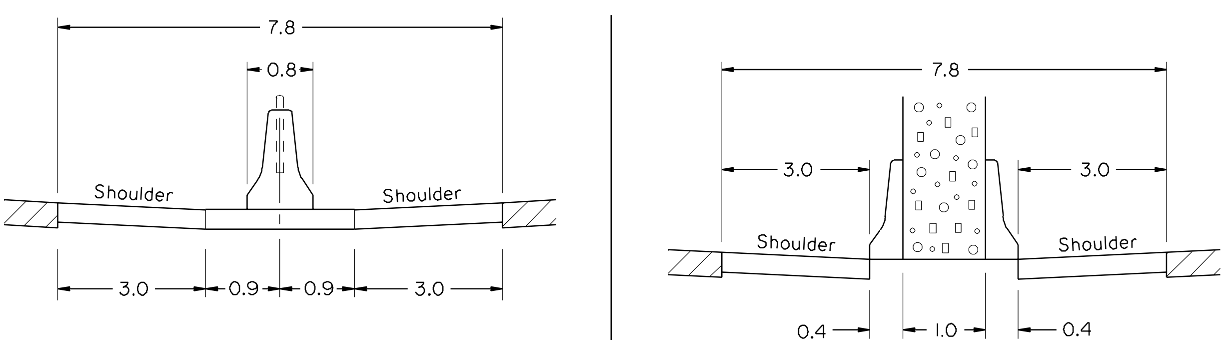


FIGURE C-6.2a RURAL-URBAN MULTI-LANE DIVIDED HIGHWAY TYPICAL CROSS-SECTIONS



NOTE: A shift of the crown line may be desirable at the six or eight lane stage to enhance roadway surface drainage. This can be achieved through cold-planing, overlay or some other method.



DETAIL 1 Flush median with concrete barrier

DETAIL 2 Flush median (with pier and concrete barrier)

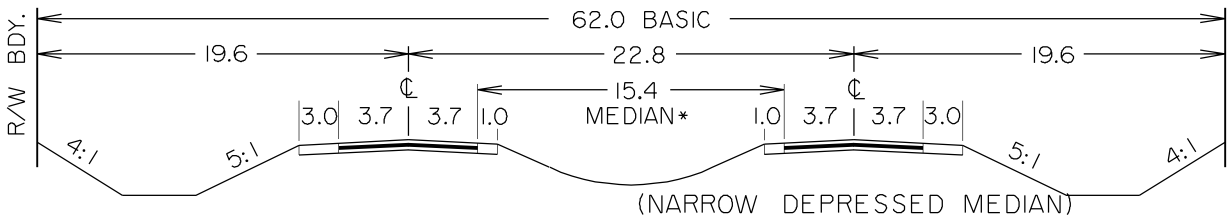
* Median will accommodate slotted left turn bays at stage 1 and 2.

NOTE: F shape median barrier shown (0.8m width is required to accommodate light pole standards, otherwise barrier width is 0.6m). Alternatively NJ shape can be used.

Current Construction   Previous Construction

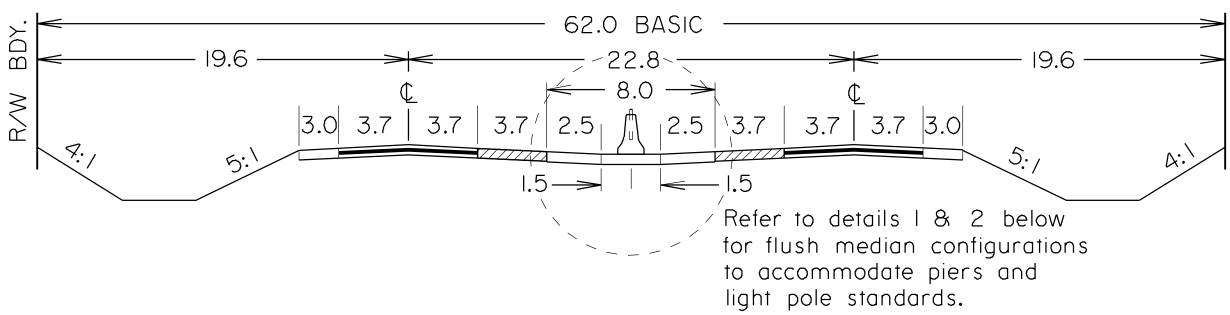
FIGURE C-6.2b RURAL-URBAN MULTI-LANE DIVIDED HIGHWAY TYPICAL CROSS-SECTIONS

ULTIMATE 6 LANE URBAN FREEWAY OR ARTERIAL (DESIGN SPEED 110-80 km/h)



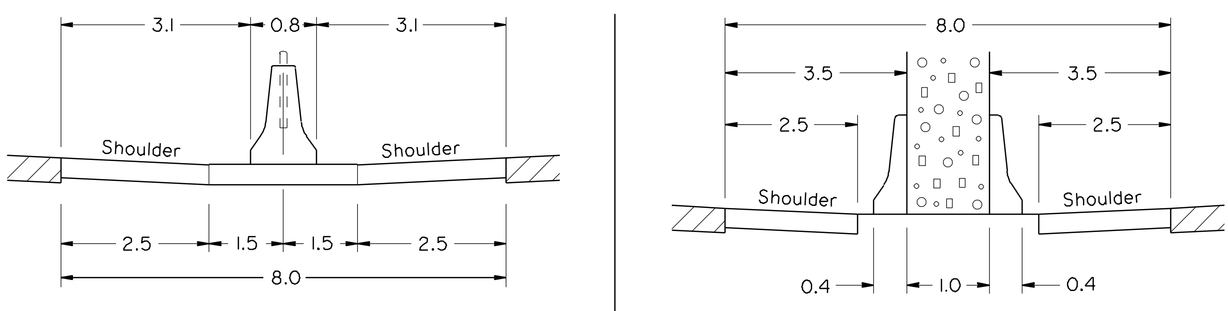
RURAL - URBAN (RAD/UAD-411.4-110/100/80) STAGE 1

* The stage 1 median will accommodate slotted left turn bays.



URBAN (UFD/UAD-616.6-110/100/80) STAGE 2

NOTE: A shift of the crown line may be desirable at the six laning stage to enhance surface drainage. This can be achieved through cold-planing, overlay or some other method.



DETAIL 1 Flush median with concrete barrier

DETAIL 2 Flush median (with pier and concrete barrier)

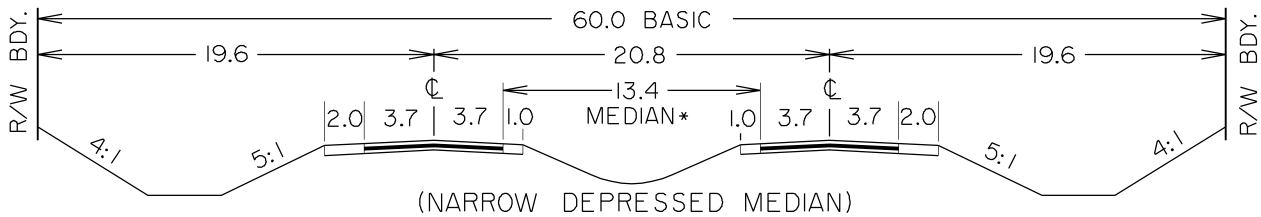
NOTE: F shape median barrier shown (0.8m width is required to accommodate light pole standards, otherwise barrier width is 0.6m). Alternatively NJ shape can be used.

Current Construction   Previous Construction

GRAPHICS FILE: TIGSFS01\REB\MANUAL\CHAPTERS\CHAP-C\DEBC62A.MAN

FIGURE C-6.2c RURAL-URBAN MULTI-LANE DIVIDED HIGHWAY TYPICAL CROSS-SECTIONS

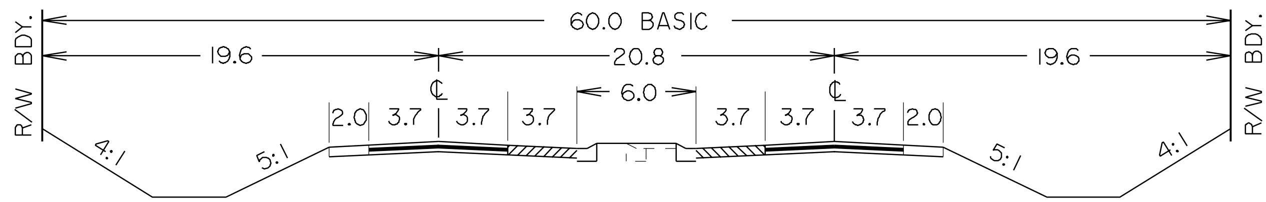
ULTIMATE 6 LANE URBAN ARTERIAL (DESIGN SPEED 110/80 km/h)



(NARROW DEPRESSED MEDIAN)

RURAL - URBAN (RAD/UAD-410.4-110/100/80) STAGE 1

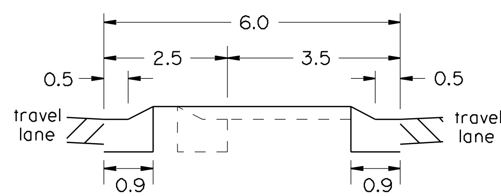
* The stage 1 median will accommodate slotted left turn bays.



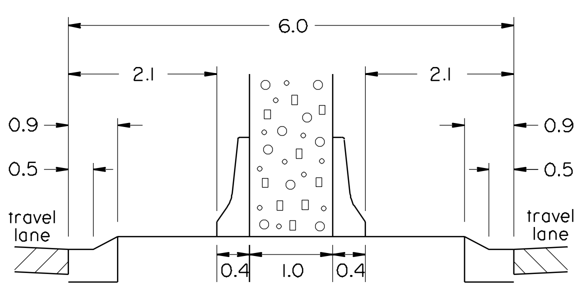
NOTE 1: 6m median will accommodate a left turn lane. (See detail 1 below)
Alternate options for raised medians are shown in details 2 & 3 below.

NOTE 2: A shift of the crown line may be desirable at the six laning stage to enhance surface drainage. This can be achieved through cold-planing, overlay or some other method.

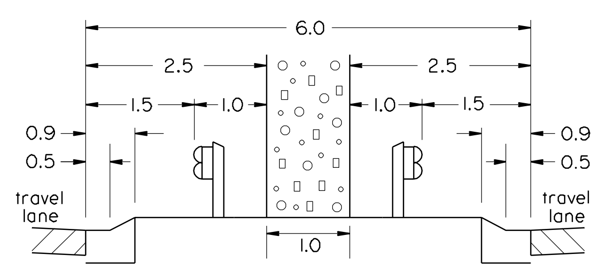
URBAN (UAD-613.1-80/60) STAGE 2



DETAIL 1 Urban arterial with left turn lane



DETAIL 2 Urban arterial with pier and concrete barrier



DETAIL 3 Urban arterial with pier and flex beam barrier

NOTE: Where the design speed exceeds 70 km/h curbs should be mountable type.
Where the design speed is 70 km/h or less barrier curb may be used.

Current Construction
Previous Construction

GRAPHICS FILE: TIGSFS01\REB\MANUAL\CHAPTERS\CHAP-C\DEBC62A.MAN

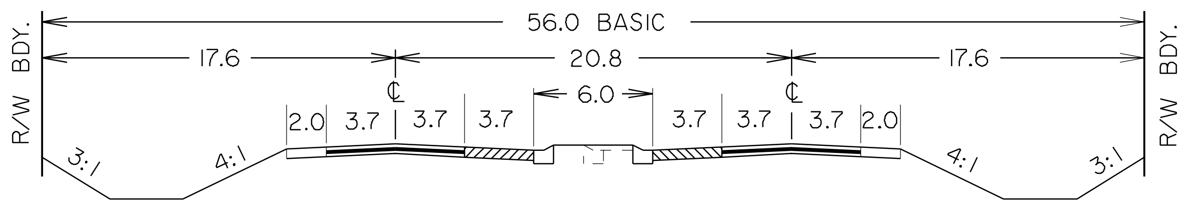
FIGURE C-6.2d RURAL-URBAN MULTI-LANE DIVIDED HIGHWAY TYPICAL CROSS-SECTIONS

ULTIMATE 6 LANE URBAN ARTERIAL (DESIGN SPEED 100/80 km/h)

(NARROW DEPRESSED MEDIAN)

RURAL - URBAN (RAD/UAD-410.4-100/80) STAGE 1

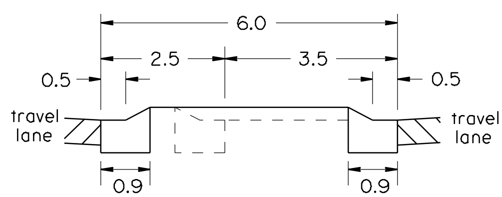
* The stage 1 median will accommodate slotted left turn bays.



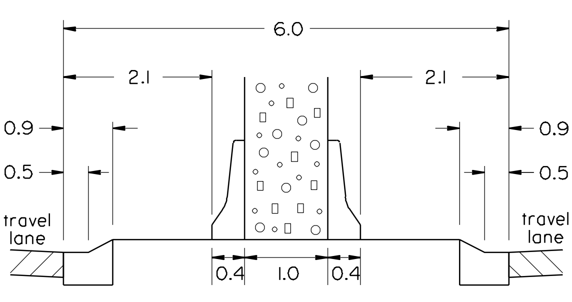
NOTE 1: 6m median will accommodate a left turn lane. (See detail 1 below) Alternate options for raised medians are shown in details 2 & 3 below.

NOTE 2: A shift of the crown line may be desirable at the six laning stage to enhance surface drainage. This can be achieved through cold-planing, overlay or some other method.

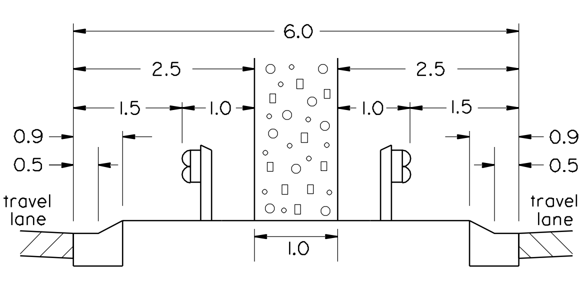
URBAN (UAD-613.1-80/60) STAGE 2



DETAIL 1 Urban arterial with left turn lane



DETAIL 2 Urban arterial with pier and concrete barrier

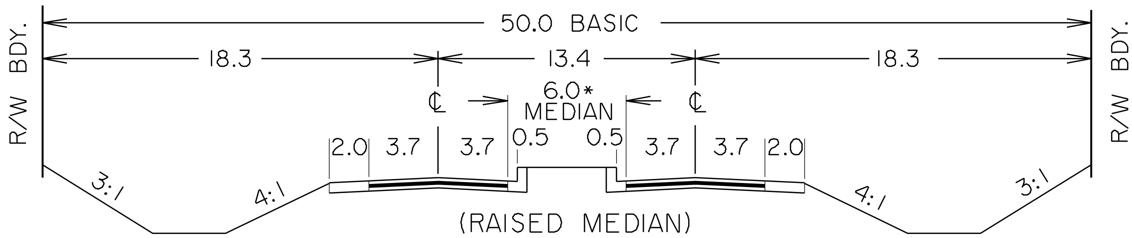


DETAIL 3 Urban arterial with pier and flex beam barrier

NOTE: Where the design speed exceeds 70 km/h curbs should be mountable type. Where the design speed is 70 km/h or less barrier curb may be used.

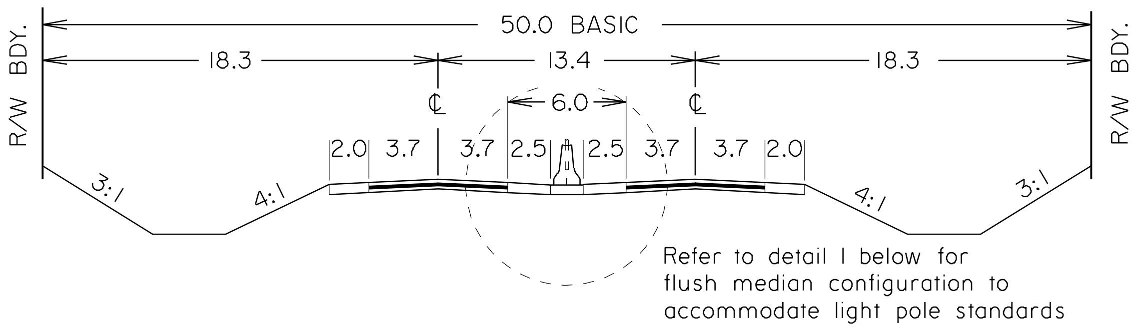
FIGURE C-6.2e RURAL-URBAN MULTI-LANE DIVIDED HIGHWAY TYPICAL CROSS-SECTIONS

ULTIMATE 4 LANE URBAN FREEWAY OR ARTERIAL

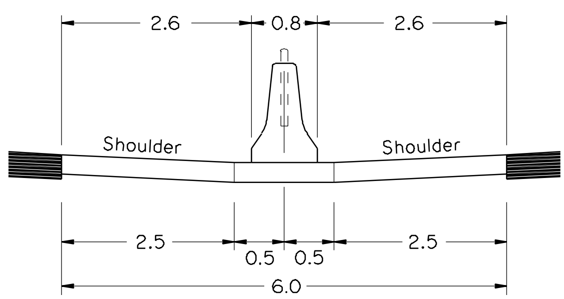


RURAL - URBAN (UAD/UCD-409.9-70) STAGE I

* The stage I median will accommodate left turn bays.

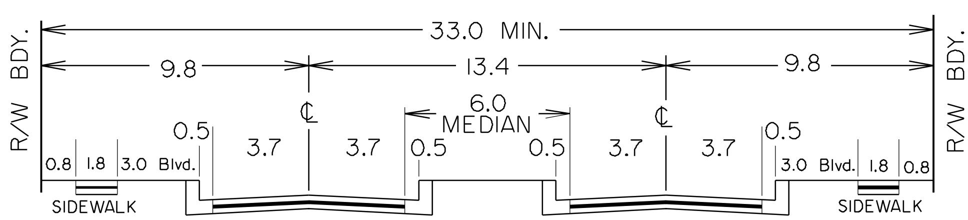


URBAN (UFD-411.9-100/80) STAGE 2



DETAIL I Flush median with concrete barrier

4 LANE COLLECTOR OR LOCAL



URBAN (UCD/ULD-408.4-60)

NOTE 1: F shape median barrier shown (0.8m width is required to accommodate light pole standards, otherwise barrier width is 0.6m). Alternatively NJ shape can be used.

NOTE 2: Where the design speed exceeds 70 km/h curbs should be mountable type. Where the design speed is 70 km/h or less barrier curb may be used.

NOTE 3: The desirable sidewalk width is 1.8m. 1.5m is the minimum sidewalk width.

Current Construction Previous Construction

GRAPHICS FILE: TIGSFS01\REB\MANUAL\CHAPTERS\CHAP-C\DEBC62A.MAN

C.7 SAFE ACCESSIBLE PEDESTRIAN ENVIRONMENTS

C.7.1 Streetscape

C.7.1.1 Introduction

Pedestrian environments which are designed to be used by the general public, including those with disabilities, should be accessible to all persons, as well as being safe, functional and attractive. The purpose of these guidelines is to bring together the principles of good design as well as to highlight some of the commonly experienced barriers in the pedestrian environment and to illustrate some design solutions.

C.7.1.2 Principles of Good Design

Pedestrian environments in public places, either publicly or privately owned, should be designed to allow safe and convenient access by all pedestrian traffic. Although the majority of pedestrian traffic is ambulatory, a significant and growing number of pedestrians have somewhat restricted mobility due to disability or age. This group includes persons using walkers, scooters, wheelchairs (both manual and electric), people with impaired vision or hearing and some seniors. An additional group may have limited mobility temporarily due to the need to bring along a baby carriage or other wheeled device on their trips.

To ensure that the design of pedestrian environments accommodates the greatest possible number of people, it is desirable to adhere to the following:

1. Allow a clear path of travel, free of obstructions to a minimum height of 1980mm. Examples of obstructions are directional signs, tree branches, guy wires and street furniture. Handrails projecting up to 100mm into the clear path of travel are permitted. See drawing Figure C-7.1.2a.
2. Provide a firm, even, non-slip, glare-free surface (for example: broom concrete finish). An elevation change of 13mm or more is considered to be a trip hazard and therefore should not be permitted in the clear path of travel.
3. Ensure that gradients along the path of travel are very gradual to allow access by all and that landings are added according to the desirable spacing shown in Table C.7.1.2, where feasible.

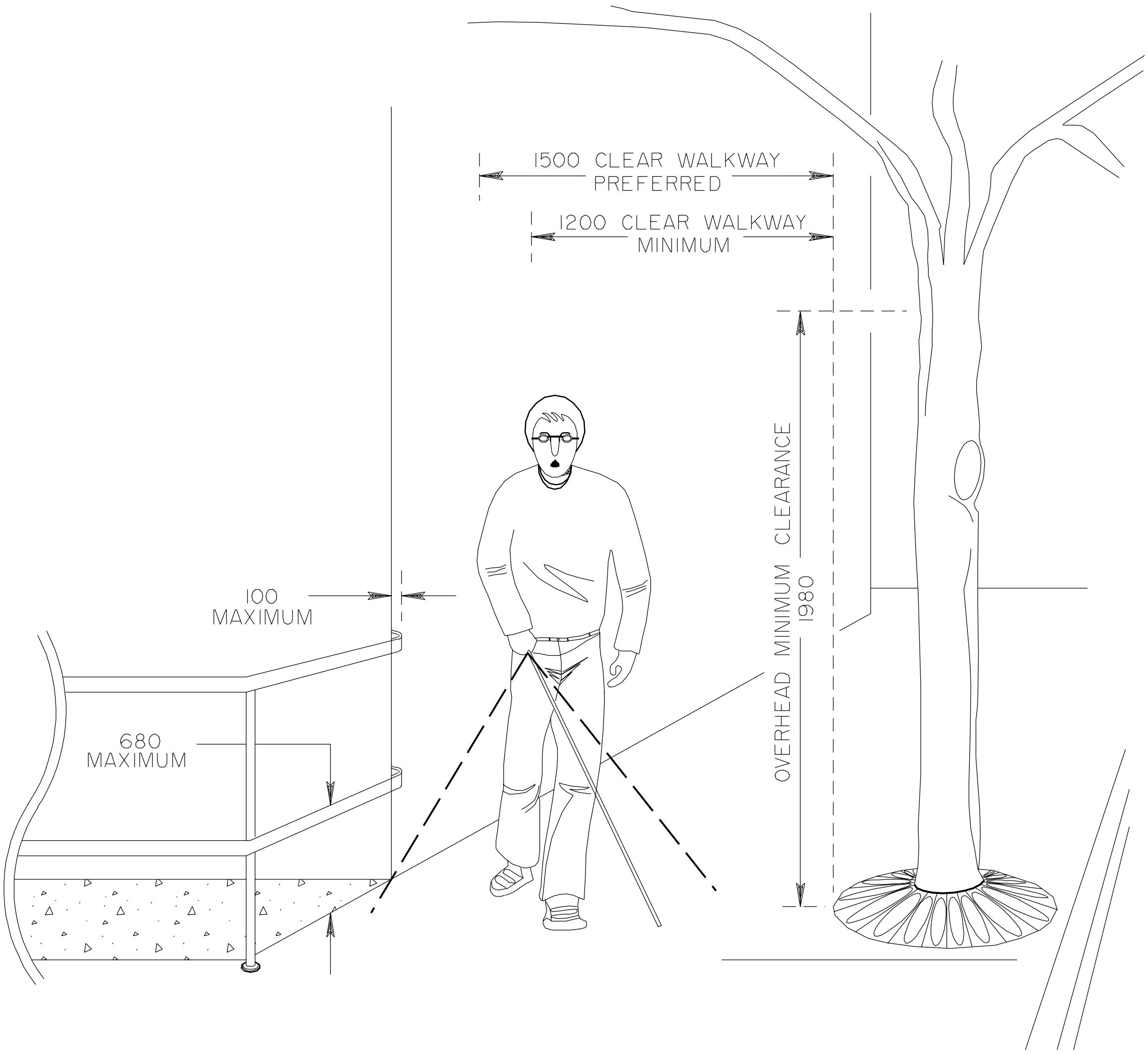
Table C.7.1.2 Sidewalk Gradients

Max. Slope	Max. Length	Max. Height	Landings
< 2%	None	None	Not required
2% < grade < 5%	None	None	Landings at 750mm Elevation differences are desirable
5%	None	None	Every 9m *
6.25%	12m	750mm	Every 9m *
8.3%	9m	750mm	Every 9m *
10%	1.5m	150mm	- *
12.5%	0.6m	75mm	- *

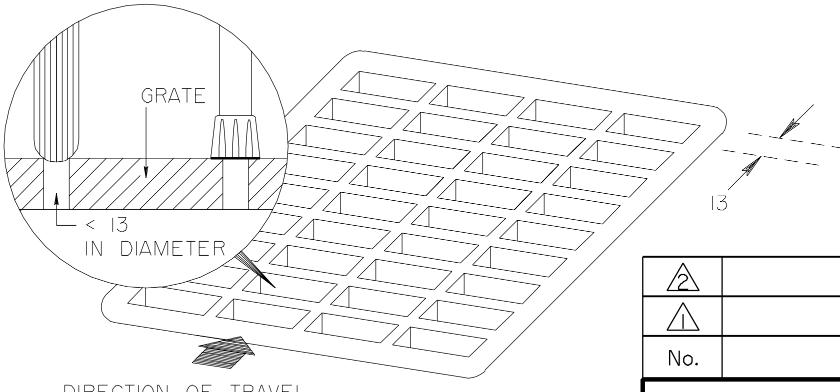
* Note: Sidewalks with gradients of 5% or steeper are generally considered to be ramps and therefore a minimum spacing of 9m between landings is suggested. It is recognized that the gradient and building layout on some streets may make the provision of landings impractical.

4. Provide a sufficiently wide path to suit the intended traffic. Generally an unobstructed clear width of 1.5m should be considered a minimum however intermittent narrower paths of 1.2m width are allowed for short segments or adjacent to obstacles.
5. Provide standardized ramps where necessary to cross curbs, etc.
6. The standardized maximum gradient (0.08m / m) used on ramps should also be applied where driveways or alleyways cross sidewalks. This maximum applies to the sides of the ramp as well as to the ramp proper.
7. Provide tactile cues for people with impaired vision and audible cross walk signals where warranted at intersections. For example, the use of a 10mm high lip is suggested to delineate the edge of roadway (beginning of ramp) or other significant boundaries, see drawing Figure C-7.1.4e. Tactile cues are also recommended to delineate the edge of hazard in pedestrian areas, for example edge of platform at rail station or top of stairs, etc.

   For additional information on Audible Traffic Signals, designers are referred to the Uniform Traffic Control Devices for Canada manual, published by the Transportation Association of Canada.
8. Ensure that drainage grates on the covers of catch basins or manholes are located off the clear path of travel where possible, i.e. not on curb ramps for example. Where it is not feasible to relocate a catch basin off a ramp, for example due to excessive cost on a retrofit project, the second choice is to offset the ramp provided that the ramp will still give direct access to the crosswalk. The third choice is to have the grate installed in the ramp however in this case the cover should be installed as shown on Figure C-7.1.2b i.e. so that the long dimension of the elongated opening is perpendicular to the pedestrian path of travel on the ramp.
9. Grates for non-drainage structures for example electrical vaults or access hatches, etc., should be located off the clear path of travel where possible. Where grates are necessary, they should have no opening that will permit the passage of a sphere more than 13mm diameter. Figure C-7.1.2a shows the maximum recommended opening size and orientation for non-drainage grates located in pedestrian areas. If the gratings have elongated openings, they should be placed so that the long dimension is perpendicular to the direction of travel.



OPENINGS LARGER THAN 13mm MAY CATCH WHEELCHAIR WHEELS OR CANES, AND MAY CAUSE A PERSON TO TRIP.



No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE C-7.1.2a

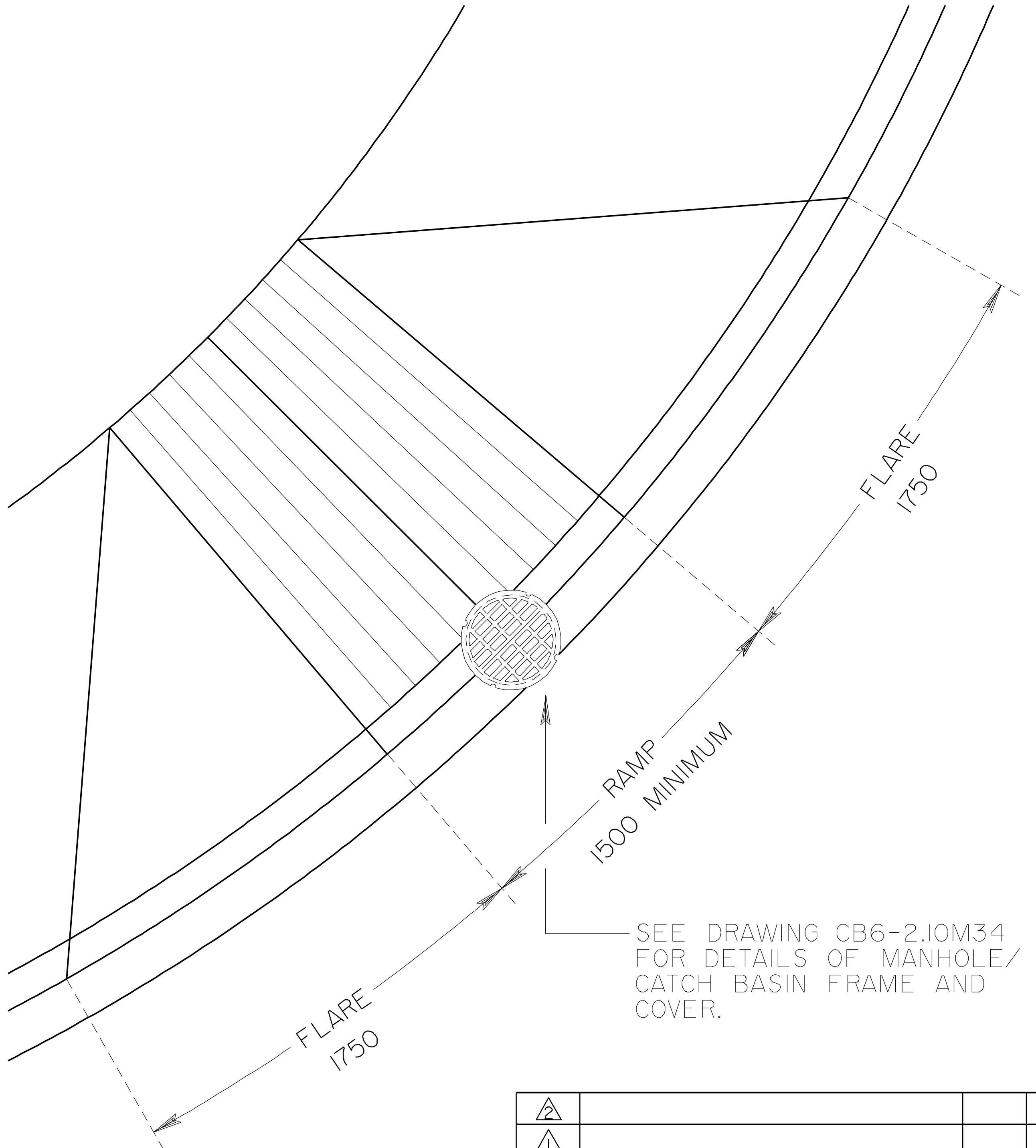
Date: DECEMBER 4, 1995

PEDESTRIAN PATH OF TRAVEL
- DIMENSIONS OF ENVELOPE
- GRATE SIZE & ORIENTATION

Prepared By: R.M.	Checked By: B.K.	Scale: N.T.S.	PAGE C-56

NOTES

1. NOMINAL DIMENSIONS IN mm.
2. IT IS PREFERRED THAT GRATES BE LOCATED OFF THE CLEAR PATH OF PEDESTRIAN TRAVEL. WHERE IT IS NECESSARY TO INSTALL GRATES IN A PATH, THE COVER SHOULD BE ORIENTED AS SHOWN HERE i.e. SO THAT THE LONG DIMENSION OF THE ELONGATED OPENING IS PERPENDICULAR TO THE PEDESTRIAN PATH OF TRAVEL.
3. THIS DRAWING IS ADOPTED FROM ALBERTA LABOUR'S BARRIER FREE DESIGN GUIDE.



TYPICAL PLAN VIEW

NOTE

1. IT IS PREFERRED THAT GRATES BE CONSTRUCTED OFF THE CLEAR PATH OF PEDESTRIAN TRAVEL WHERE FEASIBLE. WHERE IT IS NECESSARY TO INSTALL GRATES IN RAMPS, THE COVER SHOULD BE INSTALLED AS SHOWN HERE i.e. SO THAT THE LONG DIMENSION OF THE ELONGATED OPENING IS PERPENDICULAR TO THE PEDESTRIAN PATH OF TRAVEL ON THE RAMP.

No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE C-7.1.2b

Date: DECEMBER 4, 1995

WHEELCHAIR RAMP SPECIAL CATCH BASIN MANHOLE COVER

Prepared By: R.M.	Checked By: B.K.	Scale: N.T.S.	PAGE C-57

C.7.1.3 Some Barriers to Travel

Although most pedestrian environments in Alberta that have been designed and built in recent years are generally barrier-free, there are some construction and operational practices that present a barrier to the public at large and can have a much more restrictive impact on people with transportation disabilities.

One set of obstacles can generally be referred to as street furniture. This includes light poles, fire hydrants, traffic signals, signs, bus benches, mail boxes, newspaper vending machines, sandwich boards, tables, bike racks, waste receptacles, telephone booths, bollards, trees, etc. These items are frequently needed or desired on streets, however their placement should be carefully planned to ensure that they do not become a hazard for people with impaired vision or an obstacle for wheelchair users or other pedestrians.

A second area of concern, especially for older pedestrians and wheelchair users is the use of paving stones or bricks in pedestrian areas. The main difficulty with paving stones is the uneven surface that can result due to differential settlement that generally occurs within a few year of construction. Some paving stones have rounded edges on the surface which creates a wider and deeper joint. The uneven surfaces and joints can cause pedestrian to trip, will give wheelchair users a rough ride and could contribute to persons falling from their wheelchairs. Where paving stones are used in an indoor setting, although frost heaving and differential settlement may be eliminated, the stone surface still provides a less than ideal riding surface for people using wheelchairs.

Based on the above, it is preferred that an even concrete surface be provided for the main path of travel through pedestrian areas. Ideally, paving stones should be used as borders only. Where a designer chooses to use a paving stone edger on a sidewalk, the outside edge (adjacent to curb) is generally preferred. This provides a good tactile cue for people with impaired vision while also ensuring that the main path of pedestrian travel is separated from vehicular traffic. In general, a safer and more functional pedestrian environment would result if the clear path of travel was given top priority in all layouts i.e. with decorative finishes, paving stone tree surrounds and other street furniture not being permitted to encroach on the path of travel.

C.7.1.4 Design Solutions

1. Ensure street furniture does not encroach on the clear path of travel in pedestrian areas.

   In the case of lower volume residential or light industrial sidewalks where a monolithic curb, gutter and sidewalk cross-section has been selected, it is preferred that all street furniture be placed on the private property side of the sidewalk i.e. away from the roadway, so as not to encroach on the clear path of travel.

   Where additional right-of-way is available, a boulevard between roadway and sidewalk is very desirable aesthetically, provides greater safety for pedestrians and allows street furniture to be placed off the pedestrian walking surface.

   Where wider sidewalks are required, for example in commercial or business areas or in the vicinity of educational or health care facilities, the sidewalk cross-section should generally be designed to accommodate street furniture without encroaching on the clear path of travel and while still providing a minimum 800mm offset from the curb to allow for vehicle door-openings. Where buildings are constructed adjacent to sidewalks, it is best to place street furniture on the curb side of the walkway thus providing a greater offset between the pedestrian clear path of travel and the vehicular traffic. The absence of obstructions along the face of buildings is desirable.

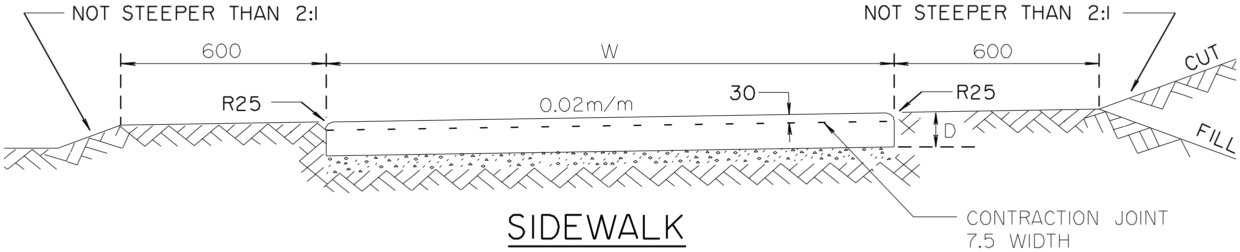
   On major arterial roads, where higher speeds and higher traffic volumes are expected, a 3m offset between curb and sidewalk is desirable. A grass surface may be used to provide a contrasting colour and texture for the boulevard.

   Figure C-7.1.4a shows the typical cross-sections for the sidewalks described here.

2. If paving stones are required on a project, they should not be placed across the main path of travel where they would be a barrier or possible hazard to some pedestrians.

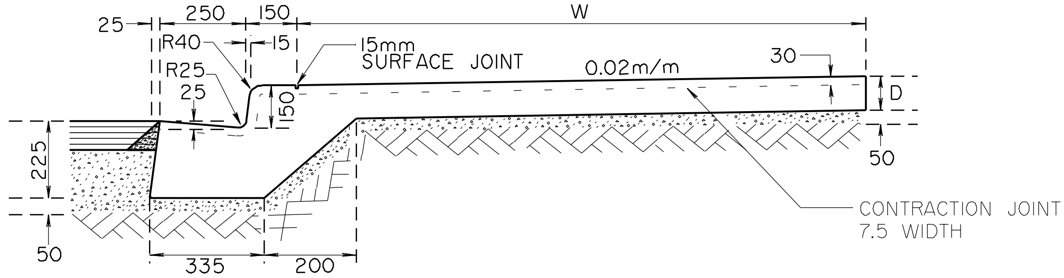
   In addition to the above, measures should be taken to ensure that the effects of frost heave and/or differential settlement of paving stones are minimized. Experience has shown that the best way to ensure the integrity of a surface is to build a strong base. The major cities in Alberta have used either lean concrete or soil cement for this purpose. A leveling course of sand is generally used on top of the base and the paving stones are placed on the sand. If the back of the walkway is within 3.0m of a building, a 50mm layer of rigid insulation is typically placed under the base to reduce frost penetration into the subgrade. A 50mm layer of crushed gravel may also be used below the insulation. The attached drawing, Figure C-7.1.4b, shows a typical structure which should provide a safe, smooth partially paved sidewalk.

Figure C-7.1.4c is a plan view of a typical urban intersection where paving stones have been used to delineate the edge of sidewalk and crosswalk while not obstructing the clear path of travel. Figures C-7.1.4d, C-7.1.4e, C-7.1.4f and C-7.1.4g are also included to show the typical layout and construction details for ramps where urban sidewalks meet crosswalks. Figure C-7.1.4h shows the details of a special catch basin / manhole frame and cover that is suitable for use on a curb ramp.



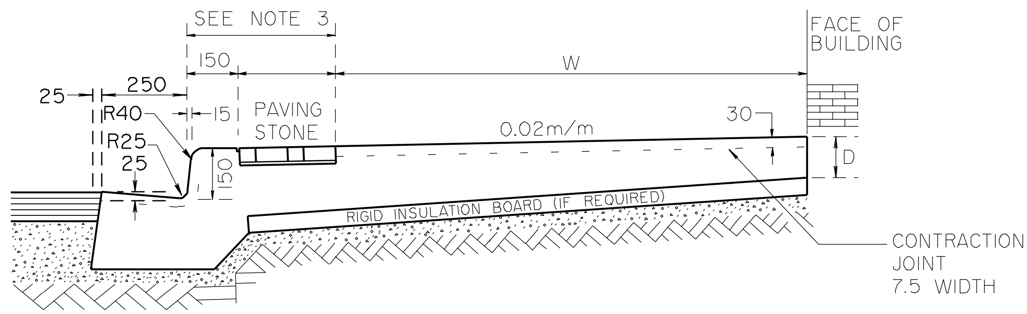
SIDEWALK

(SEE DRAWING CB6-4.2M78 FOR DETAILS)



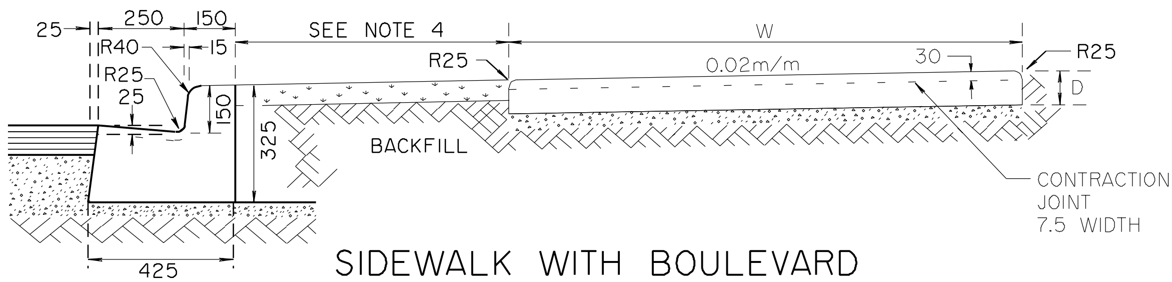
STANDARD MONOLITHIC SIDEWALK

(SEE DRAWING CB6-4.2M88 FOR DETAILS)



MONOLITHIC SIDEWALK WITH PAVING STONE EDGING

(SEE DRAWING CB6-4.2M93 FOR DETAILS)



SIDEWALK WITH BOULEVARD

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NOTES

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED.
2. 'W' IS THE WIDTH OF CLEAR PATH OF TRAVEL. 1.5m IS THE SUGGESTED MINIMUM HOWEVER, INTERMITTENT NARROWER PATHS OF 1.2m WIDTH ARE ALLOWED FOR SHORT SEGMENTS OR ADJACENT TO OBSTACLES.
3. WHERE PAVING STONE EDGING IS USED, THE WIDTH OF THE BORDER SHOULD GENERALLY ALLOW AN 800mm CLEARANCE FOR VEHICLE DOOR OPENINGS AND MAY ALSO ACCOMODATE SOME STREET FURNITURE.
4. WHERE A BOULEVARD IS USED, IT IS DESIRABLE THAT IT BE WIDE ENOUGH TO ALLOW FOR DOOR OPENINGS (800mm) AND PLACEMENT OF STREET FURNITURE. NARROW BOULEVARDS ARE NORMALLY PAVED, WIDER BOULEVARDS (APPROXIMATELY 3m) MAY BE GRASS.
5. 'D' IS THE DEPTH OF CONCRETE, AS SPECIFIED.

Alberta INFRASTRUCTURE

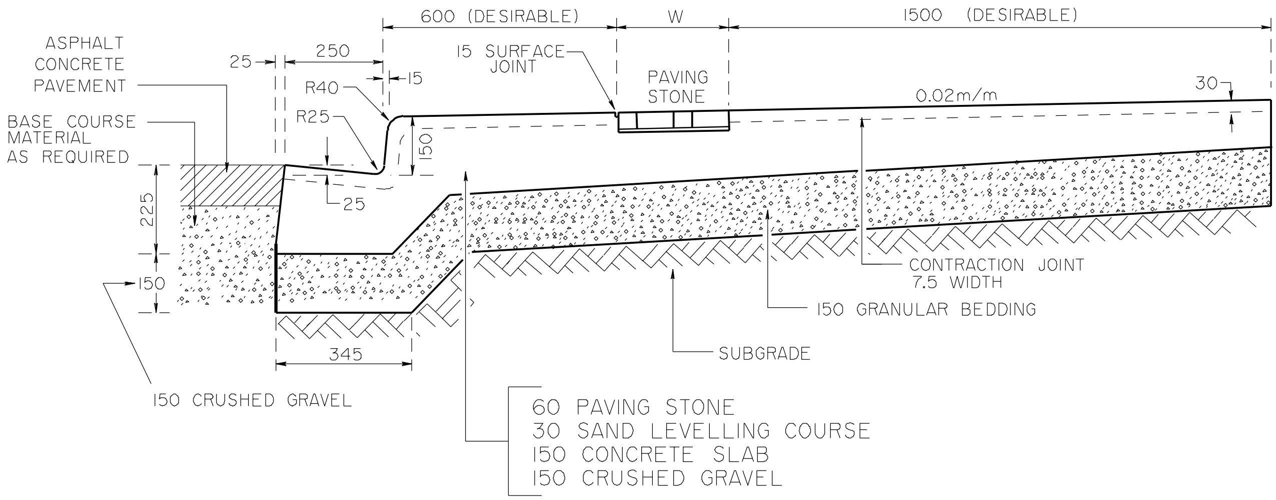
FIGURE C-7.1.4a

Date: DECEMBER 4, 1995

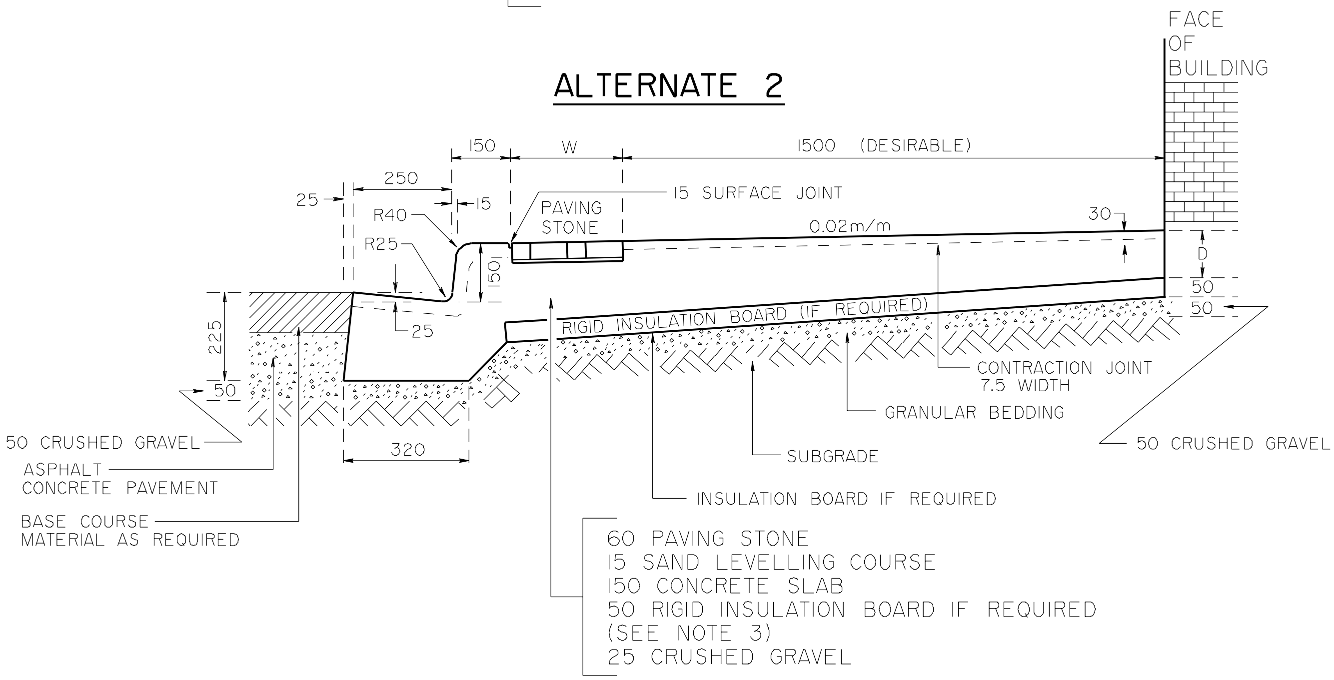
SIDEWALKS TYPICAL CROSS SECTIONS

Prepared By: R.M.	Checked By: B.K.	Scale: N.T.S.	PAGE C-60

ALTERNATE 1



ALTERNATE 2



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Alberta INFRASTRUCTURE

FIGURE C-7.1.4b

Date: DECEMBER 4, 1995

MONOLITHIC CONCRETE SIDEWALK CURB AND GUTTER (250mm GUTTER) PAVING STONE EDGING

Prepared By: R.M.	Checked By: B.K.	Scale: N.T.S.	PAGE C-61

NOTES

1. DEPTH OF CONCRETE FOR SIDEWALK 'D' AS PER DETAILED DESIGN.
2. 'W' IS THE WIDTH OF PAVING STONE EDGING GUIDE. THIS MAY BE SELECTED BASED ON OVERALL WIDTH BUT SHOULD NOT CAUSE CONCRETE SURFACE TO BE REDUCED TO LESS THAN 1500mm.
3. ALTERNATIVE 2 IS GENERALLY USED ONLY IN DOWNTOWN AREAS WHERE THE SIDEWALKS ADJACENT TO BUILDINGS AND FREQUENT FREEZE-THAW CYCLES ARE LIKELY TO CAUSE LONGITUDINAL CRACKING.
4. THE GUTTER PAN WIDTH MAY BE ADJUSTED WHERE NECESSARY TO MEET DRAINAGE REQUIREMENTS.
5. ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE NOTED.

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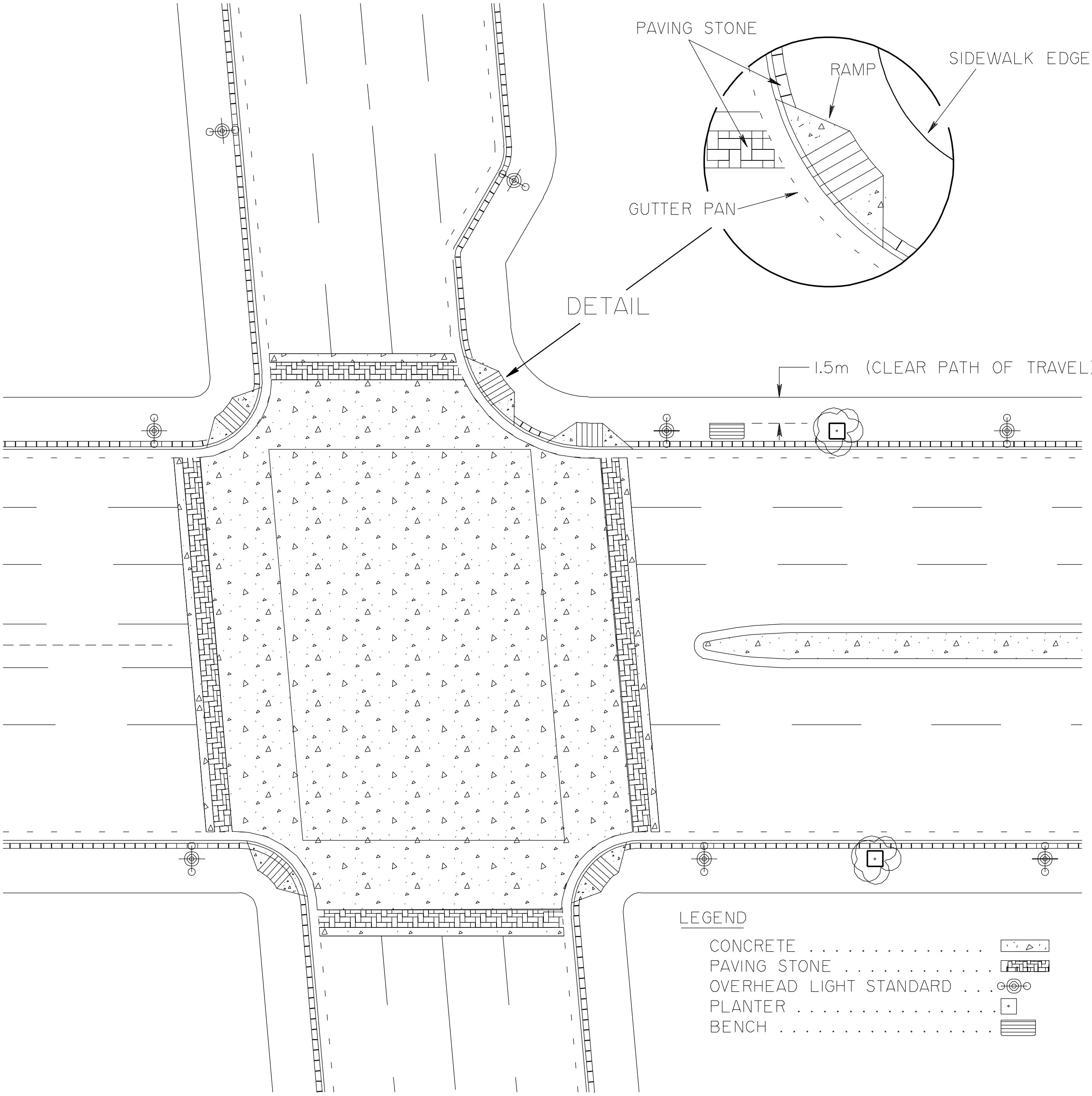

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Alberta INFRASTRUCTURE

FIGURE C-7.1.4c

Date: DECEMBER 4, 1995

EXAMPLE OF USE OF PAVING STONES ON URBAN INTERSECTION

Prepared By: R.M.	Checked By: B.K.	Scale: N.T.S.	PAGE C-62

NOTES

1. THIS DRAWING ILLUSTRATES A SIDEWALK/CROSSWALK/RAMP LAYOUT WHICH PROVIDES AN ACCESSIBLE CLEAR PATH OF TRAVEL.
2. USE OF PAVING STONES AS SHOWN IS HELPFUL TO THE VISUALLY IMPAIRED WHILE NOT BEING AN OBSTACLE FOR WHEELCHAIR USERS OR OTHER PEDESTRIANS. PAVING STONE EDGING AS SHOWN PROVIDES A TACTILE CUE FOR THE VISUALLY IMPAIRED BY DEFINING THE EDGES OF SIDEWALK AND OUTLINING AREAS TO BE USED FOR STREET FURNITURE. TO OUTLINE THE CROSSWALK, TEXURED AND/OR COLOURED CONCRETE OR OTHER MATERIALS MAY BE USED INSTEAD OF PAVING STONES.
3. PAVING STONES DO NOT ENCROACH ON THE SIDEWALK'S CLEAR PATH OF TRAVEL.

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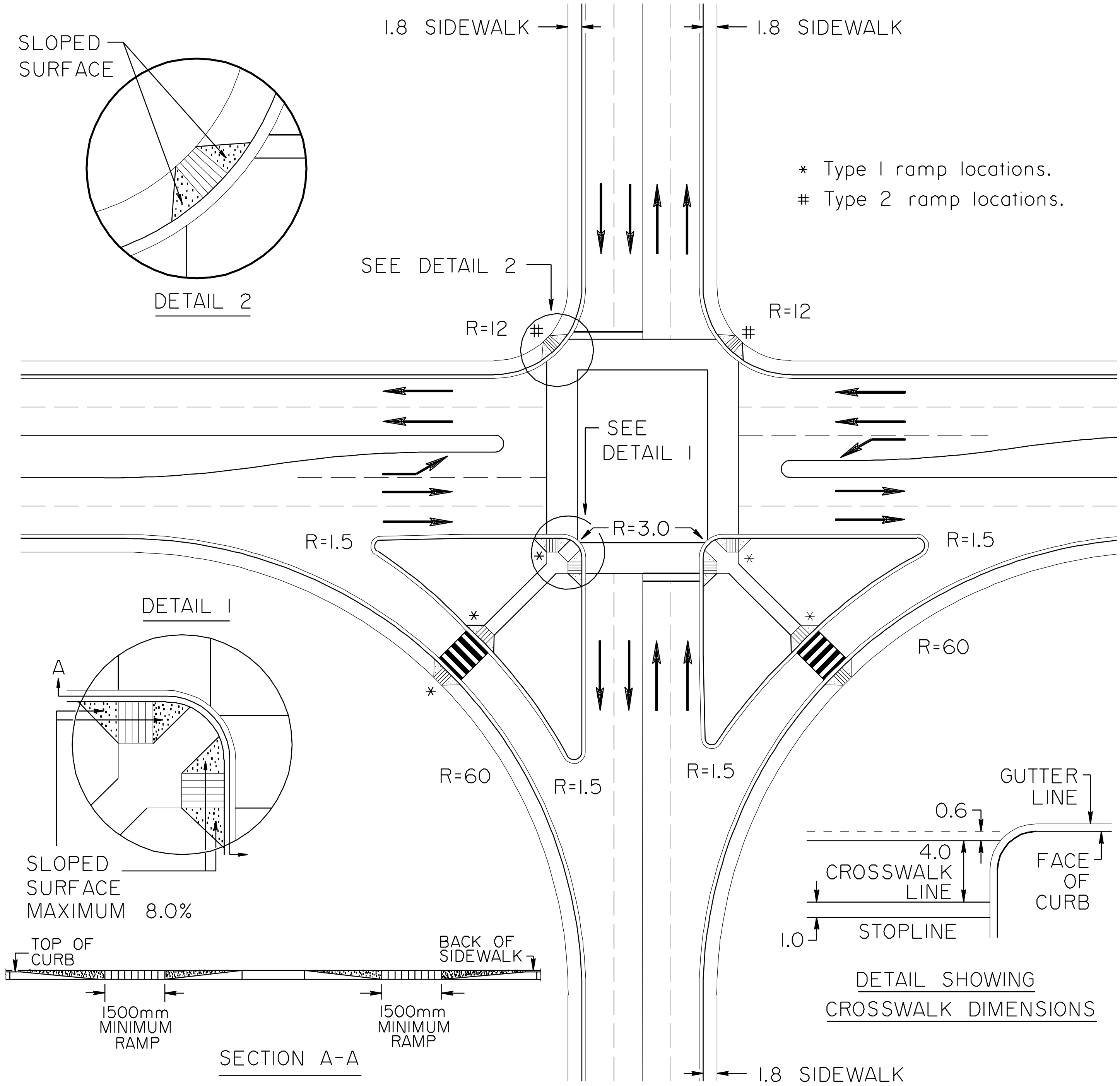
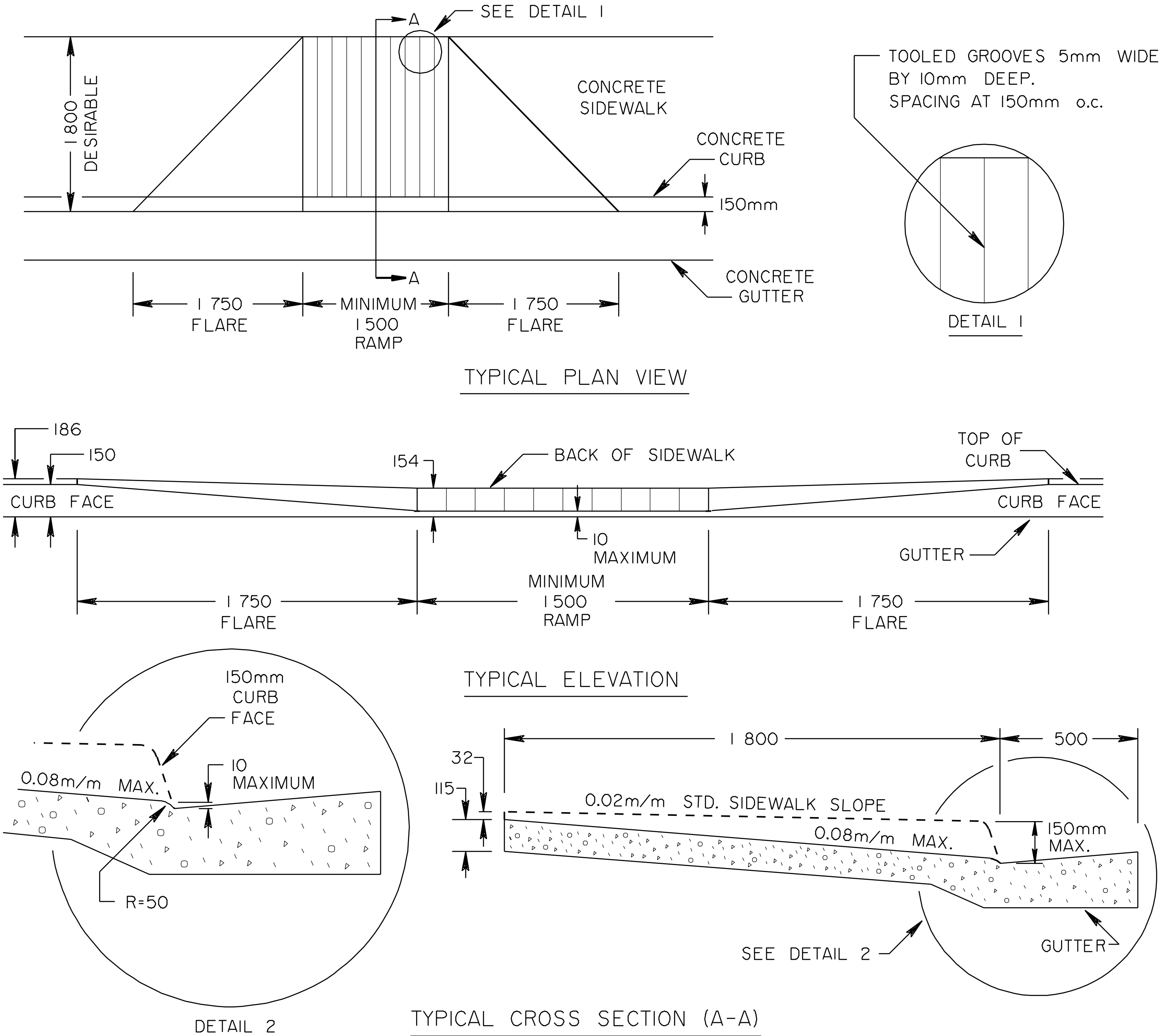
FIGURE C-7.1.4d TYPICAL LAYOUT OF CROSSWALKS AND LOCATION AND TYPE OF SIDEWALK RAMPS AT URBAN INTERSECTIONS



NOTES:

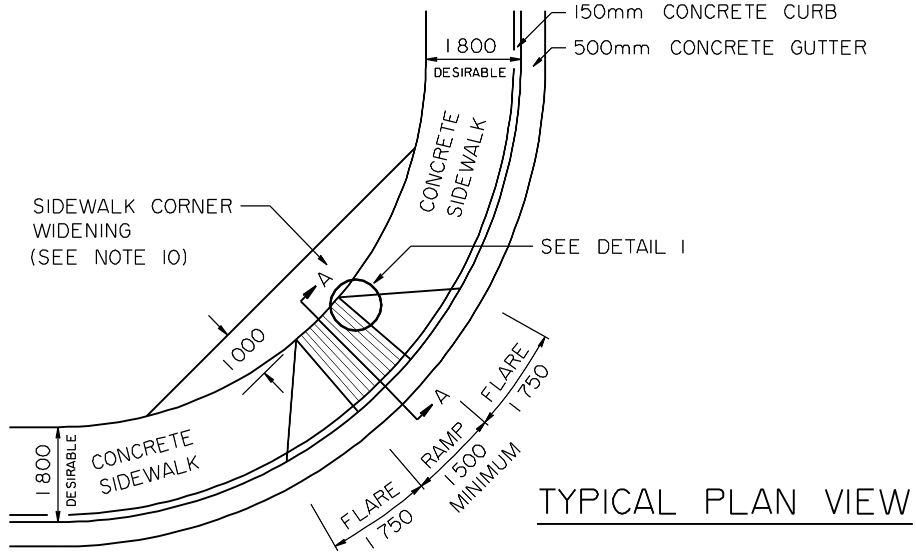
1. All dimensions are in metres unless otherwise specified.
2. Sidewalk ramps must provide access directly to crosswalks.
3. The selection of curb ramp type is dependent on the location of the crosswalk relative to the curb face. Where the curb return radius is greater than or equal to 4.0m one Type 2 ramp can be used. Where the curb return radius is less than 4.0m, two Type 1 ramps are required.
4. Where crosswalks are controlled by signals with a push-button system, the sidewalks and ramps must allow access by wheelchair to the push-button.
5. Refer to Figures C-7.1.4e and C-7.1.4f for details. of Type 1 and Type 2 ramps.
6. On a sharp corner where two Type 1 ramps are being used, the slope on the flared areas between the two ramps can be less than the 0.08m/m maximum shown. This will provide a smoother sidewalk for general use especially for pedestrians who are not using the crosswalk.

FIGURE C-7.1.4e CONCRETE SIDEWALK RAMP FOR WHEELCHAIR OR BICYCLE ON TANGENT (TYPE I)

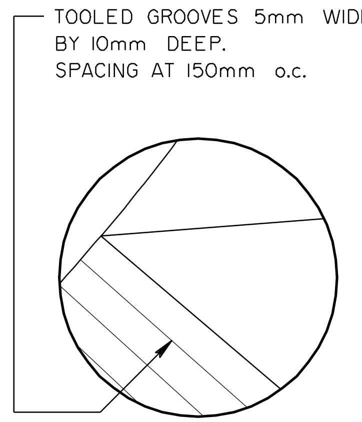


NOTES:

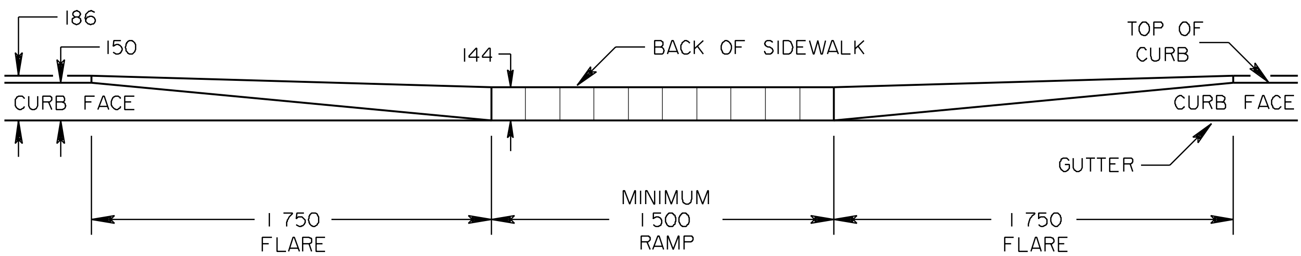
1. All dimensions are in millimetres unless otherwise specified.
2. Ramps for users of wheelchairs/bicycles should be located at all junctions of crosswalks and sidewalks.
3. Grooves on sidewalk ramps are to alert persons who are visually impaired of the curb-cut and a street crossing.
4. Where crosswalks are controlled by signals with a push-button system, the sidewalks and ramps must allow access by wheelchair to the push-button.
5. Concrete sidewalks, curbs and ramps to be poured monolithically.
6. Minimum width of ramp is 1500mm. It may be necessary to build wider ramps in busy urban areas where the volume of pedestrian traffic is high.
7. Maximum ramp slope is 0.08m/m.
8. Where the sidewalk is less than 1800mm wide, the 0.08m/m maximum slope should not be exceeded and therefore the back of the sidewalk must be lowered accordingly.
9. Refer to Figure C-7.1.4d for typical layout of crosswalks and location and the type of ramp to be used.
10. For details of typical ramps for 90 degree corners, refer to Figure C-7.1.4f.



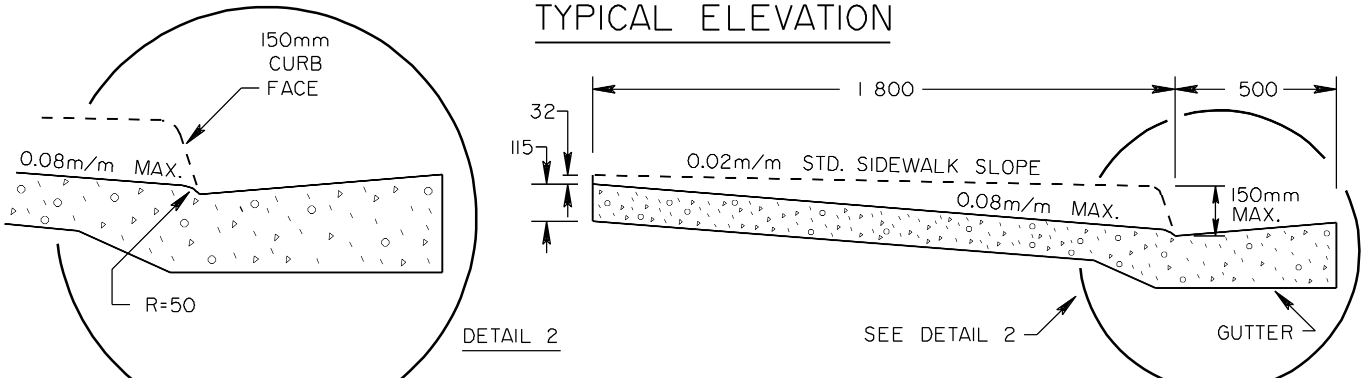
TYPICAL PLAN VIEW



DETAIL 1



TYPICAL ELEVATION



TYPICAL CROSS SECTION (A-A)

Notes:

1. All dimensions are in millimetres unless otherwise specified.
2. Ramps for users of wheelchairs/bicycles should be located at all junctions of crosswalks and sidewalks. Ramp must be located within a crosswalk.
3. Grooves on sidewalk ramps are to alert persons who are visually impaired of the curb-cut and a street crossing.
4. Where crosswalks are controlled by signals with a push-button system, the sidewalks and ramps must allow access by wheelchair to the push-button.
4. Concrete sidewalks, curbs and ramps to be poured monolithically.
5. Minimum width of ramp is 1500mm. It may be necessary to build wider ramps in busy urban areas where the volume of pedestrian traffic is high.
6. Maximum ramp slope is 0.08m/m.
7. Where the sidewalk is less than 1800mm wide, the 0.08m/m maximum slope should not be exceeded and therefore the back of the sidewalk must be lowered accordingly.
8. Refer to Figure No. C-7.1.4d for typical layout of crosswalks and location and the type of ramp to be used.
9. For details of typical ramps for tangent sections, refer to Figure No. C-7.1.4e.
10. Where right-of-way is available, the sidewalk is to be widened at corner locations as shown so that at least a 1.0m width of "flat" sidewalk is provided adjacent to the ramp.

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Alberta INFRASTRUCTURE

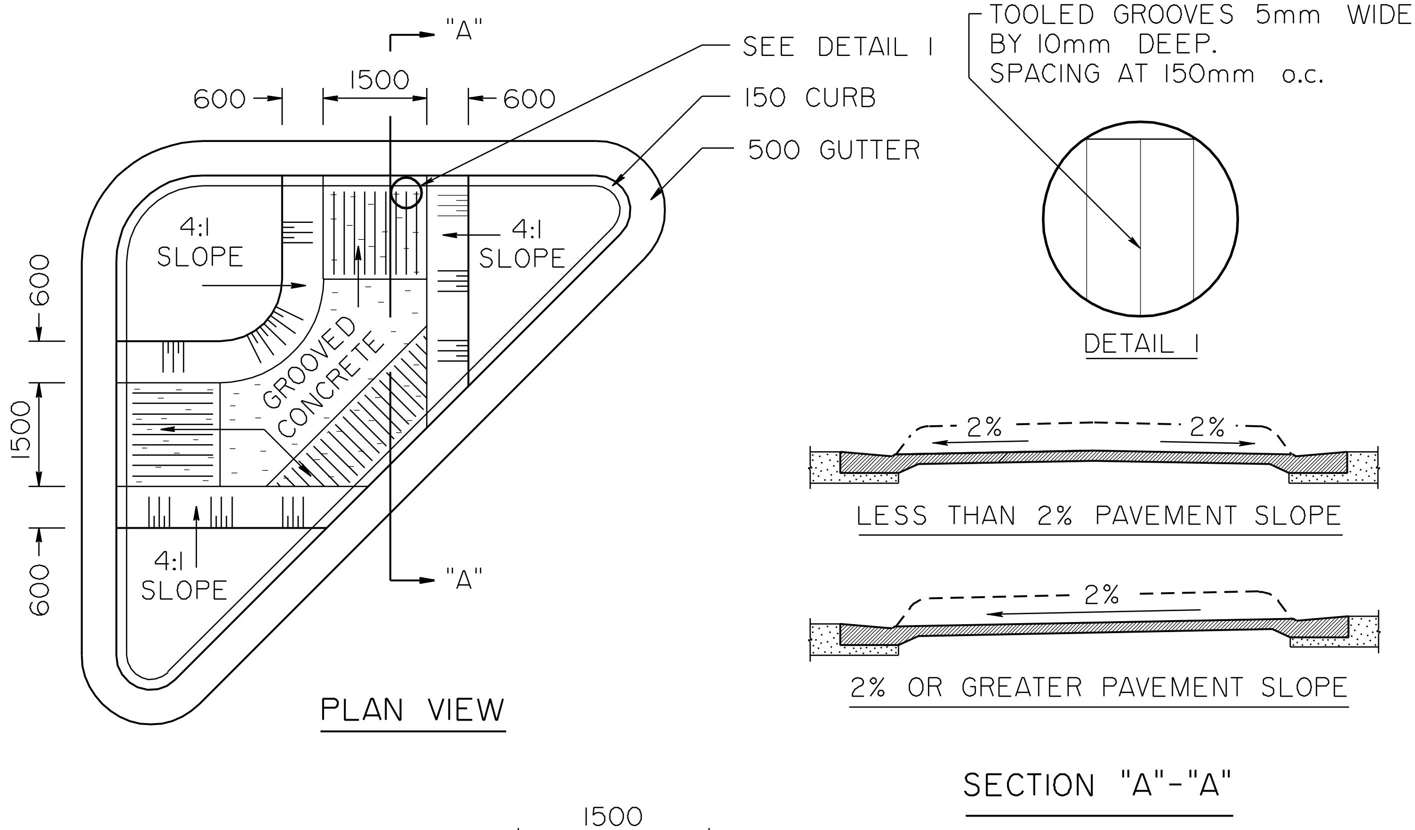
FIGURE C-7.1.4f

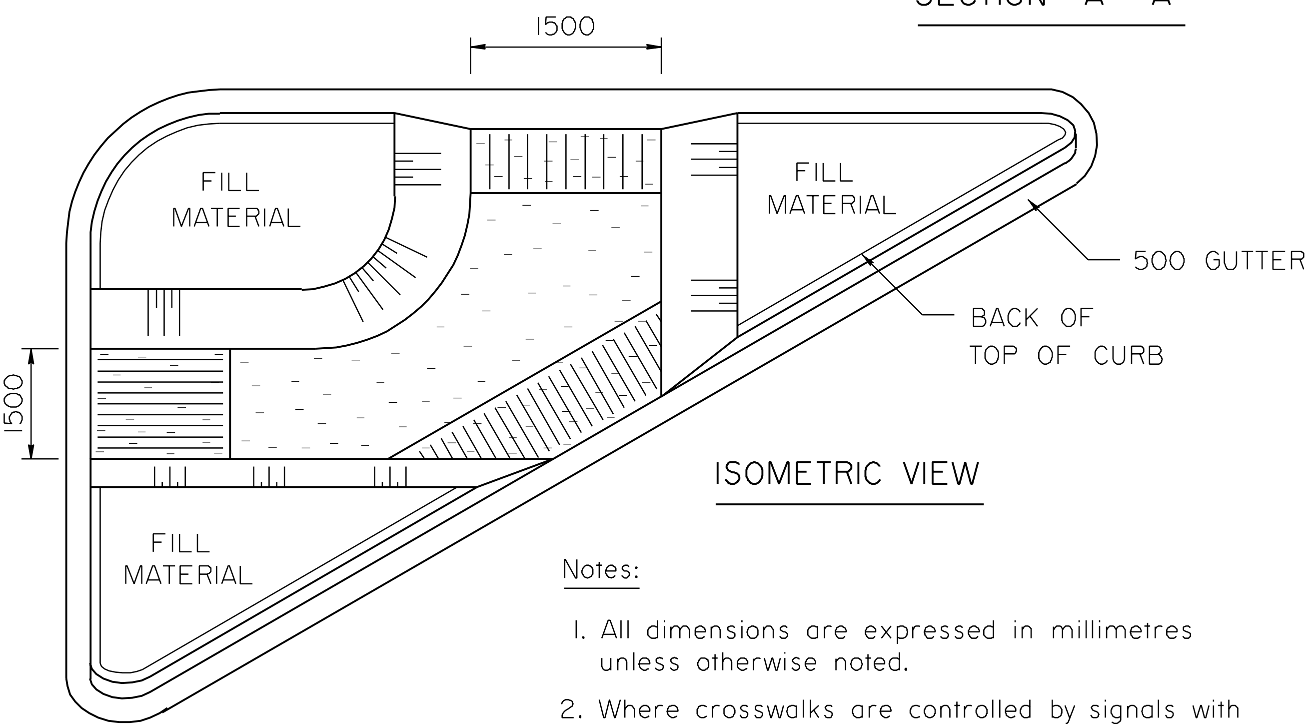
Date: JUNE 28, 1991

CONCRETE SIDEWALK RAMP FOR WHEELCHAIR OR BICYCLE ON CORNER (TYPE 2)

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-65

FIGURE C-7.1.4g TYPICAL SIDEWALK AND CROSSWALK LAYOUT OF SMALLER ISLANDS AND MEDIANS LESS THAN 6M WIDE

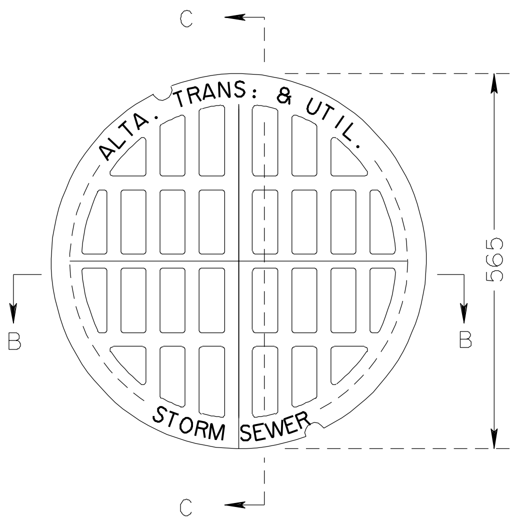




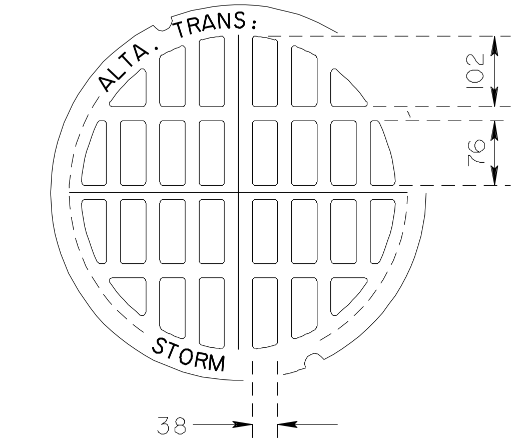
Notes:

1. All dimensions are expressed in millimetres unless otherwise noted.
2. Where crosswalks are controlled by signals with a push-button system, the sidewalks and ramps must allow access by wheelchair to the push-button.
3. Add 10M rebar to the ends of all bullnoses, medians and traffic islands.
4. Fill material for islands shall be earth, concrete or asphalt concrete as specified.
5. Sidewalk and ramps shall be concrete.

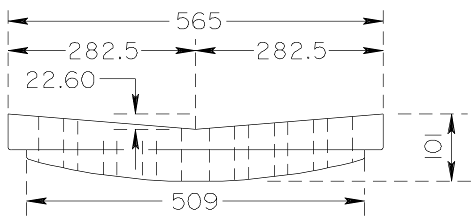
COVER-PLAN VIEW



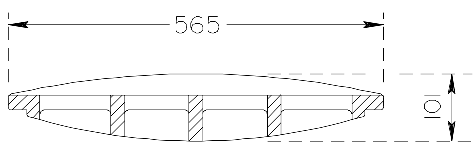
OPENING SIZES



SECTION B-B



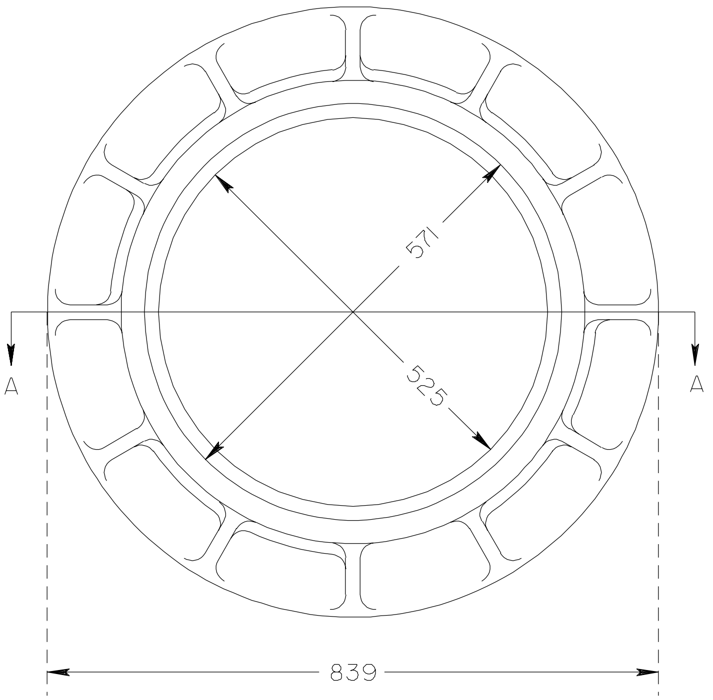
SECTION C -C



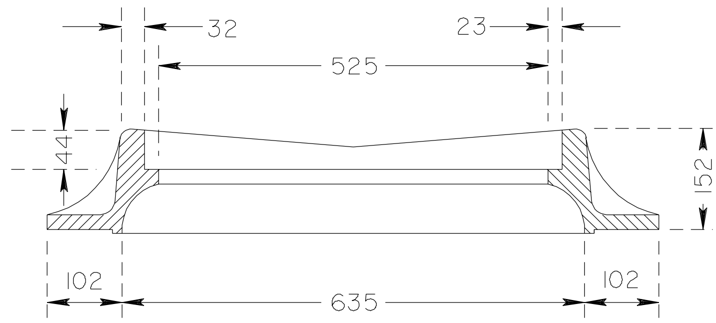
NOTES:

1. DIAGRAMS ARE BASED ON TYPE F-38 FOUNDRY CASTINGS.
2. NOMINAL DIMENSIONS IN mm.
3. THE LETTERING IS TO BE 'STANDARD RAISED CAST LETTERING' WITH 50mm SIZE LETTERS.

FRAME-PLAN VIEW



SECTION A -A



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Alberta INFRASTRUCTURE

FIGURE C-7.1.4h

Date: DECEMBER 4, 1995

WHEELCHAIR RAMP CATCH BASIN MANHOLE COVER

Prepared By: R.M.	Checked By: B.K.	Scale: N.T.S.	PAGE C-67

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C.7.2 ACCESSIBLE BUS STOPS AND BUS TRANSFER STATIONS

C.7.2.1 Introduction

As early as 1992, Alberta municipalities had begun to make their conventional transit systems more accessible for persons with disabilities and seniors. The customary transit bus is being replaced by an accessible, full-size, low floor bus as fleet replacement becomes necessary. By eliminating the need to climb stairs within buses, seniors find boarding much easier and ambulatory passengers are able to board quicker. The use of a ramp on the bus enables persons using wheelchairs or other mobility aid to easily access the vehicle and ride the public transit system.

As part of the plan to implement accessible buses into transit routes, transit management acknowledges the need to address the matter of access in the pedestrian environment, specifically at bus stops. Transit planners are enlisting the assistance of consumers to review the current status of the pedestrian environment and provide feedback on how bus stops can be made more accessible. Both consumers and transit management recognize that in order to ensure consistency across the province, it is essential that various guidelines be developed. The Alberta Chapter of the Canadian Urban Transit Association have also endorsed the need for provincial guidelines.

C.7.2.2 Background

The Alberta Committee to Review Design Guidelines, a subcommittee of the Minister of Transportation and Utilities' Advisory Committee on Barrier-Free Transportation, examined a report developed by an Ontario Ministry of Transportation task force. This task force investigated methods to improve accessibility to conventional transit services and conducted extensive examination of existing literature. They identified key issues and design considerations which are fundamental to improving the accessibility and usability of bus stops.

In developing the Alberta guidelines, the Alberta Committee, comprised of consumers and representatives from Alberta transit systems and Alberta Infrastructure personnel, reviewed the design considerations for bus stops in the Ontario report and a similar document, the BC Transit Design Guidelines for Accessible Bus Stops, and in some instances modified these designs to address conditions for Alberta transit systems.

The Alberta guidelines have been developed to assist Alberta transit systems as they move toward providing accessible transit services through the implementation of community and low floor buses. The guidelines are uniform and flexible, and reference other standards such as the Alberta Building Code and the curb ramp standards developed by Alberta Infrastructure. These guidelines are not meant to be standards but rather to serve as design guidelines which can be interpreted and adapted to specific situations in each municipality. Information contained within the guidelines can also be used for the design of boarding and alighting areas for other accessible vehicles, including taxis, charter buses/vans, and in some instances, private vehicles.

C.7.2.3 Principles of Mobility

The basic principles of mobility in a pedestrian environment are:

- Avoid level changes wherever possible.
- Provide non-slip finishes, good grip, and sure footing to ensure surfaces are safe.
- Provide opportunities for seating adjacent to travel routes.
- Plan exterior elements to minimize obstacles and eliminate travel hazards by ensuring there is adequate overhead clearance and no protrusions into the path of travel. Newspaper boxes and other street furniture should be placed close to the edge of the travel path but out of the main flow of pedestrian traffic.
- Avoid glare from surfaces in all lighting conditions.

C.7.2.4 Principles of Effective Orientation, Wayfinding and Warning

The basic principles of orientation are:

- Provide consistency and uniformity of design elements and layout.
- Simplify orientation by using right angles for design elements and layout.

- Provide visual as well as tactile cues and landmarks within designs (examples: sidewalks with grass shoulders or borders; street furnishings such as benches, trash containers, planters located adjacent to but not within path of travel; high contrasts on shelter door frames, benches and planters).

- Walkways, hazards and waiting areas should be well illuminated for orientation and security purposes.

The basic principles of wayfinding are:

- Provide logical, unbroken path of travel from sidewalk to bus boarding area.

- Paths of travel may be easily identified by proper placement of street furniture, which, for example, can be placed to highlight location of sidewalk or ends of bus zone.

- Use colour contrast, sound, light and shade to accentuate paths of travel between shelter, sidewalk and bus boarding area.

- In rare circumstances, tactile wayfinding tiles may be used to accentuate paths of travel if pedestrian pathway is broken or wayfinding is complicated (note, however, such wayfinding tiles must be consistent in design and well differentiated from tactile warning strips). Wayfinding tiles are usually of gentle and corduroy textures, whereas warning tiles are typically of raised dot textures.

The basic principles of warning are:

- A bus stop with good ergonomics and effective wayfinding/colour contrast or tactile cues will also be beneficial for safety and warning purposes.

- Placement of street furniture such as benches, newspaper stands and planters for creation of a barrier from hazards will assist in preventing mishaps.

- Tactile indicators such as tactile warning tiles may be used in rare circumstances to accentuate a large difference in elevation (note, however, such warning tiles must be consistent in design and well differentiated from tactile wayfinding tiles).

C.7.2.5 Design Envelope

When developing a design standard or guideline, it is generally necessary to select a "design user" or "user envelope", as well as a "design vehicle" in this case the bus. In the case of accessible bus stops and transit zones, a design envelope for the user has been selected to accommodate most conventional wheelchairs and other mobility aides which could gain access to low floor transit buses. This is considered to an extension of the person using the mobility aid. This envelope has the following dimensions:

1.22 m (length) x 0.76 m (width).

Height of the design envelope is not considered to be a critical factor or constraint. Accessible buses or other vehicles to be used to transport wheelchair users normally have enough vertical clearance within the vehicle to accommodate wheelchair users. The dimensions of the design envelope have been adopted by Alberta based on recommendations contained in the Americans with Disabilities Act (A.D.A.) passed in the United States of America which uses a "design envelope" of 1.20m x 0.75m (48" x 30"). Figure C-7.2.5a shows the dimensions of the design envelope to accommodate wheelchair users.

The "design vehicle" for transit zones accessible to wheelchair users is the low floor ramp-equipped transit bus as shown on Figure C-7.2.5b. Transit zones should also be suitable for smaller ramp-equipped vehicles. Modification to the concrete pad size may be required for larger buses, such as the articulated low-floor buses, or lift-equipped buses. Section C.7.3 discusses the minimum clearance area in further detail.

Figure C-7.2.5a Design Envelope to Accommodate Wheelchair Users

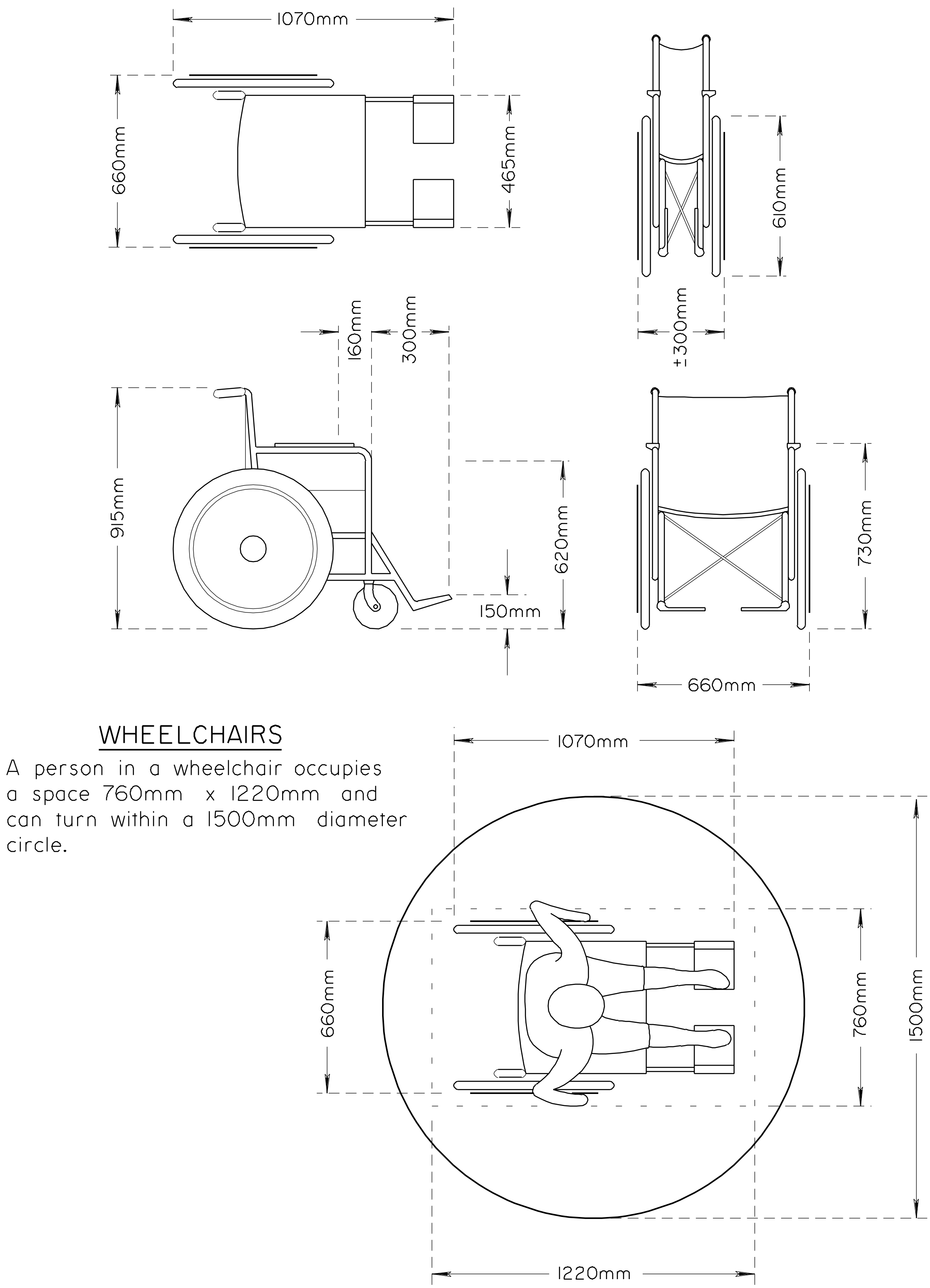
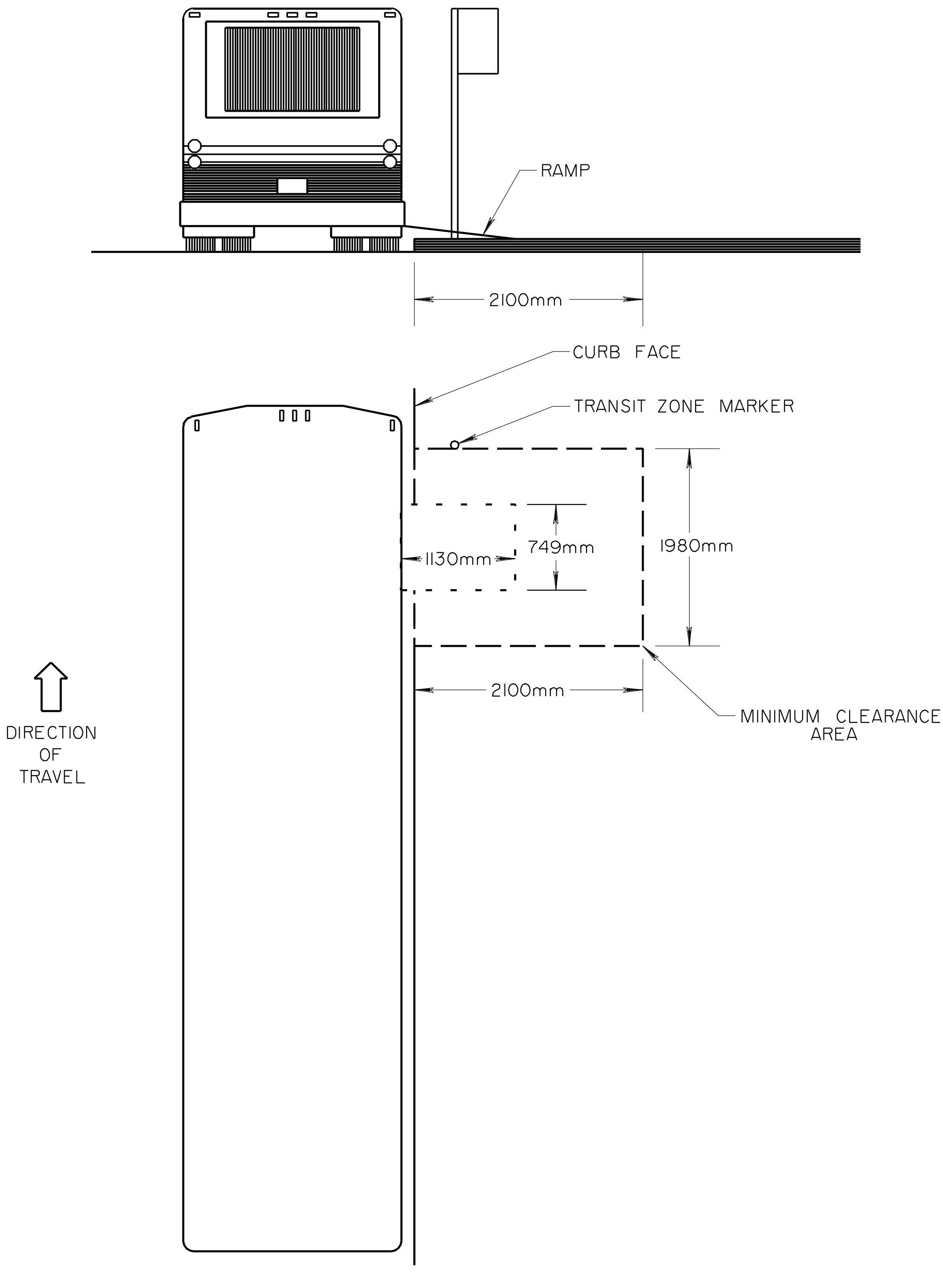


Figure C-7.2.5b Minimum Requirements for Bus Stops Accessible to Wheelchair Users



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C.7.2.6 Elements of an Accessible Environment

The barrier-free path of travel from a person's origin to his/her destination includes walkways, curb ramps, bus stops, shelters, seating, signing, lighting, and streetscape. The design considerations for these elements will be discussed in detail in the following pages and can be used as a resource tool and adapted to meet the specific needs of the particular jurisdiction.

C.7.2.6.1 Walkways

Walkways or sidewalks are the essential link between the origin/destination of the trip and the bus stop. Their proper design and regular maintenance are important in providing a barrier-free path of travel for all persons.

Design considerations:

- Provide non-slip surfaces that are solid, smooth, level and well drained in all weather conditions, with a desirable cross slope of 2%.
- Walkways must be well maintained to be clear of snow, ice, and other debris.
- Avoid service elements such as manholes or gratings on walkways. If they are used, they must be flush with the surface and must not have any opening larger than 13 mm in diameter. If the gratings have elongated openings, orient them so that the long dimension is perpendicular to the direction of travel, as shown on Figure C-7.1.2a.
- Keep obstructions, such as newspaper boxes, benches, sign posts, guy wires, tree branches, and other street furniture, out of the path of travel.
- Minimum overhead clearance from grade is 1980 mm, as illustrated in Figure C- 7.1.2a.
- To assist persons with visual impairments, the surface of the walkways should be easily discernible from the surrounding areas. Use different textures (grass, concrete, paving stone), contrasting colours, and curbs to delineate paths.
- The desirable clear walkway width is 1.8 m, although a minimum width of 1.5 m is commonly acceptable.
- In areas near hospitals and seniors' homes where wheelchairs users are more common on walkways, additional width may be required as illustrated in Figure C-7.2.6.4a.

C.7.2.6.2 Curb Ramps

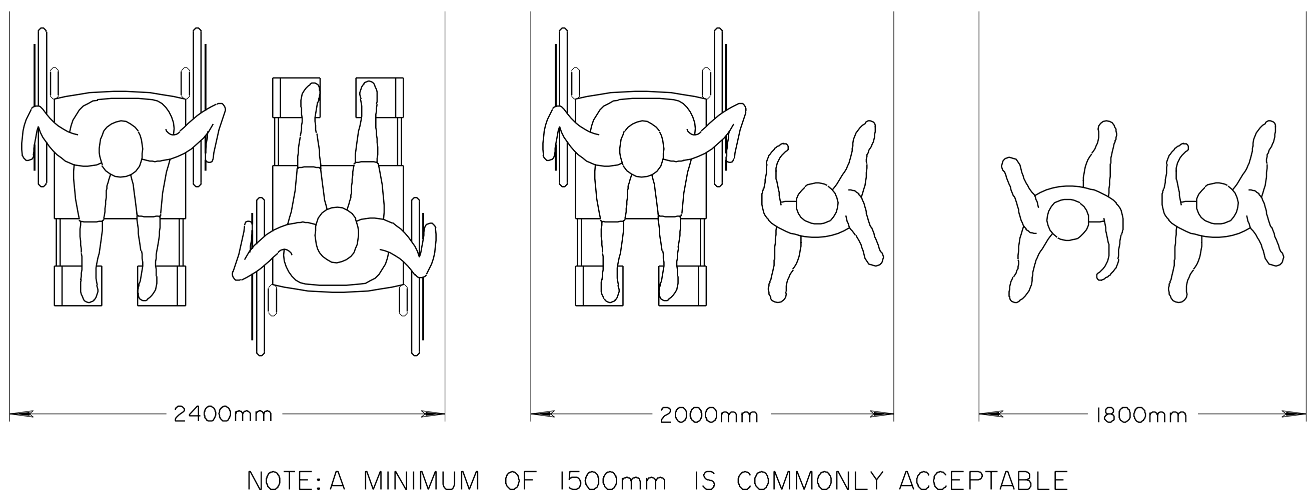
Sidewalk curbs (and raised islands) remain the single most common and difficult barrier in the path of travel for persons with reduced mobility to negotiate. Any level change without the aid of a ramp would pose a mobility barrier. It is important that curb cuts/ramps are provided at all points of level change in the path of travel.

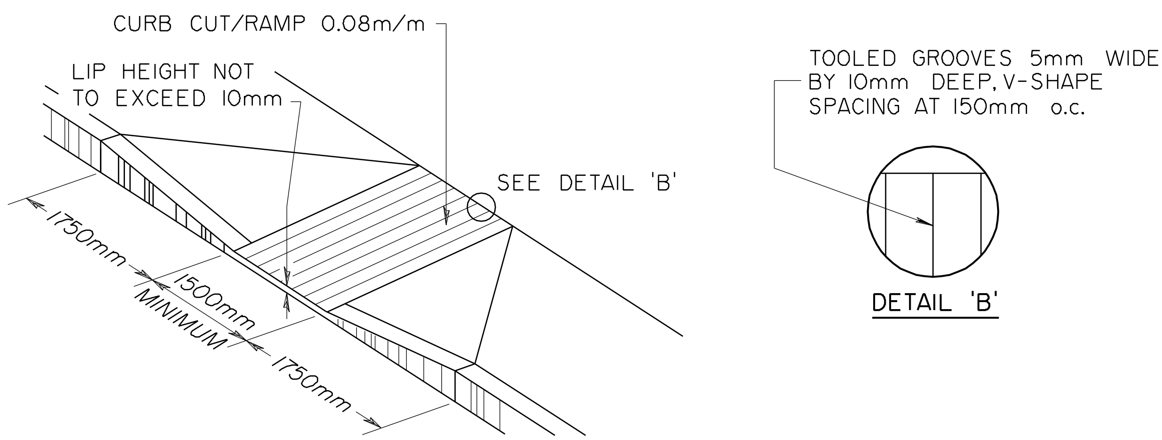
Curb ramp standards developed by Alberta Infrastructure are shown in Figure C-7.2.6.2 and Figure C-7.1.4e. The key elements are summarized as follows.

Design considerations:

- Curb ramps at intersections must be located within crosswalks. Persons using wheelchairs must be able to use the ramps safely away from the travel path of vehicular traffic.
- Ideally, the bottom of the ramp should have a cane-detectable lip. The maximum rise for that lip is 10 mm to allow a smooth path for wheelchairs. See Figure C-7.2.6.2 and Figure C-7.1.4e for illustration.
- All raised platforms/islands in transit centres must have curb ramps and appropriate ramp access into the transit centre from the adjacent pedestrian system.

Figure C-7.2.6.2 Sidewalk Widths and Curb Ramps





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C.7.2.6.3 Bus Stop Location

The location of bus stops relative to the origin and destination of the trip is important to accessibility of the system. To some users, the walking distance to a bus stop may well be the major barrier to accessing the conventional transit system. Planning for bus routes and location of bus stops should be an essential and integral part of any major development planning.

Design considerations:

- In areas near seniors' homes, hospitals, institutions and other high transit usage locations, bus stops should be located as close to these facilities as practically possible to reduce walking distances. Conversely, developers of seniors' homes and high density developments should consider locating their facilities close to transit routes / stops.

- The minimum obstruction clearance area to accommodate the deployment (lowering) of the wheelchair ramp from the bus and to allow for wheelchair movement after clearing the ramp is 2.1 m by 1.98 m, as shown on Figure C-7.2.5b. This minimum clearance area is based on the current bus ramp specifications and wheelchair design envelope.

- The waiting pad or street-side sidewalk at the bus stop should have a minimum length of 8.5 m, a minimum width of 2.1 m, and a barrier type curb height of 150 mm. Those transit systems with articulated buses may need to consider a longer bus pad.

- The 2.1 m width is considered to be a practical minimum requirement, sufficient to allow a wheelchair user to get on and off a bus. If the bus stop is expected to accommodate scooters or a high number of patrons, a wider (2.4 m) bus pad should be considered.

- At locations where more than one route uses a bus stop and the frequency of more than one bus stopping simultaneously at the same stop is high, an additional 17.3 m (12.3 m for vehicle length and 5 m pull-out space) should be added to the length of the concrete pad for each additional bus simultaneously using the stop.

- The bus pad should be clear of any obstacles, such as benches, newspaper boxes, garbage containers, trees and other street furniture. Regular maintenance is important to remove snow, ice and other debris.

- Bus stops should be located on sections of tangent and relatively flat roadway, and stops on steep slopes should be avoided.

C.7.2.6.4 Bus Stops

Bus stops and shelters are comprised of a number of individual elements that must be planned in a coordinated manner. There are a variety of road right-of-way conditions in a municipality. Each bus stop and shelter must be designed to meet the users' needs within the available right-of-way conditions and be compatible with the neighbourhood environment.

Figures C-7.2.6.4a to C-7.2.6.4e illustrate suggested bus stop and shelter arrangements in a variety of sidewalk and boulevard conditions in built-up and suburban locations. The suggested guidelines are flexible and may be tailored to the sidewalk and boulevard conditions at a particular stop. It is not possible to show every bus stop situation; however, these exhibits attempt to illustrate the principles of designing accessible bus stops. The exhibits are briefly described as follows:

- Figure C-7.2.6.4a shows a bus stop in a built-up area, such as central business districts, where the sidewalk occupies the space between the road and adjacent buildings.

- Figure C-7.2.6.4b shows a bus stop in a built-up area, where the sidewalk is separated by a boulevard from the road. Note that the placement of the shelter does not interfere with the sidewalk.

- Figure C-7.2.6.4c is a bus stop in a suburban area, where there is no boulevard separating the sidewalk from the road. The width of the bus pad is a minimum of 2.1 m, as compared to the 1.5 m width of the sidewalk.

- Figure C-7.2.6.4d shows a bus stop in a suburban area with a boulevard separating the sidewalk from the road. The sidewalk is part of the bus pad.

- Figure C-7.2.6.4e illustrates a bus stop in a suburban area with a wide boulevard (more than 2.1 m). A walkway is needed to connect the bus pad and the sidewalk.

Design considerations:

- Provide a non-slip, solid, smooth, well drained (desirable cross slope of 2%), and paved (usually with concrete) area around the shelter and with connections to adjacent walkways.
- Locate street furniture and signing to keep pedestrian access free of obstructions.
- Eliminate any level changes/steps between the bus pad and the shelter.
- If on-street parking adjacent to the bus stop is allowed, the transit zone may be extended by locating the transit zone marker 5 m ahead of the bus pad, to provide a pull-out space.
- Illuminate bus stop areas for orientation and security.
- Signing must be easily recognizable and legible.

FIGURE C-7.2.6.4 TRANSIT STOPS

Fig. C-7.2.6.4a Transit Stop - Built-up, Monolithic Sidewalk

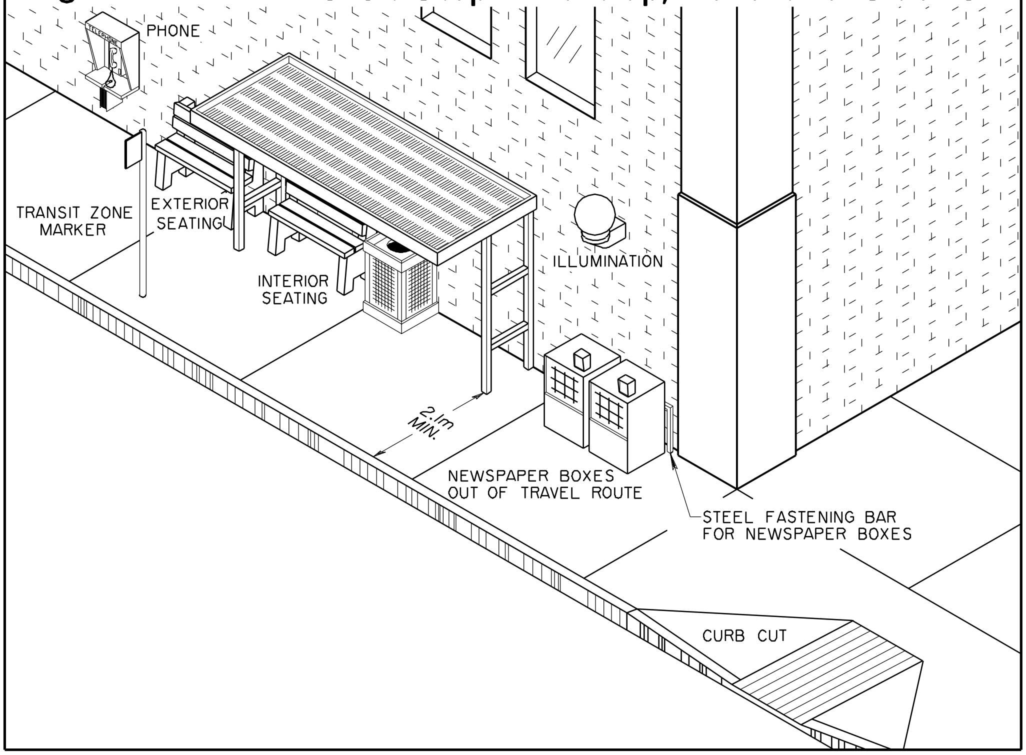
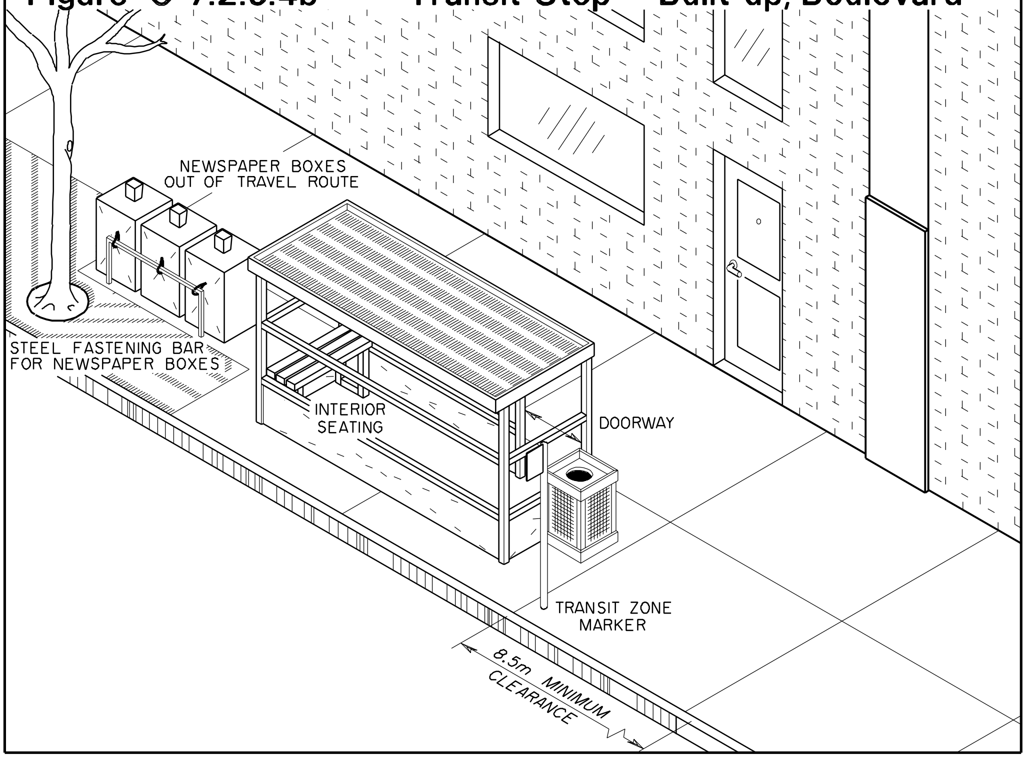


Figure C-7.2.6.4b Transit Stop - Built-up, Boulevard



Graphics File: tigsfs01\reb\manual\chapters\chap-c\debc7264.man

FIGURE C-7.2.6.4 TRANSIT STOPS

Fig. C-7.2.6.4c
Transit Stop - Suburban, Monolithic Sidewalk

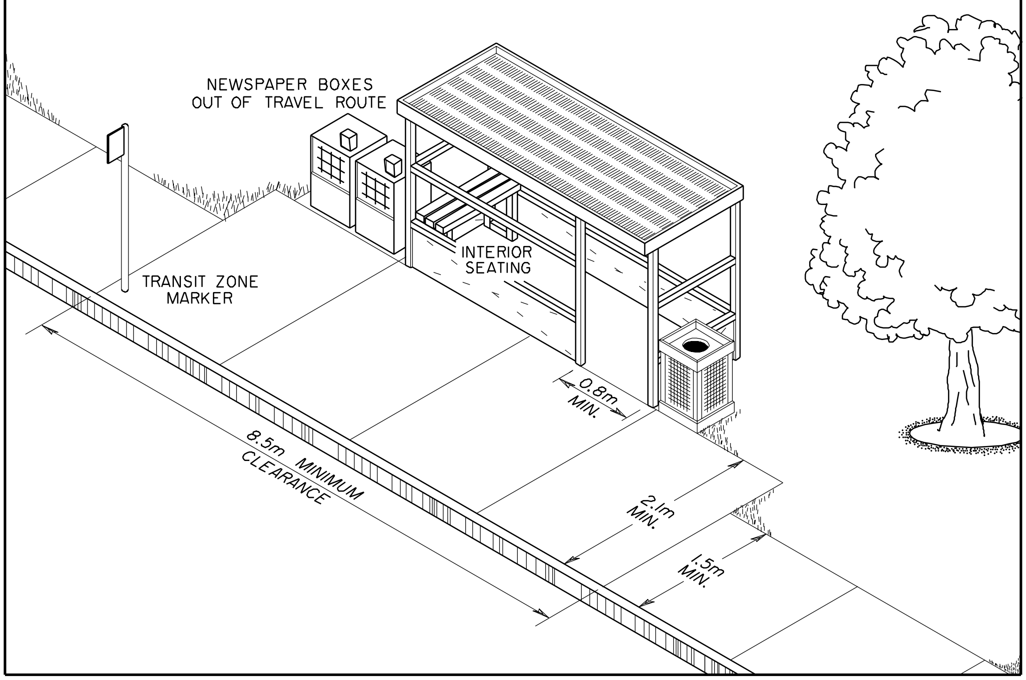


Figure C-7.2.6.4d Transit Stop - Suburban, Boulevard

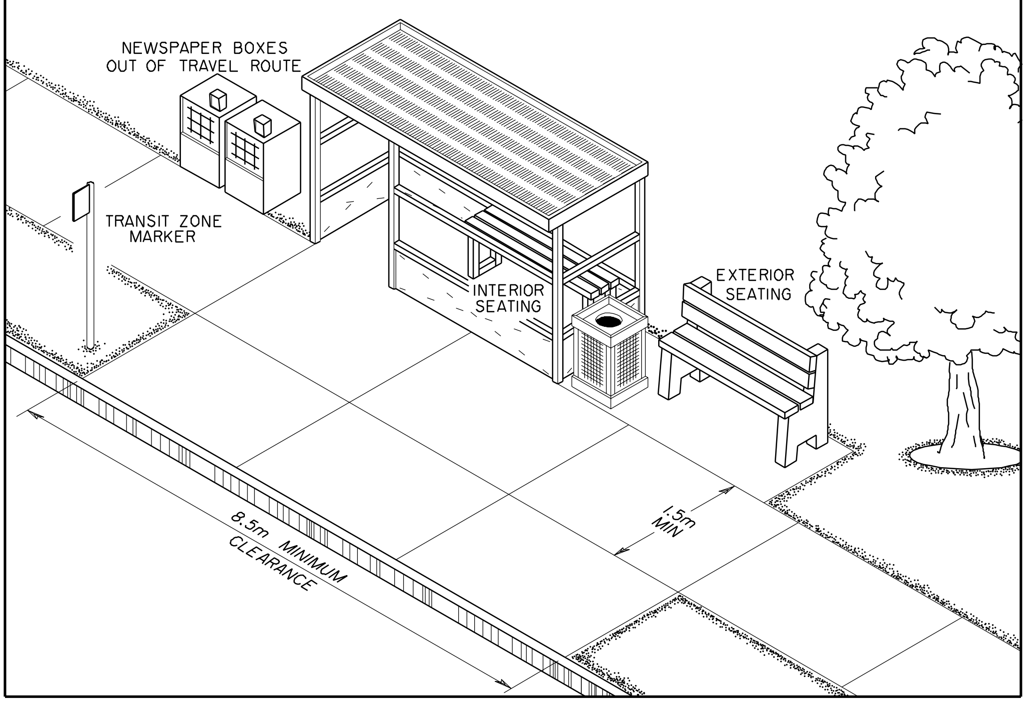


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FIGURE C-7.2.6.4 TRANSIT STOPS

Figure C-7.2.6.4e Transit Stop - Suburban, Wide Boulevard

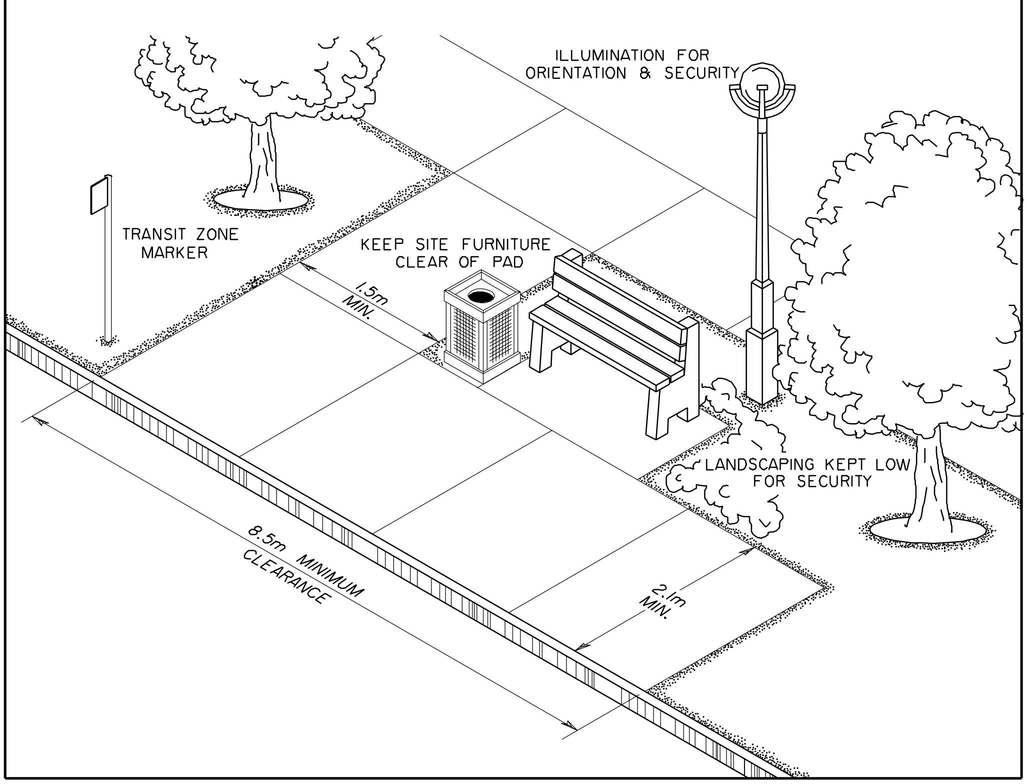
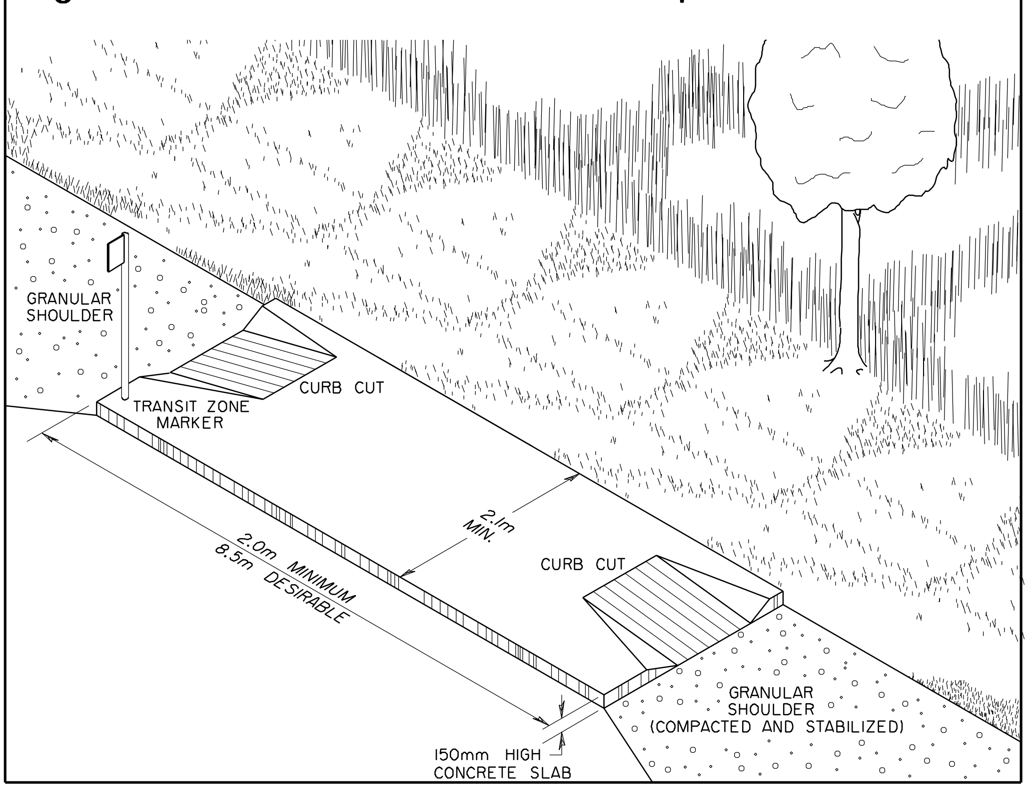


Figure C-7.2.6.4f Transit Stop - Rural Situation



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C.7.2.6.5 Shelters

Bus shelters primarily provide overhead protection and a certain degree of climatic protection. Shelters vary in materials and dimensions. Many of them are funded or provided by advertising companies for the return of the right to display advertising on the shelters. Municipalities should specify the standards and location of the shelters in the contracts with these companies, so that good design and location criteria are not compromised by the involvement of commercial interests.

Design considerations:

- Shelter dimensions vary. A size of 3 m long and 1.5 m wide is quite common.
- Shelters should be designed with transparent sides for visibility and security.
- Include transit route maps, schedules, and seating in shelters. Maps and schedules should be easily readable by persons using wheelchairs and, to the extent possible, persons with a visual impairment.
- Glass panels should be marked with horizontal contrasting stripes.
- Provide seating, if feasible, with sufficient space to move around.
- There should not be steps between the sidewalk / bus pad and the shelter.
- Shelter openings must be a minimum of 800 mm to allow a wheelchair to pass through.
- Doorways and doors in enclosed shelters in major transit centres must be designed to the standards specified in the Alberta Building Code (see the Barrier-Free Design Guide produced by Alberta Labour).
- Heated shelters should be considered in major transit centres.
- Where public telephones are provided, at least one telephone should be accessible by persons using wheelchairs. It must be located so that the receiver, coin slot and control are no more than 1200 mm above the floor.

C.7.2.6.6 Seating

It is very desirable to provide seating at bus stops. Standing for even a short time may be unacceptable or even painful for some, and would impede accessibility to the transit system.

Seating can be provided inside or outside of bus shelters. Some may find the confined space inside a shelter uncomfortable, and would welcome the provision of outside seating, which may be located directly adjacent to the shelter, if one is available.

Design considerations:

- Seating benches should be placed outside the circulation of pedestrians and should not encroach upon sidewalks or bus pads.
- Seats should be located a minimum of 600 mm from the walkways so that legs do not protrude into pedestrian traffic.
- Typical dimensions are: 450 mm to 500 mm high and 400 mm to 500 mm deep. Lengths are determined by the availability of space.
- Armrests of 180 mm to 250 mm above seat height are desirable.

C.7.2.6.7 Rural Bus Stops

There are occasions when bus stops are needed in outlying areas, where the roads have open drainage ditches along the sides. Figure C-7.3.1a on page C-77 shows an accessible bus stop that can be constructed along the shoulder of the road.

If the bus stop usage is very light, the length of the raised bus pad can be shortened to a minimum of 2 m to reduce the costs. At least one curb ramp must be provided to allow persons using wheelchair to access the bus pad.

C.7.2.6.8 Signing

Unlike other traffic signs, which conform to national standards, bus zone signing is typically unique in each municipality. The following design considerations are intended to provide some guidance on bus zone signing, and not intended to standardize signing practices. Essentially, bus zone signing should be readily identifiable, legible, clear, and consistent.

Design considerations:

- For regular bus zone marker signs (about 30 cm wide and 45 cm high) situated above normal head level, the route number should be shown in 72 point lettering (helvetica compressed) size, with at least a 70% contrast with the sign background.
- For large bus terminal marker signs (about 60 cm by 60 cm) situated above head level, the route number should be shown in 432 point lettering or about 15 cm in height (helvetica bold) size, with at least a 70% contrast with the sign background.
- Some bus zone marker signs, which do not extend beyond the edges of their support post or structure, may be located at eye level, providing a person may have a clear path of travel up to the sign.
- Schedule information must be well situated to allow approach by a person using a wheelchair and an initial or preferred approach by a person with a visual impairment.
- For name or identification signs, high contrast titles of significant bus zones may be situated at a height of about 1500 mm above the ground level and in at least 0.75 mm relief above the background (helvetica medium or similar lettering). The lettering should have a height of no less than 50 mm (X- height).
- For easy identification of a bus zone, it is desirable to have a pictorial representation of a bus on the signs.

C.7.2.6.9 Tactile Warning Strips

The use of tactile warning strips has been briefly discussed in Section C.7.2.4. Tactile warning strips are used specifically for warning an individual with a visual impairment that an obstruction (or in most cases a substantial change in elevation) is located within the person's immediate path of travel. Warning strips are not generally used for wayfinding systems.

Research work is continuing in developing effective wayfinding tactile cues which will be easily differentiated from warning surfaces. Until such work is completed, tactile warning strips must only be installed where a significant change in elevation exists (for example, train platforms, the top landings of stairs and docks). Any other application of warning strips will only create confusion in safety related situations.

Tactile warning strips are not considered necessary at bus stops. Other methods of effective wayfinding may be used for bus stops, such as effective placement of street furnishings and/or shelters (see Figure C-7.2.6.4f), to naturally guide the flow of pedestrian traffic.

C.7.3 Bus Transfer Stations

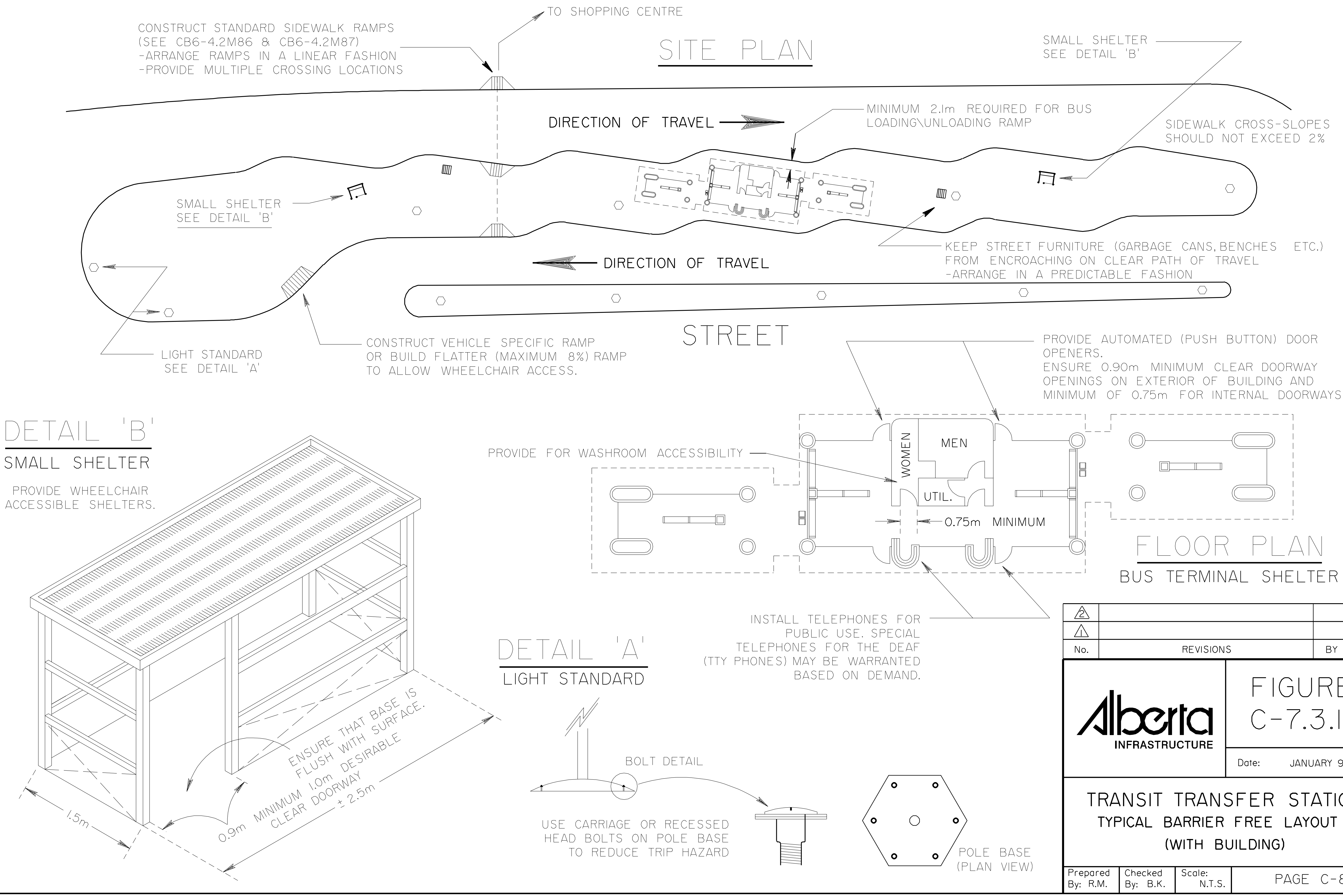
C.7.3.1 Introduction

Since the introduction of low-floor buses to public transit bus fleets, more people with mobility aids are using public transit. Some inherent design deficiencies in existing transfer stations, those with and without buildings, are making access difficult for persons with disabilities.

Using the information from the Guidelines for Design of Safe Accessible Environments and the original Design Guidelines for Accessible Bus Stops, recommendations were drafted and incorporated into Figures C-7.3.1a and C-7.3.1b. The previously prepared Design Guidelines for Accessible Bus Stops is now expanded to incorporate desirable and recommended features for Bus Transfer Stations.

Two types of bus transfer stations are illustrated in these extended guidelines:

- Transfer Stations with buildings, and
- Transfer Stations without buildings.



No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

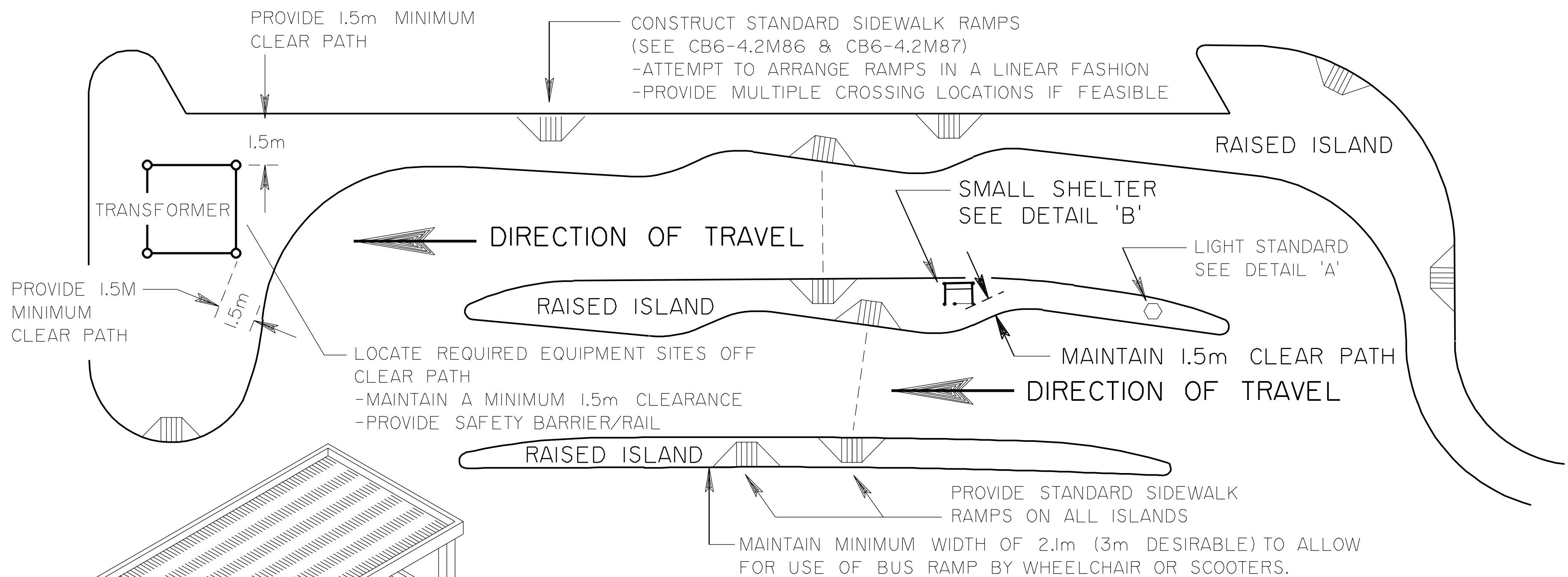
FIGURE C-7.3.1a

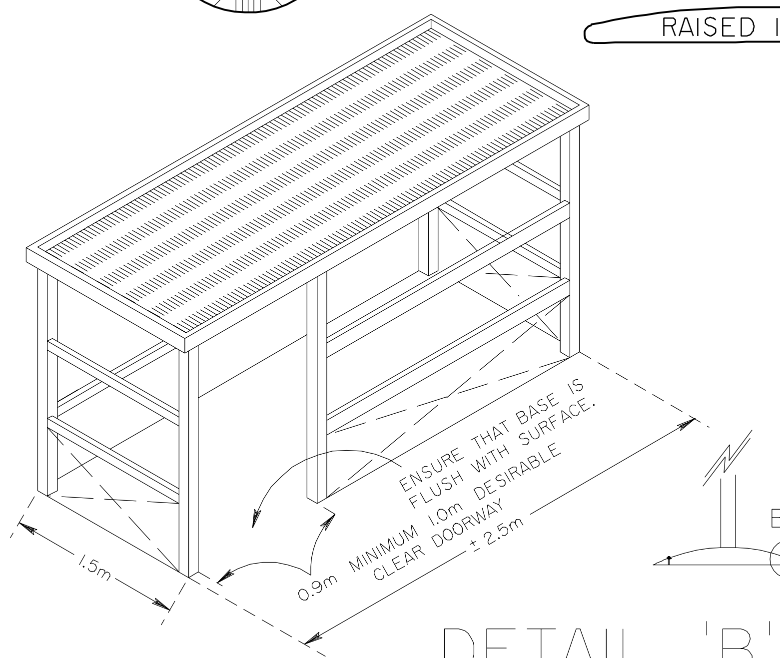
Date: JANUARY 9, 1996

TRANSIT TRANSFER STATION
TYPICAL BARRIER FREE LAYOUT
(WITH BUILDING)

Prepared By: R.M. | Checked By: B.K. | Scale: N.T.S.

SITE PLAN



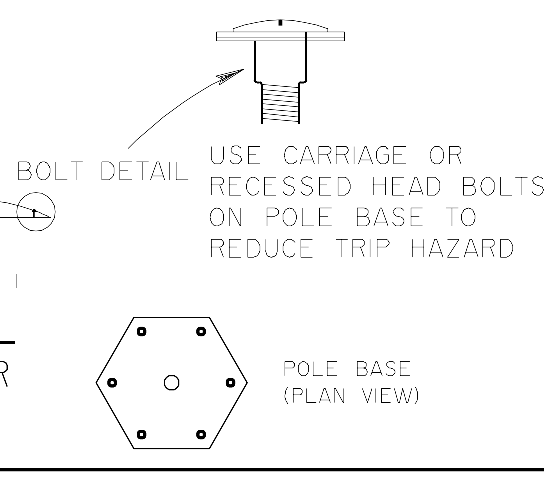


DETAIL 'B'

SMALL SHELTER

DETAIL 'A'

LIGHT STANDARD



No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE C-7.3.1b

Date: JANUARY 9, 1996

TRANSIT TRANSFER STATION
TYPICAL BARRIER FREE LAYOUT (WITHOUT BUILDING)

Prepared By: R.M.	Checked By: B.K.	Scale: N.T.S.	PAGE C-83

C.7.3.2 Buildings and Shelter Features

Buildings should be accessible around the perimeter with at least 1.5 m of relatively level walkway. The exterior doors of the building should be provided with automated (push-button) door openers with a minimum clear opening of 0.9 m. All internal doorways should have a minimum width of 0.75 m. Washroom accessibility should be included. Placement height of accessible public telephones is critical. There may be more of a need for access to telephones for persons with disabilities than able-bodied partons.

Transfer stations without a shelter building are usually constructed on smaller more compact sites. The requirements for the proper placement and alignment of curb ramps is very critical. Figure C-7.3.1b demonstrates how other fixtures should be placed to allow a minimum path of travel of 1.5 m width.

Small shelters should be accessible. Existing shelters have floors which are constructed with a 1200mm x 2400mm x 12.7mm (4' x 8' x 1/2") plywood on a 600mm x 1200mm (2' x 4') frame. The 101 mm (4") high lip at the doorway cannot be mounted by scooters or wheelchairs. It is recommended that at the doorway the floor be flat with the outside slab or a ramp be constructed which will allow wheelchairs or scooters to travel on and enter the shelter. The recommended 1.5 m shelter width allows wheelchairs freedom to manoeuvre within the structure.

C.7.3.3 Curb Ramps

Please refer to Section C.7.2.6.2 for guidelines which address this feature.

Because most transfer stations are placed in or adjacent to shopping centres, care should be exercised in placing curb ramps and aligning them for a direct path of travel to the shopping centre.

C.7.3.4 Streetscape Features

It is important to keep streetscape fixtures like garbage containers, benches etc, from encroaching on clear path of travel. Please refer to Figures C-7.2.6.4e and C-7.2.6.4f for recommended placement of fixtures.

C.7.3.5 Street Lights and Bus Stop Signs

For persons with visual disabilities, light standard and bus stop bases should not have any bolts protruding from the base. It is recommended that recessed heads be installed for all bases. Placement of poles should either be near the curb or completely out of the path of travel.

C.7.4 Curb and Gutter

A curb is a raised element running adjacent to the travel lane or shoulder whose function is to control drainage and provide delineation of the pavement edge. Curb and gutter treatments are extensively used on all types of urban highways. On rural highways, their function is primarily that of delineation since drainage is usually accommodated by drainage channels.

Basically, there are three types of curb and gutter treatments[6], as illustrated in Figure C-7.4:

- Semi-mountable type curb is considered to be mountable under emergency conditions. Its face slope ranges from 0.25m/m to 0.625m/m with a maximum vertical face height of 125mm. Semi-mountable curb is sometimes used at channelized intersections that require raised islands or medians.

- Barrier curb is relatively steep faced, with a vertical face height of 150mm (normal) to 200mm (maximum). It is intended primarily to control drainage as well as inhibit low speed vehicles from leaving the roadway. Barrier curb should not be used on rural freeways and is considered undesirable on expressways and high speed arterials (those having a design speed in excess of 70 km/h). When struck at high speeds, barrier curb can cause drivers to lose control of their vehicles. It is inadequate to prevent a vehicle from leaving the roadway and contributes to vehicle vaulting over all types of traffic barriers. Consequently, barrier curb should not be used in combination with traffic barrier systems.

- Mountable type curb contains a relatively flat sloping face (0.1m/m to 0.25m/m) to permit vehicles to easily cross over it, with its vertical face height varying from 50mm to 100mm maximum. While mountable type curb can be used in conjunction with either semi-rigid or rigid type barrier systems, only the mountable type of

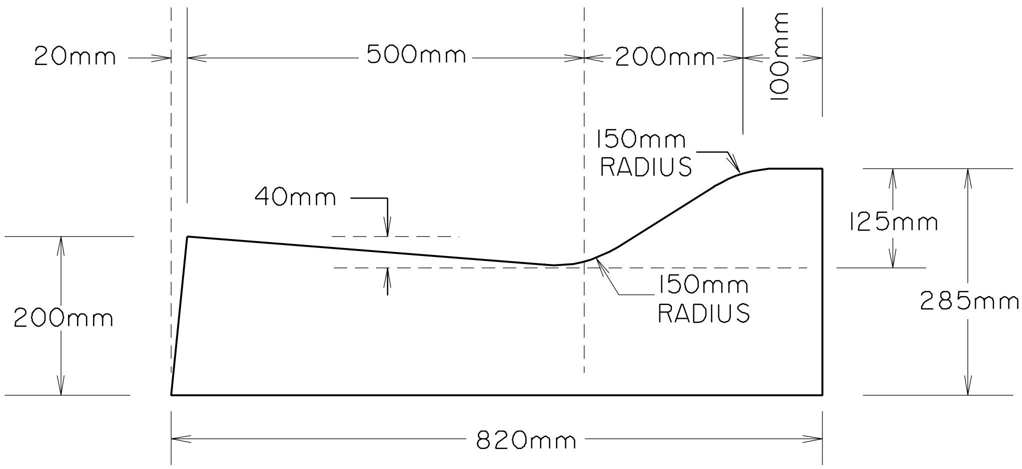
[6] Alberta Urban Supplement to the TAC 1986 Design Guide.

curb (not barrier or semi-mountable) should be employed in combination with a rigid barrier system such as concrete F-shape or New Jersey shape.

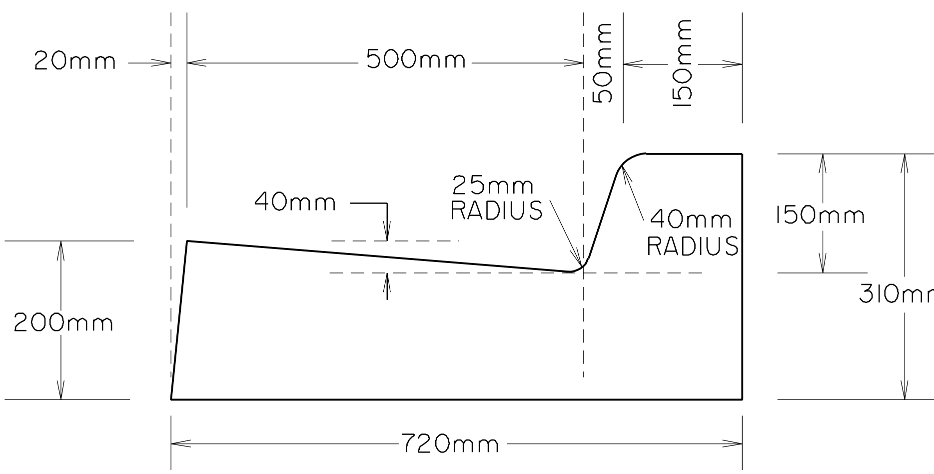
Gutters, which provide the principal drainage system for urban roadways, are located on the travel side of barrier, semi-mountable and mountable curbs. The use of 500mm wide gutters has been adopted throughout the province to contain the majority of storm water run-off and restrict the amount of overflow entering onto the outer travel lane (which in turn results in the lowering of maintenance expenditures, based on experience).

Whenever a rigid traffic barrier system is used, either in a median or along the roadside, the gutter line of the mountable type curb should be offset at least 0.7m from the rigid traffic barrier's top face. This ensures that a vehicle makes contact with the curb first before the barrier. Likewise, this 0.7m offset is also used with semi-mountable curb and gutter in combination with semi-rigid traffic barrier systems, provided the curb width equals the 0.5m gutter width. When curb width is less than the gutter width, then the minimum offset equals the curb width plus 0.2m.

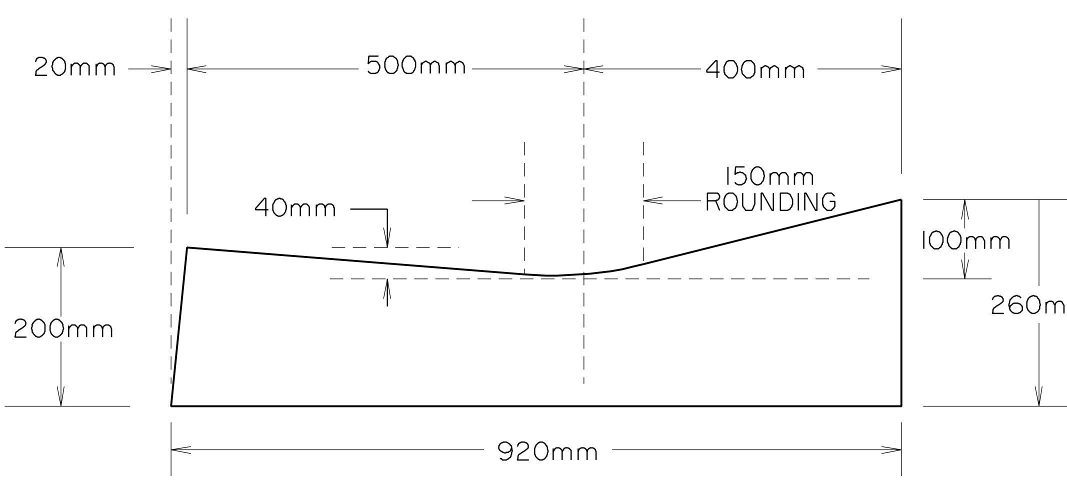
FIGURE C-7.4 CURB AND GUTTER DIMENSIONS



SEMI-MOUNTABLE



BARRIER



MOUNTABLE

C.8 STANDARD CROSS-SECTIONS FOR DESIGN DESIGNATIONS

C.8.1 Strategies to Retain Existing Pavement Widths

In 1999 Alberta Infrastructure adopted a strategy to address the problem of narrow pavements. This strategy was intended to reduce the need to grade-widen existing paved roads currently and in the future through the use of forward-thinking design concepts and innovative pavement rehabilitation methods. The strategy is approved for full implementation on all projects built in the year 2000 construction season. Subsequent projects should also be planned and designed following the same strategy.

Alberta Infrastructure's policy has been developed following extensive investigation and review with input from representatives of the Alberta Roadbuilders and Heavy Construction Association and the Consulting Engineers of Alberta. Other transportation agencies in Canada and the United States were surveyed for comments and strategies. The new policy addresses the roadway-width problem comprehensively in the three distinct phases of a roadway's life namely: the new construction, rehabilitation and reconstruction phases.

New Construction

On all 'new construction' projects, the grade and base-course is to be built wider to allow the top layer, the Asphalt Concrete Pavement (ACP), to be built at a very flat slope. This will allow two future overlays (160 mm total thickness) to be placed without any reduction in width. This is illustrated in Figures C-8.2a to C-8.2h.

Rehabilitation

When pavement rehabilitation is being undertaken, all possible alternatives to minimize the loss of surface width are to be considered, however, design choices are to be based on life cycle cost-effectiveness of various options available for each project. The residual value of the roadway, based on surface width at the end of the service life must be considered in the economic analysis.

Figures C-8.1a and C-8.1b illustrate schematically a number of alternatives that should be considered in the roadway design. The suitability of various options will depend on structural needs, existing conditions, funding availability and possibly other factors. It is essential that roadway design choices be made based on a combination of geometric design and surfacing considerations. This is best achieved through the use of an integrated team of design professionals.

Although the department's objective is to minimize pavement width loss on a network basis, it is recognized that the elimination of pavement loss on all projects is impractical. Therefore designers must analyze the various options available on each project and make appropriate cost-effective and consistent recommendations (supported by engineering and socio-economic considerations) to support the department's strategy. It is desirable to undertake this analysis at the planning or preliminary engineering stage however past experience has shown that some decisions involving surfacing / grading strategies may be made at the detailed design stage.

Reconstruction

Where grade-widening or reconstruction is required on higher volume roads, a new-construction type standard is to be provided so that future widening will not be needed for 50 years under normal circumstances.

On intermediate or lower traffic volume roadways (AADT<1500 approximately) which require grade-widening, a partial grade-widening may be provided. Several different strategies or methods of construction may be considered to achieve a partial grade-widening in a cost-effective way while still achieving acceptable quality. The strategies may include one-side widening, pre-overlay benching etc. however in all cases the design objective is to construct a roadway which will not require widening again for a period of 50 years based on current projections. Given that this will generally involve construction of very flat sideslopes, the option of widening on both sides is probably more attractive than one-side widening in most cases. Where one-side widening is being considered, designers should carefully assess the additional cost for crown shift especially related to additional pavement thickness and examine the location of the wheel paths for the proposed cross-section. A cross-section which would result in a wheel path near the joint or one wheel path on the new embankment and one on the old is undesirable. This is due to the tendency to have greater settlement in the new embankment than the old.

The options available for reconstruction of existing paved highways may be influenced or restricted due to the nature or proximity of existing developments. Where right-of-way or other physical constraints dictate, widening on one side, horizontal realignment etc. may be the most practical solution.

C.8.2 Standard Cross-Section Plans

Figures C-8.2a to C-8.2h, which follow, illustrate the standard cross-sections for each of the commonly used design designations. Guidelines for selecting appropriate design designation are shown in Chapter A. Special cross-sections showing log haul resource road, gravel surface local road (RLU-207-80), highway within a provincial park (RCU-208P-80), sections through muskeg and rock and modified cross-sections for stage construction of nine metre and 10m roadways, are illustrated in Figures C-8.2i through C-8.2p.

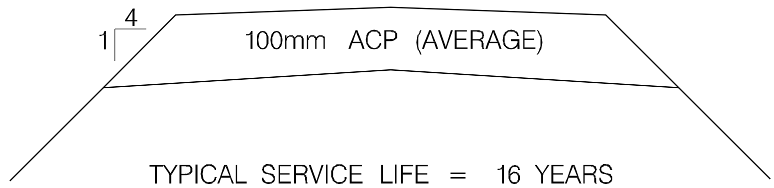
Where grade-widening is involved the life cycle cost-effectiveness of various options should be considered and therefore it is appropriate for designers to have more flexibility in choosing the width. (See Section G.1.3.)

Each of the standard cross-section plans shows a basic right of way width, in some cases this is shown as a desirable and / or minimum width.

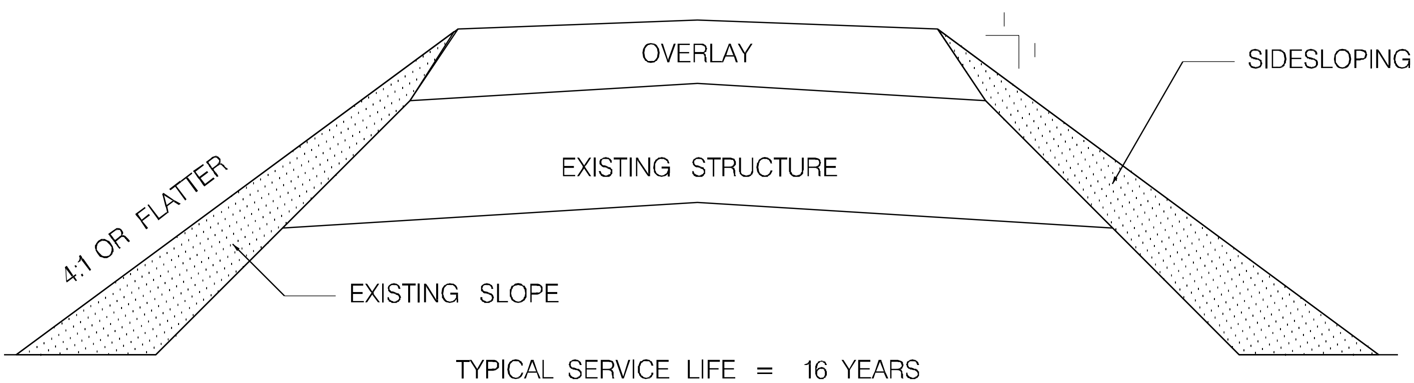
Right of way is that area of property established to accommodate a road and its accompanying features and elements. Right of way width is determined by establishing dimensions for each roadway element, such as roadway width, median width, cut and fill slope requirements, provision for landscaping or noise attenuation devices. Each of these elements, added together, establish a basic right of way width. These widths are given for each class of roadway in Chapter A, Table A.7.

FIGURE C-8.1a

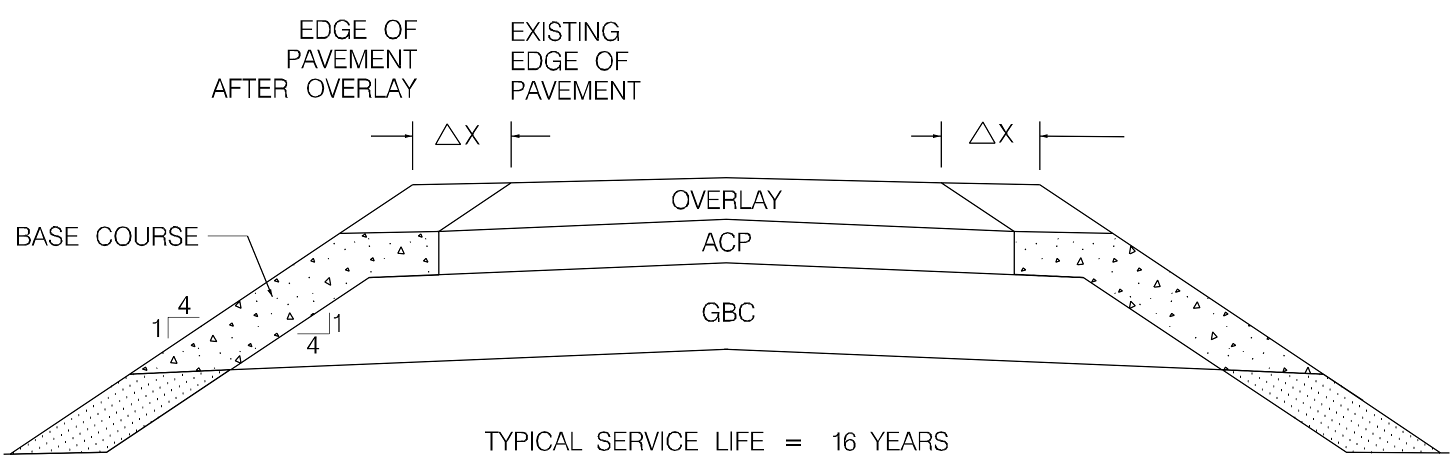
STRATEGIES TO RETAIN EXISTING PAVEMENT WIDTHS



OVERLAY



OVERLAY WITH SIDESLOPE IMPROVEMENT

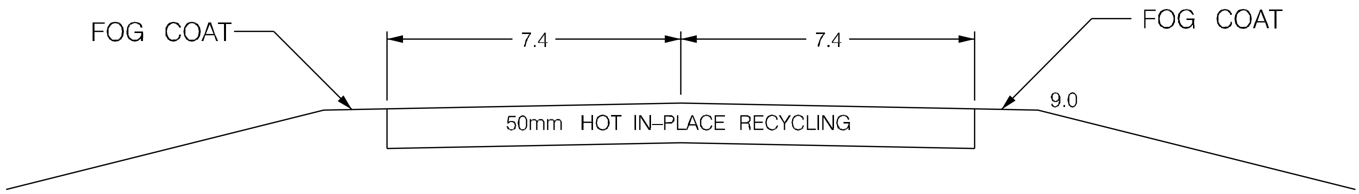


OVERLAY WITH PRE–OVERLAY BENCHING

FIGURE C-8.1b

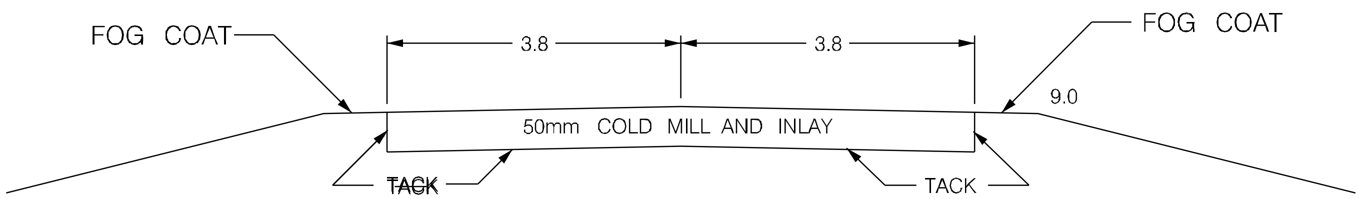
STRATEGIES TO RETAIN EXISTING PAVEMENT WIDTHS

HOT IN-PLACE RECYCLING



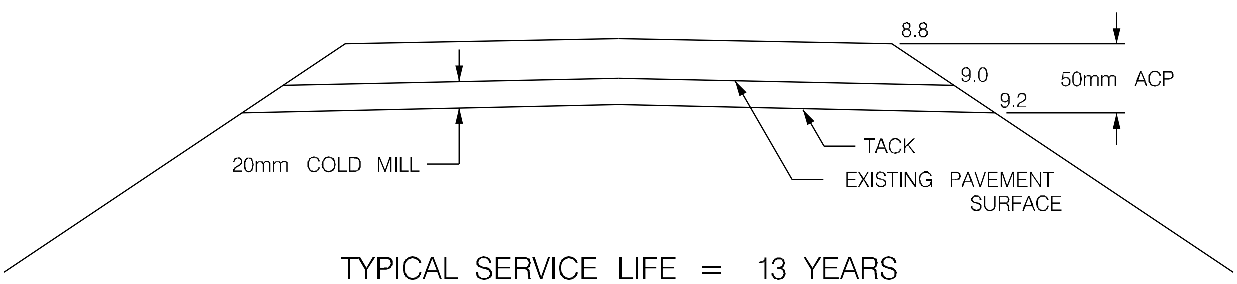
TYPICAL SERVICE LIFE = 9 YEARS

COLD MILL AND INLAY



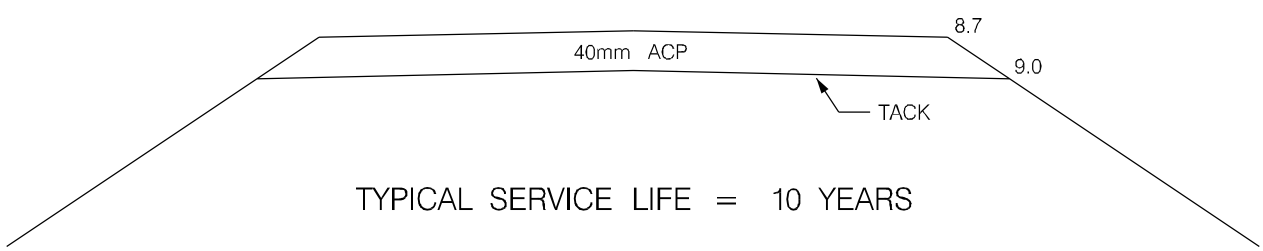
TYPICAL SERVICE LIFE = 11 YEARS

REPROFILE AND OVERLAY

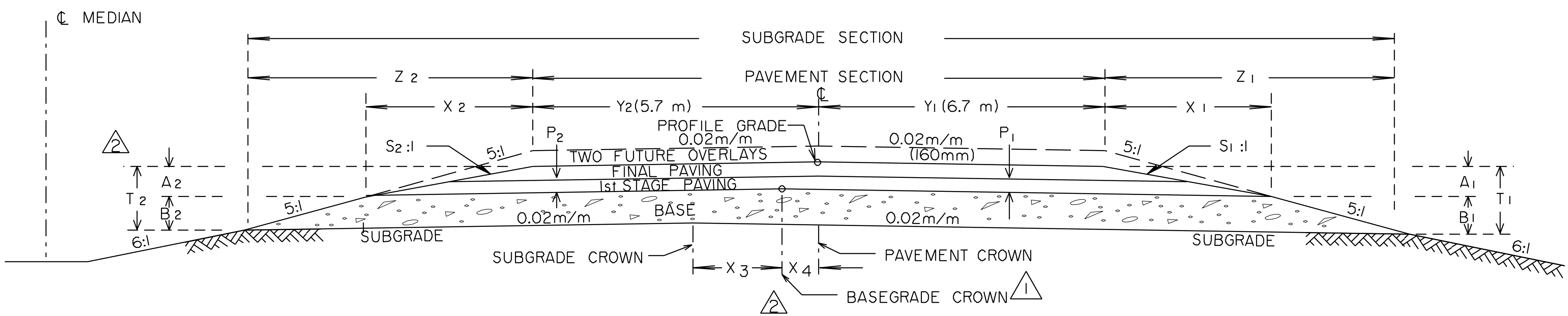


TYPICAL SERVICE LIFE = 13 YEARS

THIN OVERLAY



TYPICAL SERVICE LIFE = 10 YEARS



SUBGRADE AND SURFACING DIMENSIONS

$Z_1 = 5(T_1 + 0.16)$ $\quad$ $Z_2 = 5(T_2 + 0.16)$

$X_1 = Z_1 - 5B_1$ $\quad$ $X_2 = Z_2 - 5B_2$

$S_1 = \dfrac{5(T_1 + 0.16 - B_1)}{A_1}$ $\quad$ $S_2 = \dfrac{5(T_2 + 0.16 - B_2)}{A_2}$

WHERE:
- A_1, A_2 = THICKNESS OF ACP (1st STAGE + FINAL STAGE PAVING)
- B_1, B_2 = THICKNESS OF BASE
- $T_1 = A_1 + B_1$, $T_2 = A_2 + B_2$ (2)
- P_1, P_2 = THICKNESS OF FIRST STAGE PAVING

NOTES:
- * THE PROFILE GRADE IS ON THE CENTRELINE OF THE FINISHED TRAVEL LANES.
- * SUPERELEVATION IS NORMALLY ATTAINED BY ROTATING INDIVIDUAL ROADWAYS ABOUT THE CENTRELINE OF TRAVEL LANES.

NOTE:
THIS DRAWING MAY BE USED TO CALCULATE THE REQUIRED SUBGRADE WIDTH BASED ON SURFACING THICKNESS ON FOUR LANE DIVIDED HIGHWAYS.

No.	REVISIONS	BY	DATE
2	REV TO ACCOMMODATE FUTURE O/L	B.K.	06/99
1	ADDED NOTE	TDN	06/98

EXAMPLE: IF A_1 = 220mm, A_2 = 200mm, B_1 = 400mm, B_2 = 350mm
P_1 = 100mm, P_2 = 80mm
T_1 = 620mm, T_2 = 550mm, Y_1 = 6.70m, AND Y_2 = 5.70m

$X_3 = \dfrac{B_1 - B_2}{40} = \dfrac{400 - 350}{40} = 1.25m$; (OFFSET DISTANCE FROM SUBGRADE CROWN TO BASECOURSE CROWN) (2)

$X_4 = \dfrac{P_1 - P_2}{40} = \dfrac{100 - 80}{40} = 0.5m$; (OFFSET DISTANCE FROM BASECOURSE CROWN TO PAVEMENT CROWN)

$Z_1 = 5(T_1 + 0.16) = 5(0.62+0.16) = 3.9m$

$Z_2 = 5(T_2 + 0.16) = 5(0.55+0.16) = 3.55m$

∴ TOTAL SUBGRADE WIDTH = FINISHED PAVEMENT + Z_1 + Z_2
= 5.7 + 6.7 + 3.9 + 3.55
= 19.85 m

Alberta INFRASTRUCTURE

FIGURE C-8.2a

Date: JUNE 17, 1996

TYPICAL PAVEMENT DESIGN FOR FOUR-LANE DIVIDED HWY RFD-412.4-130 & RAD-412.4-120

Prepared By: T.N.	Checked By: B.K.	Scale: N.T.S.	PAGE C-91

GRAPHICS FILE: debc82a.man

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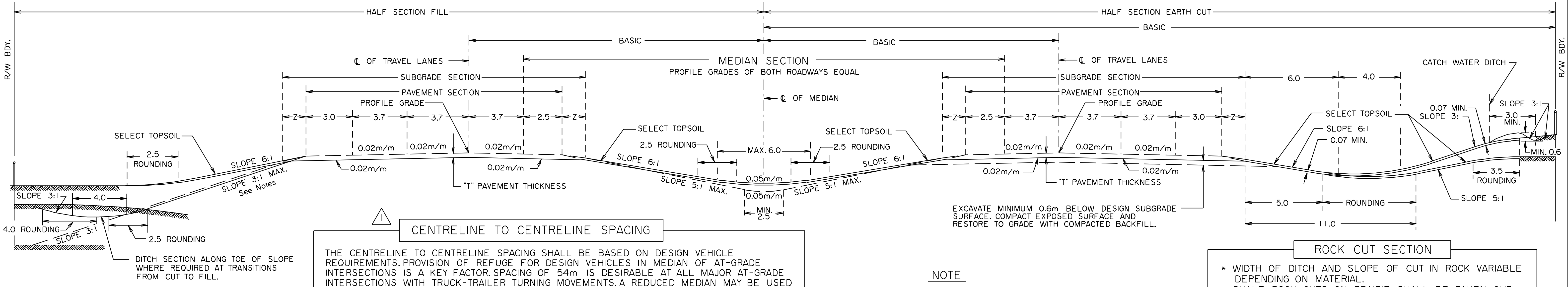


CENTRELINE TO CENTRELINE SPACING

THE CENTRELINE TO CENTRELINE SPACING SHALL BE BASED ON DESIGN VEHICLE REQUIREMENTS. PROVISION OF REFUGE FOR DESIGN VEHICLES IN MEDIAN OF AT-GRADE INTERSECTIONS IS A KEY FACTOR. SPACING OF 54m IS DESIRABLE AT ALL MAJOR AT-GRADE INTERSECTIONS WITH TRUCK-TRAILER TURNING MOVEMENTS. A REDUCED MEDIAN MAY BE USED BETWEEN INTERSECTIONS IF REQUIRED DUE TO CONSTRAINTS.

NOTES:

* Z VALUES MAY BE BASED ON FIG. C-8a OF HIGHWAY GEOMETRIC DESIGN GUIDE.
* T PAVEMENT THICKNESS IS DEPENDENT ON SURFACING DESIGN. A GREATER PAVEMENT DEPTH MAY BE USED ON THE LANES CARRYING HEAVIER VEHICLE LOADS.
* WIDTH OF SUBGRADE SECTION IS DEPENDENT ON THE DEPTH OF SURFACING MATERIAL A GUIDE FOR DETERMINATION OF TOTAL SUBGRADE WIDTH MAY BE BASED ON FIG. C-8.a OF DESIGN GUIDE.
* THE PROFILE GRADES ARE AT THE CROWN POINTS ON THE FINISHED PAVEMENT SURFACE AS SHOWN ON THE CROSS-SECTIONS ABOVE.
* SUPERELEVATION IS NORMALLY ATTAINED BY ROTATING INDIVIDUAL ROADWAYS ABOUT THE CENTRE LINE OF TRAVEL LANES.

MEDIAN SECTION

SLOPES:

* NORMAL SLOPE 6 :1
* MAXIMUM 5 :1 TO BE USED ONLY WHERE MAXIMUM DIFFERENCE BETWEEN INDEPENDENT GRADES OCCUR AND WHERE ESSENTIAL FOR DEVELOPMENT OF MEDIAN DRAINAGE.
* MINIMUM DEPTH OF MEDIAN DITCH 0.5m BELOW SUBGRADE SHOULDER.

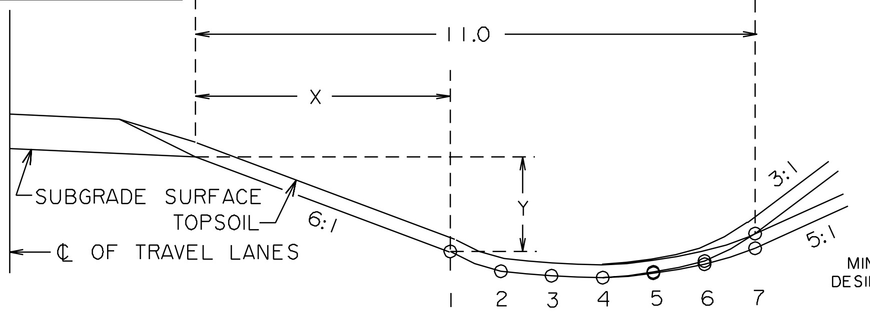
FILL SECTION

SLOPES:

* 6:1 FOR AVERAGE FILLS TO 2.5m.
* 5:1 FOR AVERAGE FILLS 2.5m TO 4m.
* 4:1 FOR AVERAGE FILLS 4m TO 6m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES TO BE USED IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.
* TRANSITION BETWEEN 6 :1 AND 3 :1 SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES; GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL BE NOT LESS THAN 100m.

NOTE

REFER TO FIGURE E-6 (CB6-2.3M37A) FOR ROUNDED DITCH APPROXIMATION FOR DESIGN PLOTTING AND WORK STAKES



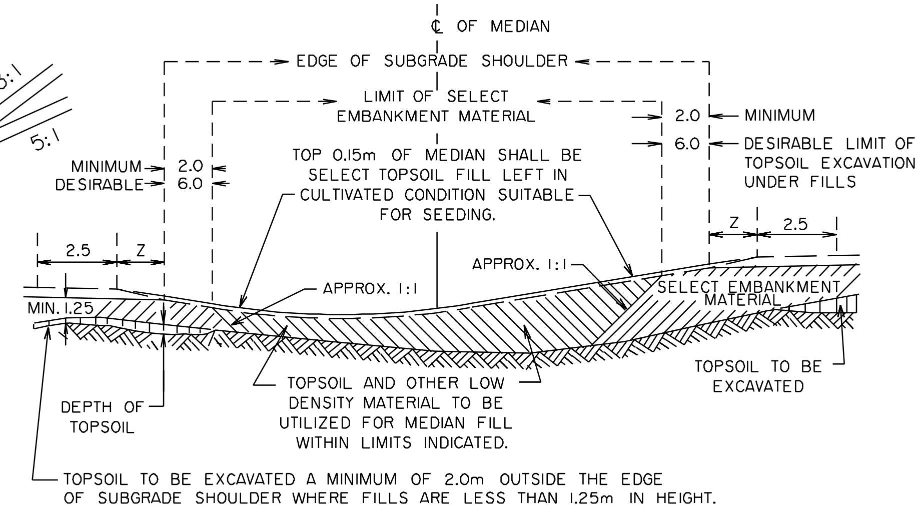
DETAIL OF DITCH ROUNDING

TABLE I

ROUNDED DITCH COORDINATE	1	2	3	4	5	6	7
X (METRES)	5	6	7	8	9	10	11
Y (METRES) 5 :1 BACKSLOPE	0.83	0.97	1.04	1.06	1.02	0.94	0.80
Y (METRES) 3 :1 BACKSLOPE	0.83	0.97	1.04	1.06	1.01	0.91	0.67

ROCK CUT SECTION

* WIDTH OF DITCH AND SLOPE OF CUT IN ROCK VARIABLE DEPENDING ON MATERIAL.
* SHALE ROCK CUTS ON PRAIRIE SHALL BE TAKEN OUT AS SHOWN FOR TYPICAL CROSS-SECTION ON TANGENT.
* MEDIAN SLOPES OF 4 :1 OR STEEPER MAY BE USED ON ROCK SECTION.
* WHERE THE MEDIAN SLOPE IS 4 :1 OR STEEPER, A GUARDRAIL ALONG THE UPPER ROADWAY IS REQUIRED.



DETAIL FOR CONSTRUCTION OF MEDIAN SECTION

NOTE: ALL DIMENSIONS ARE EXPRESSED IN METRES UNLESS OTHERWISE NOTED.

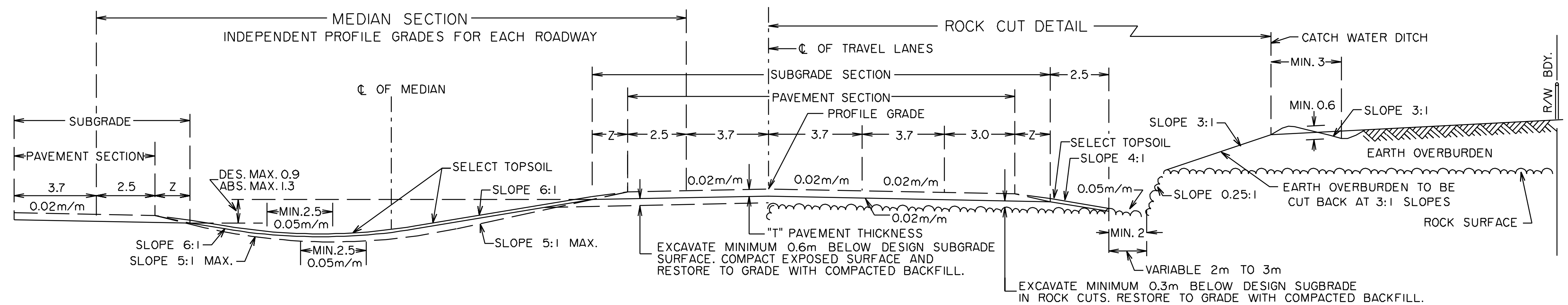
USE OF TOPSOIL

* SELECT TOPSOIL SHALL BE REMOVED WITHIN THE CONSTRUCTION LIMITS TO THE DEPTH AND WIDTH AS DIRECTED BY THE ENGINEER AND THE SALVAGED TOPSOIL STOCKPILED AT DESIGNATED POINTS WITHIN THE RIGHT-OF-WAY LIMITS FOR REDISTRIBUTION ON THE MEDIAN SECTION AND ON CUT OR FILL SLOPES AS REQUIRED.
* WHERE DETERMINED FEASIBLE, THE ENGINEER WILL REQUIRE THE EXCAVATED SELECT TOPSOIL TO BE MOVED TO ITS FINAL POSITION WITHOUT DOUBLE HANDLING.
* SURPLUS TOPSOIL AND OTHER MATERIAL DESIGNATED BY THE ENGINEER AS BEING UNSUITABLE FOR SALVAGE SHALL BE UTILIZED FOR CONSTRUCTION WITHIN THE MEDIAN AS INDICATED ON THE PLAN.
* REFER TO SPECIFICATION 2.6 "TOPSOILING" FOR DETAILS REGARDING PLACEMENT OF TOPSOIL ON MEDIAN SLOPES, CUT AND FILL SLOPES.

EARTH CUT SECTION

SLOPES:

* 6 :1 SIDESLOPE
* 5 :1 BACKSLOPE FOR AVERAGE CUT LESS 2m MEASURED FROM DITCH BOTTOM.
* 3 :1 BACKSLOPE FOR AVERAGE CUT GREATER THAN 2m.
* BACKSLOPES ARE TO BE UNIFORM THROUGHOUT EACH CUT.
* TRANSITION BETWEEN CUT AND FILL SHALL BE ATTAINED BY USING VARIABLE SLOPES BETWEEN 6 :1 AND 3 :1 LIMITS.
* DITCH WIDTH AND ROUNDING OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.



No.	REVISIONS	BY	DATE
3			
2	REV SUBGRADE SURFACING DIMENSIONS NOTES	B.K.	05/99
1	ADDED CENTRELINE SPACING NOTE	B.K.	06/97

Alberta INFRASTRUCTURE

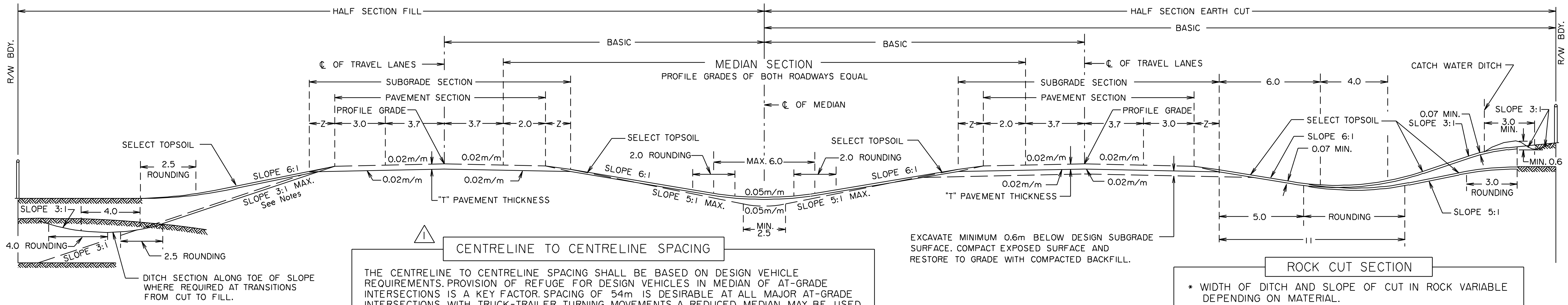
FIGURE C-8.2b

Date: APRIL 1995

STANDARD CROSS-SECTION FOR SIX-LANE DIVIDED HIGHWAY RFD/RAD-616.6-130

Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

GRAPHICS FILE: debc8.2b.man



⚠1 CENTRELINE TO CENTRELINE SPACING

THE CENTRELINE TO CENTRELINE SPACING SHALL BE BASED ON DESIGN VEHICLE REQUIREMENTS. PROVISION OF REFUGE FOR DESIGN VEHICLES IN MEDIAN OF AT-GRADE INTERSECTIONS IS A KEY FACTOR. SPACING OF 54m IS DESIRABLE AT ALL MAJOR AT-GRADE INTERSECTIONS WITH TRUCK-TRAILER TURNING MOVEMENTS. A REDUCED MEDIAN MAY BE USED BETWEEN INTERSECTIONS IF REQUIRED DUE TO CONSTRAINTS.

ROCK CUT SECTION

* WIDTH OF DITCH AND SLOPE OF CUT IN ROCK VARIABLE DEPENDING ON MATERIAL.
* SHALE ROCK CUTS ON PRAIRIE SHALL BE TAKEN OUT AS SHOWN FOR TYPICAL CROSS-SECTION ON TANGENT.
* MEDIAN SLOPES OF 4 :1 OR STEEPER MAY BE USED ON ROCK SECTION.
* WHERE THE MEDIAN SLOPE IS 4 :1 OR STEEPER, A GUARDRAIL ALONG THE UPPER ROADWAY IS REQUIRED.

⚠2 SUBGRADE AND SURFACING DIMENSIONS

* Z VALUES MAY BE BASED ON FIG. C-8a OF HIGHWAY GEOMETRIC DESIGN GUIDE.
* T PAVEMENT THICKNESS IS DEPENDENT ON SURFACING DESIGN. A GREATER PAVEMENT DEPTH MAY BE USED ON THE LANES CARRYING HEAVIER VEHICLE LOADS.
* WIDTH OF SUBGRADE SECTION IS DEPENDENT ON THE DEPTH OF SURFACING MATERIAL A GUIDE FOR DETERMINATION OF TOTAL SUBGRADE WIDTH MAY BE BASED ON FIG. C-8.I.
* THE PROFILE GRADE IS ON THE CENTRE LINE OF THE FINISHED TRAVEL LANES.
* SUPERELEVATION IS NORMALLY ATTAINED BY ROTATING INDIVIDUAL ROADWAYS ABOUT THE CENTRE LINE OF TRAVEL LANES.

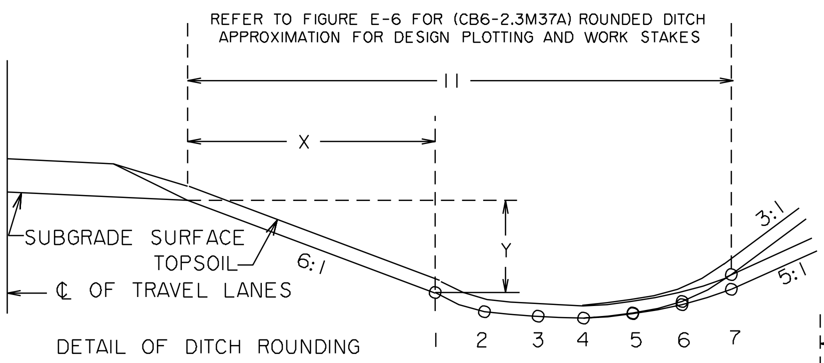
FILL SECTION

SLOPES:

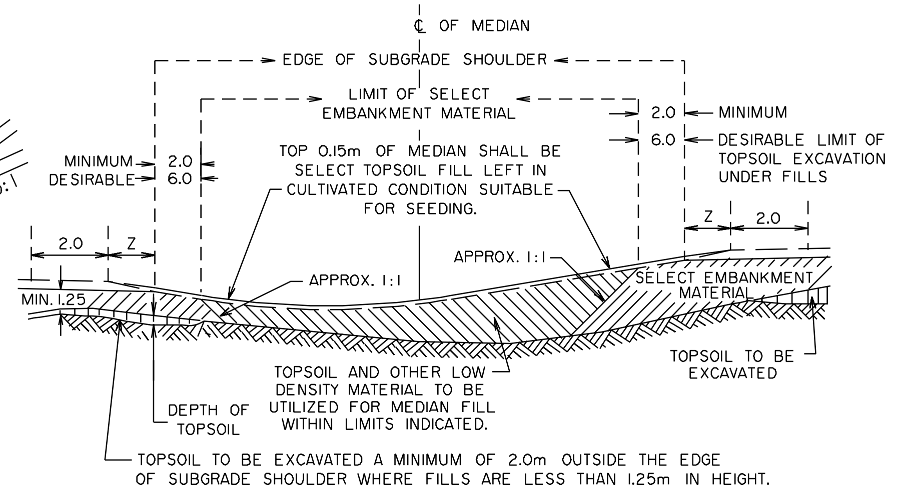
* 6:I FOR AVERAGE FILLS TO 2.5m.
* 5:I FOR AVERAGE FILLS 2.5m TO 4m.
* 4:I FOR AVERAGE FILLS 4m TO 6m.
* 4:I SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:I SLOPES TO BE USED IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:I SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:I SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.
* TRANSITION BETWEEN 6 :I AND 3 :I SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES; GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL BE NOT LESS THAN 100m.

NOTE

REFER TO FIGURE E-6 FOR (CB6-2.3M37A) ROUNDED DITCH APPROXIMATION FOR DESIGN PLOTTING AND WORK STAKES



DETAIL OF DITCH ROUNDING



DETAIL FOR CONSTRUCTION OF MEDIAN SECTION

MEDIAN SECTION

SLOPES:

* NORMAL SLOPE 6 :I
* MAXIMUM 5 :I TO BE USED ONLY WHERE MAXIMUM DIFFERENCE BETWEEN INDEPENDENT GRADES OCCUR AND WHERE ESSENTIAL FOR DEVELOPMENT OF MEDIAN DRAINAGE.
* MINIMUM DEPTH OF MEDIAN DITCH 0.5m BELOW SUBGRADE SHOULDER.

TABLE I

ROUNDED DITCH COORDINATE	1	2	3	4	5	6	7
X (METRES)	5	6	7	8	9	10	11
Y (METRES) 5 :I BACKSLOPE	0.83	0.97	1.04	1.06	1.02	0.94	0.80
Y (METRES) 3 :I BACKSLOPE	0.83	0.97	1.04	1.06	1.01	0.91	0.67

NOTE: ALL DIMENSIONS ARE EXPRESSED IN METRES UNLESS OTHERWISE NOTED.

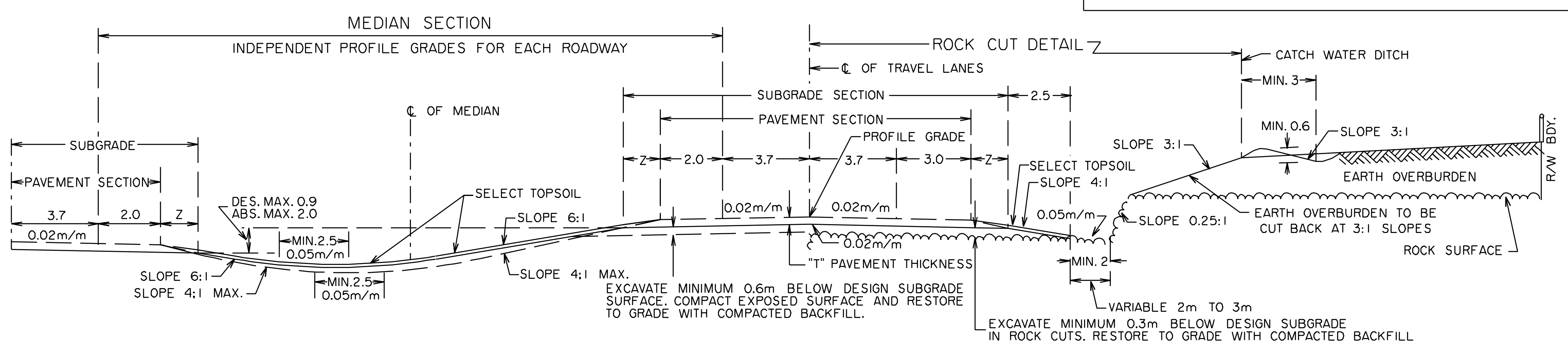
USE OF TOPSOIL

* SELECT TOPSOIL SHALL BE REMOVED WITHIN THE CONSTRUCTION LIMITS TO THE DEPTH AND WIDTH AS DIRECTED BY THE ENGINEER AND THE SALVAGED TOPSOIL STOCKPILED AT DESIGNATED POINTS WITHIN THE RIGHT-OF-WAY LIMITS FOR REDISTRIBUTION ON THE MEDIAN SECTION AND ON CUT OR FILL SLOPES AS REQUIRED.
* WHERE DETERMINED FEASIBLE, THE ENGINEER WILL REQUIRE THE EXCAVATED SELECT TOPSOIL TO BE REMOVED TO ITS FINAL POSITION WITHOUT DOUBLE HANDLING.
* SURPLUS TOPSOIL AND OTHER MATERIAL DESIGNATED BY THE ENGINEER AS BEING UNSUITABLE FOR SALVAGE SHALL BE UTILIZED FOR CONSTRUCTION WITHIN THE MEDIAN AS INDICATED ON THE PLAN.
* REFER TO "SPECIFICATION FOR TOPSOILING" FOR DETAILS REGARDING PLACEMENT OF TOPSOIL ON MEDIAN SLOPES, CUT AND FILL SLOPES.

EARTH CUT SECTION

SLOPES:

* 6 :I SIDESLOPE
* 5 :I BACKSLOPE FOR AVERAGE CUT LESS 2m MEASURED FROM DITCH BOTTOM.
* 3 :I BACKSLOPE FOR AVERAGE CUT GREATER THAN 2m.
* BACKSLOPES ARE TO BE UNIFORM THROUGHOUT EACH CUT.
* TRANSITION BETWEEN CUT AND FILL SHALL BE ATTAINED BY USING VARIABLE SLOPES BETWEEN 6 :I AND 3 :I LIMITS.
* DITCH WIDTH AND ROUNDING OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.



No.	REVISIONS	BY	DATE
⚠3			
⚠2	REV SUBGRADE SURFACING DIMENSIONS NOTES	B.K.	05/99
⚠1	ADDED CENTRELINE SPACING NOTE	B.K.	06/97

Alberta INFRASTRUCTURE

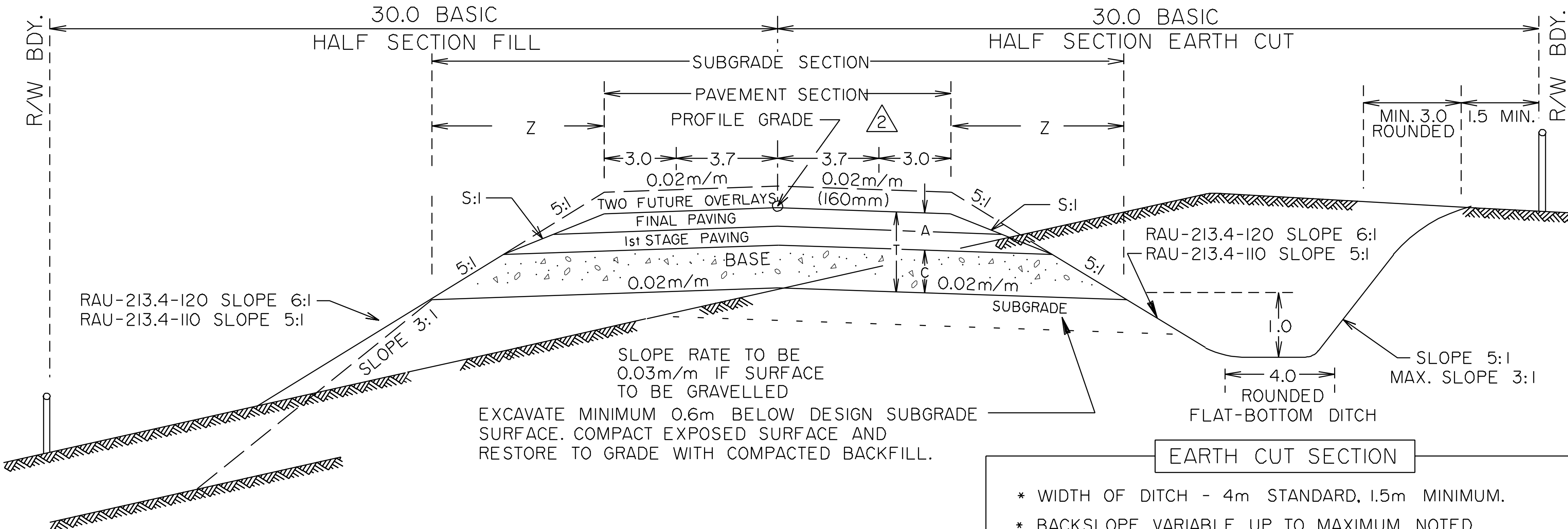
FIGURE C-8.2c

Date: APRIL 1995

STANDARD CROSS-SECTION FOR FOUR-LANE DIVIDED HIGHWAY RFD-412.4-130 & RAD-412.4-120

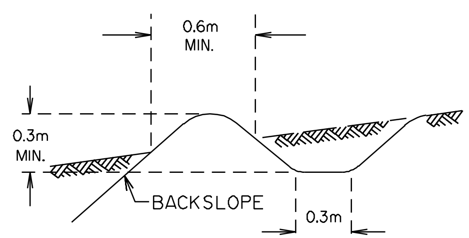
Prepared By: R.T. | Checked By: B.K. | Scale: N.T.S.

GRAPHICS FILE: debc82c.man



EARTH CUT SECTION

* WIDTH OF DITCH - 4m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.



CATCH WATER DITCHES
TO BE CONSTRUCTED WHEN NECESSARY

SUBGRADE AND SURFACING DIMENSIONS (△2, △1)

* $Z = 5(T+0.16)$
* $X = Z - 5C$
* $S = \frac{Z - 5C}{A}$

WHERE

A = THICKNESS OF ACP (1st STAGE AND FINAL STAGE)
C = THICKNESS OF BASE
T=C+A

FINAL PAVING NORMALLY PLACED WITHIN 5 YEARS OF 1st STAGE

FILL SECTION

* 6:1 (FOR 120 KM/H DESIGN SPEED) OR 5:1 (FOR 110 KM/H DESIGN SPEED) SLOPES FOR AVERAGE FILLS LESS THAN 2.0m.
* 4:1 SLOPES FOR AVERAGE FILLS UP TO 6.5m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES MAY BE USED IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 60m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

No.	REVISIONS	BY	DATE
△2	REV TO ACCOMMODATE FUTURE O/L	BK	05/99
△1	ADDED SURFACING DIMENSION NOTES	TDN	06/98

Alberta INFRASTRUCTURE

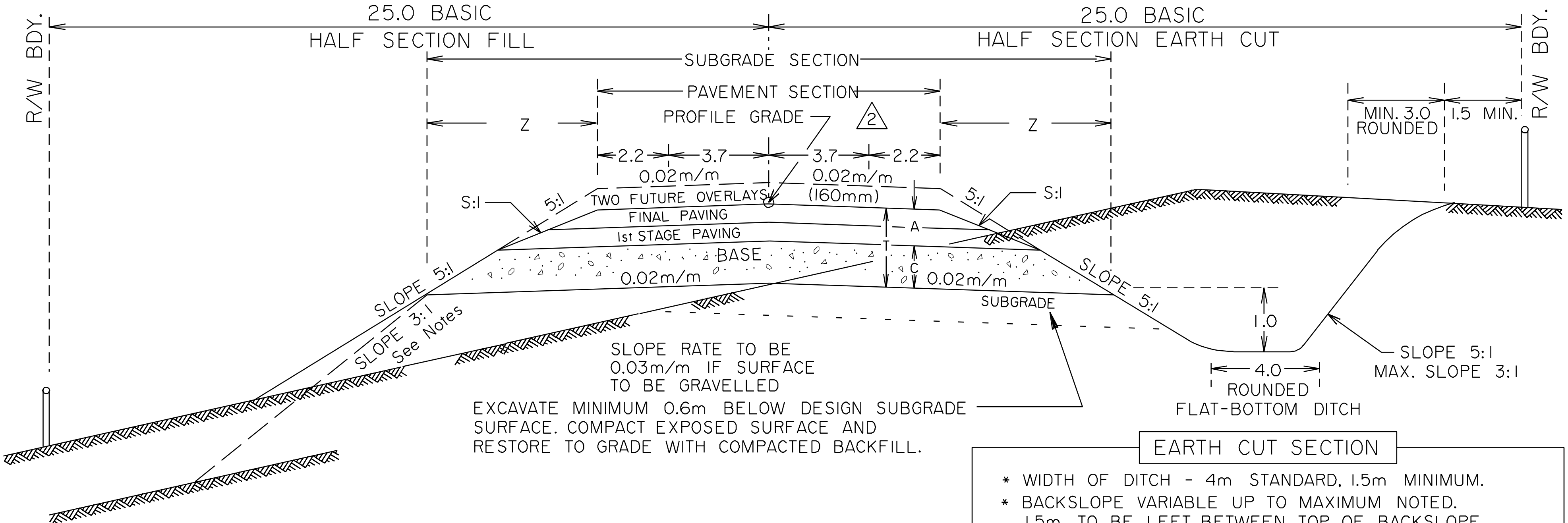
FIGURE C-8.2d

Date: APRIL 1995

STANDARD CROSS-SECTION FOR RAU-213.4-120/110

Prepared By: RT	Checked By: B.K.	Scale: N.T.S.	PAGE C-97

GRAPHICS FILE: debc82d.man



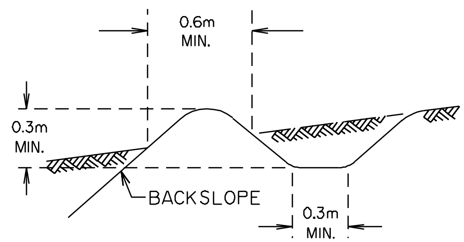
EARTH CUT SECTION

* WIDTH OF DITCH - 4m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.

SUBGRADE AND SURFACING DIMENSIONS (2) (1)

* $Z = 5(T+0.16)$
* $X = Z - 5C$
* $S = \frac{Z - 5C}{A}$

WHERE
A = THICKNESS OF ACP (1st STAGE AND FINAL STAGE)
C = THICKNESS OF BASE
T=C+A
FINAL PAVING NORMALLY PLACED WITHIN 5 YEARS OF 1st STAGE



CATCH WATER DITCHES
TO BE CONSTRUCTED WHEN NECESSARY

FILL SECTION

* 5:1 SLOPES FOR AVERAGE FILLS LESS THAN 2.0m.
* 4:1 SLOPES FOR AVERAGE FILLS UP TO 6.5m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES MAY BE USED IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER; CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 60m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

No.	REVISIONS	BY	DATE
2	REV TO ACCOMMODATE TWO FUTURE OVERLAYS	BK	05/99
1	ADDED SURFACING DIMENSIONS NOTES	TDN	06/98

Alberta INFRASTRUCTURE

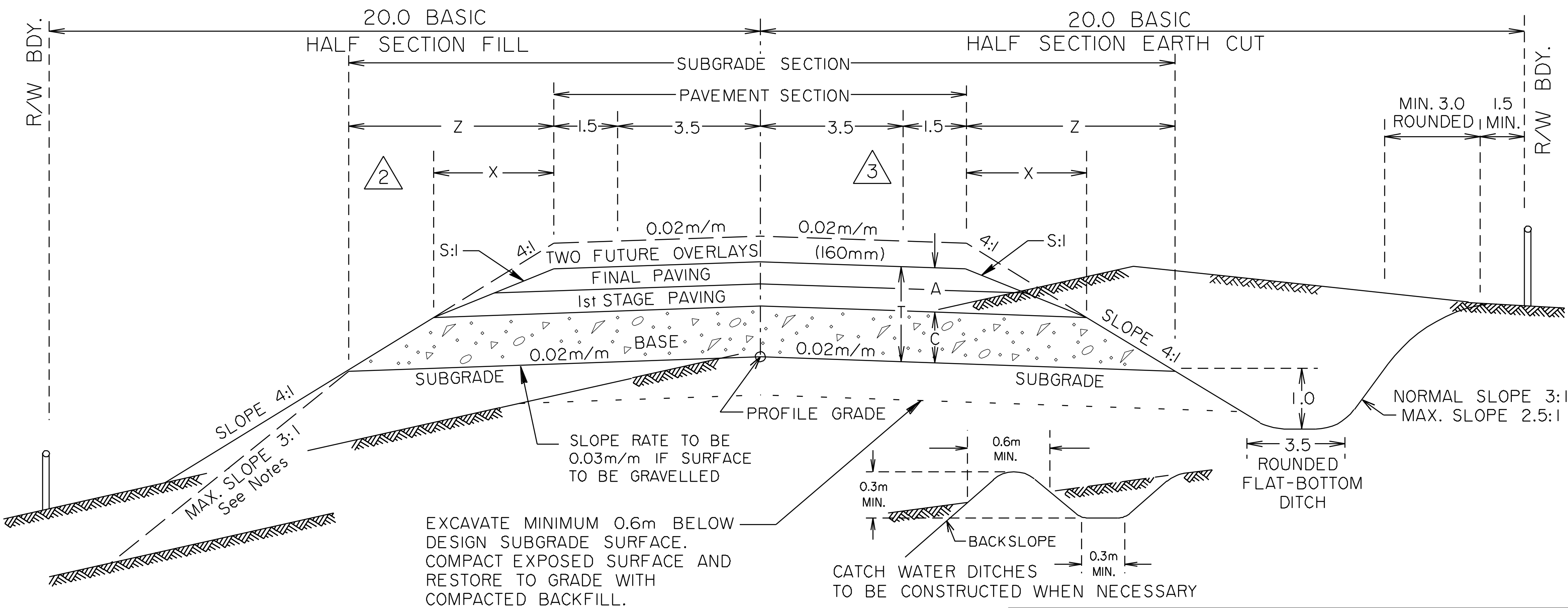
FIGURE C-8.2e

Date: APRIL 1995

STANDARD CROSS-SECTION FOR RAU-211.8-110

Prepared By: R.T.	Checked By: BK	Scale: N.T.S.	PAGE C-98

GRAPHICS FILE: debc82e.man



No.	REVISIONS	BY	DATE
3	REV TO ACCOMMODATE TWO FUTURE OVERLAYS	BK	05/99
2	REV TO ACCOMMODATE FUTURE OVERLAY	BK	08/97
1	CHANGE IN DESIGN SPEED/FILL NOTES	BK	06/93

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.

SURFACING DIMENSIONS

* $Z = 4(T + 0.16)$
* $X = Z - 4C$
* $S = \frac{4(T + 0.16 - C)}{A}$
* WHERE:
  A = THICKNESS OF ACP (1st STAGE + FINAL STAGE PAVING)
  C = THICKNESS OF BASE
  T = C + A

FILL SECTION

* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

Alberta INFRASTRUCTURE

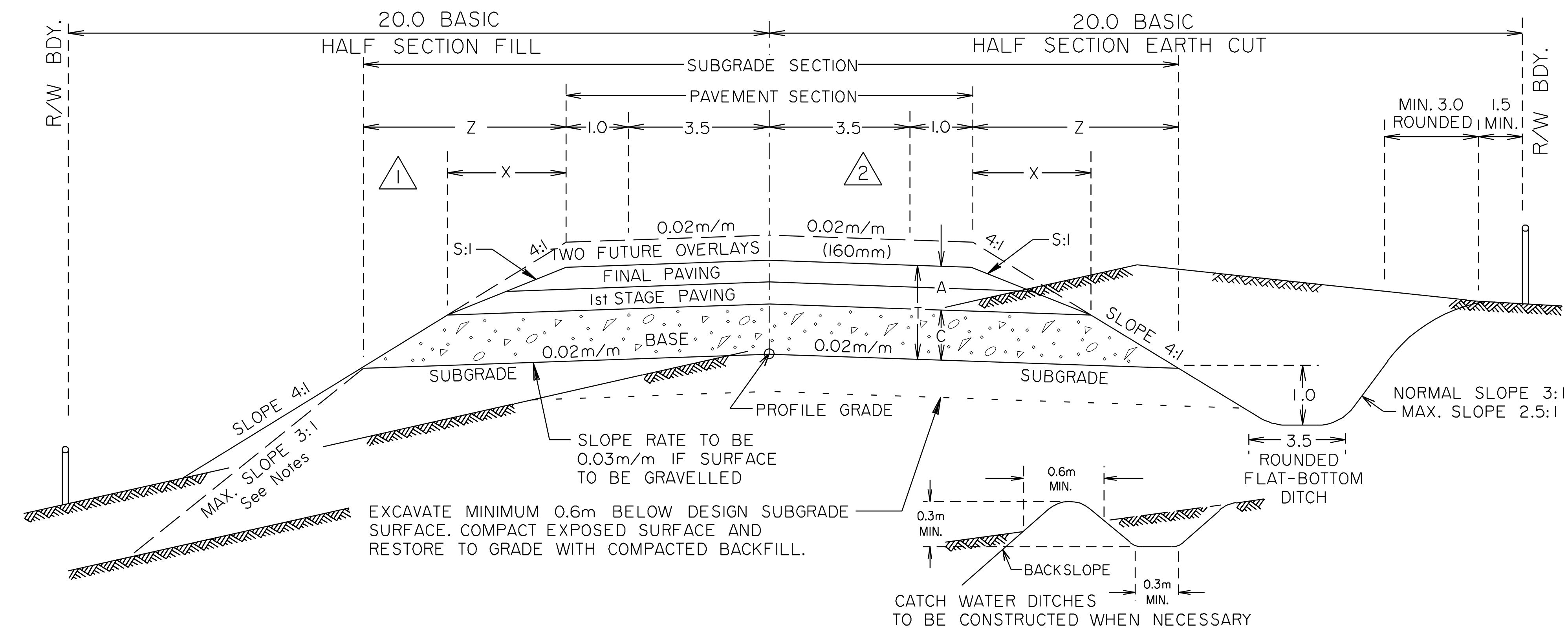
FIGURE C-8.2f

Date: APRIL 1995

STANDARD CROSS-SECTION FOR RAU-210-110

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-99

GRAPHICS FILE: debc82f.man



No.	REVISIONS	BY	DATE
2	REV TO ACCOMMODATE TWO FUTURE OVERLAYS	BK	05/99
1	REV TO ACCOMMODATE FUTURE OVERLAY	BK	08/97

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.

SURFACING DIMENSIONS

* $Z = 4(T + 0.16)$
* $X = Z - 4C$
* $S = \frac{4(T + 0.16 - C)}{A}$
* WHERE:
  A = THICKNESS OF ACP (1st STAGE + FINAL STAGE PAVING)
  C = THICKNESS OF BASE
  T = C + A

FILL SECTION

* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

Alberta INFRASTRUCTURE

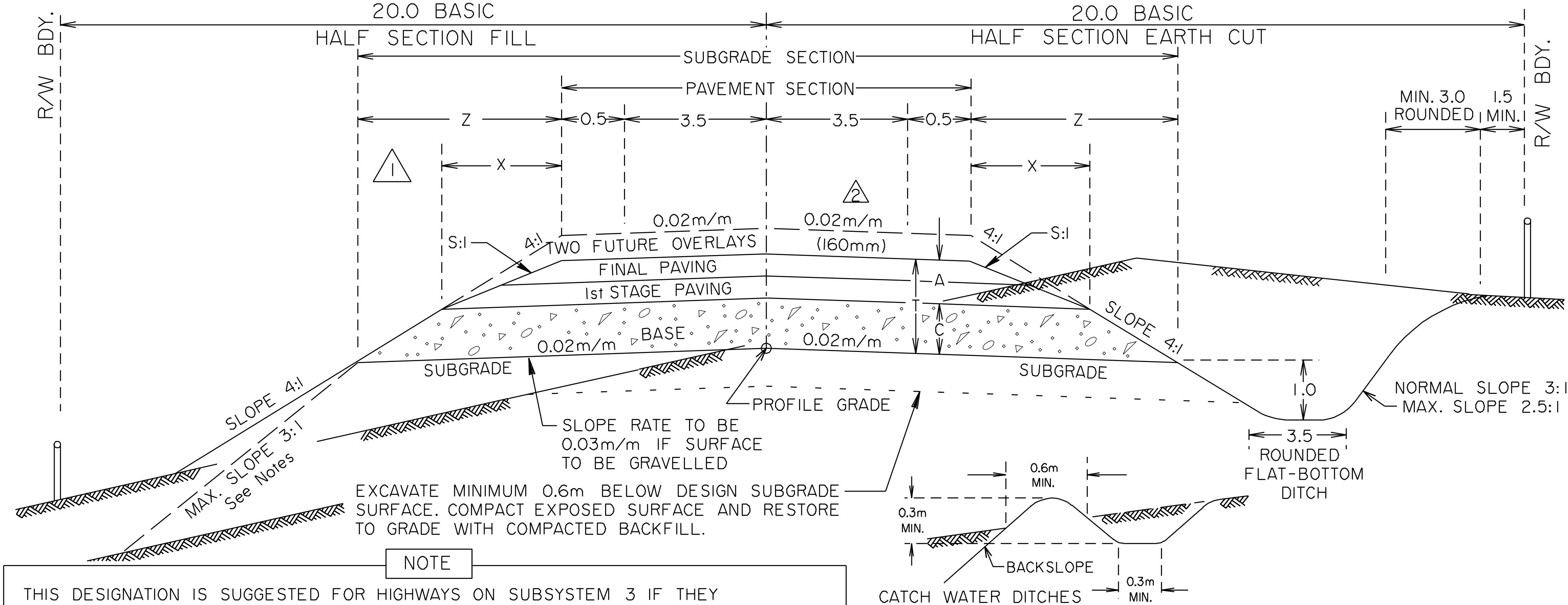
FIGURE C-8.2g

Date: APRIL 1995

STANDARD CROSS-SECTION FOR RAU/RCU-209-110

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-100

Graphics File: debc82g.man



CATCH WATER DITCHES TO BE CONSTRUCTED WHEN NECESSARY

NOTE

THIS DESIGNATION IS SUGGESTED FOR HIGHWAYS ON SUBSYSTEM 3 IF THEY WARRANT PAVING DUE TO SPECIAL CIRCUMSTANCES BUT HAVE AADT LESS THAN 200. A MAP OF ALBERTA'S FUNCTIONAL CLASSIFICATION SYSTEM IS INCLUDED IN CHAPTER A.

No.	REVISIONS	BY	DATE
2	REV TO ACCOMMODATE TWO FUTURE OVERLAYS	BK	05/99
1	REV TO ACCOMMODATE FUTURE OVERLAY	BK	08/97

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.

SURFACING DIMENSIONS

* $Z = 4(T + 0.16)$
* $X = Z - 4C$
* $S = \frac{4(T + 0.1 - C)}{A}$
* WHERE: (2)
  A = THICKNESS OF ACP (1st STAGE + FINAL STAGE)
  C = THICKNESS OF BASE
  T = C + A

FILL SECTION

* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

Alberta INFRASTRUCTURE

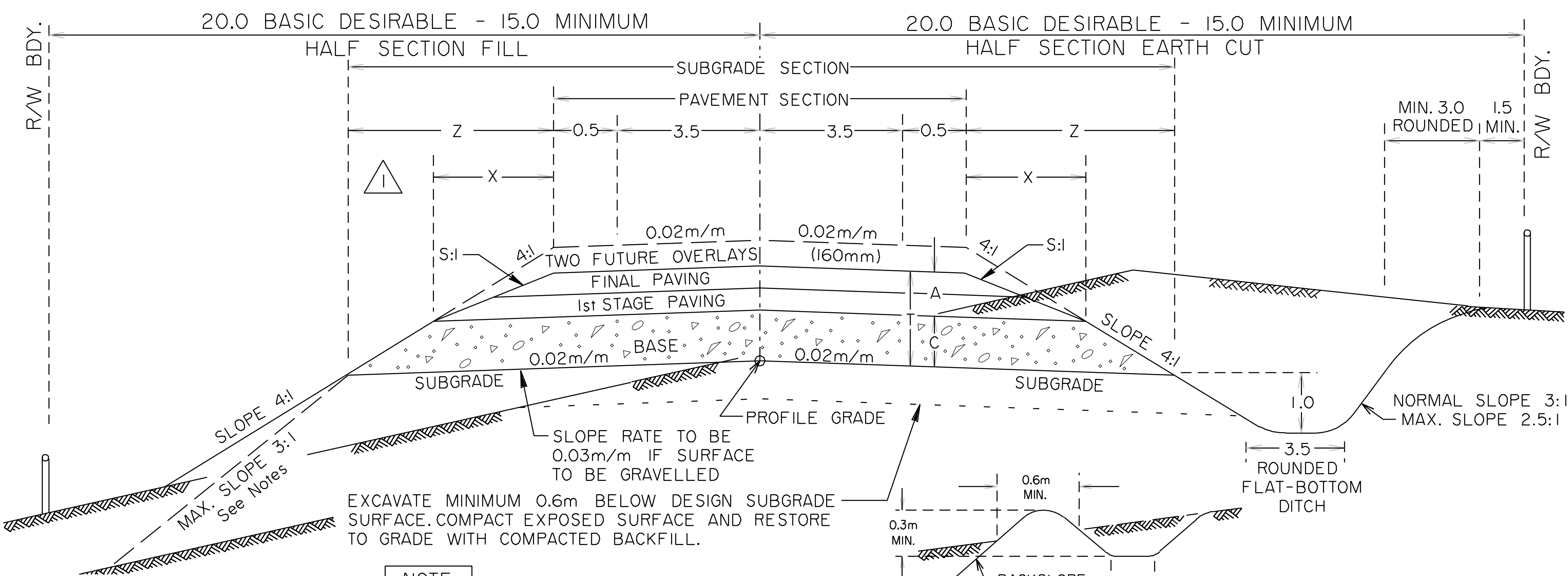
FIGURE C-8.2h

Date: APRIL 1995

STANDARD CROSS-SECTION FOR RCU-208-110/100

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-101

GRAPHICS FILE: debc82h.man



NOTE

THIS DESIGNATION IS SUGGESTED FOR HIGHWAYS ON SUBSYSTEM 4 IF THEY WARRANT PAVING DUE TO SPECIAL CIRCUMSTANCES BUT HAVE AADT LESS THAN 200. A MAP OF ALBERTA'S FUNCTIONAL CLASSIFICATION SYSTEM IS INCLUDED IN CHAPTER A.

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.

SURFACING DIMENSIONS

* $Z = 4(T + 0.1) = 4T + 0.4$
* $X = Z - 4C$
* $S = \frac{4(T + 0.1 - C)}{A}$
* WHERE:
  - A = THICKNESS OF ACP (STAGE 1 + STAGE 2)
  - C = THICKNESS OF GBC
  - T = C + A

FILL SECTION

* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

No.	REVISIONS	BY	DATE
2	REV TO ACCOMMODATE TWO FUTURE OVERLAYS	BK	05/99
1	REV TO ACCOMMODATE FUTURE OVERLAY	BK	08/97

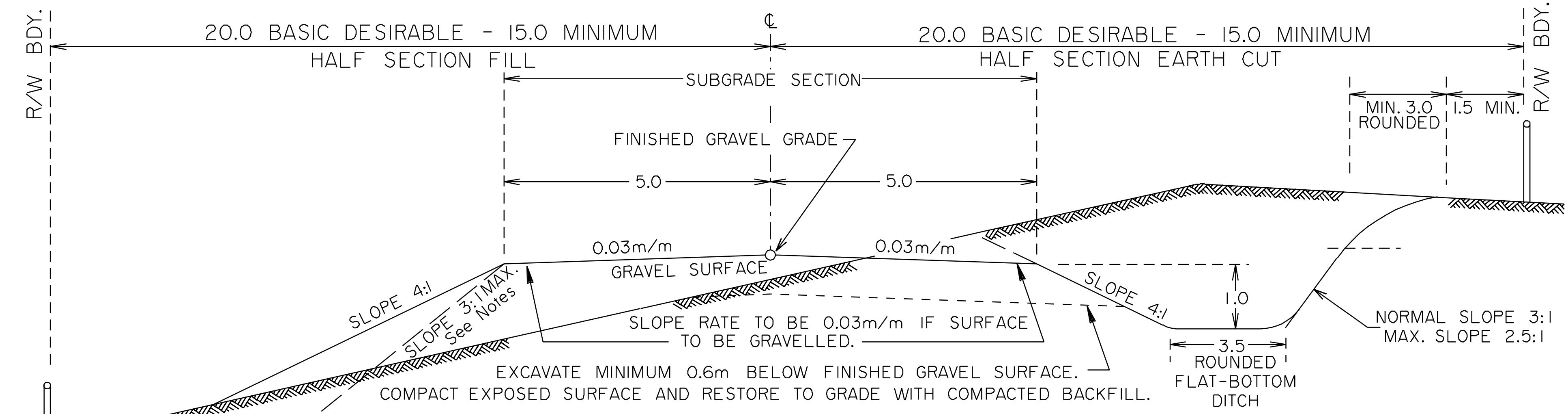
Alberta INFRASTRUCTURE

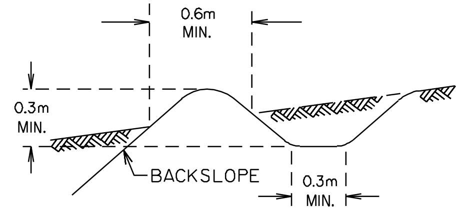
FIGURE C-8.2i

Date: APRIL 1995

STANDARD CROSS-SECTION FOR RLU-208-110/100

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-102





CATCH WATER DITCHES
TO BE CONSTRUCTED WHEN NECESSARY

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.

NOTE:

THIS DESIGNATION IS RECOMMENDED FOR SECONDARY HIGHWAYS SERVING A LOCAL FUNCTION AND HAVING LESS THAN 200 AADT.

No.	REVISIONS	BY	DATE
2			
1			

FILL SECTION

* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

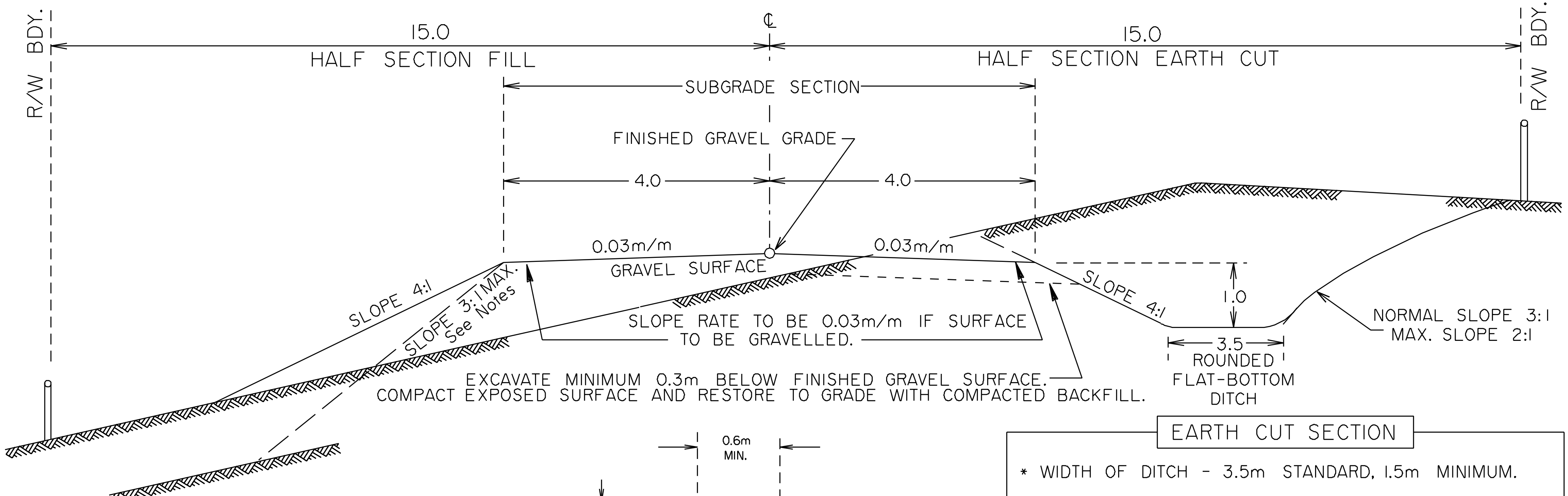
Alberta INFRASTRUCTURE

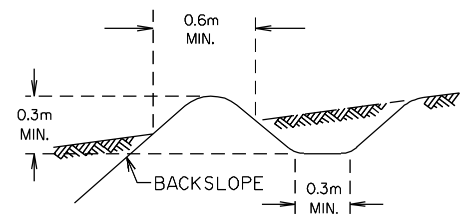
FIGURE C-8.2

Date: APRIL 1995

STANDARD CROSS-SECTION FOR RLU-210G-100

Prepared By: L.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-103





CATCH WATER DITCHES
TO BE CONSTRUCTED WHEN NECESSARY

NOTE:

SERVICE ROADS ARE GENERALLY GRAVEL SURFACED AND 8m WIDE AS SHOWN HERE UNLESS CARRYING HIGH TRAFFIC VOLUMES. HIGHER VOLUMES MAY DICTATE THE NEED FOR A PAVED SURFACE AND/OR A WIDER ROADWAY AS PER NORMAL DESIGN PRACTICE. LOWER DESIGN SPEED MAY BE USED WHERE APPROPRIATE AS PER GUIDELINES IN CHAPTER H (LOCAL ROADS).

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY LIMIT AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.

FILL SECTION

* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
  * 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM SHOULD BE CONSTRUCTED ADJACENT TO OPEN WATER.

No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

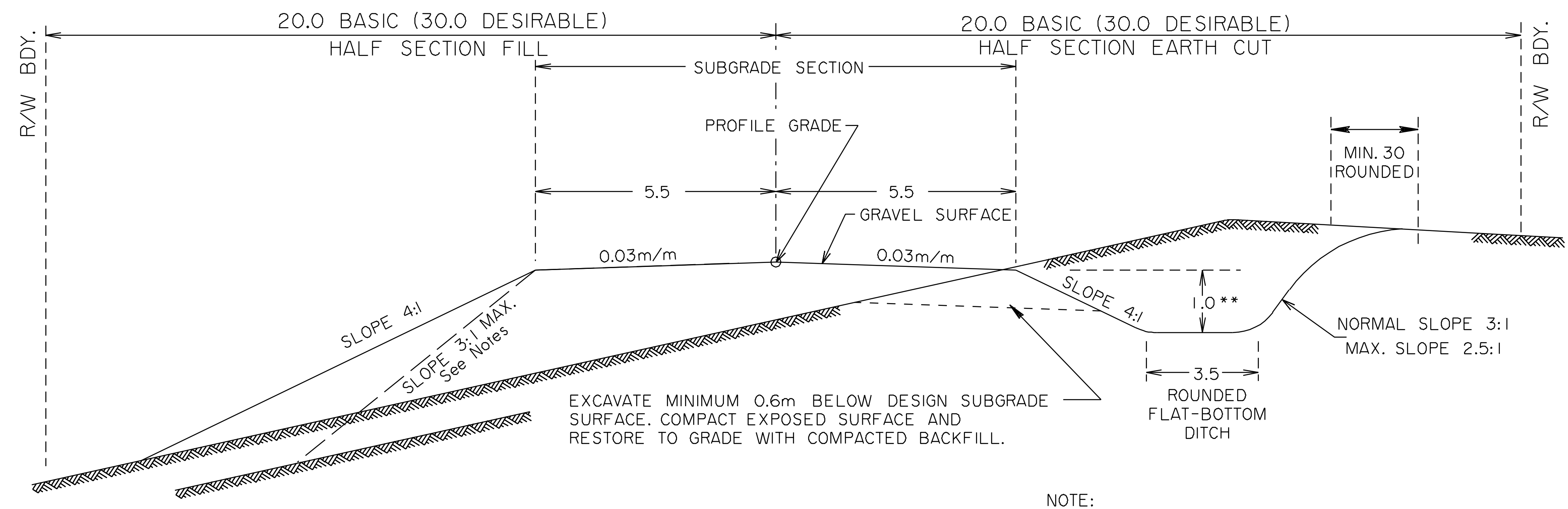
FIGURE C-8.2k

Date: APRIL 1995

STANDARD CROSS-SECTION FOR SERVICE ROADS RLU-208G-90

Prepared By: L.T.	Checked By: B.K	Scale: N.T.S.	PAGE C-104

GRAPHICS FILE: debc82k.man



NOTE:

THE GEOMETRIC DESIGN STANDARDS TO BE USED ON THIS DESIGNATION ROADWAY ARE THE SAME AS THOSE RECOMMENDED FOR RCU-209-110 ROADWAYS.

EARTH CUT SECTION

- * WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
- * BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY AS SHOWN.
- * DITCH WIDTH TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.
- ** THE BASIC DEPTH OF DITCH BELOW THE SHOULDER POINT IS SOMETIMES INCREASED UP TO 1.5m ON THIS DESIGNATION OF ROADWAY BECAUSE OF THE HEAVIER LOADS AND BECAUSE A PAVEMENT STRUCTURE WILL NOT BE BUILT.

FILL SECTION

- * 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
- * 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
- * 3:1 SLOPES OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
- * THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
- * 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
- * TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
- * BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE C-8.2l

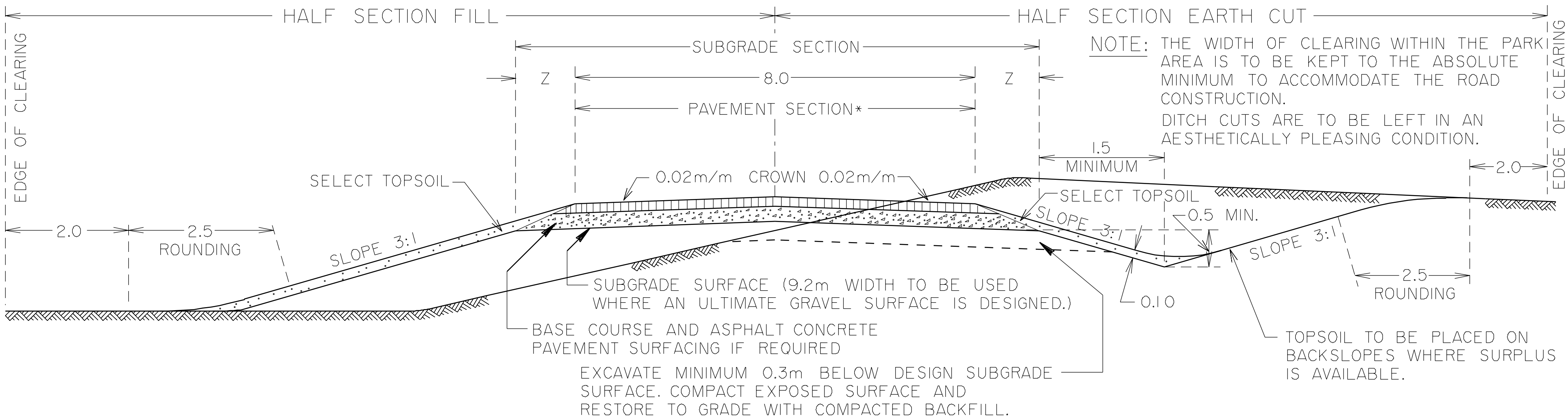
Date: APRIL 1995

STANDARD CROSS-SECTION FOR RCU-211L-110

(LOG HAUL RESOURCE ROADS)

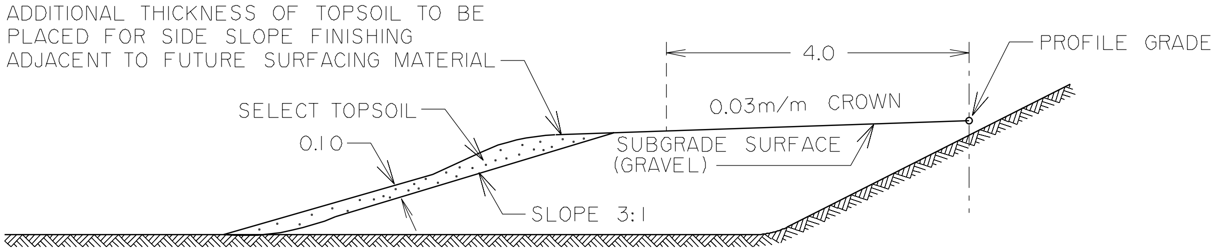
Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-105

GRAPHICS FILE: debc821.man



* 8m MINIMUM PAVEMENT WIDTH FOR TWO-WAY OPERATION
* 4m MINIMUM PAVEMENT WIDTH FOR ONE-WAY OPERATION.

TOTAL BASE COURSE AND PAVEMENT THICKNESS AT CENTER LINE	TOTAL SUBGRADE WIDTH EQUALS PAVEMENT SECTION WIDTH PLUS 2 Z
"T"	"Z"
0.10 - 0.15	0.6
0.15 - 0.25	1.0
0.25 - 0.30	1.2



DETAIL FOR PLACING TOPSOIL
ON GRADING AND GRAVEL SURFACING CONTRACTS

USE OF TOPSOIL

- SELECT TOPSOIL SHALL BE REMOVED WITHIN THE CONSTRUCTION LIMITS TO THE DEPTH AND WIDTH AS DIRECTED BY THE ENGINEER AND THE SALVAGED TOPSOIL STOCKPILED AT DESIGNATED POINTS WITHIN THE RIGHT-OF-WAY LIMITS FOR REDISTRIBUTION ON CUT OR FILL SLOPES AS REQUIRED.
- WHERE DETERMINED FEASIBLE, THE ENGINEER WILL REQUIRE THE EXCAVATED SELECT TOPSOIL TO BE MOVED DIRECTLY TO ITS FINAL POSITION WITHOUT DOUBLE HANDLING.
- SURPLUS TOPSOIL AND OTHER MATERIALS DESIGNATED BY THE ENGINEER AS BEING UNSUITABLE FOR SALVAGE SHALL BE UTILIZED FOR CONSTRUCTION OF THE CUT OR FILL SLOPES AS INDICATED ON THE PLAN.
- REFER TO SPECIFICATIONS FOR DETAILS REGARDING PLACEMENT OF TOPSOIL ON MEDIAN SLOPES, CUT AND FILL SLOPES.

No.	REVISIONS	BY	DATE
2			
1			

Alberta TRANSPORTATION AND UTILITIES Engineering Division

FIGURE C-8.2m

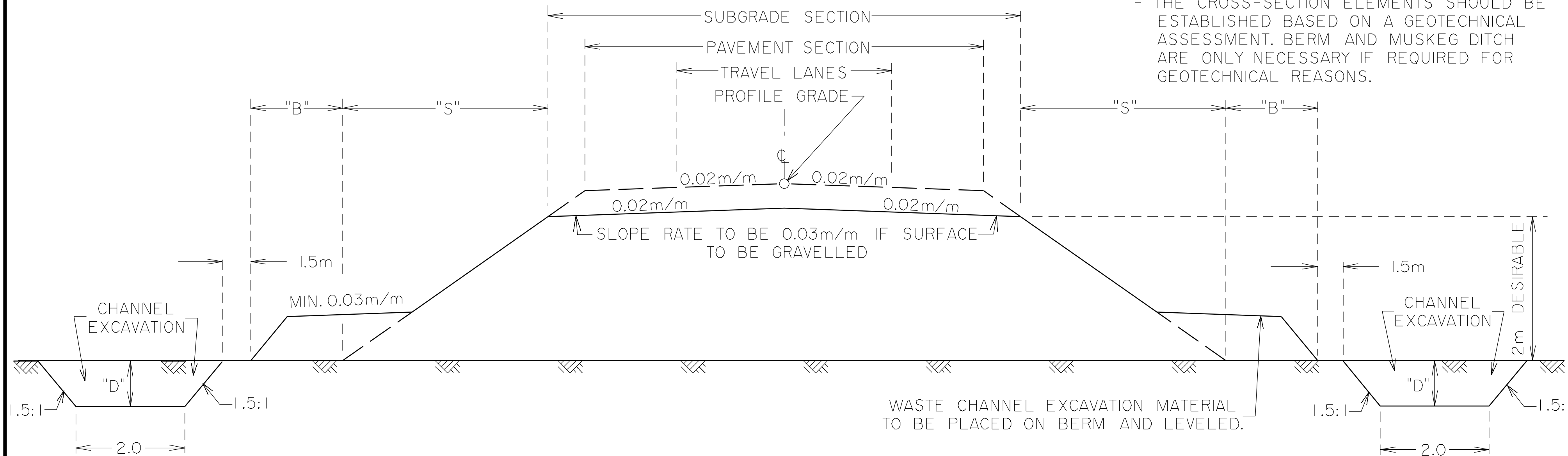
Date: APRIL 1995

STANDARD CROSS-SECTION FOR RCU-208P-80 (HIGHWAY WITHIN PROVINCIAL PARK BOUNDARY)

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-106

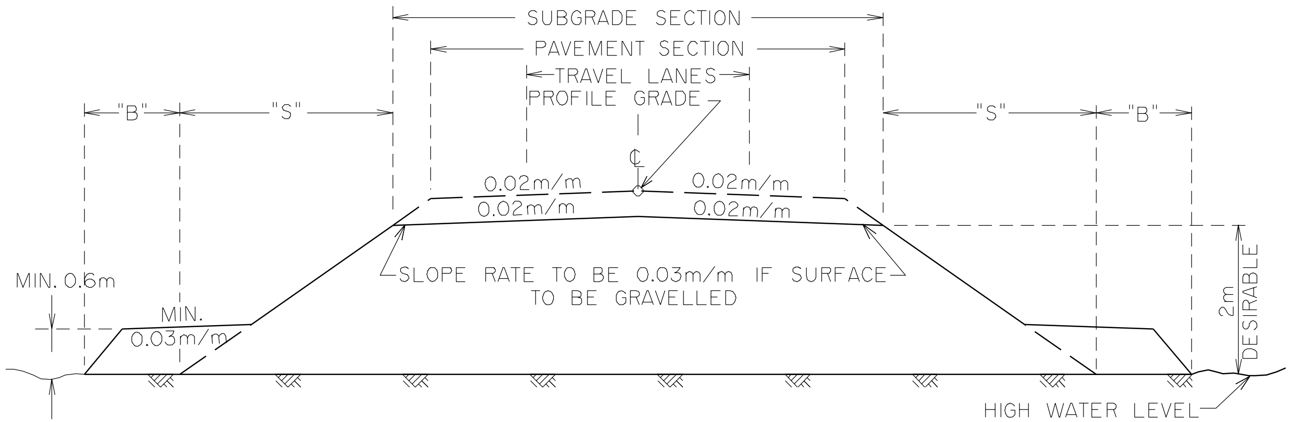
GRAPHICS FILE: debc82m.man

TYPICAL CROSS-SECTION THROUGH MUSKEG



NOTE:
- "S", "B", & "D" DIMENSIONS ARE VARIABLE. "B" IS NOT TO BE LESS THAN 4.0m.
- THE CROSS-SECTION ELEMENTS SHOULD BE ESTABLISHED BASED ON A GEOTECHNICAL ASSESSMENT. BERM AND MUSKEG DITCH ARE ONLY NECESSARY IF REQUIRED FOR GEOTECHNICAL REASONS.

TYPICAL CROSS-SECTION ADJACENT TO OPEN WATER



NOTE:
- "S" & "B" DIMENSIONS ARE VARIABLE. "B" IS NOT TO BE LESS THAN 4.0m.
- THE CROSS-SECTION ELEMENTS SHOULD BE ESTABLISHED BASED ON A GEOTECHNICAL ASSESSMENT.

NOTE:
- FOR A HIGH-SPEED ROADWAY ADJACENT TO A MAJOR DRAINAGE COURSE i.e. RIVER OR CREEK ETC., SPECIAL PROTECTION IN ADDITION TO WHAT IS SHOWN MAY BE REQUIRED.
- GUARDRAIL TO BE PROVIDED WHERE REQUIRED.

No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

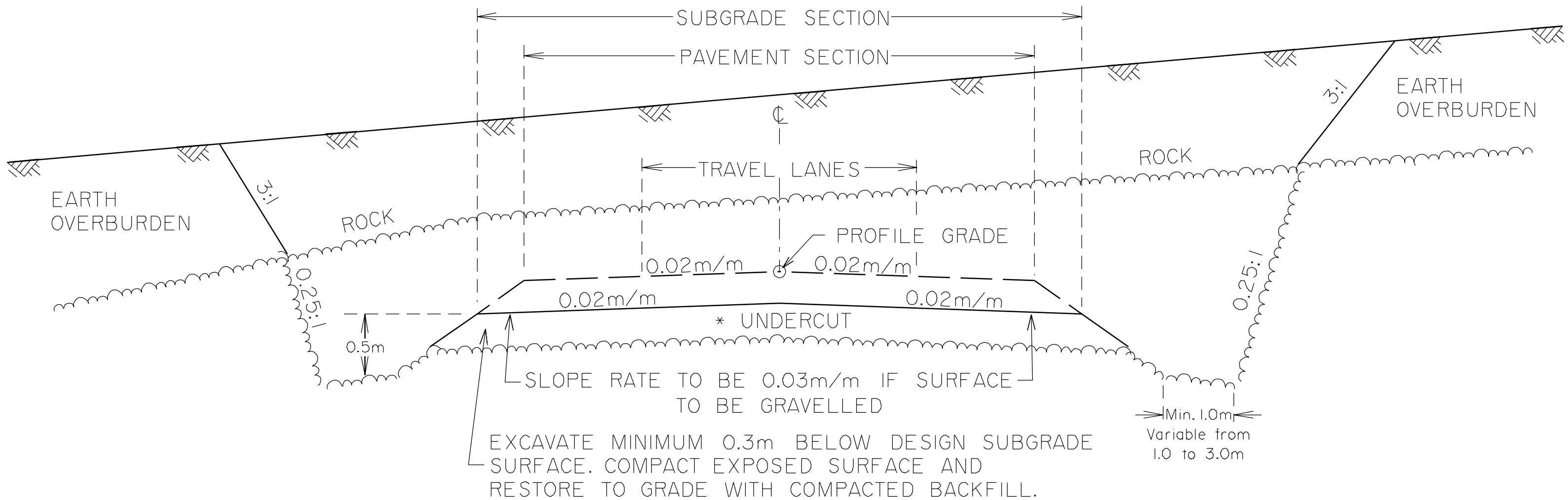
FIGURE C-8.2n

Date: APRIL 1995

STANDARD CROSS-SECTION THROUGH MUSKEG OR ADJACENT TO OPEN WATER ON 2-LANE UNDIVIDED HIGHWAYS

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-107

GRAPHICS FILE: debc82n.man



TYPICAL CROSS-SECTION IN ROCK CUT

NOTE:

- WHERE ROCK THAT IS PRONE TO WEATHERING IS ENCOUNTERED, FLATTER SLOPES ARE USUALLY NECESSARY BECAUSE VERY STEEP SLOPES WOULD NOT BE STABLE. REFER TO THE GEOTECHNICAL RECOMMENDATIONS FOR SLOPES TO BE USED.
- WHERE ROCK CAN BE EASILY EXCAVATED, THE NORMAL CROSS-SECTION FOR THE ROADWAY DESIGNATION MAY BE USED.

No.	REVISIONS	BY	DATE
2			
1			

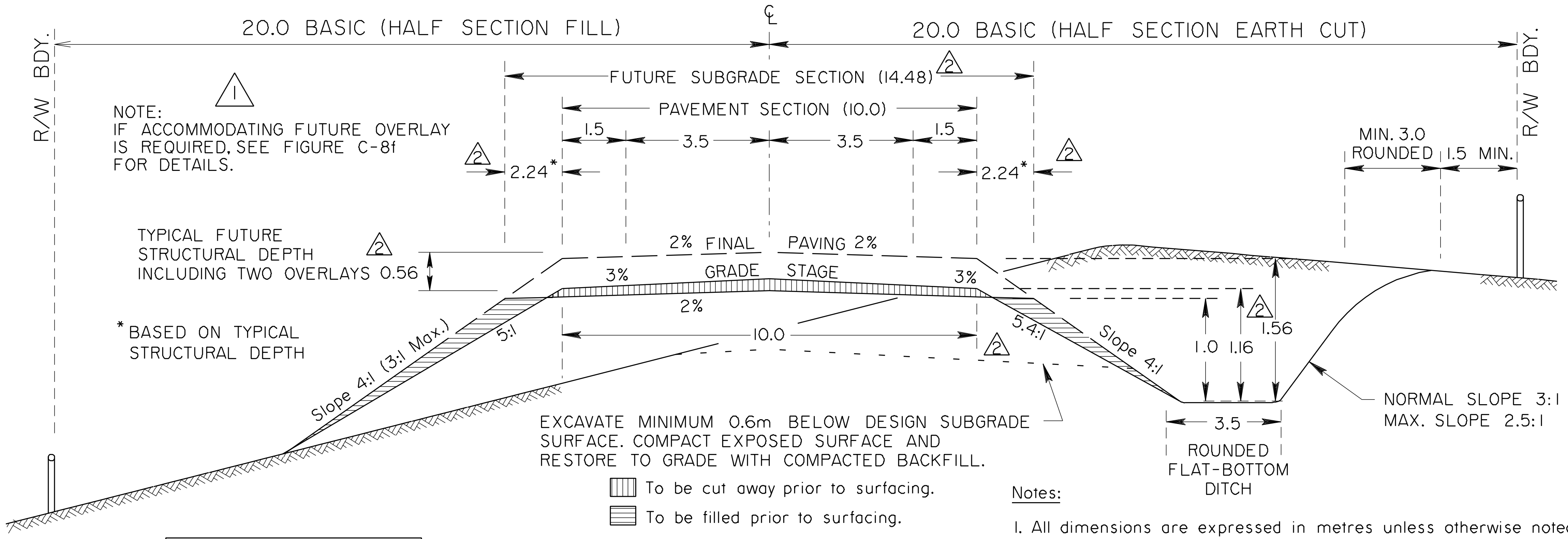
Alberta INFRASTRUCTURE

FIGURE C-8.2o

Date: APRIL 1995

STANDARD CROSS-SECTION IN ROCK CUT ON TWO-LANE UNDIVIDED HIGHWAYS

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-108

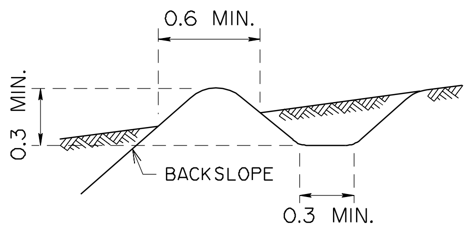


Notes:

1. All dimensions are expressed in metres unless otherwise noted.
2. Final sideslope on grade and pavement is dependent on structural depth but will be close to 4:1.
3. The modified subgrade cross section may be used for other design designations.

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.



CATCH WATER DITCHES
TO BE CONSTRUCTED WHEN NECESSARY

FILL SECTION

GRADE STAGE
* 5:1 SLOPES TO BE USED FOR THE FIRST 1.0 m. STEEPER SLOPES MAY USED USED THEREAFTER AS PER FINAL STAGE REQUIREMENTS.

FINAL STAGE
* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT, (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

No.	REVISIONS	BY	DATE
2	REV TO ACCOMMODATE TWO FUTURE OVERLAYS	BK	05/99
1	ADDED NOTE FOR FUTURE OVERLAY	BK	08/97

Alberta INFRASTRUCTURE

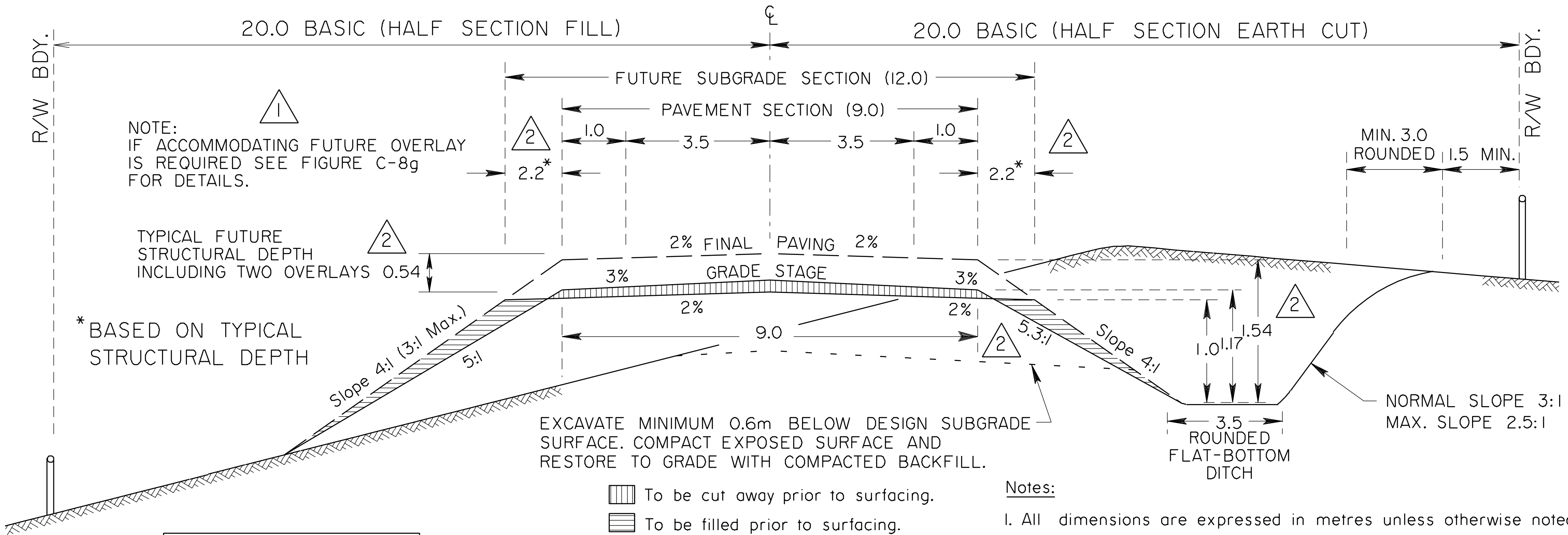
FIGURE C-8.2p

Date: APRIL 1995

STANDARD CROSS-SECTION USING MODIFIED SUBGRADE FOR RAU-210-110

Prepared By: R.T.	Checked By: B.K.	Scale: N.T.S.	PAGE C-109

GRAPHICS FILE: debc82p.man



To be cut away prior to surfacing.

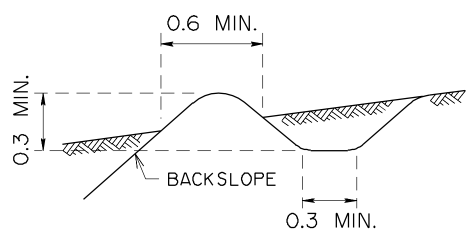
To be filled prior to surfacing.

Notes:

1. All dimensions are expressed in metres unless otherwise noted.
2. Final sideslope on grade and pavement is dependent on structural depth but will be close to 4:1.
3. The modified subgrade cross section may be used for other design designations.

EARTH CUT SECTION

* WIDTH OF DITCH - 3.5m STANDARD, 1.5m MINIMUM.
* BACKSLOPE VARIABLE UP TO MAXIMUM NOTED. 1.5m TO BE LEFT BETWEEN TOP OF BACKSLOPE AND RIGHT-OF-WAY AS SHOWN.
* DITCH WIDTH AND ROUNDING AT TOP OF BACKSLOPE TO BE INCREASED AT BEGINNING AND END OF CUT SECTIONS FOR AESTHETICS.



CATCH WATER DITCHES
TO BE CONSTRUCTED WHEN NECESSARY

FILL SECTION

GRADE STAGE
* 5:1 SLOPES TO BE USED FOR THE FIRST 1.0m. STEEPER SLOPES MAY BE USED THEREAFTER AS PER FINAL STAGE REQUIREMENTS.

FINAL STAGE
* 4:1 SLOPES FOR AVERAGE FILLS LESS THAN 4.0m.
* 4:1 SLOPES CAN BE USED ON SHORT SECTIONS OF HIGHWAY FILL UP TO 14m IN HEIGHT (TO ELIMINATE THE NEED FOR GUARDRAIL), PROVIDING THERE ARE NO OBSTRUCTIONS WITHIN OR NEAR THE RIGHT-OF-WAY LIMITS.
* 3:1 OR 2:1 SLOPES MAY BE USED UPON APPROVAL IN AREAS WHERE GUARDRAIL IS TO BE INSTALLED.
* THE CHOICE BETWEEN 4:1 SLOPE AND GUARDRAIL INSTALLATION ON HIGH EMBANKMENTS IS GENERALLY MADE BASED ON LIFE-CYCLE COST-EFFECTIVENESS.
* 3:1 SLOPES ARE TO BE USED ON ALL FILLS ADJACENT TO DRAINAGE STRUCTURES OVER 1200mm IN DIAMETER, CATTLE PASSES, OPEN WATER, ETC. WHERE GUARDRAIL INSTALLATION IS NECESSARY FOR HIGHWAY SAFETY.
* TRANSITION BETWEEN SLOPES SHALL BE ATTAINED BY USING UNIFORMLY VARYING SLOPES. GENERALLY THE MINIMUM LENGTH OF TRANSITION SHALL NOT BE LESS THAN 30m.
* BERM ALSO TO BE CONSTRUCTED ADJACENT TO OPEN WATER.

No.	REVISIONS	BY	DATE
2	REV TO ACCOMMODATE TWO FUTURE OVERLAYS	BK	05/99
1	ADDED NOTE FOR FUTURE OVERLAY	BK	08/97

Alberta INFRASTRUCTURE

FIGURE C-8.2q

Date: APRIL 1995

STANDARD CROSS-SECTION USING MODIFIED SUBGRADE FOR RAU/RCU-209-110

Prepared By: R.T.	Checked By: BK	Scale: N.T.S.	PAGE C-110

GRAPHICS FILE: debc8q.man

C.9 RAILWAY CROSSINGS

C.9.1 General

When a railway intersects with a roadway, the crossing can either take the form of an at-grade crossing or a grade separated crossing. At-grade crossings are discussed in Section C.9.2 and grade separated crossing are covered in Section C.9.3. Encroachment and drainage on railway property is discussed in Section C.9.4.

C.9.2 Railway At-Grade Crossings

C.9.2.1 Introduction

The construction of a new railway at-grade crossing, or any modification of an existing one, requires a formal application to, and approval by, the National Transportation Agency. Since January 1, 1989, all railway crossing safety considerations have come under the jurisdiction of Transport Canada's Railway Safety Directorate. Their standards regarding the construction of public at-grade road crossings outline geometric and sign/signalization requirements. All new crossings must conform to this regulation unless an exemption is granted by the Minister of Transport, Government of Canada. If a federal government contribution is required for the capital cost of crossing works, an application must be made by the railway, road authority or the department on behalf of the road authority, prior to commencement of the works.

*Note: The designer is responsible for obtaining approval from the National Transportation Agency to construct or modify at-grade railway crossings.

C.9.2.2 Horizontal Alignment

Desirably, the roadway should intersect the tracks at a right angle with no nearby intersections or driveways. In no case should the angle of crossing be less than 75 degrees unless the crossing is signalized. This layout enhances the driver's view of the crossing and tracks and reduces conflicting vehicular movements from crossroads and driveways. To the extent practical, crossings should not be located on either roadway or railroad curves. Roadway curvature inhibits a driver's view of the crossing ahead, as a driver's attention may be directed toward negotiating the curve rather than looking for a train. Railroad curvature may inhibit a driver's view along the tracks from both a stopped position at the crossing and on the approach to the crossings. Those crossings, located on both roadway and railroad curves, present maintenance problems and poor visibility for road traffic due to conflicting superelevation.

A crossing should have a width of eight metres, or the width of the highway and shoulders plus 0.5m on each side of the roadway and shoulders, as measured at the approaches to the crossing, whichever is greater. The maximum approach grade to a public crossing should be no greater than five percent. Horizontal alignment should be on tangent for at least 60m on each side of the railway crossing (see Figure C-9.2.2).

Where appropriate, applications for lower standard crossings may be submitted for approval due to lower traffic volume, low speed on the roadway, physical constraints or other factors.

C.9.2.3 Vertical Alignment

New railway grade crossings or modifications to existing crossings must meet the terms of the Railway Act.

Section 205 of the Railway Act governs the height of the track in relation to the road surface at a grade crossing:

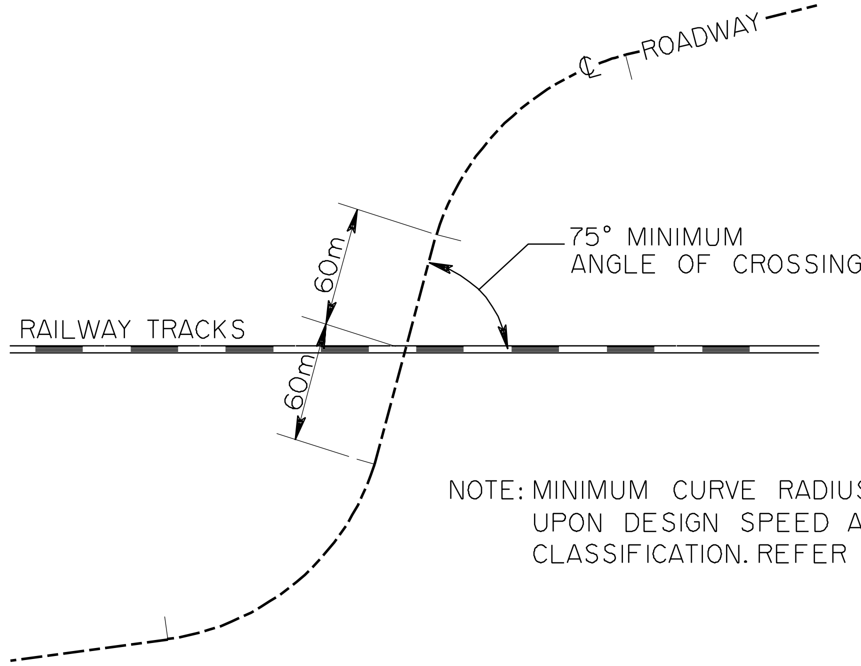
> "Whenever the railway crosses any highway at rail level, whether the level of the highway remains undisturbed or is raised or lowered to conform to the grade of the railway, the top of the rail may, when the works are completed, unless otherwise directed by the Commission, rise above or sink below the level of the highway to the extent of 1" without being deemed an obstruction."
> (1" = 25.4 mm)

It is desirable to provide a level portion, nine metres each side of crossing, connected to a suitable vertical curve with a gradient of no more than five percent, in accordance with the Railway Act.

At a railway grade crossing, the grade of the highway matches the cross slope of the railway tracks as closely as possible. Any departure from this practice might cause vehicle occupants to experience discomfort. Such discomfort, however, will not be objectionable if the values shown in Table 1, Figure C-9.2.2 for allowable difference between highway gradient and rail cross slope, are not exceeded. The sharpness of vertical curves on approaches to the crossing should be selected based on the highway design speed. In the case of crossings with multiple railway tracks, the width of the actual crossing should be adjusted accordingly.

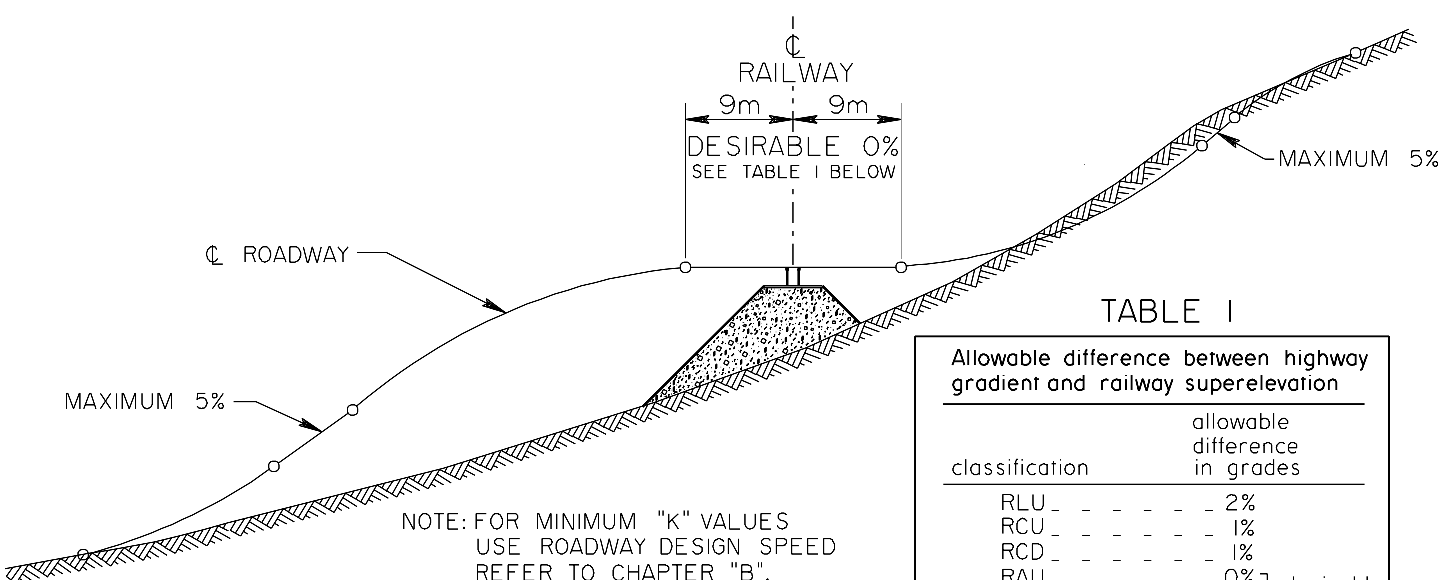
Where appropriate, applications for lower standard crossings may be submitted for approval due to low traffic volume, low speed on the roadway, physical constraints or other factors.

FIGURE C-9.2.2 RAILWAY CROSSINGS: HORIZONTAL ALIGNMENT AND PROFILE REQUIREMENTS



NOTE: MINIMUM CURVE RADIUS DEPENDENT UPON DESIGN SPEED AND ROAD CLASSIFICATION. REFER TO CHAPTER "B".

PLAN VIEW
SHOWING
DESIRABLE TANGENT
AND
MINIMUM ANGLE OF CROSSING



NOTE: FOR MINIMUM "K" VALUES USE ROADWAY DESIGN SPEED REFER TO CHAPTER "B".

ROADWAY PROFILE
ACROSS RAILWAY

TABLE I

Allowable difference between highway gradient and railway superelevation

classification	allowable difference in grades	
RLU	2%	
RCU	1%	
RCD	1%	
RAU	0%	desirable
RAD	0%	desirable
RFD	-	
ULU	3%	
UCU	2%	
UCD	2%	
UAU	0%	desirable
UAD	0%	desirable
UFD	-	

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C.9.2.4 Sight Distance at Crossings (Uncontrolled)

Sight distance is a primary consideration at railway crossings. The desirable sight distance arrangement at unsignalized crossings allows a driver sufficient time to stop the vehicle if a train is approaching (see Figure C-9.2.4). To satisfy this condition, two sides of the minimum sight triangle are:

- A distance along the highway, measured from the crossing, corresponding to the minimum stopping sight distance for the design speed of the highway, as shown in Table B.2.3. Note that this requirement is shown based on posted speed in Figure C-9.2.4 (to be consistent with Transport Canada guidelines) however for new construction projects the use of design speed is recommended.

- A distance along the track, measured from the crossing, equivalent to the distance travelled by the train during the time interval required for the highway vehicle to be brought to a stop. This depends on the maximum train speed and the design speed of the highway.

For simplicity, Transport Canada requires a minimum sight distance along the tracks equal to the distance travelled by the train (at maximum allowable speed) in 10 seconds. In order to meet the Transport Canada requirements and allow for the stopping time of vehicles on the highway, AI uses 10 seconds for posted speeds up to 80 km/h and 11 and 12 seconds for posted speeds of 90 km/h and 100 km/h, respectively.

For the purpose of measuring sight distances, an eye height of 1.05m (representative of a design passenger vehicle) and an object height of zero (representing the track level) should be used. Justification for use of low object height is based on the possible need to see an empty flat-bed rail car or a small track maintenance vehicle.

Stopping sight distances are based on a model which includes a passenger car design vehicle, braking capability based on the design vehicle, wet pavement conditions and a low eye height (1.05m). Trucks, especially the longer and heavier units, require longer stopping distances from a given speed than passenger cars. However, there is one factor that tends to balance the additional braking distance required by trucks. The truck operator, because of the higher seat position, is able to see substantially farther than a passenger car driver.

When horizontal sight restrictions occur at the approach to railway crossings, particularly at the ends of long downgrades, the greater height of eye of the truck operator is of little value and truck speeds may approach or exceed those of passenger cars. In this case, it is advisable to provide stopping sight distances that exceed the desirable stopping sight distances by a generous margin.

In some locations, it might be necessary to rely on speed control signs and other warning devices and to base sight distance on a reduced vehicle speed.

In urban areas, no sight obstructions of any kind, including commercial signs, should be permitted near a railway grade crossing for a distance of 100m measured along the roadway on each approach. The safety warning devices associated with such crossings should be clearly visible.

The sight distance requirements for unsignalized railway crossings are shown in Figure C-9.2.4.

FIGURE C-9.2.4 RAILWAY CROSSING: SIGHT DISTANCE REQUIREMENTS
(For Unsignalized Crossings)

MINIMUM RAILWAY / ROADWAY CROSSING SIGHT LINE REQUIREMENTS FOR <u>AT-GRADE CROSSINGS</u> WITHOUT AUTOMATIC WARNING DEVICES

SOURCE: Adapted from TRANSPORT CANADA RAILWAY SAFETY G4A-1992

MAXIMUM POSTED VEHICLE SPEED (km/h)	DISTANCE "H"			RAIL MINIMUM DISTANCE "T" (metres)**									
	DESIRABLE STOPPING SIGHT DISTANCE(m)	STOPPING TIME (seconds)*	MINIMUM STOPPING DISTANCE(m)	MAXIMUM TRAIN SPEED km/h									
				STOP	30	50	60	80	100	110	130	140	160
STOP	8	0	-	30	85	140	170	225	280	310	365	390	445
20	20	7.6	15	30	85	140	170	225	280	310	365	390	445
30	30	7.6	20	30	85	140	170	225	280	310	365	390	445
40	45	7.6	35	30	85	140	170	225	280	310	365	390	445
50	65	7.6	50	30	85	140	170	225	280	310	365	390	445
60	85	7.6	70	30	85	140	170	225	280	310	365	390	445
70	110	8.7	90	30	85	140	170	225	280	310	365	390	445
80	140	10.0	120	30	85	140	170	225	280	310	365	390	445
90	170	**11.0	145	30	95	155	185	245	310	340	400	430	490
100	200	**12.0	175	30	100	170	200	270	335	370	435	470	535

<u>NOTE:</u> *
Total stopping time for roadway vehicle including perception/reaction time (2.5 seconds) and braking time.

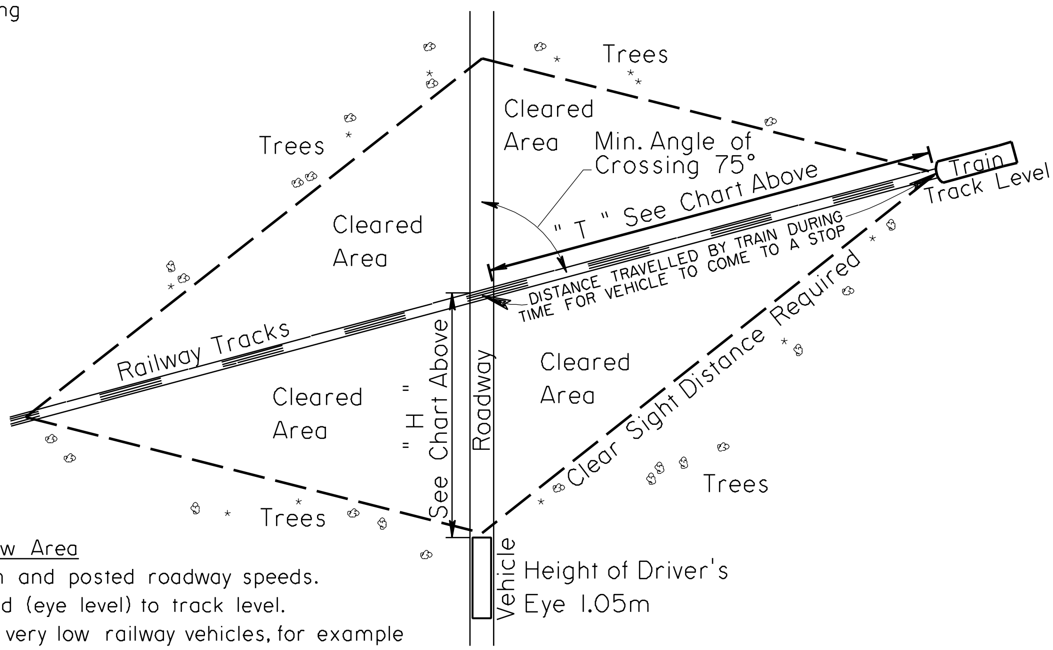
<u>NOTE:</u> **
" T " is based on the distance travelled by the train in 10 seconds, for roadway speeds up to 80km/h. 11 and 12 seconds are used for roadway speeds of 90 km/h and 100 km/h respectively to allow for vehicle stopping times.

<u>NOTES:</u> The following corrections for grade are made to "stopping distances".

Design Speed 60 km/h
- at +3% decrease of 3m
- at +6% decrease of 6m
- at -3% increase of 3m
- at -6% increase of 10m

Design Speed 80 km/h
- at +3% decrease of 6m
- at +6% decrease of 10m
- at -3% increase of 6m
- at -6% increase of 15m

Design Speed 100 km/h
- at +3% decrease of 10m
- at +6% decrease of 15m
- at -3% increase of 10m
- at -6% increase of 25m



<u>To Establish Required Clear View Area</u>
1. Use maximum allowable train and posted roadway speeds.
2. View from 1.05m above road (eye level) to track level. Track level is used to allow for very low railway vehicles, for example flatbed cars or smaller track maintenance vehicles.
3. Where gradients within 8m of rail exceed 5%, or heavy or long vehicles regularly cross, clear view from a vehicle stopped at the crossing must also extend a minimum of 50% beyond " T ", and more if necessary, so stopped vehicles have sufficient time to start up and cross safely.(see reference note below)
4. Where roadway approaches are flat or roadway has few heavy vehicles, the "minimum stopping distance" may be used instead of the "desirable stopping sight distance".
5. If clear view cannot be achieved for existing speeds, reduce speed of vehicles or trains until such time as an automatic warning system can be installed.

<u>Reference Note:</u>
To determine sight distance requirements based on vehicle speed, grade, skew, performance characteristics, dimensions and train speed, refer to section C.9 of this manual.

C.9.2.5 Protection System at Crossings

C.9.2.5.1 Basic Protection

At-grade railway crossing protection need is site specific and generally based on the traffic and train volumes, safety record and engineering assessment of the site characteristics.

The basic protection of each at-grade crossing consists of standard cross-buck, crossing warning sign (WC-4) and pavement symbol as shown in Figure C1-5 of the 1998 Manual of Uniform Traffic Control Devices for Canada. This is also shown in Alberta Infrastructure's Typical Pavement Markings plans in the Traffic Control Standards manual.

C.9.2.5.2 Signal Placement Standards for Rural Highway-Railway Crossings

Signals are considered if any one or more of the following site conditions exists:

- crossing sight clearance cannot be provided per the standards in section C.9.2.4;
- the cross product of daily train and roadway AADT exceeds 1000;
- there are specific safety concerns and operational improvement needs.

Where it has been decided that railway crossing warning signals will be placed on a rural highway, the placement standards shown in Figure C-9.2.5.2a will be used. This drawing provides the minimum and desirable offset of signals masts from the centreline of the highway and identifies the centreline for providing a cantilever signal.

Cantilever signals are required when crossing signals will have to be placed at 7.6 m away from the highway centreline or if any of the stipulations shown in Figure C-9.2.5.2b cannot be met.

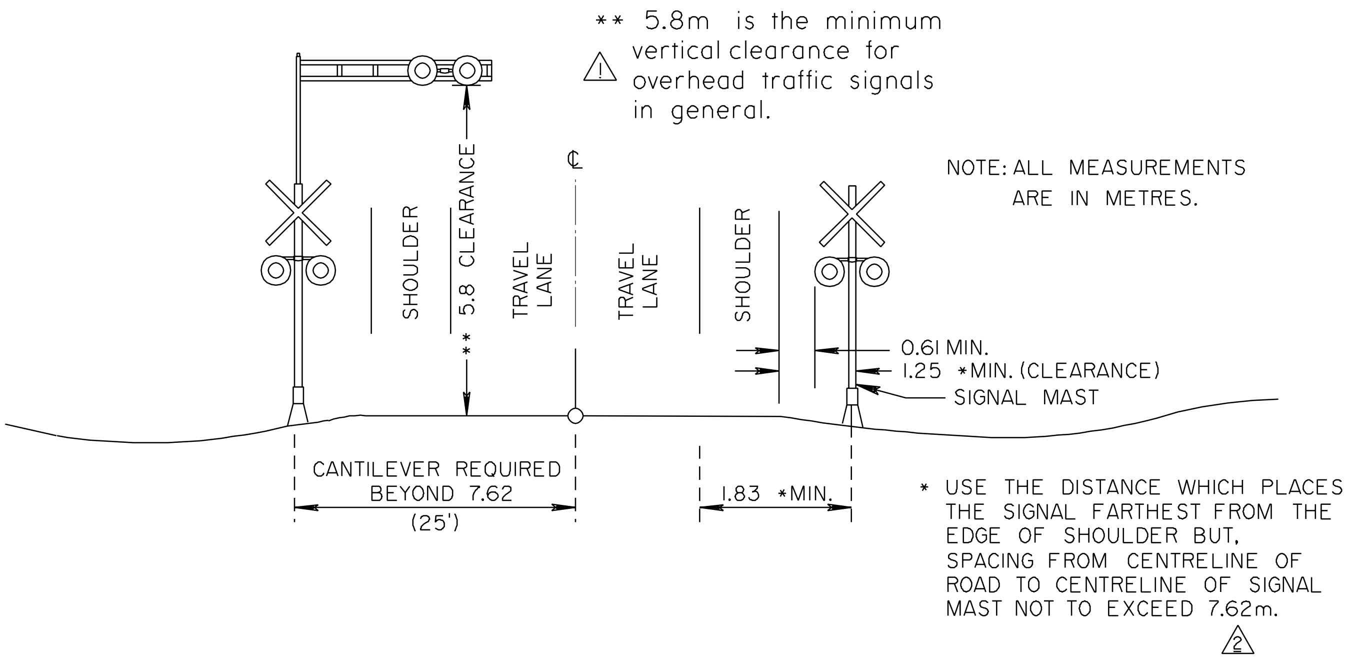
When warranted, Transport Canada or the railway company may also request that additional signal heads, and gates also be considered to give additional warning and control.

As an alternative, Transport Canada will also consider "Prepare To Stop At Railway Crossing Sign (WB-6)", equipped with a set of two alternating flashing amber beacons, as a part of a crossing protection system at locations where high vehicle speed, sight restrictions, vertical profile changes, and environmental (fog, etc) concerns exist.

C.9.2.5.3 Crossing Improvement Cost Sharing

Transport Canada provides subsidies for approved crossing improvement projects, including signal installation and improvements. The balance is shared between the railway company and the road authority. The designer should always confirm the cost sharing arrangements for crossing projects at the conceptual design stage.

FIGURE C-9.2.5.2a RAILWAY WARNING SIGNAL PLACEMENT STANDARDS RURAL HIGHWAYS



Not to Scale

REFERENCES: 1. TRANSPORT CANADA E-6
2. ASSOCIATION OF AMERICAN RAILROADS SIGNAL MANUAL (31.35-1991)

NOTES: This drawing illustrates the standards for placement of railway warning signals on rural highways. The criteria are listed below:

(i.) The vertical structure must be a minimum of 1.83m from the edge of travel lane.

(ii.) The desirable clearance between highway and signal mast is 1.25m.

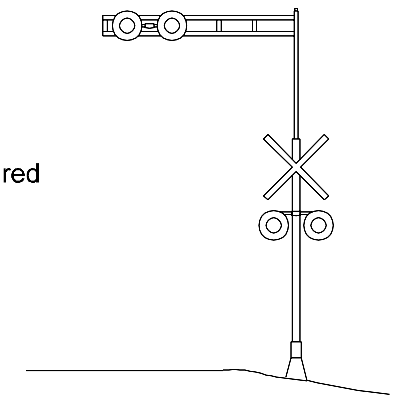
(iii.) If the spacing between centreline of highway and centreline of structure exceeds 7.62m, a cantilever is required. ⚠2

(iv.) The minimum vertical clearance for the cantilever is 5.8m. This vertical clearance is also generally used for overhead traffic signals and signs.

REVISIONS	No.	BY			DATE	
	2	BY	BK	REVISED DIMENSIONS, NOTES	DATE	12 /98
	1	BY	TN	REV TITLE, ADDED NOTE	DATE	07 /98

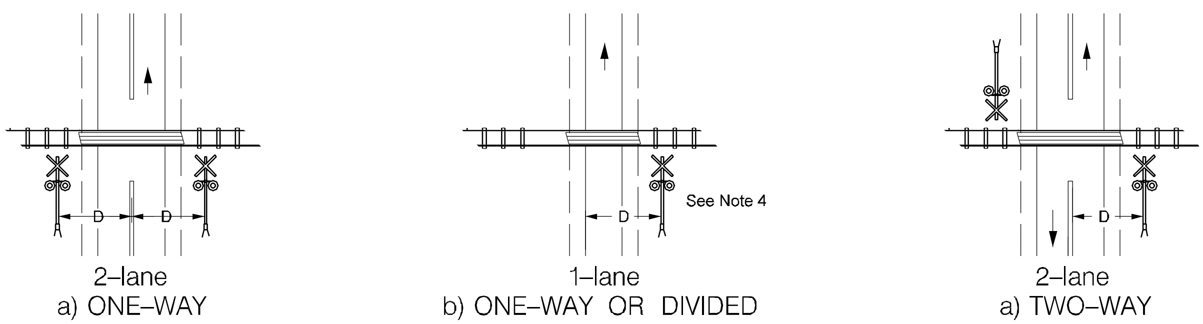
GRAPHICS FILE: debc9252a.man

FIGURE C-9.2.5.2b RAILWAY WARNING SIGNAL CANTILEVERED LIGHT UNIT WARRANT



All automatic warning systems shall be equipped with cantilevered light units where:
(a) the distance between any part of the traveled road surface in the lanes approaching the crossing surface and a crossing warning signal mast, measured on either side of the road at right angles to the road, exceeds 7.6 m (see below); or

(b) the front light units of the crossing warning signal (i.e. those on the same side of the track as approaching traffic) are not clearly visible for the minimum distance specified in Table 1 below, and cantilevered light units will bring the visibilit



NOTES:
1. Where "D" exceeds 7.6 m, cantilevered light units are required.
2. Distances measured at 90 degrees to the centre line of the road.
3. In all other cases of multi-lane one and two way roads, cantilevered light units are required.
4. The addition of cantilevered light units may be avoided be installing a second road crossing signal on the left side of the road in the case of one-way and divided roads.

MINIMUM VISIBILITY FOR APPROACHING TRAFFIC

Maximum Permissible Approach Speed (km/h)	Recommended Distance to Alignment Point of Front Light Units (meters)	Minimum Requirements "Distant Visibility" One set of Light Units (meters)
50	135	100
60	160	120
70	190	140
80	220	160
90	260	190
100 and up*	300	220

*Where maximum road speeds are 100 kph and over, light units aligned through point at this distance.

Table 1

SOURCE: TRANSPORT CANADA, ROAD RAILWAY GRADE CROSSING MANUAL

GRAPHICS FILE: debc9252b.man

C.9.3 Railway Grade Separated Crossings

Grade separations are required at all railway/freeway crossings. It is also desirable to provide grade separated crossings at all expressway and arterial highways planned for future upgrading to freeway standards. A warrant for a grade separated crossing on other primary highways and all secondary highways is to be evaluated individually. Such a warrant is normally based on the cross-product of the AADT and the number of train crossings daily. However, additional considerations are the design speed of the road and railway and the type of environment (rural or urban). For example, higher cross-products at at-grade crossings are tolerated more in urban areas than in rural areas.

C.9.3.1 Overpasses (Overhead Bridge)

The overpass bridge is defined as having the subject road passing over the railway. The following minimum clearances are to be used in conjunction with roadway design:

- The minimum vertical clearance from the top of the rail to the underside of the superstructure is 7010mm*, plus an additional 50mm of construction tolerance.

- The critical vertical clearance is established along the outside limit of the horizontal clearance box, which is discussed below.

- Unless otherwise authorized, all overpasses shall be designed to allow at least a minimum horizontal clearance of 5486mm* measured from the centerline of the tracks to both sides. The 5486mm is a maximum dimension used for cost-sharing between the highway authority and the railway company, that is where either party requests a larger clearance the additional cost is not shareable. Lower clearances may be negotiated between the highway authority and the railway company if required. An absolute minimum horizontal clearance of 3.35m from the centreline of tracks has been used previously to ensure safe passage of trains through the opening. The combination of the horizontal and vertical clearances form a clearance box. In some special cases, the clearance box may be modified to suit special structures such as tunnels. Also, in some instances, the railway company may request clearances that exceed the minimum requirements. Minimum clearances must also take into consideration the possibility of future additional tracks. See Figure C-9.3.1.

*Note: The designer is responsible for obtaining approval from the National Transportation Agency to construct railway grade separation projects.

In all cases, however, each grade separation is treated individually and the actual final vertical and horizontal clearances are to be submitted to Technical Standards Branch for review.

C.9.3.2 Underpass (Subway)

An underpass is defined as having the subject road passing under a railway. The following minimum clearances are to be used in conjunction with roadway design:

(These clearances are also appropriate for overhead signs or where the subject road passes under another roadway.)

A minimum vertical clearance of 5350mm, measured from the finished roadway surface to the bottom of the structure, is required for subway structures occurring on primary and secondary highways. In some special cases where the subject road is purely local, the minimum clearance may be reduced to 4750mm or to an absolute minimum of 4150mm. With all of these minimum vertical clearances, an additional 50mm of construction tolerance is required. Where very low K value sags are proposed at underpasses, the clearance should be checked for long wheelbase truck configurations. On private road underpasses, there is no minimum restriction and the final vertical clearance decided upon is a matter subject to agreement with the landowner.

The full highway shoulder width shall be maintained through all subways. Where an auxiliary lane or taper is extended under the structure, the shoulder width, as established preceding the structure, shall be maintained through the subway. The minimum horizontal distance from the edge of the finished shoulder to the face of the pier column shall be 2800mm on rural roadways with proper barrier protection as needed. The clearance box for railway underpasses and typical headslope details are shown on Figure C-9.3.2.

FIGURE C-9.3.1 CLEARANCE BOX FOR RAILWAY OVERPASS

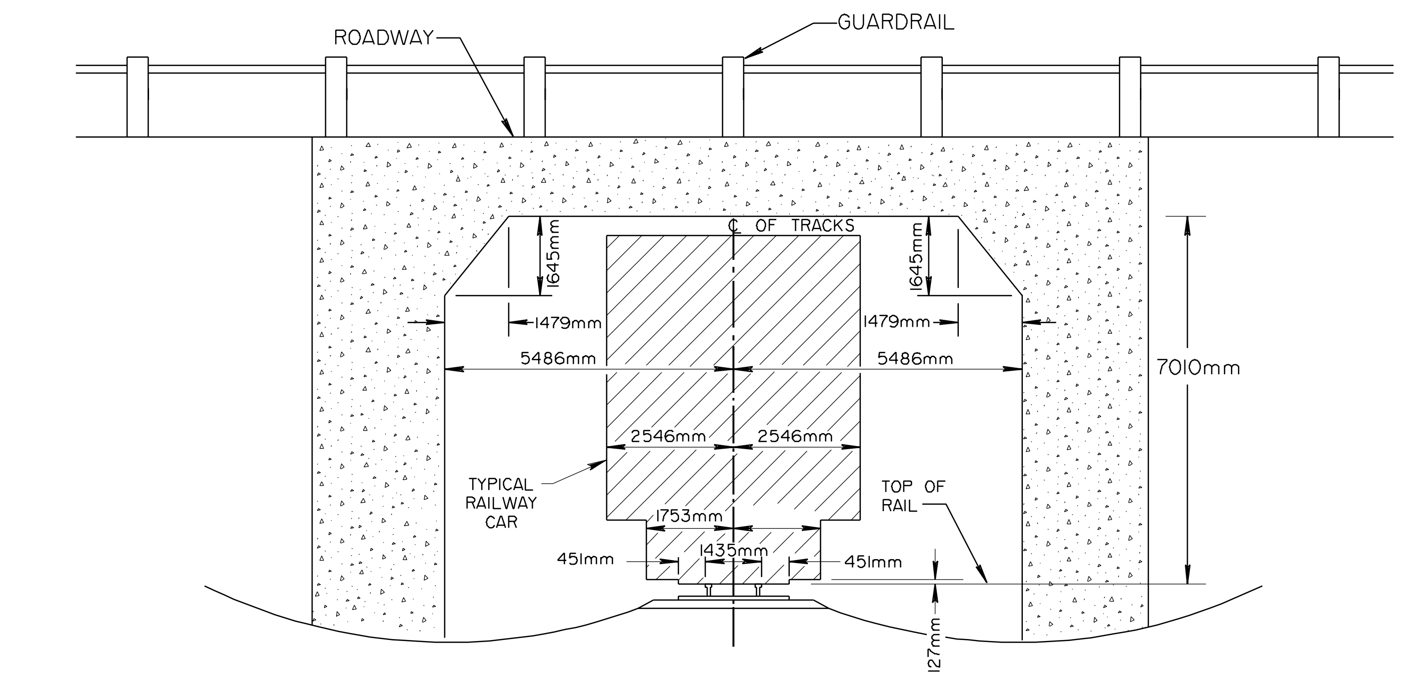
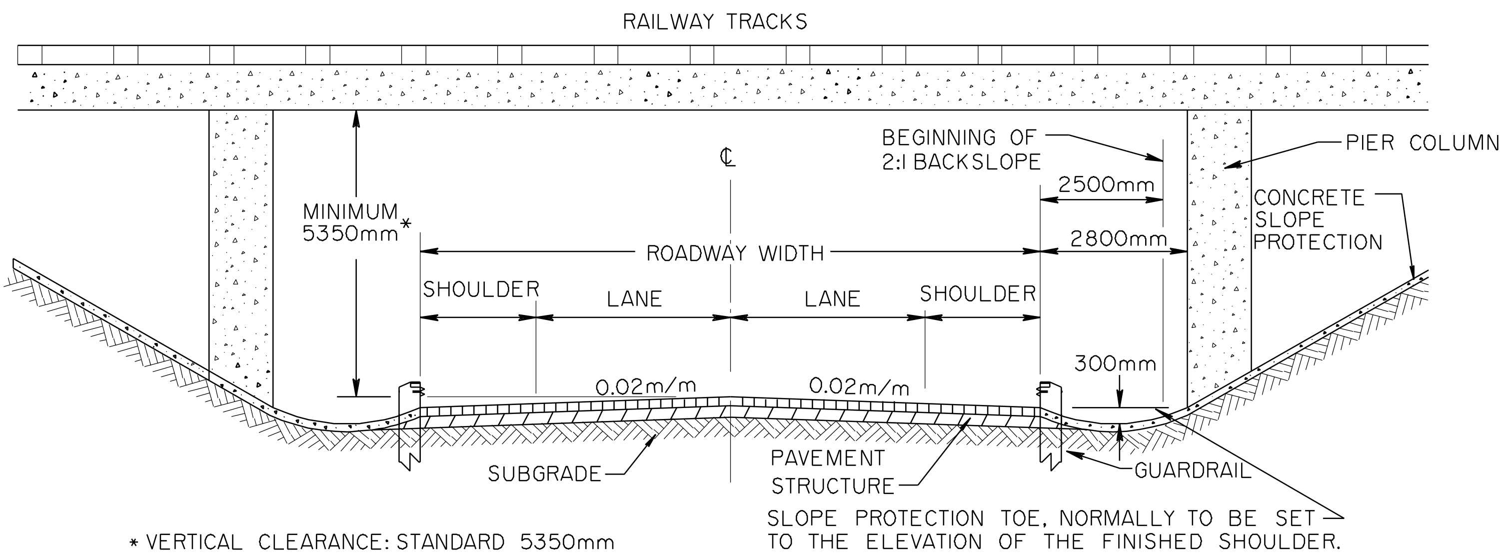


FIGURE C-9.3.2 CLEARANCE BOX FOR RAILWAY UNDERPASS



* VERTICAL CLEARANCE: STANDARD 5350mm
LOCAL (SPECIAL CASE) 4750mm
ABSOLUTE MINIMUM 4150mm

NOTES:

1. THESE CLEARANCES ARE ALSO APPROPRIATE WHERE THE SUBJECT ROADWAY PASSES UNDER ANOTHER ROADWAY. (EXCEPT FOR HIGH LOAD CORRIDORS WHERE THE CLEARANCE BOX IS 9m WIDE X 9m HIGH)
2. ⚠ THE CLEARANCE BOX USED ON SPECIAL ROUTES MAY EXCEED THE DIMENSIONS SHOWN HERE. FOR EXAMPLE ON THE HIGH LOAD CORRIDOR, THE STANDARD CLEARANCE BOX REQUIRED IS 9m x 9m (GENERALLY). ON LOG HAUL ROUTES THE VERTICAL CLEARANCE SHOULD PROVIDE FOR ALL PERMITTED LOAD SIZES.
3. ROUNDING DEPTH AND RELATIVE ELEVATION OF SHOULDER AND TOE OF SLOPE PROTECTION MAY VARY APPROXIMATELY 150mm.
4. A CONSTRUCTION TOLERANCE OF 50mm ON THE VERTICAL CLEARANCEIS GENERALLY ALLOWED FOR.

REVISIONS	No. 2	BY		DATE	
	No. 1	BY BK	ADDED CLEARANCE NOTES	DATE	AUG./1999

C.9.4 Encroachment and Drainage on Railway Property

In cases where the highway is located parallel to the railway and shares a common boundary, it is often necessary and desirable to encroach on the railway property. The encroachment may be required to accommodate large fills or to construct a common ditch for drainage and aesthetic purposes. Special precautions should be taken to ensure that railway ballast is protected from contamination by soil when highway construction work is undertaken immediately adjacent to the railway. Contamination could occur during construction of a common railway-highway ditch.

Prior to any form of construction within the railway right of way, it is necessary to request and receive permission from the railway company involved. The request for permission should provide some details and reasons for encroachment. It is usually advantageous to support the reasons with sketches and typical cross-sections.

Particular attention must be given to the design of the drainage system. It is desirable to maintain the existing, established drainage. Generally, the highway centreline culverts should provide the same capacity as the existing railway facilities. If the railway drainage system must be revised, the proposed revisions should be surveyed and the necessary plans and profile prepared to show the proposed drainage revision. This information should be collected well in advance of the proposed construction, so that the submission can be made to obtain permission from the railway company.

C.10 FENCING

C.10.1 Introduction

The fencing of highway right of ways is a design consideration on most grading projects which involve new alignment or upgrading of existing alignments that include acquisition of new right of way. The following information is required by a designer prior to estimating the fencing quantities:

- Is fencing required along right of way or elsewhere on the project, for example at borrow areas?
- What type of fencing is required?
- Is there an existing fence, and if so, is the position and condition satisfactory for the highway needs throughout the design life of the highway?
- Are gates or temporary openings required?
- Who is responsible for construction cost and maintenance of the fence?

The following section provides general information regarding the above.

C.10.2 Requirement for Fencing

The basic purpose of erecting fences is to prevent farm animals and possibly some wild animals from gaining access to the highway right of way. The presence of animals on the highway right of way constitutes a hazard to the road user, especially in high speed and poor lighting conditions. This condition is also deadly for animals. Legislation in Alberta places the responsibility for control of farm animals on the owner. This is stipulated in the Stray Animals Act 1976 which states "no person shall permit or allow any livestock owned by him or in his possession to be on any highway unless it is in his or another person's direct and continuous charge and he or that person is competent to control the livestock". Roads in counties and municipal districts are under the control and management of the local council, who may pass by-laws to enforce herd laws for controlling farm animals. Responsibility for fences is therefore transferred to livestock owners who are generally the landowners (except in the case of leases).

The following criteria are used to establish the need to provide fencing on primary highways. AI will generally construct a fence as part of a grading project involving widening or new alignment where any of the following conditions exist:

- There was an existing fence along the original right of way
- The new alignment severs existing fenced enclosures
- The landowner indicates present or immediate future use of adjacent land for livestock grazing
- The land use is predominantly livestock grazing. Isolated quarter sections which are not at present used for livestock should also be fenced
- Where fencing is required during construction to protect livestock or people from borrow excavation, and so forth. In this case, temporary fence should be installed.

All new right of way fencing shall connect to existing fences to form an enclosure.

In cases where land usage adjacent to right of way is predominantly grain farming, fencing is not required. Similarly along sections of highway that are constructed through undeveloped forested land which is often owned by the Crown, fencing is not necessary. Through Crown lands that have been leased for cattle grazing purposes, highway right of way should be fenced.

The need for fencing along secondary highways, local roads and roads through Indian Reserves is generally the same as along rural primary highways, however, the responsibility for construction and maintenance varies (see Section C.10.4).

C.10.3 Type of Fence

All of the standard types of fences used by AI are shown in Figure C-10.3. Additional drawings showing installation details of each fence including corners, gate openings and so on are included in the Standard Drawings Manual (CB-6). A special drawing is also included showing a modified Class B fence using metal stays. This may be used provided

the landowner is agreeable and that it will result in some savings in wood posts. Generally along primary highways, Class B fence is used.
Fencing is classified according to type as follows:

Class A: three barbed wires with wooden posts at five metre maximum spacing

Class B: four barbed wires with wooden posts at 3.75m maximum spacing

Class C: two barbed wires with 813mm paige wire with wooden posts

Class D: two barbed wires and 914mm paige wire with wooden posts

Class E: two barbed wires and 1067mm paige wired with wooden posts

Class F: 2134mm paige wire with wooden posts

Class G: four barbed wires with wooden posts at five metre maximum spacing

Details of each classification are shown on the plans.

Class A fence is generally used for temporary installations at borrow areas, etc.

Class C is generally used for hog enclosures.

Class D is generally used for farm yard and sheep enclosures.

Class E is generally used for ranching areas.

Class F may be used in parks in special cases. This is an extra tall fence that may prevent antelope from crossing the highway.

Standard highway fences are generally accepted to be ineffective in preventing most wildlife (such as deer or moose) from crossing the right of way. Therefore it is inadvisable to spend construction dollars in this pursuit.

C.10.4 Cost of Construction and Maintenance

In the case of primary highways, AI is responsible for the cost of fence construction, however the landowner or leasee (in the case of Crown grazing leases) is responsible for fence maintenance.

On secondary highways and local roads, the local municipality is generally responsible for fence construction costs, however, the landowner is again responsible for maintenance.

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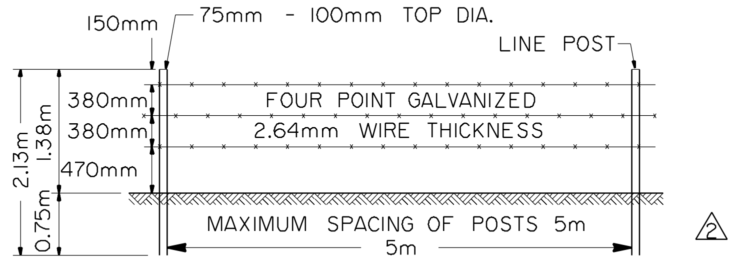
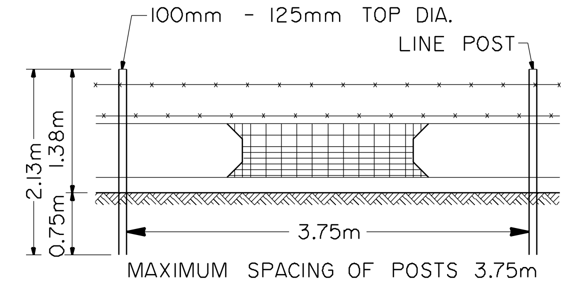


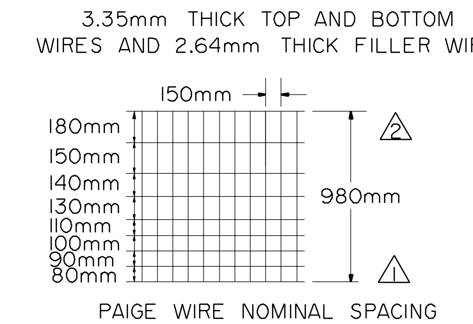
CLASS "A" FENCE

GENERALLY USED FOR TEMPORARY INSTALLATIONS AT BORROW AREAS, ETC.

MATERIAL REQUIRED FOR 1Km OF FENCING

LINE POSTS - 2.13m LONG AND 75mm - 100mm TOP DIA. _ _ 200
40mm STAPLES (APPROX. 140 STAPLES PER KG.) _ _ _ _ _ 5.9 KG.
BARBED WIRE (1 SPOOL=402m) _ _ _ _ _ _ _ _ _ _ _ 7.5 SPOOLS
(FOUR POINT GALVANIZED 2.64mm WIRE THICKNESS)



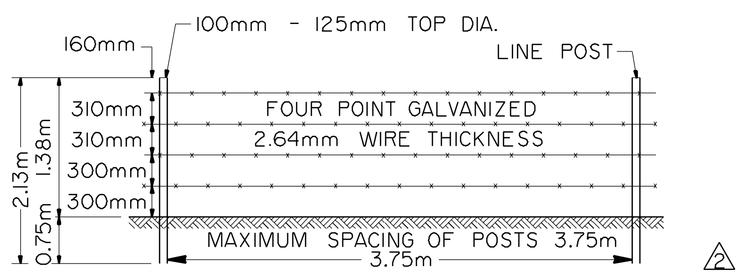


CLASS "D" FENCE

GENERALLY USED FOR FARM YARD AND SHEEP ENCLOSURES

MATERIAL REQUIRED FOR 1Km OF FENCING

LINE POSTS - 2.13m LONG AND 100mm - 125mm TOP DIA. _ 267
40mm STAPLES (APPROX. 140 STAPLES PER KG.) _ _ _ _ _ 22 KG.
BARBED WIRE (1 SPOOL=402m) _ _ _ _ _ _ _ _ _ _ _ 5 SPOOLS
(FOUR POINT GALVANIZED 2.64mm WIRE THICKNESS)
PAIGE WIRE - AVAILABLE IN 20 ROD ROLLS ONLY

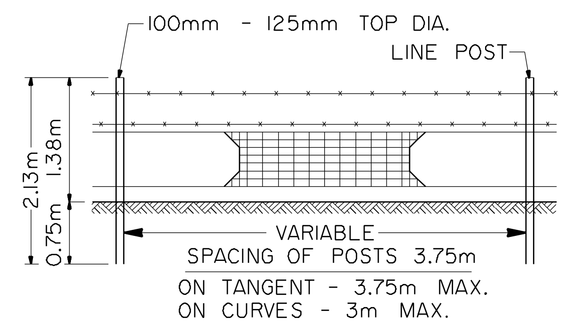


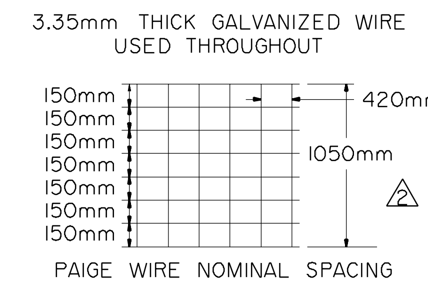
CLASS "B" FENCE

GENERALLY USED FOR PRIMARY HIGHWAYS

MATERIAL REQUIRED FOR 1Km OF FENCING

LINE POSTS - 2.13m LONG AND 100mm - 125mm TOP DIA. _ 267
40mm STAPLES (APPROX. 140 STAPLES PER KG.) _ _ _ _ _ 8.0 KG.
BARBED WIRE (1 SPOOL=402m) _ _ _ _ _ _ _ _ _ _ _ 10 SPOOLS
(FOUR POINT GALVANIZED 2.64mm WIRE THICKNESS)





CLASS "E" FENCE

GENERALLY USED FOR RANCHING AREAS

MATERIAL REQUIRED FOR 1Km OF FENCING

LINE POSTS - 2.13m LONG AND 100mm - 125mm TOP DIA. _ 267
40mm STAPLES (APPROX. 140 STAPLES PER KG.) _ _ _ _ _ 19 KG.
BARBED WIRE (1 SPOOL=402m) _ _ _ _ _ _ _ _ _ _ _ 5 SPOOLS
(FOUR POINT GALVANIZED 2.64mm WIRE THICKNESS)
PAIGE WIRE - AVAILABLE IN 20,30 AND 40 ROD ROLLS ONLY

ADDITIONAL MATERIAL REQUIRED FOR EACH CLASS

BRACE POSTS - 2.13m LONG AND
100mm - 125mm TOP DIA. _ _ _ _ _ _ _ _ _ _ EXTRA

GATE, INTERSECTION, END AND CORNER POSTS
2.43m LONG AND 175mm TOP DIA. _ _ _ _ _ _ _ EXTRA

100mm X 100mm DIMENSION LUMBER BRACES _ _ EXTRA

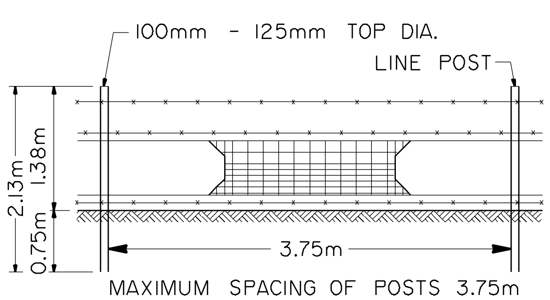
3.66mm THICK SOFT GALVANIZED WIRE
FOR DIAGONAL BRACING
(APPROX. 1.5 KG. PER BRACE) _ _ _ _ _ _ _ _ _ _ EXTRA

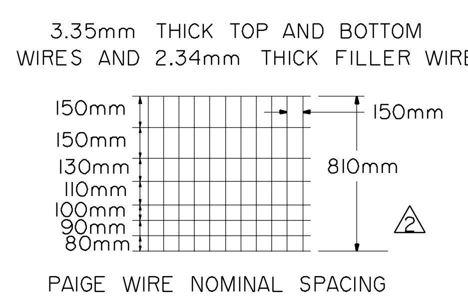
GATE STAYS - 1.2m LONG 55mm TOP DIA. _ _ _ EXTRA

7 HELICAL SPIKES FOR BRACES _ _ _ _ _ _ _ _ EXTRA

NOTES

- THE GENERAL USE DESCRIBED FOR EACH CLASS OF FENCE IS TO BE USED AS A GUIDE BUT SPECIAL CONDITIONS MAY NECESSITATE CHANGES TO MEET LOCAL REQUIREMENT.
- ALL FENCE POSTS SHALL BE PRESSURE TREATED
- PAIGE WIRE FENCE TO BE SPACED AS SHOWN WITH HINGE-LOCK KNOT CONSTRUCTION
- ALL WIRE TO BE GALVANIZED
- NOMINAL DIMENSIONS SHOWN FOR PAIGE WIRE



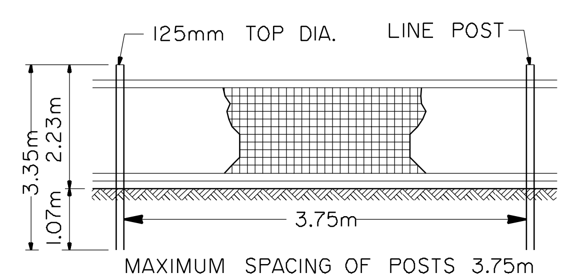


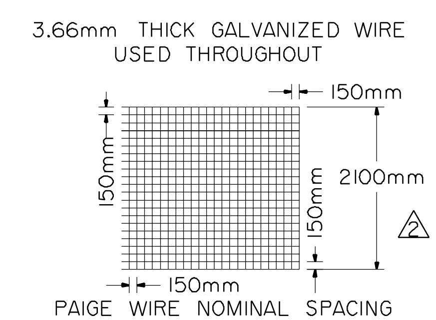
CLASS "C" FENCE

GENERALLY USED FOR HOG ENCLOSURES

MATERIAL REQUIRED FOR 1Km OF FENCING

LINE POSTS - 2.13m LONG AND 100mm - 125mm TOP DIA. _ 267
40mm STAPLES (APPROX. 140 STAPLES PER KG.) _ _ _ _ 22.0 KG.
BARBED WIRE (1 SPOOL=402m) _ _ _ _ _ _ _ _ _ 7.5 SPOOLS
(FOUR POINT GALVANIZED 2.64mm WIRE THICKNESS)
PAIGE WIRE - AVAILABLE IN 20 ROD ROLLS ONLY





CLASS "F" FENCE

USED IN PARKS IN SPECIAL CASES

MATERIAL REQUIRED FOR 1Km OF FENCING

LINE POSTS - 3.35m LONG AND 125mm TOP DIA. _ _ _ _ _ 267
40mm STAPLES (APPROX. 140 STAPLES PER KG.) _ _ _ _ _ 27 KG.
PAIGE WIRE - AVAILABLE IN 10 ROD ROLLS

No.	REVISIONS	BY	DATE
2			
1			

Alberta INFRASTRUCTURE

FIGURE C-10.3

Date: APRIL 1995

PURPOSES AND TYPES OF FENCES

Prepared By: B.G.D.	Checked By: B.K.	Scale: N.T.S.	PAGE C-125

GRAPHICS FILE: tigsfs01\reb\manual\chapters\chap-c\debc103.man