EKISTICS

1925 Main Street
Vancouver BC
V5T 3C1 Canada

T 1.604.739.7526
F 1.604.739.7532

www.ekistics.ca

4 November, 2009

Barbara R. Thomas
District Manager, Ministry of Transportation & Infrastructure
3rd Floor - 2100 Labieux Road
Nanaimo BC V9T 6E9

RE: Fairwinds: The Lakes District & Schooner Cove
Road Alignment Design Criteria & Supporting Documentation
(Technical Appendix | Supplement to the Draft Street Standards)

As a follow up to our draft proposal for Project Specific Street Standards for Fairwinds Resort Community (Nanoose Bay, BC), I am enclosing the recently completed Road Alignment Design Criteria, prepared by InterCAD Services, Ltd. The comprehensive design criteria supplements our initial discussions.

OPPORTUNITY AT HAND

Since our previous meeting, we have been making preparations for the submission of the Lakes District and Schooner Cove Neighbourhood Plans, both of which represent areas defined by the Regional District of Nanaimo as Urban Growth Areas (delineated by the Regional Growth Strategy's "Urban Containment Boundary"). During our consultation, we have recognized a strong interest expressed among the general public to explore street design with the pedestrian in mind, particularly in the context of the designated "community centres" at The Lakes District and Schooner Cove.

We continue to recognize this opportunity as remarkably unique: principles of regional growth management (as reflected in public-sector objectives), translated through technical development (public- & private-sector engineering review) and applied to project-specific street standards (private-sector implementation).

CONTEXT

Based on our previous meeting, MOTI Staff had requested three critical components to support the consideration of Project Specific Street Standards for Fairwinds. They were, in sequential order:

- Detailed comparison of MOTI Section 1400 design criteria with TAC and those proposed for use within the Lakes District / Schooner Cove boundaries;
- Review of cross-sectional & planometric design details within the ROW proposed; and,
- Plan of Proposed Street Hierarchy for The Lakes District & Schooner Cove based on design criteria developed as per the above.

The enclosed document represents the first step: the "Road Alignment Design Criteria and Supporting Documentation" is provided in its entirety and is also available in electronic format, as required.

The corresponding set of revised cross sections and planometric drawing for the proposed streets are currently being reviewed by InterCAD and will be provided under separate cover. In the meantime, we wanted to forward this report for your review and as a tangible measure of progress towards our collaborative efforts.

NEXT STEPS

Upon receipt & review of the components as requested, we would like to arrange a meeting to discuss the technical proposal and chart the steps required to finalize the Project Specific Street Standards.

On behalf of the project team, I would like to thank you for the continued opportunity to work with the Ministry. It is our hope that, through the development of the Project Specific Street Standard, we can achieve a road network that speaks to the Ministry's vision to realize "innovative, forward-thinking transportation strategies," address our responsibility for safe, effective & efficient transit and best serve the overall goals & objectives of the greater Fairwinds community.

Should you have any additional questions about the enclosed materials or any other aspect of our ongoing work together, please do not hesitate to be in touch.

Sincerely,

Paul Fenske
Principal

Cc: Russell Tibbles, Bentall LP
Stephen Clinton, InterCAD Services, Ltd
Sarah Rocchi, Opus International

Ekistics / Bentall LP
Fairwinds Resort Community

Road Alignment Design Criteria and Supporting Documentation

Prepared by:

InterCAD Services Ltd.
1111 West 8th Avenue
Vancouver, B.C.
V6H 1C5

InterCAD **MEMO**

To:	**Paul Fenske, Principal** **Ekistics Town Planning Inc** **1925 Main Street** **Vancouver, B.C. V5T 3C1**	From: **Stephen Clinton** Date: **October 13, 2009** File: **AD28** Page: **1** of **1**	

Re: **Fairwinds Resort Community & Resort - The Lakes District**
Roadway Alignment Design Criteria

Paul,

Further to our recent discussions, we enclose herewith our proposed Alignment Design Criteria for the Fairwinds Resort Community on Vancouver Island, BC.

The enclosed document consists of two parts:

1. an Alignment Design Criteria Summary which presents proposed design criteria for roadway design speeds between 60km/h and 30km/h;

2. detailed Design Criteria tables for each Design Speed which presents a comparison of alignment criteria between BC Ministry of Transportation Section 1400 (Subdivision) and the TAC Geometric Design Guide for Canadian Roads, as well as presents our proposed criteria for the project. Appended to each Design Criteria table are excerpts from each publication (MoT and TAC), documenting the source of values shown in the tables. Where appropriate, sketches and sample calculations prepared by InterCAD are also included. This part of the document is divided by tabs labelled Section 1 through Section 4.

The intent of developing criteria for the various design speeds below 60km/h is to promote the use of low design speed roadways within the proposed Lakes District Neighbourhood. The roadway layout should be established in such a way as to avoid long straight sections of road which tend to increase driven speeds. Where long straight sections cannot be avoided, we would promote the introduction of traffic calming measures to maintain lower travel speeds. The use of lower design speed roadways is the most effective way of developing a roadway network which reduces environmental impact and construction costs in hillside development areas.

We trust that the enclosed document meets your present requirements. Please do not hesitate to call if you have any questions or wish to review any aspect in further detail.

Your truly,

Stephen Clinton, PEng

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Alignment Design Criteria Summary

1. Horizontal Curve Radii

Criteria	60 km/h	50 km/h	40 km/h	30 km/h
Roadway Crossfall normal crown (-2%)	1290m	105m	55m	30m
2% superelevation	220m	90m	50m	25m
4% superelevation	150m	80m	45m	20m
6% superelevation	130m	-	-	-
Through Intersections	200m	120m	75m	-

2. Superelevation

Criteria	60 km/h	50 km/h	40 km/h	30 km/h
Maximum Superelevation	6%	4%	4%	4%
Maximum Superelevation at Intersections	4%	4%	4%	4%

3. Superelevation Transition Lengths

Criteria	60 km/h	50 km/h	40 km/h	30 km/h
Transition Lengths (2 / 4-lane roadways) normal crown to +2%	24m / 36m	22m / 34m	20m	20m
normal crown to +4%	36m / 53m	33m / 50m	30m	30m
normal crown to +6%	47m / 71m	-	-	-
Min Tangent Length between reversing curves 2% superelevation (2 / 4-lane roadways)	15m / 22m	13m / 20m	12m	12m
4% superelevation	22m / 42m	26m / 40m	24m	24m
6% superelevation	42m / 64m	-	-	-

1 Values for transition lengths include tangent runout applied at the same rate as superelevation runoff.

2 60% of superelevation runoff occurs on the tangent approach and 40% on the curve, resulting in a minimum length of tangent between reversing curves of 120% of the superelevation runoff length.

Alignment Design Criteria Summary

4. Gradients

Criteria	60 km/h	50 km/h	40 km/h	30 km/h
Minimum Grade	0.5%	0.5%	0.5%	0.5%
Maximum Grades on horizontal tangents	10%	11%	12%	12%
on minimum radius horizontal curves [1]	9%	10%	10%	10%
Grades Through Intersections Through condition approach grade	8%	8%	8%	-
approach distance for through road [2]	15m / 5m [3]	5m	0m	-
Stop condition approach grade	5%	5%	6%	6%
approach distance for stopping road [2]	20m	15m	5m	5m

1 Applies where radius is less than 1.5 times minimum allowable radius.

2 Minimum distance back from the gutter line that the specified grade may not be exceeded.

3 15m approaching a Collector Road / 5m approaching a Local Road.

5. Vertical Curve K Values

Criteria	60 km/h	50 km/h	40 km/h	30 km/h
Minimum Crest	13	8	4	2
Minimum Sag	9	7	4	2
Crest / Sag on approach to stop condition	4	3	2	2

K values listed assume that new roadways will be illuminated

6. Stopping Sight Distances

Criteria		60 km/h	50 km/h	40 km/h	30 km/h
Down grades:	12%	109	78	52	34
	9%	101	73	50	32
	6%	94	69	48	31
	3%	89	66	46	30
	0%	85	63	45	30
Up grades:	3%	81	61	44	29
	6%	78	59	42	29
	9%	76	57	41	28
	12%	73	56	40	28

7. Decision Sight Distance

Minimum decision sight distance for 60 km/h: 95m - 175m
50 km/h: 75m - 145m

1. Note that decision sight distance applies only to multi-lane roads at intersections.
2. The range of values recognizes the variation in complexity that occurs at various sites. For less complex situations, values towards the lower end of the range are appropriate and for more complexity, values at the upper end are used.

60km/h

Table 1 : Alignment Design Criteria Summary : 60 km/h Design Speed

1. Horizontal Curve Radii

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Roadway Crossfall			
normal crown (-2%)	-	1290m [2]	1290m
2% superelevation	-	220m [3]	220m
4% superelevation	-	150m [4]	150m
6% superelevation	120m [1]	130m [4]	130m
Through Intersections	-	-	200m [5]

1 Table 1420.A - Design Parameters
2 Table 2.1.2.9, Page 2.1.2.19 TAC manual - minimum radius for normal crown, e_{max} = 0.06m/m.
3 Table 2.1.2.9, Page 2.1.2.19 TAC manual - minimum radius for reverse crown, e_{max} = 0.06m/m.
4 Calculated minimum radius for high speed urban design based on Table 2.1.2.1, Page 2.1.2.7 TAC manual.
5 Applies to the through road only; Subject to applicable sight distance requirements.

2. Superelevation

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Maximum Superelevation	6% [1]	6% [2]	6%
Maximum Superelevation at Intersections	-	-	4% [3]

1 Table 1420.A - Design Parameters: parameters based on E max 0.06 m/m. Section 1420.05.08 - Superelevation notes that 0.06 m/m is applicable for design of new urban streets in the upper range of the classification system where uninterrupted flow is expected.
2 See Section 2.1.2.2 - Maximum Superelevation, Page 2.1.2.4 TAC manual.
3 Applicable when intersection is on a curve.

3. Superelevation Transition Lengths

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Transition Lengths (2 / 4-lane roadways)			
normal crown to +2%	-	24m / 36m [1]	24m / 36m
normal crown to +4%	-	36m / 53m [1]	36m / 53m
normal crown to +6%	-	47m / 71m [1]	47m / 71m
Min Tangent Length between reversing curves			
2% superelevation (2 / 4-lane roadways)	-	15m / 22m [2]	15m / 22m
4% superelevation	-	22m / 42m [2]	22m / 42m
6% superelevation	-	42m / 64m [2]	42m / 64m

1 Lengths based on Tables 2.1.2.12 and 2.1.2.13, Page 2.1.2.26 TAC manual, using 3.5m lanes. Values shown include tangent runout applied at the same rate as superelevation runoff.
2 Values based on Section 2.1.2.4 - Development of Superelevation, and Tables 2.1.2.12 and 2.1.2.13, Pages 2.1.2.25 and 2.1.2.26 TAC manual. 60% of superelevation runoff occurs on the tangent approach and 40% on the curve, resulting in a minimum length of tangent between reversing curves of 120% of the superelevation runoff length.

4. Gradients

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Grade	-	0.5% [3]	0.5%
Maximum Grades			
on horizontal tangents	8% [1]	11% [4]	10%
on minimum radius horizontal curves	7% [2]	-	9%

4. Gradients (cont'd)

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Grades Through Intersections			
Through condition	-	-	8%
approach distance for through road [5]	-	-	15m / 5m [8]
Stop condition	-	3% (desirable) [6] 6% (maximum)	5%
approach distance for stopping road [5]	-	20m [7]	20m

1 Table 1420.A - Design Parameters
2 Grades reduced by 1% for every 30 metres that the centreline radius is less than 150m. As the proposed minimum centreline radius is 120m (at 6% superelevation), the maximum grade is reduced by 1%.
3 See Section 2.1.3.2 - Minimum Grades, Page 2.1.3.3 TAC manual.
4 Maximum gradient, from TAC table 2.1.3.1 Page 2.1.3.2, for a UCU classification, 60km/h design speed in mountainous terrain.
5 Minimum distance back from the gutter line of the intersecting road that the intersection grade must apply.
6 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Page 2.3.2.8 TAC manual.
7 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Page 2.3.2.11 TAC manual.
8 15m approaching Collector Road / 5m approaching Local Road - see attached sketches.

5. Vertical Curve K Values

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Crest	13 [1]	13 [2]	13
Minimum Sag	18 [1]	9 [3]	9
Crest / Sag on approach to stop condition	-	-	4 [4]

TAC and Proposed K values listed assume that new roadways will be illuminated
1 Table 1420.A - Design Parameters: crest based on taillight height, sag based on headlight control (ie no street lighting). Section 1420.05 - Alignment notes that length of vertical curve (in m) should not be less than the design speed (in km/h).
2 See Table 2.1.3.2 - Crest Vertical Curves, Page 2.1.3.6 TAC manual.
3 See Table 2.1.3.4 - Sag Vertical Curves, Page 2.1.3.9 TAC manual.
4 A K value of 4 (40 km/h design speed) is proposed for developing vertical curves at approach platforms on the minor road at an intersection as vehicles will be slowing from design speed as they approach the stop condition.

6. Stopping Sight Distances

Criteria	Down Grades				0%	Up Grades			
	12%	9%	6%	3%		3%	6%	9%	12%
Minimum distance (m)	109	101	94	89	85 [1]	81	78	76	73

All values, see Section 1.2.5.2 - Stopping Sight Distance, Page 1.2.5.2 TAC manual.
1 Only SSD given for level grade in MoT Supplement, Section 1400, Table 1420.A - Design Parameters. MoT Value = 85m

7. Decision Sight Distances

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum decision sight distance:	95m - 175m [1]	175m - 235m [2]	95 - 175m

1 Table 1420.A - Design Parameters: Lower DSD values are appropriate at intersections within a subdivision, while higher values should be used at more complex intersections.
2 See Table 1.2.5.6 - Decision Sight Distance, Page 1.2.5.8 TAC manual. Values shown are for a UCU classification.
The range of values recognizes the variation in complexity that occurs at various sites. For less complex situations, values towards the lower end of the range are appropriate and for more complexity, values at the upper end are used. See Section 1.2.5.4, Page 1.2.5.7 TAC manual. - Note that decision sight distance applies only to multi-lane roads at intersections.

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

Table 2.1.2.9 Superelevation Rate for Urban Design, e_{max} = 0.06 m/m[9]

Radius (m)	Design Speed (km/h) 30	40	50	60	70	80	90	100
7000	NC	NC	NC	NC	NC	NC	NC	NC
5000								
4000								NC
3000						NC	NC	RC
2000					NC	RC	RC	
1500				NC	RC			
1200				RC				
1000								
900			NC					
800			RC					RC
700		NC						0.025
600		RC					RC	0.035
500	NC					RC	0.030	0.048
400	RC					0.026	0.045	Min R=440
350					RC	0.035	0.056	
300					0.025	0.045	Min R=340	
250				RC	0.036	Min R=250		
200				0.024	0.053			
180				0.030	Min R=190			
160				0.037				
140			RC	0.046				
120			0.026	Min R=120				
100			0.036					
90			0.043					
80		RC	0.052					
70		0.024	Min R=75					
60		0.032						
50		0.044						
40	RC	Min R=40						
30	0.030							
20	0.056							
	Min R=20							
min. radius for normal crown	420	660	950	1290	1680	2130	2620	3180
min. radius for reverse crown	40	80	135	220	330	450	600	770

e_{max} = 0.06 m/m
NC = normal crown (-0.02 m/m)
RC = reverse crown (+0.02 m/m)

1.1.2 &
1.1.3

Table 2.1.2.1 Maximum Lateral Friction for Rural and High Speed Urban Design[1]

Design Speed (km/h)	Maximum Lateral Friction for Rural and High Speed Urban Design
40	0.17
50	0.16
60	0.15
70	0.15
80	0.14
90	0.13
100	0.12
110	0.10
120	0.09
130	0.08

margin of safety against skidding under normal driving conditions in the urban environments. Values are presented in Table 2.1.2.2.

Minimum Radius: Design Domain

Overview

The minimum allowable radius for any design speed depends on the maximum rate of superelevation and the lateral friction force that can be developed between the pavement and vehicle tires. This relationship is expressed by:

$$R_{min} = \frac{V^2}{127(e_{max} + f_{max})} \quad (2.1.2)$$

Table 2.1.2.2 Maximum Lateral Friction for Low Speed Urban Design[1]

Design Speed (km/h)	Maximum Lateral Friction for Low Speed Urban Design
30	0.31
40	0.25
50	0.21
60	0.18

For rural and urban high speed superelevation applications there is generally reasonable opportunity to provide the desirable amount of superelevation. In rural areas the constraints are usually minimal, while on high speed urban roadways the designer has reasonable flexibility in establishing suitable superelevation. This is because in the design of new streets, particularly those with design speeds of 70 km/h or more and through generally undeveloped areas, the designer typically has greater flexibility in establishing suitable horizontal and vertical alignments and associated superelevation rates. Often it is possible to regrade adjacent properties to match superelevated sections, ensuring appropriate drainage patterns and intersection profiles.

Rural and High Speed Urban Applications: Design Domain Quantitative Aids

For rural and high speed urban applications the minimum radius is calculated using a maximum superelevation rate of either 0.04 m/m, 0.06 m/m or 0.08 m/m for a range of design speeds from 40 km/h to 130 km/h, and lateral friction factors from Table 2.1.2.1. These calculated values are shown in Table 2.1.2.3.

Low Speed Urban Applications: Design Domain Quantitative Aids

For low speed urban conditions and where a street is to be upgraded through a developed urban area, it is often not desirable or possible to utilize superelevation rates typical of high speed design as previously discussed. Design considerations other than driver discomfort may be important. Existing physical controls, right-of-way constraints, intersections, driveways, on-street parking, and economic considerations have a strong influence on design elements, including design speed and superelevation. In some cases, design speed may not be an initial design control, but rather a result of the other controls or considerations influencing the horizontal alignment and superelevation.

Moreover, in low speed ur' drivers are accustomed to a discomfort while traversing increased lateral friction factc

1.1.4

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B.**

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

1.2.1

1420.05.05 Frontage Roads

The Right-Of-Way width shall be 15 metres or the cross section width plus 3 metres, whichever is greater. (This is additional to the through road requirements.) Ensure sufficient setback at intersections to accommodate turn slots, etc., thus ensuring a bulbed connection is necessary at all frontage road intersections.

1420.05.06 Backage Roads

For these standards, backage roads shall be considered local roads.

1420.05.07 Cross Slopes

All roadways shall be constructed using a centerline crown and shall be graded and compacted with the following crossfall to ensure road drainage:

- Normal cross slopes shall be 2% for paved roads and 4% for gravel roads.

1420.05.08 Superelevation

Superelevation is generally not applied on local subdivision roads or cul-de-sacs; reverse crown is usually maintained in ≤ 800 metre radius curves @≤ 50 km/h. Rural roads of a continuous nature that provide access to a subdivision would be better classified as Low-volume roads and should be superelevated accordingly. Refer to the Low-volume Road Chapter of the BC Supplement to TAC. When the decision has been made to superelevate curves, a maximum rate of 0.04 m/m shall be used for local urban street systems. This is appropriate for design speeds up to 70 km/h and where surface icing and interrupted traffic flow are expected. Superelevation rates of 0.04 m/m and 0.06 m/m are applicable for design of new urban streets in the upper range of the classification system where uninterrupted flow is expected and where little or no physical constraints exist.

1420.06 INTERSECTIONS/ACCESSES

1420.06.01 General

Intersections shall be as near as possible to right angles. The minimum skew angle of the intersection shall be 70 degrees and the maximum skew angle shall be 110 degrees.

1420.07 UTILITY SETBACK

Utility poles or signs should be within 2 metres of the property boundary or a minimum 2 metres beyond the toe of the fill, whichever gives the greater offset from the road. See Figure 1420.C.

1420.08 DRIVEWAYS

1. Driveway location, spacing and approval shall be at the discretion of the Ministry Representative.

2. The first 5 metres (measured from the ditch centerline) of all residential driveways shall be constructed at or near a right angle (70° to 110°) to the road and at a maximum ± 2 % grade.

3. All open shoulder driveways with a level or rising grade are to be constructed with a "valley" or "swale" over the ditch line to ensure surface water enters the ditch and does not enter the road. See Figure 1420.N

4. Driveway grades shall not exceed 8% within the Right-of-Way.

5. Driveway radius and widths:
   Residential/Farm – 6 metre radius and minimum width
   Logging/Commercial – 9 metre radius and minimum width

6. All lots with cuts or fills greater than 1.8 metres shall have engineered drawings when requested by the Ministry representative.

1.2.1

weather conditions, or for other reasons, while not adversely affecting higher speed vehicles. This is especially important for roads located where winter conditions prevail several months of the year.

Urban Areas: Design Domain Quantitative Aids

In urban areas maximum superelevation values cover the range from 0.02 m/m to 0.08 m/m. Values commonly used for maximum superelevation are:

1. Locals - generally normal crown.

2. Collectors - used occasionally with maximum rates of 0.02 m/m or 0.04 m/m.

3. Minor arterials - 0.04 m/m to 0.06 m/m.

4. Major arterials - 0.06 m/m.

5. Expressways and freeways - 0.06 m/m to 0.08 m/m.

6. Interchange ramps - 0.06 m/m to 0.08 m/m.

Urban Areas: Design Domain Application Heuristics

1. In urban areas maximum superelevation values tend to be lower since vehicles travelling at slow speeds or moving away from a stopped position might experience side-slip on higher superelevation. Maximum superelevation in urban areas is typically 0.06 m/m.

2. A maximum superelevation rate of 0.04 m/m may also be used for an urban roadway system, and is appropriate where surface icing and interrupted flow is expected.

3. The maximum superelevation rates of 0.04 m/m and 0.06 m/m are generally applicable for design of new roads in the upper range of the classification system and where little or no physical constraints exist.

4. Superelevation is generally not applied on local roads.

5. On collector roads superelevation is used occasionally, and typically where beneficial in matching adjacent topography. Maximum superelevation rates in these cases are in the range of 0.02 m/m (reverse crown) to 0.04 m/m.

6. In some jurisdictions, higher superelevation values are used for ramps on urban freeways than on other urban roads to provide additional safety since freeway ramps, particularly off-ramps, tend to be over-driven more often and side-slip is less likely to occur since maintenance is better at these locations.

7. Superelevation rates in excess of 0.04 m/m are not recommended where curved alignments pass through existing or possible future intersection areas. In urban retrofit situations, it is often difficult or undesirable to provide any superelevation at all due to physical constraints. In these cases, the designer has to carefully assess the relationships of design speed, curvature, crossfall and lateral friction in choosing the optimum design solution.

8. Acceptable maximum superelevation rates are often established as a matter of policy and vary between jurisdictions based on local conditions. As an example, some jurisdictions use a maximum superelevation rate of 0.08 m/m for higher classification roads such as expressways. In the interests of maintaining consistency in design in any particular area where the responsibility for roads is divided between jurisdictions, it is desirable to maintain consistent maximum superelevation. In selecting maximum superelevation, therefore, reference should be made to values used by other road authorities in the area.

Lateral Friction: Technical Foundation Element

The lateral friction factor f is the ratio of the lateral friction force and the component of the weight of the vehicle perpendicular to the pavement. This force is applied to the vehicle

1.2.2

Table 2.1.2.12 **Length of Superelevation Runoff for Two-Lane Crowned Urban Roadways[9]**

Superelevation Rate (m/m)	Length of Runoff (Ls) (m)							
	Design Speed (km/h)							
	40	50	60	70	80	90	100	110
3.7 m lanes								
0.02	11	12	13	14	15	16	17	18
0.04	22	23	25	27	29	32	34	37
0.06	32	35	37	41	44	48	51	55
3.5 m lanes								
0.02	10	11	12	13	14	15	16	17
0.04	20	22	24	26	28	30	32	35
0.06	30	33	35	39	42	45	48	52
Minimum Length (m) for Appearance	22	28	34	39	45	50	56	62

Notes:
1. Values above the heavy lines are less than the minimum lengths based on an appearance criterion.
2. For four-lane roadways, use Table 2.1.2.13.
3. For six-lane roadways, increase lengths by factor of 2.0.

Table 2.1.2.13 **Length of Superelevation Runoff for Four-Lane, Undivided Crowned Urban Roadways, or Two-Lane Urban Roadways Without Crown[9]**

Superelevation Rate (m/m)	Length of Runoff (Ls) (m)							
	Design Speed (km/h)							
	40	50	60	70	80	90	100	110
3.7 m lanes								
0.02	16	17	19	21	22	24	26	27
0.04	32	35	37	41	44	48	51	55
0.06	48	52	56	61	66	71	76	82
3.5 m lanes								
0.02	15	17	18	20	21	23	24	26
0.04	30	33	35	39	42	45	48	52
0.06	45	49	53	58	62	67	72	77
Minimum Length (m) for Appearance	22	28	34	39	45	50	56	62

Notes:
1. Values above the heavy lines are less than the minimum lengths based on an appearance criterion.
2. For two-lane crowned roadways, use Table 2.1.2.12.
3. For six -lane crowned roadways, increase lengths by factor of 1.33.

1.3.1

crowned urban roadways, or two-lane urban roadways with a single cross-slope.

The above tables are based on using the maximum relative slope values provided in Table 2.1.2.11, rather than the recommended minimum length for appearance purposes. As a suggested practice, minimum lengths required to maintain an acceptable general appearance and to avoid abrupt grade changes, are provided along the bottom of the tables and represent the distance travelled in 2 seconds at the design speed. The heavy line within the tables separates the lengths that are below and above the recommended design minimum lengths.

Superelevation Development: Design Domain General Application Heuristics

1. On urban roads with design speeds less than 80 km/h the length of tangent runout is normally based on the same slope as the superelevation runoff. In the case of higher speed facilities, a 1:400 slope similar to that for rural roads and high speed urban roads is used.

2. In the design of superelevation runoff for both rural and urban roads ensure that the edge profiles are smooth and without abrupt changes in grade. Short vertical curves or spline curves from 20 m to 40 m long can be used. Designers should be aware that this will often result in runoff lengths longer than the minimum suggested in the tables.

3. For added safety and comfort, the superelevation runoff should be applied uniformly over a length adequate for the likely operating speeds.

4. To be pleasing in appearance the runoff pavement edges should not be distorted as the driver views them. Spiral lengths as discussed in Subsection 2.1.2.3 are based on these criteria. For this reason when a spiral curve is used, the superelevation runoff is usually applied over the whole of the spiral length and the adverse crown is completely removed by the beginning of the spiral. For curves without spirals, the superelevation runoff is applied over a length equivalent to the spiral length. In this case the superelevation runoff is located so that 60% of the runoff occurs on the tangent approach and 40% on the curve.

Methods of Developing Superelevation: Best Practices

Two-Lane Roadways with Normal Crown

Figure 2.1.2.8 illustrates the three methods of attaining superelevation on two-lane normal crowned roadways, as described below. On curves where adverse crown is desired, but where the superelevation required does not exceed the crown slope, the superelevation should be equal to the crown slope. Information on attaining superelevation on non-crowned two-lane roadways can be obtained by referring to the divided roadway examples.

Method 1	The pavement is revolved about the centreline.
Method 2	The pavement is revolved about the inside edge.
Method 3	The pavement is revolved about the outside edge.

Method 1 is applicable to two-lane and four-lane undivided roadways. Method 2 and Method 3 are applicable to two-lane undivided roadways and four-lane divided roadways.

Method 2 is applicable if the design is required to match physical features on the roadside, to facilitate drainage or on divided highways where the median shoulder is on the inside of the curve.

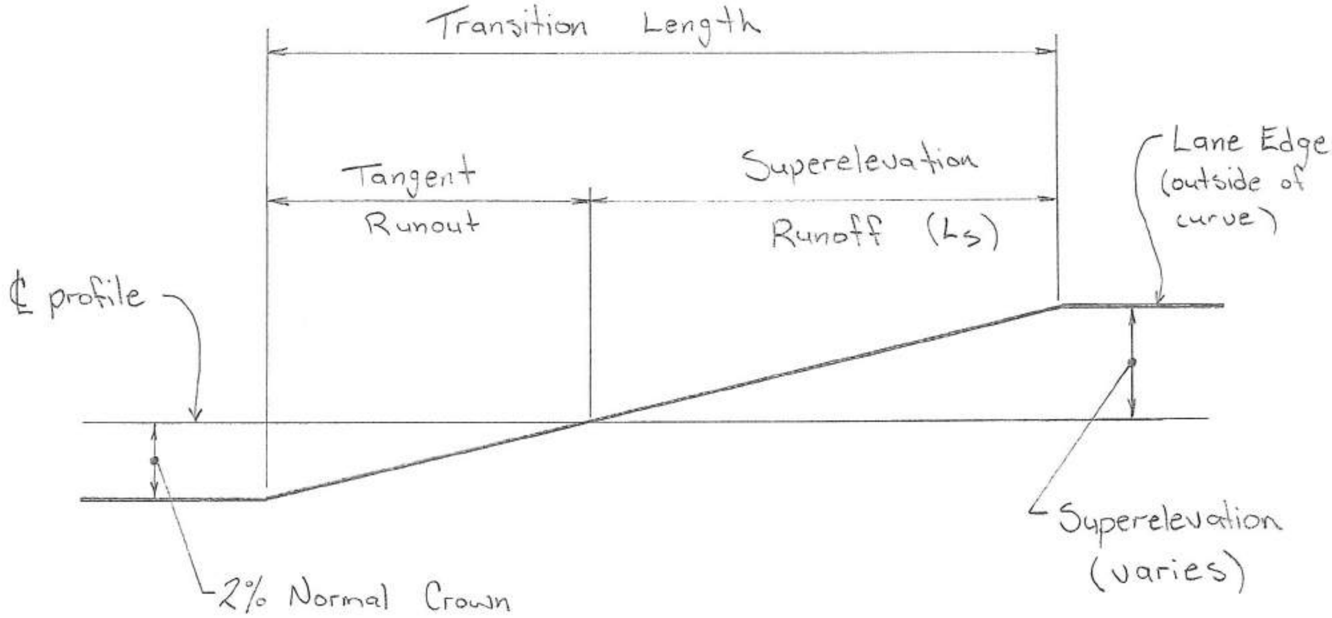
As previously discussed, the length of tangent runout is normally based on a slope of 1:400. However, in the case of low speed urban facilities the tangent runout can be made steeper, to match the slope of the superelevation runoff.

In superelevating two-lane roadways with a normal crown Method 1 is the n
approach in design becaus
change in elevation of the edg
made with less distortion tha

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria
Superelevation

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:



Superelevation Transition Schematic

(applies to all design speeds)

InterCAD

CLIENT: Ekistics / Bentall
PROJECT: Fairwinds
SUBJECT: Achievment of Superelevation - Transition Length -

SHEET: 1 OF: 5
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:

Summary - Superelevation Transition Lengths

2-Lane Roadway, 3.5m Lanes

Design Speed	NC to +2%	NC to +4%	NC to +6%
60 km/h	24 m	36m	47m
50	22 m	33 m	44 m
40	20 m	30 m	40 m
30	20 m	30 m	-

4-Lane Roadway, 3.5 m Lanes

Design Speed	NC to +2%	NC to +4%	NC to + 6%
60 km/h	36m	53m	71m
50	34 m	50 m	66 m

60 km/h Design Speed

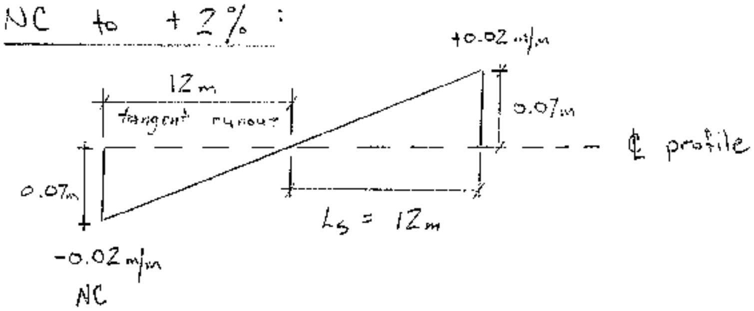
2-lane roadway, 3.5 m lanes

Superelevation runoff lengths, Table 2.1.2.12 (L_s)

NC to +2 %	12 m
NC to +4 %	24 m
NC to +6 %	35 m

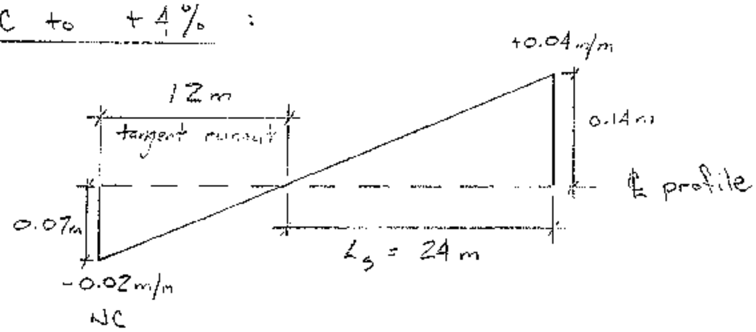
Tangent runout is based on the same slope as the superelevation runoff (page 2.1.2.27)

NC to +2 % :



transition length = 24 m

NC to +4 % :



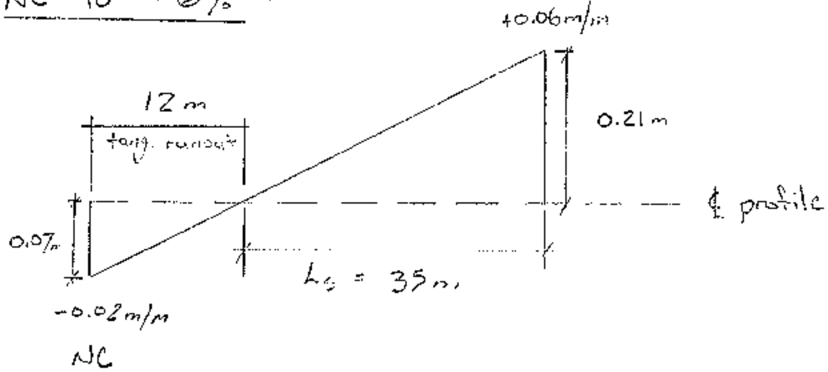
transition length = 36 m

InterCAD

CLIENT:
PROJECT:
SUBJECT:

DATE:
FILE:
BY:
CHECKED:

NC to +6% :



transition length = 47m

60 km/h Design Speed

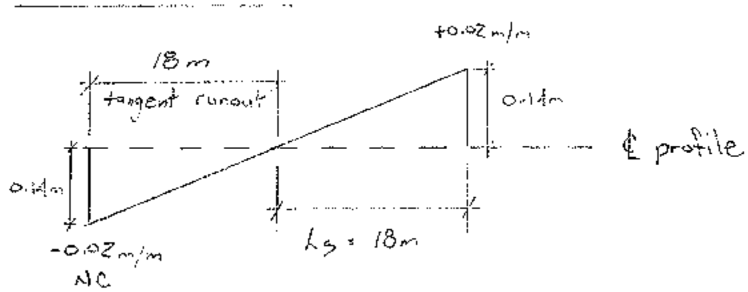
4-lane roadway, 3.5 m lanes

Superelevation runoff lengths, Table 2.1.2.13 (L_s)

NC to +2%	18 m
NC to +4%	35 m
NC to +6%	53 m

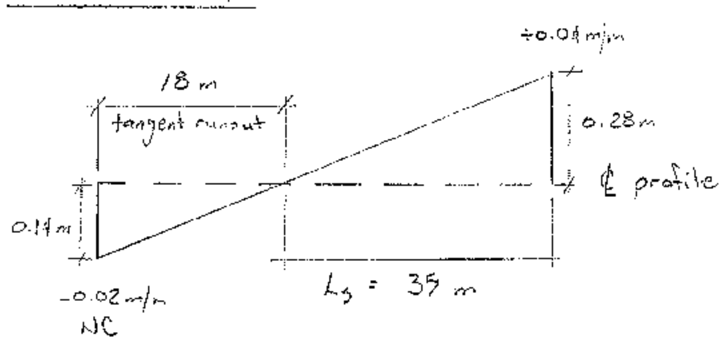
Tangent runout is based on the same slope as the superelevation runoff (page 2.1.2.27)

NC to +2%:



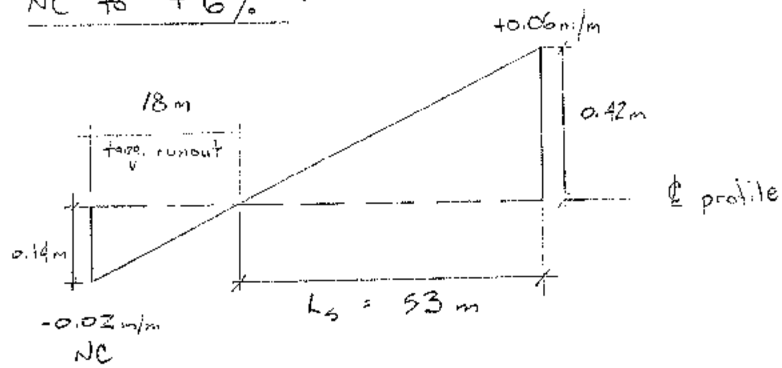
Transition length = 36 m

NC to +4%:



Transition length = 53 m

NC to +6% :



Transition Length = 71 m

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria
Superelevation

SHEET: OF:
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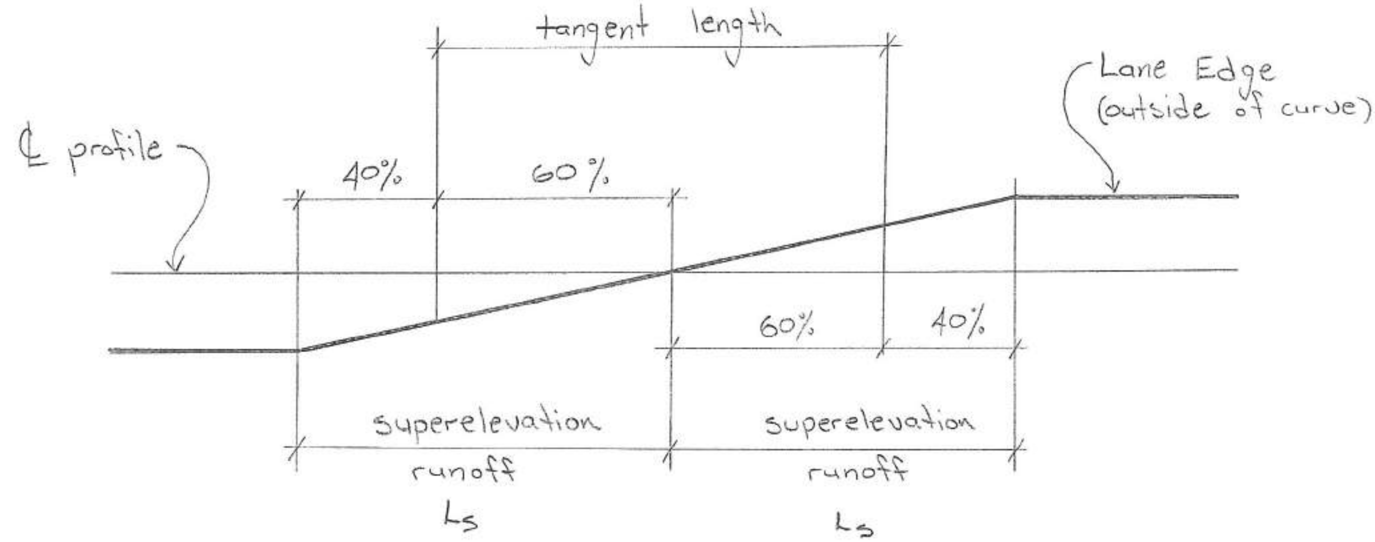
FILE: AD28
BY: SClinton
CHECKED:



Superelevation Transition Schematic between Two Reversing Curves

(applies to all design speeds)

InterCAD

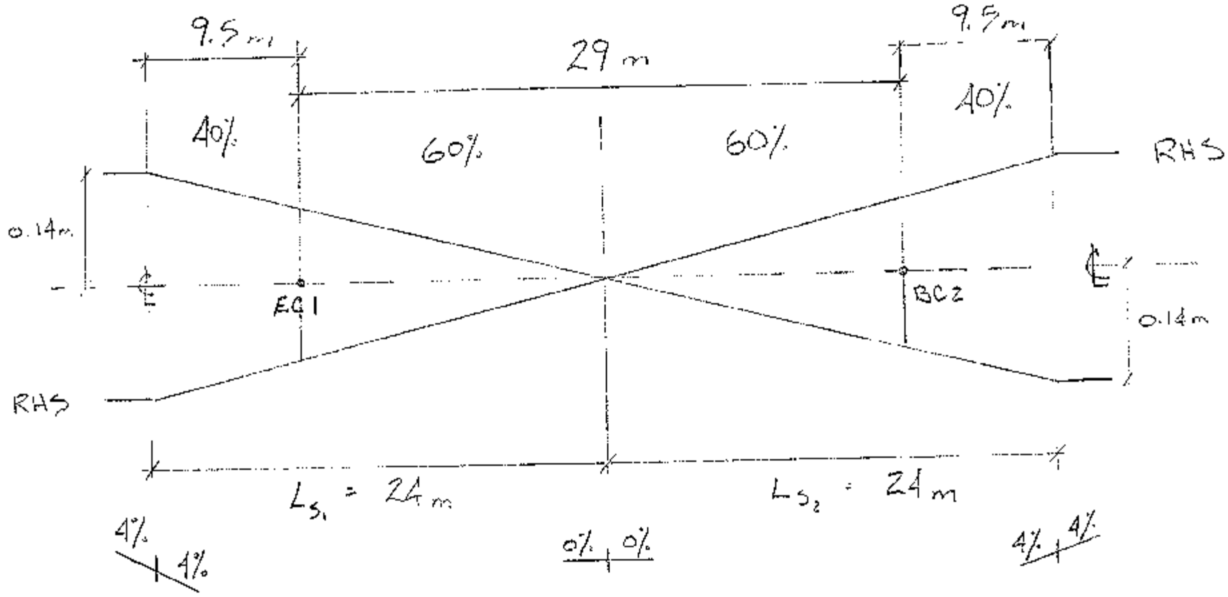
CLIENT: Ekistics / Bendall
PROJECT: Fairwinds
SUBJECT: Minimum Tangent Length Required Between Reversing Curves

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:

Design Speed = 60 km/h   Lane Width = 3.5 m

Number of Lanes = 2   Superelevation Rate = 0.04 m/m

60% of superelevation occurs on tangent approach and 40% on the curve



minimum length of tangent between successive curves = **29m**

or 120% of the L_s (superelevation runoff length)

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

1.4.1 &
1.4.2

3. Where possible, gradients lower than the maximum values shown should be used.

4. Maximum values should only be exceeded after a careful assessment of safety, cost, property and environmental implications.

5. The choice of maximum gradient may have a bearing on related design features; for example, whether or not a truck climbing lane or escape lane is required.

6. While Table 2.1.3.1 provides general guidance, the designer should be aware that the factors that should be considered in establishing the maximum grade for a section of roadway include:

    - road classification
    - traffic operation
    - terrain
    - climatic conditions
    - length of grade
    - costs
    - property
    - environmental considerations
    - in urban areas, adjacent land use

7. Maximum grades of 3 to 5% are considered appropriate for design speeds of 100 km/h and higher. This may have to be modified in regions with severe topography such as mountainous terrain, deep river valleys, and large rock outcrops.

8. Maximum grades of 7 to 12% are appropriate for design speeds of 50 km/h and lower. If only the more important roadways are considered, 7% or 8% would be a representative maximum grade for a design speed of 50 km/h.

9. Control grades for other speeds between 50 km/h and 100 km/h are intermediate between the above extremes.

Minimum Grades: Design Domain Application Heuristics

Rural Roadways

1. On uncurbed roadways, level grades are generally acceptable provided the roadway is adequately crowned, snow does not interfere with surface drainage, and ditches have positive drainage. Roadway crown is discussed in Section 2.1.5. Refer to Chapter 2.2 for guidelines for the design of roadside open ditches and to relevant drainage publications.

Curbed Roadways (generally in urban areas)

1. To ensure adequate drainage, curbed roadways typically have a minimum longitudinal grade of 0.50% or 0.60%, depending on local policy.

2. In certain rare design cases, when no other alternative is feasible, a grade of 0.30% may be used as an absolute minimum preferably in combination with highly stable soils and rigid pavements.

3. For retrofit projects, longitudinal grades below the normal minimum of 0.50% or 0.60% may be considered where flatter grades allow the retention, rather than the removal, of existing pavements.

4. The minimum gradients outlined are suitable for normal conditions of rainfall and drainage outlet spacing. Where less than the normal minimum gradient is utilized, the lengths of such grades should be limited to short distances, and their location and frequency become important considerations. In special cases, hydraulic analysis is required to determine the extent of water spread on the adjacent travel lane. False grading, (where the pavement grade is not parallel to the top of [illegible] adequate drainage is an [illegible] of maintaining minimun [illegible] highly constrained areas. [illegible] addressed in Section 2.1. [illegible]

1.4.3

Maximum Grade: Design Domain Quantitative Aids

Although the relationship between design speeds and maximum grade is relatively subjective, reasonable guides for maximum grade have been developed.

The guidelines for maximum gradients are given in Table 2.1.3.1.

Maximum Grade: Design Domain Application Heuristics

1. The range of values shown in Table 2.1.3.1 recognizes that maximum grade selected for design varies with topography and the general financial capability of the road authority to fund the capital works. For lower classification urban roads, land use is an additional consideration and land use is incorporated into the guidelines for urban local and urban undivided collectors.

2. The values shown may be adjusted to suit local and economic conditions. Maximum gradients by classification and land use are often a matter of policy, and as a result, vary from jurisdiction to jurisdiction. Normally, the local policy is established at a senior engineering and planning level. In any event, in adjusting these figures, designers should ensure that they explicitly consider the impact of such alternative maximum grade values on safety.

Table 2.1.3.1 Maximum Gradients[1,9]

Design Speed (km/h)	30/40/50		60		70		80		90		100		110		120/130	
Topography	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M
RLU	7	11	7	11	6	9	6	8	5	7	5	7	-	-	-	-
RCU	-	-	6	10	6	9	5	8	5	7	5	7	-	-	-	-
RCD	-	-	-	-	6	9	5	8	5	7	5	7	-	-	-	-
RAU	-	-	-	-	-	-	4	7	4	6	3	6	3	6	3	5
RAD	-	-	-	-	-	-	4	7	4	6	3	6	3	5	3	5
RFD	-	-	-	-	-	-	-	-	-	-	3	5	3	5	3	5
ULU – Residential	8	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ULU – Industrial/ Commercial	6	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UCU – Residential	8	12	7	11	7	10	-	-	-	-	-	-	-	-	-	-
UCU – Industrial/ Commercial	6	12	6	11	6	9	6	8	-	-	-	-	-	-	-	-
UCD	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAU	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAD	-	-	3	6	3	6	3	6	3	6	3	5	-	-	-	-
UED	-	-	-	-	-	-	5	6	4	5	4	5	4	5	3	5
UFD	-	-	-	-	-	-	-	-	4	5	3	5	3	5	3	5

Notes:
1. Short grades less than 150 m in length, and one-way down grades may be 1% higher on urban roads, and 2% higher on low volume rural roads.
2. R refers to rolling topography.
3. M refers to mountainous topography.

1.4.4

roadway through the intersection. The concept for this type of adjustment is illustrated on Figures 2.3.2.5 and 2.3.2.6.[1] Although desirable, it is not always feasible to locate a high point at the centre of the intersection as shown on the Figures. Thus variations of the concept are needed to suit the vertical alignment characteristics of the intersection. Appropriate vertical curves are incorporated into the centreline profiles of both major roadways to achieve the desired grade adjustments. The edge of pavement profiles are often determined by using a spline, since calculated vertical curves do not always fit the constraints. A spline is a flexible drafting tool used to draw curved lines. A splined edge of pavement line provides a "best fit" curve which ensures that drainage is adequate, cross-slope is suitable and that the change in grade is not too abrupt.

Grade Breaks

Significant grade changes are not desirable within and near intersections which could affect the control and operation of a vehicle passing through the intersection at the expected operating speed. Grade breaks at intersections in the order of 0.5% to 2% are typical for a design speed of 70 km/h or higher. For lower design speeds more substantial grade breaks can be accommodated if required for the specific conditions. At a design speed of 50 km/h, a maximum grade change in the order of 3% to 4% produces some discomfort for vehicular traffic but is normally not detrimental to the safe operation of the intersection, provided that the stopping sight distance for the design speed is achieved. For speeds of 30 km/h or less, grade breaks up to 6% could be used, if required.

Grades

The grades of intersecting roadways in the area of the intersection should be as flat as possible to accommodate:

- storage space for stopped vehicles
- desirable sight distance (see Section 2.3.3)
- accelerating and stopping distance

Appropriate minimum grades at intersections are important to facilitate drainage, to avoid operational safety concerns related to ponding or icing conditions, and to compensate for some pavement wear and differential settlements. Particular attention should be devoted to the grading design of curb returns and to the calculation of roadway surface water runoff in an urban environment where there are large paved surfaces at intersections. Suggested guidelines include a minimum grade of 0.5% along curb returns (urban section), and a minimum of 1.0% combined cross-slope and roadway gradient within the limits of the intersection (rural and urban sections).

Existing driveways and accesses are often a constraint in setting grade lines on intersection approaches.

Along the approach legs to the intersection where vehicles are expected to stop, such as at left- and right-turn lanes or where signals are or may in the future be warranted, it is desirable to keep grades between 0.5% and 3%. A grade as low as 0.15% may be considered as long as adequate drainage is provided through cross-slope to avoid ponding. The calculated stopping and accelerating distance for a passenger car on a grade requires correction to produce conditions equivalent to those on level roadways (see Chapter 1.2). In addition, acceleration and deceleration tapers and/or lane lengths should be adjusted for steeper grades. Most vehicle operators are unable to judge the increase or decrease in stopping or accelerating distance that is necessary because of steep grades. Their normal deductions and reactions thus may be in error at a critical time. Accordingly, grades in excess of 3% are not desirable through an intersection. For low-volume, low-speed intersections, such as at the intersection of two local residential roads where physical conditions and economic considerations dictate, approach grades of 5% to 6% may be considered as long as acceptable site distance is provided along with an adjustment in design factors. The gradient within the intersection is normally limited to 4%. This limitation assists in providing reasonable operation for low-speed turning vehicles, particularly under slippery conditions.

1.4.6

When establishing the profile for the minor cross road, it is important to consider whether or not the intersection may be signalized in the future. If signalization is probable, the minor roadway should be designed to accommodate future free-flow traffic which would occur under green-signal conditions.

The approach/departure grade should ideally extend approximately 20 m back from intersections, although this can be reduced to one or two car lengths on minor roadways with light traffic volumes.

In addition to the vertical alignment and cross-slope considerations, the horizontal alignments of approach roadways are normally kept as simple and smooth as possible. It is desirable to ensure that the combination of horizontal alignment and vertical profile allows good visibility of the intersection area from all approaches. This allows drivers to focus their attention on the intersection area, where most conflicts occur.

2.3.2.4 Combined Vertical and Horizontal Alignments

The combination of horizontal and vertical alignment at, and near an intersection will ideally produce traffic lanes that are clearly visible to operators at all times. They should be clearly comprehensible for any desired direction of travel, free from the sudden appearance of potential conflicts, and consistent with the roadway just travelled.[11]

When the superelevation of a section of roadway on a curve is in the same direction as the grade of the intersecting cross road, the vertical alignment of the cross roadway is adjusted to meet the normal pavement cross-slope of the roadway as shown in Illustration A of Figure 2.3.2.7.

For intersections on curve, the selection of an appropriate radius is a function of the design speed of the through roadway with consideration given to the grade of the crossing roadway through the intersection. For example, for a crossing roadway with a grade of 3% through an intersection, the superelevation of the intersecting roadway on curve should also be 3% to provide a smooth crossing of the through roadway by the crossing road driver. Therefore, for a design speed of 80 km/h, the desirable radius for the through roadway curve is 1200 m, with superelevation of 0.028 m/m (based on e_{max} = 0.06 m/m), according to Chapter 2.1.

However, through an intersection on curve in an urban environment, drivers are willing to accept higher lateral friction than in open conditions. As such, a smaller radius curve could be used for a desired rate of superelevation to match the crossing roadway grade through the intersection under certain constrained conditions. In a rural environment, higher lateral friction is less desirable, due to greater driver expectations in terms of roadway performance. This is discussed further in Subsection 2.3.2.5.

An intersection where the cross-slope of the curving roadway is not in the same direction as the grade of the intersecting cross roadway is not desirable. If this condition cannot be avoided, the vertical alignment of the cross roadway is adjusted a sufficient distance from the intersection to introduce a desirable alignment as indicated in Illustration B of Figure 2.3.2.7. As discussed in Subsection 2.3.2.3, grade breaks over 4% are not desirable due to discomfort to vehicular traffic; however, if necessary, the break can approach 6% for minor roadways.

Minimum design parameters for both the vertical and horizontal alignment elements are undesirable in intersection design. If a limiting or near limiting condition cannot be avoided for one element, it is desirable to ensure that the other elements are well above the minimum design guidelines. Thus intersections are generally not preferred on sharp horizontal curves with significant superelevation. Superelevation rates in excess of 0.04 m/m through intersection areas adversely affect the smooth operation, particularly for those vehicles turning against the superelevation.

Similarly, steep gradients in (1.4.7
badly skewed intersections
horizontal curves often cre

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Grades at Intersections
60 km/h on Through Road

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
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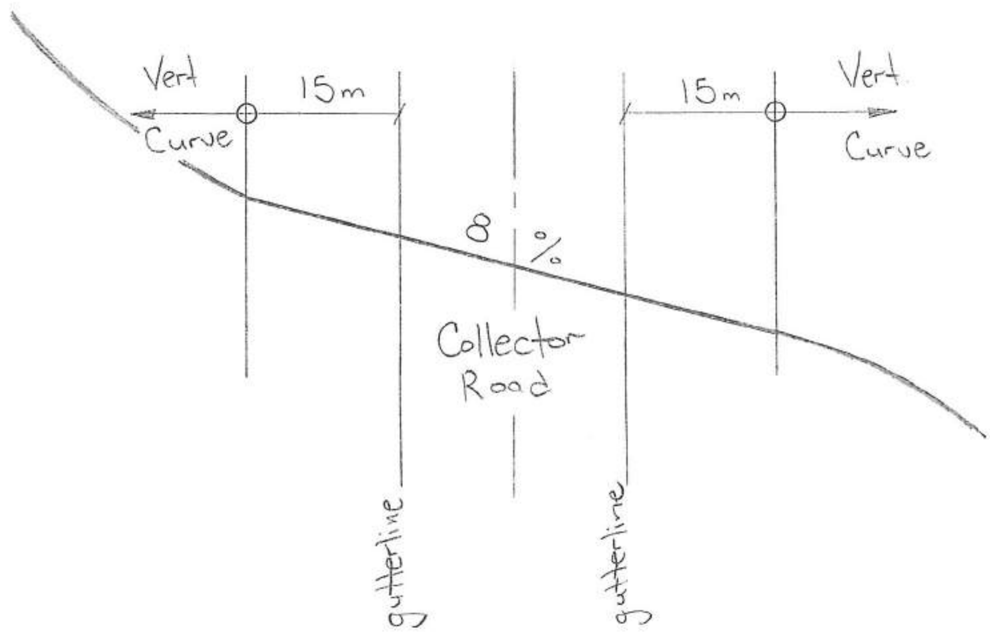

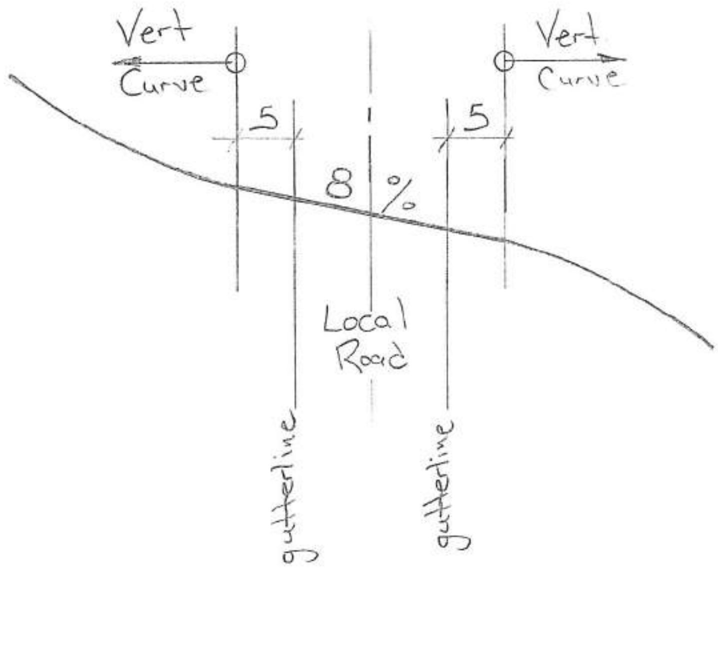

1.4.8

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Grades at Intersections
60 km/h and Stop Condition

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: S Clinton
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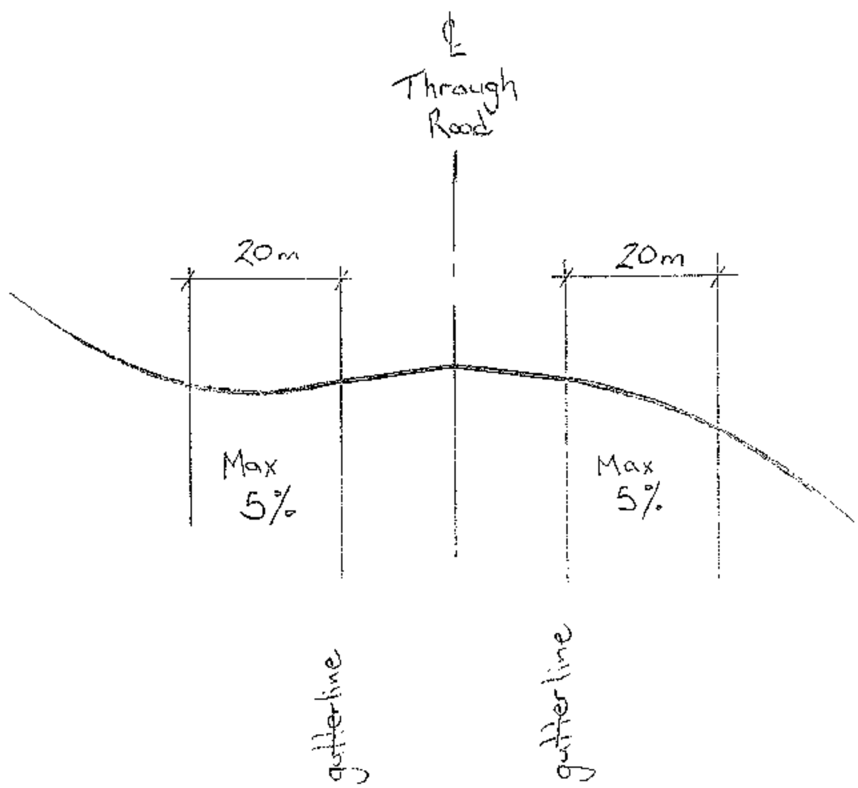

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B.**

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

1.5.1

In calculating K values for various sight distances, the height of driver's eye is 1.05 m, and the height of object is as outlined following, and discussed in more detail in Chapter 1.2.

- For stopping sight distance the most common object a vehicle has to stop for is another vehicle ahead on the road, the height of tail light is used. The legislated minimum is 0.38 m and is adopted for design. Other heights of objects can be used if necessary.
- For decision sight distance the more common height of object is 0.15 m, although other heights, such as zero for pavement markings, are not uncommon.
- For passing sight distance the height of object is 1.30 m, which represents the height of the opposing vehicle.

Crest Vertical Curves: Design Domain Quantitative Aid

Based on the above most commonly used heights of object, and on sight distances from Tables 1.2.5.3 and 1.2.5.5, the K values for stopping sight distance are provided in Table 2.1.3.2 and for passing sight distance the K values are provided in Table 2.1.3.3. The decision sight distance K values are not included because the vertical curvature depends on the height of object which is variable (depending on what the driver has to see).

The calculated K values are based on the length of curve exceeding the sight distance and they can be used without significant error when the length of curve is less than the sight distance. Appreciable differences occur only where A is small and little or no additional cost is involved in obtaining longer vertical curves.

On undivided roads non-striping sight distance is used to determine when no-passing pavement markings are required[7]. It is desirable to provide passing sight distance wherever possible but non-striping sight distance is generally adequate for safe passing manoeuvres.

Non-striping sight distance is less than passing sight distance, at each design speed. Passing manoeuvres can be completed in less than the full passing sight distance because of the timing of oncoming vehicles.

Table 2.1.3.2 K Factors to Provide Stopping Sight Distance on Crest Vertical Curves

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Vertical Curvature (K) Computed	Rate of Vertical Curvature (K) Rounded
30	30	29.6	1.6	2
40	40	44.4	3.7	4
50	47-50	57.4-62.8	6.1-7.3	6-7
60	55-60	74.3-84.6	10.2-13.3	10-13
70	63-70	94.1-110.8	16.4-22.8	16-23
80	70-80	112.8-139.4	23.6-36.1	24-36
90	77-90	131.2-168.7	32.0-52.8	32-53
100	85-100	152.0-205.0	45.8-78.0	45-80
110	91-110	179.5-246.4	59.8-112.7	60-110
120	98-120	202.9-285.6	76.4-151.4	75-150
130	105-130	227.9-327.9	96.4-199.6	95-200

Note: The above are minimum values, use higher K factors whenever possible.

1.5.2

Table 2.1.3.4 **K Factors to Provide Minimum Stopping Sight Distance on Sag Vertical Curves**[1]

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Sag Vertical Curvature (K)			
			Headlight Control		Comfort Control	
			Calculated	Rounded	Calculated	Rounded
30	30	29.6	3.9	4	2.3	2
40	40	44.4	7.1	7	4.1	4
50	47-50	57.4-62.8	10.2-11.5	11-12	5.6-6.3	5-6
60	55-60	74.3-84.6	14.5-17.1	15-18	7.7-9.1	8-9
70	63-70	99.1-110.8	19.6-24.1	20-25	10.0-12.4	10-12
80	70-80	112.8-139.4	24.6-31.9	25-32	12.4-16.2	12-16
90	77-90	131.2-168.7	29.6-40.1	30-40	15.0-20.5	15-20
100	85-100	157.0-205.0	36.7-50.1	37-50	18.3-25.3	18-25
110	91-110	179.5-246.4	43.0-61.7	43-62	21.0-30.6	21-30
120	98-120	202.9-285.6	49.5-72.7	50-73	24.3-36.4	24-36
130	105-130	227.9-327.9	56.7-85.0	57-85	27.9-42.8	28-43

Values for sag curvature based on the comfort criterion are shown in Table 2.1.3.4.

These K values for sag curves are useful in urban situations such as underpasses where it is often necessary for property and access reasons to depart from original ground elevations for as short a distance as possible. Minimum values are normally exceeded where feasible, in consideration of possible power failures and other malfunctions to the street lighting systems. Designing sag vertical curves along curved roadways for decision sight distance is normally not feasible due to the inherent flat grades and resultant surface drainage problems.

2.1.3.4 Vertical Alignment: Design Domain Additional Application Heuristics

Vertical Alignment Principles: Application Heuristics

The following principles generally apply to both rural and urban roads. A differentiation between rural and urban is made in several instances where necessary for clarity.

1. On rural and high speed urban roads a smooth grade line with gradual changes, consistent with the class of road and the character of the terrain, is preferable to an alignment with numerous breaks and short lengths of grade. On lower speed curbed urban roadways drainage design often controls the grade design.
2. Vertical curves applied to small changes of gradient require K values significantly greater than the minimum as shown in Tables 2.1.3.2 and 2.1.3.4. The minimum length in metres should desirably not be less than the design speed in kilometres per hour. For example, if the design speed is 100 km/h, the vertical curve length is at least 100 m.
3. Vertical alignment, having a series of successive relatively sharp crest and sag curves creating a "roller coaster" or "hidden dip" type of profile is not recommended. Hidden dips can be a safety concern, particularly at night. Such profiles generally occur on relatively straight horizontal alignment where the roadway profile closely follows a rolling natural ground line. Such roadways are unpleasant aesthetically and more difficult to drive. This type of profile is avoided by the use of horizontal curves or by more gradual grades.
4. A broken back grade line curves in the same directio a short section of tangent

1.5.3

Table 1.2.5.2 Coefficient of Friction for Wet Pavements[4]

Design Speed (km/h)	Operating Speed [a] (km/h)	Coefficient of Friction (f)
30	30	0.40
40	40	0.38
50	47-50	0.35
60	55-60	0.33
70	63-70	0.31
80	70-80	0.30
90	77-90	0.30
100	85-100	0.29
110	91-110	0.28
120	98-120	0.28
130	105-130	0.28

Note: [a] The range of operating speeds recognises that some drivers slow down in wet conditions: others do not.

applied. On a level roadway this distance can be determined using the following formula:

$$d = \frac{V^2}{2gf} = \frac{V^2}{2(9.81)f} \times \left(\frac{1000}{3600}\right)^2 = \frac{V^2}{254f} \quad (1.2.4)$$

Where d = braking distance (m)

V = initial speed (km/h)

f = coefficient of friction between the tires and the roadway

Then SSD = 0.278tV + d (1.2.5)

Where SSD = stopping sight distance (m)

t = perception and reaction time (s)

Table 1.2.5.3 gives the minimum stopping sight distances on level grade, on wet pavement, for a range of design speeds. These values are used for vertical curve design, intersection geometry and the placement of traffic control devices.

The stopping sight distances quoted in Table 1.2.5.3 may need to be increased for a variety of reasons, related to grade, vehicle braking capability and pavement condition.

Variation for Trucks

Geometric characteristics to achieve stopping sight distance requirements vary because of differences in driver eye height and braking characteristics. While a truck driver can generally see further than a passenger car driver due to an eye height advantage, in some instances the higher eye height is a disadvantage — for example, a sag vertical curve where visibility is "cut off" by an overpass. Truck braking characteristics are highly variable and often increase effective braking distance and, thus, stopping sight distance.

A number of tests[8] have been conducted using trucks with conventional brakes and antilock brakes, and drivers with varying levels of experience in handling emergency t situations. The use of antilock brakes wa to consistently reduce braking distan minimising variations in driver performar

1.6

Table 1.2.5.3 Stopping Sight Distance for Automobiles[4] and Trucks with Antilock Braking Systems[8]

Design Speed (km/h)	Assumed Operating Speed* (km/h)	Perception and Reaction time (s)	Perception and Reaction distance (m)	Coefficient of Friction	Braking Distance (m)	Stopping Sight Distance (rounded) (m)
40	40	2.5	27.8	0.38	16.6	45
50	47 - 50	2.5	32.7 - 34.7	0.35	24.8 - 28.1	60 - 65
60	55 - 60	2.5	38.2 - 41.7	0.33	36.1 - 42.9	75 - 85
70	63 - 70	2.5	43.7 - 48.6	0.31	50.4 - 62.2	95 - 110
80	70 - 80	2.5	48.6 - 55.5	0.30	64.2 - 83.9	115 - 140
90	77 - 90	2.5	53.5 - 62.5	0.30	77.7 - 106.2	130 - 170
100	85 - 100	2.5	59.0 - 69.4	0.29	98.0 - 135.6	160 - 210
110	91 - 110	2.5	63.2 - 76.4	0.28	116.3 - 170.0	180 - 250
120	98 - 120	2.5	68.0 - 83.3	0.28	134.9 - 202.3	200 - 290
130	105-130	2.5	72.9 - 90.3	0.28	155.0 - 237.6	230 - 330

Note: * Range of assumed operating speed is from average running speed for low-volume conditions to design speed.

utilizing more of the available friction. In fact, the results indicated that the stopping sight distances from Table 1.2.5.3 would be adequate if antilock brakes were in general use on trucks.

Table 1.2.5.4 shows stopping sight distances for trucks with conventional brakes, and compares them to the stopping sight distances given in Table 1.2.5.3.

The increased stopping sight distances for trucks with conventional brakes (i.e. the majority of the current fleet) are generally offset by increased driver eye height for the purposes of vertical curve calculations. However, where driver eye height is not an advantage, such as on horizontal curves or approaching controlled intersections, the greater stopping sight distances should be used.

Sight restrictions such as shrubs, trees, cut slopes, or buildings may occur on the inside of horizontal curves. Although truck drivers have higher eye heights, the required truck driver sight distance may not be offset by the higher eye height unless the obstructions are physically below the driver's line of sight.

The Effect of Grade

Braking distances will increase on downgrades and decrease on upgrades. When the roadway is on a grade, the formula for braking distance is:

$$d = \frac{V^2}{254\,(f \pm G)} \qquad (1.2.6)$$

Where G = the percent grade divided by 100 (up is positive, down is negative) and all other terms are as noted in Equation 1.2.4.

1.6

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

1.6.1

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

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Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
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Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

1.7.1

Because decision sight distance allows drivers to manoeuvre their vehicles or vary their operating speed rather than stop, decision sight distance is much greater than stopping sight distance for a given design speed.

Designers should use decision sight distance wherever information may be perceived incorrectly, decisions are required or where control actions are required. Some examples of where it could be desirable to provide decision sight distance are:

- complex interchanges and intersections
- locations where unusual or unexpected manoeuvres occur
- locations where significant changes to the roadway cross section are made
- areas where there are multiple demands on the driver's decision making capabilities from: road elements, traffic control devices, advertising, traffic, etc.
- construction zones

Table 1.2.5.6 shows the range of values for decision sight distance. The decision sight distance increases with the complexity of the evasive action that is taken by the driver and with the complexity of the surroundings.

The values for decision sight distance given in Table 1.2.5.6 have been developed from empirical data. When using these sight distances, the designer should consider eye and object heights appropriate for specific applications.

Table 1.2.5.6 Decision Sight Distance[4]

Design Speed (km/h)	Decision Sight Distance for Avoidance Manoeuvre (m)				
	A	B	C	D	E
50	75	160	145	160	200
60	95	205	175	205	235
70	125	250	200	240	275
80	155	300	230	275	315
90	185	360	275	320	360
100	225	415	315	365	405
110	265	455	335	390	435
120+	305	505	375	415	470

Notes:
Avoidance Manoeuvre A: stop on rural roadway.
Avoidance Manoeuvre B: stop on urban roadway.
Avoidance Manoeuvre C: speed/path/direction change on rural roadway.
Avoidance Manoeuvre D: speed/path/direction change on suburban roadway.
Avoidance Manoeuvre E: speed/path/direction change on urban roadway.

1.7.2

50km/h

Table 2 : Alignment Design Criteria Summary : 50 km/h Design Speed

1. Horizontal Curve Radii

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Roadway Crossfall			
normal crown (-2%)	-	104m [2]	105m
2% superelevation	-	86m [2]	90m
4% superelevation	-	80m [2]	80m
6% superelevation	75m [1]	-	N/A
Through Intersections	-	-	120m [3]

1 Table 1420.A - Design Parameters
2 Calculated minimum radius for low speed urban design based on Table 2.1.2.2, Page 2.1.2.7 TAC manual which is consistent with AASHTO Method 2 for distribution of e & f.
3 Applies to the through road only; Subject to applicable sight distance requirements.

2. Superelevation

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Maximum Superelevation	4% [1]	4% [2]	4%
Maximum Superelevation at Intersections	-	-	4%

1 Table 1420.A - Design Parameters: parameters based on E max 0.06 m/m, however, Section 1420.05.08 - Superelevation notes that a maximum rate of 0.04m/m shall be used for local urban streets.
2 See Section 2.1.2.2 - Maximum Superelevation, Page 2.1.2.4 TAC manual.

3. Superelevation Transition Lengths

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Transition Lengths (2 / 4-lane roadways)			
normal crown to +2%	-	22m / 34m [1]	22m / 34m
normal crown to +4%	-	33m / 50m [1]	33m / 50m
normal crown to +6%	-	44m / 66m [1]	N/A
Min Tangent Length between reversing curves			
2% superelevation (2 / 4-lane roadways)	-	13m / 20m [2]	13m / 20m
4% superelevation	-	26m / 40m [2]	26m / 40m

1 Lengths based on Tables 2.1.2.12 and 2.1.2.13, Page 2.1.2.26 TAC manual, using 3.5 m lanes. Values shown include tangent runout applied at the same rate as superelevation runoff.
2 Values based on Section 2.1.2.4 - Development of Superelevation, and Tables 2.1.2.12 and 2.1.2.13, Pages 2.1.2.25 and 2.1.2.26 TAC manual. 60% of superelevation runoff occurs on the tangent approach and 40% on the curve, resulting in a minimum length of tangent between reversing curves of 120% of the superelevation runoff length.

4. Gradients

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Grade	-	0.5% [3]	0.5%
Maximum Grades			
on horizontal tangents	8% [1]	12% [4]	11%
on minimum radius horizontal curves	6% [2]	-	10%

4. Gradients (cont'd)

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Grades Through Intersections			
Through condition	-	-	8%
approach distance for through road [5]	-	-	5m
Stop condition	-	3% (desirable) [6] 6% (maximum)	5%
approach distance for stopping road [5]	-	20m [7]	15m

1 Table 1420.A - Design Parameters
2 Grades reduced by 1% for every 30 metres that the centreline radius is less than 150m. As the minimum centreline radius is 120m (at 6% superelevation), the maximum grade is reduced by 2%.
3 See Section 2.1.3.2 - Minimum Grades, Page 2.1.3.3 TAC manual.
4 See Table 2.1.3.1 - Maximum Gradients, Page 2.1.3.2 TAC manual.
5 Minimum distance back from the gutter line of the intersecting road that the intersection grade must apply.
6 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Pages 2.3.2.8 TAC manual.
7 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Pages 2.3.2.11 TAC manual. Approach / departure grade can be reduced to one or two car lengths on minor roadways with light traffic volumes.

5. Vertical Curve K Values

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Crest	7 [1]	7 [2]	8
Minimum Sag	12 [1]	6 [3]	7
Crest / Sag on approach to stop condition	-	-	3 [4]

TAC and Proposed K values listed assume that new roadways will be illuminated

1 Table 1420.A - Design Parameters: crest based on taillight height, sag based on headlight control (ie no street lighting). Section 1420.05 - Alignment notes that length of vertical curve (in m) should not be less than the design speed (in km/h).
2 See Table 2.1.3.2 - Crest Vertical Curves, Page 2.1.3.6 TAC manual.
3 See Table 2.1.3.4 - Sag Vertical Curves, Page 2.1.3.9 TAC manual.
4 A K value of 3 (35 km/h design speed) is proposed for developing vertical curves at approach platforms on the minor road at an intersection as vehicles will be slowing from design speed as they approach the stop condition.

6. Stopping Sight Distances

Criteria	Down Grades				0%	Up Grades			
	12%	9%	6%	3%		3%	6%	9%	12%
Minimum distance (m)	78	73	69	66	63 [1]	61	59	57	56

All values, see Section 1.2.5.2 - Stopping Sight Distance, Pages 1.2.5.3 and 1.2.5.4 TAC manual.

1 Only SSD given for level grade in MoT Supplement, Section 1400, Table 1420.A - Design Parameters. MoT Value = 65m

7. Decision Sight Distances

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum decision sight distance:	75m - 145m [1]	145m - 200m [2]	75m - 145m

1 Table 1420.A - Design Parameters: Lower DSD values are appropriate at intersections within a subdivision, while higher values should be used at more complex intersections.
2 See Table 1.2.5.6 - Decision Sight Distance, Page 1.2.5.8 TAC manual. Values shown are for a UCU classification.

The range of values recognizes the variation in complexity that occurs at various sites. For less complex situations, values towards the lower end of the range are appropriate and for more complexity, values at the upper end are used. See Section 1.2.5.4, Page 1.2.5.7 TAC manual. - Note that decision sight distance applies only to multi-lane roads at intersections.

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

Table 2.1.2.1 Maximum Lateral Friction for Rural and High Speed Urban Design[1]

Design Speed (km/h)	Maximum Lateral Friction for Rural and High Speed Urban Design
40	0.17
50	0.16
60	0.15
70	0.15
80	0.14
90	0.13
100	0.12
110	0.10
120	0.09
130	0.08

margin of safety against skidding under normal driving conditions in the urban environments. Values are presented in Table 2.1.2.2.

Minimum Radius: Design Domain

Overview

The minimum allowable radius for any design speed depends on the maximum rate of superelevation and the lateral friction force that can be developed between the pavement and vehicle tires. This relationship is expressed by:

$$R_{min} = \frac{V^2}{127(e_{max} + f_{max})} \quad (2.1.2)$$

Table 2.1.2.2 Maximum Lateral Friction for Low Speed Urban Design[1]

Design Speed (km/h)	Maximum Lateral Friction for Low Speed Urban Design
30	0.31
40	0.25
50	0.21
60	0.18

For rural and urban high speed superelevation applications there is generally reasonable opportunity to provide the desirable amount of superelevation. In rural areas the constraints are usually minimal, while on high speed urban roadways the designer has reasonable flexibility in establishing suitable superelevation. This is because in the design of new streets, particularly those with design speeds of 70 km/h or more and through generally undeveloped areas, the designer typically has greater flexibility in establishing suitable horizontal and vertical alignments and associated superelevation rates. Often it is possible to regrade adjacent properties to match superelevated sections, ensuring appropriate drainage patterns and intersection profiles.

Rural and High Speed Urban Applications: Design Domain Quantitative Aids

For rural and high speed urban applications the minimum radius is calculated using a maximum superelevation rate of either 0.04 m/m, 0.06 m/m or 0.08 m/m for a range of design speeds from 40 km/h to 130 km/h, and lateral friction factors from Table 2.1.2.1. These calculated values are shown in Table 2.1.2.3.

Low Speed Urban Applications: Design Domain Quantitative Aids

For low speed urban conditions and where a street is to be upgraded through a developed urban area, it is often not desirable or possible to utilize superelevation rates typical of high speed design as previously discussed. Design considerations other than driver discomfort may be important. Existing physical controls, right-of-way constraints, intersections, driveways, on-street parking, and economic considerations have a strong influence on design elements, including design speed and superelevation. In some cases, design speed may not be an initial design control, but rather a result of the other controls or considerations influencing the horizontal alignment and superelevation.

Moreover, in low speed urban conditions drivers are accustomed to a gr discomfort while traversing cu increased lateral friction factors r

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

2.2.1

1420.05.05 Frontage Roads

The Right-Of-Way width shall be 15 metres or the cross section width plus 3 metres, whichever is greater. (This is additional to the through road requirements.) Ensure sufficient setback at intersections to accommodate turn slots, etc., thus ensuring a bulbed connection is necessary at all frontage road intersections.

1420.05.06 Backage Roads

For these standards, backage roads shall be considered local roads.

1420.05.07 Cross Slopes

All roadways shall be constructed using a centerline crown and shall be graded and compacted with the following crossfall to ensure road drainage:

- Normal cross slopes shall be 2% for paved roads and 4% for gravel roads.

1420.05.08 Superelevation

Superelevation is generally not applied on local subdivision roads or cul-de-sacs; reverse crown is usually maintained in $\leq$ 800 metre radius curves @$\leq$ 50 km/h. Rural roads of a continuous nature that provide access to a subdivision would be better classified as Low-volume roads and should be superelevated accordingly. Refer to the Low-volume Road Chapter of the BC Supplement to TAC. When the decision has been made to superelevate curves, a maximum rate of 0.04 m/m shall be used for local urban street systems. This is appropriate for design speeds up to 70 km/h and where surface icing and interrupted traffic flow are expected. Superelevation rates of 0.04 m/m and 0.06 m/m are applicable for design of new urban streets in the upper range of the classification system where uninterrupted flow is expected and where little or no physical constraints exist.

1420.06 INTERSECTIONS/ACCESSES

1420.06.01 General

Intersections shall be as near as possible to right angles. The minimum skew angle of the intersection shall be 70 degrees and the maximum skew angle shall be 110 degrees.

1420.07 UTILITY SETBACK

Utility poles or signs should be within 2 metres of the property boundary or a minimum 2 metres beyond the toe of the fill, whichever gives the greater offset from the road. See Figure 1420.C.

1420.08 DRIVEWAYS

1. Driveway location, spacing and approval shall be at the discretion of the Ministry Representative.

2. The first 5 metres (measured from the ditch centerline) of all residential driveways shall be constructed at or near a right angle (70° to 110°) to the road and at a maximum ± 2 % grade.

3. All open shoulder driveways with a level or rising grade are to be constructed with a "valley" or "swale" over the ditch line to ensure surface water enters the ditch and does not enter the road. See Figure 1420.N

4. Driveway grades shall not exceed 8% within the Right-of-Way.

5. Driveway radius and widths:
   Residential/Farm – 6 metre radius and minimum width
   Logging/Commercial – 9 metre radius and minimum width

6. All lots with cuts or fills greater than 1.8 metres shall have engineered drawings when requested by the Ministry representative.

2.2.1

weather conditions, or for other reasons, while not adversely affecting higher speed vehicles. This is especially important for roads located where winter conditions prevail several months of the year.

Urban Areas: Design Domain Quantitative Aids

In urban areas maximum superelevation values cover the range from 0.02 m/m to 0.08 m/m. Values commonly used for maximum superelevation are:

1. Locals - generally normal crown.
2. Collectors - used occasionally with maximum rates of 0.02 m/m or 0.04 m/m.
3. Minor arterials - 0.04 m/m to 0.06 m/m.
4. Major arterials - 0.06 m/m.
5. Expressways and freeways - 0.06 m/m to 0.08 m/m.
6. Interchange ramps - 0.06 m/m to 0.08 m/m.

Urban Areas: Design Domain Application Heuristics

1. In urban areas maximum superelevation values tend to be lower since vehicles travelling at slow speeds or moving away from a stopped position might experience side-slip on higher superelevation. Maximum superelevation in urban areas is typically 0.06 m/m.
2. A maximum superelevation rate of 0.04 m/m may also be used for an urban roadway system, and is appropriate where surface icing and interrupted flow is expected.
3. The maximum superelevation rates of 0.04 m/m and 0.06 m/m are generally applicable for design of new roads in the upper range of the classification system and where little or no physical constraints exist.
4. Superelevation is generally not applied on local roads.
5. On collector roads superelevation is used occasionally, and typically where beneficial in matching adjacent topography. Maximum superelevation rates in these cases are in the range of 0.02 m/m (reverse crown) to 0.04 m/m.
6. In some jurisdictions, higher superelevation values are used for ramps on urban freeways than on other urban roads to provide additional safety since freeway ramps, particularly off-ramps, tend to be over-driven more often and side-slip is less likely to occur since maintenance is better at these locations.
7. Superelevation rates in excess of 0.04 m/m are not recommended where curved alignments pass through existing or possible future intersection areas. In urban retrofit situations, it is often difficult or undesirable to provide any superelevation at all due to physical constraints. In these cases, the designer has to carefully assess the relationships of design speed, curvature, crossfall and lateral friction in choosing the optimum design solution.
8. Acceptable maximum superelevation rates are often established as a matter of policy and vary between jurisdictions based on local conditions. As an example, some jurisdictions use a maximum superelevation rate of 0.08 m/m for higher classification roads such as expressways. In the interests of maintaining consistency in design in any particular area where the responsibility for roads is divided between jurisdictions, it is desirable to maintain consistent maximum superelevation. In selecting maximum superelevation, therefore, reference should be made to values used by other road authorities in the area.

<u>Lateral Friction: Technical Foundation Element</u>

The lateral friction factor f is the ratio of the lateral friction force and the component of the weight of the vehicle perpendicular to the pavement. This force is applied to the vehicle

2.2.2

Table 2.1.2.12 **Length of Superelevation Runoff for Two-Lane Crowned Urban Roadways[9]**

Superelevation Rate (m/m)	Length of Runoff (Ls) (m)							
	Design Speed (km/h)							
	40	50	60	70	80	90	100	110
3.7 m lanes								
0.02	11	12	13	14	15	16	17	18
0.04	22	23	25	27	29	32	34	37
0.06	32	35	37	41	44	48	51	55
3.5 m lanes								
0.02	10	11	12	13	14	15	16	17
0.04	20	22	24	26	28	30	32	35
0.06	30	33	35	39	42	45	48	52
Minimum Length (m) for Appearance	22	28	34	39	45	50	56	62

Notes:
1. Values above the heavy lines are less than the minimum lengths based on an appearance criterion.
2. For four-lane roadways, use Table 2.1.2.13.
3. For six-lane roadways, increase lengths by factor of 2.0.

Table 2.1.2.13 **Length of Superelevation Runoff for Four-Lane, Undivided Crowned Urban Roadways, or Two-Lane Urban Roadways Without Crown[9]**

Superelevation Rate (m/m)	Length of Runoff (Ls) (m)							
	Design Speed (km/h)							
	40	50	60	70	80	90	100	110
3.7 m lanes								
0.02	16	17	19	21	22	24	26	27
0.04	32	35	37	41	44	48	51	55
0.06	48	52	56	61	66	71	76	82
3.5 m lanes								
0.02	15	17	18	20	21	23	24	26
0.04	30	33	35	39	42	45	48	52
0.06	45	49	53	58	62	67	72	77
Minimum Length (m) for Appearance	22	28	34	39	45	50	56	62

Notes:
1. Values above the heavy lines are less than the minimum lengths based on an appearance criterion.
2. For two-lane crowned roadways, use Table 2.1.2.12.
3. For six -lane crowned roadways, increase lengths by factor of 1.33.

2.3.1

crowned urban roadways, or two-lane urban roadways with a single cross-slope.

The above tables are based on using the maximum relative slope values provided in Table 2.1.2.11, rather than the recommended minimum length for appearance purposes. As a suggested practice, minimum lengths required to maintain an acceptable general appearance and to avoid abrupt grade changes, are provided along the bottom of the tables and represent the distance travelled in 2 seconds at the design speed. The heavy line within the tables separates the lengths that are below and above the recommended design minimum lengths.

Superelevation Development: Design Domain General Application Heuristics

1. On urban roads with design speeds less than 80 km/h the length of tangent runout is normally based on the same slope as the superelevation runoff. In the case of higher speed facilities, a 1:400 slope similar to that for rural roads and high speed urban roads is used.

2. In the design of superelevation runoff for both rural and urban roads ensure that the edge profiles are smooth and without abrupt changes in grade. Short vertical curves or spline curves from 20 m to 40 m long can be used. Designers should be aware that this will often result in runoff lengths longer than the minimum suggested in the tables.

3. For added safety and comfort, the superelevation runoff should be applied uniformly over a length adequate for the likely operating speeds.

4. To be pleasing in appearance the runoff pavement edges should not be distorted as the driver views them. Spiral lengths as discussed in Subsection 2.1.2.3 are based on these criteria. For this reason when a spiral curve is used, the superelevation runoff is usually applied over the whole of the spiral length and the adverse crown is completely removed by the beginning of the spiral. For curves without spirals, the superelevation runoff is applied over a length equivalent to the spiral length. In this case the superelevation runoff is located so that 60% of the runoff occurs on the tangent approach and 40% on the curve.

Methods of Developing Superelevation: Best Practices

Two-Lane Roadways with Normal Crown

Figure 2.1.2.8 illustrates the three methods of attaining superelevation on two-lane normal crowned roadways, as described below. On curves where adverse crown is desired, but where the superelevation required does not exceed the crown slope, the superelevation should be equal to the crown slope. Information on attaining superelevation on non-crowned two-lane roadways can be obtained by referring to the divided roadway examples.

Method 1	The pavement is revolved about the centreline.
Method 2	The pavement is revolved about the inside edge.
Method 3	The pavement is revolved about the outside edge.

Method 1 is applicable to two-lane and four-lane undivided roadways. Method 2 and Method 3 are applicable to two-lane undivided roadways and four-lane divided roadways.

Method 2 is applicable if the design is required to match physical features on the roadside, to facilitate drainage or on divided highways where the median shoulder is on the inside of the curve.

As previously discussed, the length of tangent runout is normally based on a slope of 1:400. However, in the case of low speed urban facilities the tangent runout can be made steeper, to match the slope of the superelevation runoff.

In superelevating two-lane roadways with a normal crown Method 1 is the most w
approach in design because the
change in elevation of the edge of pa
made with less distortion than with

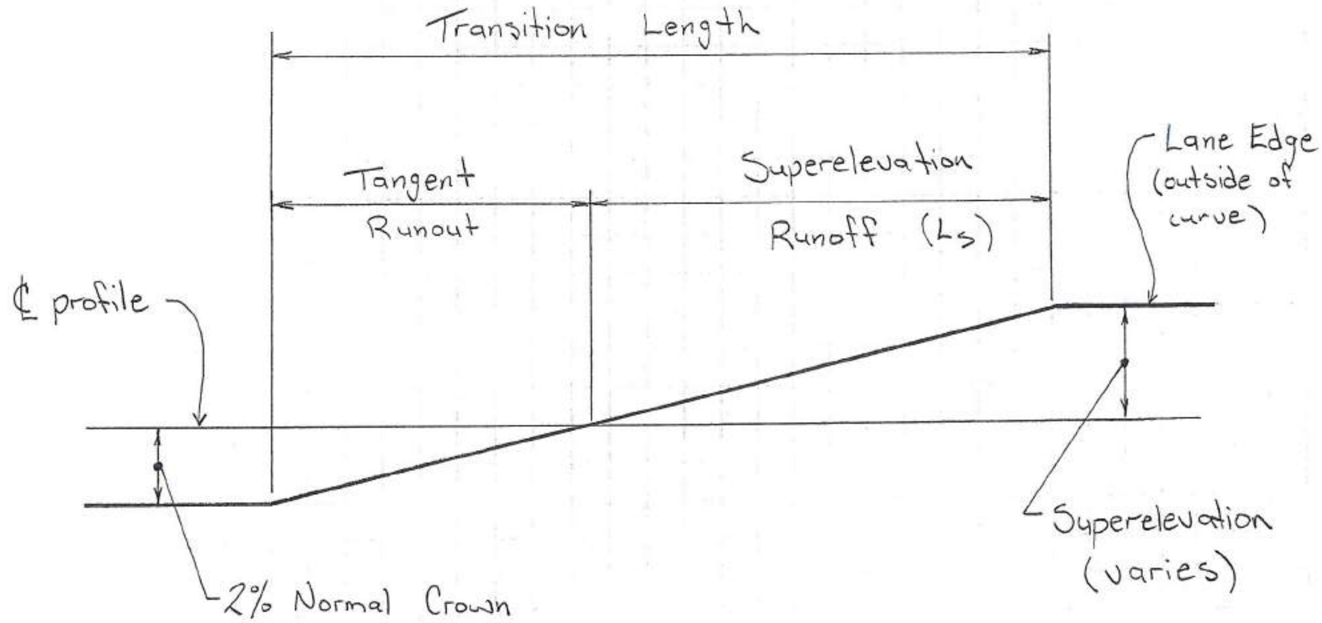
2.3.2

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria

Superelevation

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:



Superelevation Transition Schematic

(applies to all design speeds)

InterCAD

CLIENT: Ekistics / Bentall
PROJECT: Fairwinds
SUBJECT:
Achievment of Superelevation
- Transition Length -

SHEET: 1 OF: 5
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:

Summary - Superelevation Transition Lengths

2-Lane Roadway, 3.5m Lanes

Design Speed	NC to +2%	NC to +4%	NC to +6%
60 km/h	24 m	36m	47m
50	22 m	33 m	44 m
40	20 m	30 m	40 m
30	20 m	30 m	-

4-Lane Roadway, 3.5 m Lanes

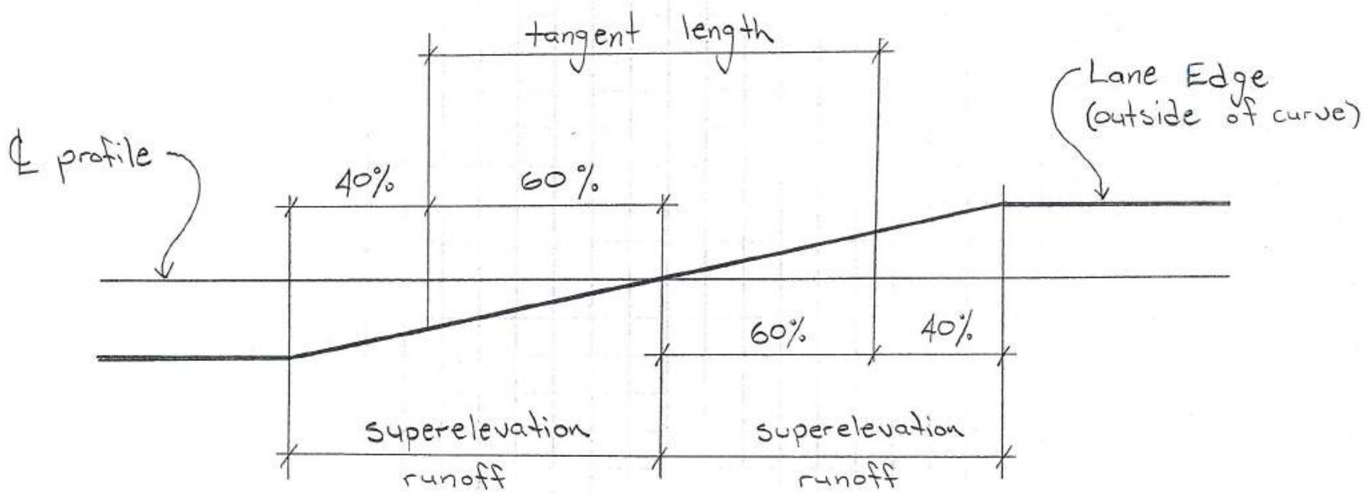
Design Speed	NC to +2%	NC to +4%	NC to +6%
60 km/h	36m	53m	71m
50	34 m	50 m	66 m

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria

Superelevation

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:



Superelevation Transition Schematic between Two Reversing Curves

(applies to all design speeds)

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

2.4.1
2.4.2

3. Where possible, gradients lower than the maximum values shown should be used.

4. Maximum values should only be exceeded after a careful assessment of safety, cost, property and environmental implications.

5. The choice of maximum gradient may have a bearing on related design features; for example, whether or not a truck climbing lane or escape lane is required.

6. While Table 2.1.3.1 provides general guidance, the designer should be aware that the factors that should be considered in establishing the maximum grade for a section of roadway include:

   - road classification
   - traffic operation
   - terrain
   - climatic conditions
   - length of grade
   - costs
   - property
   - environmental considerations
   - in urban areas, adjacent land use

7. Maximum grades of 3 to 5% are considered appropriate for design speeds of 100 km/h and higher. This may have to be modified in regions with severe topography such as mountainous terrain, deep river valleys, and large rock outcrops.

8. Maximum grades of 7 to 12% are appropriate for design speeds of 50 km/h and lower. If only the more important roadways are considered, 7% or 8% would be a representative maximum grade for a design speed of 50 km/h.

9. Control grades for other speeds between 50 km/h and 100 km/h are intermediate between the above extremes.

Minimum Grades: Design Domain Application Heuristics

Rural Roadways

1. On uncurbed roadways, level grades are generally acceptable provided the roadway is adequately crowned, snow does not interfere with surface drainage, and ditches have positive drainage. Roadway crown is discussed in Section 2.1.5. Refer to Chapter 2.2 for guidelines for the design of roadside open ditches and to relevant drainage publications.

Curbed Roadways (generally in urban areas)

1. To ensure adequate drainage, curbed roadways typically have a minimum longitudinal grade of 0.50% or 0.60%, depending on local policy.

2. In certain rare design cases, when no other alternative is feasible, a grade of 0.30% may be used as an absolute minimum preferably in combination with highly stable soils and rigid pavements.

3. For retrofit projects, longitudinal grades below the normal minimum of 0.50% or 0.60% may be considered where flatter grades allow the retention, rather than the removal, of existing pavements.

4. The minimum gradients outlined are suitable for normal conditions of rainfall and drainage outlet spacing. Where less than the normal minimum gradient is utilized, the lengths of such grades should be limited to short distances, and their location and frequency become important considerations. In special cases, hydraulic analysis is required to determine the extent of water spread on the adjacent travel lane. False grading, (where the pavement grade is not parallel to the top of curb), to ensure adequate drainage is an effective means of maintaining minimum grades in flat, highly constrained areas. False addressed in Section 2.1.5, Cro

2.4.3

Maximum Grade: Design Domain Quantitative Aids

Although the relationship between design speeds and maximum grade is relatively subjective, reasonable guides for maximum grade have been developed.

The guidelines for maximum gradients are given in Table 2.1.3.1.

Maximum Grade: Design Domain Application Heuristics

1. The range of values shown in Table 2.1.3.1 recognizes that maximum grade selected for design varies with topography and the general financial capability of the road authority to fund the capital works. For lower classification urban roads, land use is an additional consideration and land use is incorporated into the guidelines for urban local and urban undivided collectors.

2. The values shown may be adjusted to suit local and economic conditions. Maximum gradients by classification and land use are often a matter of policy, and as a result, vary from jurisdiction to jurisdiction. Normally, the local policy is established at a senior engineering and planning level. In any event, in adjusting these figures, designers should ensure that they explicitly consider the impact of such alternative maximum grade values on safety.

Table 2.1.3.1 Maximum Gradients[1,9]

Design Speed (km/h)	30/40/50		60		70		80		90		100		110		120/130	
Topography	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M
RLU	7	11	7	11	6	9	6	8	5	7	5	7	-	-	-	-
RCU	-	-	6	10	6	9	5	8	5	7	5	7	-	-	-	-
RCD	-	-	-	-	6	9	5	8	5	7	5	7	-	-	-	-
RAU	-	-	-	-	-	-	4	7	4	6	3	6	3	6	3	5
RAD	-	-	-	-	-	-	4	7	4	6	3	6	3	5	3	5
RFD	-	-	-	-	-	-	-	-	-	-	3	5	3	5	3	5
ULU – Residential	8	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ULU – Industrial/ Commercial	6	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UCU – Residential	8	12	7	11	7	10	-	-	-	-	-	-	-	-	-	-
UCU – Industrial/ Commercial	6	12	6	11	6	9	6	8	-	-	-	-	-	-	-	-
UCD	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAU	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAD	-	-	3	6	3	6	3	6	3	6	3	5	-	-	-	-
UED	-	-	-	-	-	-	5	6	4	5	4	5	4	5	3	5
UFD	-	-	-	-	-	-	-	-	4	5	3	5	3	5	3	5

Notes:
1. Short grades less than 150 m in length, and one-way down grades may be 1% higher on urban roads, and 2% higher on low volume rural roads.
2. R refers to rolling topography.
3. M refers to mountainous topography.

2.4.4

roadway through the intersection. The concept for this type of adjustment is illustrated on Figures 2.3.2.5 and 2.3.2.6.[1] Although desirable, it is not always feasible to locate a high point at the centre of the intersection as shown on the Figures. Thus variations of the concept are needed to suit the vertical alignment characteristics of the intersection. Appropriate vertical curves are incorporated into the centreline profiles of both major roadways to achieve the desired grade adjustments. The edge of pavement profiles are often determined by using a spline, since calculated vertical curves do not always fit the constraints. A spline is a flexible drafting tool used to draw curved lines. A splined edge of pavement line provides a "best fit" curve which ensures that drainage is adequate, cross-slope is suitable and that the change in grade is not too abrupt.

Grade Breaks

Significant grade changes are not desirable within and near intersections which could affect the control and operation of a vehicle passing through the intersection at the expected operating speed. Grade breaks at intersections in the order of 0.5% to 2% are typical for a design speed of 70 km/h or higher. For lower design speeds more substantial grade breaks can be accommodated if required for the specific conditions. At a design speed of 50 km/h, a maximum grade change in the order of 3% to 4% produces some discomfort for vehicular traffic but is normally not detrimental to the safe operation of the intersection, provided that the stopping sight distance for the design speed is achieved. For speeds of 30 km/h or less, grade breaks up to 6% could be used, if required.

Grades

The grades of intersecting roadways in the area of the intersection should be as flat as possible to accommodate:

- storage space for stopped vehicles
- desirable sight distance (see Section 2.3.3)
- accelerating and stopping distance

Appropriate minimum grades at intersections are important to facilitate drainage, to avoid operational safety concerns related to ponding or icing conditions, and to compensate for some pavement wear and differential settlements. Particular attention should be devoted to the grading design of curb returns and to the calculation of roadway surface water runoff in an urban environment where there are large paved surfaces at intersections. Suggested guidelines include a minimum grade of 0.5% along curb returns (urban section), and a minimum of 1.0% combined cross-slope and roadway gradient within the limits of the intersection (rural and urban sections).

Existing driveways and accesses are often a constraint in setting grade lines on intersection approaches.

Along the approach legs to the intersection where vehicles are expected to stop, such as at left- and right-turn lanes or where signals are or may in the future be warranted, it is desirable to keep grades between 0.5% and 3%. A grade as low as 0.15% may be considered as long as adequate drainage is provided through cross-slope to avoid ponding. The calculated stopping and accelerating distance for a passenger car on a grade requires correction to produce conditions equivalent to those on level roadways (see Chapter 1.2). In addition, acceleration and deceleration tapers and/or lane lengths should be adjusted for steeper grades. Most vehicle operators are unable to judge the increase or decrease in stopping or accelerating distance that is necessary because of steep grades. Their normal deductions and reactions thus may be in error at a critical time. Accordingly, grades in excess of 3% are not desirable through an intersection. For low-volume, low-speed intersections, such as at the intersection of two local residential roads where physical conditions and economic considerations dictate, approach grades of 5% to 6% may be considered as long as acceptable site distance is provided along with an adjustment in design factors. The gradient within the intersection is normally limited to 4%. This limitation assists in providing reasonable operation for low-speed turning vehicles, particularly under slippery conditions.

2.4.6

When establishing the profile for the minor cross road, it is important to consider whether or not the intersection may be signalized in the future. If signalization is probable, the minor roadway should be designed to accommodate future free-flow traffic which would occur under green-signal conditions.

The approach/departure grade should ideally extend approximately 20 m back from intersections, although this can be reduced to one or two car lengths on minor roadways with light traffic volumes.

In addition to the vertical alignment and cross-slope considerations, the horizontal alignments of approach roadways are normally kept as simple and smooth as possible. It is desirable to ensure that the combination of horizontal alignment and vertical profile allows good visibility of the intersection area from all approaches. This allows drivers to focus their attention on the intersection area, where most conflicts occur.

2.3.2.4 Combined Vertical and Horizontal Alignments

The combination of horizontal and vertical alignment at, and near an intersection will ideally produce traffic lanes that are clearly visible to operators at all times. They should be clearly comprehensible for any desired direction of travel, free from the sudden appearance of potential conflicts, and consistent with the roadway just travelled.[11]

When the superelevation of a section of roadway on a curve is in the same direction as the grade of the intersecting cross road, the vertical alignment of the cross roadway is adjusted to meet the normal pavement cross-slope of the roadway as shown in Illustration A of Figure 2.3.2.7.

For intersections on curve, the selection of an appropriate radius is a function of the design speed of the through roadway with consideration given to the grade of the crossing roadway through the intersection. For example, for a crossing roadway with a grade of 3% through an intersection, the superelevation of the intersecting roadway on curve should also be 3% to provide a smooth crossing of the through roadway by the crossing road driver. Therefore, for a design speed of 80 km/h, the desirable radius for the through roadway curve is 1200 m, with superelevation of 0.028 m/m (based on e_{max} = 0.06 m/m), according to Chapter 2.1.

However, through an intersection on curve in an urban environment, drivers are willing to accept higher lateral friction than in open conditions. As such, a smaller radius curve could be used for a desired rate of superelevation to match the crossing roadway grade through the intersection under certain constrained conditions. In a rural environment, higher lateral friction is less desirable, due to greater driver expectations in terms of roadway performance. This is discussed further in Subsection 2.3.2.5.

An intersection where the cross-slope of the curving roadway is not in the same direction as the grade of the intersecting cross roadway is not desirable. If this condition cannot be avoided, the vertical alignment of the cross roadway is adjusted a sufficient distance from the intersection to introduce a desirable alignment as indicated in Illustration B of Figure 2.3.2.7. As discussed in Subsection 2.3.2.3, grade breaks over 4% are not desirable due to discomfort to vehicular traffic; however, if necessary, the break can approach 6% for minor roadways.

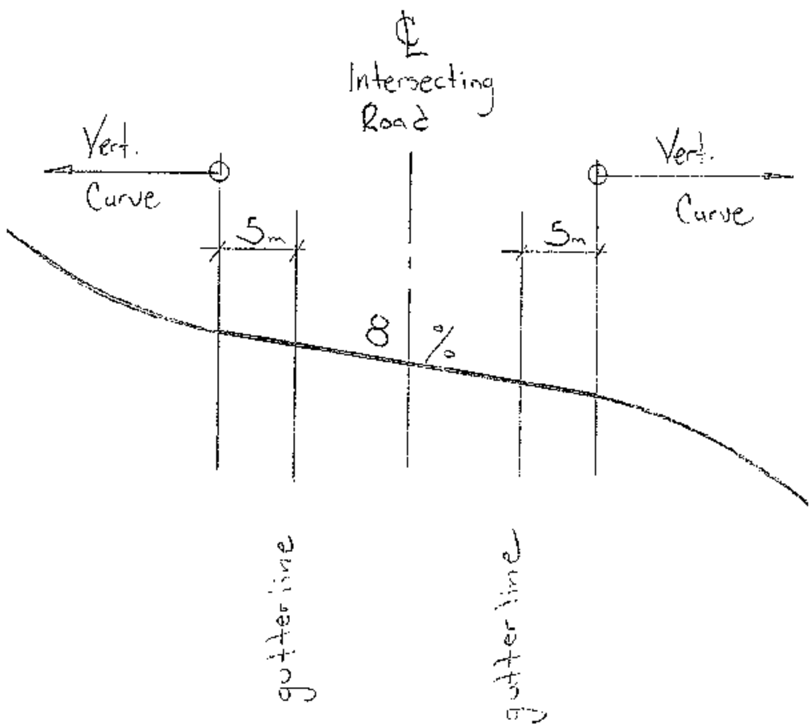
Minimum design parameters for both the vertical and horizontal alignment elements are undesirable in intersection design. If a limiting or near limiting condition cannot be avoided for one element, it is desirable to ensure that the other elements are well above the minimum design guidelines. Thus intersections are generally not preferred on sharp horizontal curves with significant superelevation. Superelevation rates in excess of 0.04 m/m through intersection areas adversely affect the smooth operation, particularly for those vehicles turning against the superelevation.

Similarly, steep gradients in coml 2.4.7 badly skewed intersections or r horizontal curves often create

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Grades at Intersections
50 km/h on Through Road

SHEET: OF:
DATE: Oct 7/09
FILE: A028
BY: S Clinton
CHECKED

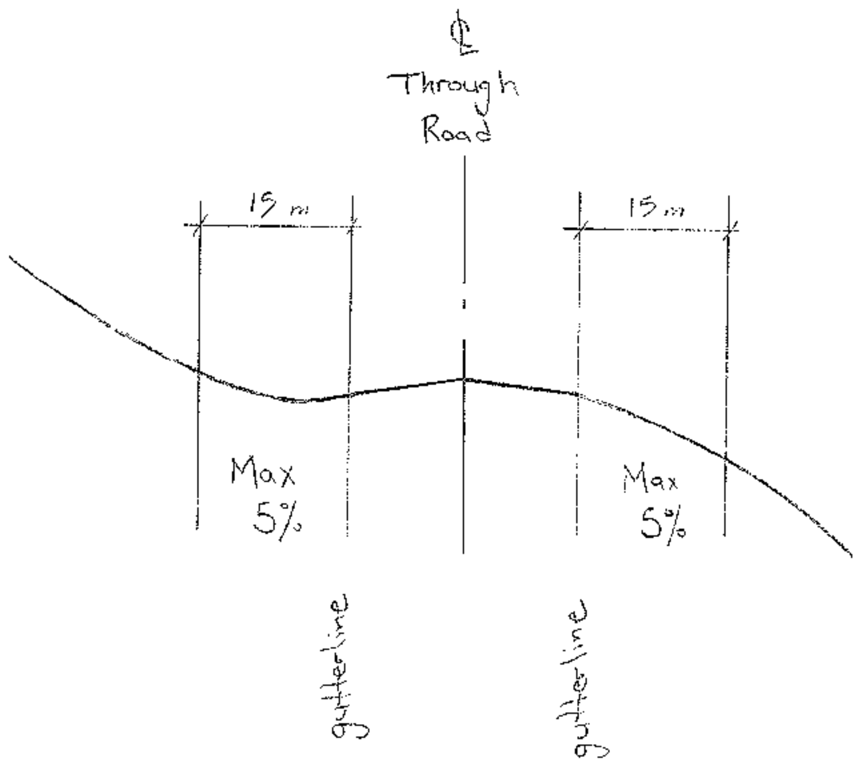


InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Grades at Intersections

50 km/h and Stop Condition

SHEET: OF:
DATE: Oct 7/07
FILE: AD28
BY: SClinton
CHECKED



1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

2.5.1

In calculating K values for various sight distances, the height of driver's eye is 1.05 m, and the height of object is as outlined following, and discussed in more detail in Chapter 1.2.

- For stopping sight distance the most common object a vehicle has to stop for is another vehicle ahead on the road, the height of tail light is used. The legislated minimum is 0.38 m and is adopted for design. Other heights of objects can be used if necessary.
- For decision sight distance the more common height of object is 0.15 m, although other heights, such as zero for pavement markings, are not uncommon.
- For passing sight distance the height of object is 1.30 m, which represents the height of the opposing vehicle.

Crest Vertical Curves: Design Domain Quantitative Aid

Based on the above most commonly used heights of object, and on sight distances from Tables 1.2.5.3 and 1.2.5.5, the K values for stopping sight distance are provided in Table 2.1.3.2 and for passing sight distance the K values are provided in Table 2.1.3.3. The decision sight distance K values are not included because the vertical curvature depends on the height of object which is variable (depending on what the driver has to see).

The calculated K values are based on the length of curve exceeding the sight distance and they can be used without significant error when the length of curve is less than the sight distance. Appreciable differences occur only where A is small and little or no additional cost is involved in obtaining longer vertical curves.

On undivided roads non-striping sight distance is used to determine when no-passing pavement markings are required[7]. It is desirable to provide passing sight distance wherever possible but non-striping sight distance is generally adequate for safe passing manoeuvres.

Non-striping sight distance is less than passing sight distance, at each design speed. Passing manoeuvres can be completed in less than the full passing sight distance because of the timing of oncoming vehicles.

Table 2.1.3.2 K Factors to Provide Stopping Sight Distance on Crest Vertical Curves

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Vertical Curvature (K) Computed	Rate of Vertical Curvature (K) Rounded
30	30	29.6	1.6	2
40	40	44.4	3.7	4
50	47-50	57.4-62.8	6.1-7.3	6-7
60	55-60	74.3-84.6	10.2-13.3	10-13
70	63-70	94.1-110.8	16.4-22.8	16-23
80	70-80	112.8-139.4	23.6-36.1	24-36
90	77-90	131.2-168.7	32.0-52.8	32-53
100	85-100	152.0-205.0	45.8-78.0	45-80
110	91-110	179.5-246.4	59.8-112.7	60-110
120	98-120	202.9-285.6	76.4-151.4	75-150
130	105-130	227.9-327.9	96.4-199.6	95-200

Note: The above are minimum values, use higher K factors whenever possible.

2.5.2

Table 2.1.3.4 K Factors to Provide Minimum Stopping Sight Distance on Sag Vertical Curves[1]

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Sag Vertical Curvature (K)			
			Headlight Control		Comfort Control	
			Calculated	Rounded	Calculated	Rounded
30	30	29.6	3.9	4	2.3	2
40	40	44.4	7.1	7	4.1	4
50	47-50	57.4-62.8	10.2-11.5	11-12	5.6-6.3	5-6
60	55-60	74.3-84.6	14.5-17.1	15-18	7.7-9.1	8-9
70	63-70	99.1-110.8	19.6-24.1	20-25	10.0-12.4	10-12
80	70-80	112.8-139.4	24.6-31.9	25-32	12.4-16.2	12-16
90	77-90	131.2-168.7	29.6-40.1	30-40	15.0-20.5	15-20
100	85-100	157.0-205.0	36.7-50.1	37-50	18.3-25.3	18-25
110	91-110	179.5-246.4	43.0-61.7	43-62	21.0-30.6	21-30
120	98-120	202.9-285.6	49.5-72.7	50-73	24.3-36.4	24-36
130	105-130	227.9-327.9	56.7-85.0	57-85	27.9-42.8	28-43

Values for sag curvature based on the comfort criterion are shown in Table 2.1.3.4.

These K values for sag curves are useful in urban situations such as underpasses where it is often necessary for property and access reasons to depart from original ground elevations for as short a distance as possible. Minimum values are normally exceeded where feasible, in consideration of possible power failures and other malfunctions to the street lighting systems. Designing sag vertical curves along curved roadways for decision sight distance is normally not feasible due to the inherent flat grades and resultant surface drainage problems.

2.1.3.4 Vertical Alignment: Design Domain Additional Application Heuristics

Vertical Alignment Principles: Application Heuristics

The following principles generally apply to both rural and urban roads. A differentiation between rural and urban is made in several instances where necessary for clarity.

1. On rural and high speed urban roads a smooth grade line with gradual changes, consistent with the class of road and the character of the terrain, is preferable to an alignment with numerous breaks and short lengths of grade. On lower speed curbed urban roadways drainage design often controls the grade design.

2. Vertical curves applied to small changes of gradient require K values significantly greater than the minimum as shown in Tables 2.1.3.2 and 2.1.3.4. The minimum length in metres should desirably not be less than the design speed in kilometres per hour. For example, if the design speed is 100 km/h, the vertical curve length is at least 100 m.

3. Vertical alignment, having a series of successive relatively sharp crest and sag curves creating a "roller coaster" or "hidden dip" type of profile is not recommended. Hidden dips can be a safety concern, particularly at night. Such profiles generally occur on relatively straight horizontal alignment where the roadway profile closely follows a rolling natural ground line. Such roadways are unpleasant aesthetically and more difficult to drive. This type of profile is avoided by the use of horizontal curves or by more gradual grades.

4. A broken back grade line (tv curves in the same direction se a short section of tangent grε

2.5.3

Table 1.2.5.2 Coefficient of Friction for Wet Pavements[4]

Design Speed (km/h)	Operating Speed [a] (km/h)	Coefficient of Friction (f)
30	30	0.40
40	40	0.38
50	47-50	0.35
60	55-60	0.33
70	63-70	0.31
80	70-80	0.30
90	77-90	0.30
100	85-100	0.29
110	91-110	0.28
120	98-120	0.28
130	105-130	0.28

Note: [a] The range of operating speeds recognises that some drivers slow down in wet conditions: others do not.

applied. On a level roadway this distance can be determined using the following formula:

$$d = \frac{V^2}{2gf} = \frac{V^2}{2(9.81)f} \times \left(\frac{1000}{3600}\right)^2 = \frac{V^2}{254f} \quad (1.2.4)$$

Where d = braking distance (m)

V = initial speed (km/h)

f = coefficient of friction between the tires and the roadway

Then SSD = 0.278tV + d (1.2.5)

Where SSD = stopping sight distance (m)

t = perception and reaction time (s)

Table 1.2.5.3 gives the minimum stopping sight distances on level grade, on wet pavement, for a range of design speeds. These values are used for vertical curve design, intersection geometry and the placement of traffic control devices.

The stopping sight distances quoted in Table 1.2.5.3 may need to be increased for a variety of reasons, related to grade, vehicle braking capability and pavement condition.

Variation for Trucks

Geometric characteristics to achieve stopping sight distance requirements vary because of differences in driver eye height and braking characteristics. While a truck driver can generally see further than a passenger car driver due to an eye height advantage, in some instances the higher eye height is a disadvantage — for example, a sag vertical curve where visibility is "cut off" by an overpass. Truck braking characteristics are highly variable and often increase effective braking distance and, thus, stopping sight distance.

A number of tests[8] have been conducted using trucks with conventional brakes and antilock brakes, and drivers with varying levels of experience in handling emergency situations. The use of antilock brakes wa to consistently reduce braking distar minimising variations in driver performa

2.6

Table 1.2.5.3 **Stopping Sight Distance for Automobiles[4] and Trucks with Antilock Braking Systems[8]**

Design Speed (km/h)	Assumed Operating Speed* (km/h)	Perception and Reaction time (s)	Perception and Reaction distance (m)	Coefficient of Friction	Braking Distance (m)	Stopping Sight Distance (rounded) (m)
40	40	2.5	27.8	0.38	16.6	45
50	47 - 50	2.5	32.7 - 34.7	0.35	24.8 - 28.1	60 - 65
60	55 - 60	2.5	38.2 - 41.7	0.33	36.1 - 42.9	75 - 85
70	63 - 70	2.5	43.7 - 48.6	0.31	50.4 - 62.2	95 - 110
80	70 - 80	2.5	48.6 - 55.5	0.30	64.2 - 83.9	115 - 140
90	77 - 90	2.5	53.5 - 62.5	0.30	77.7 - 106.2	130 - 170
100	85 - 100	2.5	59.0 - 69.4	0.29	98.0 - 135.6	160 - 210
110	91 - 110	2.5	63.2 - 76.4	0.28	116.3 - 170.0	180 - 250
120	98 - 120	2.5	68.0 - 83.3	0.28	134.9 - 202.3	200 - 290
130	105-130	2.5	72.9 - 90.3	0.28	155.0 - 237.6	230 - 330

Note: * Range of assumed operating speed is from average running speed for low-volume conditions to design speed.

utilizing more of the available friction. In fact, the results indicated that the stopping sight distances from Table 1.2.5.3 would be adequate if antilock brakes were in general use on trucks.

Table 1.2.5.4 shows stopping sight distances for trucks with conventional brakes, and compares them to the stopping sight distances given in Table 1.2.5.3.

The increased stopping sight distances for trucks with conventional brakes (i.e. the majority of the current fleet) are generally offset by increased driver eye height for the purposes of vertical curve calculations. However, where driver eye height is not an advantage, such as on horizontal curves or approaching controlled intersections, the greater stopping sight distances should be used.

Sight restrictions such as shrubs, trees, cut slopes, or buildings may occur on the inside of horizontal curves. Although truck drivers have higher eye heights, the required truck driver sight distance may not be offset by the higher eye height unless the obstructions are physically below the driver's line of sight.

The Effect of Grade

Braking distances will increase on downgrades and decrease on upgrades. When the roadway is on a grade, the formula for braking distance is:

$$d = \frac{V^2}{254\,(f \pm G)} \qquad (1.2.6)$$

Where G = the percent grade divided by 100 (up is positive, down is negative) and all other terms are as noted in Equation 1.2.4.

2.6

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

2.6.1

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Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

2.7.1

Because decision sight distance allows drivers to manoeuvre their vehicles or vary their operating speed rather than stop, decision sight distance is much greater than stopping sight distance for a given design speed.

Designers should use decision sight distance wherever information may be perceived incorrectly, decisions are required or where control actions are required. Some examples of where it could be desirable to provide decision sight distance are:

- complex interchanges and intersections
- locations where unusual or unexpected manoeuvres occur
- locations where significant changes to the roadway cross section are made
- areas where there are multiple demands on the driver's decision making capabilities from: road elements, traffic control devices, advertising, traffic, etc.
- construction zones

Table 1.2.5.6 shows the range of values for decision sight distance. The decision sight distance increases with the complexity of the evasive action that is taken by the driver and with the complexity of the surroundings.

The values for decision sight distance given in Table 1.2.5.6 have been developed from empirical data. When using these sight distances, the designer should consider eye and object heights appropriate for specific applications.

Table 1.2.5.6 Decision Sight Distance[4]

Design Speed (km/h)	Decision Sight Distance for Avoidance Manoeuvre (m)				
	A	B	C	D	E
50	75	160	145	160	200
60	95	205	175	205	235
70	125	250	200	240	275
80	155	300	230	275	315
90	185	360	275	320	360
100	225	415	315	365	405
110	265	455	335	390	435
120+	305	505	375	415	470

Notes: Avoidance Manoeuvre A: stop on rural roadway.
Avoidance Manoeuvre B: stop on urban roadway.
Avoidance Manoeuvre C: speed/path/direction change on rural roadway.
Avoidance Manoeuvre D: speed/path/direction change on suburban roadway.
Avoidance Manoeuvre E: speed/path/direction change on urban roadway.

2.7.2

40km/h

Table 3 : Alignment Design Criteria Summary : 40 km/h Design Speed

1. Horizontal Curve Radii

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Roadway Crossfall			
normal crown (-2%)	-	55m [2]	55m
2% superelevation	-	47m [2]	50m
4% superelevation	-	43m [2]	45m
6% superelevation	40m [1]	-	N/A
Through Intersections	-	-	75m [3]

1 Table 1420.A - Design Parameters
2 Calculated minimum radius for low speed urban design based on Table 2.1.2.2, Page 2.1.2.7 TAC manual which is consistent with AASHTO Method 2 for distribution of e & f.
3 Applies to the through road only.

2. Superelevation

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Maximum Superelevation	4% [1]	4% [2]	4%
Maximum Superelevation at Intersections	-	-	4%

1 Table 1420.A - Design Parameters: parameters based on E max 0.06 m/m, however, Section 1420.05.08 - Superelevation notes that a maximum rate of 0.04m/m shall be used for local urban streets.
2 See Section 2.1.2.2 - Maximum Superelevation, Page 2.1.2.4 TAÇ manual.

3. Superelevation Transition Lengths

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Transition Lengths (2-lane roadway)			
normal crown to +2%	-	20m [1]	20m
normal crown to +4%	-	30m [1]	30m
Min Tangent Length between reversing curves			
2% superelevation (2-lane roadway)	-	12m [2]	12m
4% superelevation	-	24m [2]	24m

1 Lengths based on Table 2.1.2.12, Page 2.1.2.26 TAC manual, using 3.5 m lanes. Values shown include tangent runout applied at the same rate as superelevation runoff.
2 Values based on Section 2.1.2.4 - Development of Superelevation, and Table 2.1.2.12, Pages 2.1.2.25 and 2.1.2.26 TAC manual. 60% of superelevation runoff occurs on the tangent approach and 40% on the curve, resulting in a minimum length of tangent between reversing curves of 120% of the superelevation runoff length.

4. Gradients

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Grade	-	0.5% [3]	0.5%
Maximum Grades			
on horizontal tangents	8% [1]	12% [4]	12%
on minimum radius horizontal curves	4% [2]	-	10%
Grades Through Intersections			
Through condition	-	-	8%
approach distance for through road [5]	-	-	0m
Stop condition	-	3% (desirable) [6] 6% (maximum)	6%
approach distance for stopping road [5]	-	5m [7]	5m

1 Table 1420.A - Design Parameters
2 Grades reduced by 1% for every 30 metres that the centreline radius is less than 150m. As the minimum centreline radius is 40m (at 6% superelevation), the maximum grade is reduced by 4%.
3 See Section 2.1.3.2 - Minimum Grades, Page 2.1.3.5 TAC manual.
4 Maximum gradient, from TAC table 2.1.3.1 Page 2.1.3.2, for a UCU classification, 40km/h design speed in mountainous topography.
5 Minimum distance back from the gutter line of the intersecting road that the intersection grade must apply.
6 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Page 2.3.2.8 TAC manual.
7 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Page 2.3.2.11 TAC manual. Approach / departure grade can be reduced to one or two car lengths on minor roadways with light traffic volumes.

5. Vertical Curve K Values

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Crest	4 [1]	4 [2]	4
Minimum Sag	7 [1]	4 [3]	4
Crest / Sag on approach to stop condition	-	-	2 [4]

TAC and Proposed K values listed assume that new roadways will be illuminated
1 Table 1420.A - Design Parameters: crest based on taillight height, sag based on headlight control (ie no street lighting). Section 1420.05 - Alignment notes that length of vertical curve (in m) should not be less than the design speed (in km/h).
3 See Table 2.1.3.2 - Crest Vertical Curves, Page 2.1.3.6 TAC manual.
4 See Table 2.1.3.4 - Sag Vertical Curves, Page 2.1.3.9 TAC manual.
5 A K value of 2 (30 km/h design speed) is proposed for developing vertical curves at approach platforms on the minor road at an intersection as vehicles will be slowing from design speed as they approach the stop condition.

6. Stopping Sight Distances

Criteria	Down Grades				0%	Up Grades			
	12%	9%	6%	3%		3%	6%	9%	12%
Minimum distance (m)	52	50	48	46	45 [1]	44	42	41	40

All values, see Section 1.2.5.2 - Stopping Sight Distance, Pages 1.2.5.2 and 1.2.5.4 TAC manual.
1 Only SSD given for level grade in MoT Supplement, Section 1400, Table 1420.A - Design Parameters. MoT Value = 45m

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

3.1.1

Table 2.1.2.1 Maximum Lateral Friction for Rural and High Speed Urban Design[1]

Design Speed (km/h)	Maximum Lateral Friction for Rural and High Speed Urban Design
40	0.17
50	0.16
60	0.15
70	0.15
80	0.14
90	0.13
100	0.12
110	0.10
120	0.09
130	0.08

margin of safety against skidding under normal driving conditions in the urban environments. Values are presented in Table 2.1.2.2.

Minimum Radius: Design Domain

Overview

The minimum allowable radius for any design speed depends on the maximum rate of superelevation and the lateral friction force that can be developed between the pavement and vehicle tires. This relationship is expressed by:

$$R_{min} = \frac{V^2}{127(e_{max} + f_{max})} \qquad (2.1.2)$$

Table 2.1.2.2 Maximum Lateral Friction for Low Speed Urban Design[1]

Design Speed (km/h)	Maximum Lateral Friction for Low Speed Urban Design
30	0.31
40	0.25
50	0.21
60	0.18

For rural and urban high speed superelevation applications there is generally reasonable opportunity to provide the desirable amount of superelevation. In rural areas the constraints are usually minimal, while on high speed urban roadways the designer has reasonable flexibility in establishing suitable superelevation. This is because in the design of new streets, particularly those with design speeds of 70 km/h or more and through generally undeveloped areas, the designer typically has greater flexibility in establishing suitable horizontal and vertical alignments and associated superelevation rates. Often it is possible to regrade adjacent properties to match superelevated sections, ensuring appropriate drainage patterns and intersection profiles.

Rural and High Speed Urban Applications: Design Domain Quantitative Aids

For rural and high speed urban applications the minimum radius is calculated using a maximum superelevation rate of either 0.04 m/m, 0.06 m/m or 0.08 m/m for a range of design speeds from 40 km/h to 130 km/h, and lateral friction factors from Table 2.1.2.1. These calculated values are shown in Table 2.1.2.3.

Low Speed Urban Applications: Design Domain Quantitative Aids

For low speed urban conditions and where a street is to be upgraded through a developed urban area, it is often not desirable or possible to utilize superelevation rates typical of high speed design as previously discussed. Design considerations other than driver discomfort may be important. Existing physical controls, right-of-way constraints, intersections, driveways, on-street parking, and economic considerations have a strong influence on design elements, including design speed and superelevation. In some cases, design speed may not be an initial design control, but rather a result of the other controls or considerations influencing the horizontal alignment and superelevation.

Moreover, in low speed urban conditi drivers are accustomed to a greater lev discomfort while traversing curves. He increased lateral friction factors resulting

3.1.2

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

3.2.1

1420.05.05 Frontage Roads

The Right-Of-Way width shall be 15 metres or the cross section width plus 3 metres, whichever is greater. (This is additional to the through road requirements.) Ensure sufficient setback at intersections to accommodate turn slots, etc., thus ensuring a bulbed connection is necessary at all frontage road intersections.

1420.05.06 Backage Roads

For these standards, backage roads shall be considered local roads.

1420.05.07 Cross Slopes

All roadways shall be constructed using a centerline crown and shall be graded and compacted with the following crossfall to ensure road drainage:

- Normal cross slopes shall be 2% for paved roads and 4% for gravel roads.

1420.05.08 Superelevation

Superelevation is generally not applied on local subdivision roads or cul-de-sacs; reverse crown is usually maintained in ≤ 800 metre radius curves @≤ 50 km/h. Rural roads of a continuous nature that provide access to a subdivision would be better classified as Low-volume roads and should be superelevated accordingly. Refer to the Low-volume Road Chapter of the BC Supplement to TAC. When the decision has been made to superelevate curves, a maximum rate of 0.04 m/m shall be used for local urban street systems. This is appropriate for design speeds up to 70 km/h and where surface icing and interrupted traffic flow are expected. Superelevation rates of 0.04 m/m and 0.06 m/m are applicable for design of new urban streets in the upper range of the classification system where uninterrupted flow is expected and where little or no physical constraints exist.

1420.06 INTERSECTIONS/ACCESSES

1420.06.01 General

Intersections shall be as near as possible to right angles. The minimum skew angle of the intersection shall be 70 degrees and the maximum skew angle shall be 110 degrees.

1420.07 UTILITY SETBACK

Utility poles or signs should be within 2 metres of the property boundary or a minimum 2 metres beyond the toe of the fill, whichever gives the greater offset from the road. See Figure 1420.C.

1420.08 DRIVEWAYS

1. Driveway location, spacing and approval shall be at the discretion of the Ministry Representative.

2. The first 5 metres (measured from the ditch centerline) of all residential driveways shall be constructed at or near a right angle (70° to 110°) to the road and at a maximum ± 2 % grade.

3. All open shoulder driveways with a level or rising grade are to be constructed with a "valley" or "swale" over the ditch line to ensure surface water enters the ditch and does not enter the road. See Figure 1420.N

4. Driveway grades shall not exceed 8% within the Right-of-Way.

5. Driveway radius and widths:
   Residential/Farm – 6 metre radius and minimum width
   Logging/Commercial – 9 metre radius and minimum width

6. All lots with cuts or fills greater than 1.8 metres shall have engineered drawings when requested by the Ministry representative.

3.2.1

weather conditions, or for other reasons, while not adversely affecting higher speed vehicles. This is especially important for roads located where winter conditions prevail several months of the year.

Urban Areas: Design Domain Quantitative Aids

In urban areas maximum superelevation values cover the range from 0.02 m/m to 0.08 m/m. Values commonly used for maximum superelevation are:

1. Locals - generally normal crown.

2. Collectors - used occasionally with maximum rates of 0.02 m/m or 0.04 m/m.

3. Minor arterials - 0.04 m/m to 0.06 m/m.

4. Major arterials - 0.06 m/m.

5. Expressways and freeways - 0.06 m/m to 0.08 m/m.

6. Interchange ramps - 0.06 m/m to 0.08 m/m.

Urban Areas: Design Domain Application Heuristics

1. In urban areas maximum superelevation values tend to be lower since vehicles travelling at slow speeds or moving away from a stopped position might experience side-slip on higher superelevation. Maximum superelevation in urban areas is typically 0.06 m/m.

2. A maximum superelevation rate of 0.04 m/m may also be used for an urban roadway system, and is appropriate where surface icing and interrupted flow is expected.

3. The maximum superelevation rates of 0.04 m/m and 0.06 m/m are generally applicable for design of new roads in the upper range of the classification system and where little or no physical constraints exist.

4. Superelevation is generally not applied on local roads.

5. On collector roads superelevation is used occasionally, and typically where beneficial in matching adjacent topography. Maximum superelevation rates in these cases are in the range of 0.02 m/m (reverse crown) to 0.04 m/m.

6. In some jurisdictions, higher superelevation values are used for ramps on urban freeways than on other urban roads to provide additional safety since freeway ramps, particularly off-ramps, tend to be over-driven more often and side-slip is less likely to occur since maintenance is better at these locations.

7. Superelevation rates in excess of 0.04 m/m are not recommended where curved alignments pass through existing or possible future intersection areas. In urban retrofit situations, it is often difficult or undesirable to provide any superelevation at all due to physical constraints. In these cases, the designer has to carefully assess the relationships of design speed, curvature, crossfall and lateral friction in choosing the optimum design solution.

8. Acceptable maximum superelevation rates are often established as a matter of policy and vary between jurisdictions based on local conditions. As an example, some jurisdictions use a maximum superelevation rate of 0.08 m/m for higher classification roads such as expressways. In the interests of maintaining consistency in design in any particular area where the responsibility for roads is divided between jurisdictions, it is desirable to maintain consistent maximum superelevation. In selecting maximum superelevation, therefore, reference should be made to values used by other road authorities in the area.

<u>Lateral Friction: Technical Foundation Element</u>

The lateral friction factor f is the ratio of the lateral friction force and the componen weight of the vehicle perpendicular pavement. This force is applied to the

3.2.2

Table 2.1.2.12 Length of Superelevation Runoff for Two-Lane Crowned Urban Roadways[9]

Superelevation Rate (m/m)	Length of Runoff (Ls) (m)							
	Design Speed (km/h)							
	40	50	60	70	80	90	100	110
3.7 m lanes								
0.02	11	12	13	14	15	16	17	18
0.04	22	23	25	27	29	32	34	37
0.06	32	35	37	41	44	48	51	55
3.5 m lanes								
0.02	10	11	12	13	14	15	16	17
0.04	20	22	24	26	28	30	32	35
0.06	30	33	35	39	42	45	48	52
Minimum Length (m) for Appearance	22	28	34	39	45	50	56	62

Notes:
1. Values above the heavy lines are less than the minimum lengths based on an appearance criterion.
2. For four-lane roadways, use Table 2.1.2.13.
3. For six-lane roadways, increase lengths by factor of 2.0.

Table 2.1.2.13 Length of Superelevation Runoff for Four-Lane, Undivided Crowned Urban Roadways, or Two-Lane Urban Roadways Without Crown[9]

Superelevation Rate (m/m)	Length of Runoff (Ls) (m)							
	Design Speed (km/h)							
	40	50	60	70	80	90	100	110
3.7 m lanes								
0.02	16	17	19	21	22	24	26	27
0.04	32	35	37	41	44	48	51	55
0.06	48	52	56	61	66	71	76	82
3.5 m lanes								
0.02	15	17	18	20	21	23	24	26
0.04	30	33	35	39	42	45	48	52
0.06	45	49	53	58	62	67	72	77
Minimum Length (m) for Appearance	22	28	34	39	45	50	56	62

Notes:
1. Values above the heavy lines are less than the minimum lengths based on an appearance criterion.
2. For two-lane crowned roadways, use Table 2.1.2.12.
3. For six -lane crowned roadways, increase lengths by factor of 1.33.

3.3.1

crowned urban roadways, or two-lane urban roadways with a single cross-slope.

The above tables are based on using the maximum relative slope values provided in Table 2.1.2.11, rather than the recommended minimum length for appearance purposes. As a suggested practice, minimum lengths required to maintain an acceptable general appearance and to avoid abrupt grade changes, are provided along the bottom of the tables and represent the distance travelled in 2 seconds at the design speed. The heavy line within the tables separates the lengths that are below and above the recommended design minimum lengths.

Superelevation Development: Design Domain General Application Heuristics

1. On urban roads with design speeds less than 80 km/h the length of tangent runout is normally based on the same slope as the superelevation runoff. In the case of higher speed facilities, a 1:400 slope similar to that for rural roads and high speed urban roads is used.

2. In the design of superelevation runoff for both rural and urban roads ensure that the edge profiles are smooth and without abrupt changes in grade. Short vertical curves or spline curves from 20 m to 40 m long can be used. Designers should be aware that this will often result in runoff lengths longer than the minimum suggested in the tables.

3. For added safety and comfort, the superelevation runoff should be applied uniformly over a length adequate for the likely operating speeds.

4. To be pleasing in appearance the runoff pavement edges should not be distorted as the driver views them. Spiral lengths as discussed in Subsection 2.1.2.3 are based on these criteria. For this reason when a spiral curve is used, the superelevation runoff is usually applied over the whole of the spiral length and the adverse crown is completely removed by the beginning of the spiral. For curves without spirals, the superelevation runoff is applied over a length equivalent to the spiral length. In this case the superelevation runoff is located so that 60% of the runoff occurs on the tangent approach and 40% on the curve.

Methods of Developing Superelevation: Best Practices

Two-Lane Roadways with Normal Crown

Figure 2.1.2.8 illustrates the three methods of attaining superelevation on two-lane normal crowned roadways, as described below. On curves where adverse crown is desired, but where the superelevation required does not exceed the crown slope, the superelevation should be equal to the crown slope. Information on attaining superelevation on non-crowned two-lane roadways can be obtained by referring to the divided roadway examples.

Method 1	The pavement is revolved about the centreline.
Method 2	The pavement is revolved about the inside edge.
Method 3	The pavement is revolved about the outside edge.

Method 1 is applicable to two-lane and four-lane undivided roadways. Method 2 and Method 3 are applicable to two-lane undivided roadways and four-lane divided roadways.

Method 2 is applicable if the design is required to match physical features on the roadside, to facilitate drainage or on divided highways where the median shoulder is on the inside of the curve.

As previously discussed, the length of tangent runout is normally based on a slope of 1:400. However, in the case of low speed urban facilities the tangent runout can be made steeper, to match the slope of the superelevation runoff.

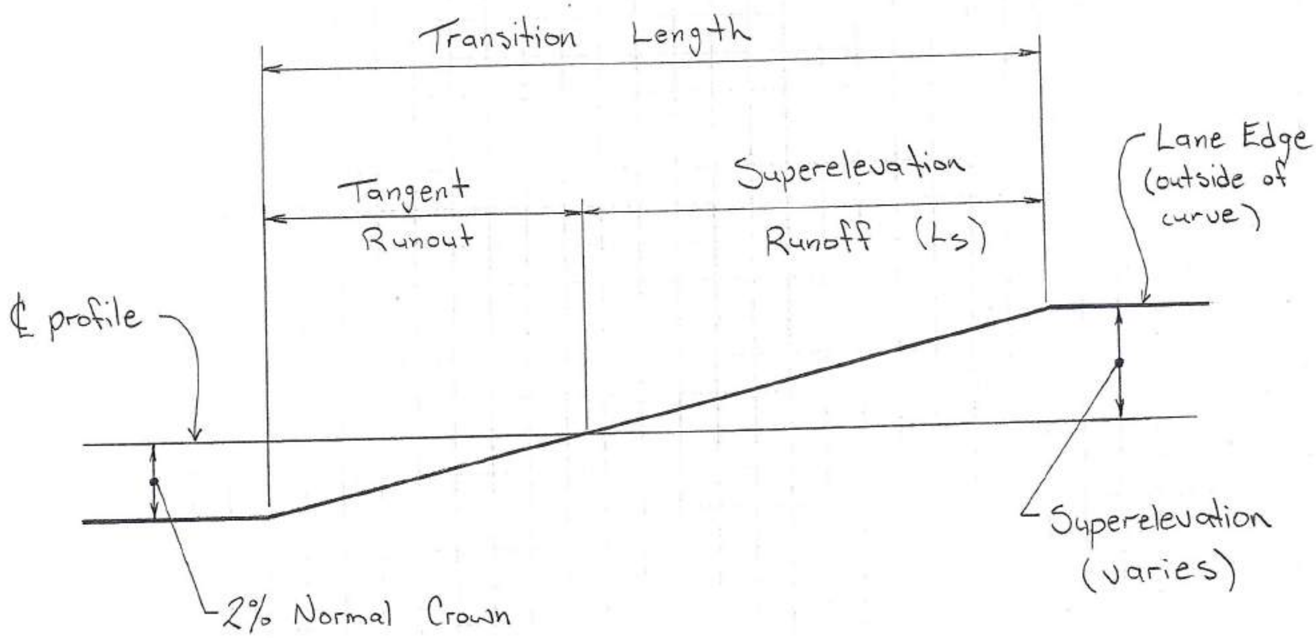
In superelevating two-lane roadways with a normal crown Method 1 is the most wic
approach in design because the ı
change in elevation of the edge of pav
made with less distortion than with t

3.3.2

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria
Superelevation

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:



Superelevation Transition Schematic

(applies to all design speeds)

InterCAD

CLIENT: Ekistics / Bentall
PROJECT: Fairwinds
SUBJECT: Achievment of Superelevation - Transition Length -

SHEET: 1 OF: 5
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:

Summary - Superelevation Transition Lengths

2-Lane Roadway, 3.5m Lanes

Design Speed	NC to +2%	NC to +4%	NC to +6%
60 km/h	24 m	36m	47m
50	22 m	33 m	44 m
40	20 m	30 m	40 m
30	20 m	30 m	-

4-Lane Roadway, 3.5m Lanes

Design Speed	NC to +2%	NC to +4%	NC to +6%
60 km/h	36m	53m	71 m
50	34 m	50 m	66 m

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria
Superelevation

SHEET: OF:
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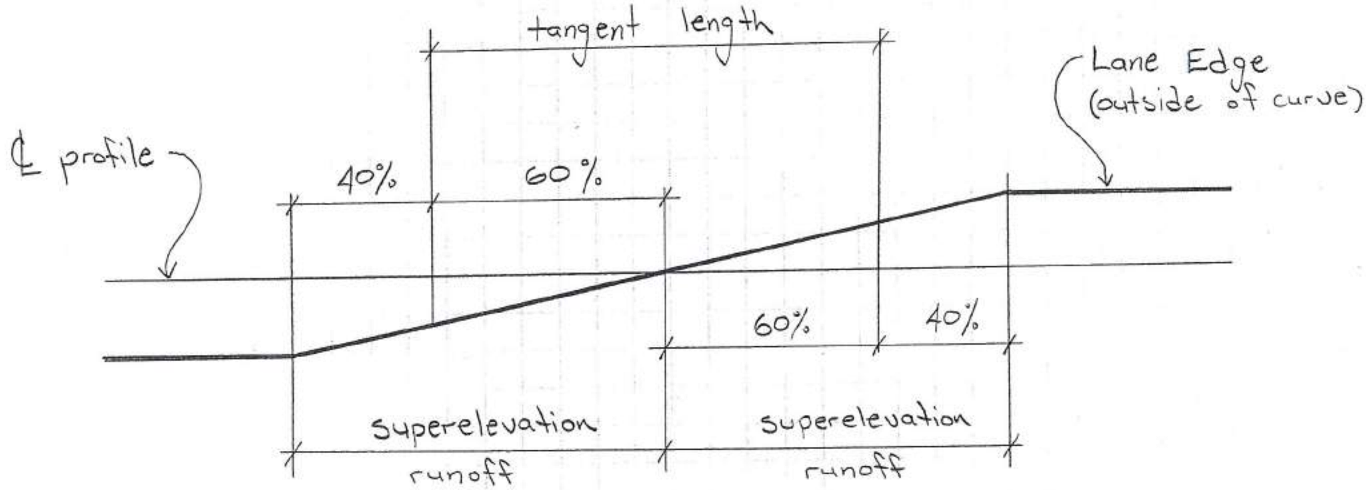

Superelevation Transition Schematic between Two Reversing Curves

(applies to all design speeds)

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

3.4.1 &
3.4.2

3. Where possible, gradients lower than the maximum values shown should be used.

4. Maximum values should only be exceeded after a careful assessment of safety, cost, property and environmental implications.

5. The choice of maximum gradient may have a bearing on related design features; for example, whether or not a truck climbing lane or escape lane is required.

6. While Table 2.1.3.1 provides general guidance, the designer should be aware that the factors that should be considered in establishing the maximum grade for a section of roadway include:

   - road classification
   - traffic operation
   - terrain
   - climatic conditions
   - length of grade
   - costs
   - property
   - environmental considerations
   - in urban areas, adjacent land use

7. Maximum grades of 3 to 5% are considered appropriate for design speeds of 100 km/h and higher. This may have to be modified in regions with severe topography such as mountainous terrain, deep river valleys, and large rock outcrops.

8. Maximum grades of 7 to 12% are appropriate for design speeds of 50 km/h and lower. If only the more important roadways are considered, 7% or 8% would be a representative maximum grade for a design speed of 50 km/h.

9. Control grades for other speeds between 50 km/h and 100 km/h are intermediate between the above extremes.

Minimum Grades: Design Domain Application Heuristics

Rural Roadways

1. On uncurbed roadways, level grades are generally acceptable provided the roadway is adequately crowned, snow does not interfere with surface drainage, and ditches have positive drainage. Roadway crown is discussed in Section 2.1.5. Refer to Chapter 2.2 for guidelines for the design of roadside open ditches and to relevant drainage publications.

Curbed Roadways (generally in urban areas)

1. To ensure adequate drainage, curbed roadways typically have a minimum longitudinal grade of 0.50% or 0.60%, depending on local policy.

2. In certain rare design cases, when no other alternative is feasible, a grade of 0.30% may be used as an absolute minimum preferably in combination with highly stable soils and rigid pavements.

3. For retrofit projects, longitudinal grades below the normal minimum of 0.50% or 0.60% may be considered where flatter grades allow the retention, rather than the removal, of existing pavements.

4. The minimum gradients outlined are suitable for normal conditions of rainfall and drainage outlet spacing. Where less than the normal minimum gradient is utilized, the lengths of such grades should be limited to short distances, and their location and frequency become important considerations. In special cases, hydraulic analysis is required to determine the extent of water spread on the adjacent travel lane. False grading, (where the pavement grade is not parallel to the top of curb), to ensure adequate drainage is an effective means of maintaining minimum grades in flat, highly constrained areas. False gradin addressed in Section 2.1.5, Cross-Slo

3.4.3

Maximum Grade: Design Domain Quantitative Aids

Although the relationship between design speeds and maximum grade is relatively subjective, reasonable guides for maximum grade have been developed.

The guidelines for maximum gradients are given in Table 2.1.3.1.

Maximum Grade: Design Domain Application Heuristics

1. The range of values shown in Table 2.1.3.1 recognizes that maximum grade selected for design varies with topography and the general financial capability of the road authority to fund the capital works. For lower classification urban roads, land use is an additional consideration and land use is incorporated into the guidelines for urban local and urban undivided collectors.

2. The values shown may be adjusted to suit local and economic conditions. Maximum gradients by classification and land use are often a matter of policy, and as a result, vary from jurisdiction to jurisdiction. Normally, the local policy is established at a senior engineering and planning level. In any event, in adjusting these figures, designers should ensure that they explicitly consider the impact of such alternative maximum grade values on safety.

Table 2.1.3.1 Maximum Gradients[1,9]

Design Speed (km/h)	30/40/50		60		70		80		90		100		110		120/130	
Topography	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M
RLU	7	11	7	11	6	9	6	8	5	7	5	7	-	-	-	-
RCU	-	-	6	10	6	9	5	8	5	7	5	7	-	-	-	-
RCD	-	-	-	-	6	9	5	8	5	7	5	7	-	-	-	-
RAU	-	-	-	-	-	-	4	7	4	6	3	6	3	6	3	5
RAD	-	-	-	-	-	-	4	7	4	6	3	6	3	5	3	5
RFD	-	-	-	-	-	-	-	-	-	-	3	5	3	5	3	5
ULU – Residential	8	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ULU – Industrial/ Commercial	6	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UCU – Residential	8	12	7	11	7	10	-	-	-	-	-	-	-	-	-	-
UCU – Industrial/ Commercial	6	12	6	11	6	9	6	8	-	-	-	-	-	-	-	-
UCD	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAU	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAD	-	-	3	6	3	6	3	6	3	6	3	5	-	-	-	-
UED	-	-	-	-	-	-	5	6	4	5	4	5	4	5	3	5
UFD	-	-	-	-	-	-	-	-	4	5	3	5	3	5	3	5

Notes:

1. Short grades less than 150 m in length, and one-way down grades may be 1% higher on urban roads, and 2% higher on low volume rural roads.
2. R refers to rolling topography.
3. M refers to mountainous topography.

3.4.4

roadway through the intersection. The concept for this type of adjustment is illustrated on Figures 2.3.2.5 and 2.3.2.6.[1] Although desirable, it is not always feasible to locate a high point at the centre of the intersection as shown on the Figures. Thus variations of the concept are needed to suit the vertical alignment characteristics of the intersection. Appropriate vertical curves are incorporated into the centreline profiles of both major roadways to achieve the desired grade adjustments. The edge of pavement profiles are often determined by using a spline, since calculated vertical curves do not always fit the constraints. A spline is a flexible drafting tool used to draw curved lines. A splined edge of pavement line provides a "best fit" curve which ensures that drainage is adequate, cross-slope is suitable and that the change in grade is not too abrupt.

Grade Breaks

Significant grade changes are not desirable within and near intersections which could affect the control and operation of a vehicle passing through the intersection at the expected operating speed. Grade breaks at intersections in the order of 0.5% to 2% are typical for a design speed of 70 km/h or higher. For lower design speeds more substantial grade breaks can be accommodated if required for the specific conditions. At a design speed of 50 km/h, a maximum grade change in the order of 3% to 4% produces some discomfort for vehicular traffic but is normally not detrimental to the safe operation of the intersection, provided that the stopping sight distance for the design speed is achieved. For speeds of 30 km/h or less, grade breaks up to 6% could be used, if required.

Grades

The grades of intersecting roadways in the area of the intersection should be as flat as possible to accommodate:

- storage space for stopped vehicles
- desirable sight distance (see Section 2.3.3)
- accelerating and stopping distance

Appropriate minimum grades at intersections are important to facilitate drainage, to avoid operational safety concerns related to ponding or icing conditions, and to compensate for some pavement wear and differential settlements. Particular attention should be devoted to the grading design of curb returns and to the calculation of roadway surface water runoff in an urban environment where there are large paved surfaces at intersections. Suggested guidelines include a minimum grade of 0.5% along curb returns (urban section), and a minimum of 1.0% combined cross-slope and roadway gradient within the limits of the intersection (rural and urban sections).

Existing driveways and accesses are often a constraint in setting grade lines on intersection approaches.

Along the approach legs to the intersection where vehicles are expected to stop, such as at left- and right-turn lanes or where signals are or may in the future be warranted, it is desirable to keep grades between 0.5% and 3%. A grade as low as 0.15% may be considered as long as adequate drainage is provided through cross-slope to avoid ponding. The calculated stopping and accelerating distance for a passenger car on a grade requires correction to produce conditions equivalent to those on level roadways (see Chapter 1.2). In addition, acceleration and deceleration tapers and/or lane lengths should be adjusted for steeper grades. Most vehicle operators are unable to judge the increase or decrease in stopping or accelerating distance that is necessary because of steep grades. Their normal deductions and reactions thus may be in error at a critical time. Accordingly, grades in excess of 3% are not desirable through an intersection. For low-volume, low-speed intersections, such as at the intersection of two local residential roads where physical conditions and economic considerations dictate, approach grades of 5% to 6% may be considered as long as acceptable site distance is provided along with an adjustment in design factors. The gradient within the intersection is normally limited to 4%. This limitation assists in providing reasonable operation for low-speed turning vehicles, particularly under slippery conditions.

3.4.6

When establishing the profile for the minor cross road, it is important to consider whether or not the intersection may be signalized in the future. If signalization is probable, the minor roadway should be designed to accommodate future free-flow traffic which would occur under green-signal conditions.

The approach/departure grade should ideally extend approximately 20 m back from intersections, although this can be reduced to one or two car lengths on minor roadways with light traffic volumes.

In addition to the vertical alignment and cross-slope considerations, the horizontal alignments of approach roadways are normally kept as simple and smooth as possible. It is desirable to ensure that the combination of horizontal alignment and vertical profile allows good visibility of the intersection area from all approaches. This allows drivers to focus their attention on the intersection area, where most conflicts occur.

2.3.2.4 Combined Vertical and Horizontal Alignments

The combination of horizontal and vertical alignment at, and near an intersection will ideally produce traffic lanes that are clearly visible to operators at all times. They should be clearly comprehensible for any desired direction of travel, free from the sudden appearance of potential conflicts, and consistent with the roadway just travelled.[11]

When the superelevation of a section of roadway on a curve is in the same direction as the grade of the intersecting cross road, the vertical alignment of the cross roadway is adjusted to meet the normal pavement cross-slope of the roadway as shown in Illustration A of Figure 2.3.2.7.

For intersections on curve, the selection of an appropriate radius is a function of the design speed of the through roadway with consideration given to the grade of the crossing roadway through the intersection. For example, for a crossing roadway with a grade of 3% through an intersection, the superelevation of the intersecting roadway on curve should also be 3% to provide a smooth crossing of the through roadway by the crossing road driver. Therefore, for a design speed of 80 km/h, the desirable radius for the through roadway curve is 1200 m, with superelevation of 0.028 m/m (based on e_{max} = 0.06 m/m), according to Chapter 2.1.

However, through an intersection on curve in an urban environment, drivers are willing to accept higher lateral friction than in open conditions. As such, a smaller radius curve could be used for a desired rate of superelevation to match the crossing roadway grade through the intersection under certain constrained conditions. In a rural environment, higher lateral friction is less desirable, due to greater driver expectations in terms of roadway performance. This is discussed further in Subsection 2.3.2.5.

An intersection where the cross-slope of the curving roadway is not in the same direction as the grade of the intersecting cross roadway is not desirable. If this condition cannot be avoided, the vertical alignment of the cross roadway is adjusted a sufficient distance from the intersection to introduce a desirable alignment as indicated in Illustration B of Figure 2.3.2.7. As discussed in Subsection 2.3.2.3, grade breaks over 4% are not desirable due to discomfort to vehicular traffic; however, if necessary, the break can approach 6% for minor roadways.

Minimum design parameters for both the vertical and horizontal alignment elements are undesirable in intersection design. If a limiting or near limiting condition cannot be avoided for one element, it is desirable to ensure that the other elements are well above the minimum design guidelines. Thus intersections are generally not preferred on sharp horizontal curves with significant superelevation. Superelevation rates in excess of 0.04 m/m through intersection areas adversely affect the smooth operation, particularly for those vehicles turning against the superelevation.

Similarly, steep gradients in combinati badly skewed intersections or near-l horizontal curves often create unde 3.4.7

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

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Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

35.1

In calculating K values for various sight distances, the height of driver's eye is 1.05 m, and the height of object is as outlined following, and discussed in more detail in Chapter 1.2.

- For stopping sight distance the most common object a vehicle has to stop for is another vehicle ahead on the road, the height of tail light is used. The legislated minimum is 0.38 m and is adopted for design. Other heights of objects can be used if necessary.
- For decision sight distance the more common height of object is 0.15 m, although other heights, such as zero for pavement markings, are not uncommon.
- For passing sight distance the height of object is 1.30 m, which represents the height of the opposing vehicle.

Crest Vertical Curves: Design Domain Quantitative Aid

Based on the above most commonly used heights of object, and on sight distances from Tables 1.2.5.3 and 1.2.5.5, the K values for stopping sight distance are provided in Table 2.1.3.2 and for passing sight distance the K values are provided in Table 2.1.3.3. The decision sight distance K values are not included because the vertical curvature depends on the height of object which is variable (depending on what the driver has to see).

The calculated K values are based on the length of curve exceeding the sight distance and they can be used without significant error when the length of curve is less than the sight distance. Appreciable differences occur only where A is small and little or no additional cost is involved in obtaining longer vertical curves.

On undivided roads non-striping sight distance is used to determine when no-passing pavement markings are required[7]. It is desirable to provide passing sight distance wherever possible but non-striping sight distance is generally adequate for safe passing manoeuvres.

Non-striping sight distance is less than passing sight distance, at each design speed. Passing manoeuvres can be completed in less than the full passing sight distance because of the timing of oncoming vehicles.

Table 2.1.3.2 K Factors to Provide Stopping Sight Distance on Crest Vertical Curves

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Vertical Curvature (K) Computed	Rounded
30	30	29.6	1.6	2
40	40	44.4	3.7	4
50	47-50	57.4-62.8	6.1-7.3	6-7
60	55-60	74.3-84.6	10.2-13.3	10-13
70	63-70	94.1-110.8	16.4-22.8	16-23
80	70-80	112.8-139.4	23.6-36.1	24-36
90	77-90	131.2-168.7	32.0-52.8	32-53
100	85-100	152.0-205.0	45.8-78.0	45-80
110	91-110	179.5-246.4	59.8-112.7	60-110
120	98-120	202.9-285.6	76.4-151.4	75-150
130	105-130	227.9-327.9	96.4-199.6	95-200

Note: The above are minimum values, use higher K factors whenever possible.

3.5.2

Table 2.1.3.4 K Factors to Provide Minimum Stopping Sight Distance on Sag Vertical Curves[1]

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Sag Vertical Curvature (K)			
			Headlight Control		Comfort Control	
			Calculated	Rounded	Calculated	Rounded
30	30	29.6	3.9	4	2.3	2
40	40	44.4	7.1	7	4.1	4
50	47-50	57.4-62.8	10.2-11.5	11-12	5.6-6.3	5-6
60	55-60	74.3-84.6	14.5-17.1	15-18	7.7-9.1	8-9
70	63-70	99.1-110.8	19.6-24.1	20-25	10.0-12.4	10-12
80	70-80	112.8-139.4	24.6-31.9	25-32	12.4-16.2	12-16
90	77-90	131.2-168.7	29.6-40.1	30-40	15.0-20.5	15-20
100	85-100	157.0-205.0	36.7-50.1	37-50	18.3-25.3	18-25
110	91-110	179.5-246.4	43.0-61.7	43-62	21.0-30.6	21-30
120	98-120	202.9-285.6	49.5-72.7	50-73	24.3-36.4	24-36
130	105-130	227.9-327.9	56.7-85.0	57-85	27.9-42.8	28-43

Values for sag curvature based on the comfort criterion are shown in Table 2.1.3.4.

These K values for sag curves are useful in urban situations such as underpasses where it is often necessary for property and access reasons to depart from original ground elevations for as short a distance as possible. Minimum values are normally exceeded where feasible, in consideration of possible power failures and other malfunctions to the street lighting systems. Designing sag vertical curves along curved roadways for decision sight distance is normally not feasible due to the inherent flat grades and resultant surface drainage problems.

2.1.3.4 Vertical Alignment: Design Domain Additional Application Heuristics

Vertical Alignment Principles: Application Heuristics

The following principles generally apply to both rural and urban roads. A differentiation between rural and urban is made in several instances where necessary for clarity.

1. On rural and high speed urban roads a smooth grade line with gradual changes, consistent with the class of road and the character of the terrain, is preferable to an alignment with numerous breaks and short lengths of grade. On lower speed curbed urban roadways drainage design often controls the grade design.

2. Vertical curves applied to small changes of gradient require K values significantly greater than the minimum as shown in Tables 2.1.3.2 and 2.1.3.4. The minimum length in metres should desirably not be less than the design speed in kilometres per hour. For example, if the design speed is 100 km/h, the vertical curve length is at least 100 m.

3. Vertical alignment, having a series of successive relatively sharp crest and sag curves creating a "roller coaster" or "hidden dip" type of profile is not recommended. Hidden dips can be a safety concern, particularly at night. Such profiles generally occur on relatively straight horizontal alignment where the roadway profile closely follows a rolling natural ground line. Such roadways are unpleasant aesthetically and more difficult to drive. This type of profile is avoided by the use of horizontal curves or by more gradual grades.

4. A broken back grade line (two vertical curves in the same direction separated by a short section of tangent grade) is not

Table 1.2.5.2 Coefficient of Friction for Wet Pavements[4]

Design Speed (km/h)	Operating Speed [a] (km/h)	Coefficient of Friction (f)
30	30	0.40
40	40	0.38
50	47-50	0.35
60	55-60	0.33
70	63-70	0.31
80	70-80	0.30
90	77-90	0.30
100	85-100	0.29
110	91-110	0.28
120	98-120	0.28
130	105-130	0.28

Note: [a] The range of operating speeds recognises that some drivers slow down in wet conditions: others do not.

applied. On a level roadway this distance can be determined using the following formula:

$$d = \frac{V^2}{2gf} = \frac{V^2}{2(9.81)f} \times \left(\frac{1000}{3600}\right)^2 = \frac{V^2}{254f} \quad (1.2.4)$$

Where d = braking distance (m)

V = initial speed (km/h)

f = coefficient of friction between the tires and the roadway

Then SSD = 0.278tV + d (1.2.5)

Where SSD = stopping sight distance (m)

t = perception and reaction time (s)

Table 1.2.5.3 gives the minimum stopping sight distances on level grade, on wet pavement, for a range of design speeds. These values are used for vertical curve design, intersection geometry and the placement of traffic control devices.

The stopping sight distances quoted in Table 1.2.5.3 may need to be increased for a variety of reasons, related to grade, vehicle braking capability and pavement condition.

Variation for Trucks

Geometric characteristics to achieve stopping sight distance requirements vary because of differences in driver eye height and braking characteristics. While a truck driver can generally see further than a passenger car driver due to an eye height advantage, in some instances the higher eye height is a disadvantage — for example, a sag vertical curve where visibility is "cut off" by an overpass. Truck braking characteristics are highly variable and often increase effective braking distance and, thus, stopping sight distance.

A number of tests[8] have been conducted using trucks with conventional brakes and antilock brakes, and drivers with varying levels of experience in handling emergen[illegible] situations. The use of antilock brake[illegible] to consistently reduce braking di[illegible] minimising variations in driver perfor[illegible]

3.6

Table 1.2.5.3 Stopping Sight Distance for Automobiles[4] and Trucks with Antilock Braking Systems[8]

Design Speed (km/h)	Assumed Operating Speed* (km/h)	Perception and Reaction time (s)	Perception and Reaction distance (m)	Coefficient of Friction	Braking Distance (m)	Stopping Sight Distance (rounded) (m)
40	40	2.5	27.8	0.38	16.6	45
50	47 - 50	2.5	32.7 - 34.7	0.35	24.8 - 28.1	60 - 65
60	55 - 60	2.5	38.2 - 41.7	0.33	36.1 - 42.9	75 - 85
70	63 - 70	2.5	43.7 - 48.6	0.31	50.4 - 62.2	95 - 110
80	70 - 80	2.5	48.6 - 55.5	0.30	64.2 - 83.9	115 - 140
90	77 - 90	2.5	53.5 - 62.5	0.30	77.7 - 106.2	130 - 170
100	85 - 100	2.5	59.0 - 69.4	0.29	98.0 - 135.6	160 - 210
110	91 - 110	2.5	63.2 - 76.4	0.28	116.3 - 170.0	180 - 250
120	98 - 120	2.5	68.0 - 83.3	0.28	134.9 - 202.3	200 - 290
130	105-130	2.5	72.9 - 90.3	0.28	155.0 - 237.6	230 - 330

Note: * Range of assumed operating speed is from average running speed for low-volume conditions to design speed.

utilizing more of the available friction. In fact, the results indicated that the stopping sight distances from Table 1.2.5.3 would be adequate if antilock brakes were in general use on trucks.

Table 1.2.5.4 shows stopping sight distances for trucks with conventional brakes, and compares them to the stopping sight distances given in Table 1.2.5.3.

The increased stopping sight distances for trucks with conventional brakes (i.e. the majority of the current fleet) are generally offset by increased driver eye height for the purposes of vertical curve calculations. However, where driver eye height is not an advantage, such as on horizontal curves or approaching controlled intersections, the greater stopping sight distances should be used.

Sight restrictions such as shrubs, trees, cut slopes, or buildings may occur on the inside of horizontal curves. Although truck drivers have higher eye heights, the required truck driver sight distance may not be offset by the higher eye height unless the obstructions are physically below the driver's line of sight.

The Effect of Grade

Braking distances will increase on downgrades and decrease on upgrades. When the roadway is on a grade, the formula for braking distance is:

$$d = \frac{V^2}{254\,(f \pm G)} \qquad (1.2.6)$$

Where G = the percent grade divided by 100 (up is positive, down is negative) and all other terms are as noted in Equation 1.2.4.

3.6

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

3.6.1

30km/h

Table 4 : Alignment Design Criteria Summary : 30 km/h Design Speed

1. Horizontal Curve Radii

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Roadway Crossfall			
normal crown (-2%)	-	24m [2]	30m
2% superelevation	-	21m [2]	25m
4% superelevation	-	20m [2]	20m
6% superelevation	20 [1]	-	N/A
Through Intersections	-	-	-

1 Table 1420.A - Design Parameters

2 Calculated minimum radius for low speed urban design based on Table 2.1.2.2, Page 2.1.2.7 TAC manual which is consistent with AASHTO Method 2 for distribution of e & f.

2. Superelevation

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Maximum Superelevation	4% [1]	N.C. [2]	4%
Maximum Superelevation at Intersections	-	-	4%

1 Table 1420.A - Design Parameters: parameters based on E max 0.06 m/m, however, Section 1420.05.08 - Superelevation notes that a maximum rate of 0.04m/m shall be used for local urban streets.

2 See Section 2.1.2.2 - Maximum Superelevation, Page 2.1.2.4 TAC manual.

3. Superelevation Transition Lengths

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Transition Lengths (2-lane roadway)			
normal crown to −2%	-	-	20m
normal crown to +4%	-	-	30m
Min Tangent Length between reversing curves			
2% superelevation (2-lane roadway)	-	-	12m
4% superelevation	-	-	24m

4. Gradients

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Grade	-	0.5% [3]	0.5%
Maximum Grades			
on horizontal tangents	8% [1]	15% [4]	12%
on minimum radius horizontal curves	4% [2]	-	10%
Grades Through Intersections			
Stop condition	-	3% (desirable) [6] 6% (maximum)	6%
approach distance [5]	-	5m [7]	5m

1 Table 1420.A - Design Parameters

2 Grades reduced by 1% for every 30 metres that the centreline radius is less than 150m. As the minimum centreline radius is 20m (at 6% superelevation), the maximum grade is reduced by 4%.

3 See Section 2.1.3.2 - Minimum Grades, Page 2.1.3.5 TAC manual.

4 Maximum gradient, from TAC table 2.1.3.1 Page 2.1.3.2, for a ULU classification, 30km/h design speed in mountainous topography.

5 Minimum distance back from the gutter line of the intersecting road that the intersection grade must apply.

6 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Pages 2.3.2.8 TAC manual.

7 See Section 2.3.2.3 - Vertical Alignment and Cross Slope, Pages 2.3.2.11 TAC manual. Approach / departure grade can be reduced to one or two car lengths on minor roadways with light traffic volumes.

5. Vertical Curve K Values

Criteria	Section 1400 MoT Supplement to TAC	TAC	Proposed for Fairwinds
Minimum Crest	2 [1]	2 [2]	2
Minimum Sag	4 [1]	2 [3]	2

TAC and Proposed K values listed assume that new roadways will be illuminated

1 Table 1420.A - Design Parameters: crest based on taillight height, sag based on headlight control (ie no street lighting). Section 1420.05 - Alignment notes that length of vertical curve (in m) should not be less than the design speed (in km/h).

2 See Table 2.1.3.2 - Crest Vertical Curves, Page 2.1.3.6 TAC manual.

3 See Table 2.1.3.4 - Sag Vertical Curves, Page 2.1.3.9 TAC manual.

6. Stopping Sight Distances

Criteria	Down Grades				0%	Up Grades			
	12%	9%	6%	3%		3%	6%	9%	12%
Minimum distance (m)	34	32	31	30	30 [1]	29	29	28	28

All values, see Section 1.2.5.2 - Stopping Sight Distance, Pages 1.2.5.2 and 1.2.5.4 TAC manual.

1 Only SSD given for level grade in MoT Supplement, Section 1400, Table 1420.A - Design Parameters. MoT Value = 30m

1420.05 ALIGNMENT

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Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

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1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

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- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B.**

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
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Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

4.1.1

Table 2.1.2.1 **Maximum Lateral Friction for Rural and High Speed Urban Design**[1]

Design Speed (km/h)	Maximum Lateral Friction for Rural and High Speed Urban Design
40	0.17
50	0.16
60	0.15
70	0.15
80	0.14
90	0.13
100	0.12
110	0.10
120	0.09
130	0.08

margin of safety against skidding under normal driving conditions in the urban environments. Values are presented in Table 2.1.2.2.

Minimum Radius: Design Domain

Overview

The minimum allowable radius for any design speed depends on the maximum rate of superelevation and the lateral friction force that can be developed between the pavement and vehicle tires. This relationship is expressed by:

$$R_{min} = \frac{V^2}{127(e_{max} + f_{max})} \qquad (2.1.2)$$

Table 2.1.2.2 **Maximum Lateral Friction for Low Speed Urban Design**[1]

Design Speed (km/h)	Maximum Lateral Friction for Low Speed Urban Design
30	0.31
40	0.25
50	0.21
60	0.18

For rural and urban high speed superelevation applications there is generally reasonable opportunity to provide the desirable amount of superelevation. In rural areas the constraints are usually minimal, while on high speed urban roadways the designer has reasonable flexibility in establishing suitable superelevation. This is because in the design of new streets, particularly those with design speeds of 70 km/h or more and through generally undeveloped areas, the designer typically has greater flexibility in establishing suitable horizontal and vertical alignments and associated superelevation rates. Often it is possible to regrade adjacent properties to match superelevated sections, ensuring appropriate drainage patterns and intersection profiles.

Rural and High Speed Urban Applications: Design Domain Quantitative Aids

For rural and high speed urban applications the minimum radius is calculated using a maximum superelevation rate of either 0.04 m/m, 0.06 m/m or 0.08 m/m for a range of design speeds from 40 km/h to 130 km/h, and lateral friction factors from Table 2.1.2.1. These calculated values are shown in Table 2.1.2.3.

Low Speed Urban Applications: Design Domain Quantitative Aids

For low speed urban conditions and where a street is to be upgraded through a developed urban area, it is often not desirable or possible to utilize superelevation rates typical of high speed design as previously discussed. Design considerations other than driver discomfort may be important. Existing physical controls, right-of-way constraints, intersections, driveways, on-street parking, and economic considerations have a strong influence on design elements, including design speed and superelevation. In some cases, design speed may not be an initial design control, but rather a result of the other controls or considerations influencing the horizontal alignment and superelevation.

Moreover, in low speed urban conditions, drivers are accustomed to a greater lev discomfort while traversing curves. He increased lateral friction factors resulting

4.1.2

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A.** The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B.**

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	**30**	**40**	**50**	**60**	**70**	**80**
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K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.
** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.
*** This includes cul-de-sacs, frontage roads, and backage roads.

4.2.1

1420.05.05 Frontage Roads

The Right-Of-Way width shall be 15 metres or the cross section width plus 3 metres, whichever is greater. (This is additional to the through road requirements.) Ensure sufficient setback at intersections to accommodate turn slots, etc., thus ensuring a bulbed connection is necessary at all frontage road intersections.

1420.05.06 Backage Roads

For these standards, backage roads shall be considered local roads.

1420.05.07 Cross Slopes

All roadways shall be constructed using a centerline crown and shall be graded and compacted with the following crossfall to ensure road drainage:

- Normal cross slopes shall be 2% for paved roads and 4% for gravel roads.

1420.05.08 Superelevation

Superelevation is generally not applied on local subdivision roads or cul-de-sacs; reverse crown is usually maintained in ≤ 800 metre radius curves @≤ 50 km/h. Rural roads of a continuous nature that provide access to a subdivision would be better classified as Low-volume roads and should be superelevated accordingly. Refer to the Low-volume Road Chapter of the BC Supplement to TAC. When the decision has been made to superelevate curves, a maximum rate of 0.04 m/m shall be used for local urban street systems. This is appropriate for design speeds up to 70 km/h and where surface icing and interrupted traffic flow are expected. Superelevation rates of 0.04 m/m and 0.06 m/m are applicable for design of new urban streets in the upper range of the classification system where uninterrupted flow is expected and where little or no physical constraints exist.

1420.06 INTERSECTIONS/ACCESSES

1420.06.01 General

Intersections shall be as near as possible to right angles. The minimum skew angle of the intersection shall be 70 degrees and the maximum skew angle shall be 110 degrees.

1420.07 UTILITY SETBACK

Utility poles or signs should be within 2 metres of the property boundary or a minimum 2 metres beyond the toe of the fill, whichever gives the greater offset from the road. See Figure 1420.C.

1420.08 DRIVEWAYS

1. Driveway location, spacing and approval shall be at the discretion of the Ministry Representative.

2. The first 5 metres (measured from the ditch centerline) of all residential driveways shall be constructed at or near a right angle (70° to 110°) to the road and at a maximum ± 2 % grade.

3. All open shoulder driveways with a level or rising grade are to be constructed with a "valley" or "swale" over the ditch line to ensure surface water enters the ditch and does not enter the road. See Figure 1420.N

4. Driveway grades shall not exceed 8% within the Right-of-Way.

5. Driveway radius and widths:
   Residential/Farm – 6 metre radius and minimum width
   Logging/Commercial – 9 metre radius and minimum width

6. All lots with cuts or fills greater than 1.8 metres shall have engineered drawings when requested by the Ministry representative.

4.2.1

weather conditions, or for other reasons, while not adversely affecting higher speed vehicles. This is especially important for roads located where winter conditions prevail several months of the year.

Urban Areas: Design Domain Quantitative Aids

In urban areas maximum superelevation values cover the range from 0.02 m/m to 0.08 m/m. Values commonly used for maximum superelevation are:

1. Locals - generally normal crown.
2. Collectors - used occasionally with maximum rates of 0.02 m/m or 0.04 m/m.
3. Minor arterials - 0.04 m/m to 0.06 m/m.
4. Major arterials - 0.06 m/m.
5. Expressways and freeways - 0.06 m/m to 0.08 m/m.
6. Interchange ramps - 0.06 m/m to 0.08 m/m.

Urban Areas: Design Domain Application Heuristics

1. In urban areas maximum superelevation values tend to be lower since vehicles travelling at slow speeds or moving away from a stopped position might experience side-slip on higher superelevation. Maximum superelevation in urban areas is typically 0.06 m/m.
2. A maximum superelevation rate of 0.04 m/m may also be used for an urban roadway system, and is appropriate where surface icing and interrupted flow is expected.
3. The maximum superelevation rates of 0.04 m/m and 0.06 m/m are generally applicable for design of new roads in the upper range of the classification system and where little or no physical constraints exist.
4. Superelevation is generally not applied on local roads.
5. On collector roads superelevation is used occasionally, and typically where beneficial in matching adjacent topography. Maximum superelevation rates in these cases are in the range of 0.02 m/m (reverse crown) to 0.04 m/m.
6. In some jurisdictions, higher superelevation values are used for ramps on urban freeways than on other urban roads to provide additional safety since freeway ramps, particularly off-ramps, tend to be over-driven more often and side-slip is less likely to occur since maintenance is better at these locations.
7. Superelevation rates in excess of 0.04 m/m are not recommended where curved alignments pass through existing or possible future intersection areas. In urban retrofit situations, it is often difficult or undesirable to provide any superelevation at all due to physical constraints. In these cases, the designer has to carefully assess the relationships of design speed, curvature, crossfall and lateral friction in choosing the optimum design solution.
8. Acceptable maximum superelevation rates are often established as a matter of policy and vary between jurisdictions based on local conditions. As an example, some jurisdictions use a maximum superelevation rate of 0.08 m/m for higher classification roads such as expressways. In the interests of maintaining consistency in design in any particular area where the responsibility for roads is divided between jurisdictions, it is desirable to maintain consistent maximum superelevation. In selecting maximum superelevation, therefore, reference should be made to values used by other road authorities in the area.

<u>Lateral Friction: Technical Foundation Element</u>

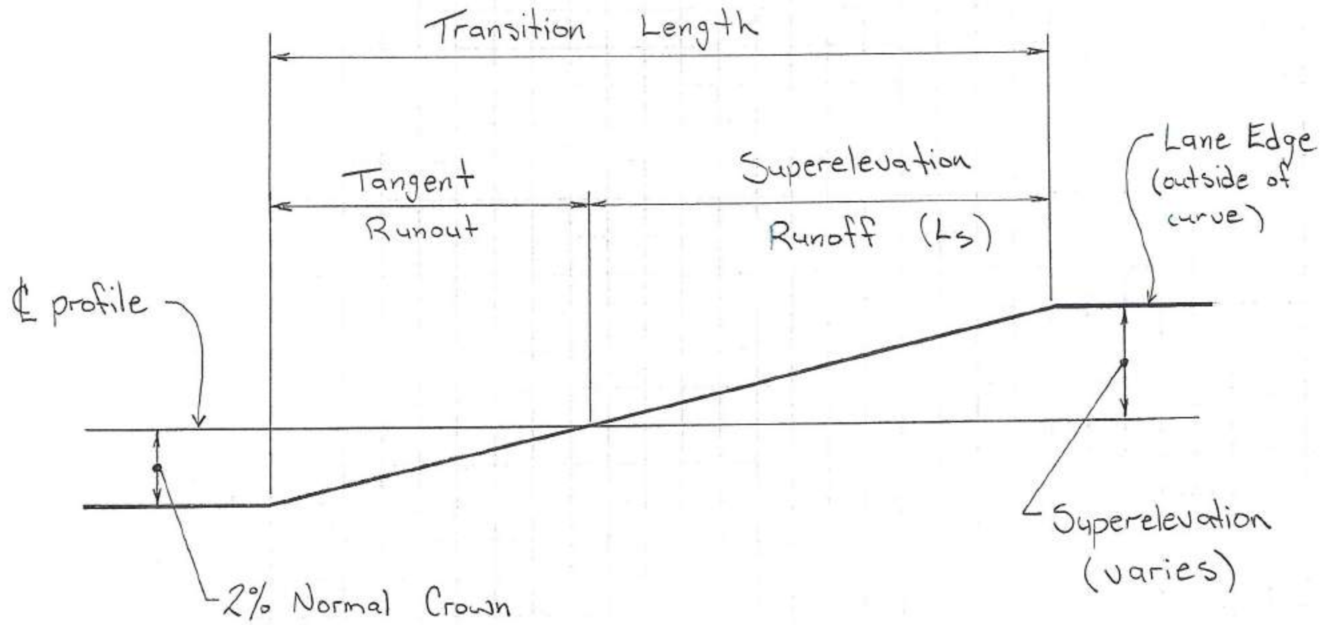
The lateral friction factor f is the ratio of the lateral friction force and the component of the weight of the vehicle perpendicular to the pavement. This force is applied to the vehicle 4.2.2

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria

Superelevation

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:



Superelevation Transition Schematic

(applies to all design speeds)

4.3

InterCAD

CLIENT:	Ekistics / Bentall	SHEET: 1 OF: 5	
PROJECT:	Fairwinds	DATE:	Oct 7/09
SUBJECT:	Achievment of Superelevation - Transition Length -	FILE:	AD28
		BY:	SClinton
		CHECKED:	

Summary - Superelevation Transition Lengths

2-Lane Roadway, 3.5m Lanes

Design Speed	NC to +2%	NC to +4%	NC to +6%
60 km/h	24 m	36m	47m
50	22 m	33 m	44 m
40	20 m	30 m	40 m
30	20 m	30 m	-

4-Lane Roadway, 3.5m Lanes

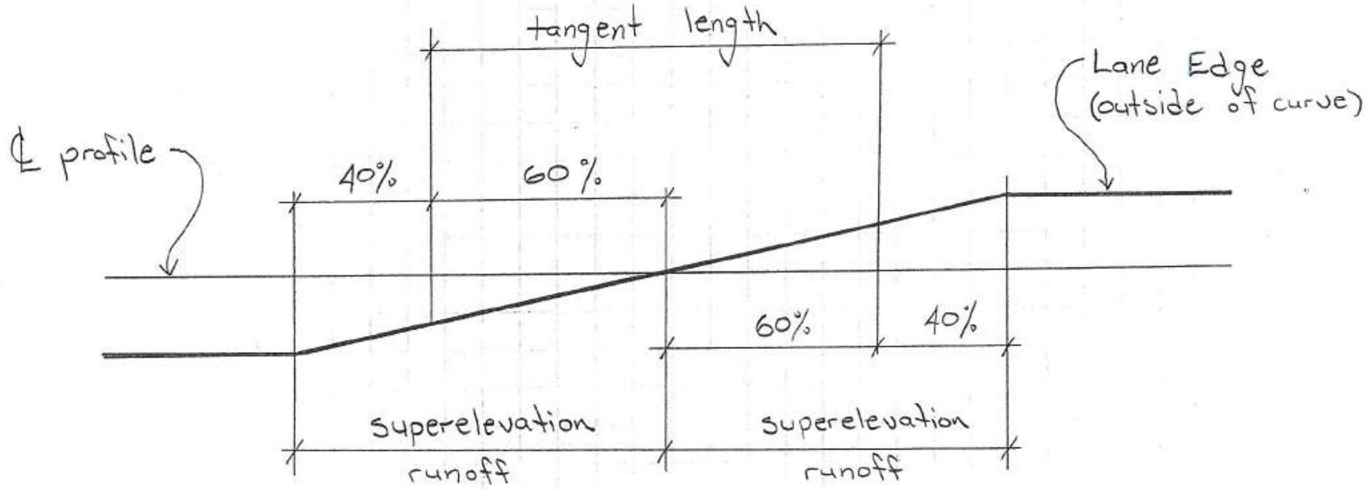
Design Speed	NC to +2%	NC to +4%	NC to +6%
60 km/h	36m	53m	71 m
50	34 m	50 m	66 m

InterCAD

CLIENT: Ekistics / Bentall LP
PROJECT: Fairwinds
SUBJECT: Alignment Design Criteria

Superelevation

SHEET: OF:
DATE: Oct 7/09
FILE: AD28
BY: SClinton
CHECKED:



Superelevation Transition Schematic between Two Reversing Curves

(applies to all design speeds)

1420.05 ALIGNMENT

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The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

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- Minimum finished top: 10 metres.
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Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

4.4.1 &
4.4.2

3. Where possible, gradients lower than the maximum values shown should be used.

4. Maximum values should only be exceeded after a careful assessment of safety, cost, property and environmental implications.

5. The choice of maximum gradient may have a bearing on related design features; for example, whether or not a truck climbing lane or escape lane is required.

6. While Table 2.1.3.1 provides general guidance, the designer should be aware that the factors that should be considered in establishing the maximum grade for a section of roadway include:

   - road classification
   - traffic operation
   - terrain
   - climatic conditions
   - length of grade
   - costs
   - property
   - environmental considerations
   - in urban areas, adjacent land use

7. Maximum grades of 3 to 5% are considered appropriate for design speeds of 100 km/h and higher. This may have to be modified in regions with severe topography such as mountainous terrain, deep river valleys, and large rock outcrops.

8. Maximum grades of 7 to 12% are appropriate for design speeds of 50 km/h and lower. If only the more important roadways are considered, 7% or 8% would be a representative maximum grade for a design speed of 50 km/h.

9. Control grades for other speeds between 50 km/h and 100 km/h are intermediate between the above extremes.

Minimum Grades: Design Domain Application Heuristics

Rural Roadways

1. On uncurbed roadways, level grades are generally acceptable provided the roadway is adequately crowned, snow does not interfere with surface drainage, and ditches have positive drainage. Roadway crown is discussed in Section 2.1.5. Refer to Chapter 2.2 for guidelines for the design of roadside open ditches and to relevant drainage publications.

Curbed Roadways (generally in urban areas)

1. To ensure adequate drainage, curbed roadways typically have a minimum longitudinal grade of 0.50% or 0.60%, depending on local policy.

2. In certain rare design cases, when no other alternative is feasible, a grade of 0.30% may be used as an absolute minimum preferably in combination with highly stable soils and rigid pavements.

3. For retrofit projects, longitudinal grades below the normal minimum of 0.50% or 0.60% may be considered where flatter grades allow the retention, rather than the removal, of existing pavements.

4. The minimum gradients outlined are suitable for normal conditions of rainfall and drainage outlet spacing. Where less than the normal minimum gradient is utilized, the lengths of such grades should be limited to short distances, and their location and frequency become important considerations. In special cases, hydraulic analysis is required to determine the extent of water spread on the adjacent travel lane. False grading, (where the pavement grade is not parallel to the top of curb), to ensure adequate drainage is an effective means of maintaining minimum grades i highly constrained areas. False gra addressed in Section 2.1.5, Cross-S

4.4.3

Maximum Grade: Design Domain Quantitative Aids

Although the relationship between design speeds and maximum grade is relatively subjective, reasonable guides for maximum grade have been developed.

The guidelines for maximum gradients are given in Table 2.1.3.1.

Maximum Grade: Design Domain Application Heuristics

1. The range of values shown in Table 2.1.3.1 recognizes that maximum grade selected for design varies with topography and the general financial capability of the road authority to fund the capital works. For lower classification urban roads, land use is an additional consideration and land use is incorporated into the guidelines for urban local and urban undivided collectors.

2. The values shown may be adjusted to suit local and economic conditions. Maximum gradients by classification and land use are often a matter of policy, and as a result, vary from jurisdiction to jurisdiction. Normally, the local policy is established at a senior engineering and planning level. In any event, in adjusting these figures, designers should ensure that they explicitly consider the impact of such alternative maximum grade values on safety.

Table 2.1.3.1 Maximum Gradients[1,9]

Design Speed (km/h)	30/40/50		60		70		80		90		100		110		120/130	
Topography	R	M	R	M	R	M	R	M	R	M	R	M	R	M	R	M
RLU	7	11	7	11	6	9	6	8	5	7	5	7	-	-	-	-
RCU	-	-	6	10	6	9	5	8	5	7	5	7	-	-	-	-
RCD	-	-	-	-	6	9	5	8	5	7	5	7	-	-	-	-
RAU	-	-	-	-	-	-	4	7	4	6	3	6	3	6	3	5
RAD	-	-	-	-	-	-	4	7	4	6	3	6	3	5	3	5
RFD	-	-	-	-	-	-	-	-	-	-	3	5	3	5	3	5
ULU – Residential	8	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ULU – Industrial/ Commercial	6	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UCU – Residential	8	12	7	11	7	10	-	-	-	-	-	-	-	-	-	-
UCU – Industrial/ Commercial	6	12	6	11	6	9	6	8	-	-	-	-	-	-	-	-
UCD	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAU	6	10	6	9	5	8	5	7	-	-	-	-	-	-	-	-
UAD	-	-	3	6	3	6	3	6	3	6	3	5	-	-	-	-
UED	-	-	-	-	-	-	5	6	4	5	4	5	4	5	3	5
UFD	-	-	-	-	-	-	-	-	4	5	3	5	3	5	3	5

Notes:
1. Short grades less than 150 m in length, and one-way down grades may be 1% higher on urban roads, and 2% higher on low volume rural roads.
2. R refers to rolling topography.
3. M refers to mountainous topography.

4.4.4

roadway through the intersection. The concept for this type of adjustment is illustrated on Figures 2.3.2.5 and 2.3.2.6.[1] Although desirable, it is not always feasible to locate a high point at the centre of the intersection as shown on the Figures. Thus variations of the concept are needed to suit the vertical alignment characteristics of the intersection. Appropriate vertical curves are incorporated into the centreline profiles of both major roadways to achieve the desired grade adjustments. The edge of pavement profiles are often determined by using a spline, since calculated vertical curves do not always fit the constraints. A spline is a flexible drafting tool used to draw curved lines. A splined edge of pavement line provides a "best fit" curve which ensures that drainage is adequate, cross-slope is suitable and that the change in grade is not too abrupt.

Grade Breaks

Significant grade changes are not desirable within and near intersections which could affect the control and operation of a vehicle passing through the intersection at the expected operating speed. Grade breaks at intersections in the order of 0.5% to 2% are typical for a design speed of 70 km/h or higher. For lower design speeds more substantial grade breaks can be accommodated if required for the specific conditions. At a design speed of 50 km/h, a maximum grade change in the order of 3% to 4% produces some discomfort for vehicular traffic but is normally not detrimental to the safe operation of the intersection, provided that the stopping sight distance for the design speed is achieved. For speeds of 30 km/h or less, grade breaks up to 6% could be used, if required.

Grades

The grades of intersecting roadways in the area of the intersection should be as flat as possible to accommodate:

- storage space for stopped vehicles
- desirable sight distance (see Section 2.3.3)
- accelerating and stopping distance

Appropriate minimum grades at intersections are important to facilitate drainage, to avoid operational safety concerns related to ponding or icing conditions, and to compensate for some pavement wear and differential settlements. Particular attention should be devoted to the grading design of curb returns and to the calculation of roadway surface water runoff in an urban environment where there are large paved surfaces at intersections. Suggested guidelines include a minimum grade of 0.5% along curb returns (urban section), and a minimum of 1.0% combined cross-slope and roadway gradient within the limits of the intersection (rural and urban sections).

Existing driveways and accesses are often a constraint in setting grade lines on intersection approaches.

Along the approach legs to the intersection where vehicles are expected to stop, such as at left- and right-turn lanes or where signals are or may in the future be warranted, it is desirable to keep grades between 0.5% and 3%, A grade as low as 0.15% may be considered as long as adequate drainage is provided through cross-slope to avoid ponding. The calculated stopping and accelerating distance for a passenger car on a grade requires correction to produce conditions equivalent to those on level roadways (see Chapter 1.2). In addition, acceleration and deceleration tapers and/or lane lengths should be adjusted for steeper grades. Most vehicle operators are unable to judge the increase or decrease in stopping or accelerating distance that is necessary because of steep grades. Their normal deductions and reactions thus may be in error at a critical time. Accordingly, grades in excess of 3% are not desirable through an intersection. For low-volume, low-speed intersections, such as at the intersection of two local residential roads where physical conditions and economic considerations dictate, approach grades of 5% to 6% may be considered as long as acceptable site distance is provided along with an adjustment in design factors. The gradient within the intersection is normally limited to 4%. This limitation assists in providing reasonable operation for low-speed turning vehicles, particularly under slippery conditions.

4.4.6

When establishing the profile for the minor cross road, it is important to consider whether or not the intersection may be signalized in the future. If signalization is probable, the minor roadway should be designed to accommodate future free-flow traffic which would occur under green-signal conditions.

The approach/departure grade should ideally extend approximately 20 m back from intersections, although this can be reduced to one or two car lengths on minor roadways with light traffic volumes.

In addition to the vertical alignment and cross-slope considerations, the horizontal alignments of approach roadways are normally kept as simple and smooth as possible. It is desirable to ensure that the combination of horizontal alignment and vertical profile allows good visibility of the intersection area from all approaches. This allows drivers to focus their attention on the intersection area, where most conflicts occur.

2.3.2.4 Combined Vertical and Horizontal Alignments

The combination of horizontal and vertical alignment at, and near an intersection will ideally produce traffic lanes that are clearly visible to operators at all times. They should be clearly comprehensible for any desired direction of travel, free from the sudden appearance of potential conflicts, and consistent with the roadway just travelled.[11]

When the superelevation of a section of roadway on a curve is in the same direction as the grade of the intersecting cross road, the vertical alignment of the cross roadway is adjusted to meet the normal pavement cross-slope of the roadway as shown in Illustration A of Figure 2.3.2.7.

For intersections on curve, the selection of an appropriate radius is a function of the design speed of the through roadway with consideration given to the grade of the crossing roadway through the intersection. For example, for a crossing roadway with a grade of 3% through an intersection, the superelevation of the intersecting roadway on curve should also be 3% to provide a smooth crossing of the through roadway by the crossing road driver. Therefore, for a design speed of 80 km/h, the desirable radius for the through roadway curve is 1200 m, with superelevation of 0.028 m/m (based on e_{max} = 0.06 m/m), according to Chapter 2.1.

However, through an intersection on curve in an urban environment, drivers are willing to accept higher lateral friction than in open conditions. As such, a smaller radius curve could be used for a desired rate of superelevation to match the crossing roadway grade through the intersection under certain constrained conditions. In a rural environment, higher lateral friction is less desirable, due to greater driver expectations in terms of roadway performance. This is discussed further in Subsection 2.3.2.5.

An intersection where the cross-slope of the curving roadway is not in the same direction as the grade of the intersecting cross roadway is not desirable. If this condition cannot be avoided, the vertical alignment of the cross roadway is adjusted a sufficient distance from the intersection to introduce a desirable alignment as indicated in Illustration B of Figure 2.3.2.7. As discussed in Subsection 2.3.2.3, grade breaks over 4% are not desirable due to discomfort to vehicular traffic; however, if necessary, the break can approach 6% for minor roadways.

Minimum design parameters for both the vertical and horizontal alignment elements are undesirable in intersection design. If a limiting or near limiting condition cannot be avoided for one element, it is desirable to ensure that the other elements are well above the minimum design guidelines. Thus intersections are generally not preferred on sharp horizontal curves with significant superelevation. Superelevation rates in excess of 0.04 m/m through intersection areas adversely affect the smooth operation, particularly for those vehicles turning against the superelevation.

Similarly, steep gradients in combinatio badly skewed intersections or near-lir horizontal curves often create undes 4.4.7

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A.** The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B.**

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

4.5.1

In calculating K values for various sight distances, the height of driver's eye is 1.05 m, and the height of object is as outlined following, and discussed in more detail in Chapter 1.2.

- For stopping sight distance the most common object a vehicle has to stop for is another vehicle ahead on the road, the height of tail light is used. The legislated minimum is 0.38 m and is adopted for design. Other heights of objects can be used if necessary.
- For decision sight distance the more common height of object is 0.15 m, although other heights, such as zero for pavement markings, are not uncommon.
- For passing sight distance the height of object is 1.30 m, which represents the height of the opposing vehicle.

Crest Vertical Curves: Design Domain Quantitative Aid

Based on the above most commonly used heights of object, and on sight distances from Tables 1.2.5.3 and 1.2.5.5, the K values for stopping sight distance are provided in Table 2.1.3.2 and for passing sight distance the K values are provided in Table 2.1.3.3. The decision sight distance K values are not included because the vertical curvature depends on the height of object which is variable (depending on what the driver has to see).

The calculated K values are based on the length of curve exceeding the sight distance and they can be used without significant error when the length of curve is less than the sight distance. Appreciable differences occur only where A is small and little or no additional cost is involved in obtaining longer vertical curves.

On undivided roads non-striping sight distance is used to determine when no-passing pavement markings are required[7]. It is desirable to provide passing sight distance wherever possible but non-striping sight distance is generally adequate for safe passing manoeuvres.

Non-striping sight distance is less than passing sight distance, at each design speed. Passing manoeuvres can be completed in less than the full passing sight distance because of the timing of oncoming vehicles.

Table 2.1.3.2 K Factors to Provide Stopping Sight Distance on Crest Vertical Curves

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Vertical Curvature (K) Computed	Rounded
30	30	29.6	1.6	2
40	40	44.4	3.7	4
50	47-50	57.4-62.8	6.1-7.3	6-7
60	55-60	74.3-84.6	10.2-13.3	10-13
70	63-70	94.1-110.8	16.4-22.8	16-23
80	70-80	112.8-139.4	23.6-36.1	24-36
90	77-90	131.2-168.7	32.0-52.8	32-53
100	85-100	152.0-205.0	45.8-78.0	45-80
110	91-110	179.5-246.4	59.8-112.7	60-110
120	98-120	202.9-285.6	76.4-151.4	75-150
130	105-130	227.9-327.9	96.4-199.6	95-200

Note: The above are minimum values, use higher K factors whenever possible.

4.5.2

Table 2.1.3.4 K Factors to Provide Minimum Stopping Sight Distance on Sag Vertical Curves[1]

Design Speed (km/h)	Assumed Operating Speed (km/h)	Stopping Sight Distance (m)	Rate of Sag Vertical Curvature (K)			
			Headlight Control		Comfort Control	
			Calculated	Rounded	Calculated	Rounded
30	30	29.6	3.9	4	2.3	2
40	40	44.4	7.1	7	4.1	4
50	47-50	57.4-62.8	10.2-11.5	11-12	5.6-6.3	5-6
60	55-60	74.3-84.6	14.5-17.1	15-18	7.7-9.1	8-9
70	63-70	99.1-110.8	19.6-24.1	20-25	10.0-12.4	10-12
80	70-80	112.8-139.4	24.6-31.9	25-32	12.4-16.2	12-16
90	77-90	131.2-168.7	29.6-40.1	30-40	15.0-20.5	15-20
100	85-100	157.0-205.0	36.7-50.1	37-50	18.3-25.3	18-25
110	91-110	179.5-246.4	43.0-61.7	43-62	21.0-30.6	21-30
120	98-120	202.9-285.6	49.5-72.7	50-73	24.3-36.4	24-36
130	105-130	227.9-327.9	56.7-85.0	57-85	27.9-42.8	28-43

Values for sag curvature based on the comfort criterion are shown in Table 2.1.3.4.

These K values for sag curves are useful in urban situations such as underpasses where it is often necessary for property and access reasons to depart from original ground elevations for as short a distance as possible. Minimum values are normally exceeded where feasible, in consideration of possible power failures and other malfunctions to the street lighting systems. Designing sag vertical curves along curved roadways for decision sight distance is normally not feasible due to the inherent flat grades and resultant surface drainage problems.

2.1.3.4 Vertical Alignment: Design Domain Additional Application Heuristics

Vertical Alignment Principles: Application Heuristics

The following principles generally apply to both rural and urban roads. A differentiation between rural and urban is made in several instances where necessary for clarity.

1. On rural and high speed urban roads a smooth grade line with gradual changes, consistent with the class of road and the character of the terrain, is preferable to an alignment with numerous breaks and short lengths of grade. On lower speed curbed urban roadways drainage design often controls the grade design.

2. Vertical curves applied to small changes of gradient require K values significantly greater than the minimum as shown in Tables 2.1.3.2 and 2.1.3.4. The minimum length in metres should desirably not be less than the design speed in kilometres per hour. For example, if the design speed is 100 km/h, the vertical curve length is at least 100 m.

3. Vertical alignment, having a series of successive relatively sharp crest and sag curves creating a "roller coaster" or "hidden dip" type of profile is not recommended. Hidden dips can be a safety concern, particularly at night. Such profiles generally occur on relatively straight horizontal alignment where the roadway profile closely follows a rolling natural ground line. Such roadways are unpleasant aesthetically and more difficult to drive. This type of profile is avoided by the use of horizontal curves or by more gradual grades.

4. A broken back grade line (two ver curves in the same direction separate a short section of tangent grade) is

4.5.3

Table 1.2.5.2 Coefficient of Friction for Wet Pavements[4]

Design Speed (km/h)	Operating Speed [a] (km/h)	Coefficient of Friction (f)
30	30	0.40
40	40	0.38
50	47-50	0.35
60	55-60	0.33
70	63-70	0.31
80	70-80	0.30
90	77-90	0.30
100	85-100	0.29
110	91-110	0.28
120	98-120	0.28
130	105-130	0.28

Note: [a] The range of operating speeds recognises that some drivers slow down in wet conditions: others do not.

applied. On a level roadway this distance can be determined using the following formula:

$$d = \frac{V^2}{2gf} = \frac{V^2}{2(9.81)f} \times \left(\frac{1000}{3600}\right)^2 = \frac{V^2}{254f} \quad (1.2.4)$$

Where d = braking distance (m)

V = initial speed (km/h)

f = coefficient of friction between the tires and the roadway

Then SSD = 0.278tV + d (1.2.5)

Where SSD = stopping sight distance (m)

t = perception and reaction time (s)

Table 1.2.5.3 gives the minimum stopping sight distances on level grade, on wet pavement, for a range of design speeds. These values are used for vertical curve design, intersection geometry and the placement of traffic control devices.

The stopping sight distances quoted in Table 1.2.5.3 may need to be increased for a variety of reasons, related to grade, vehicle braking capability and pavement condition.

Variation for Trucks

Geometric characteristics to achieve stopping sight distance requirements vary because of differences in driver eye height and braking characteristics. While a truck driver can generally see further than a passenger car driver due to an eye height advantage, in some instances the higher eye height is a disadvantage — for example, a sag vertical curve where visibility is "cut off" by an overpass. Truck braking characteristics are highly variable and often increase effective braking distance and, thus, stopping sight distance.

A number of tests[8] have been conducted using trucks with conventional brakes and antilock brakes, and drivers with varying levels of experience in handling emergency b situations. The use of antilock brakes wa to consistently reduce braking distan minimising variations in driver performan

4.6

Table 1.2.5.3 Stopping Sight Distance for Automobiles[4] and Trucks with Antilock Braking Systems[8]

Design Speed (km/h)	Assumed Operating Speed* (km/h)	Perception and Reaction time (s)	Perception and Reaction distance (m)	Coefficient of Friction	Braking Distance (m)	Stopping Sight Distance (rounded) (m)
40	40	2.5	27.8	0.38	16.6	45
50	47 - 50	2.5	32.7 - 34.7	0.35	24.8 - 28.1	60 - 65
60	55 - 60	2.5	38.2 - 41.7	0.33	36.1 - 42.9	75 - 85
70	63 - 70	2.5	43.7 - 48.6	0.31	50.4 - 62.2	95 - 110
80	70 - 80	2.5	48.6 - 55.5	0.30	64.2 - 83.9	115 - 140
90	77 - 90	2.5	53.5 - 62.5	0.30	77.7 - 106.2	130 - 170
100	85 - 100	2.5	59.0 - 69.4	0.29	98.0 - 135.6	160 - 210
110	91 - 110	2.5	63.2 - 76.4	0.28	116.3 - 170.0	180 - 250
120	98 - 120	2.5	68.0 - 83.3	0.28	134.9 - 202.3	200 - 290
130	105-130	2.5	72.9 - 90.3	0.28	155.0 - 237.6	230 - 330

Note: * Range of assumed operating speed is from average running speed for low-volume conditions to design speed.

utilizing more of the available friction. In fact, the results indicated that the stopping sight distances from Table 1.2.5.3 would be adequate if antilock brakes were in general use on trucks.

Table 1.2.5.4 shows stopping sight distances for trucks with conventional brakes, and compares them to the stopping sight distances given in Table 1.2.5.3.

The increased stopping sight distances for trucks with conventional brakes (i.e. the majority of the current fleet) are generally offset by increased driver eye height for the purposes of vertical curve calculations. However, where driver eye height is not an advantage, such as on horizontal curves or approaching controlled intersections, the greater stopping sight distances should be used.

Sight restrictions such as shrubs, trees, cut slopes, or buildings may occur on the inside of horizontal curves. Although truck drivers have higher eye heights, the required truck driver sight distance may not be offset by the higher eye height unless the obstructions are physically below the driver's line of sight.

The Effect of Grade

Braking distances will increase on downgrades and decrease on upgrades. When the roadway is on a grade, the formula for braking distance is:

$$d = \frac{V^2}{254\,(f \pm G)} \qquad (1.2.6)$$

Where G = the percent grade divided by 100 (up is positive, down is negative) and all other terms are as noted in Equation 1.2.4.

4.6

1420.05 ALIGNMENT

The developer shall complete all road designs within the design speed range of 30 km/h to 80 km/h, as determined by the road classification, or as requested by the Ministry Representative. When selecting a design speed, the ultimate road classification must be considered (e.g. if a dead end road will be extended as a through road in the future, it should be designed to the ultimate classification).

Vertical curves shall be standard parabolic curves. The length of vertical curve (in metres) should not be less than the design speed (in km/h).

The developer shall demonstrate that every reasonable effort has been made to minimize the road grades. Short pitches of steeper grades may be acceptable on tangent sections provided the overall grade is less than 8%.

Minimum parameters for various design speeds shall be as shown in **Table 1420.A**. The developer shall consult with the local Ministry Maintenance Contractor to ensure that road maintenance equipment can manoeuver within the proposed parameters. Design speeds of 40 km/h should typically be limited to lot access roads that do not perform a collector function. The developer must submit written justification when proposing roads with 30 km/h design speeds.

1420.05.01 Arterials/Primary

Arterials are generally network roads which are built and maintained by the Ministry of Transportation and shall not be discussed in this guideline.

1420.05.02 Collectors (Network Roads)

Rural Collector/Secondary

The Right-of-Way shall be 25 metres wide or the cross section width, plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8 metres.
- Gravel Shoulder: 1.0 metres.

Urban Collector /Secondary (Curb and Gutter)

The desirable minimum Right-of-Way width is 25 metres, or the cross section width plus 3 metres on each side, whichever is greater.

- Minimum finished top: 10 metres.
- Minimum paved top: 8.2 metres to leading edge of curb (parking one side).
- Gravel Shoulder: 0.3 metres behind curb, see **Figure 1420.B**.

Table 1420.A – Design Parameters

Road Classification	Local Roads***		Local/Collector	Collector Roads		
Speed (km/h)	30	40	50	60	70	80
Radius, (metres)*	20	40	75	120	190	250
Minimum stopping sight distance, (metres)	30	45	65	85	110	140
Decision Sight Distance, DSD (metres)**	40-110	55-110	75-145	95-175	125-200	155-230
K value crest, vertical curves, taillight height	2	4	7	13	23	36
K value sag, vertical curves, Headlight control	4	7	12	18	25	32
Minimum Overhead Clearance (metres)	5.0	5.0	5.0	5.0	5.0	5.0
Maximum desirable grade in percent*	8	8	8	8	8	8

Parameters based on E max: 0.06 m/m, normal crown: 0.02 m/m.

*Avoid the combined use of maximum grade and minimum radius. Maximum grades are to be reduced by 1% for each 30 metres of radius below 150 metres.

** Lower DSD values are appropriate at intersections within a subdivision, while the higher values should be used at more complex intersections. DSD along numbered highways may even be higher.

*** This includes cul-de-sacs, frontage roads, and backage roads.

4.6.1

EKISTICS

1925 Main Street
Vancouver BC
V5T 3C1 Canada

T 1.604.739.7526
F 1.604.739.7532

www.ekistics.ca

16 November, 2009

Barbara R. Thomas
District Manager, Ministry of Transportation & Infrastructure
3rd Floor - 2100 Labieux Road
Nanaimo BC V9T 6E9

RE: Fairwinds: The Lakes District & Schooner Cove
Project Specific Street Standards | Technical Drawings

As a follow up to our submission of the Road Alignment Design Criteria, I am enclosing the full set of technical plan and cross-sectional drawings for the proposed Project Specific Street Standards for Fairwinds.

CONTEXT: A PROJECT-SPECIFIC STREET STANDARD

Given the location of Fairwinds & Schooner Cove within the Regional District of Nanaimo's designated Urban Containment Boundaries, the Project Team has recognized the opportunity to collaborate with the MoTI to develop a set of Project Specific Street Standards to best address the overlapping principles & objectives of regional growth management, neighbourhood planning & design, and transportation efficacy, efficiency & safety.

THE PATH AHEAD: A FAIRWINDS STREET STANDARD & THE NEIGHBOURHOOD PLANS

Based on our previous meeting, MOTI Staff had requested three critical components to support the consideration of Project Specific Street Standards for Fairwinds. They were, in sequential order:

- Detailed comparison of MOTI Section 1400 design criteria with TAC and those proposed for use within the Lakes District / Schooner Cove boundaries; ***provided 23 October 2009***
- Review of technical drawings: cross-sectional & plan design details within the ROW proposed; and,
- Plan of Proposed Street Hierarchy for The Lakes District & Schooner Cove based on design criteria developed as per the above. (To be provided following finalization of Project Specific Street Standrds.)

The enclosed document represents the second step: the "technical drawings: cross-sectional & plan design details within the ROW proposed" are provided in their entirety (in the attached .pdf book) and three hardcopies have been couriered to your attention.

The enclosed plans & sections detail the proposed road hierarchy of:

- Community Parkway Street (assumes 50 km/h design speed*);
- Neighbourhood Collector Street (assumes 50 km/h design speed*); and,
- Neighbourhood Local Street (assumes 40 km/h design speed*).

** All proposed design speeds reflect Section 7.0 of the original proposal: "Draft Hillside Street Standards" and are further detailed within the recently submitted Road Alignment Design Criteria.*

NEXT STEPS

In anticipation of our scheduled meeting in Nanaimo (27 November at 1:00 pm), we look forward to discussing the technical merits of this proposal in a conference call proposed for the week prior to our meeting (scheduling subject to availability of participants).

If you have any immediate questions about the enclosed materials or any other aspect of our ongoing work together, please do not hesitate to be in touch.

Best regards,

Paul Fenske
Principal

Cc: Deborah O'Brien, MoTI

Russell Tibbles, Bentall LP
Stephen Clinton, InterCAD Services, Ltd
David Shillabeer, KOERS & Associates Engineering, Ltd.
Sarah Rocchi, Opus International

Community Parkway Street

Plan

November 2009

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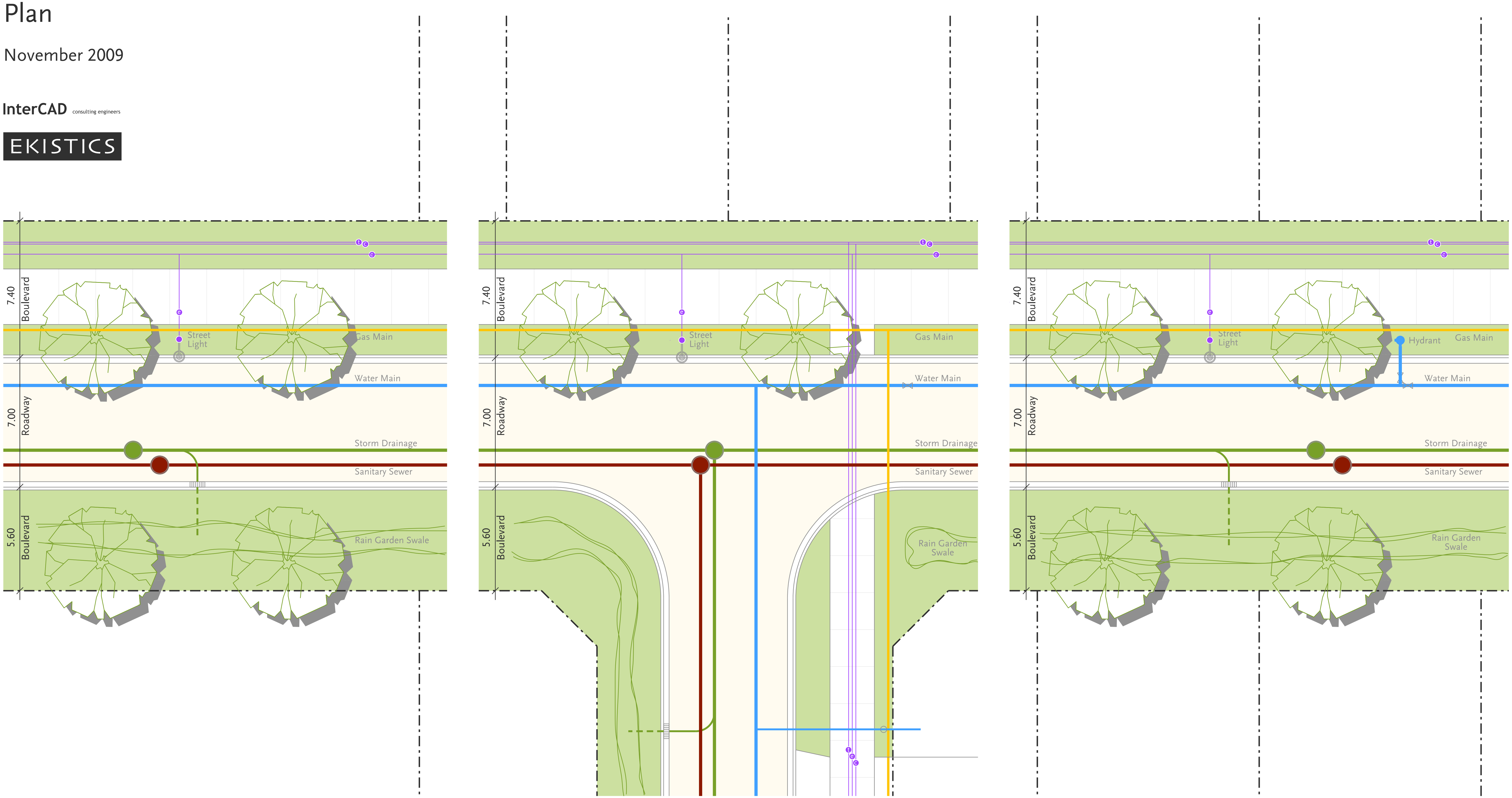

Community Parkway Street
Typical Condition

Neighbourhood Collector Street

Plan

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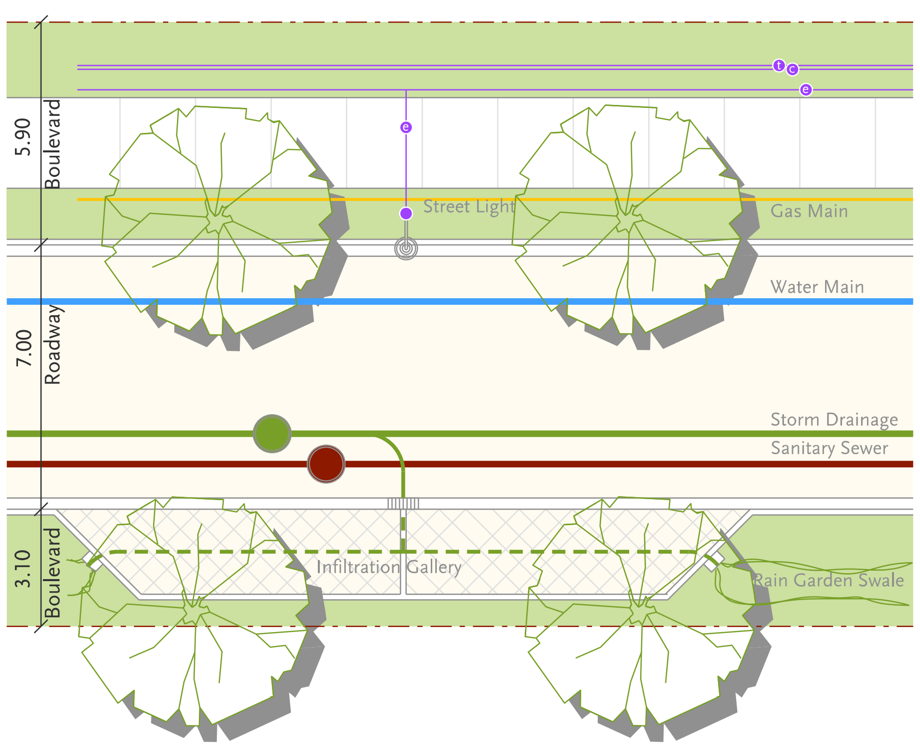
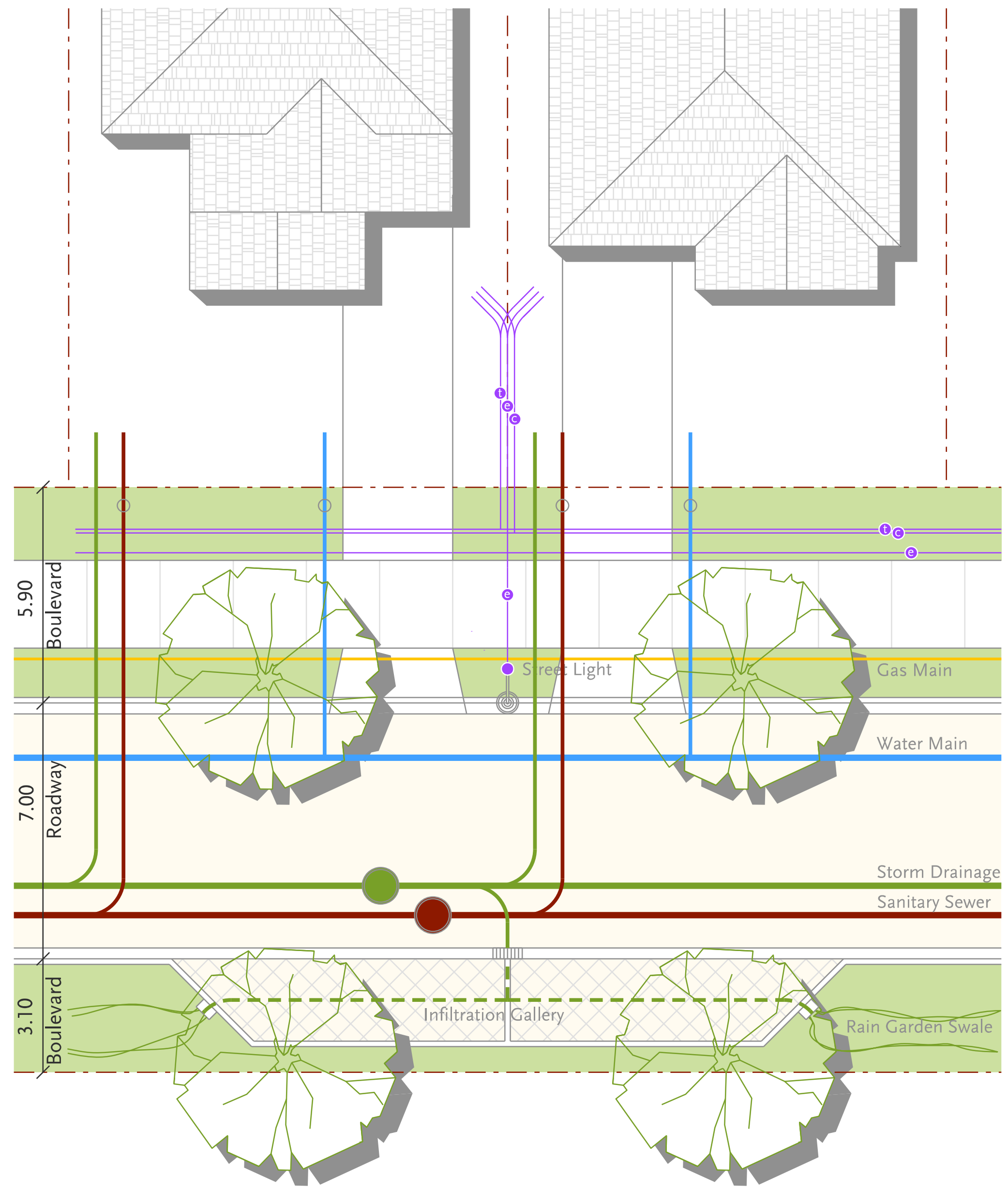
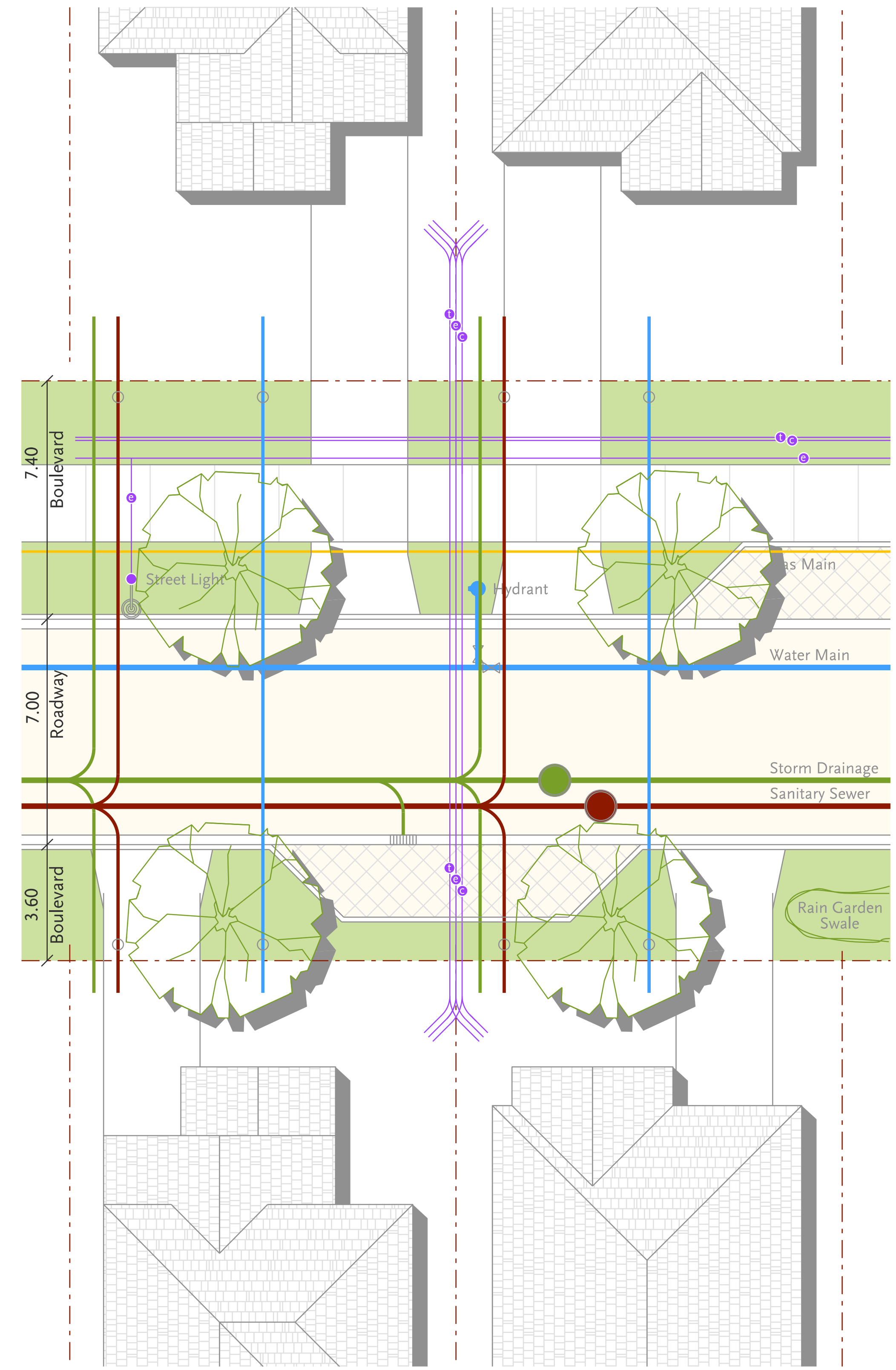


Neighbourhood Collector Street
Typical Non Fronting Condition - A



Neighbourhood Collector Street
Typical Single Fronting Condition - B



Neighbourhood Collector Street
Typical Double Fronting Condition - C

Neighbourhood Local Street

Plan

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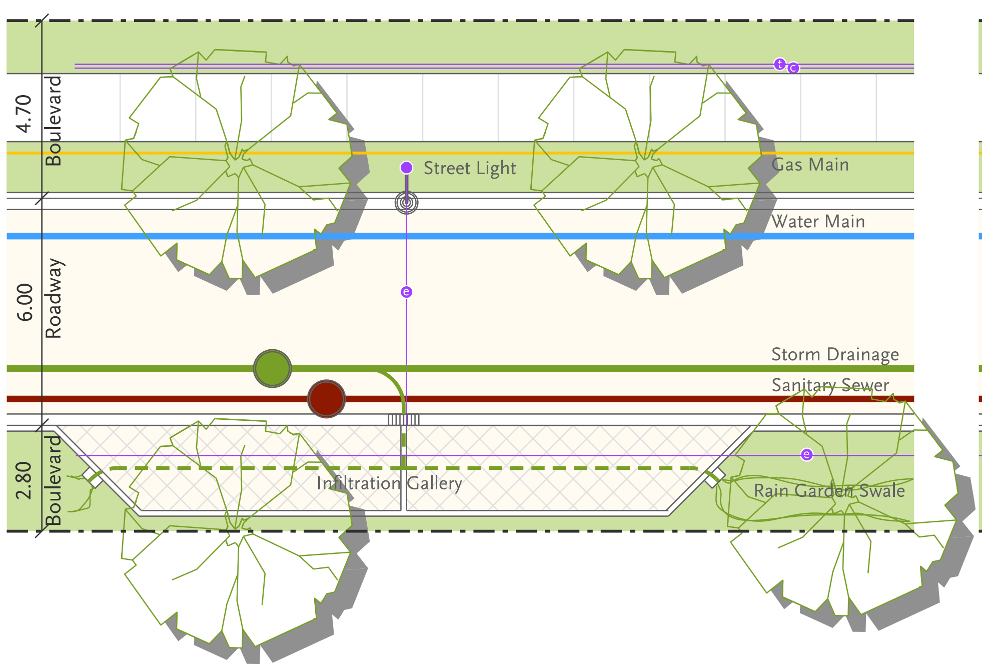
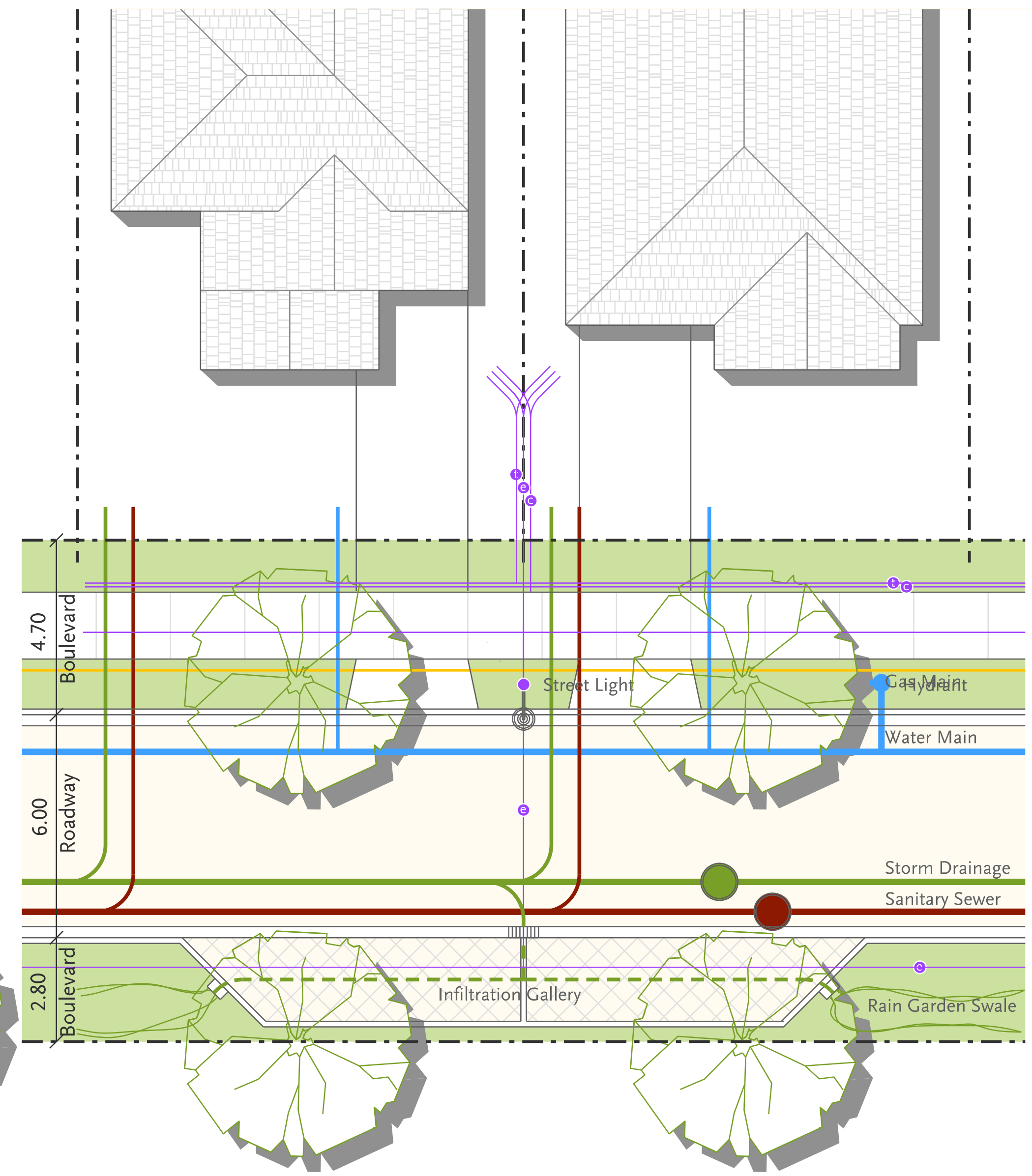
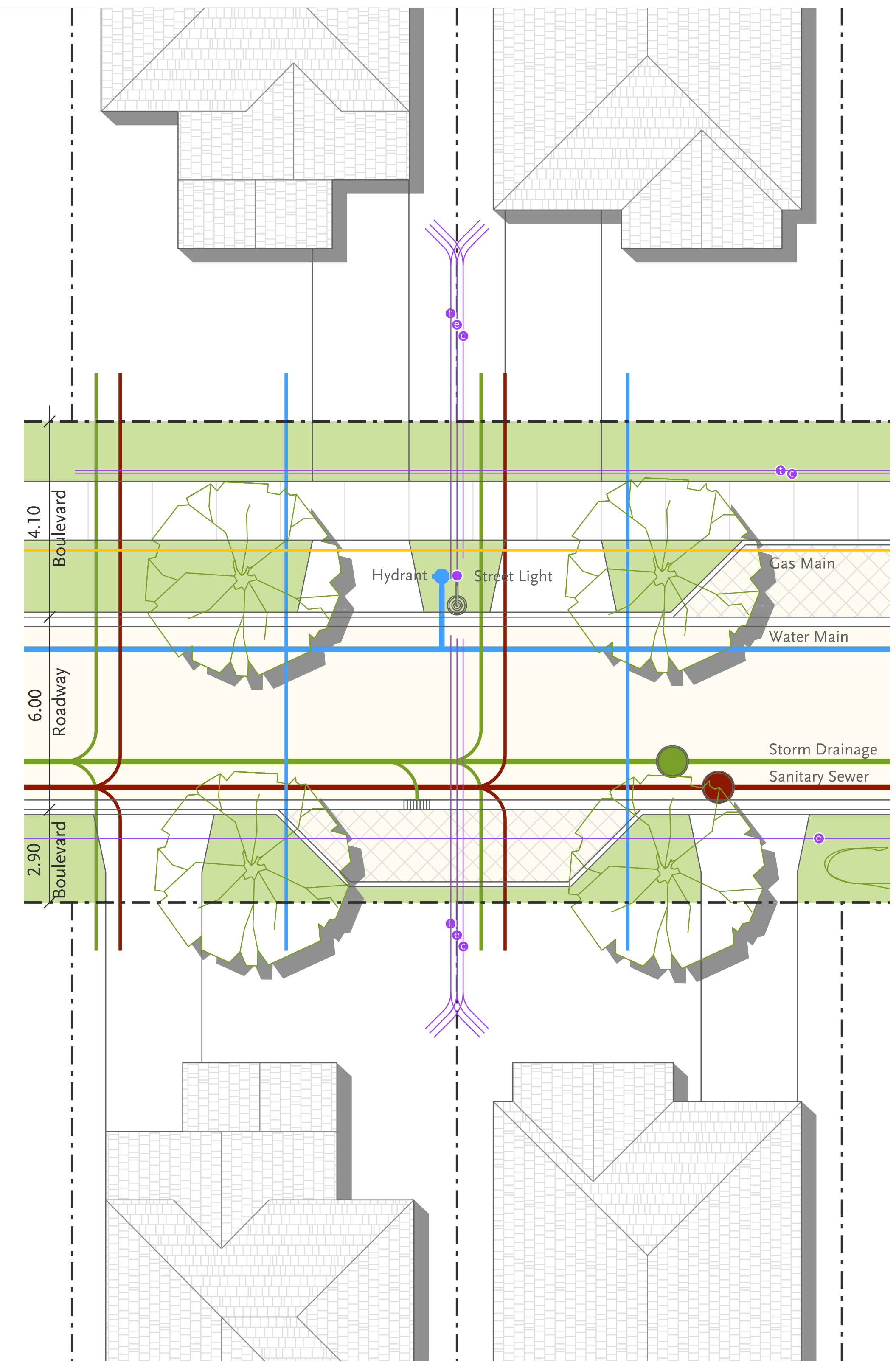


Neighbourhood Local Street
Typical Non Fronting Condition - A



Neighbourhood Local Street
Typical Single Fronting Condition - B

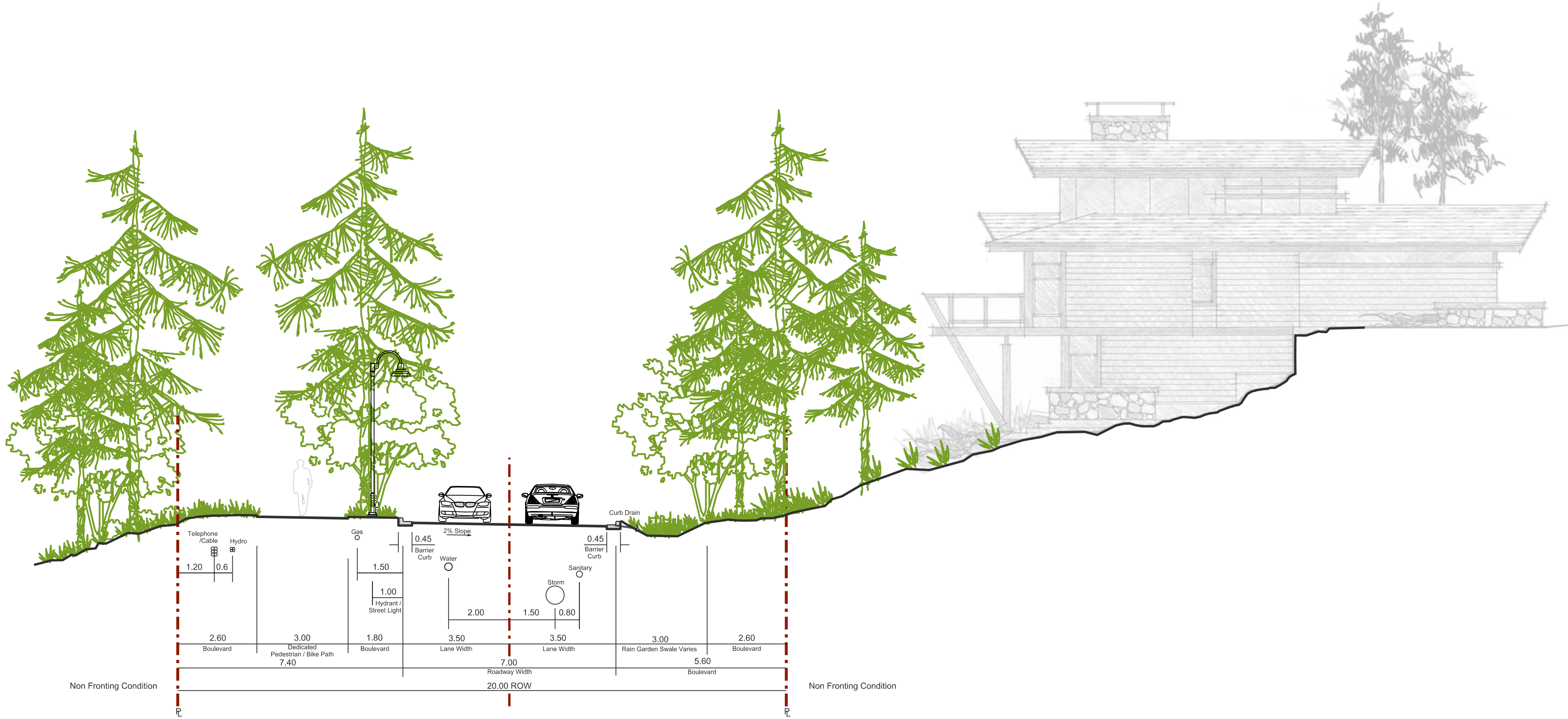


Neighbourhood Local Street
Typical Double Fronting Condition - C

Community Parkway Street

Cross Section

November 2009



Community Parkway Street
Typical Condition

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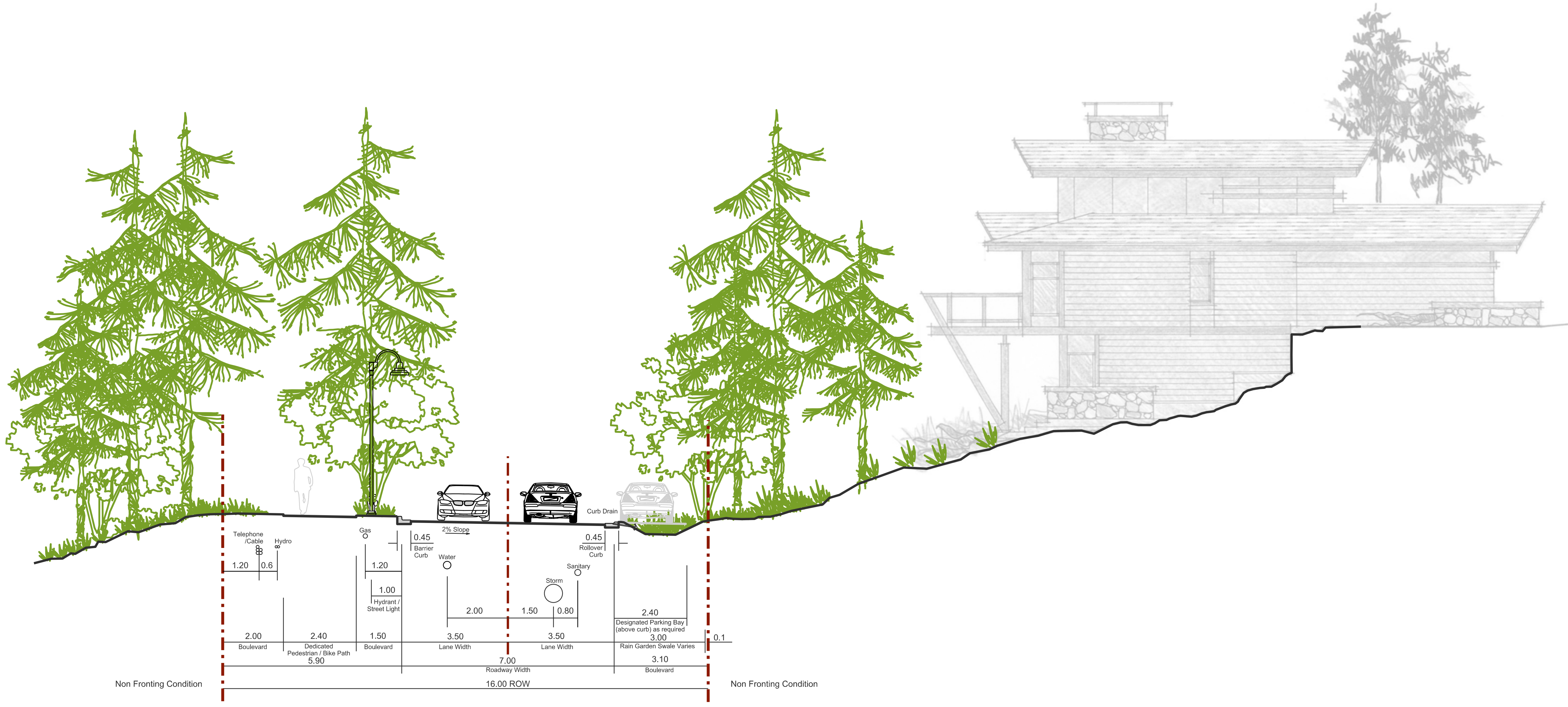
Neighbourhood Collector Street

Cross Section

November 2009



Neighbourhood Collector Street
Typical Non Fronting Condition - A

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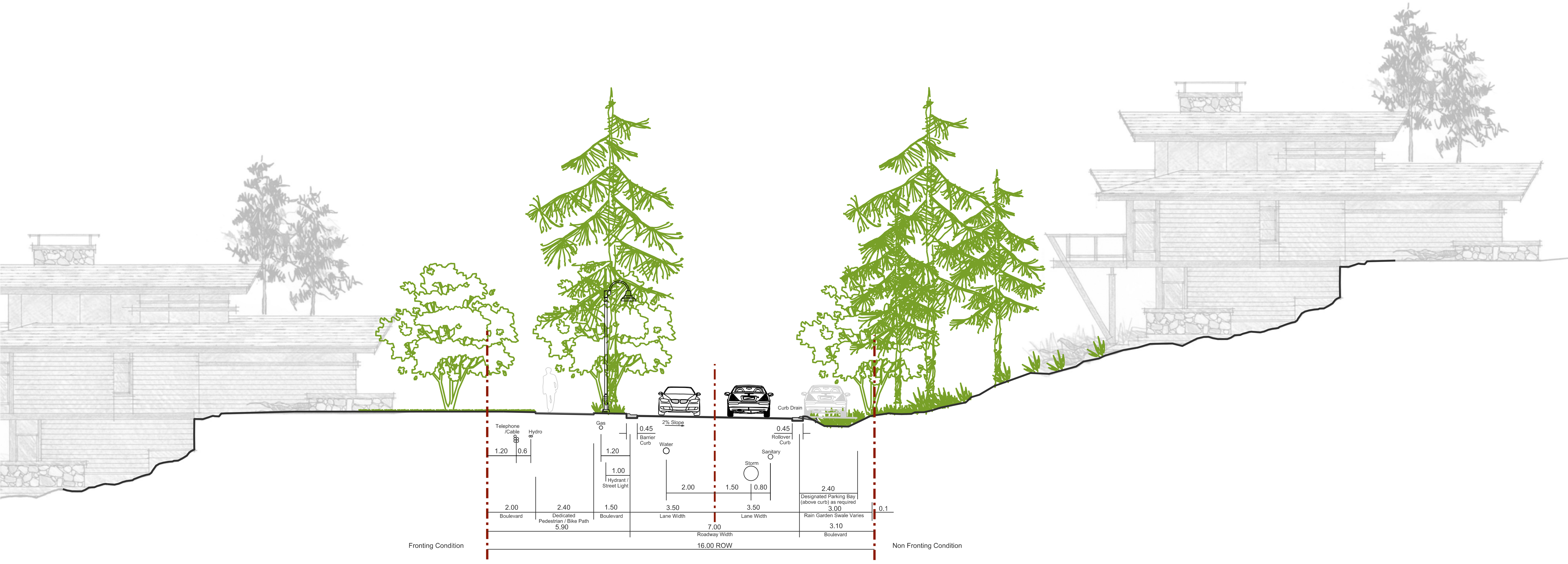
Neighbourhood Collector Street

Cross Section

November 2009



Neighbourhood Collector Street
Typical Single Fronting Condition - B

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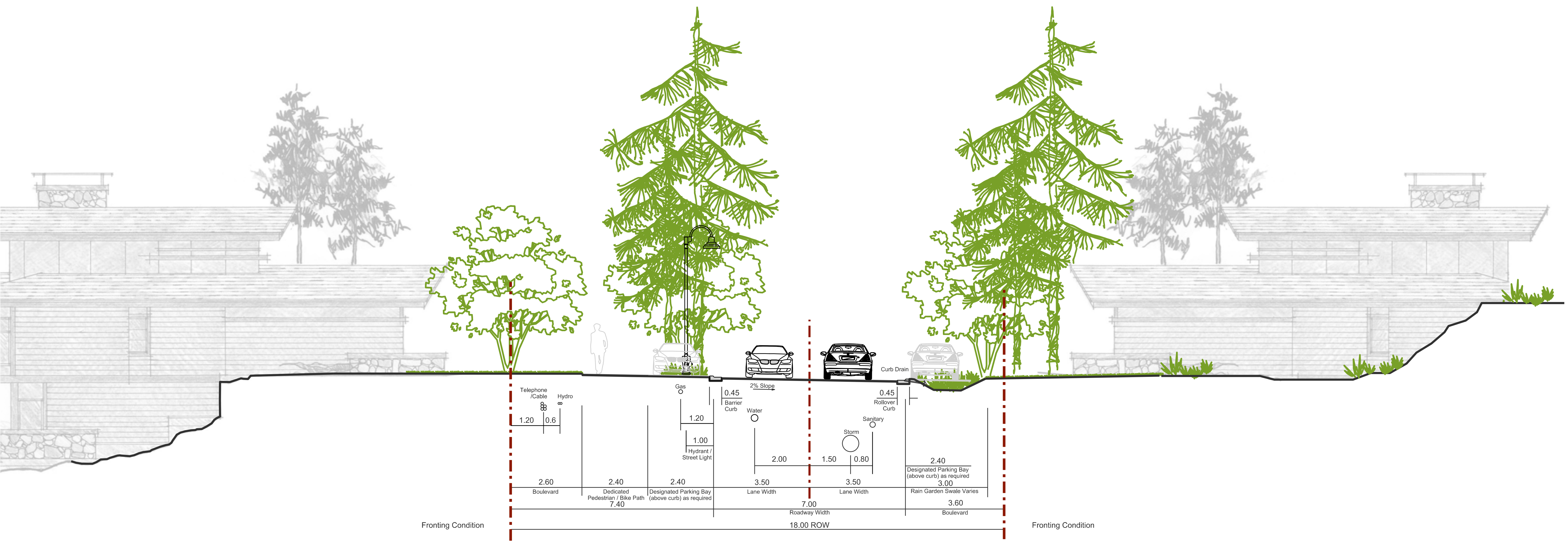
Neighbourhood Collector Street

Cross Section

November 2009



Neighbourhood Collector Street
Typical Double Fronting Condition - C

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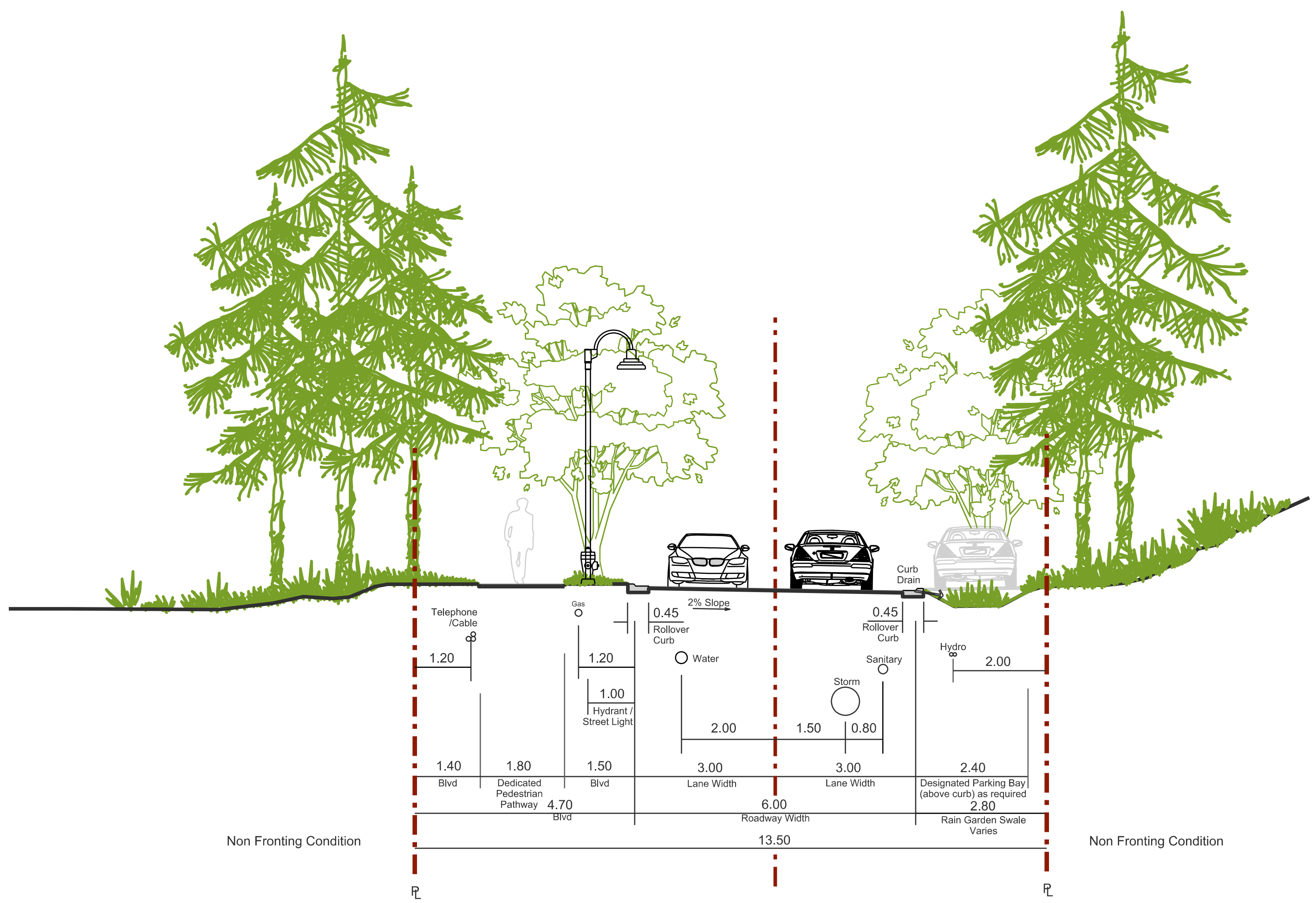
Neighbourhood Local Street

Cross Section

November 2009



Neighbourhood Local Street

Typical Non Fronting Condition - A

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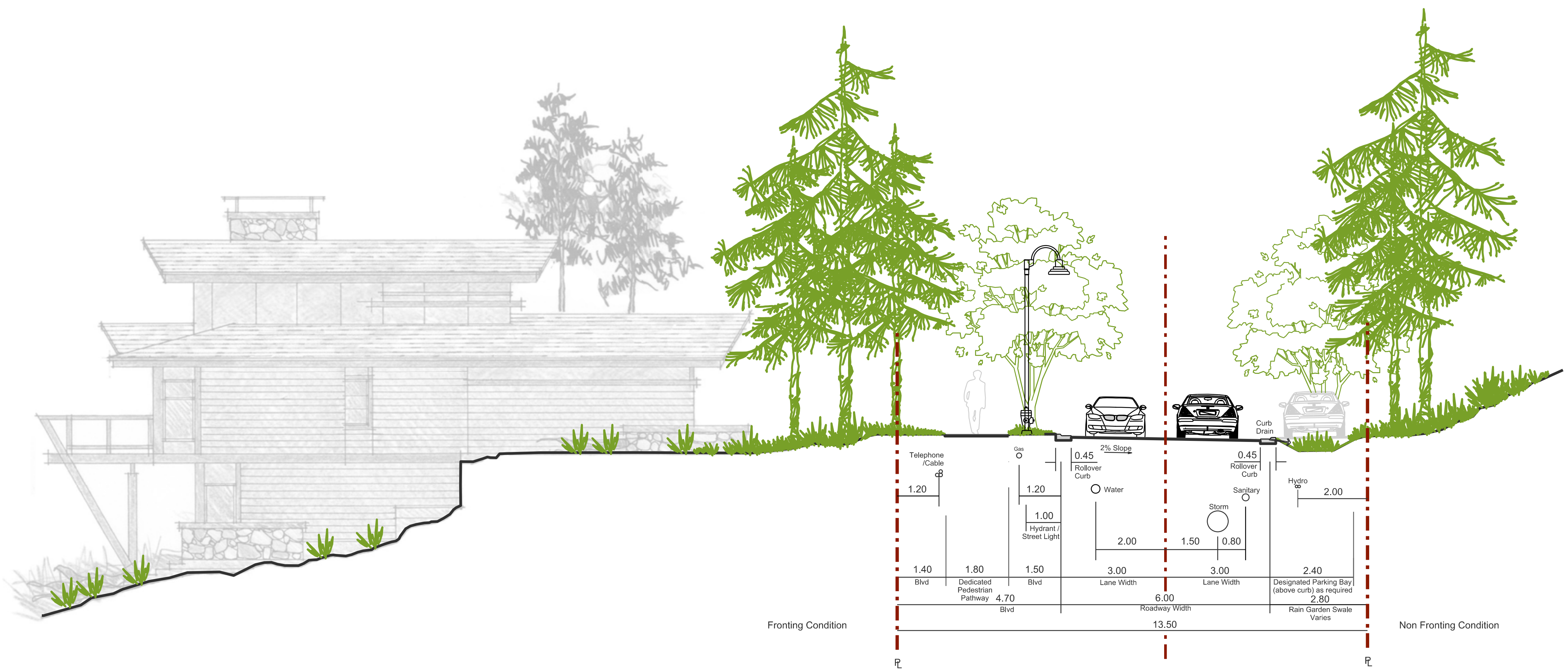
Neighbourhood Local Street

Cross Section

November 2009



Neighbourhood Local Street
Typical Single Fronting Condition - B

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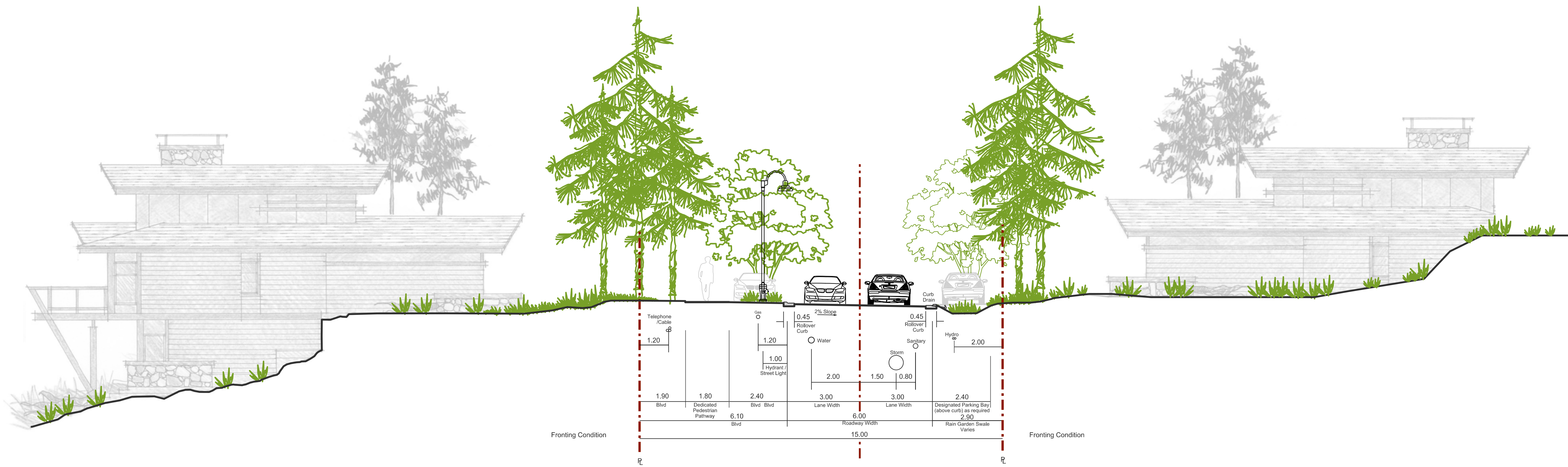
Neighbourhood Local Street

Cross Section

November 2009



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