CHAPTER E
FREEWAYS AND INTERCHANGES

TABLE OF CONTENTS

CHAPTER E
FREEWAYS AND INTERCHANGES

LIST OF FIGURES

CHAPTER E
INTERCHANGES

LIST OF TABLES

CHAPTER E
FREEWAYS AND INTERCHANGES

E.1 FREEWAY SYSTEMS

Freeways are the highest classed roadway in the network and are intended to provide maximum mobility for regional and long distance vehicle travel. Freeways are also major public investments that transform land uses and values and that affect the economy and quality of life. A careful and deliberate systems approach to planning and design is therefore needed and must consider the critical and complex relationships with surrounding land uses and driver factors. This design guide provides an overview of the freeway planning and design best practice philosophy used in Alberta, much of it built on the principles used in other jurisdictions across Canada and internationally. For further guidance designers should refer to the extensive materials on the subject available from AASHTO [1], TAC [2], and ITE [3].

E.1.1 Classification

Freeways are defined as high capacity, high speed, free-flow, multi-lane divided roadways with access provided only at interchange on and off ramps. Freeways are generally highway linkages having regional, provincial, national, and international connectivity, and serve long distance travel with preference given to through traffic by prohibiting crossing at-grade. Freeways may also serve as major urban highway linkages in corridors with heavy demand.

Freeways carry a mix of private and commercial vehicles, including inter and intra urban buses on express routes. Their primary function is to provide maximum mobility at consistently high speeds, safely and efficiently. Freeways must perform this function in a controlled environment that minimizes turbulence, considering the full range of visibility, weather conditions, and traffic mix.

In order to provide maximum mobility for through traffic, access to freeways (including ingress and egress) is permitted only via interchange ramps where provision can be made to minimize speed differentials between entering and exiting vehicles and main line traffic. Freeway rights-of–way should be fenced where appropriate in order to delineate and reduce the potential for undesired access or random movement of any kind to and from the freeway main line. Freeways exclude specific accommodation of bicycles, pedestrians, and slow-moving vehicles. Planning to accommodate these modes through supporting infrastructure should occur in parallel with freeway planning.

Freeways directly connect only to other freeways, expressways, and arterials. In rural areas, freeways may also connect to rural collector highways or equivalent municipal roadways providing access to specific destinations such as towns, villages, hamlets, and parks. Freeways are not access roadways for adjacent land-uses of any kind.

E.1.2 Economic Benefits

Freeways provide the basic infrastructure for the flexible and efficient movement of goods and people with random origins and destinations. Proper freeway design and operation facilitates this movement in a safe, fuel-efficient and consistent speed environment.

Canadians, and specifically Albertans, live, work and compete in an economic environment that is continental in scope, and efficient transportation networks are important economic enablers. As an example, the U.S. Interstate Highway System is one of the key infrastructure components that supports the world's leading economy. In recognition of the important role of freeways in supporting economic growth, specific legislation is in place that permits the Alberta Government to designate freeways, specify access points to each route, and ensure that the freeway system can be implemented over time.

E.1.3 Environmental Benefits

Freeways are more environmentally friendly than other types of roadways in a number of ways. In terms of space, a freeway lane is a much higher capacity traffic conduit than an equivalent lane on a lower classification roadway, although freeway right-of-way requirements are generally greater than for other roadway types. Free-flow travel and consistent speeds, without stop-and-go traffic, allows fuel efficient vehicle operation, with lower volumes of emissions per vehicle mile than other roadway types.

Concentration of major traffic volumes into freeway corridors relieves other areas of high volumes of heavy vehicles and other road traffic, allowing more capacity and less congestion on land access roadways. Access that is restricted to appropriately spaced interchanges only, with consistent and high standards of geometry allows safe vehicular operation on freeways, reducing accidents and their associated economic and social costs.

E.1.4 Planning Horizon and Staging

A long term planning horizon of at least 30 years is critical in achieving a system that serves needs far into the future and justifies investment. In planning a freeway or system of roadways, it is recognized that initial stages of the roadway development may involve construction and operation of parts or all of the roadway at lower than full freeway standards. Economic considerations and initial traffic demands may not justify full freeway standards at the earlier stages. See Chapter I for typical access management staging scenarios.

When undertaking freeway corridor planning it is critical to determine the ultimate stage up front, prior to design and construction of first stage projects. Some elements of the ultimate stage may need to be advanced into a first stage or subsequent stages of freeway development in order to avoid costly and disruptive re-construction. The earlier the ultimate system standards are known and applied in planning, the more economical the implementation of future stages will become, with the least disruption. Right-of-way protection for eventual acquisition to accommodate all stages of freeway development is critical in achieving objectives.

On staged freeway facilities that are initially built to arterial or expressway standards, temporary access that will require removal at the full freeway stage should be avoided. Such accesses are often difficult to remove from mature development areas as existing travel patterns are changed. Locating commercial land-use/development at designated access locations (future interchange sites) with appropriate setbacks is recommended to minimize disruption and avoid lengthy access roads at time of interchange construction.

E.1.5 Traffic Forecasting and Level of Service

At the planning stages, it is critical to size the ultimate design of the freeway for the appropriate Level of Service (LOS) target. Level of Service targets are given in Table A-6-1a, with further discussion in Chapter A.6. Future freeway traffic volumes can be estimated through trip generation analyses for anticipated development areas, based on assumed land-uses and / or counts of existing traffic for developed areas. In large urban or metropolitan areas, travel demand models may also be available to assist in traffic forecasting. Traffic demand management techniques such as ramp metering, High Occupancy Vehicle (HOV) or High Occupancy Toll (HOT) lanes may be considered in some corridors to maintain a higher Level of Service.

It should be recognized that traffic forecasts can and will vary as redevelopment occurs, proposed land-uses are modified, technology changes, and fuel, vehicle, and other costs fluctuate. With this inherent variability in mind, flexibility is key to successful long term planning so that plans that can easily be adapted or modified based on the latest conditions and requirements as implementation nears. Well derived traffic forecasts and planning for the target LOS will allow some flexibility in future use.

E.1.6 Design Consistency

Freeways are high speed, high capacity, multi-lane facilities that carry a mix of passenger and commercial vehicles. Drivers require the assurance of a consistent operating environment that will provide a minimum number of decisions with maximum time to make them in high volume situations. This is a critical objective in freeway design and an absolute requirement for optimizing safety and investment return. The U.S. Interstates are an example of a true freeway system. The system features a consistent standard of design with full control of access throughout all of the rural and urban routes that make up a network that covers the entire country.

Driver expectations are formed based on driver experience with local, regional and international systems, and consistency in standards for these systems is crucially important. Road users should know what to expect from the freeway system anywhere in Alberta.

A predictable operating environment is provided through consistency of all design features and roadway elements. Each driver knows what to expect from the roadway under any operating condition in a properly designed system. This expectation is critical to safety of operation and minimizes the number of decisions a driver needs to make, particularly if an unexpected incident occurs.

Consistent design throughout the system also allows logical and effective motorist information systems to be utilized. Application of Intelligent Transportation Systems (ITS) technology such as variable message signs for weather, accident and emergency routing, and GPS / navigation systems, and emerging autonomous vehicle technologies are simplified in systems with consistent design features.

E.1.7 Flexible Design Approach

Minimum design standards for freeway systems are well established in TAC, ASSHTO, and internationally. These include gentle horizontal and vertical curvature required to accommodate freeway speeds and safe operation of the full range of motor vehicles using the facility, long sight distances, medians, and shoulders for emergency stopping. Speed transition zones outside of the main traffic lanes are provided for acceleration and deceleration at ramp entrances and exits. These standards specify minimums below which design of specific elements is not considered adequate for the facility.

In the application of design standards, combining minimum standards for a number of interacting design elements does not usually produce an acceptable design. This is because the technical basis for a minimum standard does not usually assume that all other interacting elements will also be minimums. The application of higher than minimum standards in every area where it is physically and economically possible is good planning and design practice.

This approach in the application of standards is absolutely critical in the planning stage, where not all constraints are always known. It also allows for maximum flexibility in future expansion and operation, thereby maintaining the value of the investment.

E.1.8 Lane Balance and Continuity

Lane balance, basic lane, and route continuity principles must be applied during planning and design of the freeway system. Continuity of basic lanes implies that a consistent number of continuous or “through” lanes should be provided throughout a freeway segment in order to meet driver expectations and to minimize the amount of lane changing and reduce turbulence in the traffic stream. Auxiliary lanes can be used between interchanges to add additional capacity where required; however, lane balance must be achieved at all ramp exits and entrances. The basic number of lanes should not be reduced at exits, rather these lane reductions should occur on the mainline at least 300 m beyond the exit ramp with appropriate signing and where the applicable decision sight distance can be achieved.

E.1.9 Alignment

Minimum alignment parameter applicable to freeways are provided in Chapter B. Exceeding the minimum parameters where possible is recommended in order to attain the best curvature design in both horizontal and vertical alignment. Incorporating the best possible alignment not only optimizes the operating environment; it also allows maximum flexibility in future expansion or modification.

A specific example relates to bridges carrying freeway traffic on curves. In the Alberta climate, bridge decks are subject to icing that may not be present on the remainder of the roadway. Use of minimum curvature standards for alignment involving bridges can be hazardous under some weather conditions and reinforces the requirement to apply higher than minimum standards.

E.1.10 Cross-section

Typical Freeway cross sections are provided in Chapter C. Designers should pay special particular attention to the following critical safety elements:

- Wide depressed medians to separate traffic and reduce likelihood of collision with opposing traffic. They also provide the following benefits:
  - Allows flexibility for future expansion
  - Provides stormwater drainage and snow storage
  - Reduces maintenance costs
  - Permits the use of independent profiles for the divided roadways
- Gentle side-slopes in medians and roadway edges to allow errant vehicles to recover
- Wide shoulders to provide for emergency stopping
- Barriers to protect traffic from roadside obstacles

Use of barriers should be minimized either in medians or at obstacles, since barriers themselves are safety hazards. Median barriers, for example, may cause undesirable snow drifting and drainage situations that negatively impact safety. In locations where barriers are necessary, refer to Chapter H for details regarding acceptable use of median and roadside barriers.

In urban areas it may be cost prohibitive to provide depressed medians associated with rural freeway (RFD) designs. In these areas, urban freeway (UFD) design with median barrier separation may be acceptable. Refer to Chapter A for functional class selection.

E.1.10.1 Cross section with Collector-Distributor (C-D) Roads

On rural freeways (RFD) with Collector-Distributor (C-D) roads, a 17 m outer separation minimum dimension has been adopted to provide sufficient space between roadways so that a depressed ditch may be constructed. Typical rural freeway (RFD) cross section with C-D roads is shown in Figure E-1-10-1a. This configuration accommodates a minimum number of roadside hazards and therefore less need for roadside barriers. Drivers are also prevented from crossing over between roadways. Such illegal cross-overs (from the mainline to the Collector / Distributor road and vice-versa) can lead to operational problems.

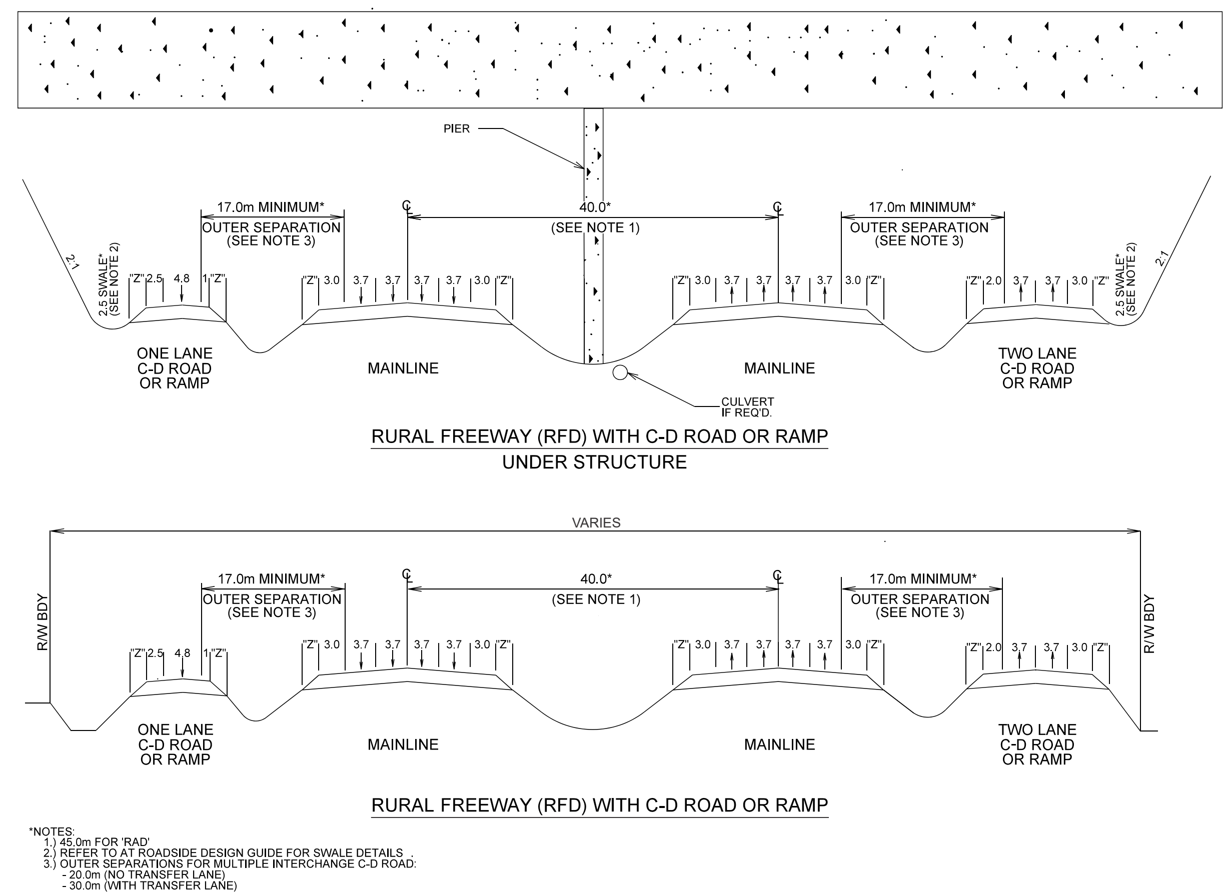
On urban freeways (UFD), barriers are used to prevent crossovers. The outer separation should be sized based on required minimum shoulder widths and shy-line offsets. Typical urban freeway (UFD) cross section with C-D roads is shown in Figure E-1-10-1b.

Figure E-1-10-1a should be used on all new construction of rural divided highways and bridges. Figure E-1-10-1b should be used on all new construction of urban freeways or expressways. On retrofit of existing divided highways at interchange locations, designers should strive to achieve the cross-section shown in

Figures E-1-10-1a and E-1-10-1b. These cross-section should also be used as a template if bridge re-construction is required. Where a different cross-section is proposed for an interim or final stage, this should be justified and approved as per Alberta Transportation Design Exception Guidelines [4].

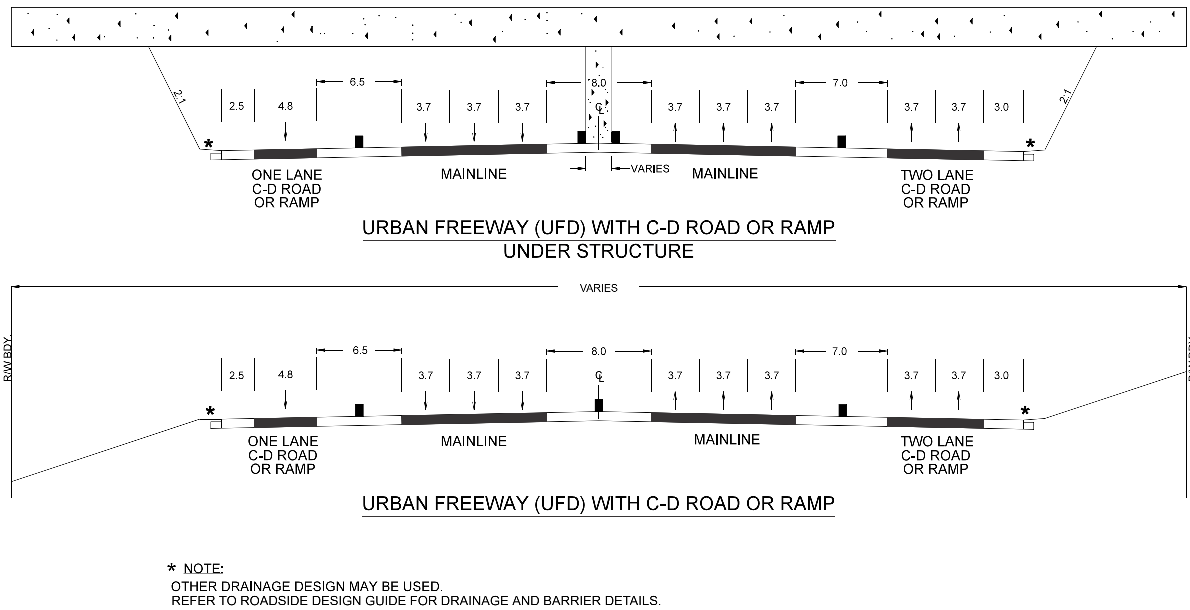
Where C-D roads extend through multiple interchanges, wider separation may be required in order to accommodate transfer lanes between the mainline and the C-D road.

Figure E-1-10-1a Rural Freeway (RFD) with C-D Road Typical Cross Section



REVISIONS	No. 2	By: XX		Date: Mmm dd/yy
	No. 1	By: XX		Date: Mmm dd/yy
Prepared: FS	Date: Feb 2022		RURAL FREEWAY (RFD) WITH C-D ROAD TYPICAL CROSS SECTION	Figure E-1-10-1a
Checked: LM	Scale: NTS			

Figure E-1-10-1b Urban Freeway (UFD) with C-D Road Typical Cross Section



REVISIONS	No. 2	By: XX		Date: Mmm dd/yy
	No. 1	By: XX		Date: Mmm dd/yy
Prepared: FS	Date: Feb 2022		URBAN FREEWAY (UFD) WITH C-D ROAD TYPICAL CROSS SECTION	Figure E-1-10-1b
Checked: LM	Scale: NTS			

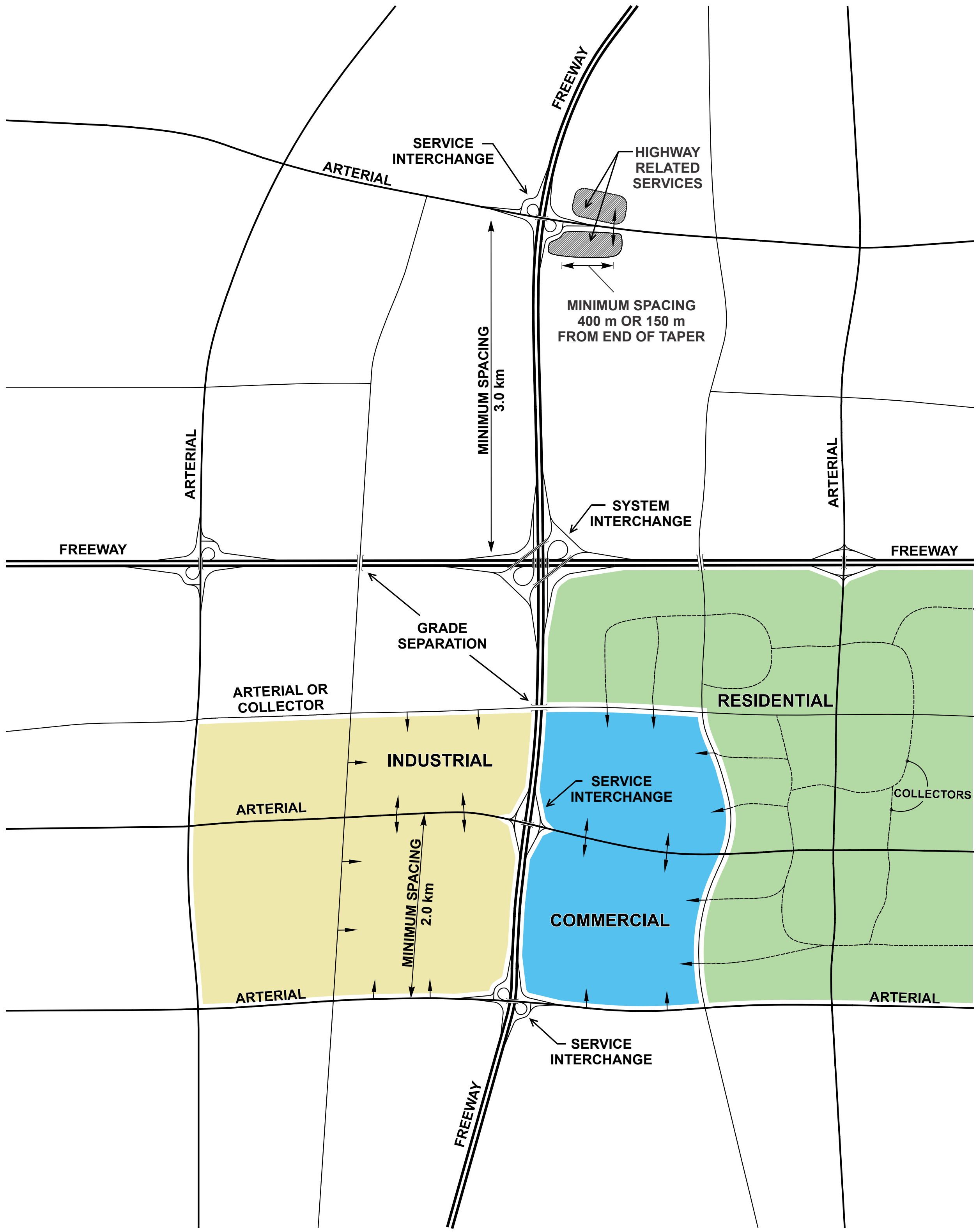
E.1.11 Roadway Hierarchy and Land Access

Coordination of land use planning, roadway network hierarchy, and access locations at the planning and design stages is critical to ensure that the freeway will operate as intended. Protection of the infrastructure investment is also optimized by planning and designing a system that limits freeway access to properly spaced interchanges.

Freeways are not land access roadways, and direct access is not permitted. Direct access to land-uses for traffic is made via lower function roadways, which in turn provide access to the freeway according to the appropriate roadway network hierarchy. A supporting network of arterial and collector roadways are therefore required to carry the shorter trips rather than place them on the freeway system for short distances.

Figure E-1-11a provides an example of typical roadway hierarchy in an urban area. This roadway network hierarchy is critical to the maintenance of freeway function and should not be compromised. Consistency in this principle is critical to maintaining driver confidence and rational decision making and also protects the freeway infrastructure investment as land uses change and redevelop. The supporting roadway network can be modified to serve land-use changes and other variations at much lower cost than modifying the freeway infrastructure. Rest areas and vehicle inspection stations are considered part of the freeway corridor and therefore direct ingress and egress to these facilities is permitted as drivers have an expectation of continuing on in their original direction after stopping. Refer to Chapter F for roadside facilities. No access is permitted between the freeway and adjacent roadways via these roadside facilities.

Figure E-1-11a Typical Roadway Hierarchy and Freeway Access



E.1.12 Interchange Spacing

Planning for and maintaining appropriately spaced interchanges that allow proper operation of the freeway mainline is a key factor in protecting the infrastructure investment. Mainline freeway operations and safety are generally enhanced by reducing the number of interchanges, thereby reducing the number of points of turbulence introduced by entrance and exit maneuvers. Interchange spacing must be balanced against the traffic demand for freeway use, interchange capacity, and the constraints on the connecting roadway systems. Refer to Chapter I for more information.

In urban areas, minimum spacing between service interchanges is 2.0 km. Where a supplementary road system cannot be implemented, some exceptions may be required. System interchanges (interchanges between two freeways) are preferably spaced 3.0 km or more from adjacent service interchanges. These spacing requirements relate to the need for adequate distances for weaving and directional signing. System interchanges generally involve longer ramps and higher volumes than service interchanges, thus increasing the minimum spacing requirement. Where interchanges are located at or below the minimum spacing, minimum weaving length of 600 m between service interchange ramps and 800 m between a system interchange ramp and a service (or another system) interchange ramp is required.

Where development demands and / or existing roadway systems complicate the application of these spacing requirements, frontage roads and C-D roads should be considered to maintain the integrity of the basic spacing requirements.

A grade separated connection, or “flyover”, may also be considered to allow traffic and/or pedestrians to cross a freeway without access to the freeway. These connections reduce the amount of short trips on a specific section of freeway. These connections are typically costly and should only be used where there is an identified need and long term benefit. No interim at-grade intersections should be provided at these locations as the future grade separations will prohibit existing access to the freeway.

For rural areas the intensity of development and the local road system will determine spacing requirements for interchanges on freeways. Typical rural interchange spacing is 8 to 16 km.

E.1.13 Operational Considerations

Proper freeway operations require high standard / high visibility information and control signing, along with adequate roadway lighting in urban areas and at some heavy movement / interchange locations in rural areas.

Efficient use of freeway systems is dependent on reliable information transmitted in a consistent way to drivers. The provision of information through directional signing is enhanced by many of the individual design features listed above, particularly use of right-hand, single exit geometry only and provision of all return movements at interchanges. These factors must be taken into account during the planning and design stages. Refer to Highway Guide and Information Sign Manual [5] for more information.

Another best practice is the numbering of interchanges (exits) in a logical manner. Motorists can pre-select destination points by number, simplifying navigation. This feature also ties in well with geographic information / navigation systems available to motorists that identify highway services and other key destinations.

Highway services development is logically accessed by freeway users when concentrated adjacent to local interchanges. This arrangement also facilitates provision of information on these services to drivers in a consistent location and manner. The specific access to each business requires careful design considering the operation of the interchange and crossroads as well as the access needs of the business.

Rest areas are a safety feature that should be considered in freeway planning. Rest areas should be separated from the freeway mainline, provide parking for large vehicles as well as regular passenger vehicles, and have restroom facilities. Refer to Chapter F for more information.

E.2 INTERCHANGES

Interchanges are relatively complex and have many components which need to be designed to suit the through and connecting roadways as well as the traffic volumes, speed, context, and any constraints imposed by the physical environment. This design guide does not deal comprehensively with the subject of interchanges.

In Alberta, the conceptual or functional design of interchanges that identifies the configuration and general layout, is normally done at the planning stage. This sometimes involves identifying several stages of development for the interchange. As planning work is often done many years in advance of design, there is a need to review the technical details of a planning study to ensure that current design vehicles, speeds and practices have been used. Much of that information is contained in other chapters of this design guide.

For bridge related geometric design and interchange requirements, refer to the latest version of the Bridge Conceptual Design Guidelines [6].

As this Design Guide does not fully cover the subject of Interchange Design, designers should refer to AASHTO [1], TAC [2], and ITE [3] for more information.

E.2.1 Design Consistency

Interchanges, as points of access and / or changes of direction in freeway systems are the significant points of turbulence and decision-making in freeway systems. Consistency of design features is absolutely critical to driver confidence in system usage. Right-hand, single exit design at all interchanges is a best practice that contributes to this confidence. This design feature allows entry and exit maneuvers to be made from the lower speed lane and all traffic interface with the freeway main line is on the driver’s side of the vehicle for maximum visibility. Right-hand entrances are preferable for the same reasons. Right-hand, single exit design at all interchanges also provides consistency in directional signing; however, where multiple named routes intersect at a single interchange, separate exit ramps for each named roadway may be more appropriate in order to facilitate route continuity and signing.

Provision of all movements at each interchange is important in order to satisfy driver expectations. If a vehicle leaves a freeway at an interchange there is a logical expectation that the driver may return to the freeway at the same location, either travelling on in the same direction, or returning in the opposite direction. Interchanges that provide only partial movements are often confusing to drivers and may cause maneuvers that are unsafe. Drivers will search for return movements and this can cause wrong-way movements on ramps and freeway main lines, or median crossings at prohibited locations, with serious accident potential. For these reasons, Right-In-Right-Out (RIRO) ramps that do not provide nearby return movements are not permitted on Alberta highways. Half-interchanges, with movements to and from one direction may be acceptable in some situations, if planned as part of a proper network of interchanges and connecting arterial roadways that minimize circuitous travel or backtracking.

The only cases where driver expectations do not involve return movements in all directions are for freeway related facilities at rest areas and vehicle inspection / weigh stations. Drivers generally expect to carry on in their original direction after using these facilities.

Consistency of design in terms of logical turning directions at ramp terminal intersections in service interchanges is also recommended. For example, the use of both Parclo-A and Parclo-B interchanges causes drivers to turn in different directions at different interchanges to achieve access to or egress from the freeway. Not all drivers are familiar, and inconsistent design features can result in dangerous wrong-way movements.

Access to and from commercial land uses should be from the cross road at a service interchange, with proper spacing between the ramp terminal intersection and the crossroad. Drivers' expectations are then consistently maintained. The first crossroad access or intersection in proximity to an interchange should be a minimum of 400 metres from the ramp terminal intersections or 150 metres from the end of ramp tapers, whichever is greater. Refer to Chapter I for more information. If individual access ramps to specific land uses are provided without logical return movements in all directions, confusion and unsafe driver decisions will result. No access of any kind is permitted directly off freeway ramps for the same reasons.

Interchange exit and entrance areas are the critical speed change areas in freeway operations and require careful design. The combination of horizontal and vertical sight distances at these locations are crucial to driver reaction and smooth transitional maneuvers at entrance and exit locations. Structures, sign supports, lighting and other roadway hardware can impact decision sight distances as well as the horizontal and vertical design at these critical locations, requiring a coordinated design of all elements.

E.2.2 Vertical Configuration of Service Interchanges

In order to provide increased guidance to engineers and planners and promote a more consistent design philosophy on Alberta Transportation's interchange projects, Alberta Transportation has adopted a preferred practice for vertical configuration of Service Interchanges. Service interchanges are defined as interchanges in which only one of the interchanging roadways is considered as a high speed, free-flow roadway through the interchange area (usually a freeway). The crossing roadway is a lower class roadway which permits at-grade intersections.

There are four generalized vertical configurations differentiated by whether the major roadway (normally a freeway) crosses over or under the minor roadway and whether the interchange is in cut or fill, as shown in Figure E-2-2a and described as follows:

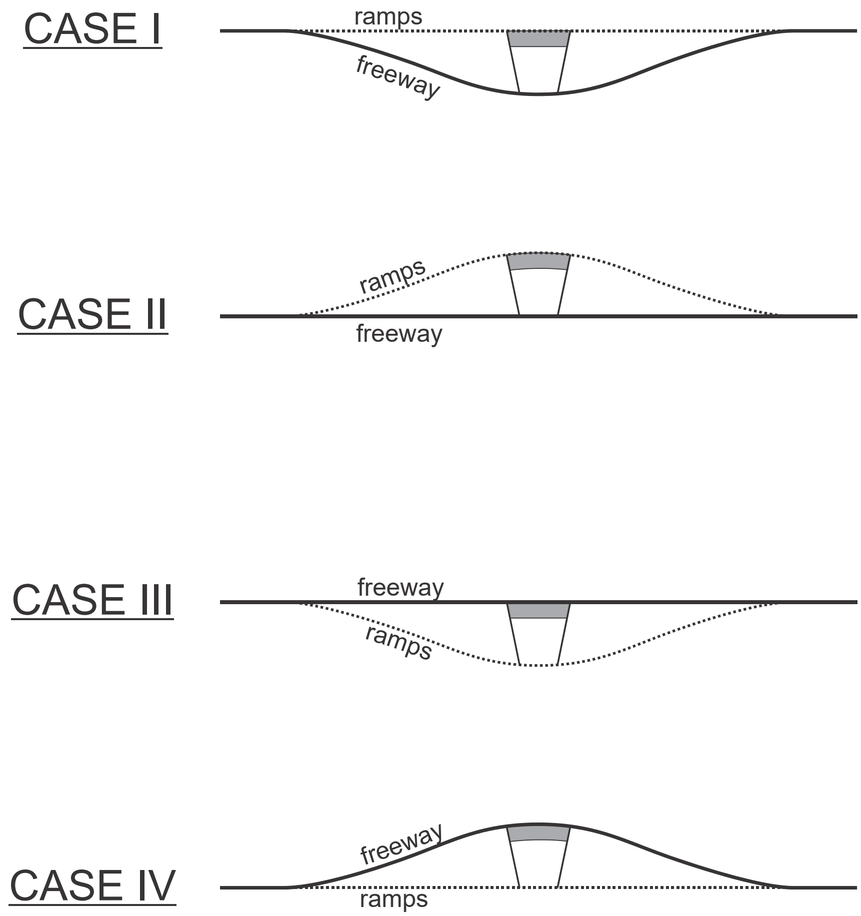
- Case I: freeway under, interchange in cut
- Case II: freeway under, interchange in fill
- Case III: freeway over, interchange in cut
- Case IV: freeway over, interchange in fill

Case I and Case II are differentiated by the profile of the freeway relative to the elevation at the ramp gores at either end of the interchange (which would normally be coincidental with the natural ground level). Similar Case III and Case IV are differentiated by the profile of the freeway relative to the elevation at the ramp gores at either end of the interchange.

Vertical configurations which are designed between the extremes of Case I and Case II, or between the extremes of Case III and Case IV are also possible, depending on site-specific conditions. For example, in the *freeway under configuration*, the crossing roadway could be partially elevated above the natural ground level with the freeway partially depressed below the natural ground level. Such configurations would possess traits of both Cases to a certain degree.

Taking into account safety and operational considerations, economic considerations, and social/community impacts, Case II is the preferred practice where topography is not a major influence in design. Engineers and planners should clearly outline a rationale for deviating from the Case II design. A detailed discussion and comparison of the four cases is provided in the following sections. Advantages and disadvantages for each case are listed. A detailed engineering study including but not limited to life-cycle cost analysis over the long term should be conducted to justify interchange designs which deviate from the preferred practice.

Figure E-2-2a Vertical Configurations at Service Interchanges



Note: Ramp profiles shown assume diamond type ramps in all quadrants of the interchange. Ramp profiles for partial interchanges or interchanges with loop ramps may differ from the figure. The relative vertical position between the freeway mainline and the bridge structure defines the Case.

E.2.2.1 Safety and Operational considerations

Effect of grade

Ramps at service interchanges serve to transition vehicles between the lower speed crossroad and the higher speed freeway, requiring vehicles to accelerate when entering the freeway and decelerate when exiting the freeway. Due to gravity, the direction of the ramp grade (negative or positive) will either serve to help or hinder acceleration and deceleration over the length of these ramps.

For Case II, exit ramps occur on upgrades and entrance ramps occur on downgrades. This assists vehicles in decelerating along exit ramps and accelerating along entrance ramps [1] [2] [3], allowing for smoother operation and potentially (depending on the ramp configuration and design speeds) shorter ramps. Conversely, for Case III, vehicles on the entrance ramp must work against gravity in accelerating uphill, and extra braking is needed to decelerate downhill on exit ramps. This increases stopping distance, which may surprise some drivers as they reach the end of the ramp.

Sight distances at ramps and gores

The view the freeway driver has of the upcoming exit ramp gore, the view of the ramp geometry, and the view of the ramp terminal intersection where the ramp meets the crossroad all provide the driver with critical visual information in order to anticipate and smoothly transition from the higher speed freeway onto the lower speed crossroad, and vice-versa. Providing sufficient decision sight distances through these areas assists merging drivers, exiting drivers, and drivers on the freeway mainline, helps reduce the number of sudden or erratic manoeuvers, and leads to overall improved safety and operation of the interchange.

The *freeway under configuration*, in particular Case II, provides sight distance advantages as follows:

- For drivers exiting the freeway, the view of the exit ramp gore from the freeway is usually superior [2] due to the sag curve at the beginning of the exit ramp followed by an upgrade as the ramp rises from freeway level.
- For vehicles entering the freeway, most (or all) of the entrance ramp is visible due to the ramp downgrade followed by a sag curve at the freeway entrance gore. This gives an entering driver a commanding view of the freeway and the upcoming merge area. This situation is much preferred to Case III in particular, which can have restricted sight distance at the freeway entrance gore due to the ramp upgrade followed by a crest curve.

Sight distances at ramps terminal intersections

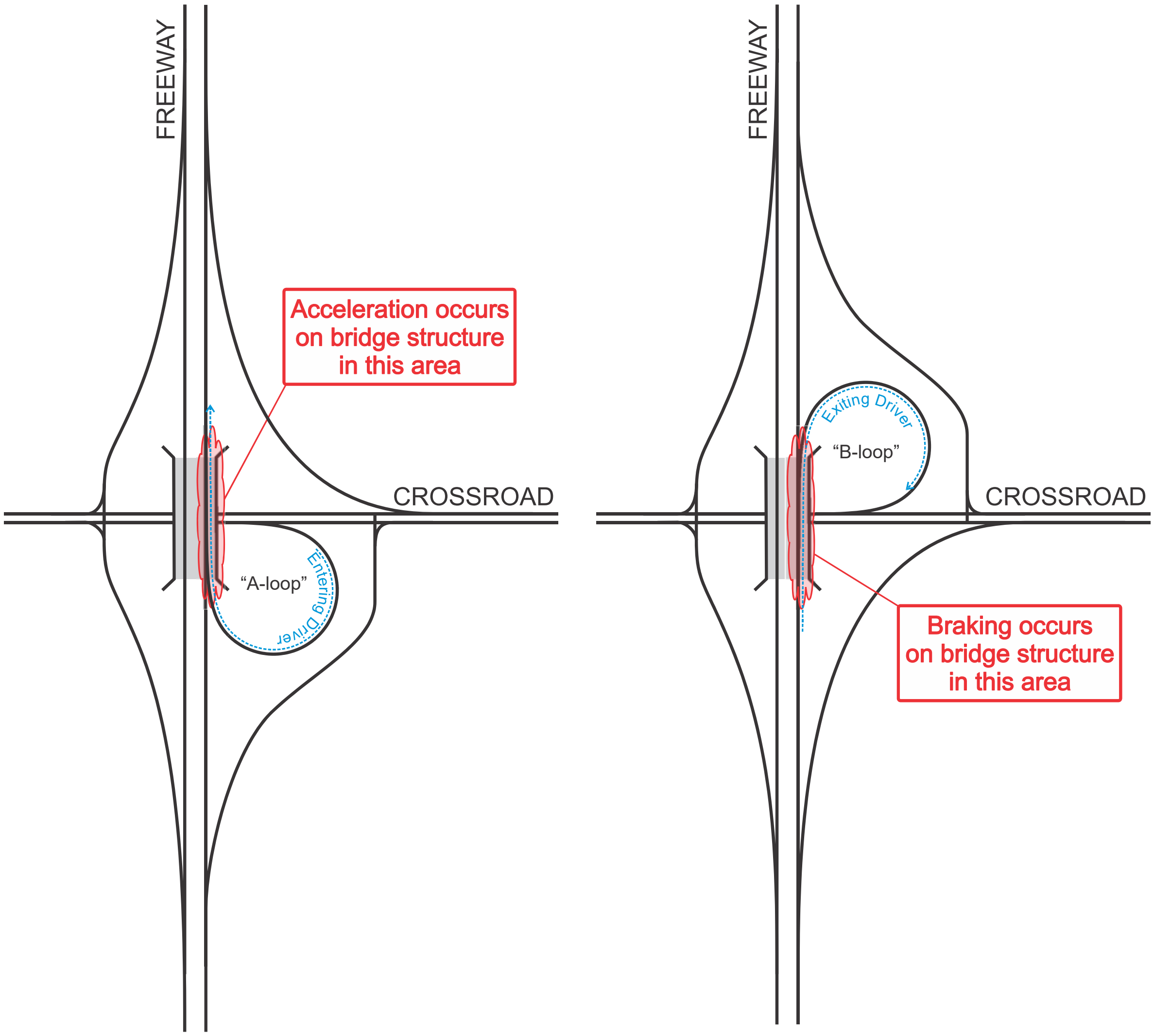
For service interchanges, sight distances at the ramp terminal intersections must also be considered. This is particularly important at stop-controlled junctions where intersection sight distance is critical to the operation of the intersection. The freeway under configuration (Case I & II) is preferred as there tends to be less visual obstructions such as bridge piers, and retaining walls, which are characteristic of the freeway over configuration (Case III & IV) [2]. Case I offers the best sightlines due to the fact that the crossroad remains at-grade through the interchange area. For Case II, intersection sight distances are dependent on the gradeline of the crossroad. For example, a steep grade combined with a sharp crest curve through the overpass can result in restricted intersection sight distances for vehicles attempting to turn left or right from the ramp terminal intersection. Caution must also be used in designing bridge parapets and barrier systems (such as high tension cable barrier, guardrail, etc.), particularly at unsignalized ramp terminal intersections, so as to minimize any visual obstructions. Roundabouts at the ramp terminal intersection may significantly reduce the sigh distance requirements in all cases.

Bridge operational safety

Bridge structures along roadways introduce a number of safety and operational issues which tend to be compounded with higher speeds and higher traffic volumes. For these reasons the freeway under configuration (Case I & II) has a number of safety and operational advantages due to the fact that the bridge structure is located along the crossroad which carries relatively lower volumes at lower speeds. Specific bridge related issues which can be minimized with the *freeway under configuration* include:

- Collisions related to preferential icing on the bridge deck going from unfrozen roadway surface to possibly icy bridge surface.
- Braking and acceleration which occurs along the freeway at the crossing area of cloverleaf and partial-cloverleaf interchanges (see Figure E-2-2-1a). Braking on the freeway occurs in advance of “B-loops” which are located beyond the bridge structure while acceleration occurs on the freeway following “A-loops”, which join the freeway prior to the bridge structure. Areas where braking and acceleration or where changes in direction occur (while merging, diverging, and weaving) tend to aggravate bridge icing safety issues. It is generally preferable that this braking, weaving, and acceleration not occur on a bridge structure at freeway speeds.

Figure E-2-2-1a Location of Vehicle Acceleration and Braking on “A-loop” and "B-loop" Interchanges



Freeway geometry

The use of either the freeway over or *freeway under configuration* is fundamental to the development of the freeway alignment through the service interchange area, particularly when curvilinear freeway alignments are necessary. Bridge structures tend to increase the risk of barrier related collisions and other loss of control incidents, particularly in Alberta’s winter climate conditions where preferential icing can. Introducing curves in these locations further increases driver workload and increases the risk of loss of control incidents. To minimize these occurrences, it is desirable that bridges only be used in combination with straight (tangent) sections of the roadway alignment. Where the roadway alignment design necessitates bridge structures on curves, these should be located close to the centre of the curve so as not to include spiral or superelevation transition sections. Due to these limitations, with the *freeway under configuration*, there is more flexibility in designing the freeway alignment, which, when design trade-offs are necessary, takes precedence over the alignment of the crossroad.

Roadside design
Lateral barriers such as guardrail can often be avoided in the freeway under configuration by designing sufficient lateral offset distance under the structure to ensure that all obstacles are located outside the clear zone. Lateral barriers will be required on the crossroad overpass; however, it is desirable that these barriers be located on the relatively lower speed and lower volume roadways.

Utilities
If the freeway is situated within a transportation and utility corridor or the freeway alignment is otherwise parallel to a linear underground utility, it may be prohibitive to excavate below grade. Case II and Case IV, where all roadways are situated at or above ground level, are likely to better accommodate existing parallel underground utilities.

Drainage
Interchanges with portions of roadway below the natural ground level (Case I and Case III) will require special systems to ensure that water can be drained properly and not accumulate on the roadway surface. It is particularly critical that proper drainage be achieved in Case I, where the freeway is below the natural ground level, as the freeway should be planned to the highest level of flood control possible in order that it remain in operation during emergencies. Refer to Chapter C for more information. Accommodating proper drainage is usually more difficult in Case I due to the larger volume of cut below the natural ground level. If the freeway must pass over the crossroad, troublesome drainage problems may be reduced by elevating the freeway without altering the crossroad grade [1] (Case IV).

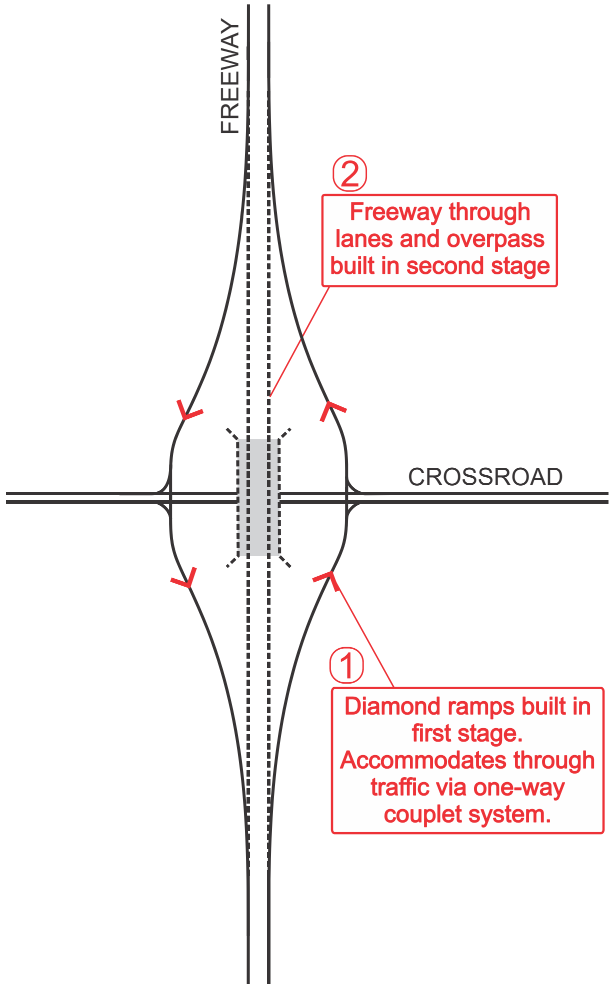
Bridge visual impact
The *freeway under configuration* requires that a bridge structure cross the freeway. Although subtle, the visual cue provided by a looming overpass structure along a freeway:

- Alerts the driver to the possible presence of an interchange, offering the driver more time to determine whether it is the desired exit and to make appropriate lane changes and adjustments in speed to take the exit [1] [2] [3].
- Assists the long distance driver on a rural freeway, who may experience boredom or tiredness, to remain alert, by offering a change of scene and tend to break the monotony of an unchanging roadway section [2].

Staging
Where a new freeway is to be constructed crossing an existing roadway, Case IV will cause fewer traffic disturbances and a detour during construction is usually not needed [1]. With the *freeway over configuration* (Case III or Case IV) there is also an opportunity to phase-in construction of diamond interchange ramps while incurring minimal throw-away costs at final construction (Figure E-2-2-1b). This is accomplished by first building the interchange ramps in their final configuration, providing temporary additional capacity on these ramps if needed, to accommodate through traffic. The freeway overpass is then constructed at a later time with minimal disruption to the crossroad below or to through traffic.

On the other hand, when a new interchange is added to an existing roadway (either a freeway or an expressway or arterial roadway which is being upgraded to a freeway), Case II is least disruptive, as the gradeline of the existing roadway does not need to be altered.

Figure E-2-2-1b Staged Construction of a Diamond Interchange (Case III and IV)



Maintenance and reconstruction
The *freeway under configuration* provides better opportunity to perform maintenance, rehabilitation, reconstruction, or expansion activities on the interchange bridge structure(s) without diverting or interfering substantially with freeway traffic flow [1]. Bridge maintenance and reconstruction activities for the *freeway over configuration* on the other hand would normally require either partial interference with traffic flow or in the worst case, total closure of the roadway. This is a significant operational and safety issue as the freeway is generally high speed and volumes typically increase with time. In winter, Case I can also produce increased snow removal efforts. With the other cases, the freeway is exposed to the wind, lessening the amount of accumulation.

Overdimensional load accommodation
The *freeway over configuration* is advantageous if the freeway is a high load corridor as there is no vertical clearance limitation [1]. Whereas, in the freeway under configuration, special provisions are required in order to accommodate high loads, particularly at non *diamond*-interchanges. This could include additional ramps or median crossings so that the high loads are able to "bypass" the bridge structure. Conversely, the *freeway under configuration* accommodates heavy loads without the need to strengthen the bridge structure, and special provisions are required in order to accommodate heavy loads along the freeway in the *freeway overpass configuration*.

E.2.2.2 Economic Considerations

The freeway under configuration has economic benefits (as compared to the *freeway over configuration*) attributable to the initial and life cycle cost of the bridge structure(s) at the interchange. This is because the width of the freeway would normally exceed that of the crossroad, particularly in rural areas, equating to less total bridge deck area. Furthermore, to achieve the required centerline-to-centerline separation between carriageways on rural freeways, costs normally dictate two separate structures for the *freeway over configuration*. There are also savings due to significantly less earthwork with the freeway under configuration [1] [3]. User cost savings are also apparent in the freeway-under configuration as there are fewer impacts to the flow of vehicles on the freeway during maintenance and reconstruction activities. Case IV can be an economical solution when a new freeway is constructed crossing several existing roadways. In this case right-of-way requirements can be reduced by keeping the crossroads at-grade. Case I and Case IV will incur higher user costs due to the undulating grade line on the higher traffic volume roadway.

E.2.2.3 Social / Community Impacts

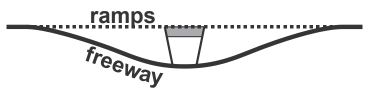
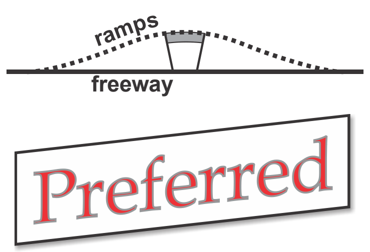
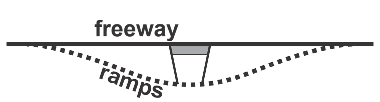
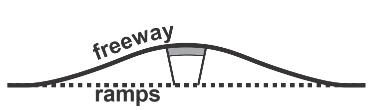
The freeway under configuration provides important social benefits which are particularly important in urban areas and in rural or semi-rural areas where interchanges are situated adjacent to development. These benefits are a result of the freeway being at ground level (Case II) or below ground level (Case I) which results in:

- Less visual impact, particularly for Case I where the freeway is entirely out of view from the surrounding area. Case II can be further mitigated with the use of berms.
- Less noise impact to surrounding areas [1] [2], particularly for Case I. Case II can be mitigated further with the use of berms adjacent to the freeway.
- For Case II, less truck noise due to gentler acceleration on the entrance ramps (downgrades) and gentler braking on the exit ramps (upgrades) [2].

E.2.2.4 Preferred Interchange Vertical Configuration

A summary of the advantages and disadvantages of each of the four interchange vertical configurations is provided in Table E-2-2-4a. It can be seen that there are numerous safety, operational, economic, and social benefits to providing the *freeway under configuration*, particularly when the freeway remains at ground level with the crossroad elevated above the under-passing freeway (Case II). **Case II is therefore the preferred practice** for service interchanges on Alberta highways, where topography is not a major influence. Designs which deviate from this practice should be supported through an engineering study outlining the reasons why Case II configuration is not appropriate and rationale for the proposed alternate configuration.

Table E-2-2-4a Summary of Vertical Configuration Considerations

	Ramp grade	Sight distances - ramps and gores	Sight distances - ramp terminal intersections	Bridge operational safety	Freeway geometry	Roadside design	Other design considerations	Other operational considerations	Construction staging and maintenance	Economic considerations	Social / Community
CASE I 			Best sightlines at ramps terminal intersections.	High speed / high volume road users protected against potential preferential bridge deck icing safety issues.	Greater flexibility in freeway geometry.	Lateral barriers along the freeway can be avoided by designing sufficient lateral offset distance under the structure.	Potential for conflicts with utilities crossing the freeway. Proper drainage of the freeway lanes can be difficult to achieve.	Presence of an overpass alerts the freeway driver to a possible upcoming interchange. Heavy loads can be accommodated along the freeway without requiring structural strengthening Increased snow removal efforts.	Better opportunity for bridge structure maintenance, reconstruction, or expansion without diverting freeway traffic.	Lower structural costs, higher earthwork costs. Higher user costs due to the undulating grade line on the higher traffic volume roadway.	Least visual and noise impact of the freeway where the freeway is entirely out of view from the surrounding area.
CASE II 	Exit ramps on up-grades and entrance ramps on downgrades assists in vehicle acceleration and deceleration.	Best view of the exit ramp from freeway. Most (or all) of the entrance ramp is visible.	Sight distance dependant on grade line of crossroad.	High speed / high volume road users protected against potential preferential bridge deck icing safety issues.	Most flexibility in freeway geometry.	Lateral barriers along the freeway can be avoided by designing sufficient lateral offset distance under the structure.		Presence of overpass alerts the freeway driver to a possible upcoming interchange. Heavy loads can be accommodated along the freeway without requiring structural strengthening.	Better opportunity for bridge structure maintenance, reconstruction, or expansion without diverting freeway traffic. Least disruptive when adding an interchange to an existing freeway.	Least costly (less bridge deck area and earthworks).	Least truck noise due to gentler acceleration on the entrance ramps and less braking on the exit ramps. Ramps tend to block some of the freeway visual and noise. Noise impact to surrounding areas can be further mitigated with the use of berms adjacent to the freeway.
CASE III 	Exit ramps on downgrades and entrance ramps on upgrades hampers vehicle acceleration and deceleration.	Reduced sight distance on the entrance and exit ramps. View of entrance gore area can be hidden from view. Exit ramp may be hidden from view until driver reaches the exit gore.	Obstructions at the ramp terminal intersections (bridge piers, guardrails, retaining walls, etc.) can impair sight distance.	Bridge deck on higher volume / higher speed roadway increases potential for safety issues related to preferential bridge deck icing. Compounded at cloverleaf or partial cloverleaf interchanges where braking, acceleration, and weaving occurs on structure.	Bridge structure limits freeway alignment options. Curves on structure should not include spiral or superelevation transition sections. Tangent sections are preferred.	Lateral barriers are required along the freeway on structure. Wider shoulders are required to meet shy line offset distance requirements for high-speed freeway.	Potential conflicts with utilities parallel to the freeway.	High-load vehicles accommodated along the freeway without having to rely on the ramps or other bypass routes.	Better construction staging opportunities as interchange can be phased with minimal throw-away costs.	Higher user costs during maintenance and rehabilitation of the bridge structures.	Visual and noise impact to surrounding areas can be mitigated with the use of berms adjacent to the freeway.
CASE IV 			Obstructions at the ramp terminal intersections (bridge piers, guardrails, retaining walls, etc.) can impair sight distance.	Bridge deck on higher volume / higher speed roadway increases potential for safety issues related to preferential bridge deck icing. This is compounded at cloverleaf or partial cloverleaf interchanges where braking, acceleration, and weaving occurs on structure.	Bridge structure limits freeway alignment options. Curves on structure should not include spiral or superelevation transition sections. Tangent sections are preferred.	Lateral barriers are required along the freeway on structure. Wider shoulders are required to meet shy line offset distance requirements for high-speed freeway.		High-load vehicles accommodated along the freeway without having to rely on the ramps or other bypass routes.	Less disturbances to existing surface roadways. Better construction staging opportunities as interchange can be phased with minimal throw-away costs.	Can be less costly in urban areas when crossing multiple existing roadways. Higher user costs due to undulating grade line on higher traffic volume roadway. Higher user costs during maintenance and rehabilitation of the bridge structures.	High visual and noise impact of the freeway.

E.2.3 Ramp Terminal Design

Ramp terminals are the transition between the freeway (or other roadway) lanes and a ramp and can be either direct taper or parallel lane designs. Alberta Transportation generally uses the tapered design and since the tapered exit and entrance terminal design is the predominant type of ramp within the province, deviations from this type would violate driver expectancy and should be avoided if possible. Parallel lane design should therefore only be used in areas of constraint or where it can be shown to be superior to the taper design. Table E-2-3a summarizes a comparison between tapered and parallel lane design.

As a general guide, if the designer is faced with any of the following situations a parallel lane could be considered:

1. The ramp terminal is on a crest curve and the decision sight distance to the bullnose cannot be achieved with a standard exit terminal.
2. The ramp terminal is on a crest curve and the sight distance to the end of the taper cannot be achieved with a standard entrance terminal.
3. An entrance ramp is on an up-grade and additional acceleration length is required to get vehicles up to speed before entering the through traffic. In this case, an additional length of parallel lane, added to the standard taper should be used.
4. Spacing of successive exits and entrances may be such that a continuous parallel lane between them would provide additional capacity and operational benefits.
5. Exits and entrances on tight curves would benefit from a parallel lane design.
6. Exit ramps on left-handed curves have a tendency to lead drivers off the through lanes. If possible they should be avoided. However, if they are designed, a parallel lane with a short taper (30 m long) will provide a visual cue that a ramp is beginning. If possible, the parallel lane should begin upstream or downstream of the tangent to curve (or spiral), but never at the tangent to curve (or spiral) as it will appear as an extension of the tangent and confuse drivers. The preferred design, which will usually avoid operation problems, is to begin the parallel lane a considerable distance upstream of the beginning of the curve (Tangent to Curve or Spiral - TC or TS).
7. Generally, tapered designs require less property and are less costly for the same length of ramp. However, at times other factors, such as when crossing bridges, may come into play and warrant that a cost analysis be undertaken to determine if a taper or parallel lane design is more economical.

Table E-2-3a Comparison of Tapered Versus Parallel Lane Entrances and Exits

Tapered Entrance	**Parallel Lane Entrance**
Acceleration length is accomplished on the ramp upstream of the painted gore.	A portion of the acceleration length is downstream of the painted gore.
Running speed of entering traffic is expected to be at or near that of through traffic.	Running speed of entering traffic may be less than that of through traffic.
Large painted gore area limits the amount of merging time.	A long acceleration lane provides more time for the merging traffic to find an opening in the through-traffic stream.
	Reduced cost where the entrance terminal is located on top of or under a structure.
Tapered Exit	**Parallel Lane Exit**
The taper type exit fits the direct path preferred by most drivers	Short taper and added lane width at the beginning of the parallel lane is very apparent and provides an inviting exit area.
Vehicles leave the through lanes at relatively high speeds reducing the risk of rear-end collisions as a result of deceleration on the through lane	Operates best when drivers chose to exit early and decelerate in the parallel lane. Drivers that do not exit early will likely make a more abrupt reverse curve maneuver which is somewhat unnatural and may result in slowing down in the through lane.
	Parallel lane provides additional storage for queuing vehicles.
	Two lane parallel exit terminals require an exiting vehicle to make more lane changes than the taper design.
	Reduced cost when the exit terminal is located on or under a structure.
General	**General**
A taper design on a left hand curved alignment would result in a tangential alignment for the edge of pavement and may be confusing to the driver.	Parallel lanes are preferred on sharp curves such as those on roadways of 80 km/h or less. At exits they are less likely to confuse through traffic and on entrances they will usually result in smoother merging operations. Short tapers on exits provide a visual cue that a ramp is beginning.

E.2.3.1 Tapered Ramp Terminal Design

In the direct taper exit terminal design, the right edge of the ramp terminal gradually widens from the beginning of the ramp terminal to the nose. Exiting vehicles are expected to maintain close to full speed until they are entirely off the through lanes to avoid impeding through traffic.

In the direct taper entrance design, a uniform taper is provided from the entrance nose to the edge of through lane. The taper rate is chosen to allow vehicles entering the highway to accelerate to close to the through traffic speed before having to merge.

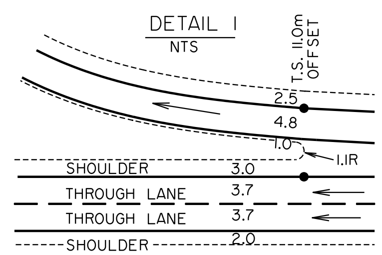
Typical single lane tapered ramp terminal designs are shown in Figures E-2-3-1a to E-2-3-1c for layout of single-lane on-ramps and off-ramps on the through highway. At dual lane entrance ramps, the outside lane should be terminated into the inside lane in order to ensure that the merging traffic stream is adjacent to the shoulder. See Figure E-2-3-1d for typical dual-lane on-ramps and off-ramp designs.

E.2.3.2 Parallel Ramp Terminal Design

In the parallel entrance terminal design, an auxiliary lane of constant width is added to the right of the through lanes and is discontinued, by means of a taper, some distance downstream. The driver entering a parallel lane is expected to accelerate to a suitable speed before merging with through traffic.

In the parallel exit terminal design, a short taper is used to develop a lane of constant width for some distance gradually widening at the nose. Exiting vehicles are expected to change lanes and decelerate without impeding the through traffic.

Refer to Section 10.8 of TAC [2] for parallel terminal design.



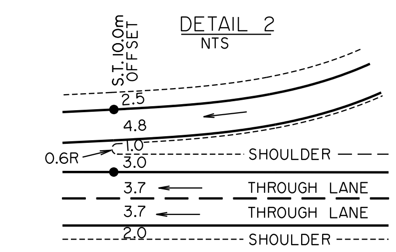
*NOTES:

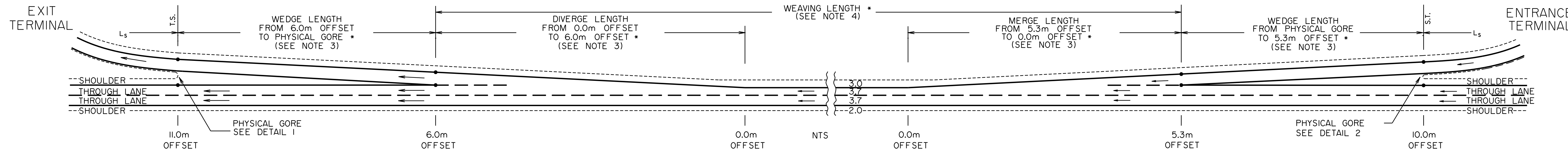
1.) MINIMUM LOOP RAMP RADIUS IS APPLICABLE TO ENTRANCE ("A") LOOPS. EXIT ("B") LOOPS THAT ARE LOCATED AT THE END OF THE DECELERATION LANE SHOULD USE TYPICAL LOOP RAMP RADIUS.

2.) TARGET SPEED IS 80 TO 90% OF DESIGN SPEED.

3.) FOR TYPICAL PAVEMENT MARKINGS FOR INTERCHANGE RAMPS REFER TO THE HIGHWAY PAVEMENT MARKING GUIDE.

4.) MINIMUM WEAVING LENGTH IS 600m BETWEEN TWO SERVICE RAMPS AND 800m FOR SYSTEM RAMPS.





FOR DIMENSIONS, REFER TO FIGURE E-2-3-1C

FOR DIMENSIONS, REFER TO FIGURE E-2-3-1B

BASIC PARAMETERS / EXIT TERMINAL FROM HIGHWAY

MAINLINE DESIGN SPEED (km/h)	RAMP CONTROLLING RADIUS * (SEE NOTE 1) TYPICAL (m)	MINIMUM (m)	LOOPS TYPICAL (m)	LOOPS MINIMUM (m)	SPEED AT PHYSICAL GORE ** (km/h) (SEE INSET TABLE)	NORMAL TAPERED DECELERATION LANE PARAMETERS (GRADIENT -3% TO +3%) RATIO AND TOTAL LENGTH (m)	WEDGE LENGTH (m)	DIVERGE LENGTH (m)	TAPERED DECELERATION LANE RATIO FOR GRADIENTS > 3% -3% TO -5%	<-5%	+3% TO +5%	>+5%
60	90	55	55	55	48	165 @ 15:1	75	90	20:1	20:1	15:1	15:1
80	190	55	55	55	64	220 @ 20:1	100	120	25:1	25:1	20:1	15:1
90	215	70	70	55	79	220 @ 20:1	100	120	25:1	25:1	20:1	15:1
100	250	90	90	55	80	220 @ 20:1	100	120	25:1	25:1	20:1	15:1
110	340	130	90	55	87	275 @ 25:1	125	150	30:1	35:1	25:1	20:1
120	440	130	90	70	90	275 @ 25:1	125	150	30:1	35:1	25:1	20:1
130	440	190	90	90	93	330 @ 30:1	150	180	35:1	40:1	30:1	25:1

ENTRANCE TERMINAL TO HIGHWAY

MAINLINE DESIGN SPEED (km/h)	TARGET SPEED AT 2.0m OFFSET* (SEE NOTE 2)	NORMAL TAPERED ACCELERATION LANE PARAMETERS (GRADIENT -3% TO +3%) RATIO AND TOTAL LENGTH (m)	WEDGE LENGTH (m)	MERGE LENGTH (m)	TAPERED ACCELERATION LANE RATIO FOR GRADIENTS > 3% -3% TO -5%	<-5%	+3% TO +5%	>+5%
60	52	200 @ 20:1	94	106	20:1	20:1	25:1	30:1
80	71	250 @ 25:1	117.5	132.5	25:1	25:1	≥ R90 30:1 R55-R90 35:1	≥ R90 35:1 R55-R90 40:1
90	79	≥ R110 300@30:1 R55-R110 230@35:1	141 164.5	159 185.5	30:1	30:1	≥ R110 50:1 R55-R110 55:1	60:1
100	88	≥ R130 350@35:1 R55-R130 400@40:1	164.5 188	185.5 212	35:1	35:1	≥ R130 50:1 R55-130 60:1	≥ R130 60:1
110	94	≥ R160 500@50:1 R55-R160 550@55:1	235 258.5	265 291.5	40:1	40:1	DUE TO THE LONG DISTANCES REQUIRED FOR ACCELERATION, CONSIDERATION SHOULD BE GIVEN TO REDUCING MAINLINE GRADIENT, OR PROVIDING A PARALLEL ACCELERATION LANE, SUCH THAT VEHICLES OBTAIN THE TARGET SPEED AT 2.0m OFFSET. SEE CHAPTER D FOR TYPICAL VEHICLE PERFORMANCE CHARACTERISTICS.	
120	101	≥ R190 500@50:1 R70-R190 600@60:1	235 282	265 318	50:1	40:1		
130	108	≥ R215 500@50:1 R90-R215 600@60:1	235 282	265 318	50:1	40:1		

SPIRAL PARAMETERS FOR EXIT AND ENTRANCE TERMINALS BASED ON MAINLINE DESIGN SPEED AND RAMP CONTROLLING RADIUS (e=0.06)

MAINLINE DESIGN SPEED (km/h)	40 km/h R55	45 km/h R70	50 km/h R90	55 km/h R110	60 km/h R130	65 km/h R160	70 km/h R190	75 km/h R215
60	P=3.205 O=32.345 A=60 Lc=64.430 Ls=65.455	P=2.154 O=29.993 A=65 Lc=59.860 Ls=60.357	P=1.801 O=31.125 A=75 Lc=62.166 Ls=62.500	P=1.629 O=32.744 A=85 Lc=65.422 Ls=65.682	P=1.242 O=31.094 A=90 Lc=62.149 Ls=62.308	P=1.016 O=31.210 A=100 Lc=62.394 Ls=62.500	P=0.889 O=31.812 A=110 Lc=63.605 Ls=63.684	P=0.869 O=33.461 A=120 Lc=66.904 Ls=66.977
80	P=5.874 O=43.589 A=70 Lc=86.520 Ls=89.091	P=3.799 O=39.741 A=75 Lc=79.187 Ls=80.357	P=2.328 O=35.371 A=80 Lc=70.619 Ls=71.111	A=85	A=90	A=100	A=110	A=120
90	A=70	A=75	A=80	A=85	A=90	A=100	A=110	A=120
100	P=12.427 O=62.679 A=85 Lc=123.224 Ls=131.364	P=7.778 O=56.564 A=90 Lc=112.239 Ls=115.714	P=4.604 O=49.625 A=95 Lc=98.901 Ls=100.278	P=3.111 O=45.197 A=100 Lc=90.221 Ls=90.909	P=2.764 O=46.340 A=110 Lc=92.548 Ls=93.007	P=2.103 O=44.882 A=120 Lc=89.684 Ls=90.000	P=1.481 O=41.054 A=125 Lc=82.066 Ls=82.237	P=1.196 O=39.258 A=130 Lc=78.488 Ls=78.605
110	A=85	A=90	A=95	A=100	A=110	A=120	A=125	A=130
120	*	P=9.600 O=62.684 A=95 Lc=124.134 Ls=128.929	P=5.638 O=54.857 A=100 Lc=109.241 Ls=111.111	P=4.543 O=54.545 A=110 Lc=108.783 Ls=110.000	P=3.907 O=55.051 A=120 Lc=109.373 Ls=110.769	P=2.475 O=48.677 A=125 Lc=97.257 Ls=97.656	P=1.732 O=44.393 A=130 Lc=88.731 Ls=88.947	P=1.608 O=45.513 A=140 Lc=90.981 Ls=91.163
130	*	*	A=100	A=110	A=120	A=125	A=130	A=140

MAINLINE DESIGN SPEED (km/h)	80 km/h R250	90 km/h R340	100 km/h R440	110 km/h R600	120 km/h R750	130 km/h R950
60	P=1.024 O=39.168 A=140 Lc=78.314 Ls=78.400	P=0.694 O=37.632 A=160 Lc=75.253 Ls=75.294	P=0.706 O=43.161 A=195 Lc=86.313 Ls=86.350	P=0.587 O=45.973 A=235 Lc=91.939 Ls=91.963	P=0.525 O=48.593 A=270 Lc=97.182 Ls=97.200	P=0.420 O=48.940 A=305 Lc=97.877 Ls=97.889
80	A=140	A=160	A=195	A=235	A=270	A=305
90	A=140	A=160	A=195	A=235	A=270	A=305
100	A=140	A=160	A=195	A=235	A=270	A=305
110	A=140	A=160	A=195	A=235	A=270	A=305
120	P=1.348 O=44.951 A=150 Lc=89.870 Ls=90.000	A=160	A=195	A=235	A=270	A=305
130	A=150	A=160	A=195	A=235	A=270	A=305

**** ASSUMED SPEED PROFILE AT EXIT TERMINALS**

MAINLINE DESIGN SPEED km/h	NORMAL TAPER RATIO	SPEED AT 3.7m OFFSET km/h	LENGTH OF TAPER AVAILABLE FOR DECELERATION (7.3m x RATIO)	SPEED AT PHYSICAL GORE (20% REDUCTION) km/h	SPIRAL	CONTROLLING RADIUS
60	15:1	60	109.5	48	VEHICLES ARE EXPECTED TO BRAKE COMFORTABLY ON SPIRALS PRECEEDING LOOPS.	OPERATING SPEED SHOULD BE LESS THAN DESIGN SPEED OF CONTROLLING RADIUS
80	20:1	80	146	64		
90	20:1	90	146	72		
100	20:1	100	146	80		
110	25:1	109	182.5	87		
120	25:1	112.5	182.5	90		
130	30:1	116	219	93		

IT IS ASSUMED THAT VEHICLES EXITING THE HIGHWAY WILL MAINTAIN THE MAINLINE OPERATING SPEED UNTIL THE POINT WHERE THE TAPERED LANE IS 3.7m WIDE. AT THE PHYSICAL GORE, IT IS ASSSUMED THAT VEHICLES HAVE SLOWED DOWN TO 80% OF THE MAINLINE SPEED. THIS DECELERATION RATE IS VERY GRADUAL AND CAN GENERALLY BE ACHIEVED BY STANDARD TRANSMISSION VEHICLES IN GEAR WITHOUT BRAKES BEING APPLIED. THE SPIRAL LENGTHS ARE DESIGNED TO ALLOW A COMFORTABLE TRANSITION TO THE CONTROLLING SPEED OF THE CIRCULAR CURVE. GENERALLY ON RAMPS WHERE THE RAMP DESIGN SPEED EXCEEDS 70 km/h, THE REDUCTION IN SPEED ON THE TRANSITION IS VERY GRADUAL AND CAN BE ACHIEVED WITHOUT BRAKING. HOWEVER, WHERE CONSTRAINTS EXIST, FOR EXAMPLE AT LOOP EXITS WITH DESIGN SPEEDS LESS THAN 70 km/h, THE DESIGN LENGTH PROVIDES FOR COMFORTABLE BRAKING. ALTHOUGH SOME BRAKING IS REQUIRED ON APPROACHES TO LOOPS, THE RATE OF DECELERATION IS GENERALLY LESS THAN HALF THAT REQUIRED ON THE APPROACH TO TURNING ROADWAYS AT CHANNELIZED INTERSECTIONS AND IS WELL WITHIN THE RANGE OF COMFORTABLE BRAKING.

No.	REVISIONS	BY	DATE

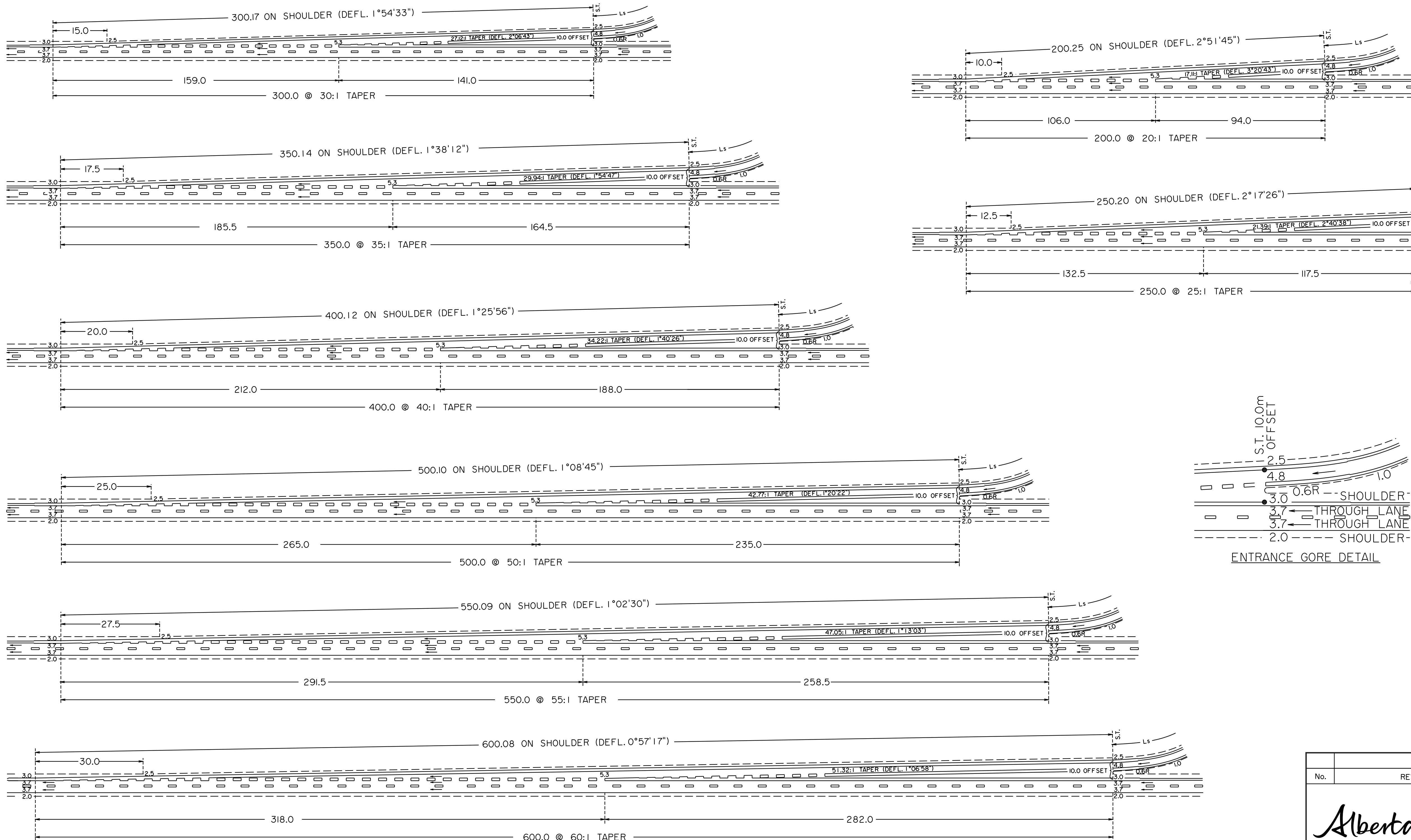
Alberta

FIGURE E-2-3-1A

Date: FEBRUARY 2022

DESIGN STANDARDS OF EXIT & ENTRANCE TERMINALS FOR DIVIDED HIGHWAYS - SINGLE LANE

Prepared By: F.S. | Checked By: L.M. | Scale: N.T.S.



NOTES:

1. THE CHOICE OF TAPER RATIO SHOULD BE MADE BASED ON DESIGN SPEED AND GRADIENT; SEE FIGURE E-2-3-1A
2. DECISION SIGHT DISTANCE SHOULD BE AVAILABLE AT THE MERGE AREA. (REFER TO SECTION CHAPTER B)
3. FOR TYPICAL PAVEMENT MARKINGS REFER TO THE HIGHWAY PAVEMENT MARKING GUIDE.
4. FOR WEAVING LENGTH REFER TO FIGURE E-2-3-1A

No.	REVISIONS	BY	DATE

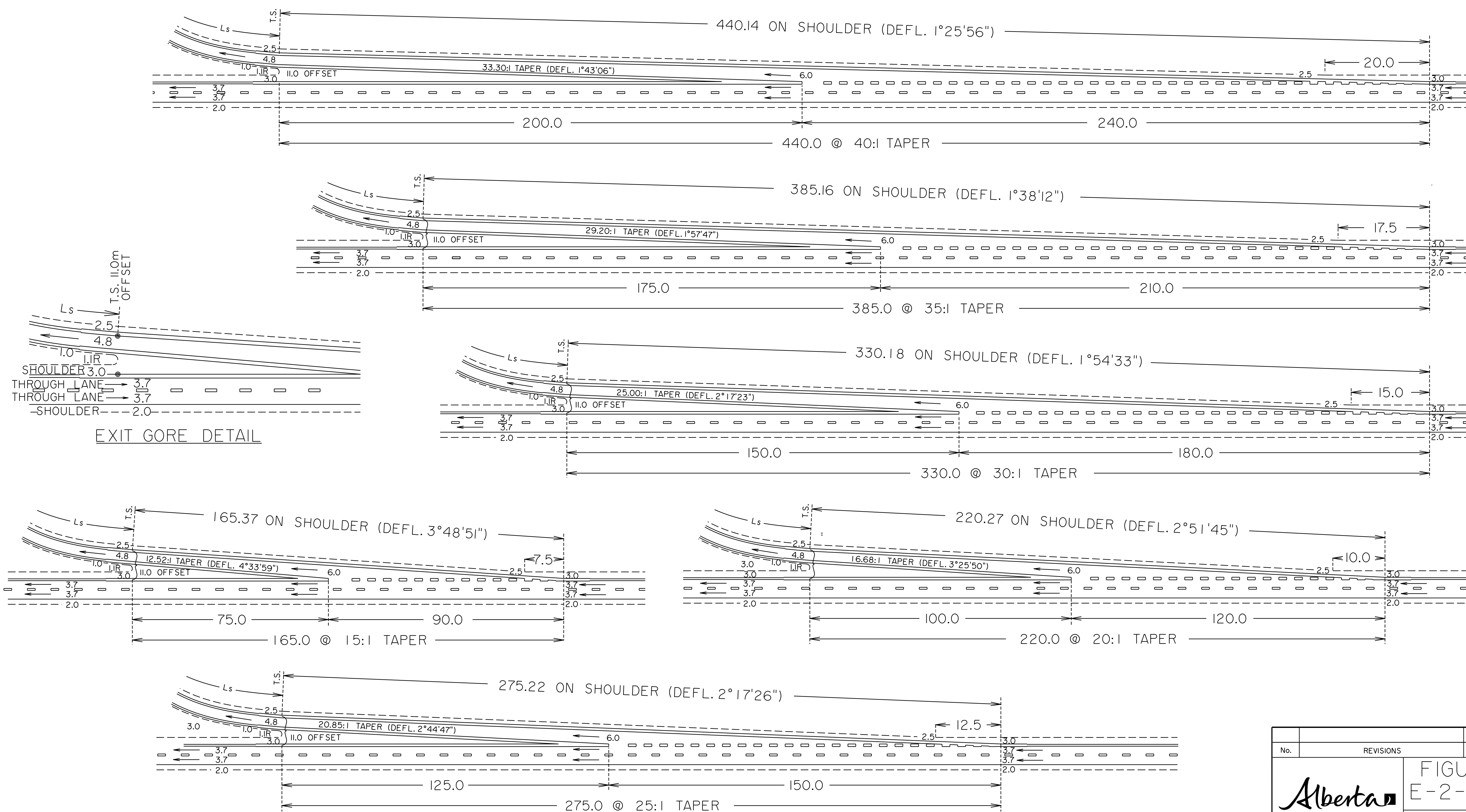
Alberta

FIGURE E-2-3-1B

Date: FEBRUARY 2022

DETAILS OF ENTRANCE TERMINALS ON DIVIDED HIGHWAYS AT INTERCHANGES

Prepared By: F.S. | Checked By: L.M. | Scale: N.T.S.



NOTES:

1. THE CHOICE OF TAPER RATIO SHOULD BE MADE BASED ON DESIGN SPEED AND GRADIENT; SEE FIGURE E-2-3-IA
2. DECISION SIGHT DISTANCE SHOULD BE AVAILABLE AT THE MERGE AREA. (REFER TO SECTION CHAPTER B)
3. FOR TYPICAL PAVEMENT MARKINGS REFER TO THE HIGHWAY PAVEMENT MARKING GUIDE.
4. FOR WEAVING LENGTH REFER TO FIGURE E-2-3-IA

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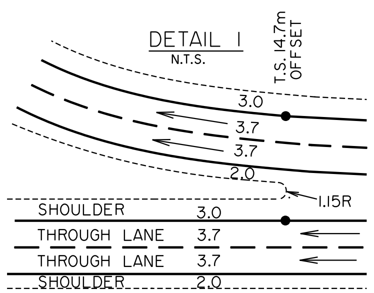
FIGURE E-2-3-1C

Date: FEBRUARY 2022

DETAILS OF EXIT TERMINALS ON DIVIDED HIGHWAYS AT INTERCHANGES

Prepared By: F.S.	Checked By: L.M.	Scale: N.T.S.



*NOTES:

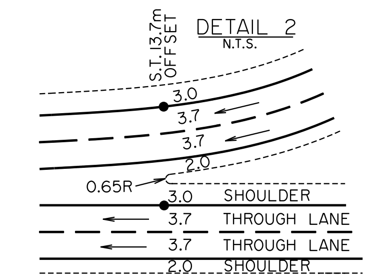
1.) MINIMUM RADIUS FOR DUAL-LANE RAMPS IS 90m.

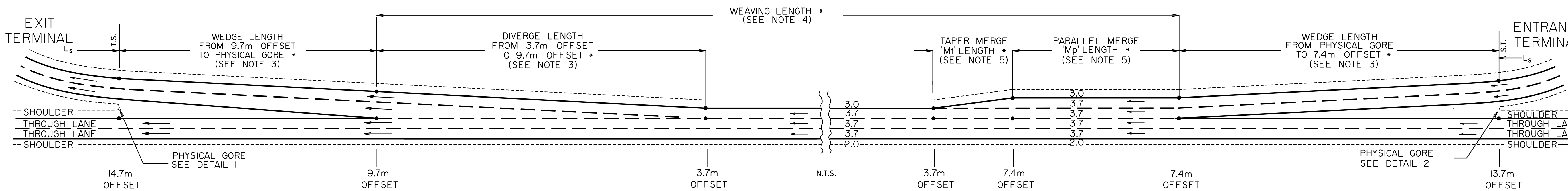
2.) TARGET SPEED IS 80% OF DESIGN SPEED AT THE PAINTED GORE (7.4m OFFSET).

3.) FOR TYPICAL PAVEMENT MARKINGS FOR INTERCHANGE RAMPS REFER TO THE HIGHWAY PAVEMENT MARKING GUIDE.

4.) MINIMUM WEAVING LENGTH IS 600m BETWEEN TWO SERVICE RAMPS AND 800m FOR SYSTEM RAMPS.

5.) DESIGN LENGTHS INDICATED FOR DUAL-LANE ENTRANCE RAMPS ARE REPRESENTATIVE. DESIGN OF DUAL-LANE ENTRANCES NORMALLY MUST CONSIDER ADJACENT RAMP SPACING AND WEAVING FLOWS.





BASIC PARAMETERS				EXIT TERMINAL FROM HIGHWAY								ENTRANCE TERMINAL TO HIGHWAY								
MAINLINE DESIGN SPEED (km/h)	RAMP CONTROLLING RADIUS * (SEE NOTE 1)			SPEED AT PHYSICAL GORE ** (km/h) (SEE INSET TABLE)	NORMAL TAPERED DECELERATION LANE PARAMETERS (GRADIENT -3% TO +3%)			TAPERED DECELERATION LANE RATIO FOR GRADIENTS > 3%				TARGET SPEED AT PAINTED GORE* (SEE NOTE 2)	NORMAL TAPERED ACCELERATION LANE PARAMETERS (GRADIENT -3% TO +3%)				TAPERED ACCELERATION LANE RATIO FOR GRADIENTS > 3%			
	TYPICAL (m)	MINIMUM (m)	LOOPS MINIMUM (m)		RATIO AND TOTAL LENGTH (m)	WEDGE LENGTH (m)	DIVERGE LENGTH (m)	-3% TO -5%	<-5%	+3% TO +5%	>+5%		TOTAL LENGTH (m)	WEDGE RATIO AND LENGTH (m)	'Mp' LENGTH (m)	'Mt' RATIO AND LENGTH (m)	-3% TO -5%	<-5%	+3% TO +5%	>+5%
90	215	90	90	72	220 @ 20:1	100	120	25:1	25:1	20:1	15:1	72	325	189 @ 30:1	62	74 @ 20:1	30:1	30:1	50:1	60:1
100	250	90	90	80	220 @ 20:1	100	120	25:1	25:1	20:1	15:1	80	375	220.5 @ 35:1	80.5	74 @ 20:1	35:1	35:1	50:1	60:1
110	340	130	90	87	275 @ 25:1	125	150	30:1	35:1	25:1	20:1	88	525	315 @ 50:1	117.5	92.5 @ 25:1	40:1	40:1	DUE TO THE LONG DISTANCES REQUIRED FOR ACCELERATION, CONSIDERATION SHOULD BE GIVEN TO REDUCING MAINLINE GRADIENT, SUCH THAT VEHICLES OBTAIN THE TARGET SPEED AT THE PAINTED GORE. (7.4m OFFSET) SEE CHAPTER D FOR TYPICAL VEHICLE PERFORMANCE CHARACTERISTICS.	
120	440	130	90	90	275 @ 25:1	125	150	30:1	35:1	25:1	20:1	96	565	315 @ 50:1	157.5	92.5 @ 25:1	50:1	40:1		
130	440	190	90	93	330 @ 30:1	150	180	35:1	40:1	30:1	25:1	104	650	315 @ 50:1	224	111 @ 30:1	50:1	40:1		

SPIRAL PARAMETERS FOR EXIT AND ENTRANCE TERMINALS BASED ON MAINLINE DESIGN SPEED AND RAMP CONTROLLING RADIUS (e=0.06)

MAINLINE DESIGN SPEED (km/h)	50 km/h R90	55 km/h R110	60 km/h R130	65 km/h R160	70 km/h R190	75 km/h R215	80 km/h R250	90 km/h R340	100 km/h R440	110 km/h R600	120 km/h R750	130 km/h R950
90	P=2.328 0=35.371 A=80 Lc=70.619 Ls=71.111	P=1.629 0=32.744 A=85 Lc=65.422 Ls=65.682	P=1.242 0=31.094 A=90 Lc=62.149 Ls=62.308	P=1.016 0=31.210 A=100 Lc=62.394 Ls=62.500	P=0.889 0=31.812 A=110 Lc=63.605 Ls=63.684	P=0.869 0=33.461 A=120 Lc=66.904 Ls=66.977	P=1.024 0=39.168 A=140 Lc=78.314 Ls=78.400	P=0.694 0=37.632 A=160 Lc=75.253 Ls=75.294	P=0.706 0=43.161 A=195 Lc=86.313 Ls=86.350	P=0.587 0=45.973 A=235 Lc=91.939 Ls=91.963	P=0.525 0=48.593 A=270 Lc=97.182 Ls=97.200	P=0.420 0=48.940 A=305 Lc=97.877 Ls=97.889
100	A=80	A=85	A=90	A=100	A=110	A=120	A=140	A=160	A=195	A=235	A=270	A=305
110	P=4.604 0=49.625 A=95 Lc=98.901 Ls=100.278	P=3.111 0=45.197 A=100 Lc=90.221 Ls=90.909	P=2.764 0=46.340 A=110 Lc=92.548 Ls=93.007	P=2.103 0=44.882 A=120 Lc=89.684 Ls=90.000	P=1.481 0=41.054 A=125 Lc=82.066 Ls=82.237	P=1.196 0=39.258 A=130 Lc=78.488 Ls=78.605	A=140	A=160	A=195	A=235	A=270	A=305
120	A=95	A=100	A=110	A=120	A=125	A=130	A=140	A=160	A=195	A=235	A=270	A=305
130	P=5.638 0=54.857 A=100 Lc=109.241 Ls=111.111	P=4.543 0=54.545 A=110 Lc=108.783 Ls=110.000	P=3.907 0=55.051 A=120 Lc=109.373 Ls=110.769	P=2.475 0=48.677 A=125 Lc=97.257 Ls=97.656	P=1.732 0=44.393 A=130 Lc=88.731 Ls=88.947	P=1.608 0=45.513 A=140 Lc=90.981 Ls=91.163	P=1.348 0=44.951 A=150 Lc=89.870 Ls=90.000	A=160	A=195	A=235	A=270	A=305

**** ASSUMED SPEED PROFILE AT EXIT TERMINALS**

MAINLINE DESIGN SPEED km/h	NORMAL TAPER RATIO	SPEED AT 3.7m OFFSET km/h	LENGTH OF TAPER AVAILABLE FOR DECELERATION (7.3m x RATIO)	SPEED AT PHYSICAL GORE (20% REDUCTION) km/h	SPIRAL	CONTROLLING RADIUS
90	20:1	90	146	72	VEHICLES ARE EXPECTED TO BRAKE COMFORTABLY ON SPIRALS PRECEEDING LOOPS.	OPERATING SPEED SHOULD BE LESS THAN DESIGN SPEED OF CONTROLLING RADIUS
100	20:1	100	146	80		
110	25:1	109	182.5	87		
120	25:1	112.5	182.5	90		
130	30:1	116	219	93		

IT IS ASSUMED THAT VEHICLES EXITING THE HIGHWAY WILL MAINTAIN THE MAINLINE OPERATING SPEED UNTIL THE POINT WHERE THE TAPERED LANE IS 3.7m WIDE. AT THE PHYSICAL GORE, IT IS ASSSUMED THAT VEHICLES HAVE SLOWED DOWN TO 80% OF THE MAINLINE SPEED. THIS DECELERATION RATE IS VERY GRADUAL AND CAN GENERALLY BE ACHIEVED BY STANDARD TRANSMISSION VEHICLES IN GEAR WITHOUT BRAKES BEING APPLIED. THE SPIRAL LENGTHS ARE DESIGNED TO ALLOW A COMFORTABLE TRANSITION TO THE CONTROLLING SPEED OF THE CIRCULAR CURVE. GENERALLY ON RAMPS WHERE THE RAMP DESIGN SPEED EXCEEDS 70 km/h, THE REDUCTION IN SPEED ON THE TRANSITION IS VERY GRADUAL AND CAN BE ACHIEVED WITHOUT BRAKING. HOWEVER, WHERE CONSTRAINTS EXIST, FOR EXAMPLE AT LOOP EXITS WITH DESIGN SPEEDS LESS THAN 70 km/h, THE DESIGN LENGTH PROVIDES FOR COMFORTABLE BRAKING. ALTHOUGH SOME BRAKING IS REQUIRED ON APPROACHES TO LOOPS, THE RATE OF DECELERATION IS GENERALLY LESS THAN HALF THAT REQUIRED ON THE APPROACH TO TURNING ROADWAYS AT CHANNELIZED INTERSECTIONS AND IS WELL WITHIN THE RANGE OF COMFORTABLE BRAKING.

No.	REVISIONS	BY	DATE

Alberta

FIGURE E-2-3-1D

Date: FEBRUARY 2022

DESIGN STANDARDS OF EXIT & ENTRANCE TERMINALS FOR DIVIDED HIGHWAYS - DUAL LANE

Prepared By: F.S.	Checked By: L.M.	Scale: N.T.S.

E.2.4 Ramp Junctions

Ramp junctions connect the freeway entrance and exit ramps with the crossroad. The design and layout of these terminals should be suitable for the traffic as well as being consistent with previous Alberta practice for this type of junction. The layout should be suitable for the turning movement of all appropriate design vehicles.

Designers should be aware that interchanges should generally be designed for all design vehicles up to and including the largest Long Combination Vehicles (LCV). The only exceptions may be the Alberta Log Haul Truck and the high/wide load vehicles if the interchange does not allow the vehicles (currently and in the future). As interchanges are generally built on divided highways which generally permit Long Combination Vehicles, it is a good design practice to design for LVCs even if they are not currently permitted. This is due to the ongoing trend to permit LCVs on a larger proportion of Alberta's highway network.

REFERENCE

[1] American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Roadways and streets, Washington, D.C., 2018.

[2] Transportation Association of Canada, Geometric Design Guide for Canadian Roads, Ottawa, 2017.

[3] ITE, Freeway and Interchange Geometric Design Handbook, Washington, DC, 2006.

[4] Alberta Transportation, "Design Exceptions Guideline," [Online]. Available: https://www.alberta.ca/design-exceptions.aspx.

[5] Alberta Transportation, Highway Guide and Information Sign Manual, Edmonton: Government of Alberta, 2006.

[6] Alberta Transportation, "Bridge Conceptual Design Guidelines," [Online]. Available: https://open.alberta.ca/publications/bridge-conceptual-design-guidelines-version-3-0.