1 INTERCHANGE COMPONENTS

Despite their often complex appearance, interchanges comprise only four basic components, these being:

- the through road
- the crossing road
- the structure(s) separating these two roads, and
- the ramps providing trafficable connections between them.

The two roads are dealt with in the ordinary way for design, and they may even be existing roads with a grade separation, to which the interchange ramps are added.

To the geometric planner, the principal concern regarding the structure would be the thickness of the deck, although in special cases the location and size of the piers and possible haunching of the supporting elements may be important. The geometric planner must liaise with the structural engineer in this regard once he establishes a preliminary layout for the road crossing. Generally, a vertical clearance of at least 5,1 m would be required at the critical tie point. Note that vehicles may also traverse the shoulder, so the determination of tie-points must include consideration of the shoulders.

It may be found, when one tries to add the ramps to the two crossing roads (whether these exist on the ground or only “on paper”), that the alignment of the two roads is not suitable for the grading of the ramps, say, or does not allow a suitable horizontal alignment to be fitted in for the ramp. The two roads then require adjustment, and the whole design exercise is usually an iterative process. The design of each component is generally just the normal procedure of designing a road alignment or junction, albeit with several constraints regarding clearance widths and heights, and fitting in an alignment of acceptable standards in a confined space. These notes concentrate further on factors that affect ramp design.

Each ramp can be subdivided into two sub-components viz

- the terminals, which are its connections to the through- and the crossroad
- the mid-section

As discussed in the lecture on Interchange layout, it is prudent to develop the configuration of each ramp separately, considering the traffic service it must provide, the traffic volume it must cater for, and the nature of the terrain and the available space. When the layout of all ramps has been developed in this way, they may all be put together as a whole interchange, of whatever type may result.

2 TERMINALS

There are three forms of terminal that may be required. These are:

- the free-flowing terminal used as the connection between the ramp and a freeway, (as illustrated in Figures I3.1 and I3.2 at the end).
- the stop-condition terminal which serves as the connection to a crossing road that has at-grade intersections elsewhere along its length, e.g. an urban arterial,
- the major fork and merge, both of which are free-flowing but differ from the free-flowing ramp terminal in that the latter attaches an inferior status to the ramp, where-as all the legs at a major fork or merge may be viewed as full freeway sections, not ramps, calling for a different set of limitations and design approach.

2.1 Free-flowing terminals

The free-flowing terminal is intended to accommodate merging or diverging manoeuvres involving high operating speeds and small differences in speed between vehicles. These are thus executed at speeds matching uninterrupted flow conditions and involve flat angles of merging with or diverging from traffic on the through lanes, typically 1:15 in the case of freeway off-ramp terminals and 1:50 for freeway on-ramp terminals. The relatively sharper taper for an off-ramp assists in giving target value to the exit, provided that the edge-line has a kink and is not rounded. The flatter taper of an on-ramp helps to make the relative speed between vehicles as low as possible and improves the view (in the rear-view mirror) of the traffic in the outer lane of the freeway. Furthermore, the greater length of taper eases the task of finding an acceptable gap in the outer-lane traffic of the freeway.

Alternative Ramp Terminal Layouts: Whether on- or off-, the ramp terminal may comprise either a simple taper or a combination of taper and a section of auxiliary lane parallel to the through lanes. The latter layout forces a reverse curve line of travel on vehicles and is thus not universally favoured.

The freeway exit or entry manoeuvres should be executed at freeway speeds. If, for any reason, ramp speeds are required to become substantially lower than freeway speeds somewhere close to the freeway terminal, it would be necessary to provide sufficient length of ramp for the necessary speed-change, to better match the ramp and the freeway speeds. This may sometimes have to be done using a parallel auxiliary lane, resulting in the selection of a terminal with a combined taper and auxiliary lane. Considering the case where the freeway passes over the crossing road, the on-ramp will probably have a positive gradient. If the freeway also has a positive gradient, the ramp gradient may become substantial, and require a considerable distance to achieve the freeway operating speed from a near stop-condition at the crossroad. A logical location for any required additional length of ramp might possibly be on an auxiliary lane at the merging area. In the case of an off-ramp, a steep negative gradient or a tight radius curve would require the addition of an auxiliary length of ramp to provide an opportunity for decelerating to below freeway speeds in relative safety. Depending on the available space, this might be added to the ramp after it has diverged from the freeway, or it might be an auxiliary lane length alongside the freeway.

The use of such an auxiliary lane is a way of providing additional ramp length with minimum costs for both land acquisition and construction. It is not widely used in South Africa, and in the quest for maintaining uniformity and meeting driver expectations, the auxiliary lane combined with a merging taper is typically reserved for freeway-to-freeway junctions.

Nose and Gore Area: Figures I3.1 and I3.2 show some details of the straight taper layouts. The ramp “nose” is commonly defined, (somewhat arbitrarily), as the point at which, after the ramp and freeway have diverged from each other, there is a separation of exactly two metres between their adjacent shoulder edge-lines. The same applies on the section before the merging area of an on-ramp. The area between the two diverging shoulder lines is referred to as the “gore”. In the case of an off-ramp, the gore is the location of the last sign in the sequence of exit signs, confirming the exit number and having a chevron plus a horizontal “exit” arrow to draw attention to the exit.

The layout and marking of a free-flowing ramp terminal is intended to provide the driver with a clear signal regarding the commencement of the ramp. If the start of the taper is a smooth curve, the driver could, particularly under conditions of poor visibility or at night, be misled into believing that the continuous line actually demarcated the outside edge of the freeway lane. This belief is shattered when the nose (or perhaps the cross-road stop line) looms up out of the mist. Surprise! The consequent reaction, particularly when executed on a wet pavement, might take the vehicle across the nose and through the road sign or back into the freeway traffic in a semi-broadside attitude. A deliberately introduced discontinuity, i.e. a kink, should make it clear that this edge line is not that of the freeway. (For additional clarity, the outer edge of the freeway is normally marked through the ramp terminal by a wide broken white line, a “continuity line”).

The nose, and the gore beyond it, are the major indicators of the commencement of the ramp. They must be highly visible. In previous years, the nose was demarcated by raised kerbing. The kerbing brought new meaning to the words "target value", and because of the hazard of such kerbs in the gore area, painted markings are now used exclusively. Decision sight distance to the exit nose is a requirement.

2.2 Stop-condition terminals

These terminals are used when a ramp joins a crossing road which is not a freeway, although in the case of heavily trafficked major arterials, some form of free-flowing treatment (slip-lane) may be called for. These terminals are designed basically as ordinary intersections with one or two special conditions because the number of turning movements is generally limited.

Because of urban speed restrictions and also because of the design of the ramp itself, vehicle speeds at these terminals are low. Because of the stop condition, the relative speeds of the vehicles on the different approaches to such terminals are high. These terminals should thus intersect with the crossing road at angles of the order of $90^{0,}$ and be designed as conventional intersections. However, certain features of the crossroad ramp terminal distinguish it from a conventional intersection.

The crossroad may be one-way or two-way and ramps are typically one-way (the adjacent ramp terminals of a Par-Clo being the exception). The terminal of an individual ramp is thus a special case of a three-legged intersection. It is desirable, from an operational point of view, to reduce the number of intersections on the arterial road, and therefore to group stop-condition ramp terminals together. In the case of a diamond interchange, the off- and succeeding on-ramp terminals are placed opposite each other, creating a special form of four-legged intersection, with three approaches. The ramps form a one-way "crossing" at the crossroad, but virtually every one of the vehicles on the off-ramp turns left or right at the cross-road and almost no vehicles cross straight over.

In reality, there is little need to accommodate a movement straight over the crossing road (coming from the freeway and straight back onto the freeway). The need could arise for three acceptable reasons, and should preferably be made possible:

- an abnormal load of excessive height that has to be diverted around a structure where the freeway passes under the crossing road
- the freeway being temporarily closed for maintenance work on the structure or by someone electing to drive into someone else or a bridge pier
- a driver being momentarily confused rather than totally lost and simultaneously aware of a quick way of reinstating his travel path along the freeway.

Due to the one-way nature of ramp traffic, the number of turn-paths and possible conflicts is less than at an ordinary crossing, simplifying design somewhat. However, the consequences of a wrong-way movement such as up an off-ramp and onto the freeway, are very probably fatal, and every possible step must be taken to prevent that. A reasonably standard approach to eliminate an incorrect right turn is to provide a median island on the crossing road, even if only in the vicinity of the interchange area, with the median opening designed so that the right turn is difficult, if not actually impossible to perform. The incorrect left turn is more difficult to design out. An intersection angle of greater than 90^0 and the relatively narrow width of the ramp can allow the left turn to be made very awkward, thus alerting the driver.

A fairly recent form of the diamond interchange, the "Single Point Diamond Interchange" has all conflicting movements of the four ramps meeting on the crossroad in one large intersection. The left turns at the ramp terminals are dealt with by slip lanes which separate these movements from the central intersection. The central intersection then deals only with right turns and with the straight-through traffic on the arterial. This normally has signal control which is said to operate very efficiently. The construction tends to be very costly, but there are likely savings in the area of land required.

2.3 Major forks and merges

The high-speed terminals described above attach an obviously inferior status to the ramp, compared to the freeway they serve. To satisfy driver expectations, they are always located adjacent to the outside lane of the freeway. The situation can however arise when the status of the merging or diverging carriageways is equal. Cases in point are where two freeways from outlying areas merge to share a common reserve on approaching the core area of a city, or where directional ramps split to become two ramps, one serving the left turn and the other the right.

These movements are accommodated by major forks and merges. Seeing that the legs involved are of equal status, the stricture regarding the use of the outer freeway lane does not apply. Furthermore, and for the same reason, deliberate discontinuity of the edge marking to signal a reduction in status from freeway to a ramp, is not appropriate.

2.4 Geometry of Free-Flow Terminals

Two key aspects of the placing and design of free-flow ramp terminals are considered here. These are the spacing of successive terminals and the taper rates employed. (As already indicated, stop-condition ramp terminals are designed as conventional intersections).

2.4.1 Terminal spacing

The spacing of successive terminals must be such that the operation of one terminal does not affect that of the adjacent terminal. An entrance terminal shortly before an exit can effectively be blocked to the entering vehicles by a large number of vehicles trying to exit at the next terminal. An exit followed by another exit does not present any such problem because there are no entering vehicles there, but it is very necessary for drivers to be able to differentiate clearly between the destinations served by the two adjacent exits. Space should be allowed for an adequate sign sequence. Generally an urban freeway distance of 300 m should be viewed as the minimum for this purpose. This distance could be reduced to 240 metres if the successive terminals are on a collector-distributor road.

2.4.2 Terminal Layout

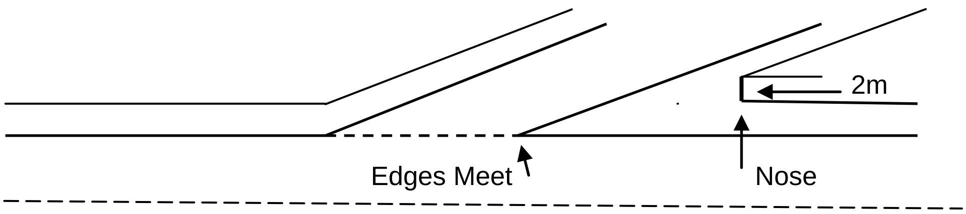
Free-flowing terminals can be either parallel or taper. The latter is a simple constant taper and the former is a taper in combination with a short length of auxiliary lane. The lengths of parallel auxiliary lanes may relate to speed-change requirements and could be as much as 600 m or so. (The distance of 600 m corresponds to a typical travel time of about 20 seconds which is double the reaction time required for complex decisions).

<u>Taper Terminals:</u> Different criteria apply to the taper rate for an off-ramp or an on-ramp.
The <u>off-ramp</u> must depart at a sufficiently sharp angle for it to be very clear to the driver that a

discontinuity has presented itself. At the same time, the driver must be able to negotiate the change of direction at the operating speed of the freeway. A cross-fall of 2 % across the width of the carriageway and across the taper as well, would correspond to the super-elevation required for a curve of radius 280 m at a speed of 100 km/h. A vehicle can be contained within the width of the travelled way available to it while negotiating a curve of this radius if the taper rate is in the region of 1:15. Lower speeds will permit sharper tapers.

At an entrance, the prime criteria are the driver's need to find a gap in the traffic in the outside freeway lane, and also the mechanics of visibility of approaching vehicles in the rear-view mirror. It has been found that a taper rate of about 1:50 provides an adequate convergence length and is also effective in terms of rear-view visibility for typical freeway speeds.

Over the length of the actual taper (from the start of taper to the point where the full ramp width is attained), the ramp terminal and the freeway through-lanes are designed with a constant cross-fall across their full width, right across to the ramp outside shoulder. The point at which the full ramp width is attained is referred to as where "edges meet". The taper continues further at a constant rate (1:15 or 1:50) up to the nose which, according to a typical standard design, is where the taper is wide enough for the ramp plus both shoulders in the gore, plus two metres. (see Figures I3.1 and I3.2). From this nose position it is permitted for the ramp to curve away from the fixed line of the taper off the freeway. From "edges meet", a change in crossfall of the ramp may be introduced gradually by means of a slope change along the lane edges. This would form a "cross-over crownline" which is similar to the crown along the middle of a cambered road, where the crossfall changes by 4% from 2% one way to the 2% in the opposite direction.



3 RAMP MID-SECTIONS

Ramp terminals signal an immediate transition from the freeway or the crossing road to a changed circumstance. The ramp mid-section offers the driver time to adapt from one operating environment to another. The uninterrupted long distance and high speed of the freeway desensitises the driver to speed, to an extent whereby travel at 60 km/h may seem to be only marginally faster than getting out and walking. Conversely, the driver on the crossing road needs a little encouragement to adopt the higher speed of the freeway.

The length of the mid-section depends on various factors such as gradient and curvature and including the extent of speed change required on the ramp. The off-ramp requires deceleration across the range from freeway speed to crossroad operating speed including possibly allowing for a stop at the crossing road. It is presumed that this deceleration will commence only after the nose has been passed. The on-ramp must allow for acceleration at a rate of say 1 m/s^2 to achieve freeway speed at the merging end. This rate is predicated on a level grade. Positive gradients will force a lower rate of acceleration and negative gradients allow a higher rate with corresponding change in the required length.

If the entrance taper is considered as accommodating a portion of the acceleration stage of the vehicle's trajectory, the driver is forced to divide his attention more than is desirable (between attaining speed and gap-finding). Mention has already been made of the driver as a single-stream data processing system. The merge requires that the vehicle must be located relative to a gap in the traffic stream and at a speed close to or preferably greater than that of the vehicle defining the end of the gap. In addition, the driver must ensure that he is not closing on the leading vehicle, while simultaneously slotting in ahead of the trailing vehicle. If these judgements have to be made while still at a speed substantially lower than general freeway speeds, the ability of the vehicle to achieve that speed before running out of taper (which arises some 150 metres before the yellow-line break point) is a further factor that the driver has to take into account. This complication is unnecessary and unsafe, and is readily eliminated by correct mid-section design.

3.1 Ramp mid-section geometry

3.1.1 Design speed

Design speed as applied to ramp mid-sections will vary along the length of the ramp, ranging between that of the freeway and that at the crossing road. For a simple, reasonably directional ramp such as in a diamond interchange, the variation can be a roughly uniform reduction or increase depending on whether the ramp destination is the crossing road or the freeway. Where the crossing road is also a freeway, the design speed of the ramp should theoretically be that of the adjacent freeways. In practice, spatial restrictions will make some reduction necessary, but this reduction should not be more than 20 % of the freeway design speed.

Ramps serving right turns may do so by means of a 270^0 change of direction (i.e. loops). To achieve this at freeway speeds would demand a king's ransom in terms of land acquisition. Think of a cloverleaf interchange with a reserve width measuring 2 km by 2 km!

In general, a design speed of 40 km/h is adequate for loops because the advantages of a higher design speed will generally be nullified by the additional travel distance involved. (Some clients specify 45 km/h). As the free-flow terminal must operate at freeway speeds, the mid-section between the taper and the minimum loop radius may require a compound-curve approach.

When high volumes of right-turning traffic are expected, a directional ramp layout may be employed. Free-flowing terminals at either end of the ramp will operate at close to freeway speeds so that a low design speed on the ramp mid-section will have a restrictive effect on the performance of the ramp. This effect should be reduced as far as possible, if not totally eliminated. Recommended design speeds for semi-directional or directional ramps are thus not very much less than the through-road speeds, as shown in Table I3.1 below.

Outer connectors for left turns, such as on cloverleaf interchanges, should also be designed for the speeds suggested in the table.

Diamond ramps and Par-Clo ramps usually have a free-flowing terminal at one end and a stop-condition terminal at the other. The free-flowing terminal and adjacent section of ramp should have a design speed equivalent to the operating speed of the through road. From the nose area it may be reduced progressively according to the distance from the nose, and the gradient. If the ramp is unusually long for any other reason, the speed should not be reduced below 80 km/h until approaching the crossroad, where the design speed may be reduced to 40 km/h at the stop-condition terminal. Par-Clo ramps would typically have a minimum radius appropriate to a design speed of 40 km/h.

Table I3.1: DESIGN SPEED OF SEMI-DIRECTIONAL OR DIRECTIONAL RAMPS

Through Road (km/h)	Ramp (km/h)
60	60
80	70
100	80
120	90

3.1.2 Decision sight distance

Under certain circumstances, it is necessary for the driver to be able to see the actual road surface for a given distance ahead. The required sight distance is then measured from the standard eye height of 1,05 m to an object height of zero, i.e. on the road surface. The sight distance must be sufficient to see the road markings and then make the corresponding decisions about vehicle path or speed change and is referred to as decision sight distance. In the case of free-flowing terminals it is necessary for the driver to be able to distinguish the road markings of the painted nose sufficiently far in advance to be able to react appropriately. Although ramps usually have a single lane, the stop-condition terminal invariably has more than one lane in order to accommodate the two turning movements involved. There, it may again be necessary for the driver to be able to see the road markings in good time, if there is an unusual layout.

Table I3.2: DECISION SIGHT DISTANCE ON LEVEL TANGENTS (metres)		
Design Speed (km/h)	To Off-Ramp Noses	To a Lane shift
40	N/A	85
60	200	100
80	250	150
100	350	200
120	400	250

3.2 Horizontal curvature on ramps

The minimum radii of curvature given in the table below are calculated from maximum rates of superelevation and the maximum allowable side friction appropriate to the design speed selected. They are the same as those quoted for curves on other sections of road as well because the fact of the curve being on a ramp does modify the dynamics, nor the calculation.

Table I3.3: MINIMUM RADII OF HORIZONTAL CURVATURE ON RAMPS	
Design Speed (km/h)	Radius (m)
40	50
60	110
80	210
100	350
120	530

3.3 Superelevation development

Where a circular curve is tangential to a straight, without transition, there is no theoretical formula to determine the length of superelevation runoff. Rates of superelevation development have been established in practice, relating mainly to driver comfort and to appearance. The runoff length and rate of development is also dependent on the width of road concerned. The rate of superelevation development may be expressed as the relative slope between the fixed line/grade-line (often the centreline) and the road edge concerned, or it may be expressed as the rate of change of cross-fall per unit distance along the ramp. An example of the former is a relative slope between the fixed line and the rotating edge of 1:200 or 0,5%. This means that the figure of 1:200 (relative slope factor) should not be exceeded for the given two-lane road. The alternative way to describe it is to talk of a rate of change of superelevation (e.g. 0,1% per metre).

A formula in common use for the runoff length on a single carriageway road is

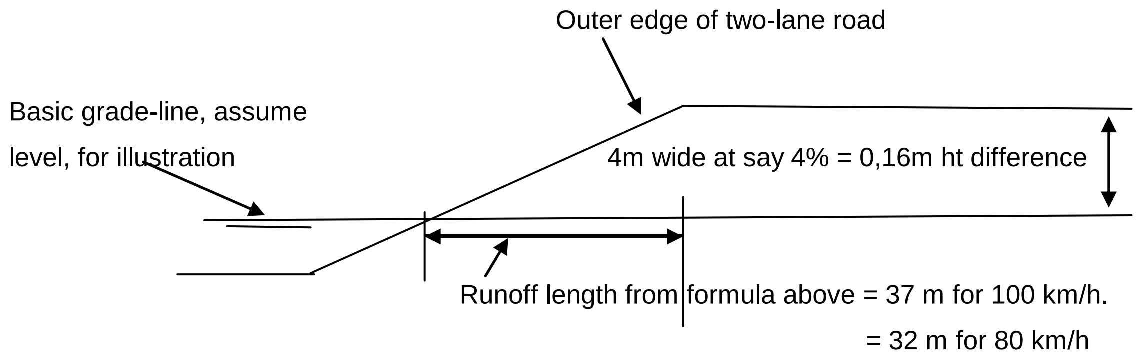
$$L = E.w.s \text{ (metres)}$$

Where E= superelevation rate (m/m), w = lane width in m, and s = relative slope factor.

Suggested values for s :

S = Relative Slope Factor	
60 km/h	170
80 km/h	200
100 km/h	230
120 km/h	260

<u>To illustrate:</u>



Where the height of the outer edge changes relative to the centreline by 0,16 m over the indicated length of 32 m, and the grade-line is level (0%), then the gradient of the outer edge over the development length is <u>0,16 over 32 m</u> which is 100 x (0,16 /32) = 0,5% which is the relative gradient between edge and c/l. This is the 0,5% required above.

Alternatively, the crossfall at the start of superelevation is 0%, and the crossfall at the end is 4% or a change of 0,04 m/m. The rate of change is thus .04 in 32 m, and this rate of change is 100 x (0,04/32) i.e. 0,125% per metre.

The same formula may be applied to a ramp, which is typically a single lane of 4m width. Interchanges must often be designed in the smallest possible space, and there may be little room for the desired length to develop superelevation. The rate of development may be increased slightly, (up to 20%) over that applicable to a two-lane road, and there will also probably be a need to start the runoff as close as possible to the nose area. As discussed above under Terminal Geometry, this may be done from the point where “edges meet”, using the cross-over crown-line principle which creates a kink in the cross fall along the edge line of the ramp or freeway.

3.4 Vertical alignment

The derivation of the vertical alignment is generally based on the individual grading of each ramp edge rather than defining a single gradeline and a rotation about it. In this way, the superelevation and its development becomes an integral part of the vertical alignment.

Gradients steeper than those specified for other roads may have to be accepted on ramps, on the basis that the affected travel distances are short. Also, steep up-gradients on off-ramps and steep down-gradients for on-ramps can be advantageous in terms of the reduction in distance required for speed changes. This is yet another example of the interaction between the horizontal and vertical alignment.
Vertical curvature is based on sight distance. The normal object-in-the-road model does not always apply because much of the information that is to be conveyed to the driver is transmitted by way of road markings, requiring a zero object-height. Where it is necessary to be able to see the road surface, the values of decision sight distance quoted above should be used.

Very often, the determination of the vertical alignment by defining gradients and linking them with parabolic curves is not practical. Recourse can then be had to graphical grading using splines or ship curves (and heavy vertical scale distortion) if working on paper, or by drawing smooth curves on the screen. Lines are developed in this way, for both edges, generating the required superelevation with the proper lengths for runoff. This is always a trial-and-error iterative process which allows the development of aesthetically pleasing and smoothly flowing edge lines that meet all the technical requirements. Before finishing, it is essential for the profiles to be checked against standard vertical curves, particularly to ensure adequate sight distance.

3.5 Ramp cross-section

Access ramps are generally single lanes. Directional ramps can be long however, with a correspondingly high probability of vehicles being forced into platoons on the ramp. Two-lane operation then becomes necessary.

At the crossroad ramp terminal, the cross-section is designed as for an at-grade intersection, frequently with multiple lanes. Everything possible must be done to prevent the development of queues which back up to the freeway, which can create a very hazardous situation - some catastrophic multi-fatality collisions have been attributed to stationary queues in the outside freeway lanes.

In the mid-section of the ramp, the need to pass stalled vehicles becomes a consideration, and on long directional ramps, the need to pass slow or stalled vehicles likewise. Insufficient space will cause the generation of a queue, causing irritation, frustration and probably leading to dangerous overtaking attempts. A queue backing up into the freeway because of a stalled vehicle is more dangerous than one at an exit which is regularly overloaded because of the unexpected nature of the event. Lane widths are thus selected to allow for passing of a stalled vehicle. A typical cross-section is a four-metre lane with shoulders of two metres width on either side. Two-lane cross-sections use lane and shoulder widths matching those of the freeway, with allowance for curve widening if radii are very short.

4 RAMP TYPES

It is convenient to name ramp types according to the interchange configurations in which they typically occur. Thus we find…….

4.1 Diamond ramp

The diamond ramp has a free-flowing terminal at its freeway end and an at-grade intersection or stop-condition terminal at the far end. The at-grade intersection allows for turns both to right and to left and, in urban areas, is frequently signalised.

The crossroad ramp terminal is often located fairly close to the structure carrying the crossing road over (or under) the freeway. As a result, careful consideration of intersection sight distance is called for. There could be a crest curve on the structure inhibiting sight distance and a frequent cause of loss of sight distance is the bridge balustrade obstructing the sight triangle. In the case of the urban interchange (the Single-Point variation of the diamond) the crossing road ramp terminals are brought together over the structure. This has the dual effect of reducing sight distance problems and, more importantly, the cost of land acquisition which, to the road authority, is a telling argument in its favour. (If the intersection is below the structure, the sight distance may be very awkward).

The crossing road ramp terminal could also be located remote from the structure, i.e. beyond the end of the approach fills. This configuration requires substantially more land acquisition than is the case with a narrow diamond, and may have an impact on travel distances, depending on the relative volumes of left- and right-turning traffic. This layout can also allow for the ultimate addition of loops to facilitate right turns by allowing them to happen by way of left turns off the arterial when traffic build-up warrants the upgrading of the diamond. In the past, the wide diamond was even seen as a stage in the ultimate development of a cloverleaf. This practice has largely fallen away, but loops are certainly still being added to some existing wide diamonds to ease right-turn congestion.

4.2 The Par-Clo Loop Ramp

Par-Clo is verbal shorthand for Partial Cloverleaf. In its original form, the Par-Clo loop ramp was a loop with free-flowing terminals at either end and was intended to serve right turning traffic by means of a 270^0 change of direction. It is now generally reduced to a 180^0 change on the ramp and 90^0 either way, left or right, at its intersection with the crossing road. It will have stop or signal control at the intersection with the crossroad.

The Par-Clo loop ramp may be compared in operation to a diamond ramp, noting that its stop-condition terminal is on the far side of the crossing road. Benefits available from this alternative are that

- ❑ topographic or developmental restraints in a particular quadrant of the main-road crossing can be avoided without too severe a penalty in terms of bridge widening

- ❑ right and left turns to the crossing road are transposed, so that the heavier turning volumes may be converted to left turns instead of right turns.
- ❑ the crossroad ramp terminals are remote from the structure

4.3 Directional ramps

The directional ramp is to serve right turning traffic and has free-flowing terminals at either end. This type of ramp typically encountered on a systems interchange and is designed for high speeds as well as high volumes.

The design standards applied to directional ramps are virtually of the order of those applying to the freeway. In addition, they also require their own structures to separate them from the through- and cross-roads, and they are the most expensive of the various ramp types to construct.

4.4 Outer connectors

These are equivalent to directional ramps in terms of the general appearance of their horizontal alignments except that they serve the left turn. They have high speed terminals at each end, nd do not require separating structures as they do not cross the main roads.

4.5 C-D Roads

Collector-distributor roads came about when weaving between loops of a cloverleaf became a problem. The loop serving traffic turning right from the cross-road enters the freeway immediately upstream of the loop serving the right turn from the freeway. These two streams have to weave within a very short distance, typically just under the structure. With the weave occurring on the freeway, the freeway effectively loses it outer through-traffic lane for some distance upstream of the interchange, as vehicles seek to avoid the maelstrom in that outer lane. The idea of the C-D road is that the weaving manoeuvre is removed from the freeway and allowed to take place on the parallel C-D facility.

This C-D Road is linked to the outer connectors, with a terminal design according to the requirements for a major merge or fork.

Historically, the C-D road was the first example of treating drivers to sequential decision making in navigating their way around a freeway system.

4.6 The quarter link

The quarter-link is a type of ramp used at an interchange between two arterial roads, and specifically does not occur in any interchange with a freeway. It is typically a two-way road with conventional intersections as terminals at each arterial road. There may be priority or signal control at each terminal. It finds application where it is not possible, by virtue of height restraints, to locate the intersection at the point where two routes cross, and more particularly where traffic volumes demand a grade separation between the two crossing arterials.

Figure I3.1: Single-lane entrance

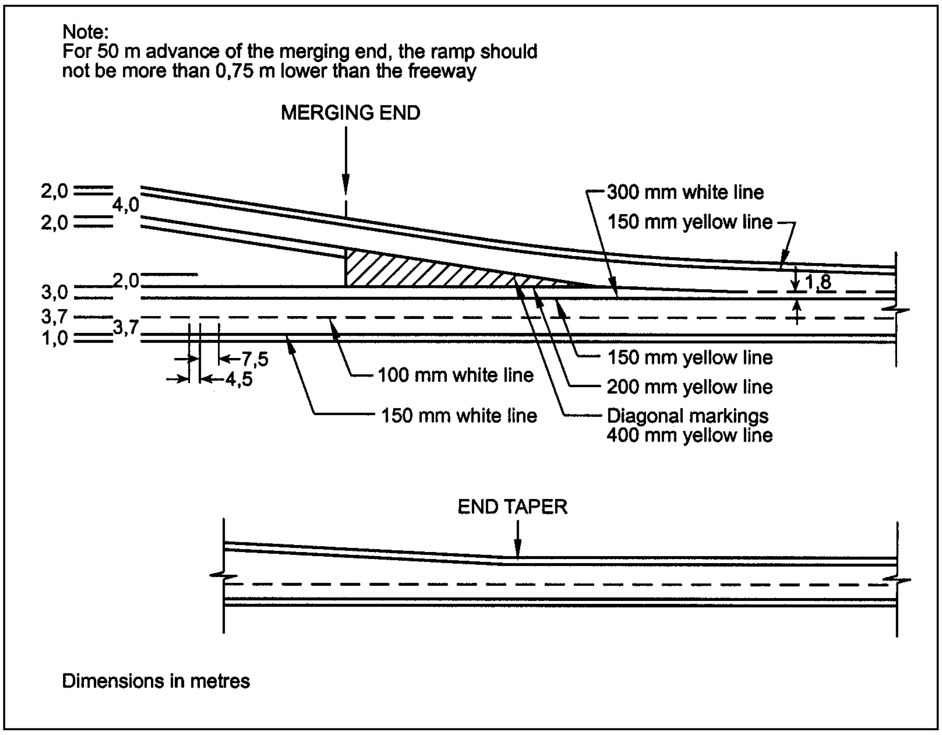


Figure I3.2 Signal-lane exit