UTG 7 (Draft)

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Komitee van Stedelike Vervoerowerhede

Committee of Urban Transport Authorities

Draft UTG 7

GEOMETRIC DESIGN OF URBAN LOCAL RESIDENTIAL STREETS

1989

URBAN TRANSPORT GUIDELINES

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PREFACE

URBAN TRANSPORT GUIDELINES (UTG) is a series of documents written for practicing transportation engioneers which describes current recommended practice with regard to selected aspects of urban transportation. They are based on South African experience and research and enjoy the full support and approval of the Committee of Urban Transport Authorities.

To confirm their validity in practice, UTGs are circulated in draft form for a two-year period before receiving the final approval of CUTA. During this period, suggestions for improvement may be sent to:

The Secretary
Committee of Urban Transport Authorities
PO Box 395
PRETORIA 0001

After final approval by CUTA, the revised document will be issued as a full UTG in both official languages.

SYNOPSIS

This document deals with the geometric design of urban local residential streets. It forms part of a series on freeways, arterials, collectors and local streets.

Aspects covered in the document relate to basic design concepts and criteria. From these, guidelines in respect of horizontal and vertical alignment and cross-sections are derived. The location and design of intersections and driveways, turning spaces and parking are also discussed.

SINOPSIS

Hierdie dokument handel oor die geometriese ontwerp van plaaslike strate in stedelike woongebiede. Dit maak deel uit van 'n reeks oor deurpaale, hoofverkeersare, versamelaars en plaaslike strate.

Die aspekte wat in hierdie dokument behandel word hou verband met basiese ontwerpkonsepte en-kriteria. Hieruit word riglyne met betrekking tot horisontale en vertikale belyning en dwarssneë afgelei. Die liggingsbepaling en ontwerp van padkruisings en opritte, draai- en parkeerplekke word ook behandel.

KEYWORDS

Geometric design, urban local residential streets, horizontal alignment, vertical alignment, cross-section, intersections, driveways, turning spaces, parking.

ACKNOWLEDGEMENTS

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1 INTRODUCTION

1.1 PURPOSE OF THE GUIDELINES

The Committee of Urban Transport Authorities (CUTA) was formed in 1982 to provide a forum for discussion in order to promote coordination and, where appropriate, uniformity on technical standards for, and approaches to, the road and transport systems of urban areas in South Africa. The various agencies responsible for the design of urban roads have been concerned for some time about the wide range of geometric design standards and policies relating to the design of urban roads, not only between, but even within the various metropolitan areas.

At the first meeting of CUTA in August 1982, it was decided to establish an Ad Hoc Technical Committee on Geometrics (AHTG). This committee decided to produce guidelines for the geometric design of urban roads with the following objectives:

(1) To promote a uniform approach to the adoption of geometric design standards for urban roads.

(2) To recommend dimensions for geometric design elements with the aim of providing adequate standards of safety and convenience on urban roads under South African conditions.

(3) As restricted space often prevents the provision of geometric design elements to ideal dimensions when upgrading or constructing new roads within built-up urban areas, guidelines should be provided for the adoption of reduced dimensions which would, under the prevailing circumstances, still provide reasonable levels of safety and convenience within economic, environmental, social and political constraints under South African conditions.

For easy reference, a separate guidelines document will be produced for each class of urban road. The first document on arterial roads was published in 1986, Ref. 1, the second document on collector roads in 1987, Ref. 2.

This, the third document, gives guidelines on local residential streets. It must be stressed that the guidelines contained in this document are relevant only to residential streets and as such should not be used when considering the design of commercial and industrial streets. The layout requirements and design criteria for commercial and industrial townships are significantly different to those of residential townships and will therefore be the subject of a separate guidelines document.

1.2 USE OF THE GUIDELINES

The purpose of these guidelines is to strike a balance between housing, planning, public utility, highway and user interests and to avoid preconceived design solutions.

The relationship between drivers and pedestrians is not constant. On a freeway the *driver has absolute priority, whereas in a residential cul-de-sac pedestrians and cyclists are more important and the form of the road should reflect this. A journey has three parts : departure, travelling and arrival. It is only at the travelling stage that speed is a major consideration and where vehicles should have precedence. On the roads where we live and where our journeys begin and end the pedestrian and the cyclist should be allowed precedence. To achieve this, roads must be divided into two distinct types : those which lead to places and those which are places. It should be remembered that the primary function of local streets is to provide access to property.*

These guidelines are intended to complement design expertise and as such should not be used primarily as a specification of design standards but rather as a basis for the preparation of such specifications. The application of these guidelines in imaginative and innovative ways will, it is hoped, result in improved ways of designing, locating and coordinating the layout of residential townships.

The principles set forth in these guidelines apply equally to private developments and public townships.

1.3 DESIGN REFERENCE

The guidelines have been deliberately kept brief so that information can be readily found by the experienced designer. They therefore do not provide an exhaustive record of the information that the designer needs. It is important that the guidelines be supplemented by other standard texts. In this regard the following texts are recommended as suitable references for the design of local streets in residential areas:

DEPARTMENT OF COMMUNITY DEVELOPMENT. *Guidelines for the Provision of Engineering Services for Residential Townships.* Government Printer, Pretoria, 1983.

DEPARTMENT OF THE ENVIRONMENT, DEPARTMENT OF TRANSPORT. *Residential roads and footpaths layout considerations.* Design Bulletin 32. HMSO, 1979.

MCCLUSKEY, JIM. *Road Form and Townscape,* (First Edition). The Architectural Press, London, 1979.

SOUTH AFRICAN INSTITUTION OF CIVIL ENGINEERS. *Guidelines on the Planning and Design of Township Roads and Stormwater Drainage.* 2nd edition, Johannesburg, August 1981.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS. *A Policy on Geometric Design of Highways and Streets.* Washington DC, 1984. This is an updated combination of:

(i) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. *A Policy on Geometric Design of Rural Highways.* Washington DC, 1965 and

(ii) AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS. *A Policy on Design of Urban Highways and Arterial Streets,* Washington DC, 1973.

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH. *The South African Road Traffic Signs Manual.* 2nd edition, CSIR Manual K55, Pretoria, CSIR, 1982.

The reader is reminded that individual local authorities and other road authorities or owners may have their own standards and/or specific requirements.

1.4 ASSOCIATED DESIGN FEATURES

Geometric features of road design are highly dependent on other road features, such as drainage, lighting, location of utilities, surface treatment, signing, safety barriers and traffic control devices, all of which, if properly combined will lead to the safe design of roads effectively integrated in the urban environment. The references at the end of this document are recommended in this regard along with other documents which are being developed by other CUTA committees.

2 DESIGN CONCEPT

2.1 CO-ORDINATION OF PLANNING AND ENGINEERING FUNCTIONS

One of the most significant problems that has been identified with respect to township planning and layout design is that engineering services may cost more than necessary when the special layout needs of each service are not co-ordinated in the overall layout from the beginning. Good design must be based on an approach which covers the entire design of the township as a single entity.

It is, therefore, recommended that the planning and layout of new townships be approached on a co-ordinated basis with simultaneous input for all aspects of design. The various professional disciplines must be brought together at an early stage to determine the development needs, the planning parameters and the objectives for the development in question.

The planning team will need to compromise on requirements for the various services, as no layout can possibly satisfy all the requirements for each township service. Roads are the largest capital items but a road layout which does not take into account other services may make these services and/or houses unnecessarily expensive.

Bearing in mind that the layout of townships has traditionally been the responsibility of town planners, it is essential that in order to obtain cost-efficient services in future, engineers and planners should work in close collaboration and mutual understanding from the outset of the planning process. They should also continue to liaise with and consult each other during the period when layouts are being developed. It is suggested that a common "development target" relating to township layout will assist in establishing the necessary common ground between the various engineers, planners, surveyors and other professionals.

A great deal of background information peculiar to each site is essential, which goes a long way towards ensuring that the design target is attainable and that services can be provided in a co-ordinated manner. This information may be subdivided into three categories:

(i) Statutory determinants, eg. provincial ordinances and local by-laws.

(ii) Site determinants, eg. topography, geology, drainage.

(iii) Development requirements eg. socio-economic status of residents, relation to other land uses.

If complying with the above requirements has not already established liaison between the developers and the local authority, it is essential that liaison be established as a part of the initial design process. This can help to eliminate delays during the processing of applications.

As such it is recommended that, to ensure co-ordination, the development be planned and designed by a multi-disciplinary team working as a unit. Information collected and the consultation involved in the preliminary stages of township planning will form the basis of the initial township layout. Early consultation will also enable the providers of the public utilities to phase their planning to ensure the provision of service by the predetermined date. However, individual services will have further constraints or determinants affecting the township layout. The township designer should be aware of these determinants from the outset to understand their relative importance and to be in a position to make the necessary compromise between any conflicting requirements.

2.2 MAIN OBJECTIVES FOR THE LAYOUT OF RESIDENTIAL ROADS

Within the framework provided by the constraints, it is essential that the designer be guided towards the target of an acceptable living environment by positive factors. As a basis of the design principles and standards contained in this guideline the following seven goals have been accepted:

- ECONOMY
- FUNCTIONAL EFFICIENCY
- SAFETY
- CONVENIENCE
- ENVIRONMENTAL QUALITY
- PRIVACY
- SECURITY OF PERSON AND PROPERTY

To attain the above goals it is necessary to design the road layout in such a way that capital, operating, maintenance and replacement costs are optimised and in keeping with the resources available. While bearing the above in mind it is also important to ensure that acceptable levels of access to property and mobility to residents are provided and that the other services can operate efficiently and are easily accessible for maintenance.

Differences between residential and other types of roads are not only of scale; considerations are involved which do not apply elsewhere in the urban road system. Residential roads and footpaths are an integral part of housing layout where surroundings free from traffic nuisance are of prime importance and where the patterns of movement around buildings should, with due regard for safety and convenience, give equal priority to the needs of pedestrians and vehicles. To achieve this balance it is important that extraneous traffic be minimized by actively discouraging route continuity.

It is also important that the layout minimize the risk of flooding and the impact on the total stormwater catchment.

It should also not be forgotten that the residents have a need for privacy and protection of person, property and services.

The objectives necessary to meet these goals should provide a guide to each of the professionals involved in the planning process and serve as a reference point for the process of co-ordination.

These considerations demand that the layout of the road hierarchy as a whole should, within the context of the site and its setting:

(i) minimise the danger and nuisance which can be created by through traffic;

(ii) keep vehicle flows and speeds as low as possible in the vicinity of houses, preferably by application of appropriate township layout principles, and bearing safety considerations in mind;

(iii) provide safe and convenient pedestrian routes between the houses and to local community facilities;

(iv) minimise danger to pedestrians and inconvenience to emergency and other services which can be caused by on-street parking;

(v) create safe routes for vehicle movement;

(vi) enable the needs for statutory and other services to be met efficiently.

2.3 CONSTRAINTS

Within the general context provided by development plans and other local policies it is necessary to establish any constraints on access to the site and requirements for the roads and footpaths within it which may result from considerations such as:

(i) the function of the surrounding roads based on the volume, type and destinations of traffic using them; how these patterns are likely to change in the future; and the likelihood of through traffic wanting to take short-cuts;

(ii) the volume and type of traffic likely to be generated by the scheme itself and the main directions in which such traffic is likely to go;

(iii) the location of public transport routes and bus stops;

(iv) the location of any existing or proposed cycle networks and the need to link up with or extend them;

(v) the location of existing or proposed community facilities such as shops, schools, parks and playgrounds;

(vi) the location of existing or proposed gas, water, electricity, telephone and sewerage services and equipment;

(vii) the requirements of those who provide emergency services;

(viii) characteristics such as shape, size and topography of the site and its surroundings.

2.4 URBAN TRAFFIC CIRCULATION

Based largely on research into the distribution and causes of vehicular and pedestrian accidents and the pattern of residential trip generation, it is now generally acknowledged that traffic circulation should be based on a functional classification of urban roads. The major functional components are the distance and destination of travel which may be ordered to provide a functional road hierarchy. Agreement on the urban road hierarchy is an essential element in the co-ordination of urban planning and development and it is recommended that a standardised hierarchy be defined and applied throughout the Republic of South Africa.

The function of the urban road network is to distribute traffic between land use activities which are linked in a physical hierarchy of urban districts, communities and neighbourhoods. In an ideal urban structure the roads should divide districts into community groups and community groups into neighbourhoods.

To support this idealised structure, the classes of road can be listed in descending order of hierarchy as:

(i) Freeways

(ii) Arterials (including expressways)

(iii) Collectors

(iv) Locals

The hierarchy is defined according to the scale at which traffic movement occurs. This reflects the relationship between operational needs, road geometrics and function. It is, therefore, important that the geometrics and road reserves should reflect street usage.

At the top end of the scale, freeways are dedicated to movement and have access limited to interchanges with grade separation of conflicting movements.

At the bottom of the scale local streets should be designed purely to provide access to fronting property on a scale compatible with other forms of movement and activity in residential neighbourhoods. The designer should recognise the need to provide for future growth when reserving land for the higher classes of road, but at the lower end of the hierarchy the road reserve should not provide for any future upgrading or widening. It should cater instead for the roadway width required and the space requirements for all surface and underground utilities.

Table 2.1 summarises the function and characteristics of the various classes of urban roads. Ref. 3.

Figure 2.1 illustrates the changing emphasis on movement and access for the various classes of road. The range covered in these guidelines is shown shaded. Ref. 4 and Ref. 5.

In *Guidelines for the Provision of Engineering Services in Residential Townships* a useful table is provided which sets out the various terms used by different authorities in South Africa, the United Kingdom, the United States and Australia to describe the various classes of roads. Ref. 6, p. B113-B114

TABLE 2.1

Functions and characteristics of road classes

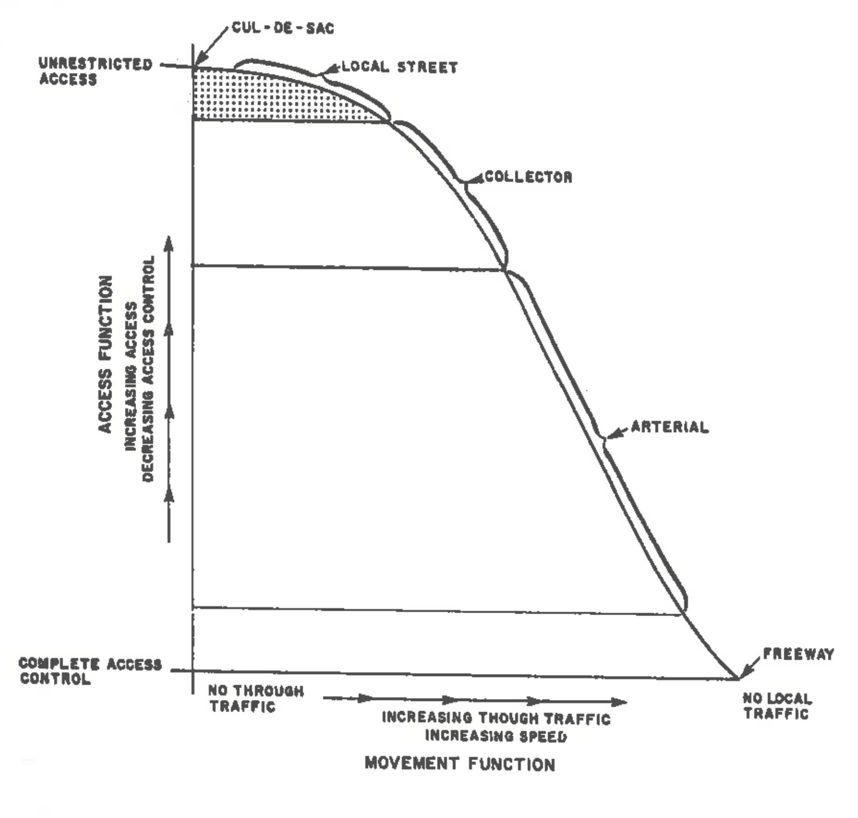
Function	Locals	Collectors	Arterials	Freeways
1. TRAFFIC Movement	Secondary to function of property access	Equal to function of property access	Primary	Primary
Flow conditions	Interrupted flow	Interrupted flow	Uninterrupted flow except at intersections and mid-block pedestrian crossings	Free-flow
Running speeds normal (km/h)	20-40	30-70	40-90	70-120
Vehicle types	Primarily passengeri cars	All types including buses	All types including buses	Motor-vehicles including express buses
2. PROPERTY ACCESS	Primary consideration	Equal to function of traffic movement	Preferably excluded	No access
3. CONNECTIONS	Collectors, locals	Arterials, collectors, locals	Freeways, arterials, collectors	Freeways arterials
4. PARKING	Accepted	Accepted	Preferably excluded	Excluded

Source : Adapted from Ref. 3, Table A.5b, p. A.13.

This hierarchy of roads is shown diagrammatically in **Figure 2.2.**

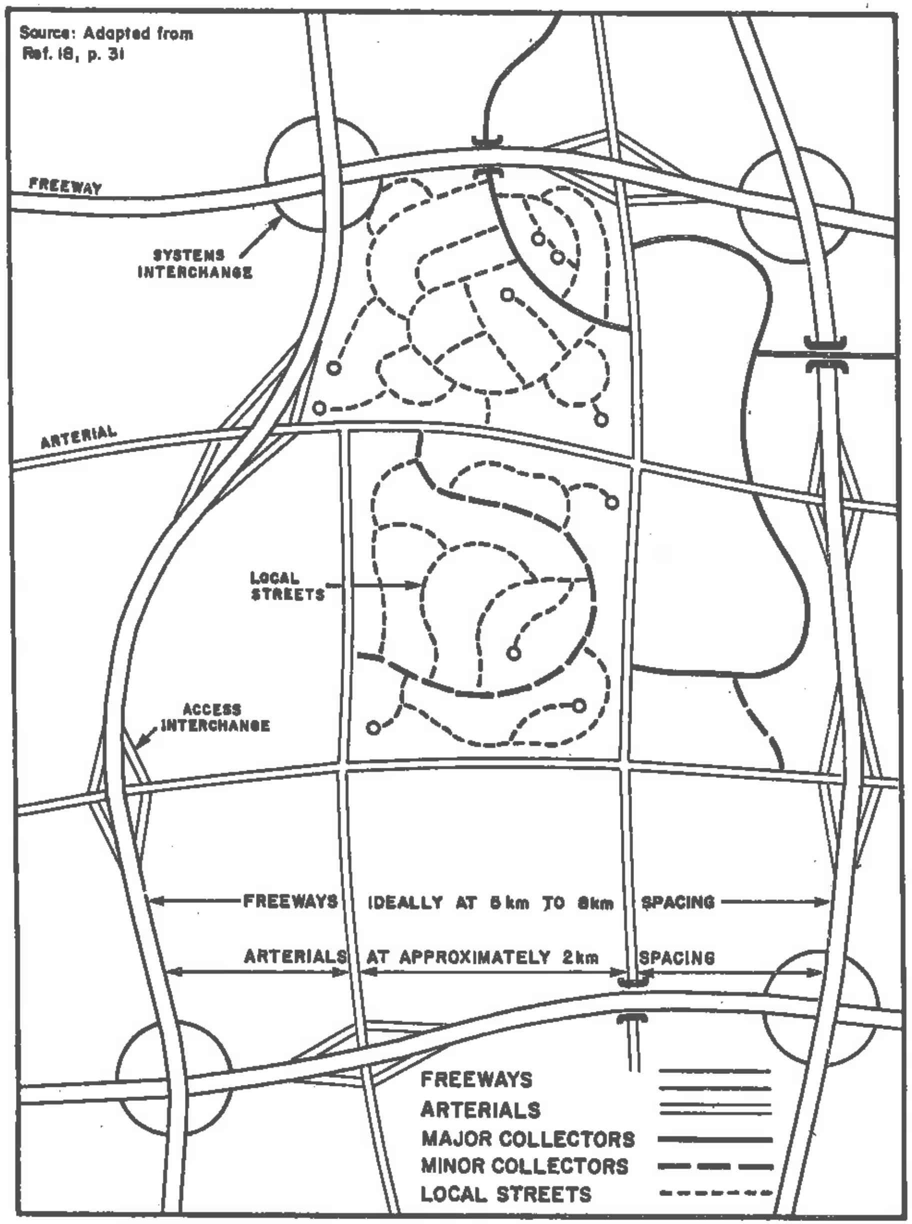
Residential local streets (referred to as class 5 roads in the Department of Community Development "Guidelines for the Provision of Engineering Services in Residential Townships") can be listed in the following descending priority in the hierarchy.

(a) Major residential access link (Class 5a), provides a link between the minor collector and other access roads but should not provide a convenient short cut for any section of the minor or major collector network. Access to dwellings is permitted except where stopping sight distance is inadequate.



Source : Adapted from Ref. 4, p. 12! & Ref. 5, p. 17

MOVEMENT - ACCESS FUNCTIONS   FIGURE 2.1



MAJOR ROAD NETWORK HIERARCHY
GRID PATTERN ROAD FRAMEWORK

FIGURE 2.2

(b) Residential access loop (Class 5b), provides direct property access and can be used as a link for culs-de-sac, access courts and private roads to a major residential access link and with a minor collector in exceptional circumstances.

(c) Access cul-de-sac (Class 5c), small informal road spur not exceeding about 120m to 150m in length, unless a greater length is specially motivated for very low densities. Its width and/or horizontal curvature should restrict speeds to less than about 30km/h.

(d) Access way (Class 5d), a closed system road having an exit at one end only. It may link access courts to each other and/or to other local streets and is not intended to provide much direct access to single buildings. The access courts it serves may provide links between adjacent access ways to provide for emergency or service vehicles but these links should be designed to discourage general use.

(e) Access court (Class 5e), a surface for joint use by pedestrians and vehicles and likely to be used by children at play : it is a place rather than a transport route. Special attention should be given to the enhancement of security and the environment.

(f) Access strip (double panhandle) (Class 5f).

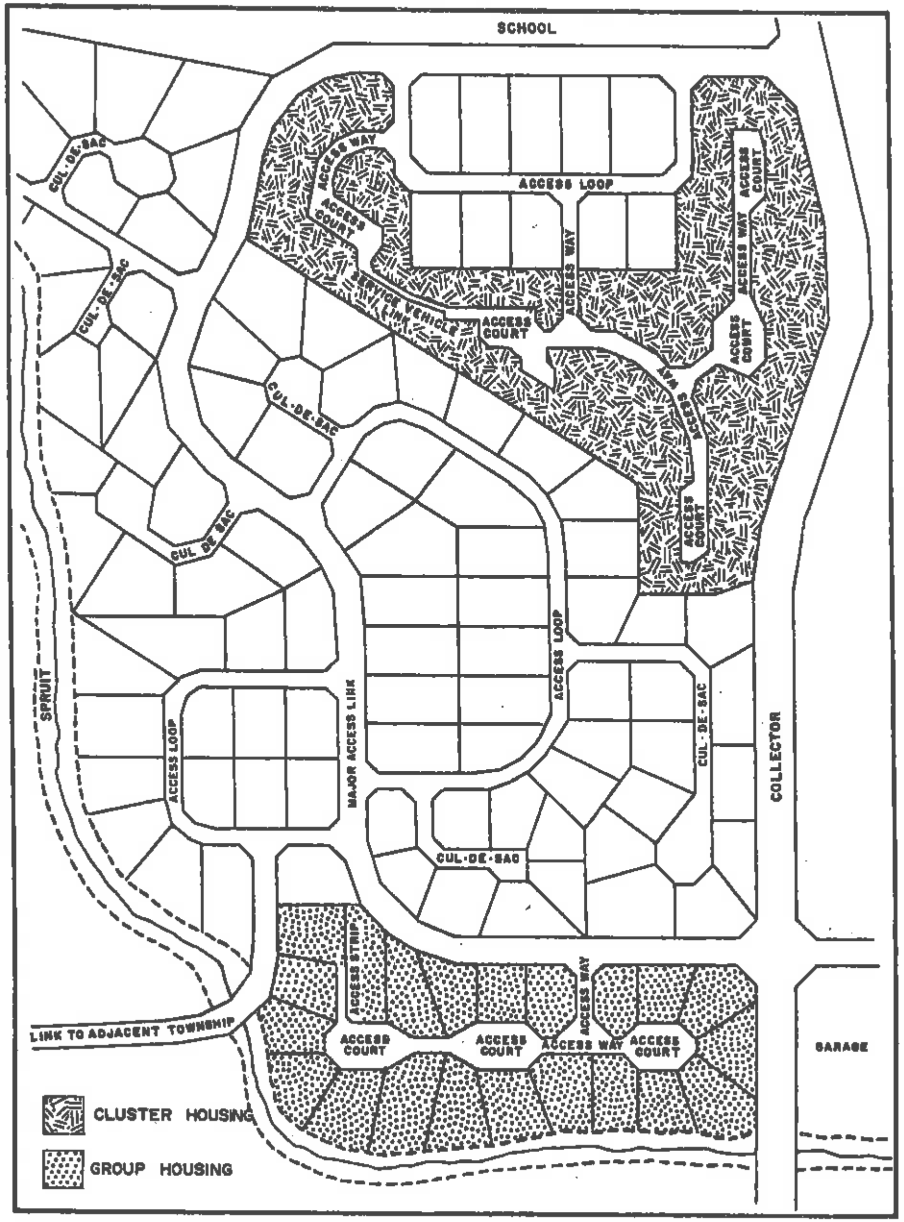
This hierarchy of local streets is shown diagrammatically in **Figure 2.3.**

TABLE 2.2

Recommended lengths of roads and numbers of dwelling units served

Road Class	Dwelling units served	Desirable max length	Fronting** residential uses permitted
a) Major residential access link	Up to 200	Less than 500m	Res. I, II III & IV
b) Access loop	Up to 120	300-500m	Res. I & II
c) Access cul-de-sac	6-60	150m	Res. I & II
d) Access way	Up to 60	50m between speed restricting elements	Res. I & II
e) Access court	Up to 30	50m	Res. I & II
f) Access strip	Up to 4	Depth of erf	Res. I & II

** **Dwelling Unit Types**
Residential I : detached houses
Residential II : multiple dwelling units, group housing
Residential III : blocks of flats, low rise
Residential IV : high rise blocks of flats



HIERACHY OF INTERNAL TOWNSHIP ROADS — FIGURE 2.3

The figures provided for dwelling units are only an indication, not an absolute design standard. Obviously, different combinations of local streets should be used, depending on density, topography and the shape of the township. However, to satisfy objectives for safety and environmental quality, it is recommended that, wherever possible, the majority of houses in a community should be served by slow-speed roads (classes 5 b, c, d, e and f). This means that the major residential access link should be kept as short as possible, merely serving as a link between the housing roads and the collector network. This will ensure that few houses front onto roads carrying volumes of traffic greater than 200 vehicles in the peak hour, but will yet be within a short walking distance of a bus route. Because of the low traffic generation characteristics of residential areas, capacity is not normally an issue in the design of local residential streets.

2..5 EXISTING TOWNSHIPS

In **existing** urban areas all roads should also be classified according to function. In developing an efficient and safe function-related hierarchy, certain roads will need to be upgraded or improved to serve the demands of through movement, while others should be modified to provide physical and psychological impressions of their local, low speed characters. This is discussed in more detail in Section 12 of this document.

In many existing areas the lower levels of the road hierarchy may not be easily recognisable. It is essential for the local authority to define the adjacent road network so that the effects of new development on the local road network may be considered and an appropriate decision reached about the categories of roads which may be required in the new development.

In practice many factors can influence the final alignment of roads such as existing roads which are to be incorporated in the new network and the location and type of existing traffic generators. The portions of the major roads which fall within a proposed township should form the basis of the internal road network and should be aligned accurately on the common boundaries with existing and proposed major roads in adjoining townships.

2.6 DESIGN AND OPERATING SPEEDS

2.6.1 Definitions

(i) Design speed : Design speed is the maximum safe speed that can be maintained over a specified section of street when conditions are so favourable that the design features of the street govern. Ref. 7, p.60.

(ii) Operating speed : Operating speed is the highest overall speed at which a driver can travel on a given street under favourable weather conditions and under prevailing traffic conditions without exceeding the safe speed as determined by the design speed on a section-by-section basis. Ref. 7, P.60.

(iii) Running speed : Running speed represents the distance over a given section divided by the running time. It generally applies to uninterrupted flow and is usually less than the speeds defined in (i) and (ii) above. Ref. 7, p.68.

Because urban design speeds are generally of a low order, the capability of motor vehicles and the generous road space for peak conditions effectively means that design speed is the "minimum speed that can be maintained on a specified section of highway under ideal conditions". This leads to the conclusion that the concept of "design speed" has serious imperfections for application to certain classes of urban road. Accordingly the correlation of geometric elements to achieve given speeds is only relevant for roads on which traffic is free-flowing, such as collectors and arterials. On residential roads, geometric and non-geometric elements should be used to inhibit the free flow of traffic. Ref. 6, p.B73.

Residential access roads should, therefore, be designed according to a **ceiling speed** which can be defined as the "desired maximum running speed".

2.6.2 Desired maximum running speeds for local residential streets

Running speeds of approximately 50km/h for residential access roads cannot be justified simply on the grounds of convenience or journey time. Slower speeds of between 15 and 40km/h, if applied in the layout forms suggested in Section 4, will provide reasonable journey times. With sensitive design, more attractive and safer surroundings will be created. Speed control must be self-regulating and must recognise that some drivers will exceed those speeds which are appropriate for residential conditions. The recommended desired maximum running speeds for local residential streets are summarised in Table 2.3.

TABLE 2.3

Design speed for residential roads

Road class	Design speed (km/h)	Desired maximum speed (km/h)
a) Major residential access link	40-60	40
b) Access loop	40	40
c) Access cul-de-sac	30	30
d) Access way	30	20
e) Access court	30	20
f) Access strip	N/A	N/A

2.6.3 Relating speed to the length of straights and continuous roadway sections

The continuity of roadways exerts an influence on driver behaviour, particularly on choice of route and speed. For residential access roads the design feature most effective in reducing speed is the avoidance of long, straight roads. Implementation of the functional hierarchy will ensure that these roads are planned to discourage higher speed through traffic.

In existing townships where the road layout is not designed to restrict speed there are a number of measures that can be implemented to reduce the effective length of streets and thus improve safety. These measures are discussed in detail in Section 12 of this document.

Local streets serving 200 dwellings or less should seldom need to exceed 500 metres over continuous sections and curves should be introduced at least every 150-200 metres to help regulate vehicle speed on class a) roads. For the lower order roads (5b, c, d, e and f) there is some merit in introducing speed-restricting elements at 50-100m intervals or, alternatively, their total length should be less than 150 metres.

Although horizontal curvature may be one of the elements or features used to restrict speed, a severe bend every 50 metres will not be practical or desirable. Curvature may be introduced every 100-150 metres on the lower order roads but it should be complementary to other elements such as ramps, humps, landscaping or narrowing of the roadway.

It must be stressed that these types of speed reducing elements should be used with caution and only after the most careful consideration. Road humps are a vehicle speed controlling device, designed only for use on well lit, low speed local streets. In certain circumstances humps can make an important contribution to road safety, but they are not appropriate for all roads. The choice of humps or some other remedial measure will depend on the nature of the road safety problem to be resolved and on an evaluation of cost-effectiveness. Road humps may result in some traffic diverting to other roads which needs to be taken into account in the assessment of any hump proposal. Humps should only be used in conjunction with other features such as sharp bends or road junctions. Side road junctions along a humped road should not be too skewed to avoid the possibility of a vehicle from any direction meeting a hump too fast. Appropriate warning signs and road markings must be used wherever humps are constructed.

3. BASIC CRITERIA

From their study of human factors in highway design and operations, Lunenfeld and Alexander concluded that "because drivers read the road and its information, and tend to believe what it appears to be telling them, a road that is substandard may not operate properly", and further that "properly designed and operated facilities that take human factors into account generally operate safely and efficiently" Ref. 8, p.157.

In Southern Africa, with population groups from the First World and the Third World, designers have to recognise the variety of skills at "reading" the road among the road users. Consistent design standards are thus all the more important.

The basic criteria for road design are common to all types of roads as they relate to typical characteristics of drivers and the performance of vehicles.

Knowledge of the design vehicle, its dimensions and performance characteristics, is necessary before maximum permissible grades, intersection layout and turning roadway radii and width can be decided on. The driver's eye height above the road surface and his reaction time are used to derive stopping and other sight distances. When these sight distances are known, rates of vertical curvature can, in turn, be derived. The coefficient of friction of the road surface, in conjunction with the parameters relating to the driver, determines the various sight distances and also affects superelevation rates, from which minimum horizontal radii for the various design speeds are calculated.

The derivation of the recommended values is given so that the designer dealing with some other design vehicle or circumstances will be in a position to calculate appropriate values.

3.1 THE DESIGN VEHICLE

The basic design vehicle for residential local streets is the passenger car, although design should allow for the passage and manoeuvring of larger vehicles such as pantechnicons, refuse disposal vehicles and fire-fighting vehicles. The only South African design vehicle for which dimensions have been established is the passenger car Ref. 9, p.3-14. For the pantechnicon and the refuse disposal vehicle the dimensions given in the Department of Community Development's "Guidelines for the Provision of Engineering Services in Residential Townships" have been adopted. Ref. 6, p.B129.

It is recommended however that the relevant local authority be contacted to ascertain the dimensions of the particular refuse disposal vehicles and fire-fighting vehicles that they use.

3.1.1 Dimensions

The dimensions adopted for the various design vehicles are given in Table 3.1.

TABLE 3.1

Dimensions of design vehicles

Vehicle	Wheel base (m)	Front overhang (m)	Rear overhang (m)	Width (m)
Passenger car*	2,85	0,75	1,20	1,80
Refuse vehicle**	4,00	1,45	2,45	2,40
Pantechnicon**	5,24	1,29	3,04	2,52

*Ref. 9, p.3-14
**Ref. 6, p.B129

3.1.2 Templates

Templates are considered useful for establishing the layout of intersections and median openings, and their use is recommended. Once roadway edges have been established, it is further recommended that they should, for ease of construction, be approximated by simple or compound curves. **Figure 3.1** gives dimensions for the construction of templates, for the three vehicles whose dimensions are shown in Table 3.1.

3.1.3 Minimum turning radius

In constricted situations where the templates are not appropriate, the capabilities of the design vehicle become critical. Minimum turning radii for the outer side of the vehicle body are given in Table 3.2. It is stressed that these radii are appropriate only to crawl speeds

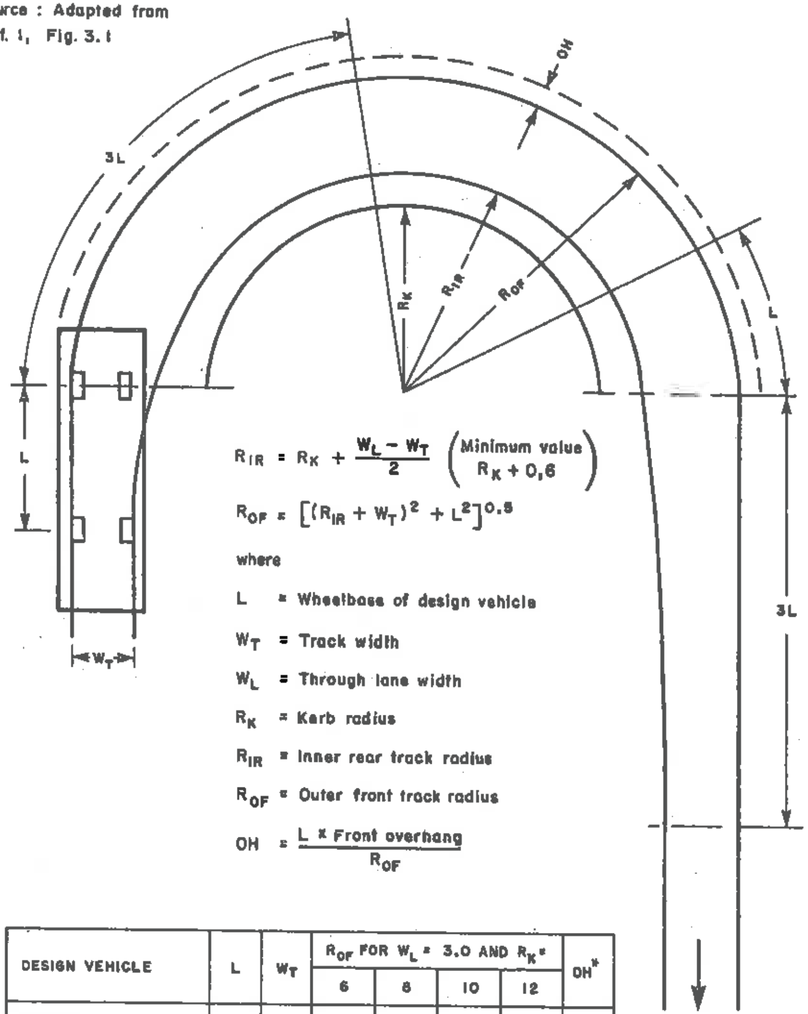
TABLE 3.2

Minimum outer turning radii

Vehicle	Minimum outer turning radius (m)
Passenger car	6,20*
Refuse vehicle	10,23**
Pantechnicon	11,10**

*Ref. 9, p.3-14
**Ref. 6, pp.B129,B131

Source : Adapted from
Ref. 1, Fig. 3.1



$$R_{IR} = R_K + \frac{W_L - W_T}{2} \quad \left(\begin{matrix}\text{Minimum value}\\ R_K + 0,6\end{matrix}\right)$$

$$R_{OF} = \left[(R_{IR} + W_T)^2 + L^2\right]^{0,5}$$

where

L = Wheelbase of design vehicle

W_T = Track width

W_L = Through lane width

R_K = Kerb radius

R_{IR} = Inner rear track radius

R_{OF} = Outer front track radius

$$OH = \frac{L \times \text{Front overhang}}{R_{OF}}$$

DESIGN VEHICLE	L	W_T	R_{OF} FOR W_L = 3,0 AND R_K =				OH*
			6	8	10	12	
PASSENGER CAR	2,85	1,8	8,9	10,8	12,7	14,7	0,17
REFUSE VEHICLE	4,00	2,4	N/A	11,7	13,6	15,5	0,43
PANTECHNICON	5,24	2,52	N/A	12,3	14,1	16,0	0,46

* for R_K = 10

Dimensions in metres

WHEEL TRACKS OF RIGID CHASSIS VEHICLES FIGURE 3.1

3.2 THE DRIVER

3.2.1 Eye height

Research has indicated that 95 per cent of passenger car drivers have an eye height at or above 1,05m, and 95 per cent of truck drivers an eye height of 1,8m or more. These values have accordingly been adopted for use in these guidelines. Ref. 10 and Ref. 11.

3.2.2 Reaction time

A figure of 2,5 seconds has been generally adopted as the reaction time for response to a single stimulus. Ref. 7, p.137.

3.3 THE ROAD SURFACE

The road surface has numerous qualities which can affect the driver's perception of the situation ahead of him, but skid resistance is the only one of these qualities taken into account in these guidelines.

3.3.1 Skid resistance

Skid resistance has been the subject of research worldwide, and it has been locally established that the derived values of brake force coefficient are appropriate to the South African environment. There is a considerable range of values. At 50km/h the skid resistance of a worn tyre on a smooth surface is half that of a new tyre on a rough surface, and at 100km/h it is five times lower. Skid resistance also depends on speed, and reduces as speed increases. Ref. 12.

Brake force coefficients are given in Table 3.3. No allowance is made for a safety factor, as these represent actually measured values for a worn tyre on a smooth wet surface, which in engineering terms constitutes a "worst case". Furthermore, the coefficient of friction is lower in sliding than in rolling, so that, as long as the driver is not involved in an emergency situation, he has adequate distance for a comfortable stop under normal conditions.

TABLE 3.3

Brake force coefficient for various speeds

Speed (km/h)	Brake force coefficient
20	0,47
30	0,42
40	0,38
50	0,35
60	0,32

Source : Ref. 7, Table 111-1 and Figure 111-1.

3.4 SIGHT DISTANCE

Sight distance is a fundamental criterion in the design of any road, be it urban or rural. It is essential for the driver to be able to perceive hazards on the road, with sufficient time to initiate any necessary evasive action safely. On a two-lane two-way road it is also necessary for him to be able to enter the opposite lane safely while overtaking. In intersection design, the application of sight distance is slightly different from its application in design for the open road but safety is always the chief consideration.

3.4.1 Stopping sight distance (SSD)

Stopping distance involves the ability of the driver to bring his vehicle safely to a standstill, and is thus based on speed, driver reaction time and skid resistance. The total distance travelled in bringing the vehicle to a stop comprises two components:

-the distance covered during the driver's reaction period, and

-the distance required to decelerate to 0km/h.

The stopping distance is expressed as

$$s = 0{,}7v + v^2/254f$$

where s = total distance travelled (m)

v = speed (km/h)

f = brake force coefficient

Stopping sight distances for a range of design speeds and appropriate brake force coefficients are given in Table 3.4.

TABLE 3.4

Stopping sight distance on level roads

Design speed (km/h)	Stopping sight distance (m)
20	18
30	30
40	45
50	65
60	85

For local residential streets stopping sight distance is generally measured from an eye height of 1,05m to an object of 0,60m. This provides for a practical design with an adequate margin of safety for the protection of children, pets and other obstacles which are typically encountered on this class of road. This object height is used because an obstacle of a lower height would not normally represent a significant hazard. Object height is taken into account because measuring the sight distance to the road surface would substantially increase the length of the vertical curve; hence the earthworks required.

Values in Table 3.4 are recommended for design.

The gradient has a marked effect on the stopping sight distance requirements. Gradient (G) modifies the stopping sight distance formula to

$$s = 0{,}7v + v^2/(254\ (f \pm 6))$$ Ref. 7, p. 143.

where G is the percent of grade divided by 100.

Stopping sight distance can also be affected by a visual obstruction (such as a cut slope or a wall) next to the carriageway on the inside of a horizontal curve, as shown in Figure 7.2.

3.4.2 Passing sight distance (PSD)

Because of the short lengths of this class of road, overtaking distance is of academic interest only. Only stationary vehicles and objects will occasion overtaking, in which case the safe stopping sight distance provided in Table 3.4 will suffice.

4. LAYOUT DESIGN PRINCIPLES

4.1 TRAFFIC AND ROAD LAYOUT

The overriding principle relating to the layout of local streets is that the system should be developed to a functional hierarchy which segregates traffic movements by destination and journey length. In the development of a road and traffic hierarchy the following principles should be observed:

(i) The physical layout of local street systems should actively discourage use of the streets by traffic not originating or terminating in the area in question.

(ii) The layout of the network should seek to minimize the number of intersections, especially on higher order roads. It should also facilitate a logical gradation from one level to another, avoiding the possibility of intersection between high and low order roads. Roads should generally intersect only with other roads one level above or below them in the hierarchy.

(iii) The road network should be related to and fully integrated with the land use system of the area which it serves, and vice versa. Neighbourhood or residential zoning and density policies which affect the aggregate and directional demand for travel should seek to minimise internal vehicular travel. Traffic from the more intensive vehicular traffic generators should not have to pass less intensive generators on the way to higher order roads. Non-complementary land uses, eg schools and shopping centres, should be separated to avoid a potentially dangerous mix of traffic.

(iv) Access to arterial and other main urban roadways should be restricted in order to minimise conflicts between local and through traffic (especially heavy vehicles). The construction of private driveways onto arterials and collector routes should be prohibited.

(v) Design of the road network should seek to minimise the number of opportunities for conflict between pedestrians and vehicles. Separate pedestrian and/or cycle facilities should be provided within the road reserve at places where pedestrian/cycle movements are concentrated and where there are large speed differentials between vehicles and other road users.

(vi) Local street systems should be designed for a relatively uniform, low volume of traffic and should discourage excessive speeds.

(vii) The street system should not be so complex and discontinuous as to increase travel distance significantly. While layouts should make through-movement inconvenient, they should facilitate contact between adjacent residential blocks and communities.

(viii) Streets should be designed and constructed so that their physical appearance and performance reflect their function. The street form should also be logical and comprehensible to strangers and occasional visitors.

(ix) The street layout should create a traffic circulation system which functions logically and without the need for numerous traffic regulations.

(x) Layout of residential areas should provide for economic transit routes which are complementary to the pedestrian circulation system and the pattern of land development.

(xi) Public service vehicles should not be required to reverse over distances in excess of about 20m.

4.2 TOPOGRAPHY AND LAYOUT

The topography and geomorphology of the site for a township can be the most compelling factor in the quality of the layout. To achieve a good result, taking into account aesthetics and environmental quality, efficient functioning of sewers, economic building design, effective retardation of stormwater run-off and economic traffic circulation, the design must work <u>with</u> the topography, rather than trying to impose preconceived solutions onto it. It is here that integrated inter-professional cooperation and coordination in the initial design stages can be most fruitful.

The conflicting requirements must also be seen in the perspective of the total cost to the householder. Thus, before even a tentative road alignment is drawn, the topography of the site must be analysed. When the designers are thoroughly conversant with the site and its possibilities and constraints, consideration can be given to the alignment of roads in the desired directions of travel.

Steeper gradients and crossfalls are acceptable on most lower order roads. The exception is an access court which is also a parking and play court, where neither gradient nor crossfall should exceed 4%. Courts have been used successfully in hilly terrain by linking several small, flattish areas by means of narrow ramps to take up differences in level. Steep gradients are also a deterrent to pedal cycling.

Sudden changes in the level of the land may make it difficult to prevent private houses and gardens being overlooked from roads at the higher level. Road alignments and/or land use may have to be modified if they do not contribute to the goal of privacy.

4.3 INTERSECTIONS

Analysis of available data has shown that more accidents occur at intersections than in any other part of residential areas in South Africa. Ref. 13. The most dangerous intersections occur along higher order roads. This has led to the layout design principle that the number of intersections should be minimized.

It becomes clear that the spacing and location of intersections is governed not only by desired direction of movement (convenience) and the need to produce developable erven, but by considerations relating to the goals of safety and efficiency. Road layout (ie the location of intersections) can make as much contribution to safety performance as detailed geometric design.

Intersection design is discussed in detail in Section 8 of this document.

4.4 FACILITATING PEDESTRIAN MOVEMENT

Pedestrian routes include all the routes available to people on foot : shared road surfaces, sidewalks and independent footpaths. Good links are needed from houses to schools, shops and bus stops and although research undertaken by NITRR indicates that between 20 and 90 per cent of household trips are on foot, a particular route will not be well used if it does not fulfill the needs of pedestrians

To provide footways and footpaths which are sufficiently safe, convenient and secure, and cause the least inconvenience to residents, it is necessary to ensure that:

(i) The shortest routes between the homes and community facilities:
  - o are segregated, where possible, from collector and arterial roads and from heavily trafficked residential roads;
  - o have the slightest gradients possible, especially for the elderly and disabled;
  - o are protected as far as possible from driving wind and rain;
  - o are busy, overlooked by dwellings or passing traffic and well-lit after dark.

(ii) Footways are normally provided where dwellings or parking spaces are directly served by roads.

(iii) Segregated footpaths are provided where family dwellings are directly served by the more heavily trafficked residential roads.

(iv) The layout as a whole discourages children from playing in the immediate vicinity of homes which are likely to be occupied by the elderly, minimizes the disturbance which can be caused by people using community buildings late at night, and discourages the use of footpaths by cyclists.

(v) Footways and footpaths provide the most direct practicable routes between dwellings for those who make regular door-to-door collections and deliveries, and are laid out to assist strangers in finding their way around.

(vi) Footways and footpaths are sufficiently wide and well-aligned to:

  - o avoid the need for pedestrians passing each other to step out into busy carriageways or to cause damage to planted areas;
  - o allow for ramped crossings into garage drives or parking spaces;
  - o allow, when necessary, for occasional access along footpaths by emergency vehicles;
  - o provide for statutory and other services underground.

(vi) Kerbs and other barriers discourage or prevent vehicles from mounting footways or verges.

(viii) Pedestrian crossings are suitably placed and relevant to the children's routes to schools from bus stops or from their homes.

4.5 PROVISION FOR CYCLISTS

Routes for cyclists should be direct, convenient, with acceptable gradients and smooth surfaces. They should be well trafficked in remote areas and require good lighting and good sightlines because of the braking distance needed, especially downhill. Separate cycle ways are recommended only on collectors.

Definitions of the terms used in the planning of bicycle facilities are contained in Section 5.1.2 and further details can be found in the *"Guidelines for the Planning and Design of Bicycle Facilities in Urban Areas"*. Ref. 14.

5. FACTORS AFFECTING ROADWAY WIDTH

The roadway includes all the cross-section elements between the faces of the kerbs on either side.

5.1 TRAFFIC COMPOSITION

In order to provide for safe vehicular movement and to minimize the damage and nuisance which can be caused by vehicles, it is necessary to ensure that the widths and alignment of roadways are commensurate with the expected speed and volume of traffic and the frequency with which various types of vehicles may need to pass each other. The ease, and hence the speed, with which vehicles may move along roadways depends in part upon the tolerances available both between vehicles and between vehicles and kerbs.

5.1.1 Motorized traffic

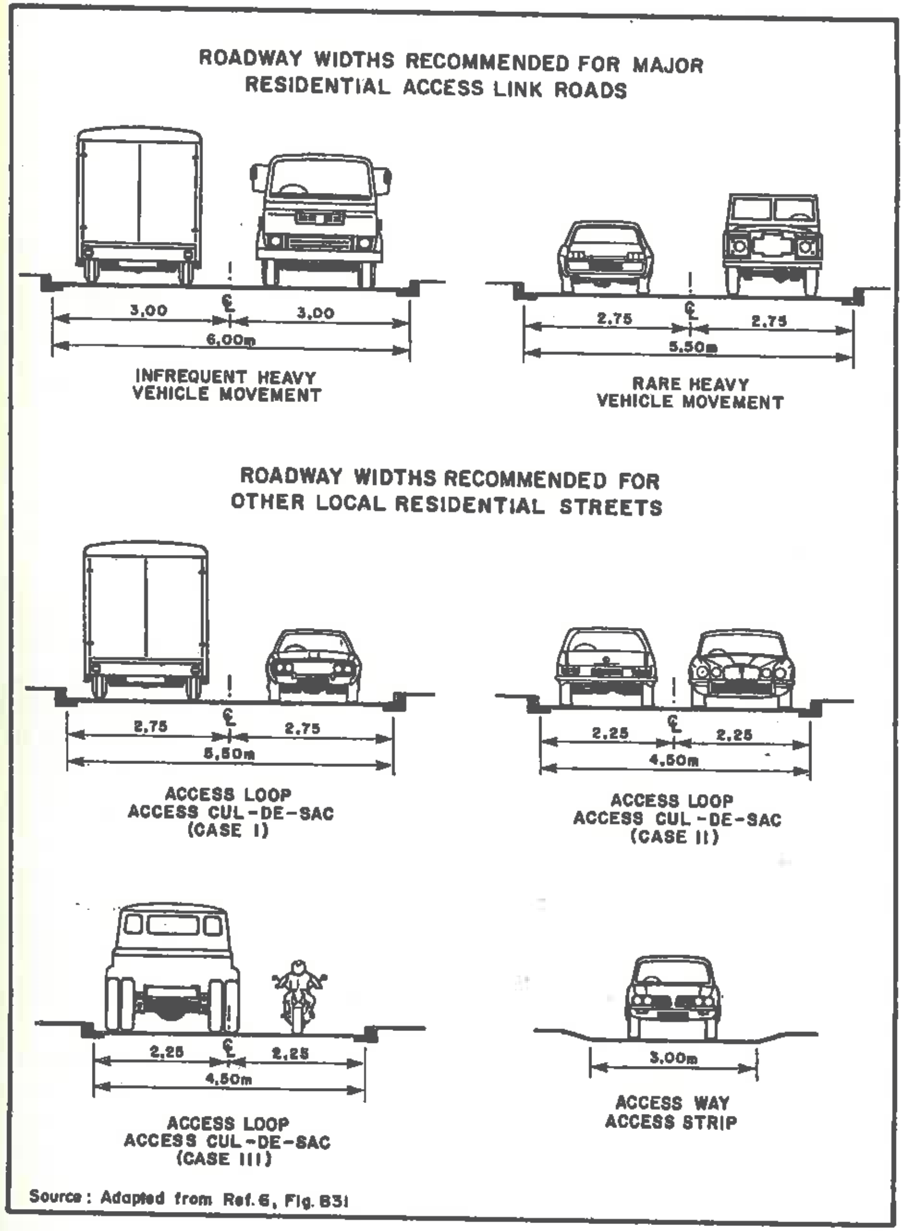
Figure 5.1 shows roadway widths that will allow for comfortable two-way movement at consistent low speed for all private vehicles and for the infrequent heavy vehicle movement encountered on local residential streets.

For access loops and culs-de-sac the three different cases shown indicate the type of opposing vehicle movements that can be accommodated, under free-flow conditions, by different roadway widths:

- o Case I will allow free passage for a heavy vehicle and a passenger car but still allow two heavy vehicles to pass at crawl speeds;
- o Case II will allow relatively free passage for two passenger cars and will enable a passenger car to pass a heavy vehicle which is stationary or travelling at crawl speed. The passage of two heavy vehicles would require the provision of passing bays;
- o Case III is shown to indicate that a 4,5m roadway will also accommodate the free passage of a heavy vehicle and a motor-cycle or pedal-cycle.

The choice of roadway width will depend on the frequency with which various vehicle combinations could be expected to meet and on traffic volume in general.

Table 5.1 shows roadway widths for the various classes of residential road, differentiating between a recommended width and a basic minimum, the latter being more appropriate for low-income areas.



EXAMPLES OF ROADWAY WIDTHS FOR THE VARIOUS CLASSES OF RESIDENTIAL ROAD — FIGURE 5.I

TABLE 5.1

Advisory roadway widths

Road class	Roadway width (m)*	
	Recommended	Absolute minimum
a) Major residential access link	6,0	5,5
b) Access loop	5,5	4,5
c) Access cul-de-sac	5,5	4,5
d) Access way	3,0 minimum with passing bays where necessary	
e) Access court	3,0 at pinch points	
f) Access strip	4,0 (shared)	3,0 (single erf)

* *These figures do not include variations for cyclists, pedestrians or widening on curves.*

Source:Adapted from Ref. 6. Table B9, p.B62

As can be seen, the basic minimum roadway width permitted for lower order roads (Classes 5 d, e, and f) is 3,0m. The access way has a variable width surface with passing bays of up to 5,0m wide, where needed. For inter-visible sections the roadway may, therefore, be a single track, although this length should not exceed about 50m and widening should occur at bends, crests and where landscaping reduces visibility. In the case of the access court, the minimum of 3,0m only applies to gates and pinch points or links between adjacent access courts.

A method for determining widening on variable width access roads is shown in **Figure 5.2** Ref. 15. The figure illustrates that the forward visibility distance is determined by the combined stopping distances of opposing vehicles plus the distances required between bays necessary to cope with the anticipated traffic volumes. Research suggests that for two-way flows of the magnitude likely to be generated in lower-order residential streets, a distance between bays of up to 50m will be satisfactory without imposing significant delays.

It should be emphasised that the illustration shown in Figure 5.2 is purely diagrammatic. The shape and size of passing bays required will depend largely on the types and volumes of traffic to be coped with. Their location and design at junctions may also be affected by the need to allow vehicles to turn past others waiting in the passing bays. This again will be influenced by the volume of traffic but may also be influenced by the direction of turn at the point of intersection.

5.1.2 Bicycle traffic

The needs of non-motorized vehicular traffic and pedestrians should also be considered in determining roadway width.

If new townships are planned and designed according to the objectives and standards contained in this guideline, traffic volumes and speeds on most residential streets will be such that no special provision need be made for cyclists. Road classes from b) access loop, and lower should predominate and all could function as joint-use surfaces. In view of the potential increase in popularity of cycling, the layout of new townships should consider convenient means of linking low order streets to form continuous and direct cycle routes.

This is the cheapest and probably safest means of providing for cyclists and no roadway widening is required on this type of surface.

For the class a) major residential access link, special cycle facilities may only be warranted on the approach to junctions with collectors. As these roads are not continuous (ie do not encourage through movement), vehicular traffic on them will be concentrated on the approach to junctions. Considering that almost all 4-wheel vehicle movements on this class of road will be made by private cars (vehicle width 1,8m) and will involve tidal movements, a 6,8m roadway will provide edge clearance of 2,2m allowing 1,0m clearance between opposing vehicle movements at or near the centre of the road.

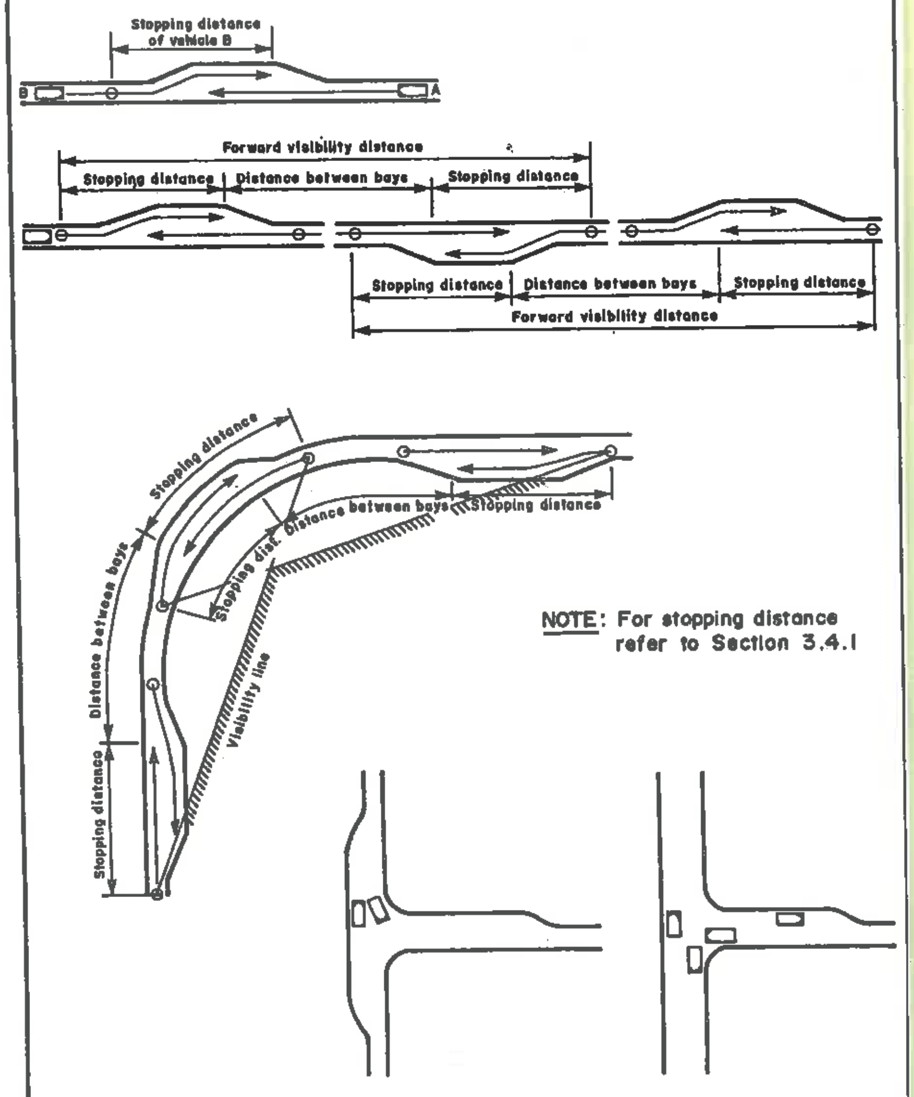
The Department of Transport has prepared a manual for the planning and design of cycle routes, which provides a classification of cycle facilities with appropriate design norms. It distinguishes between four types of facility, namely cycle roads, cycle ways, cycle lanes and on-street cycle routes **(See Figure 5.3)** and should be referred to if cycle facilities are to be planned. Ref. 14.

5.1.3 Pedestrian traffic

In the case of certain culs-de-sac or short loops it may be acceptable to design the roadway as a shared surface. On these shared surfaces the width of the roadway should be used to control vehicle speeds, and as such the needs of pedestrians have a negative influence on roadway width. On other classes of road a separate footway should be provided in the road reserve.

5.2. WIDENING ON CURVES

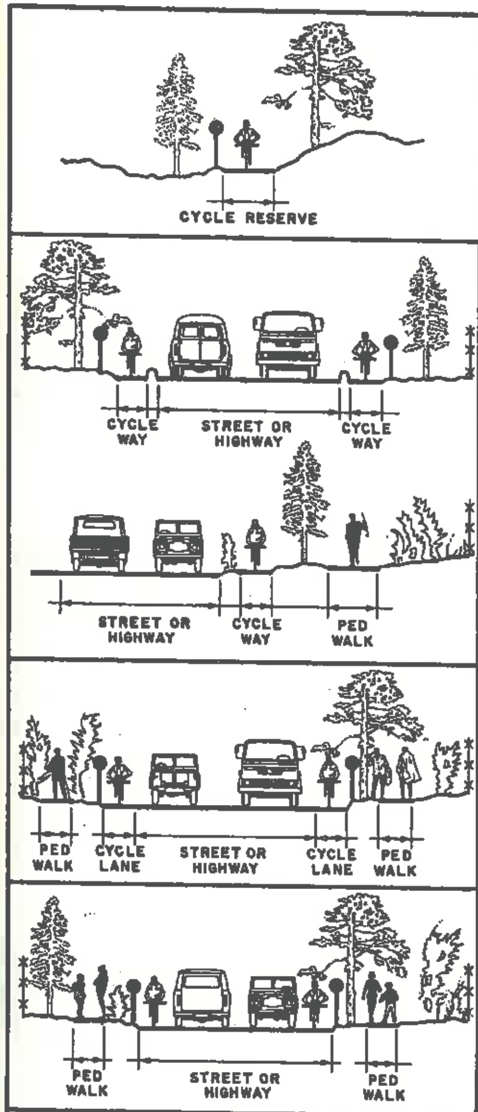
For lower order roads curves are among the elements used to control speeds, widening would thus be counter-productive. It is recommended that the width at bends should only be sufficient to allow two vehicles (South African design car) to pass at slow speeds and that the standard roadway width be used (see Table 5.1).



NOTE: For stopping distance refer to Section 3.4.1

Source: Ref. 15, p. 68

A METHOD OF DETERMINING DISTANCE BETWEEN PASSING BAYS ON NARROW ROADWAYS — FIG. 5.2



CLASS I - CYCLE ROAD	WIDTH - 1-WAY 1,8m 2-WAY 3,0m
CLASS II - CYCLE WAY	WIDTH - 1-WAY 1,8m 2-WAY 3,0m
CLASS III - CYCLE LANE	WIDTH - 1,8m TO 2,3m ALWAYS 1-WAY BUT EITHER WITH-OR CONTRA-FLOW
CLASS IV - ON-STREET CYCLE ROUTE	

NOTE: STANDARDS PROVIDED ARE DESIRABLE RATHER THAN MINIMA WHERE FACILITIES ARE SHARED BY PEDESTRIANS THE MINIMUM 1-WAY WIDTH SHOULD BE 2,0m

Source: Ref. 14, Fig 5.1

THE SOUTH AFRICAN CLASSIFICATION OF CYCLE PATHS — FIG 5.3

It is recommended that widening at bends should be normal practice only if authorities wish to stipulate design speed which only has relevance, however, to free-flowing facilities. Bends or curves should be introduced to regulate speed on all major residential access links provided that they are not at the end of straights longer than about 150m. Provided that sight distances are adequate, there should be no necessity for widening where the standard roadway width is 6,0 metres.

5.3 EMBAYMENTS

Generally provision for parking should be made elsewhere than on the roadway. Embayments will, however, be required in certain cases on some major link roads for loading and parking. For parallel parking and loading, embayments should normally be 2,5m wide, with a minimum for parking of 2,2m. The minimum dimension should not however be used in conjunction with the "basic minimum" roadway width. Ref. 9.

5.4 OPERATING SPEED

Operating speeds are influenced by a number of factors including forward visibility, vertical curvature, traffic volumes and road width. It is, however, difficult to estimate relationships between speed and lateral clearances in the relatively low-speed conditions encountered in residential areas. Roadway width is an element which must, however, be taken into account in efforts to influence speed or make it self-regulating. It is considered that the roadway widths provided in Table 5.1 will provide the necessary clearances for safe vehicle operation for the design speeds and maximum speeds considered desirable for residential roads.

5.5 BLOCKAGES

Where roadways allow only for single-file traffic, blockages may be caused by vehicle breakdown, road maintenance, or by the need to gain access to underground services. While none are likely to occur very frequently, they may cause problems of access particularly on the more heavily trafficked roads unless means can be found to by-pass them. The use of short loops or culs-de-sac, which may be temporarily connected together to form a loop, may achieve this.

6. FACTORS AFFECTING ROAD RESERVE WIDTH

6.1 THE SCOPE OF ITEMS TO BE ACCOMMODATED IN ROAD RESERVES

The underground services which will usually require accommodation in the road reserve are cables for domestic electricity, street and public lighting, and telephones, sewers, water mains and stormwater drains. In certain parts of the country there may also be requirements for the accommodation of piped gas.

The surface elements include the travelled way (roadway), as described in Section 5, which varies in width according to functional type, kerbs, footways, bicycle lanes and clear spaces, which may accommodate all or some of the following : loading and parking embayments, road signs, pedestrian refuges, electric light poles, metering or distribution boxes, hydrants, telephone kiosks and trees and other landscape elements.

6.2 CO-ORDINATION

Requirements for the installation of services in road reserves will vary according to site conditions and road layout. Optimal output for each of the services will not always be possible because of conflicting objectives and principles. However, it is possible to satisfy the requirements for all services by making greater use of space beneath the roadway for those services which require little maintenance, although some local authorities are reluctant to permit this practice. Reduction in lateral clearance for each of the services, or use of space under the roadway, or the use of shared trenches will, however, require improved co-ordination in both planning and implementation. The authorities providing services should be approached as early as possible to ascertain their general requirements.

6.3 DETERMINATION OF ROAD RESERVE WIDTHS

Local practice, topography, housing type and density, and the service options available, are factors which influence road reserve widths. No single minimum standard can be used throughout the country but a number of determinants which influence the derivation of reserve width are listed below.

6.3.1 Reserve width determinants

(i) It is not necessary to associate the width of the travelled way (and thus the traffic function of the road) with the width of the road reserve.

(ii) The reserve need not always be a uniform width for the entire length of the road.

Local widening is permissible to accommodate discrete elements such as sub-stations.

(iii) Reserve widths should be derived to accommodate all services and elements in accordance with local practice and the policies of controlling authorities.

(iv) For residential access roads, reserves do not need to provide for future upgrading of the travelled way because layouts should be designed to preclude through traffic and can thus be planned for ultimate development.

(v) Final reserve boundaries should be fixed only after the detailed requirements of the service undertakings have been ascertained and the most suitable layout has been selected.

(vi) The roadway need not be centrally placed in the road reserve, it may be offset or move from one side of the reserve to the other, or the reserve itself may follow an irregular alignment.

(vii) Only those engineering service elements which are continuous (ie present along the entire road reserve length) should be considered when determining the minimum reserve width.

(viii) Ready access must be available at all times to all parts of service routes in case of emergency.

(ix) In areas of severe topography and especially where there are steep cross-falls, it will be necessary to make provision within the road reserve for earthworks and possibly special provisions for access.

6.3.2 Procedure for determining road reserve widths

The following are brief descriptions to illustrate the procedure for deriving the appropriate reserve widths for various classes of road:

(a) Major Access Links **(Figure 6.1)**

Major residential access links are not designed to carry buses or other heavy through traffic. It may be necessary to provide footways on this class of road depending on the volume of pedestrian and vehicular traffic. The recommended reserve widths range between 12,0m and 13,5m which is sufficient to accommodate the advisory surface and underground elements. This width may be reduced to an absolute minimum of 10,5m if space is not needed for sewers and stormwater drainage.

It should be noted that some local authorities have specific requirements for the design and location of street lighting poles and equipment.

It should also be noted that where larger diameter pipes or trunk services are located in such reserves, reserve width may require a corresponding increase.

(b),(c) & (d) Access loops, Culs-de-sac and Access Ways **(Figure 6.2)**

Figure 6.2 provides an indication of how surface and underground elements may be accommodated in the narrower road reserves (8,0m to 10,5m). Space for street trees is available on only one side of the access loop and cul-de-sac reserves. The planting of street trees on both verges is not recommended, but local widening for more informal or grouped planting is. **(See Figure 6.3)**

The above comment regarding street lighting also applies here.

(e) Access Courts

No cross-sections or dimension are provided for these access roads, either because they are of irregular shape and form (access courts) or because they may be subject to controls outside the road reserve (access strips or panhandles). **(See Figure 6.4.)**

Access courts will generally be of variable width, with a minimum of 9,0m between buildings or garages (zero building lines on the frontages are permissible) to cater for reversing and to provide adequate daylight and sunlight. Generally however, the paved "road" surfaces will be wider (up to 14,0m), thus providing ample space for underground services.

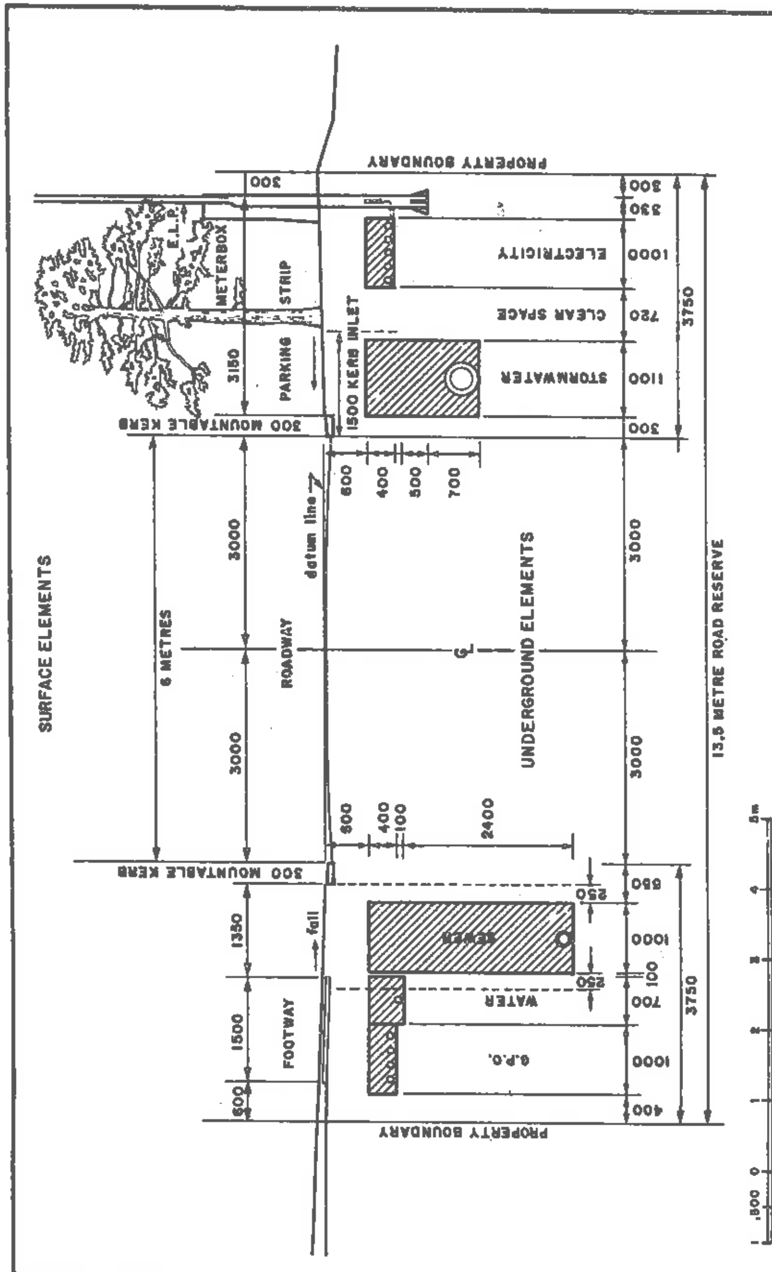
Extraneous traffic must be excluded from access courts by both general road network layout and by detailed design. The minimum width of the travelled way at pinch points, gates or ramps should be 3,0m and the effective width of the travelled way between these speed restricting elements should be about 4,5m. Incidental widening in positions where the extra width is required (e.g. for play equipment or shade trees) will contribute to the unique quality of a court.

6.4 SPLAYS

Boundary splays should be provided at all intersections to ensure adequate sight triangles and forward visibility. The sight triangles at intersections should be kept clear of all obstructions over 0,6m in height except light poles, traffic signals and control signs or route markers, which must nevertheless be set back from the kerb.

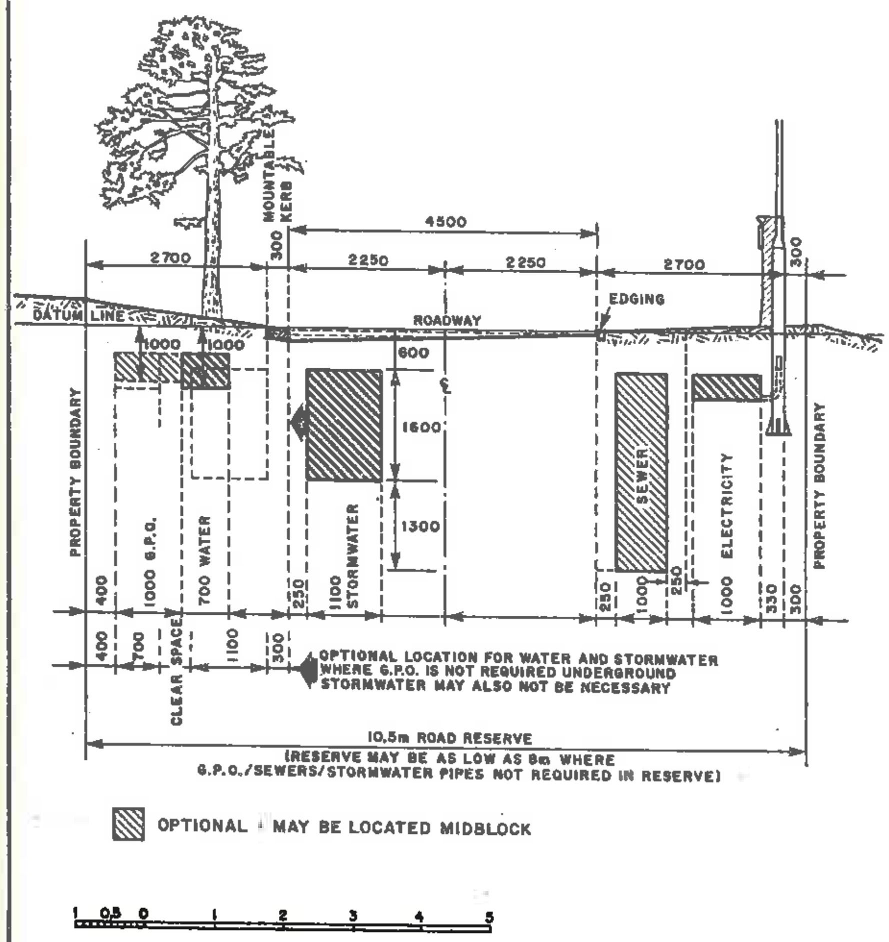
The actual splay dimensions will depend on verge widths, kerb radii and the approach speed of traffic on intersecting roads. Methods of calculating forward visibility at curves and sight triangles at intersections are provided in Sections 7 and 8 respectively, however, 6,0m x 6,0m splays will generally be suitable for residential roads.

Figure 6.5 provides an indication of how various elements of services relate to curve radius and splays on corner properties in a typical residential street.



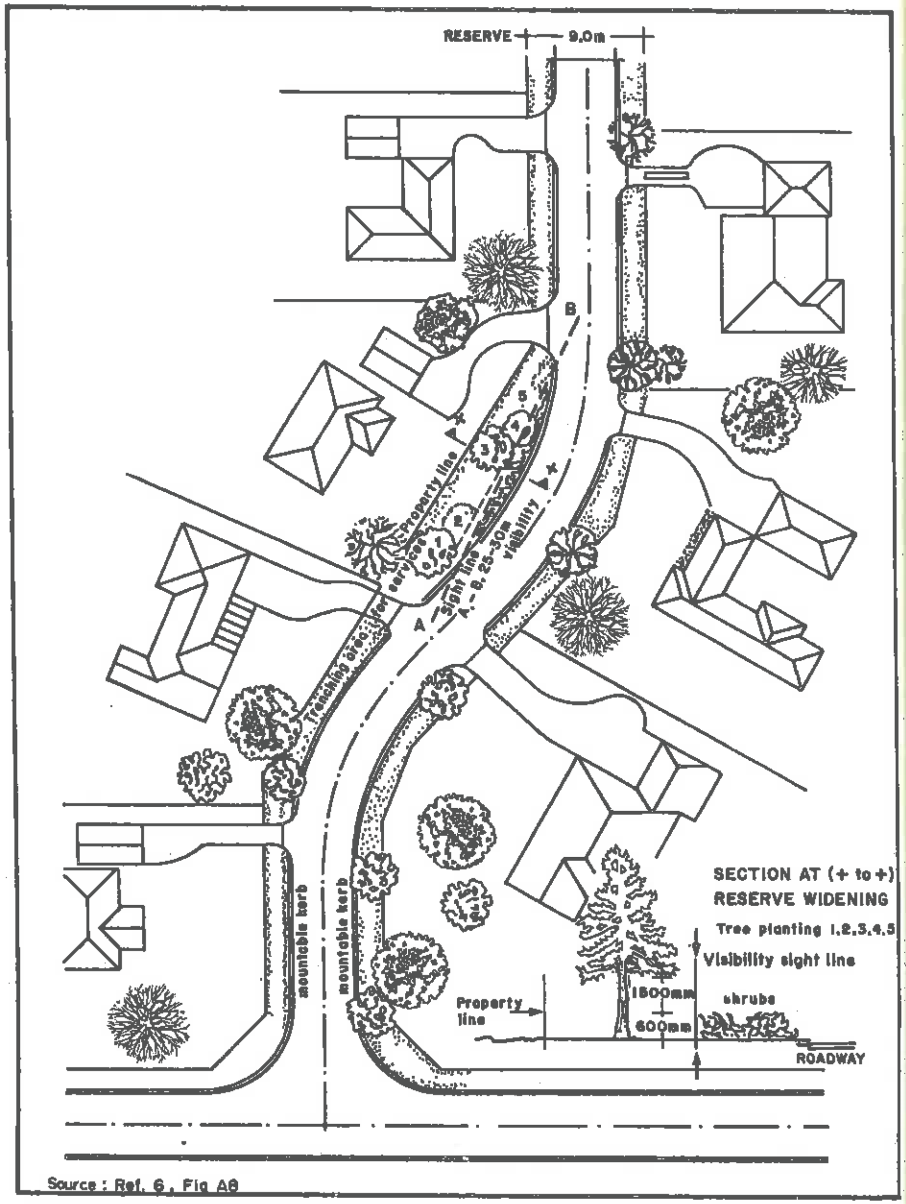
Source: Ref. 6, Fig. A6

SAMPLE CROSS-SECTION SHOWING SERVICES IN A MAJOR RESIDENTIAL ACCESS LINK FIG 6.1

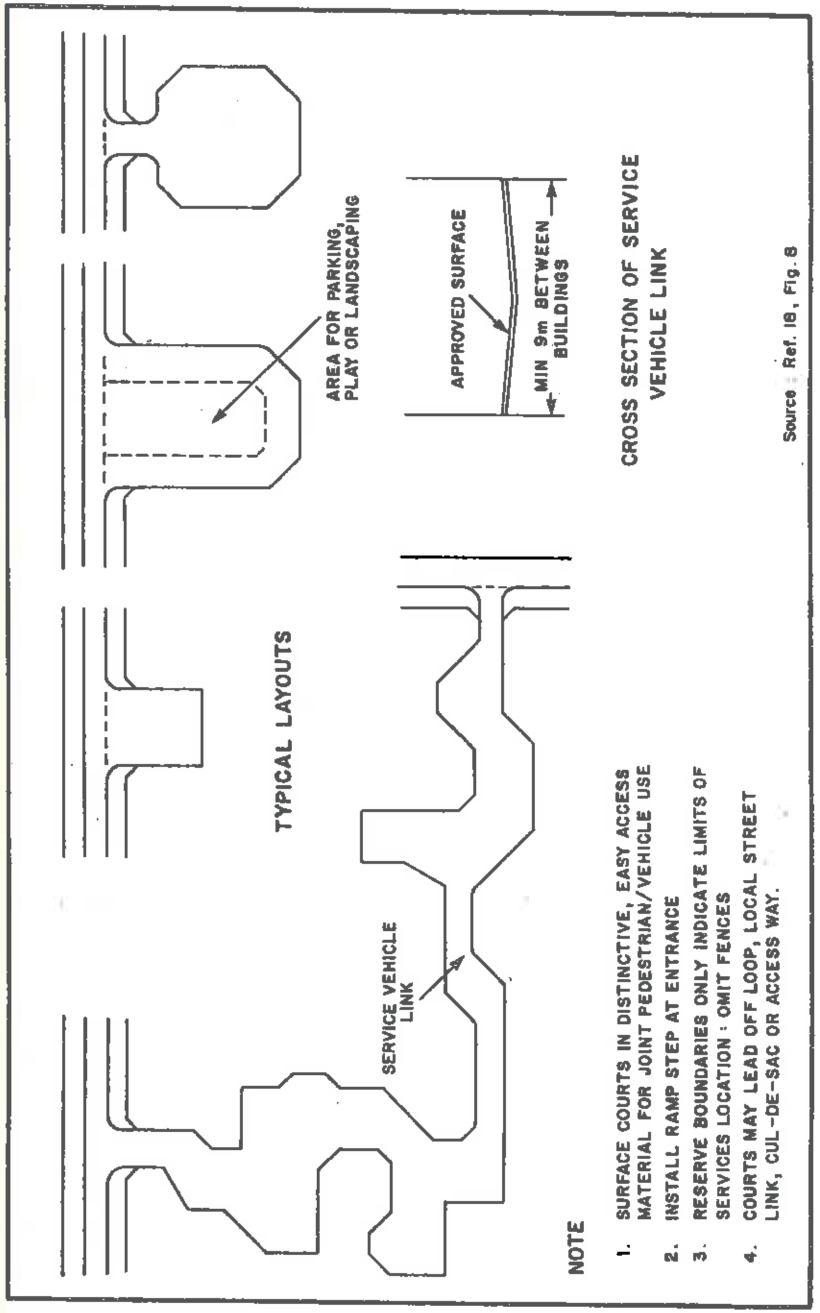


Source: Ref. 6, Fig. A7

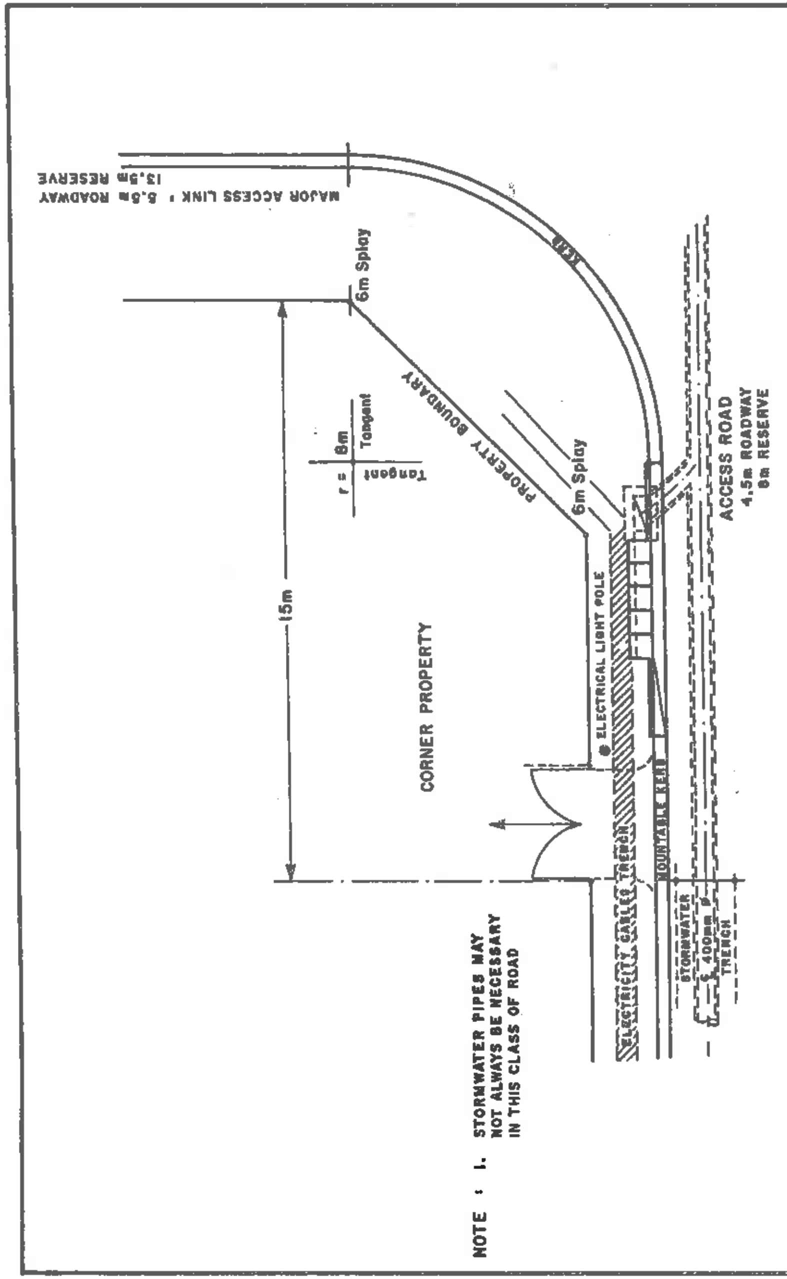
A SAMPLE CROSS-SECTION SHOWING SERVICES IN ACCESS LOOP, CULS-DE-SAC AND ACCESS WAYS FIG 6.2



RESERVE WIDENING TO INCLUDE LANDSCAPING FIG 6.3



ACCESS COURTS AND SERVICE VEHICLE LINK FIGURE 6.4



Source : Ref. 6, Fig. A10

PLAN SHOWING UNDERGROUND SERVICES & KERB LAYOUT AT A JUNCTION

FIG 6.5

7 ALIGNMENT, CURVATURE AND GRADIENT

7.1 HORIZONTAL ALIGNMENT

7.1.1 General philosophy

Local residential streets should be designed to discourage operating speeds higher than 40km/h. Along with other aspects of design such as street length and width, curvature is one of the elements which can be used to restrict speed. If the straight approaches to the curves are short, so that the build-up of speed is limited to about 40km/h,then low radius curves can be safely negotiated with a small reduction of speed. Thus it is **the combination** of length of approach to curves, forward visibility through the curve and the curve centre line radius that is the important issue for safe design.

7.1.2 Minimum radius for horizontal curves and superelevation

The relationship between curve radius and speed can be represented by the following formula:

$$R = \frac{V^2}{127\,(e+f)}$$

where R = radius of curve in metres

V = design speed in km/h

e = superelevation rate in metres per metre

f = side friction factor

127 = a constant for metric units

Horizontal curves on low-speed residential streets are usually designed without superelevation because of various factors such as property access, drainage considerations and frequency of intersections, which makes its use impractical.

The recommended method for counteracting the effects of centrifugal force in local residential street design is to introduce superelevation only after all available side friction is utilised. Ref. 7. The values used for side friction in the higher order streets are more concerned with driver comfort than with limiting friction between tyres and roadway. In local street design, where driver comfort is of less importance, partly because of short trip lengths, higher values of side friction factors can be accepted. Table 7.1 shows the values of the side friction factor, f, recommended for low-speed urban roads by AASHTO.

TABLE 7.1

Side friction factors for various speeds

Speed (km/h)	Side friction factor f
20	0,35
30	0,30
40	0,25
50	0,22
60	0,18

Source : Ref. 7. Chapter III

Where superelevation is used the maximum rate should be 0,04.

Figure 7.1 gives the maximum safe and comfortable speeds for horizontal curves on low-speed local residential streets, for superelevation rates varying between -0,040 and +0,040.

7.1.3 Transition curves

Transition curves need not be used on local residential streets.

7.1.4 Superelevation run-off

There are a number of procedures that can be used to achieve transition from normal camber to superelevation, but the procedure preferred for local residential streets is to rotate about the centre line of the roadway. The basic principles are to achieve visually smooth transitions and to maintain proper drainage run-off.

Length of run-off is determined by the relative difference in grade of the centre line profile and the roadway edge profile. For low-speed residential streets, relative differences of between 0,5% and 1,0% are generally acceptable.

7.1.5 Lane widening

Lane widening is not generally required on residential local streets unless roadway width is less than 5,0m. The turning template given in Figure 3.1 can be used to determine width requirements for manoeuvrability of larger vehicles on low radius curves.

7.1.6 Sight distance on horizontal curves

As local residential streets are often not designed to allow for the completely unhindered passage of larger vehicles on horizontal curves, it is necessary to provide sufficient forward visibility to enable vehicles to slow down or even stop in cases where curves do not provide sufficient clearance.

A method for constructing forward visibility curves based on stopping sight distance is given in **Figure 7.2**. Ref. 15.

7.1.7 General horizontal alignment controls

When considering the design of horizontal alignment for local residential streets, the relationship between curve radius, speed, forward visibility and roadway width, for given roadway widths and vehicle approach speeds, must be taken into account.

In order to make appropriate use of this relationship in the design process, the following factors should be considered by the design engineer:

(i) The length of approaches to curves should be restricted so that the build up of speed is limited to about 40km/h.

(ii) Curve radius should be selected to help control speed but should be appropriate for anticipated approach speed. Minimum radii should only be used where approach speed has been effectively controlled.

(iii) As roadway width on curves is not designed to allow the unhindered passage of larger vehicles, sufficient forward visibility must be provided to allow approaching vehicles to slow down or stop.

(iv) Abrupt reversal of alignment should be avoided, short tangent sections should be used between curves.

(v) Broken back" curves (where two curves in the same direction are separated by a short tangent) should be avoided because they are contrary to the driver's expectations.

(vi) Alignment should be consistent and coordinated with vertical profile. Sudden changes from large radius curves to small radius curves should be avoided.

(vii) The total deflection angle of curves should not exceed 90°.

(viii) For small deflection angles, curves should be sufficiently long to avoid the appearance of a kink.

(ix) Alignment should follow the existing topography to minimise the need for cuts and fills without reducing safety.

7.2 VERTICAL ALIGNMENT

Vertical alignment is the combination of sections of uniform grades and parabolic vertical curves. The selection of rates of grade and lengths of vertical curves is based on assumptions about the characteristics of the driver, vehicle and roadway.

Vertical curvature may impose limitations on sight distances, particularly when combined with horizontal curvature. The gradient of tangent sections introduces forces which affect vehicle speed, driver comfort and the ability to accelerate and decelerate.

The vertical alignment should also be designed to be aesthetically pleasing. In this regard due recognition should be given to the inter-relationship between horizontal and vertical curvature. As a general guide, a vertical curve that coincides with a horizontal curve should, if possible, be contained within the horizontal curve, and should ideally be of similar length.

A smooth grade line with gradual changes appropriate to the class of road and the character of the topography is preferable to an alignment with numerous short lengths of grade and vertical curves.

7.2.1 Vertical curvature

The rate of vertical curvature, K, is the distance required to effect a 1% change of grade. Vertical curves are specified in terms of this factor, K,

$$K = \frac{L}{A}$$

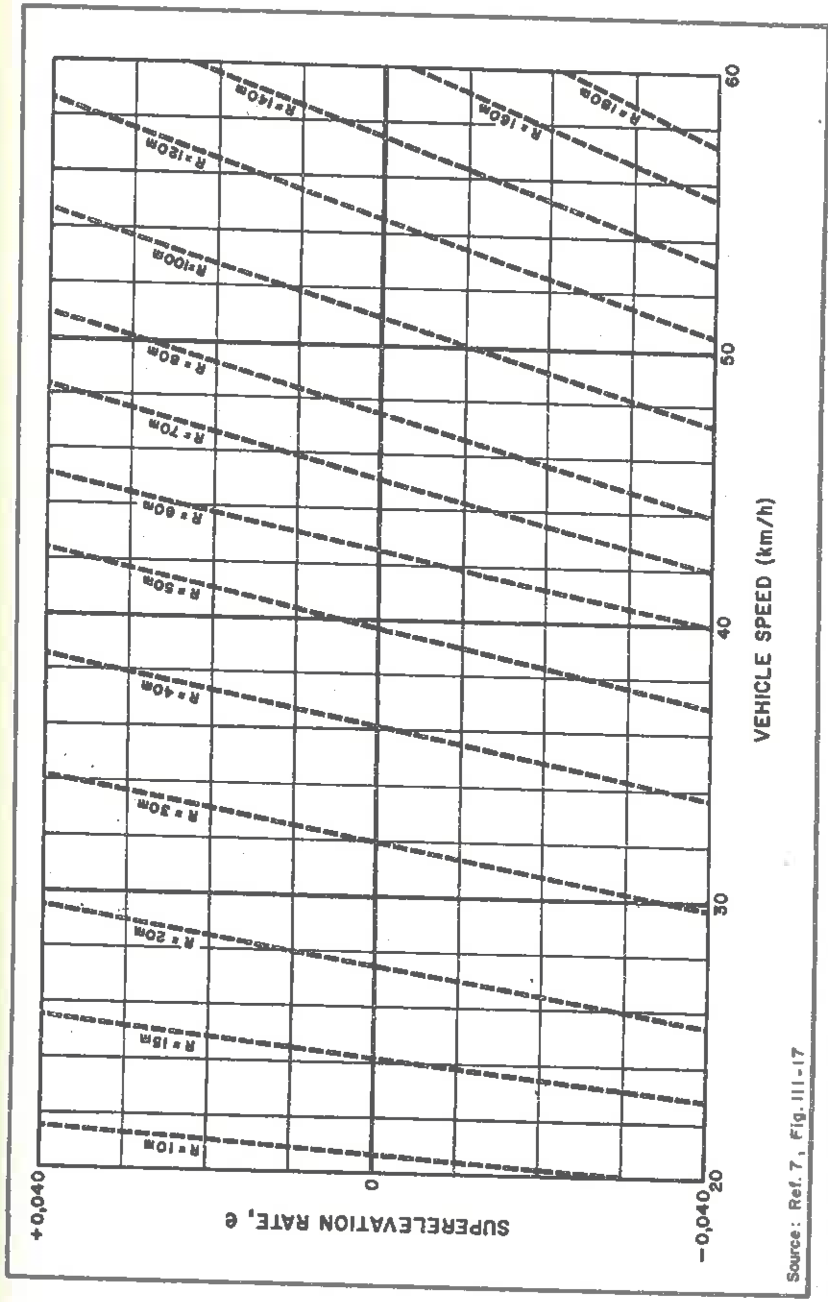
where L = length of vertical curve in metres

A = the algebraic difference between grades in percentage

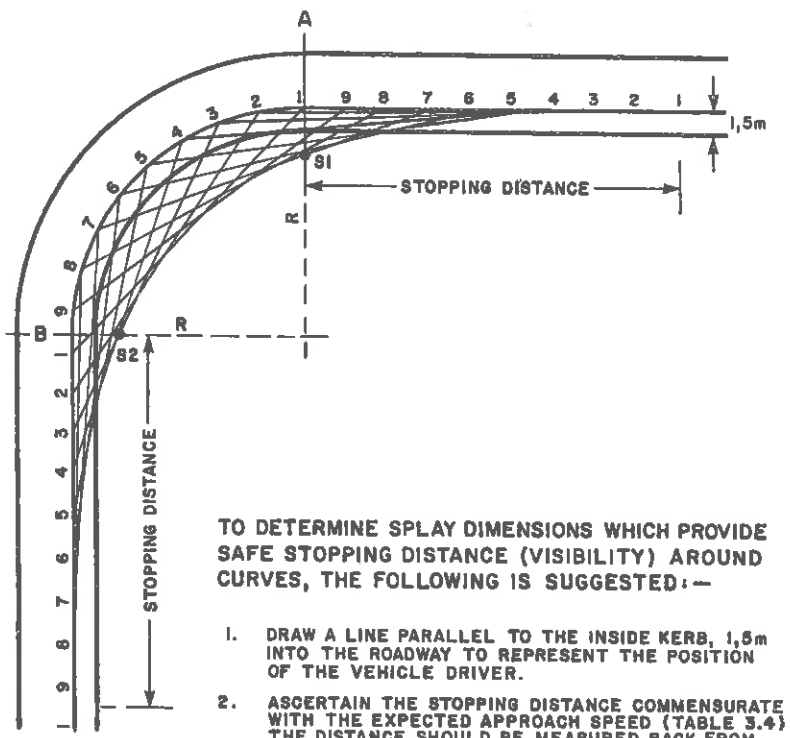
The minimum rate of curvature is determined by sight distance as well as by considerations of comfort of operation and aesthetics. The sight distance criterion generally applied is the stopping sight distance as discussed in Section 3.4.1 of this document. In the case of sag curves, the sight distance is replaced by a headlight illumination distance of the same magnitude, assuming a headlight height of 0,6m and a divergence angle of one degree above the longitudinal axis of the headlights.

Where adequate streetlighting prevails, the headlight criterion does not apply since the driver is able to see further ahead than headlights illuminate. Under these conditions, sharper curves can be introduced and comfort is the criterion that limits values.

Values of K, based on stopping sight distance in the case of crest curves, and headlight illumination distances and comfort in the case of sag curves, are given in Table 7.2.



MAXIMUM SAFE AND COMFORTABLE SPEEDS FOR HORIZONTAL CURVES FIGURE 7.1



TO DETERMINE SPLAY DIMENSIONS WHICH PROVIDE SAFE STOPPING DISTANCE (VISIBILITY) AROUND CURVES, THE FOLLOWING IS SUGGESTED:—

1. DRAW A LINE PARALLEL TO THE INSIDE KERB, 1,5m INTO THE ROADWAY TO REPRESENT THE POSITION OF THE VEHICLE DRIVER.
2. ASCERTAIN THE STOPPING DISTANCE COMMENSURATE WITH THE EXPECTED APPROACH SPEED (TABLE 3.4) THE DISTANCE SHOULD BE MEASURED BACK FROM THE TANGENT A.
3. DIVIDE THE STOPPING DISTANCE INTO EQUAL INCREMENTS OF APPROXIMATELY 3m AND NUMBER THESE
4. REPEAT AROUND THE CURVE, FINISHING AT A FULL STOPPING DISTANCE BEYOND THE TANGENT POINT B.
5. THE AREA WHICH IS TO BE KEPT CLEAR OF OBSTRUCTION SHOULD THEN BE CONSTRUCTED BY JOINING INCREMENTS OF THE SAME NUMBER TOGETHER, i.e. 1 TO 1, 2 TO 2 etc.
6. THE MINIMUM SPLAY (RESERVE WIDTH UNKNOWN) IS THE POINT AT WHICH THE SIGHT LINE CROSSES THE TANGENT RADIUS LINE (i.e. S1 AND S2)
7. THE USE OF THIS PROCESS IS ESSENTIAL WHERE THERE ARE NARROW VERGES. SIGHT LINES SHOULD BE KEPT FREE OF OBJECTS MORE THAN 0,6m HIGH.

Source: Ref. 15, p. 62

A METHOD OF CONSTRUCTING FORWARD VISIBILITY CURVES — FIGURE 7.2

TABLE 7.2

Minimum values of K for vertical curves

Speed (km/h)	Stopping sight distance (m)	K		
		Crest	Sag	
			Headlight	Comfort
20	18	1	2	2
30	30	1	2	2
40	45	2	6	4
50	65	6	11	6
60	85	10	17	8

7.2.2 Minimum length of vertical curves

Where the algebraic difference between successive grades is small, the intervening minimum vertical curve becomes very short, and, particularly where the tangents are long, this can create the impression of a kink in the grade line. For local residential streets where the difference in grade is less than 2,0 per cent, the vertical curve can be omitted. For algebraic differences in grade greater than 2,0 per cent, minimum lengths are suggested in Table 7.3 for purely aesthetic reasons.

TABLE 7.3

Minimum lengths of vertical curves

Design speed (km/h)	Length of curve (m)
20	20
30	20
40	30
50	30
60	40

7.2.3 Maximum gradients

For local residential streets, maximum gradient is a function of road classification and design speed, but in addition it also has a significant effect on the cost of township development. Where possible road alignment should be designed to minimise the extent and cost of earthworks on adjacent land to avoid problems with access, house design and general property development. In the light of this it is accepted that short sections of steep gradients may be necessary in some township developments.

The recommended maximum gradients for the different classes of local residential roads are given in Table 7.4. Notwithstanding the values given, the following important points should be taken into consideration.

(i) Gradients for a particular township should be selected in consultation with the stormwater design engineer.

(ii) Steep gradients on short access loops and culs-de-sac can result in stormwater drainage problems; in the case of culs-de-sac property may be inundated or surface run-off wash across intersecting roads. Consequently, wherever possible, culs-de-sac should follow the contours of the land.

(iii) Access courts, which are multiple-use surfaces, should be flat to provide play-spaces for children and safe parking for vehicles.

(iv) In areas where cycling is an important mode of travel it may be necessary to consider the effects of gradients on cycling in deciding on the road alignment. The Department of Transport has produced a *Manual for the Planning and Design of Bicycle Facilities in Urban Areas* which should be referred to in this regard. Ref. 14.

TABLE 7.4

Maximum gradients

Road class	Recommended maximum gradient %)	Maximum gradient over short sections Gradient (%)	Maximum length (m)
a) Major residential access link	10	12,5	70
b) Access loop	12	16	50
c) Access cul-de-sac	12	16*	50
d) Access way	12	16	30
e) Access court	4	N/A	N/A
f) Access strip	12	16	30

* The last 20m towards the turning area of the cul-de-sac should have a gradient **not exceeding 5%.**

7.2.4 Minimum gradients

The recommended minimum gradient is 0,4 per cent, ie 1 in 250, but this should be only decided upon in conjunction with the stormwater drainage design.

7.3 VERTICAL CLEARANCES

The standard minimum vertical clearance from any point in a roadway to an overhead structure or cable is 5,1m. However, many special circumstances require specific vertical clearances either above or below the road surface. These clearances have to be determined in consultation with the appropriate authority. For example, when a road passes under a high voltage line, special clearances are necessary under the Machinery and Occupational Safety Act, 1983, No. 6, 1983. Ref. 17.

Vertical clearances for bicycles should be 2,6m minimum and for pedestrians 2,2m minimum.

7.4 HORIZONTAL CLEARANCES

The minimum horizontal clearance for service poles, road signs etc, is 0,5m from the roadway edge. Where possible, sight triangles at intersections should be kept clear of all obstructions.

8 INTERSECTIONS

8.1 PRINCIPLES GOVERNING INTERSECTION DESIGN

Figure 8.1 shows a variety of intersection forms relating to the principles which should govern intersection design and are detailed below:

(i) There should be a continuous gradation in function from one level of the hierarchy to the next, avoiding intersection between high and low order roads.

(ii) Roads should generally intersect only with other roads one level above or below them in the hierarchy.

(iii) Crossroads, because of the number of conflict points, are generally the most dangerous (see **Figure 8.2**) and should normally be avoided except:

- at main entrances to the township where the volume of cross-traffic is sufficient to warrant the installation of traffic signals or roundabouts;
- where cross-traffic is minimal and where volumes and speeds are extremely low, such as where there are short culs-de-sac off a major access link.

(iv) Where there is cross-traffic and relatively low volumes occur on the major road, a discontinuity by means of a staggered cross-road may be considered, with the right-left stagger being favoured (**Figure 8.3**). The right-left stagger is preferred because it avoids hooking movements and minimizes delay to traffic on the main road. For staggered cross-roads to work effectively, depending on the amount of cross traffic envisaged, they should be staggered by at least the minimum "opposite" spacing given in Table 8.1.

(v) T-intersections are the preferred intersection type for roads in residential areas. As a general rule, the major flow should be on the straight section or "through" road as this accords automatic priority. However, there may be special situations where it is necessary to slow the major flow by forcing traffic to turn or, at the head of a closed system, it will be necessary to place the busier road in the foot of the T. Cross traffic will be negligible in the latter situation.

(vi) The preferred angle of intersection is 90° but the minimum angle of intersection of T-junctions should be 70° to preserve adequate sight lines and to avoid awkward erf shapes in subdivision. The layout of the intersection should preserve the continuity of the higher order road, thus Y-junctions are not recommended.

(vii) The recommended junction spacings for local streets are summarised in Table 8.1. Class 5 c, e and f roads are closed systems so there will seldom, if ever,

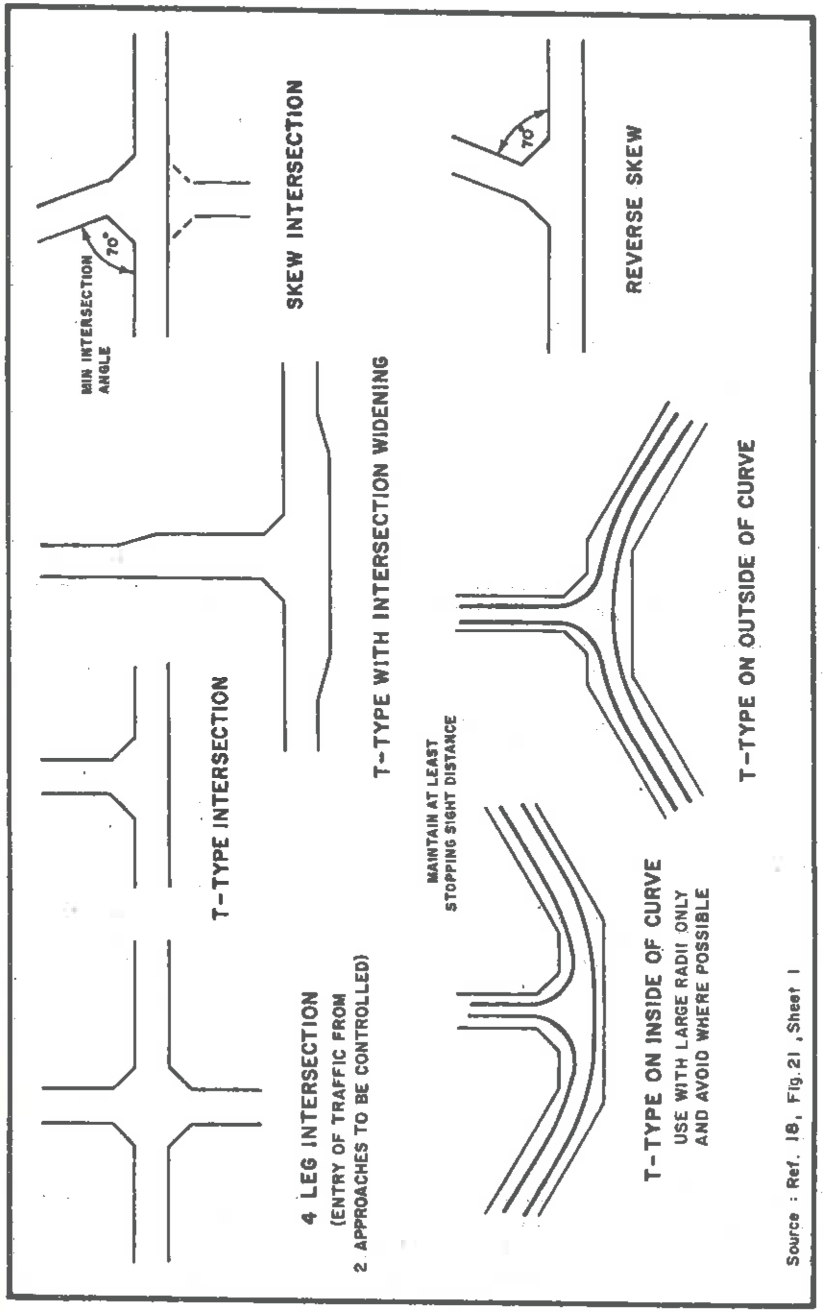
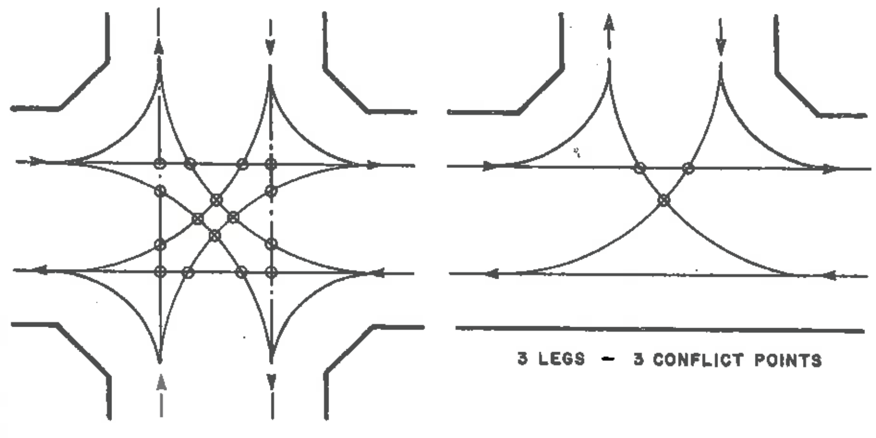
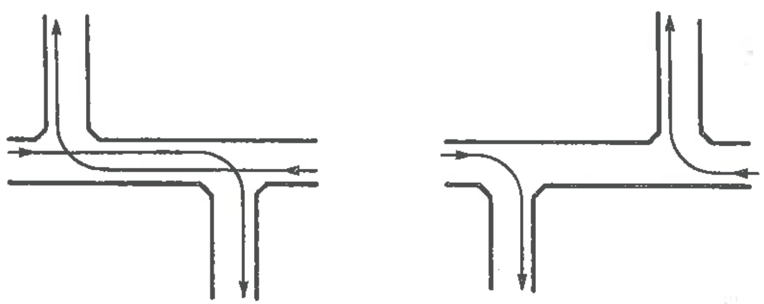


FIGURE 8.1 INTERSECTION FORMS



POTENTIAL CONFLICT POINTS IN CROSS-AND T-INTERSECTIONS FIG 8.2



HOOKING MOVEMENTS AT STAGGERED CROSS-ROADS FIG 8.3

be intersections on these roads. However, where for example access strips are provided off culs-de-sac or access loops, junctions should be spaced the width of two erf frontages if adjacent and one erf frontage if opposite.

TABLE 8.1

Intersection spacing (centre line to centre line)

Road class		Minimum intersection spacing along the road (m)	
		Adjacent	Opposite
a)	Major residential access link	60	30
b)	Access loop	40	20
c)	Access cul-de-sac	N/A	N/A
d)	Access way	40	20
e)	Access court	N/A	N/A
f)	Access strip	N/A	N/A

Source : Ref. 6, pB96.

(viii) The road layout should consistently give automatic right-of-way on the higher order road, ie the straight or continuous section should be used for the higher order road. This will ensure that the traffic flow at intersections is self-regulating.

(ix) To ensure that intersections do not join the list of "hazardous locations", their surroundings must conform to geometric design standards. Thus, land uses which generate traffic or parking problems should have access points well away from intersections. Driveways are in effect at-grade intersections and should not be situated within the "functional boundary" of at-grade street intersections. Higher volume driveways should therefore be sufficiently far away from the intersection to avoid blocking off ingress movements. Ref. 16.

8.2 SIGHT TRIANGLES AT INTERSECTIONS

To enable drivers emerging from the stem or side-road to see and be seen by drivers proceeding along the through road, unobstructed visibility is required within what is known as a "sight triangle". This triangle is formed by the driver's eye at the apex and the stopping distances on either side of the stem-road which forms the base. The construction of this sight triangle is shown in **Figure 8.4** and the recommended x and y dimensions are given in Table 8.2. Ref. 6.

For all local residential street intersections, the minimum x dimension of 2,4m may be applied. This enables the driver of a stationary vehicle on the stem-road to see down the through-road without encroaching onto it. Within the residential road network, where traffic flows are low and where the need to avoid delay is of low priority, the y dimension may be based on the expected speed of the vehicle on the through road and hence on the distance required for it to slow down or stop in order to avoid collisions with vehicles emerging from the stem.

At all junctions, the sight triangle should be kept clear of obstructions, including street furniture and landscape elements. However, objects less than 0,6m in height, such as street name signs, may be placed in the triangle.

TABLE 8.2

Recommended sight triangle dimensions

Through road class		X and Y dimensions (m)	
		x	y
a)	Major residential access link	2,4	45
b)	Access loop	2,4	35
c)	Access cul-de-sac	2,4	35
d)	Access way	2,4	-
e)	Access court	N/A	N/A
f)	Access strip	N/A	N/A

Source : Ref. 6, p.B99.

8.3 INTERSECTION RADII

As the kerb radius increases, so do paving costs and the intersection area required for a pedestrian to traverse, and higher turning speeds are encouraged. Conversely sub-standard radii result in lane encroachment which leads to increased traffic conflict and accident potential. Four potential conflict points which may result in delay, inconvenience or accidents are shown in **Figure 8.5.**

The extent to which such potential conflicts need to be avoided, and thus the choice of radius, will depend on the composition of traffic and the likely frequency of passing movements at intersections. If the layout design principles described in Section 4 of this document are adhered to, the dominant vehicle type will be the private car. The need to design intersections to facilitate the passage of two large vehicles, or even a large vehicle and a small vehicle, is rarely warranted for residential streets except at

the entrance to residential cells and between collectors and local streets. It is recommended, therefore, that intersections on local residential streets need only provide for the passage of two standard design passenger cars.

A range of intersection radii recommended for general application is given in Table 8.3. It should be noted that the choice of radius should correspond to the specific situation but those given are recommended as suitable to improve manouevrability of larger vehicles at the intersections of narrow roadways. No special intersection design features, such as tapers, turning lanes, turning roadways, etc, are warranted for local streets in residential areas.

TABLE 8.3

Kerb radii at intersections

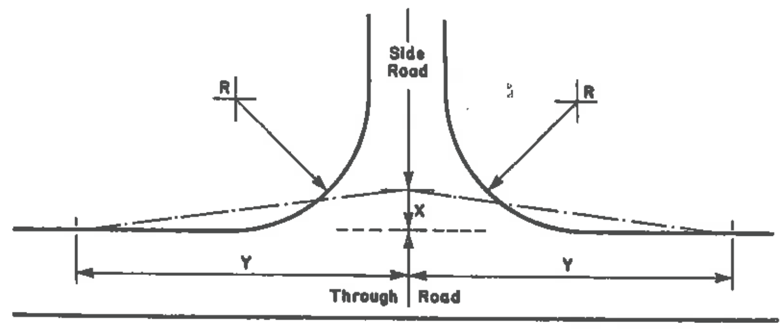
Major road		Recommended radius (m) for varying minor roadway widths (m) of:				
		6,0	5,5	5,0	4,5	3,0
Collector width (m):	8,0	10,0	12,0	N/A	N/A	N/A
	7,4	10,0	12,0	N/A	N/A	N/A
	6,8	12,0	12,0	N/A	N/A	N/A
Major residential access link width (m):	6,0	N/A	4,2-6,0	4,2-8,0	8,0-10,0	10,0
	5,5	N/A	4,2-8,0	6,0-8,0	8,0-10,0	10,0
Other local residential roads width (m)	5,5	N/A	4,2-8,0	4,2-8,0	6,0-8,0	10,0
	5,0	N/A	4,2-8,0	4,2-8,0	6,0-8,0	10,0

Source : Ref. 6, p.B102

The standards recommended in Table 8.3 are based on the following assumptions and considerations:

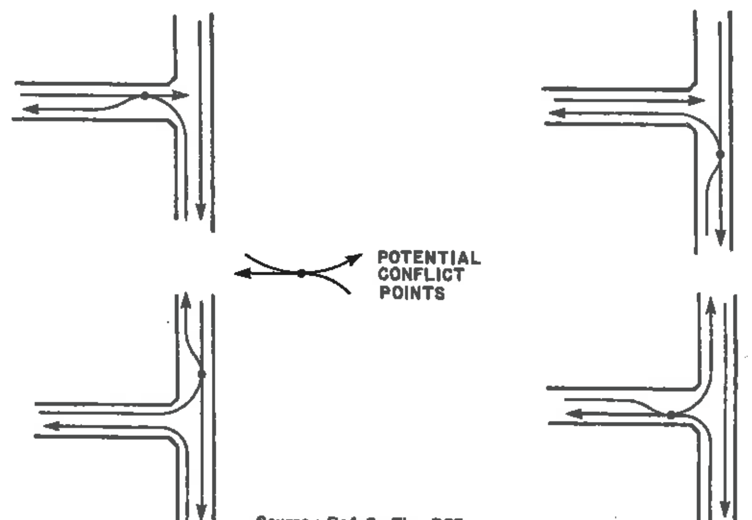
(i) On collectors, delays caused by turning vehicles should be minimal. The kerb radius at collectors/locals intersections should, therefore, enable a large rigid-chassis vehicle, such as a refuse vehicle, to turn into or out of the lower order road without over-tracking kerbs or crossing the centre-line. (See **Figure 8.6a.**)

(ii) Major access link/loop intersections will generally experience relatively low peak volumes of private vehicles travelling mostly in one direction. The kerb radii, therefore, need only facilitate the simultaneous passage of two standard design cars, but will also facilitate turning movements by larger vehicles with minor delays. If over-tracking is to be avoided with low radii, it is essential that barrier



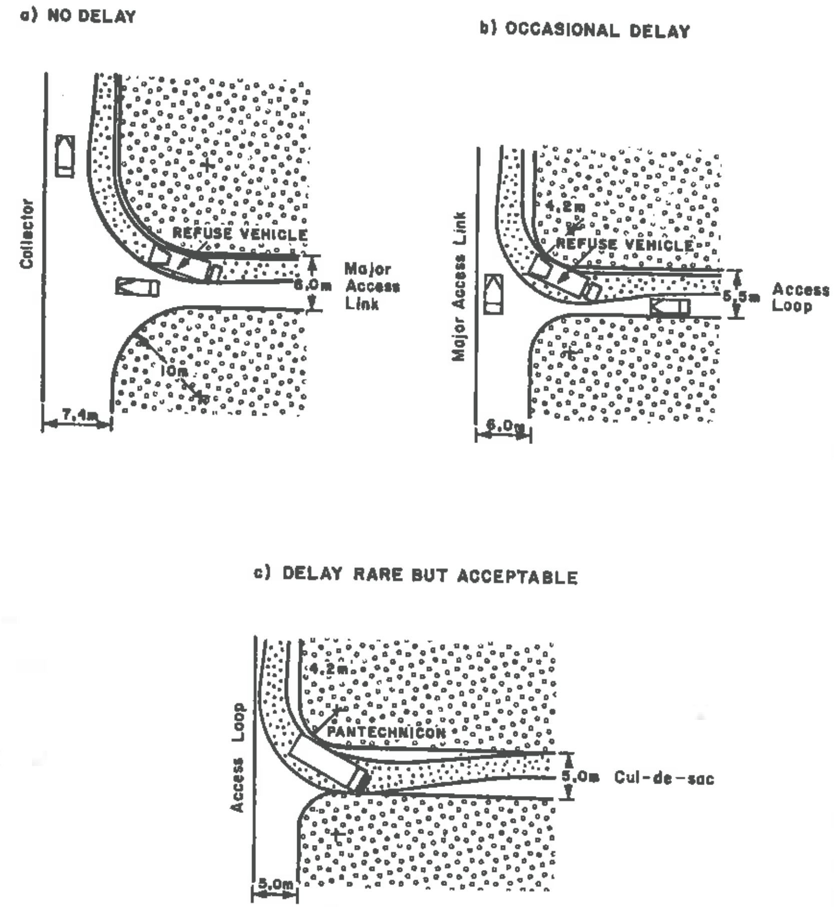
Source : Ref. 6, Fig. B54

X AND Y DIMENSIONS FOR SIGHT TRIANGLES AT INTERSECTIONS FIG 8.4



Source : Ref. 6, Fig. B55

THE EFFECT OF KERB RADII ON VEHICLE TURNING MOVEMENTS FIG 8.5



Source : Adapted from Ref. 6, Fig. B 56

ILLUSTRATIONS OF INCREASING ACCEPTABILITY OF DELAYS AT INTERSECTIONS ON LOWER ORDER ROADS FIG 8.6

kerbs be provided at these intersections where the minimum radius is used. (See **Figure 8.6b**).

(iii) All other local street intersections do not need to provide for the simultaneous passage of a pantechnicon and a car, but should allow for the entry of refuse and other heavy vehicles without overtracking of either the nearside or offside kerb. (See **Figure 8.6c.**)

8.4 THE APPROACH TO INTERSECTIONS

It is desirable for all intersections to meet at approximately 90°. Skewed intersections should be avoided and in no case should the angle be less than 70°. Studies have shown that skewed intersections have generally higher accident rates than those intersecting at 90°. On difficult sites the intersecting road may need a small radius curve in order to reduce the skew of the approach. It is desirable, however, to provide a tangent section of roadway approaching the intersection of at least the length of two or three cars. For a safe approach there should not be a long stretch leading up to the curve to encourage excessive speeds.

It is desirable for gradients to be flatter on the approaches to intersections, whether uphill or downhill, than the maximum permitted gradient for that class of road. Where practical the maximum grade on the approach leg should not exceed 5% for a minimum distance of 20m from the edge of the intersecting roadway.

Pedestrian and vehicular routes converge at intersections, therefore the design of kerbs should include scoops or ramps flush with the roadway to permit people with prams and wheelchairs to cross the roadway.

9 TURNING SPACES

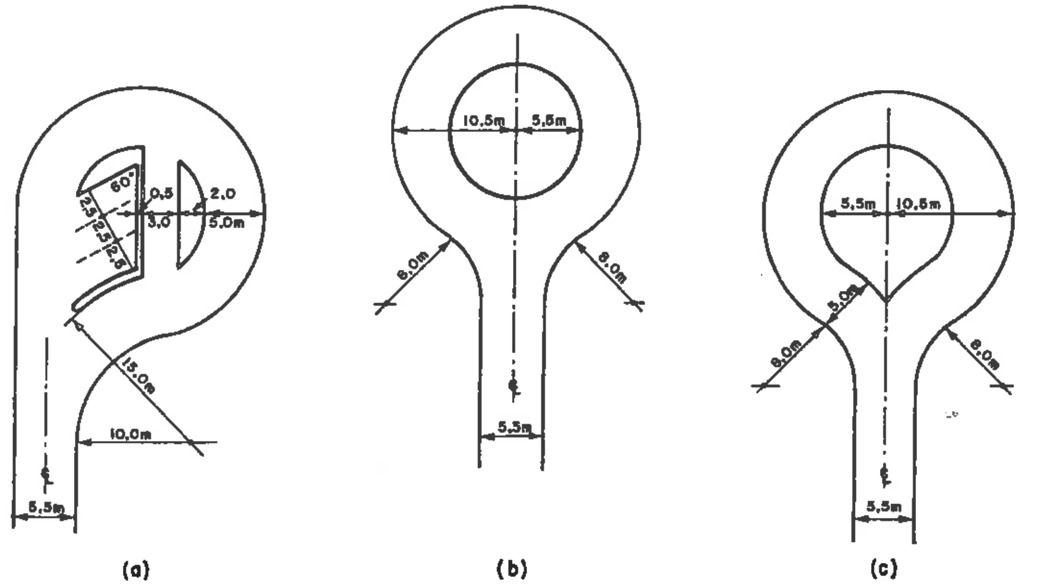
A local street open at one end only should have a special turning space at the closed end. The layout and dimensions of turning spaces should take into account the size and turning characteristics of the vehicles expected to use them and the need to avoid vehicles having to reverse over long distances. The turning characteristics of vehicles, which are discussed in Section 3 of this document, provide the minimum envelope required to accommodate the necessary movements. Consideration should be given, however, to the desirable tolerances and to the layout and type of kerb to be used.

Turning spaces can take the form of various configurations of turning circles (**Figure 9.1**) or "hammer heads" (**Figure 9.2**). There is a great divergence of opinion as to which form is preferable and as a guide to selection Table 9.1 lists some advantages and disadvantages of both basic forms. Turning circles are more appropriate at the end of longer culs-de-sac, and/or where there is more likelihood of frequent heavy vehicle movements and where features such as parking and landscaping are desired. Hammer heads are more appropriate to lower cost development where street length is shorter and there is less likelihood of heavy vehicle movements.

TABLE 9.1

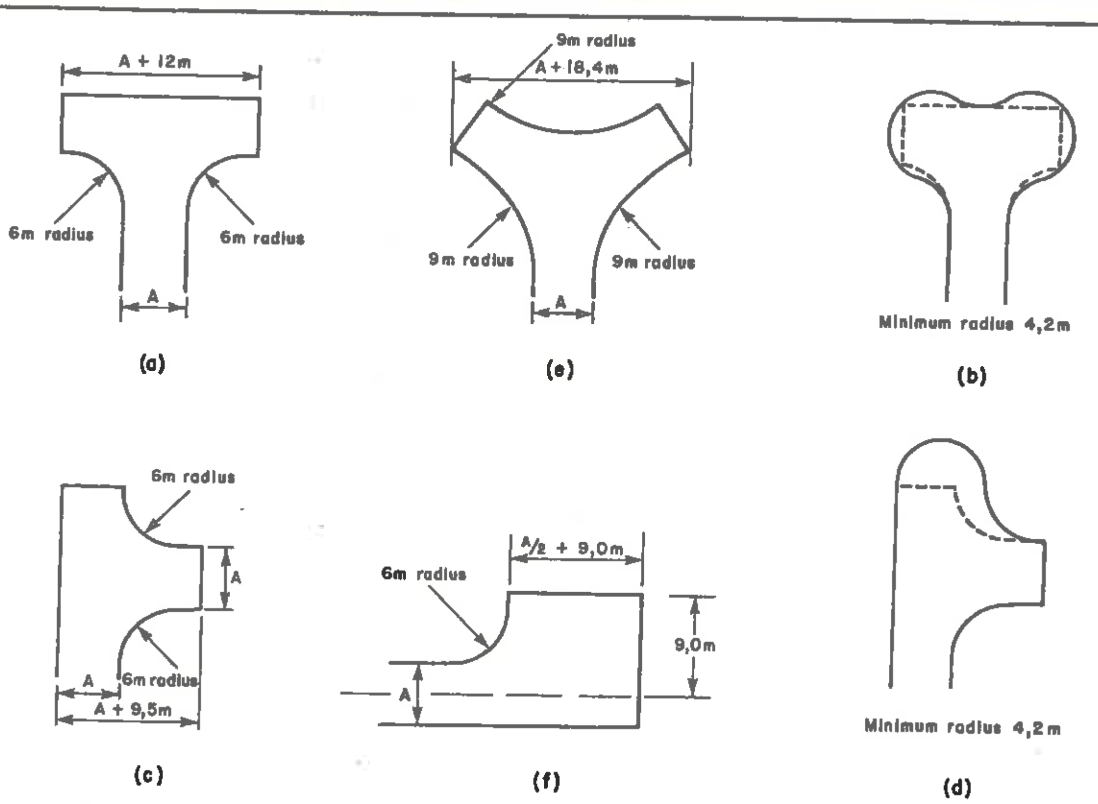
Advantages and disadvantages of the two basic forms of turning spaces

Form	Advantages	Disadvantages
Turning circles	1. Turning vehicles generally only proceed forwards, most vehicles should not need to reverse. 2. They can be designed to act, in effect, as small access courts serving as frontage to erven and providing space for parking, landscaping and play.	1. Require much greater road surface and are thus more costly to construct. 2. Require considerably more land for road reserve. 3. Can create sub-division problems if erven are very small.
Hammer Heads	1. Smaller road surface area thus cheaper to construct. 2. Require minimum amount of land for road reserve. 3. Subdivision easier where erven are very small.	1. Necessitate reversing which could be hazardous to property and children at play. 2. Not generally adequate to allow for parking or landscaping elements.



Source : Ref. 6, Fig. B57

DIMENSIONS OF TURNING CIRCLES ON CUL-DE-SAC — FIGURE 9.1



Source : Adapted from Ref. 6, Fig. B58

ALTERNATIVE DESIGNS FOR TURNING HEADS — FIGURE 9.2

9.1 TURNING CIRCLES

Recommended turning circle dimensions are given in Figure 9.1. Of the two types of turning circle the off-set type is preferred, with the approach to the head placed on the straight section as shown in Figure 9.1(a). The central island may be omitted, or planned to allow provision for parking and/or landscaping. Where the central island is used as shown in Figure 9.1(b) and (c) careful thought must be given to the design to avoid maintenance problems and damage by over-riding.

Reserve width should be related to underground services requirements and street lighting. It is not necessary to assign land for surface elements such as footways or parking strips, and the reserve need not have a constant width around the entire perimeter of the circle.

9.2 HAMMER HEADS

There are various forms of hammer head such as the T-, Y- or L-shaped configurations shown in Figure 9.2 with the appropriate dimensions. Where appropriate, the angularity of these features may be softened by the introduction of amorphous forms as shown in Figures 9.2(b) and (d) in order to conform with the informal character of the street.

10 DRIVEWAYS

Driveways connect public roadways to private property and in some cases to public property. Geometric design details of driveways vary considerably, depending on traffic demand and vehicle type. In locating and designing driveway connections to the public street system, attention should be given to the Town Planning Scheme or regulations applying to the local area.

The Institute of Transportation Engineers published *Guidelines for Driveway Design and Location* in 1974. Ref. 19. This a recommended reference work for the engineer involved in the detailed design of driveways.

10.1 DRIVEWAY TYPES

Although there are a number of driveway types, the most common to be found in the design of local residential streets will be the low-volume, motor-car type of driveway. This is therefore the only type described in more detail in this document. For more information on higher type driveways the reader is referred to *Draft Guidelines for the Geometric Design of Urban Collector Roads.* Ref. 2.

Low-volume, motor-car refers to the normal driveway serving low density residential properties, up to approximately 20 residential units per driveway.

High volume generators and petrol stations, which require higher type driveways, should not be located on local residential streets.

10.2 DRIVEWAY LOCATION

In general, driveways should be located some distance away from intersections to avoid confusion and conflict between turning movements. The distance varies with the complexity of the nearest intersection and whether right turn movements in and out of the driveway are required. The distance will also be greater if the driveway volumes are high and queues are formed by the entering traffic.

The recommended minimum distance between low volume, motor car driveways and the near road reserve boundary of a crossing road is 10m on an approach to an intersection and 10m on lanes leading away from an intersection. Where the approach is to a signalised intersection, the minimum distance should be 20m. Ref. 18, Fig. 31.

10.3 SIGHT DISTANCES AND DRIVEWAYS

Sight distance at driveway entrances should be regarded in the same manner as at intersections and as discussed in Section 8.2 of this document. For low volume motor car driveways the value of X should generally be 2,7m and the value of Y as given in Table 8.2. The slightly larger value for X allows for the fact that vehicles generally reverse onto the street from private driveways.

Where the on-site design is such that reversing is unnecessary or operating speeds do not generally exceed 30km/h, X may equal 2,4m.

As with intersections, the sight triangle formed by X and Y (both sides of driveway entrance) should be kept clear of obstructions, including street furniture and landscape elements. Objects less than 0,6m in height may however be placed in the triangle.

10.4 DRIVEWAY GEOMETRICS

For low volume driveways such as those to private residences and small residential complexes, it is common practice not to form an intersection with kerb returns. It is preferable simply to form the driveway up to the back of the mountable kerb on the main road. Sometimes a gentler ramp to make up a kerb height of 150mm over 600mm from the channel line is used. An example of a low volume vehicle entrance at a barrier kerb is shown in **Figure 10.1**.

Typical driveway widths are given in Table 10.1. Widths are measured at and parallel to the road reserve boundary.

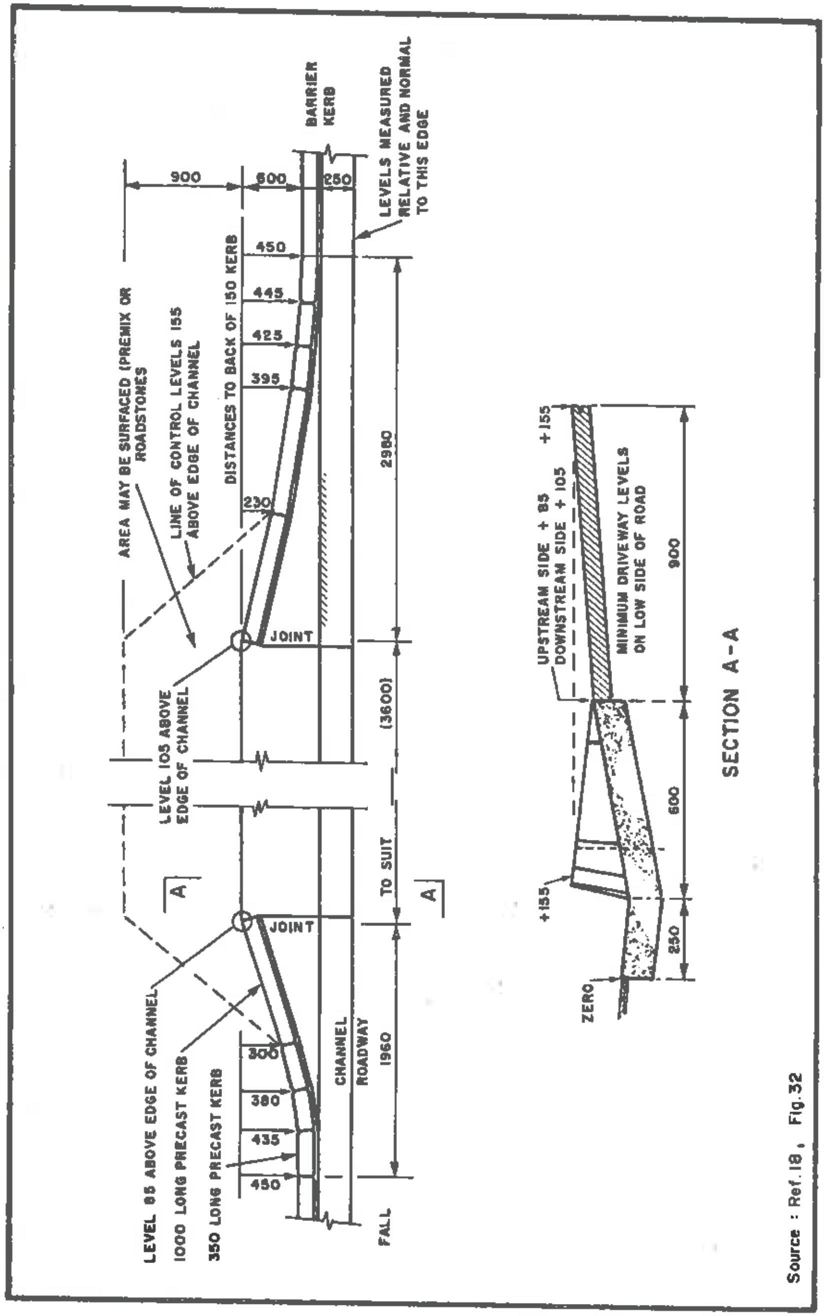
TABLE 10.1

Typical driveway widths

Description of driveway		Width (m)
Residential	Single family	3
	Low density (10 units)	5
	Medium density (20 units)	6

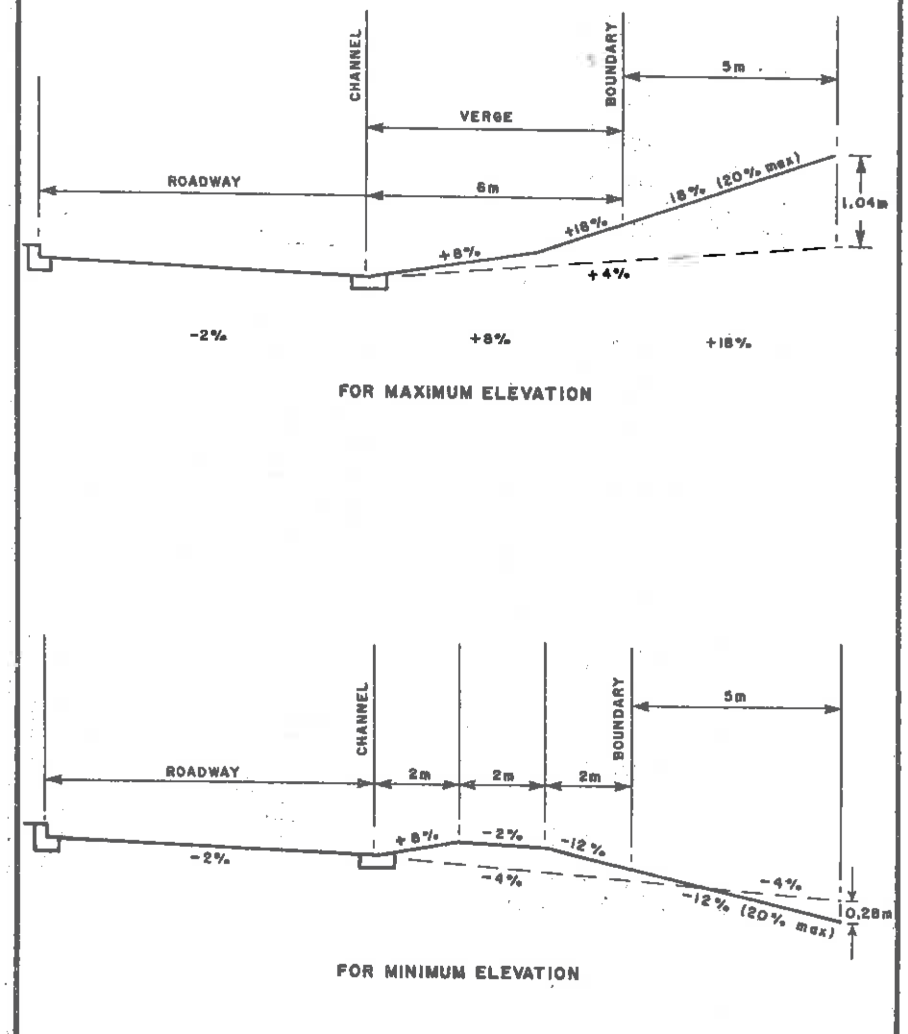
For all driveways the maximum width at the roadway edge should be 9m.

The profile or longitudinal section of a driveway may be quite complicated, particularly near the intersection with the main road. Consideration should be given to avoiding drainage run-off from the road down the driveway, to cross falls on the sidewalk of the main road, to a reasonably level storage area for one or more vehicles waiting to gain



VEHICLE ENTRANCE AT BARRIER KERB

FIGURE 10.1



Source: Ref. 2, Fig. 9.2

TYPICAL DRIVEWAY PROFILES — FIGURE 10.2

access to the main road, to sight distance, and to vehicle underside clearances over sharp breaks in grade.

Whereas most motor cars can operate on 20 per cent (1:5) gradients, the Institute of Transportation Engineers recommends gradients of no more than 15 per cent for residential driveways. Changes in grade from one section of profile to the next should not exceed 8 to 10 per cent without an intervening blending grade or vertical curve the length of the wheelbase of a typical vehicle. National Building Regulations require that the last 5m of a ramp or driveway closest to the road reserve boundary should not exceed a 4 per cent gradient. Whereas this is usually desirable and corresponds to a normal maximum gradient of 4 per cent across a verge, the requirement could be unduly restrictive in conditions of severe topography. Typical driveway profiles are shown in **Figure 10.2.** These show details that will work adequately for normal residential access in severe topography conditions. If requested, a local authority may permit deviation or grant exemption from building regulations. Ref. 20.

11 PARKING

11.1 POLICY

A number of studies overseas have shown that the presence of parked vehicles is a significant factor in accident potential on all types of streets and particularly in accidents involving pedestrians (mainly children) in residential areas. It is important that cars should not be parked within sight triangles at intersections or on roadways. Cars are left in dangerous and unsuitable places if the supply or location of parking spaces is inadequate.

The policy should therefore be to minimise the use of roadways for parking and to provide sufficient parking which is convenient to use and closer to destinations than alternative parking on the roadway. This is especially the case in higher density developments and at local shops.

11.2 PROVISION OF PARKING

The amount of car parking to be provided will vary with the level of car ownership and the requirements of the local town planning scheme. The following parking needs have been identified and should be taken into account in the detailed planning stage;

(i) Residents
- long stay, eg overnight or during repair
- short term, eg lunch time or during car washing

(ii) Visitors
- long stay, eg for the evening or a weekend
- short term, eg to deliver a message or have lunch

(iii) Service vehicles
- long stay, eg furniture vans or builders vehicles
- short term, eg refuse collection or milk delivery

There can also be a need for temporary parking associated with the renewal and maintenance of services. In this regard there should be liaison with the local authority and the statutory contractors.

11.2.1 Off-street parking

The Department of Transport has recommended the following minimum standards for off-street parking in residential areas:

TABLE 11.1

Summary of recommended minimum standards for off-street parking

Land use	Standard
1. Residential dwelling units, general residential	
(i) Dwelling unit of 1 habitable room	1,0 space/unit
(ii) Dwelling unit of 2 habitable rooms	1,0 space/unit
(iii) Dwelling unit of 3 habitable rooms	1,25 spaces/unit
(iv) Dwelling unit of 4 or more habitable rooms	1,5 spaces/unit
(v) Visitors	0,5 additional space/unit
2. Old-age homes, orphanages, etc	0,3 space/habitable room
3. Places of worship	0,15 space/seat
4. Educational	
(i) Nursery school	1 space/class room or office*
(ii) Primary school	1 space/class room or office*
5. Recreation, sport and entertainment	
(i) Community centres	2 spaces/100m² GLA
(ii) Halls	0,25 space/seat or 20 spaces/100m² GLA

* Plus sufficient on- and off-loading area.

Source : Ref. 9.

It is recognised that the number of habitable rooms may not be the best indicator of car ownership and parking demand in residential townships, and the designer is urged to use discretion when applying this recommendation.

For single dwelling residential sub-divisions in low and medium density residential areas, the following rates of parking provision are recommended (including verge parking).

(i) **High car ownership** (high and middle income)
Standard : 4 spaces
Basic Minimum : 3 spaces

(ii) **Lower car ownership** (low income)
Standard : 3 spaces
Basic Minimum : 2 spaces

In addition to the above it is recommended that parking for visitors be provided at the rate of 2 spaces in areas of high car ownership and 1 space in areas of low car ownership.

11.2.2 On-street parking

On-street parking by visitors may be acceptable if the roadway is sufficiently wide to allow for adequate vehicle movement as well. This should however be regarded as the exception rather than the rule. Similarly short-stay, service vehicles such as milk floats and refuse collection vehicles, which do not remain stationary for long, are unlikely to cause hazards or inconvenience.

Parking strips and/or embayments in the road reserve are ineffective and expensive when erf frontages are very narrow because there is space for only one car between each driveway. It may be more efficient in this case to provide grouped visitor parking in the road reserve and for house-owners to park on-site.

Angle parking along the kerbs should never be allowed in local residential streets. The rate of accidents tends to be much higher than with parallel parking when the through traffic lanes are used for parking and unparking manoeuvres. Therefore all such bays and lots allowing for any parking other than parallel, should be physically separated from the roadway.

11.3 LOCATION OF PARKING

Regardless of the amount of provision made or the use of various measures to control parking, residents, visitors and service vehicle drivers usually park as near as is convenient to their homes and destinations, and problems of on-street parking arise if the roadway is more convenient to use than the parking spaces.

With multiple dwelling units it may not always be possible to provide parking for residents within the curtilages of the blocks, while at the same time providing sufficient private and common open space immediately around the buildings. It is often necessary to provide grouped hardstandings for both residents' and visitors' cars. Problems may arise if the parking spaces provided for visitors' cars and service vehicles are found more convenient by residents than their allocated garages or hard-standings. Such problems can lead not only to conflicts between users but to unacceptable levels of on-street parking and to blocked access for service vehicles.

While the aim must be to locate the parking spaces in well-distributed groups between the carriageways and the building entrances, or immediately opposite, it may in addition be necessary to locate, allocate and control the spaces so that the residents are assigned parking closest to their homes.

It must be emphasised, however, that experience has proved the difficulties of enforcement associated with all such formal methods of control and the importance of providing well-located parking spaces and permanent barriers to help ensure that such controls are unnecessary.

Another concern of motorists is security from vandalism and mugging. If on-site parking for both residents and visitors cannot be provided, public parking areas must be well-lit, well-trafficked and overlooked from adjacent buildings and roads.

In residential areas, parking spaces attract children as places for playing. It is therefore realistic to design areas such as access courts to be safe play areas. The design should encourage slow speeds. The turning spaces must give drivers a good view of all other road users, particularly drivers of heavy vehicles which may have to reverse.

Landscaping of parking areas which incorporate suitable shade trees will make them more attractive to motorists, particularly in hotter climates.

11.4 PROVISIONS FOR SERVICE VEHICLES

Problems are often encountered when parking spaces and turning areas provided for service vehicles are blocked by residents' or visitors' cars.

It is also common for emergency services such as ambulances and fire-fighting vehicles to find carriageways blocked by parked vehicles in schemes where inadequate provision for off-street parking is made and where the carriageways are too narrow. It is also in these situations that the greatest damage occurs to footways, kerbs and verges.

Long-stay service vehicles such as furniture removal vans will not visit very frequently and they may normally use the grouped visitors' or residents' parking spaces if located as conveniently to the homes as suggested above.

Special problems arise where grouped hardstandings must be located further away from the buildings than is required for access by service and emergency vehicles. The service access routes required in these situations will be used and sometimes blocked by residents' and visitors' cars unless formal controls are used at the entrance to the routes.

Again it must be emphasised that such formal control measures are difficult to enforce and that the best form of control is achieved by sensitive design and well-located parking spaces.

12 EXISTING TOWNSHIPS

This section is a summary of the information contained in The Influence of the Layout of the Road Network on Road Safety : A Literature Review. Ref. 21.

12.1 BACKGROUND

A feature which has a great impact on contemporary traffic circulation and safety is the gridiron street layout system used in many of the older residential townships. The consequence of this is that it is difficult to develop a natural road hierarchy. In many cases through-traffic on these residential streets, following the line of least resistance, makes every street a collector.

A number of studies both local and overseas have indicated that there is a definite correlation between traffic accident rates and road network features. It should be appreciated that an understanding of the role of the various elements of the network, in promoting safe circulation, is essential for urban network planning.

Among the unsuitable features that have been created by the old style of planning are:

- multi-leg (more than four), and acute angled intersections;
- frequent, closely spaced intersections between local streets and higher order roads;
- presence of through traffic on streets whose primary function is residential access;
- roadway lengths which encourage undesirably high speeds.

The limited-access type of residential township layout as proposed in these guidelines should provide a safer and more desirable operating environment for local traffic. A number of comparative studies have shown the following:

(i) Although limited-access layouts can have more internal intersections than gridiron layouts they show significantly lower accident rates.

(ii) Cross-roads which predominate in gridiron layouts experience much higher accident rates than T-junctions which predominate in limited-access townships.

(iii) Conversion of cross-roads to T-junctions in gridiron layouts yields a significant reduction in accident rates.

The implications of the above are that when planning new residential townships the designer must take great care how they are connected to adjacent older townships and that in certain cases existing gridiron layouts should be effectively converted into limited-access layouts.

12.2 BASIC PRINCIPLES

The most important basic principles which relate to the aforementioned are:

(i) Minimisation of conflict by:

- functional and modal separation of traffic;
- reduction of the number of intersections (especially cross-roads);
- reduction of the number of turning movements.

(ii) The creation of a logical and comprehensible traffic system which minimises the total demand for travel within the urban area by:

- control of land use;
- development of a road hierarchy.

In existing residential areas all roads should be classified according to function. In developing an efficient and safe function-related hierarchy, certain roads should be upgraded or improved to serve the demands of through movement, while others may be modified to suit their local, low speed character.

12.3 REMEDIAL MEASURES

Although it is not possible to redesign the entire urban traffic environment according to the principles described in these guidelines, with careful selection it is possible to achieve considerable benefits by alterations to the gridiron pattern.

The following are some of the ways of transforming a gridiron layout into a limited-access layout that conforms with the foregoing principles:

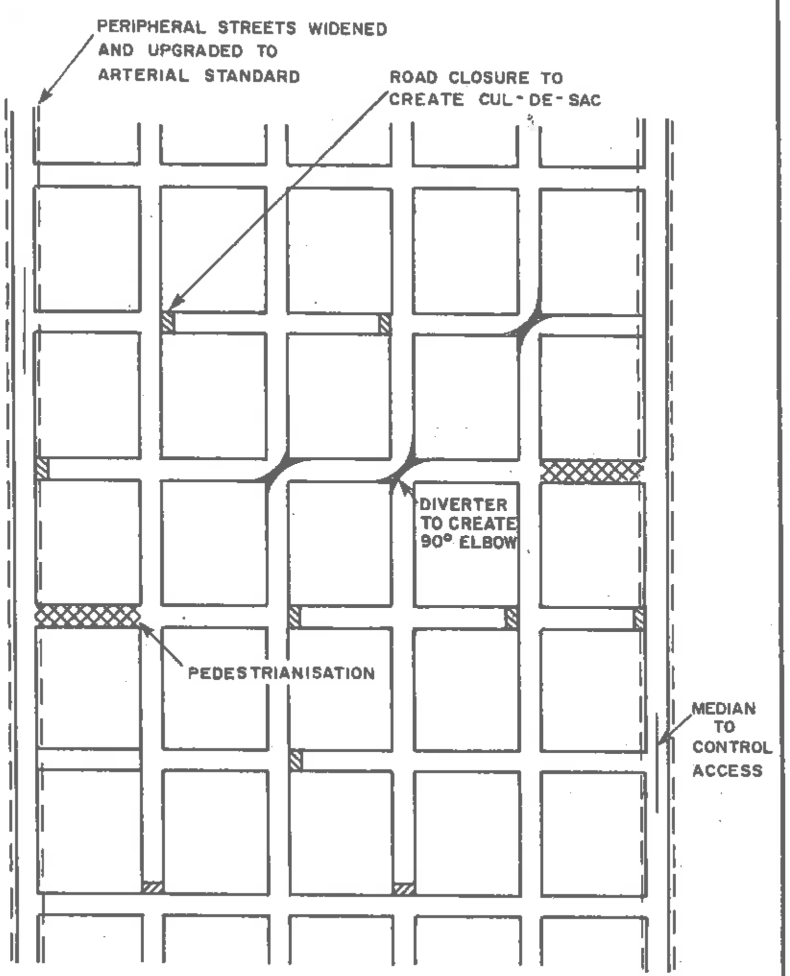
(i) As many streets as possible should be made discontinuous by pedestrianisation, creating culs-de-sac and elbows.

(ii) Capacity of peripheral arterial streets should be improved to enhance the mobility of through traffic.

(iii) Exits to the adjacent major road system should be located with regard to minimising movement within the subdivision.

(iv) Where there are frequent intersections with adjacent arterial routes, median islands in the arterials can be used to control the entry to, and movement of traffic within, the area.

These principles are indicated in **Figure 12.1**.



Source: Adapted from Ref. 21, Fig. 13 and Fig. 18

EXAMPLE OF MODIFICATIONS TO GRIDIRON LAYOUT FIG. 12.1

12.4 CONSTRAINTS

When employing the remedial measures above, the following constraints should be borne in mind:

(i) The street system should not be made so complex and discontinuous as to increase travel distance significantly. While layouts should make through-movement inconvenient, they should facilitate contact between adjacent residential blocks and communities. Any device which limits or reduces the total amount of travel, should result in a safer traffic environment.

(ii) The street form should be logical and comprehensible to strangers. Drivers who are lost or confused are inclined to make dangerous manoeuvres and unpredictable changes of direction. Layouts which are incomprehensible to drivers can also produce unnecessarily lengthy travel.

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