ANNEX I
to SWOV report
Safety effects of road design standards
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Road classification and categorization

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Notice to the reader

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1. Introduction

The European community, with all its social and economic activities, would benefit from a road infrastructure which is able to perform the tasks imposed on it efficiently. This means that for transport by road, guarantees must be in place for reliable planning with respect to costs, the time required by and route of the journey, high circulation quality along most of the route, good accessibility of the destinations and, above all, a safe and comfortable completion of the journey. These functional requirements should be realized by us, traffic experts, in one way or another through the design, execution and management of the road infrastructure. In addition, we cannot ignore the demands placed on us by other social and economic functions in society. For example, protection of the environment deserves particular attention. These tasks are largely placed on the shoulders of the designers, builders and administrators of roads. We could work according to European guidelines for road design and so contribute to the harmonious incorporation of a (newly) organized road infrastructure in the European community. These guidelines should in that case aim at coordinating the functional organization of roads in the European road network. The classification or categorization of roads as applied here must be viewed in that light.

Not only traffic experts, but also town planners, urban developers and environmental experts will have to acknowledge the important role road transport plays in their plans. If we assume that the town planning of a region and the function allocation of roads within that region are properly executed, the classification of roads into categories will be to the advantage of road users and the community. For a categorization to be effective, the road and traffic characteristics associated with these categories should represent the correct image to the road users with respect to the driving behaviour anticipated from them and with respect to the actions of other road users. Research and practical experience over the years have led to the accumulation of sufficient knowledge to allow the practicality of a categorization of the road network to be established.

However, despite many discussions held amongst traffic experts both nationally and internationally, a universally accepted categorization or classification of road categories has not yet been achieved. Each nationality has therefore named and designed its roads according to individual insight. Road users themselves are generally unaware of the classification principles. For them, the design of the road, the current code of behaviour, the transient volume of traffic and relevant road maps consulted to offer some holdfast in assessing the function of the road. Because the design as applied to the same function allocation can differ markedly both within and between nations, the European road user will not be able to form a clear expectation of the function of the road, and will therefore not always accurately predict the required behaviour on that road.

Although an unambiguous classification into road categories has not yet been organized in practice, there is clearly a need for a structured and more uniform approach towards the road traffic system, also for sectors besides traffic and transport. This thought underlies this contribution to the discussion on the categorization of roads.

2. Road classifications in Europe

The organization of the current road network is largely historically determined. This does not mean that there has not been any logical organization to date. This would severely detract from the important work contributed by various national and international committees in recent decades, resulting in the ordering of the current road categories and the development of guidelines in the process. This chapter therefore offers a brief overview of the regulations laid down in the guidelines of some European countries.

Belgium
In Belgium, the classification of (new) roads outside the built up area is only related to the (predicted) daily volume of all vehicles.
Four categories can be distinguished in this regard:
- motorway with 2x3 lanes and an volume of over 40,000 vehicles per day;
- motorway with 2x2 lanes and a volume of between 18,000 and 40,000 vehicles per day;
- road with 2x2 lanes and a volume of between 9,000 and 18,000 vehicles per day;
- road with 2 lanes and a volume of fewer than 9,000 vehicles per day.

The road design is further distinguished into high, average and low volumes in the following categories:
class 1: high volumes of over 18,000 vehicles per day;
class 2: average volumes of between 9,000 and 18,000 vehicles per day;
class 3: average volumes of between 4,000 and 9,000 vehicles per day;
class 4: average volumes of between 2,000 and 4,000 vehicles per day;
class 5: low volumes of fewer than 2,000 vehicles per day.
The design speeds for both types of motorways are 120 or 90 km/hr; 120, 90 or 60 km/hr for roads with 2x2 lanes; and 90 or 60 km/hr for single carriageway, two-lane roads.
Roads with 4 lanes without a median strip and roads with 3 lanes are not (or no longer) recommended for reasons of safety.
The guidelines are approved by the European Accord for international trunk roads as agreed in Geneva in 1975.
Roads within the built up area have not been classified.

Denmark
Outside the built up area, the Danish road network applies four road categories which are functionally distinguished as follows according to permitted traffic type ('level of mobility') on the one hand and level of accessibility on the other:
I: permitted for motor vehicles with no or a limited number of (residential) connections ('access control');
II. permitted for motor vehicles or for all vehicles - provided slow traffic (pedestrians, cyclists and moped riders) uses parallel facilities - with a limited number of (residential) connections;
III. permitted for all vehicles, provided slow traffic drives on the parallel facilities with a limited number of (residential) connections;
IV. permitted for all vehicles, where slow traffic may or may not use parallel facilities with no restriction in the number of (residential) connec-

tions.
Within each road category, five to seven road types have been distinguished on the basis of characteristics of the cross section. The motorway is represented by four types in class I: 6 and 4 lane, with broad and with narrow cross section. Class I includes another three types, namely the 4 lane road with central reservation and a broad and narrow 2 lane road. Class II only includes 2 types of motorway, with a narrow profile. In addition, this class comprises the 4 lane road, with and without central reservation and the 2 lane road with three different widths. Class III represents the 4 lane road, also both types, and the 2 lane roads in four widths. The last class has 2 lane roads in three widths and roads which only have one lane, also in three widths. In total, there are 13 road types of which four can occur in three road classes.
The five intervals for the design speeds vary as follows:
- 110/120 km/hr for classes I and II;
- 90/100 km/hr for classes I, II and III;
- 70/80 km/hr for classes II and IV;
- 50/60 km/hr fr class IV;
- 30/40 km/hr for class IV.

The design and the distance between junctions are also linked to the road classes; see Appendix 2.
Inside the built up area, road traffic in Denmark is categorized according to traffic type into three major road networks:
- the road network for motorized traffic;
- the road network for slow traffic (pedestrians and cyclists);
- the road network for public transport.

Inside the built up area, the first road network is classified by planners by means of a functional distinction between trunk roads and roads inside the areas between the trunk roads ('local traffic precincts'). This results in two road classes:
- arterial, or 'traffic' roads, i.e. roads carrying through traffic;
- local roads, i.e. roads carrying destination traffic only.

The traffic roads are subdivided on the basis of the speeds permitted:
- high driving speeds;
- average to high driving speeds;
- low driving speeds.

A similar speed classification is applied to local roads:
- average to high driving speeds;
- low driving speeds;
- extremely low driving speeds.

In practice, the following questions are put when allocating a traffic function to an existing road, specifically in the built up area:
- to what degree does the road have a function for through traffic?
- does the road already form part of a clear road infrastructure?
- Does the road, together with other traffic roads, enclose an area of suitable dimensions?
- does the adjacent buildings have direct access to the road?
- are there no (or only few) pedestrians and cyclists who use the road?
- if there are many cyclists, is a cycle path available or can a path be constructed?
- are there no (or only few) homes or other sound-sensitive functions located in the vicinity of the road?
- does the road have sufficient capacity or width to function as a traffic road?

Although it is rare for all these questions to be answered in the positive, a road should always be classified. In particular, it should be clear which roads belong to the 'local roads', due to the measures which should then be taken to discourage through traffic and reduce the speed of local traffic.
When roads are classified, much attention is devoted to the design and distance between junctions (see Appendix 3). Inside the built up area, a strategy is proposed for the reorganization of the road traffic system, based on the achievements of modern traffic control ('traffic calming').
Similar to the motorway network, the cycle lane network is divided into main paths and local paths. In planning and designing that network, attention is devoted both to road safety and to social security.
The bus network is given separate treatment.

France
The rural roads in France are divided into three categories:
Type L: the rural motorway; exclusively used by motor vehicles, with no at-grade junctions, no connections other than through interchanges, dual carriageways and a general speed limit of 130 km/hr.
Type T: the expressway; equivalent to the motorway, with the exception of the number of carriageways and the speed limit: the expressway has one carriageway with two or three lanes and a speed limit of 90 km/hr;
Type R: the standard arterial road: for all traffic types, with at-grade intersections, residential connections, in general single carriageway with two or three lanes and a speed limit of 90 km/hr. In the odd case of dual carriageways, the junctions must be constructed as roundabouts.
The urban arterial roads are subdivided into two categories:
Type A: the urban motorway: equivalent to the rural motorway, but not always with separate carriageways and a speed limit of 110 km/hr or less;
Type U: other urban arterial roads: in general intended for all traffic types, at-grade intersections controlled by traffic lights, otherwise recommended as roundabout, no direct residential connections, no parking alongside the road and a speed limit of 70 km/hr when the requirements are met, otherwise 50 km/hr. The arterial roads can be either single or dual carriageways.

Germany
The functional classification of the German road network is based on groups of road categories, organized according to:
- three functions: connection, distribution and residential;
- urban and rural area;
- with and without adjacent buildings.
This results in the following five categories:
A: road with a connecting function, without buildings and in a rural area;
B: road with a connecting function, without buildings and in an urban area;
C: road with a connecting function, with buildings and in an urban area;
D: road with a distributor function, with buildings and in an urban area;
E: road with residential function, with buildings and in an urban area.
Within each group, road categories are distinguished on the basis of a further sub-classification of the three functions. For the connecting function (for motor vehicles), six phases are indicated, starting from the connection between two main centres of urbanization (about two hours' driving distance) to a connection between two properties.

Group A normally represents all phases, therefore six road categories are allocated: AI to AVI.
Group B has three categories: the last two phases are not represented and the first is associated with practical difficulties; therefore, categories BII to BIV apply.
Group C only has two road categories in the middle phases which can be applied without difficulty: CII and CVI.
Groups D and E also have two road categories each: DIV and DV, and EV and EVI, respectively.
In total, therefore, 15 road categories have been determined on a qualitative basis, although the realization on the basis of various design criteria is quantitative in character. It is also indicated whether characteristics such as single and dual carriageways or at-grade and fly-over junctions can be included in these road categories. The admission of specific vehicle types, motor vehicles only or all vehicles is not consistently proposed for all categories; see Appendix 1, road categories AII and AIV.

Great Britain
In Great Britain, a hierarchical road classification is proposed based on the desired function, rather than on the current use of the roads. The transport distance determines the order of ranking of the road functions; transport over short distances should take place over a hierarchically low-ranking road category.
On road networks of the great cities, five categories, from low to high, are allocated; see also Appendix 6:
1. pedestrian street;
2. access road;
3. local distributor;
4. district distributor;
5. primary distributor.

In small towns, the district distributor may represent the highest ranking in the hierarchy.
This hierarchy of roads is considered useful for planning proposes. Specific planning criteria can be developed and applied, given the road category and the categories derived from the designated function, such as design speed, road width, control of pedestrian traffic, parking of vehicles and access roads.
In addition, the advantages of this classification are pointed out, both for traffic activities and for residential activities. The capacity of the allocated arterial roads will increase, also because the number of junctions and potential conflicts is reduced. Road safety benefits, and the negative consequences of traffic for the environment are reduced on the whole, due to the concentration of traffic flow on a limited number of selected routes.
Outside the built up area, a less clear road classification exists. The following are distinguished, in order:
- a trunk road; an important road for through traffic which forms part of the national road network;
- a principal road; a less important road with through traffic and also part of the national road network;
- a classified road, subdivided into three categories; these roads belong to the local road networks outside the built up area;
- a primary route; a route for through traffic consisting of roads which permit access to all vehicle types;

- a special road; a road on which only certain vehicle types are permitted. Pedestrians, animals, cycles and the like are prohibited. It may not always be a motorway;
- a motorway; a special road, but not necessarily a trunk road;
- an all purpose road; any road which does not fit the category of special road.

Ireland

Ireland has divided its rural roads into three functional categories:
- national roads, subdivided into primary and secondary roads;
- regional roads;
- rural roads.

The urban road network is further divided into three (unofficial) categories:
- arterial roads;
- collection roads;
- local roads.

Within these main categories, the road types can be distinguished on the basis of geometric characteristics. The major characteristics are those associated with the motorway and the single or dual carriageways road profile.
In addition, the traffic intensity exerts an important influence on the width of the carriageway, the hard shoulder and the banking and on the design of the junctions. The other factors, such as topographical conditions, town planning and available resources also determine road design, specifically through the choice of design speed.
In total, thirty road categories are distinguished: see Appendix 4.

Italy

The classification of roads in Italy is determined by the design speed and the characteristics of the cross section, such as:
- the number of carriageways with the number of lanes;
- the presence of a hard shoulder;
- the means by which carriageways and lanes are separated, either physically or by painted markings.

Six road types are distinguished, as follows:
I. design speed 140/110 km/hr and a separation between carriageways with a width of at least 4 m;
II. design speed 120/90 km/hr and a central reservation of 2 m;
III. design speed 100/80 km/hr narrow lanes (3.50 m) and a central reservation (1.10 m);
IV. design speed 100/80 km/hr, two lanes;
V. design speed 80/60 km/hr, two narrow lanes (3.50 m);
VI. design speed 60/40 km/hr, two lanes measuring 3.00 m.
In addition, three road types are cited which have a specific function:
A. design speed 80/60 km/hr, dual carriageways with a separation of only 0.50 m, existing of a double line marking or a guard rail. This type of road is limited in length and carries a high volume of primarily motor vehicles. An example of this 'penetrating road' is a road which primarily carries tourist traffic;
B. design speed 40 km/hr or less, a two lane road which is only accessible to vehicles with a maximum height of 2.50 m;
C. design speed 40 km/hr or less, a single lane road with an extremely low volume in both directions. However, an opportunity to overtake

should be present at 500 m intervals.

The Netherlands
The categorization of roads in the Netherlands outside the built up area is based on a functional distinction between three road networks:
- road network with the highest traffic function; an integrated system of connections between regions and urban centres;
- road network with a median function; roads with a distributor function for regional traffic;
- road network with the lowest function; roads with a distributor function which goes down to the level of residential access.
Four main categories are offered to the road user:
A. motorway;
B. motorroad;
C. arterial road not accessible to slow traffic;
D. local road for all types of traffic.
For each road network, two of these main categories may be present:
A and B on the primary road network;
B and C on the second road network;
C and D on the third road network.
Each main category is again subdivided into two road categories on the basis of differences in the environment (urban and rural), design speed, number of carriageways and design of junctions (at-grade intersection or fly-over). In total, therefore, eight road categories are present outside the built up area; see Appendix 5.
Inside the built up area, no official road classification is available, although there are manuals with instructions and recommendations for the technical design of traffic engineering measures. These also offer a broad road classification; a decision is made according to traffic areas on the one hand and residential areas on the other. The design of these roads is furthermore so different for cities and villages that hardly any generalizations can be made. In fact, each city applies its own road classification.
Since 1991, a new concept has been proposed for discussion, describing a sustainable-safe (re)organization of the road traffic system. Broadly speaking, this implies a strict and consistent categorization of roads into three functional categories:
- roads with a flow function;
- roads with a distributor function;
- roads with an access function.
This categorization applies to roads both in rural and urban areas. Three safety principles apply:
- to prevent incorrect use of the infrastructure;
- to prevent conflicts with great differences in speed, direction and mass;
- to prevent uncertainty amongst road users leading to erratic behaviour.
The consequences of these principles for the functional road categories and for the design of the road types they represent are still being investigated through a number of pilot projects.

Portugal
In Portugal, the roads are considered to be part of the national road network provided they meet the following requirements:
- functional requirements; these relate to the size of the areas connected to each other by means of the road in question. Three functional connec-

tions are cited in this regard: those between major district centres, between urban centres and between major ports and border crossings;
- operational requirements: road are included in the national road network if they are over 10 km in length and carry a volume of over 4,300 motor vehicles per day (in 1990);
- accessibility requirements; all major locations ("concelho") should be connected to the national road network.
This national road network is divided into two categories only:
- roads which belong to the national arterial road network ('Basic National Network') and are responsible for the principal functional connections. Pedestrians, cyclists and horse-drawn carriages are not admitted to the main carriageways. Neither may properties connect directly to the road;
- roads which supplement the national road network ('National Complementary Network') and are responsible for fulfilling the remaining functional connections.

Summary
The roads in most European countries are generally hierarchically subdivided according to a characteristic which is directly or indirectly related to the number of motor vehicles, the traffic speed and the transport distances of those vehicles. In all cases, a distinction is made on the basis of roads inside and outside the built up area, not least according to the degree of accessibility of private properties. Sometimes, only a formal classification is given of the (main) roads outside the built up area. Whether or not slow traffic is permitted on the main carriageway, specifically cyclists and pedestrians, is an important classification criterium for some countries. In other countries, slow traffic is regarded as 'marginal' or is entirely disregarded.
The clarity of road categories for the target group, i.e. the road users, is only considered once in a road classification. In all cases, the road categorization is primarily intended to assist the road designer, and sometimes also the town planner.
Despite the current planning guidelines, there is no uniformity in the design of roads and junctions, let alone the structure of parts of the road network. This applies both nationally and internationally in Europe. The guidelines are not compelling and do not lead to strict uniformity. For example, roads in a particular category may be entirely or partially closed to slow traffic, while flyover crossings are permitted in certain categories and under specific conditions. Detail elements of the cross section are subject to values which tend not to be redundant within that category. In fact, the differences between roads which represent more or less the same function are much greater than the guidelines suggest. Roads with the same functional description can be both single and dual carriageways. Roads for all traffic types - the large group of national roads - are very diverse in design and also in their application. They sometimes have two lanes, but tend to be too small to allow this. Side lines may be present. Verges and obstacle-free zones are not uniform for these types of road in particular, and are generally not continuous. The recognizability of the function of the road and the behaviour in traffic on the basis of the design will therefore leave much to be desired, certainly with roads classified lower in the hierarchical order.

3. Sustainable-safe road categories

Reasons for a new concept

The philosophy behind a new concept for safe road traffic is a sustainable-safe traffic system, designed in response to the road safety measures of recent decades. We intended to improve the safety of the road traffic system primarily by considering the contribution of the separate components of the man-vehicle-road system. Influencing human behaviour, fitting safety constructions to the vehicles and well thought out design and (re)construction of roads and junctions have without doubt exerted a positive influence on the development of road safety. However, we note that there is still no question of a truly fundamental level of safety. Each year, we register many thousands of traffic fatalities in Europe, a sacrifice that we would not tolerate in any other system.

In comparison with rail and aviation traffic, we run some 100 to 200 times greater risk in road traffic per passenger kilometre travelled. Road traffic would find it impossible to meet the standards imposed by society on the working environment, technological-power installations and natural disasters: participation in traffic per unit of time is no less than 1,000 times more hazardous.

In the road traffic system, we have to deal with non-professional motorists, unequipped with automatic pilot, who are still confronted by all types of surprising traffic situations. We must realize that not all human error and mistakes can be eliminated through education, training, information, regulations, police enforcement and penalizing measures.

With respect to vehicle safety, a multitude of safety devices are now fitted to motor vehicles, but these will primarily protect the occupants, while not detracting at all from the vulnerability of the unprotected road user - quite the opposite.

There are untold traffic situations where, each time, we are misled by the road as presented to us or by traffic situations where fellow road users come at us from unexpected directions. Even on the well-designed motorways, situations arise which lead to serious accidents.

From curative treatments to preventative measures

In our attempt to realize a sustainable-safe road traffic system, we advocate a road infrastructure in which safety is fundamentally incorporated, taking into account the interplay with the two other components, man and vehicle.

The infrastructure of road traffic is characterized by the structure and organization of the road network, the design of the roads and intersections and the regulations organizing traffic. To determine the characteristics of a sustainable-safe infrastructure, we will first consider the various road networks currently in use in Europe and how road hazard has developed within these networks.

A road traffic system has traditionally had the task of enabling a certain aspect of mobility, viz. fulfilling the need for transport by road. This task or function was imposed where possible on the existing road network, even after the marked rise in the number of motorized vehicles. Not that long ago, we built the first roads in Europe which were specifically intended for rapid movement by motor vehicle. Many thousands of traffic fatalities had to occur each year before society became aware of the mag-

nitude of the sacrifice it was prepared to make to satisfy the mobility urge by motorized vehicles. In the 1970s, when the number of traffic fatalities in many countries reached a record high, we began to look at road safety measures. The residential areas were the first to be considered. The safe design of the 'woonerf' was a prominent initiative. This favourable development continued with the 30 km/hr zones which are now being introduced into Europe on a broad scale. In those countries where the cycle has proved a good alternative for the car, promotion activities have commenced to stimulate the use of the cycle and to design and construct facilities for slow traffic. This represents an acknowledgement of the differentiation in road function. A road is not only intended to allow rapid transport by car, it also serves other modes of transport, and even other needs than simply mobility. It has also become clear that many of these road functions cannot be combined on one and the same road.
At both extremes of the scale for road function - the motorway on the one hand and the 30/km/hr roads in the residential areas on the other - we are now on the way toward reducing the risk to which road users are exposed. However, there are clearly many roads remaining in the intermediate, 'grey' zone for which the risks are far more difficult to combat. The manuals published over the last two decades in order to tackle "black spots" have meantime realized their effect in a number of European countries; the major local 'design faults' which made traffic situations hazardous have been defined.
Despite these curative treatments, the non-motorways outside the built up area and the non-residential streets inside the built up area have demonstrated a high accident risk for all modes of transport. It is precisely for this category of roads that the sustainable-safe system approach should offer a solution. This approach is intended to made the road traffic system fundamentally safe through preventative measures.

Sustainable-safe road infrastructure
First, we consider the functions of the road infrastructure and the sustainable-safe tripartite division of traffic functions which we propose. Then we look at the function, design and use of the road network. In addition, preliminary principles and functional conditions are described, where an initial definition is proposed for a sustainable-safe category classification of the European road network. The contribution will conclude with several points of discussion and recommendations.

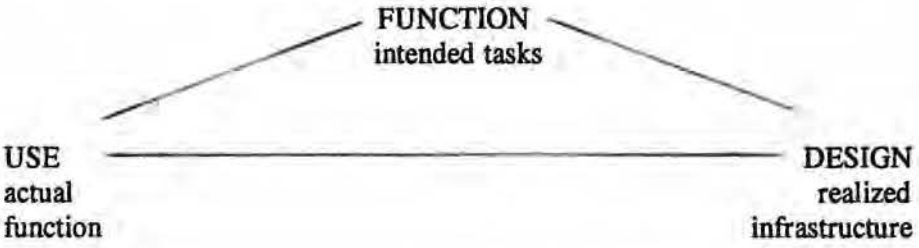
4. Functions of the road infrastructure

We have long lived with the notion that within the road infrastructure, a functional distinction can be made on the basis of residential area and traffic area. People live, work and spend their leisure time in the residential (including working) areas, while traffic areas are intended for the transport of people and goods, generally by means of vehicles. The traffic area is filled with road networks which offer a great diversity in means of transport to suit the various types of vehicles.

It is mainly the speed options which imply a major consequence for road hazard on these road networks and for the quality of life in the adjoining residential areas. Roads are indeed intended for driving over, but not all roads are constructed to allow fast driving. For example, there are roads which enable access to properties, open up districts and towns and link up regions on a national and international scale. Although vehicles are allowed to enter residential areas, the speed at which they travel should not be excessive.

4.1. Function, design and use

The function, or the purpose, of the road should be clearly expressed as part of the traffic policy plan. It is then the task of the road designer to give 'shape' to those functional requirements. In addition to the road infrastructure, there are also traffic rules which must shape the 'use' of traffic facilities. The relationship between 'function', design' and 'use' is easy to depict as a triangle:



The triangle starts at the top, at 'function'. The term 'function' is understood to mean the tasks which should be fulfilled by the infrastructure. This envisaged functioning is generally drawn up in a traffic plan, after town planners, technical experts and politicians have expressed their views. The registered transport needs may or may not be accepted and proposals can be made for the improvement and expansion of traffic facilities.

Next, the 'design' translates the functional requirements for traffic facilities to road constructions and traffic measures.

'Use' is understood to mean the behaviour in traffic as manifested on the realized road network. This actual function of the traffic facilities can then be compared with the envisaged function. The difference between

objective and reality can be measured through the signals received about undesirable traffic obstructions, accidents, noise pollution and other forms of traffic inadequacies.

Using a hierarchical classification of the road network, we can steer many aspects of traffic behaviour in a desirable direction. Such a structural approach will exert a positive influence on the quality of the traffic process in terms of flow, safety, comfort, the environment and costs with the use of the road network. This means that road users should also have an understanding, conscious or otherwise, of the functional relationship between parts of the road network. In other words: the function of the road and its environment, respectively, will have to be communicated in one way or another to road users and persons residing along that road, since behaviour after all is the manifestation of actual function.

4.2. Residential functions

In urban areas, roads and streets currently tend to have a more or less dominant residential function in addition to a traffic function. That is to say, that on these roads and in these streets, activities take place which have nothing to do with the transport of people or goods, but are the result of the presence of construction in the immediate environment (shopping, walking the dog, washing the car, children playing, parked cars, etc.). In practice, the traffic function can be associated with driving traffic, and the residential function with the presence of pedestrians.

Traffic function and residential function do not tolerate each other well. Only when the traffic function is very much subsidiary can it be combined with a residential function. This is the basic notion underlying the 'woonerf' concept and the pedestrian shopping zone. In all other cases, it is common to offer both functions their own area, in principle: driving lanes and cycle paths for the traffic function, and pavements for the residential function.
This report in principle will only consider those areas which are primarily intended for driving traffic. The presence of a (dominant or less dominant) residential function will only be taken into account if, in some cases, the possibility is acknowledged that pedestrians must cross a road with a traffic function.
In European countries, urban roads currently are not subject to a formally accepted category classification, as is generally applied to rural roads. In many cases, an ad hoc classification is used, based on arterial roads and residential streets, where the boundary between the two is not always clearly indicated.

4.3. Traffic functions

Certain parts of the road infrastructure can be allocated one of the three following traffic functions:
- flow function: rapid processing of through traffic;
- distributor function: making districts and regions accessible;
- access function: allowing properties to be reached.

On flow roads, traffic should be able to circulate as efficiently as possible, that is to say with minimal disruption, also at junctions; on distributor roads, however, emphasis should be placed on the possibility of mul-

tiple exchange of traffic to and from other roads at intersections; and on the residential access road, traffic which is travelling to or from its final destination must be taken into account along the full length of that road. When we divide roads into one of these categories, we must ensure that each classified road actually only fulfils that one function. With the exception of the majority of motorways (suitable as flow roads), the existing roads tend to be unsuitable for fulfilling one of the three cited functions without any adaptation. A sustainable-safe road traffic system cannot be achieved, therefore, without changes in the design of the road network and the individual roads. 'Design' is seen in its broadest context here; traffic regulations are also considered to be part of this. The situation only becomes ideal if the actual function (use) of each road agrees with the function attributed to that road in a sustainable-safe system (the 'envisaged function').
For roads outside the built up area, a category classification is currently in use in most European countries. The investigated classifications are not yet clearly based on the notion that each road only has one of the traffic functions described. A combination of two or more (traffic) functions is frequently found. Insofar road functions are referred to, these do not correspond precisely with the traffic functions described above.
A sustainable-safe category classification should be associated with a difference in design, based on a difference in function.
The three traffic functions are described below.

4.3.1. *Flow function*

The flow function of the road is primarily determined by the qualitative possibilities traffic should be offered to allow it to 'flow'. The quality of flow increases with greater continuity and higher speeds (within the stipulated limits) of the vehicles using that road. At a higher traffic volume, the same quality of flow can be offered by widening the road. This means that the allocation of the flow function in principle is independent of traffic volume. Continuity and a relatively high flow speed are made possible through a continuous flow (without traffic turning off, crossing or entering). In general, the desired quality requirements for 'flow' will be set at a higher level as the volume of through traffic increases. A distinction between through traffic and local traffic on a stretch of road is easy to make, in theory: through traffic does not have its origin nor its destination along that stretch of road. The physical road characteristics which accentuate a flow function are recognized by the cross section (for example broad, dual carriageways), by the design and by the longitudinal profile (for example, due to the lack of tight horizontal and vertical curves). The more dynamic characteristics of the flow function are determined by the traffic itself: for example, high and homogenous speeds by motor vehicles only, driving in one direction without being hindered by intersecting traffic.

4.3.2. *Distributor function*

The distributor function of a road is determined by the means made available to access or leave the road. The quantity of this 'distribution' increases as the number of discontinuities rises (intersections, connections and parking possibilities). In addition, the distributor function increases when more use of the intersections etc. is envisaged. The distributor

function will perform better if the vehicles on the road move at a lower speed.
The road characteristics which indicate the distributor function can be found at all intersections, connections and parking facilities along the road. The frequency and densities of such connections determine in part the flexibility of distribution. In addition, dynamic characteristics also determine the distributor function, for example markedly varying speeds over the length of the road as a result of a relatively large number of vehicles intersecting, turning off, parking or moving on. The design of the connections and the permitted volume of through and local traffic - the use - should be derived from the function, the envisaged task of the road.

4.3.3. *Access function*

The access function of a road can be indirectly derived from the envisaged function of the area in the vicinity of that road. An important section of the public road, specifically the pavement, serves to harbour people. People can also be found on the road itself, for example to reach the other side or alight from a parked vehicle. The static characteristics of the access function are of course determined by the construction and the additional environmental factors alongside the road. This environment is enormously diversified, due to the many possibilities offered by human activity. Recognizing the nature of these activities, despite the many variables, should not be a problem for the road user. However, the intensity of the activities is often wrongly assessed. In traffic, it is mainly the pedestrians - who are seen on the pavement and on the road - who, sometimes too late, make the access or residential function of the road recognizable.

5. Discussion and recommendations

5.1. General discussion

Traffic situations must offer clear information to road users about transport possibilities and the route and manoeuvre choices. Road characteristics tend to be associated with traffic characteristics; they elicit a certain expectation from driving behaviour, based on experience with combinations of road and traffic characteristics. For example, motorists driving on roads with divided carriageways, broad lanes and a straight course will generally anticipate high speeds and not take into account slow traffic and intersecting traffic at junctions, exits, crossings and the like. However, if on such a road unexpected traffic characteristics occur (for example, the presence of an agricultural vehicle) or a sudden change in road characteristics (for example, a sharp bend), then this demands extra effort from the road user as he must make unanticipated manoeuvres, thereby endangering road safety. In many cases, the traffic characteristics can be deduced from the road characteristics, so that continuity in road characteristics can lead to a better anticipation of behaviour in traffic. The way in which road users 'translate' road characteristics into behaviour on the road is subject to assumptions and expectations. This assumed and desirable behaviour in traffic forms the basis for a safe design of the infrastructure.

The planners and designers of road networks, roads and junctions will have to take more account of the behaviour and opinions of road users. The principles recommended here for a classification of roads envisage a road traffic system geared towards an efficient - and, most importantly, sustainable-safe - use of the road.

We have outlined several principles for such a traffic system. These principles are under discussion and hence, their translation into more concrete guidelines for the structure, categorization and design of the road network.

Study has shown that the current road hazard is predominantly caused by the fact that large parts of the current road network are unsuitable for the function they are expected to fulfil, as a result of poor design.

For example, many roads which originally had a residential access function have meantime acquired a dominant district distributor function or even a flow function, while still fulfilling the original function as well. It seems quite feasible to adjust the design and regulations associated with a road via a strict allocation of a specific function on the basis of the safety principles formulated here: eliminate unintended use, encounters with implicit risk and erratic behaviour. By using three functionally related road categories with largely unequivocal characteristics and codes of behaviour, these principles can be met to a significant degree.

These functions are once again described:

- flow function: the rapid processing of through traffic;
- distributor function: the collection and dispersion of traffic to and from districts and residential areas on the one hand and flow roads on the other;
- access function: making private property accessible.

These three functional road categories are not hierarchical and do not differ in importance. This categorization is applicable to roads both in

rural and in urban areas. The frequency of properties alongside and in the immediate vicinity of the road does determine its design. So do traffic volumes of course, specifically with regard to the cross section of the road. Depending on the frequency of properties and on vehicle volumes, several road types may be distinguished within one road category. The point is to keep the function of the road clear to road users, despite differences in design.
Based on the three principles named above, we now formulate the functional conditions for a sustainable-safe road network. These will then be examined in brief and made available for discussion. The traditional principles, such as uniformity of the infrastructure, continuity of traffic flows and consistency of the road design are also considered.
The conditions, or requirements, which we wish to impose on a sustainable-safe road network can be characterized as strict in some cases. There is a possibility that these requirements lead to designs which cannot be considered realistic. Designs which have no hope of succeeding are better not promoted. It may therefore be necessary at a certain stage of the process to relax certain requirements.

5.2. Proposals for a road categorization

We base the system on three categories, equivalent to the three functions; this leads to a classification into flow roads, distributor roads and access roads. Depending on the required capacity and on the immediate environment (rural or in the vicinity of a town, inside or outside the built up area) we can distinguish several models within each category, to be denoted as road types.
In addition to the three categories given, two other types of connections can be distinguished, cycle paths and goods transportation roads.

Flow roads
Traffic on the flow roads is subject to a relatively low exchange level, or expressed in another way: the percentage of entering and exiting traffic per km road length is lower than a certain (yet to be determined) limiting value.
The flow roads form a closed network where possible, so that an important part of the journey can be covered on these roads without interruption. The density of the network of flow roads (the 'mesh') and the density of the junctions connected to these roads determine how much time the road user should maximally drive on lower category roads. This is dependent on the journey segments between origin and flow road and between flow road and destination. In a concrete situation, the network will be strongly dependent on traffic movement in that region and take into account the existing roads that meet the requirements of a flow road function.
Two types of flow road can be distinguished: the motorway and the motorroad. The choice is primarily determined by the traffic volume: over a certain limiting value, for example 20,000 vehicles per day, a motorway becomes a possibility. Because efficient circulation on flow roads is essential, and the road user should be assured of an uninterrupted journey, a safe processing level should be assured. Although traffic jams are not at all times avoidable, there is reason to ensure that these roads have sufficient capacity. When the capacity is (temporarily) inadequate, additional exit and access points should be created to safeguard unre-

stricted circulation as much as possible.
Slow traffic is not permitted on either road type; separate facilities are provided for these vehicles, whether or not parallel to the flow roads. Of course, there is no means of access from these roads, unless it concerns facilities provided for traffic on the motorway (restaurants, petrol stations, laybys). But in this case also, the transition from flow road to the 'property' is not abrupt.
The applicable speed limit, the junction density and often also the space required to build these roads imply that they only rarely run through built up areas. Apart from the permitted maximum speeds, the speed limit for motorways is set at 100 to 120 km/hr and for expressways at 80 to 100 km/hr, depending on the area (rural or urban) and probably also on the proportion of goods traffic.
On the motorroad also, separate carriageways for both driving directions are applied, i.e. two carriageways which are only one lane wide. On longer stretches, an overtaking facility should be provided at intervals still to be determined, e.g. by widening one carriageway over a certain distance. Because this again introduces a potentially hazardous situation, these overtaking zones must be carefully designed. It is possible that a combination of a maximum and minimum speed limits can strongly reduce the need to overtake.
The distances from one flow road junction to another are determined by the mesh width of the flow road network, to be derived from the journey time requirements. In urban areas, the network is somewhat denser and the distance between junctions smaller. The density of junctions and connections to roads belonging to the secondary road network is also determined by journey time requirements and the associated mesh width of that secondary road network. Junctions at flow roads are in principle not at-grade, but are constructed as multi-level interchanges.
The interchanges between motorways should preferably be designed to allow a high capacity and limited detours. From the point of view of uniformity, it is better to apply only one type of design for compact interchanges. With more complex interchanges, where the design is difficult to oversee by the road user, the road design at the crucial points should at least be uniform.
For intersections at motorroads, an interchange solution is often not considered feasible in view of the space and cost this involves. A simpler solution for fly-over junctions is also difficult to realize, because these always involve some at-grade connections. Therefore, in such cases, a large roundabout is probably the most suitable solution.
Junctions between flow roads and local distributor roads should however be constructed at different heights; the at-grade connection poses no problem for the latter road category.

Local distributor roads
The function of the local distributor road is to form connections between the flow roads and the access roads. The significance of these roads can also be indicated by concepts such as a collection and dispersion function. This also implies that a relatively high level of exchange may be anticipated on these roads, generally above a (still to be determined) limiting value.
These roads also form a closed network in combination with the flow roads, or else become access roads. The density of the network is primarily determined by the journey time requirement. The network should be

selected such that short and immediate connections are formed with the flow roads. The actual allocation in a concrete situation can be determined from the traffic requirements, taking into account the existing roads where possible.
Depending on the surroundings (rural or urban, inside or outside the built up area), the distances to be covered and the intensities to be anticipated, several road types can be distinguished within this category.
For distributor roads outside the built up area, the associated speed limits beyond the junctions are set at around 80 km/hr and 60 km/hr. With the first type, a division between carriageways is recommended and agricultural traffic should be prohibited; with the second type, no carriageway division should be necessary and agricultural traffic can be permitted on the road. Cycles do not use the road, but if the road is part of the cycle connection network, separate cycle paths are available.
Inside the built up area, the distributor roads are assumed to be subject to a speed limit of approx. 50 km/hr and to have parallel cycle paths.
Flow road junctions are not at-grade, as we already discussed when dealing with this category. Intersections between local distributor roads should preferably be realized as a roundabout, where both 3-spoke and 4-spoke roundabouts are feasible.
The connections to access roads are constructed such that the distributor road has priority. In exceptional cases - for example connections to roads which allow access to extensive and intensively used parking facilities - roundabouts or traffic lights may be considered. Suitable facilities are provided for cyclists who cross these roads, such as:
- multi-level solutions at high motor vehicle and cycle volumes;
- separate cycle paths at roundabouts;
- traffic lights for crossing cyclists.

If the road inside the built up area is less busy and has relatively little intersecting cycle traffic, an at-grade crossing is also permissible outside the roundabouts.
These roads do not give access to private property either; where necessary, facilities are provided for this, for example in the form of a parallel road, which can then be used by cycling traffic.

Access roads
The road in the third category, the access road, offers an approach to buildings such as homes, offices, industry, farms, shopping (centres) and all other destinations such as parking areas, storage areas, hotels, catering and recreation facilities, etc. On the pavements alongside these roads inside the built up area, the residential function will tend to dominate and possibly exert a certain 'effect' on the road itself.
The access roads in principle are not directly connected to a flow road, but only to a local distributor road. The number and placement of the access roads is primarily determined by the destinations they service, and also by the journey time requirement.
Of essential importance is the placement of these roads in relation to the higher category roads; their position should ensure that each access road becomes unattractive for through traffic. Where this cannot be achieved automatically, supplementary measures are required in the form of increased resistance to motor vehicles (= extension of driving time) on these roads and/or facilitated driving on the surrounding, higher category roads.
Some of these roads fulfil parallel facilities for flow and distributor roads,

in which case they often play a role for cycle traffic in addition to their access function. The roads have a single carriageway, are in principle accessible to all traffic and have no separate cycle facilities. Sufficient safety is achieved by restricting speed to a level of approximately 40 km/hr. The speed limit for access roads inside the built up area (streets) will have to be about 30 km/hr, suitable for a fully mixed traffic composition.
Connection to local distributor roads is realized by a T-junction subject to priority rule or, in special cases, by a roundabout or traffic lights.

Cycle paths
Firstly, the separate cycle paths, which, together with the access roads and cycle paths parallel to the roads for motorized traffic should form a closed network for cyclists. For this category, the selection of direct connections with a minimal detour factor is at least as important as for motorized traffic. One exception can be made for the typical tourist cycle paths, which are virtually exclusively designed to cater to recreational cyclists.

Goods transportation roads
On through roads where there is a predominance of goods traffic, special goods transportation roads should be considered. In that case, the parallel road for remaining traffic should no longer be accessible to goods traffic, so that a total separation is realized. On carriageways with more than two lanes and a preponderance of goods traffic, a solution is possible in the form of special lanes reserved for goods traffic. Any future application should be dependent on the experience gained with this solution.

Straßenfunktion			Entwurfs – und Betriebsmerkmale				
Kategoriengruppe	Straßenkategorie		Verkehrsart	zul. Geschw. V_{zul} (km/h)	Querschnitt	Knotenpunkte	Entwurfsgeschwindigkeit V_e (km/h)
1	2		3	4	5	6	7
A anbaufreie Straßen außerhalb bebauter Gebiete mit maßgebender Verbindungsfunktion	A I	Fernstraße	Kfz Kfz	keine ≤ 100 (≤ 120)	zweibahnig einbahnig	planfrei (planfrei) plangleich	120 100 100 90 (80)
	A II	überregionale/regionale Straße	Kfz (Kfz) Allg	keine (≤ 100) ≤ 100	zweibahnig einbahnig	planfrei (plangleich) plangleich	100 90 (80) 90 80 (70)
	A III	zwischengemeindliche Straße	Kfz Allg	≤ 100 ≤ 100	zweibahnig einbahnig	(planfrei) plangleich plangleich	(90) 80 70 80 70 60
	A IV	flächenerschließende Straße	Allg	≤ 100	einbahnig	plangleich	70 60 (50)
	A V	untergeordnete Straße	Allg	≤ 100	einbahnig	plangleich	(50) keine
	A VI	Wirtschaftsweg	Allg	≤ 100	einbahnig	plangleich	keine
B anbaufreie Straßen im Vorfeld und innerhalb bebauter Gebiete mit maßgebender Verbindungsfunktion	B II	anbaufreie Schnellverkehrsstraße	Kfz	≤ 80	zweibahnig	planfrei (plangleich)	80 70 (60)
	B III	anbaufreie Hauptverkehrsstraße	Allg Allg	≤ 70 ≤ 70	zweibahnig einbahnig	plangleich plangleich	70 60 (50) 70 60 (50)
	B IV	anbaufreie Hauptsammelstraße	Allg	≤ 60	einbahnig	plangleich	60 50
C angebaute Straßen innerhalb bebauter Gebiete mit maßgebender Verbindungsfunktion	C III	Hauptverkehrsstraße	Allg Allg	50 (≤ 70) 50 (≤ 60)	zweibahnig einbahnig	plangleich plangleich	(70) (60) 50 (40) keine (60) 50 (40)
	C IV	Hauptsammelstraße	Allg	≤ 50	einbahnig	plangleich	50 (40)
D angebaute Straßen innerhalb bebauter Gebiete mit maßgebender Erschließungsfunktion	D IV	Sammelstraße	Allg	≤ 50	einbahnig	plangleich	keine
	D V	Anliegerstraße	Allg	≤ 50	einbahnig	plangleich	keine
E angebaute Straßen innerhalb bebauter Gebiete mit maßgebender Aufenthaltsfunktion	E V	Anliegerstraße	Allg	≤ 30 Schrittgeschw.	einbahnig	plangleich	keine
	E VI	Anliegerweg	Allg	Schrittgeschw.	einbahnig	plangleich	keine

Bild 11: Straßenkategorien, Entwurfs- und Betriebsmerkmale

Germany

Beilage 1

Denmark outside b.u.a.

Bilaga 2

Road Class	Description			
	Kind of traffic permissible	Access control	Layout of junction	Suggested distance between junctions
I	Automobile 1) traffic	Full or partial control	2-level, or 1-level channelized	5 km
II	Automobile traffic or 1) all kinds of traffic separated	Partial control	1-level channelized or 2-level	2 km
III	All kinds of traffic, separated	Partial control	1-level channelized if necessary	1 km
IV	All kinds of traffic separated or mixed	No control	1-level	-

1) Pedestrian, bicycle, and moped traffic may be handled by the construction of parallel separate paths, or along roads with a small amount of traffic.

Figure 1. Suggested road class characteristics.

The road class characteristics shown in figure 1 form the basis of the consequence estimations, the results of which are presented in chapter 7.

If, in a specific case, the road characteristics differ essentially from the ones described in figure 1, new calculations ought to be made, as described in chapters 4, 5, 6, and 8.

Kiglage 3

Denmark inside b.u.a.

Road class	Speed class	Distance between intersections	
		Roundabout or traffic light contr. intersec.	T-intersec.
Traffic road	High	7-800 m *)	3-400 m
	Medium	5-600 m	150 m
	Low	3-400 m	100 m
Local road	Medium	-	100 m
	Low	-	50 m
	Very Low	-	-

*) Distances of this length may create problems for the flow of a green wave, as it is difficult to keep vehicles close together from one intersection to the next.

Figure 36. Recommended distances between intersections

8.4.7 Adjoining facilities

To the extent possible service stations, car parks, etc. should be sited so that road junctions can be placed in accordance with the distances between intersections recommended in figure 36. In this connection, however, separate access and exit junctions, e.g. in connection with service stations, should be regarded as one junction.

The design of such junctions should comply with the rules for road intersection design as they appear in this section and in the details of volume 4 on Road Intersections.

8.4.8 Lengths of roads and stretches

Where possible, one should attempt when deciding the length of local roads to motivate car drivers to travel at suitable speeds.

Ireland Bylage 4

TABLE A2. Road Design Classification

Location	Class	Type	Design speed km/h	Code
RURAL	National	Motorway	120 100 80	RNM 120 RNM 100 RNM 80
		Divided	120 100 80	RND 120 RND 100 RND 80
		Undivided	100 80 60 40	RNU 100 RNU 80 RNU 60 RNU 40
	Regional	Divided	100 80 60	RRD 100 RRD 80 RRD 60
		Undivided	100 80 60 40	RRU 100 RRU 80 RRU 60 RRU 40
	County	Undivided	80 60 40	RCU 80 RCU 60 RCU 40
URBAN	Arterial*	Motorway	80	UAM 80
		Divided	80 60	UAD 80 UAD 60
		Undivided	80 60	UAU 80 UAU 60
	Collector*	Divided	80 60	UCD 80 UCD 60
		Undivided	60 40	UCU 60 UCU 40
	Local*	Undivided	Not yet defined	ULU

* not officially designated.

The Netherlands.

Bijlage 5

Hoofdwegennet

Het hoofdwegennet verbindt economische en bestuurlijke centra en omvat wegen waarop een hoge afwikkelingskwaliteit vereist is. In het algemeen zijn dit autosnelwegen. Bij wegen die qua intensiteit en/of door hun ligging in een urbane wegomgeving met een daaraan verbonden gebruik geen autosnelwegen behoeven te zijn om het gewenste kwaliteitsniveau te bieden kan worden volstaan met uitvoering als autoweg.

Figuur 1 *Categorie-indeling voor wegen buiten de bebouwde kom;*

WEGGEBRUIKER						ONTWERPER													
		mogelijk aanwezig		situatie						dwarsprofiel		kruispunt vorm		kruisings-vorm				
Hoofdcategorie	Categorie-aanduiding	Afhankelijk van wijze van gesloten verklaring	Alle soorten voertuigen alsmede voetgangers	Tegemoetkomend verkeer	Kruisend verkeer	BENAMING	CAT	WEGOMGEVING	ontw. snelh. km/u	Dubbelbaans	Enkelbaans	Ongelijkvloers	Gelijkvloers	Ongelijkvloers	Gelijkvloers	Hoogste functie	Middelste functie	Laagste functie
A						AUTOSNELWEG	I	ALLE SITUATIES	120	▨		▨		▨		▨		
						STADSAUTOSNELWEG	II	URBAAN	90	▨		▨		▨		▨		
B				▨	1)	AUTOWEG	III	ALLE SITUATIES	100		▨		1)	▨		▨	▨	
					▨	AUTOWEG	IV	ALLE SITUATIES	100 2)	▨			▨	▨			▨	
C		▨		▨	▨	WEG MET EEN GEHEEL OF GEDEELTELIJK GESLOTEN VERKLARING VOOR LANGZAAM VERKEER IN ELK GEVAL GESLOTEN VOOR (BROMFIETSERS)	V	ALLE SITUATIES	80		▨		▨		▨		▨	▨
							VI	ALLE SITUATIES	60		▨		▨		▨		▨	▨
D		▨	▨	▨	▨	WEG VOOR ALLE SOORTEN VERKEER	VII	ALLE SITUATIES	< 60		▨		▨		▨			▨
							VIII	ALLE SITUATIES	-		▨		▨		▨			▨

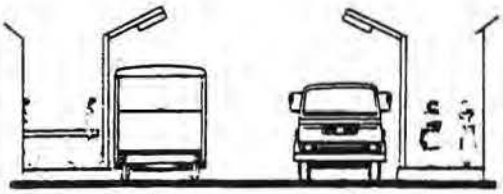
▨ aanwezig of van toepassing

| | niet aanwezig of niet van toepassing

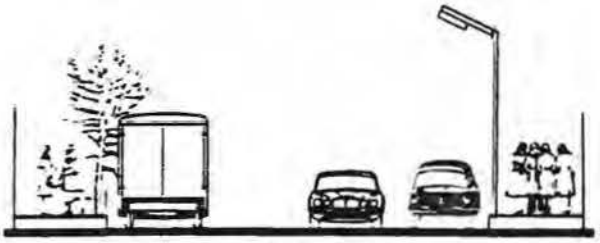
1) Ongelijkvloerse kruispunten kunnen in bepaalde omstandigheden voorkomen

2) Op het hoofdwegennet alleen in urbane wegomgeving toepasbaar met een ontwerpsnelheid van 80 km/h

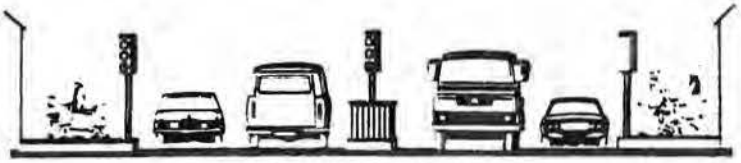
(a) Pedestrianised Streets



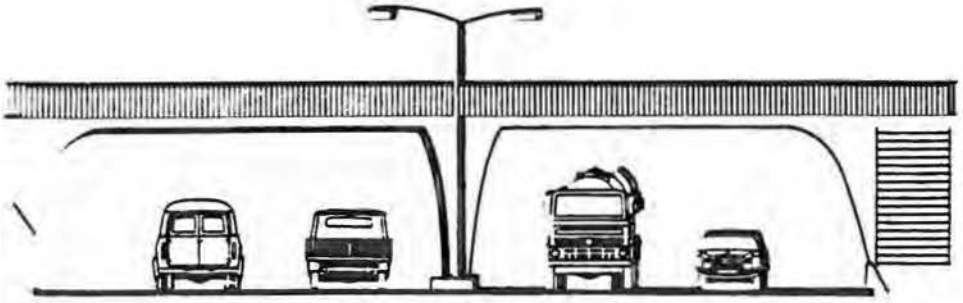
(b) Access Roads



(c) Local Distributors



(d) District Distributors



(e) Primary Distributors

Figure 5.2 Illustrations of the use of different types of road within a hierarchy