URBAN PLANNING, TRAFFIC PLANNING AND TRAFFIC SAFETY OF PEDESTRIANS AND CYCLISTS

Report presented to the 1979 Road Research Symposium on Safety of Pedestrians and Cyclists, OECD Headquarters, Paris, 14-16 May 1979 Session III. Physical Countermeasures; Subsession III.1. Urban planning and traffic planning

R-79-7
F.C.M. Wegman
Voorburg, March 1979
Institute for Road Safety Research SWOV, The Netherlands

TABLE OF CONTENTS

Abstract

I. Framework for urban planning and traffic planning

I.1. Interrelationships with other policy fields

I.2. The hierarchy in the planning process

I.3. Urban planning

I.4. Traffic planning

II. Traffic planning and traffic safety of pedestrians and cyclists

II.1. Outside built-up areas

II.2. Town centres

II.3. Routes and networks for bicycles and mopeds

II.4. Residential areas

III. Points for discussion

Tables II.1.-II.3.

Figures I.1.-I.4. and II.1.-II.4.

References

ABSTRACT

The traffic safety of pedestrians and cyclists can be improved by means of urban planning and traffic planning, as one of the possibilities. This paper discusses the framework of these (counter)-measures and activities and also the effects on the field of traffic planning.

Chapter I shows that it is hardly possible to isolate planning measures for improving the traffic safety of cyclists and pedestrians. Changes in the traffic system have an impact on almost all aspects of our society (the social-cultural system, the economic system and the physical (planning) system).

Within the traffic system, traffic safety as a rule cannot be improved without affecting other aspects (operational and quality aspects).

In Chapter II the problem as a whole is divided into four parts, based on a solution selective approach to the subject (outside built-up areas, town centres, routes and networks for bicycles and mopeds, and residential areas), each with its own character and its own possible solutions or lack of solutions.

Such a classification does not, of course, mean that the problems and solutions of each subdivision are unrelated. This becomes evident in Chapter I.

In Chapter III a number of points for discussion are presented.

I. FRAMEWORK FOR URBAN PLANNING AND TRAFFIC PLANNING

I.1. Interrelationships with other policy fields

The traffic safety of pedestrians and cyclists and traffic safety in general is only one of the aspects of policy-making process on traffic and transport.
It could be quite misleading to discuss such a specific topic at a symposium without realising that it is merely one element in an entire system.
It is misleading both for decision-making process and for the planning process. It does not seem right, particularly as concerns urban and traffic planning, to discuss pedestrian and cyclist safety out of this context.
Improvement of traffic safety by urban and traffic planning measures will have to dovetail with current policy-making processes in this field, even if it is thought that traffic safety is not given enough priority in the plans. It should be quite possible to ensure higher priority for traffic safety within existing urban planning and traffic and transport procedures.

This presumably hardly needs clarifying at a symposium such as this. There are justifications enough for it in everyone's practical experience. Just as an illustration some words to it.
Ultimately, measures and activities aimed at improving traffic safety simply try to change traffic behaviour. That is to say: traffic behaviour in a very wide sense: choice of destination and time of arrival, vehicle, route and manoeuvre.
Changing traffic behaviour means intervening in the traffic process in general. The changes will usually also affect other characteristics of the traffic system; accessibility, traffic flows, nuisances due to traffic and so on. Changes in the traffic process will in turn affect other social processes as well.

The impact of such measures and activities may therefore be noticeable in many policy fields while, conversely, policy in these other fields may have an effect on traffic safety.

To illustrate this with an example or two: construction of a ring road round a town or the opening of a supermarket in a city centre or on its outskirts. It is very evident from this interrrelationship with other policy fields that an isolated approach to traffic safety leads to an incorrect picture of the problem and moreover probably to not wished solutions.

This finding should influence the planning process and the organisation of the decision-making process inside the administration. It hardly seems relevant at this symposium to go further into the administrative organisation.
But the planning process is very relevant.

I.2. The hierarchy in the planning process

A fairly easy way to improve traffic safety is to fight against so called black spots, which is probably a matter of repressing the symptoms. Medical science has gone through the same stages: the medicine-man, the barber, the surgeon, the doctor. There are all kinds of very obvious reasons for this, but... A story of everyday: An intersection has been the scene of an accident involving a child. Public opinion is shocked. The public blame those politically responsible. The intersection is dangerous, and action threatens. The causes of the "bad situation" can be traced easily and quickly with a little common sense: vehicles drive too fast, or there are too many vehicles, pedestrians have too little opportunity to cross the street. Countermeasures seem to be taken very easily. But then people realise that cars simply have to pass this particular intersection and cannot possibly take a different route. And a certain speed-level is necessary to keep travelling time acceptable, while very few pedestrians have to cross the road in question.
The moral of this story: of course countermeasures are not so simple, and might merely move the problem to the next intersection. Grade separation is often impossible because of the cost. So what is to be done?
Obviously, alternatives have to fit into a frame. If the framework

is inside the traffic system as a whole, the countermeasures will follow from a traffic plan made at best for an area or town as a whole. But the basis may be nothing better than people's unexpressed feelings.
A traffic plan is closely related to urban planning and doesn't just appear from nowhere.
The only reason for telling this story is that both the problems and the solutions can be arranged in a kind of hierarchy, which will also have to be recognised in the planning process (See also Mühlrad, 1976).

An example of such a hierarchical planning process can be given. There are three distinct levels, each with its own plan.

A. Urban planning - structure plan - relation of land use - transport and traffic system - entire town or village.
B. Traffic planning or management - layout plans - structure of traffic facilities - town centre, residential area.
C. Traffic engineering - traffic plan - design of traffic facilities - detailing (counter)measures - spots.

A structure plan is not usually very detailed and provides for the longer term. Principles have to be established for the main infrastructural network:

- concentration of activities around and along public transport facilities;
- hierarchical road network structure;
- no through traffic in residential areas;
- external distributors in residential areas;
- segregated networks for pedestrians and cyclists.

As an example, two schemes are given from the newest New Town in The Netherlands: Almere (Figure I.1.).
A good structure plan should obviate traffic safety problems at both the lower levels.
In the second phase, more detailed information is presented in a plan in which vehicle-flow levels on the road system conform to the quality aspects of the system. In this plan we find concrete con-

frontation between "accessibility - livability" (and traffic safety as an aspect of livability).

Next features have to be discussed on the second level:
- kind of traffic segregation on main traffic arteries;
- traffic arteries and vehicle-free areas;
- location of pedestrianisations;
- location of cycle tracks.

The third level is the localised, detailed, spot-oriented implementation plan. This brings us to the traffic engineering field.

During this session we shall be discussing the two highest levels: urban planning and traffic planning.

Working according to a hierarchical planning process deals best with complicated and interrelated policy fields and provides the best scope for built-in safety in our traffic system.

I.3. Urban planning

It is when nearly all the far-reaching urban planning decisions have been taken that people start thinking about the adverse consequences upon traffic safety. Let us consider town planning and developments in our towns in recent decades to illustrate this rather bold statement.
In many of the world's cities there has been a process of degeneration - poverty and slums. Moreover, people wanted more space - in their own homes and in their immediate surroundings (See Figure I.2.). In consequence, more new houses had to be built. Existing towns were extended, new towns were built; suburbanisation began. But shopping centres, cultural facilities and places of work stayed put. Parallel to this, there was a startling increase in car-ownership. More and more space was needed for transportation by car. The struggle between cities and cars started (Jane Jacobs in The Death and Life of Great American Cities: Erosion of cities or attrition of automobiles, 1961).

Distances became so great that cycling and walking were no longer regarded as a reasonable alternative means of travelling to town. Pedestrians and cyclists were expelled to road space not necessary for cars.

All these developments went down to the very roots of the traffic and transport system and, consequently, of traffic safety.

This outline of developments should suffice for present purposes. The number of trips, the length of trips, the travelling time and also the modal split had changed incredibly.

The number of trips obviously depends on many other features besides urban planning: income, car-ownership and so on (perhaps de-zoning brings about a trip reduction: by mixed-use developments). But trip length and travelling time are closely linked with urban planning activities, the aim of course being to shorten trip-lengths (See Lea et al, undated).

On a macro scale (city-wide) increasing building density is a possible solution (greater densities around public transport stations, building new houses in "holes", and so on).

On a micro scale, special care could be paid to location or relocation of houses, schools, playgrounds and shopping areas, in relation to the road system.

The shortest possible trip-distance should not be the overriding objective. Some features have the opposite effect, for instance green belts, or privacy.

A conclusion as to how traffic safety can be given higher priority is not relevant here. What is relevant is that traffic safety is a matter of urban planning and this ought to be recognised.

I.4. Traffic planning

Transportation by road arises from people's wish to reach a destination. This sentence defines the two functions of a road: to carry traffic (the traffic - movement - function); to reach destinations (the access function).

Most roads have to perform both functions in the same space.

Besides these functions, roads have a function which has nothing to do with traffic proper, i.e. the "street function", a public place where people meet each other, where social relations exist, that is to say: the residential function.

People realised long ago that these three functions are incompatible as long as different means of transport are allowed in the same space, as long as each has its own characteristics and consequently requires its own road layout and design.
Based on this incompatibility, philosophies have been evolved encouraging or discouraging certain functions on certain roads. The situation is quite clear at both ends of a theoretical scale: the motorway and the residential path. In the principles of planning, efforts are made to classify roads in a system according to function. Such a classification should result in improved accessibility and in better protection for vulnerable road users (pedestrians and cylcists).

Two objectives can be formulated:
- a certain classification of the road system according to the hierarchy principle;
- a layout and design based on the road's position in the classification and hence on its function.

Classification of the road system will have to be in line with road layout and design (See Janssen, 1976). One is impossible without the other; they support each other. Two well-know (but not so well documented) ways are segregation and integration.
Some effects of some types of segregation for traffic safety are more or less well known. The effects on the safety of pedestrians and cyclists are discussed in Chapter II.
As regards integration (shared surfaces) there has been no safety research up to the present time.

The access and residential functions are usually compatible. Compatibility does, however, mean in our present-day streets that the dominant position of motor vehicles must be modified. Their behaviour must be adapted to the unpredictability of events in a street as such, for example children at play. This definitely necessitates low speed-levels.

The traffic and access functions (and certainly the traffic and residential functions) are incompatible with one another for most of the time.
Traditionally, we have solved the incompatibility problem with a graded hierarchy of roads, with the access function gradually gaining prominence as the traffic movement function decreases down the scale of road types (See Figure I.3.).
As already stated, the extremes on the scale are quire clear, but the middle area is grey. Here we meet the problem of the "local distributors" or "collectors".
Figure I.3. is based on the assumption that both access and traffic functions are a continuum. Brindle (1978) suggests that the access function is more like a Yes/No condition. We can talk of a low access function relative to traffic function on main roads, and a high access function in culs-de-sac, only because the traffic movement has dramatically declined from one end of the spectrum to the other, while the access function has hardly changed (See Figure I.4.).
His suggestion leads us to conclude that the difference between an access street and a local distributor is simply the vehicle-level, coupled with length and width of carriageway and speed-level.
Brindle regards this as the explanation for the findings of Bennett & Marland (1978) from their comparison of accident rates between access streets and local distributors.

Perhaps we should reflect about the philosophy of road classification. We are not yet capable of developing useful guidelines for road layout and design of existing road systems based on the classification philosophy, even though the philosophy as such has already existed for twenty years or more.

II. TRAFFIC PLANNING AND TRAFFIC SAFETY OF PEDESTRIANS AND CYCLISTS

II.1. Outside built-up areas

When people think about improving traffic safety specifically for pedestrians and cyclists, very many of them immediately think of the problem inside built-up areas.
If this is because people know that most accidents involving these two categories of road users occur inside built-up areas and it is therefore just a question of allocating priorities, this seems reasonable, because there is no reason at all to deny that the problem exists outside such areas. For instance, what about village children attending secondary school in a town and cycling to and from every day? Moreover, it is a well-known and well-documented fact that accidents on rural roads are more serious than in city streets (e.g. Waller & Reinfurt, 1969).

In planning for cycling facilities outside built-up areas, thought must first of all be given to the principle of traffic segregation. This can be done by designing and constructing a completely separate system for bicycles and/or mopeds or by locating facilities alongside existing roads.
There are no findings available setting forth the advantages and disadvantages of the two principles as far as safety research is concerned.
No simple conclusions can be drawn as long as:
- not all intersections are graded;
- houses need entrances along roads;
- the degree of separation is a question of careful cost/benefit assessment;
- the safest route is not the shortest one.

A recent Dutch study (DHV, 1979) analysed different types of facilities for cyclists and moped riders as regards traffic safety; it related only to road sections outside built-up areas.
The provisional indication is that roads with one-way cycle paths on

either side are safer for cyclists and moped riders (in injury accidents per km) than roads with no cycle paths. (The same indication was found in Denmark as regards cycle tracks inside built-up areas (OECD, 1978A). On roads with two-way cycle paths on one side, a favourable effect was found only with higher traffic volumes, than on roads with no cycle paths. On roads with two-way cycle paths on one side there are more bicycle and moped injury accidents than on roads with one-way paths on either side (Figure II.1.).

The results indicate that the number of bicycle and moped accidents is greatly affected by the degree of separation (width of separator) and the width of cycle path. A combination of narrow path and a narrow verge causes strikingly more accidents than if both of these are wide enough (Figure II.2.).
These results again support the assumption that design details influence the safety effects of countermeasures. Consequently, care must be taken in presenting and interpreting research results.

II.2. Town centres

In recent decades it has no longer been possible in many cities to meet the growing demand for space for moving and parked motor vehicles. In many cities the existing road system has been adapted to the demand for more and more space; it has been extended with ingenious but often costly and space-consuming solutions.
But despite these countermeasures, the road system threatened to become saturated, making destinations less accessible.
Cities, especially old city centres, threatened to suffocate. There were hardly any perspectives for a policy to meet the demand for more space (for private cars).
It could be said as: "Our cities are here to stay; we should try to accept them as they are and to remember that motor traffic should be a servant only in our modern society" (IFHP, 1973).
Reorientation towards pedestrians and cyclists was certainly not aimed at improving traffic safety, but of halting the increasing demand for space for motor traffic. The increasing traffic hazards

affecting pedestrians and cyclists was an additional argument for breaking out of the vicious circle.

The objective of plans made by many towns and villages was to improve accessibility and livability.
This meant fewer accidents, less traffic noise and air pollution, thereby reducing environmental nuisance due to traffic.
It also meant better accessibility (preferential treatment for public transport users, pedestrians and cyclists), thereby creating live, lively and flourishing town centres.
Bosaeus (1975) gives the purpose of traffic reorganisation in Uppsala as:
"The Uppsala solution aims to restore this human scale factor as the primary one, thereby preserving the old city pattern and environment while attaining acceptable levels of accessibility".

Traffic reorganisation measures have been taken or are in course of preparation in many cities throughout the world.
A number of case studies were presented at the OECD Conference on "Better towns with less traffic" (OECD, 1975). In these, there is a great resemblance between goals and objectives, conditions for countermeasures and the countermeasures themselves.
Besides a goal as formulated by Boseaus, there were some comparable objectives (e.g. Miyazaki (1975) for Japanese town of Nagoya):
- traffic volume reduction
- traffic flow management
- preferential treatment for pedestrians and cyclists.

In a number of the cases (e.g. Bologna, Besançon), another important objective was to increase the use of public transport.
The following countermeasures can be considered for achievement of all these objectives:
- one-way systems (e.g. Reading);
- traffic-cells (e.g. Stockholm, Bremen, Nagoya);
- pedestrian precincts (e.g. Göteborg, Bologna).

Effects of countermeasures cannot usually be generalised.

The types of countermeasures and the conditions in which they are applied differ very greatly. Every "experiment" is unique. Consequently, it is quite a problem to predict anything about the effect or to learn easily from countermeasures adopted elsewhere. Although there has been little research, one main finding can be stated: the total number of accidents decreases considerably in areas where countermeasures have been taken (except for the Singapore-case) (See Table II.1.). Little research results are reported regarding pedestrian and cyclist accidents.

Countermeasures have been taken to improve accessibility and livability on a smaller scale than in an entire town centre. In most cases, some type of pedestrian shopping precinct was provided, with the intention of making shopping more convenient (and hence improving sales).
But especially in the case of such small-scale countermeasures, "Care should be taken that the formation of a pedestrian shopping precinct, or the construction of a regional shopping mall, does not reduce the accident record at the site of the new mall at the expense of increasing the accident record at another location" (Tuohey, 1978). Tuohey reports about the traffic effects of pedestrian shopping facilities (precincts and malls) in New Zealand. He emphasises that no two precincts or malls are the same. We learn from his research that the effects may be widespread, and he suggests that the external (negative) effects may be greater than the internal (positive) effects. About the same conclusion has been drawn by Eburah (1976) from the Oxford Street experiment in London. There was a significant reduction in accidents in Oxford Street itself, but in the area surrounding Oxford Street the position is much less satisfactory. The Oxford Street Accident Study 1969-1975 does, however, show that early assessment (some months) of the effects of traffic management on accidents can be misleading. Bosaeus (1975) found the same, and attributed it to road users feeling unfamiliar with the situation in the early stages.

II.3. Routes and networks for bicycles and mopeds

Routes and networks (a comprehensive system of routes) for "light" two-wheelers, avoiding contact with other road users as fully as possible, can be looked upon as one of the best solutions for traffic segregation inside built-up areas.
In planning new urban areas, facilities for light two-wheelers could be included from the beginning (e.g. Stevenage in the U.K. and Almere in The Netherlands) (See Diepenmaat, 1978).

Creating facilities on existing roads is considerably more complicated for several reasons. Providing space specifically for cyclists and moped riders means taking it from someone else (motorists and/or pedestrians).
In unsaturated traffic conditions, where part of the road surface is reserved for light two-wheelers, this is simply a technical problem and a question of money. The same can be said of facilities which do not cost any parking space.
In reducing traffic flows or the number of parking places (especially in shopping streets), facilities for the exclusive use of light two-wheelers are much more far-reaching and the planning decisions are political ones.

To achieve the optimum use of facilities, some research results should be taken into account (e.g. Statens Planverk, 1975). Cyclists are apparently very familiar with an axiom in mathematics: the shortest distance between two points is a straight line. They therefore try to make a beeline, even if they commit traffic offences in the process. Facilities must be comfortable, with a smooth road surface, no steep gradients, protected from the wind, located in attractive surroundings and uninterrupted, so that the cyclist should not have to stop or get off. From the security angle, they should not be too "remote".

Research into the effect of two cycle routes in The Hague and Tilburg in The Netherlands on the use of bicycles shows an increase in general, and an increase on the routes in particular (Hoekwater, 1978).

Another Dutch study (Katteler et al., 1978) was aimed at ascertaining the number of people riding bicycles and to what extent. Only 10 per cent of the respondents (a sample representative of the Dutch population between the ages of 15 and 74) said the lack of cycling facilities in the immediate surroundings was the reason why they did not ride a bicycle. The principal objections were discomfort (the weather, hardly any possibility of carrying baggage), traffic hazards in general and the poor image that cycling has. No major change in modal-split is likely in view of these results.

Many kinds of facilities are in use for bicycles and mopeds. Their design still involves major problems, because the question of heavy mopeds first has to be sorted out. What has to be done about mopeds that look more like motor cycles than motorised bicycles? It is very doubtful whether heavy mopeds should be allowed to use cycle paths - not only for considerations of safety, but also because of the noise. In The Netherlands there are examples of neighbourhoods that accepted cycle paths for bicycles, but strongly objected the moment it became known that they could be used for mopeds too.
Beukers (1978) reviews a number of different kinds of cycling facilities: suggested lane, bicycle lane, adjacent cycle path, separate cycle path, parallel route. He makes some suggestions for design criteria: widths of lanes and paths and type and width of separator.

No research into traffic safety is available comparing various types of cycling facilities in various traffic and road conditions, neither as regards the effects on use, on accident occurrence, or on feelings of safety. Exceptions are a study of traffic conflicts by the University of Lund (Hydén, 1973) and an accident study in Denmark (OECD, 1978A). Both studies disclosed a favourable effect with respect to accidents, though in Denmark they did not find this at intersections. The sparsity of results might be explained by the lack of such facilities in the world.
Another explanation might be methodological problems in research. In Finland, accidents in an experimental area (with separate facilities for cyclists and pedestrians) and in a control area (all other roads

in Finland) were compared. This study (NBPRW, not published) showed that the total number of pedestrian and cyclist accidents decreased more in the control than in the experimental area. Many explanations can be advanced for these unexpected results: but because of the lack of relevant data (exposure?) the hypotheses could not be verified.

No design or layout guidelines have so far been worked out for certain cycling facilities inside built-up areas (except in Sweden - See Statens Planverk, 1975). If criteria have to be used in designing facilities, it would be quite acceptable to take motor-vehicle volumes and speed-levels (ITTE, 1973). A Finnish study (Velhonoja, 1977) would seem to support this assumption. Though the researcher seems doubtful about generalising his results, he found that the accident rate (accidents involving pedestrians, cyclists and moped per 10^6 km a year)
- increases with increasing speed levels of motor-vehicles;
- increases with increasing motor-vehicle volumes (Figure II.3.).

II.4. Residential areas

II.4.1. Similarities and differences

Residential areas comprise very many varieties (OECD, 1978C).
There are vast differences in:
- building development: one-family houses, high-rise flats;
- road layout: hierarchy, irregular pattern, grid-pattern;
- urban location: near town centre or on outskirts, village;
- space: space inside houses and open, public spaces;
- other land use: commercial, industrial;
- population characteristics: family structure, car ownership.

The traffic safety problem and the scope for solving it may be totally different owing to the differences in the above areas. On the other hand there are similarities, specifically in respect of traffic safety.
Accidents in residential areas often have a very profound and direct

impact on the community; accidents are remembered many years after. It is often neighbours or acquaintances who are involved in accidents. The inhabitants regard the street as their home territory (See Appleyard, 1976, p. 20).

Another point of similarity concerns the nature of the problem and is related directly to the possible solutions. It is the exception rather than the rule to find black-spot locations in residential areas. Accidents are scattered over the area as a whole (Figure II.4.). One might say: the entire system is dangerous, and not a single intersection. This brings us to an area-wide approach for design and implementation of countermeasures.

Differences between residential areas are very determinative, certainly as regards countermeasures for improving traffic safety. An example will illustrate this:
In The Netherlands, many residential areas are laid out as a so-called "woonerf" (estimated at about five hundred).
This has caused no problems where enough space was available. But what is to be done in areas where shortage of space makes an adequate woonerf impossible? Or where there is a constant parking problem? Parking facilities in garages are quite expensive and residents have to pay for them themselves in The Netherlands, apart from government subsidies.

Besides major physical and technical differences in possible countermeasures, the residents themselves will have their own ideas about the most desirable environment. In somewhat exaggerated terms: every resident want the most benefits for himself and will try to pass the drawbacks on to residents in another street. Every resident also creates his own balance between accessibility and livability. It cannot be overemphasised that it is extremely important to involve residents very closely and intensively in planning their own environment (OECD, 1978C; Appleyard, 1976). Residents can help to detect and analyse the problems and to discuss alternatives.

It is not good planning practice to base plans purely on the traffic safety aspect (See Chapter I). A balance must be struck between livability and accessibility. But it is quite clear that environmental management plans demand a totally different way of thinking compared with that in "old-fashioned traffic management" (See Table II.2.).

II.4.2. Countermeasures in existing residential areas

Roads and streets have three functions, as stated in I.4.
The structure of a road system should be such that streets in residential areas have two functions only: access and residential. Pfundt et al. (1975) concluded after an accident study that "safe" residential areas are developed in such a way that through-traffic and local distributor roads are outside residential areas. Gunnarson (1974) also advocates external instead of internal distributors. Furthermore, Pfundt et al. felt that residential areas are obviously safer as the conditions for classifying streets in the system are stricter: through streets or main roads (no roadside housing development), collectors (as free as possible from roadside housing development) and residential access streets.

But the creation of such a system with such strict guidelines is almost impossible in existing areas and calls for fairly drastic alterations. Consequently, we still have to live with streets that have two functions (traffic and access), where it is impossible to alter a function, for instance by changing access to houses or by modifying the structure of the system.
The remaining possibility is mixed-traffic management. Action is required about the collector streets that have an access function, in view of the results of research by Bennett & Marland (1978). They conclude that accidents in the areas studied were greatly concentrated in certain streets (not on certain spots in those streets) (Table II.3.):
"The mean pedestrian accident rate (accidents per 10.000 persons per year) in simple culs-de-sac was less than one-sixth of the overall mean, while that in the bus routes was three times the mean". Bus

routes are likely to be located on collector streets. The relationship established between accident rates for pedestrians and the observed vehicle flow may explain the high accident rates on collectors as well as on bus routes.

Bennett & Marland have another quite interesting conclusion:
"The analysis to data suggests that the simple cul-de-sac provides a markedly safer residential environment than any other type of street or combination of street types (Table II.4.).

This suggestion agrees with the findings of Pfundt et al. (1975). They compared the total number of accidents in culs-de-sac and loop streets. Residential areas with access streets planned as culs-de-sac are safer than those with loop streets. The same applies to local distributors.

These research results lead to the next conclusions:

- maximise the proportion of accesses with fronts on to the lowest order access streets;
- minimise the proportion of accesses with fronts on to local distributors;
- the planning principle in residential areas both for access streets as well as for local distributors might be the cul-de-sac approach;
- management of mixed traffic especially on local distributors is rather important, which means the creation of an "environment of care" and putting an end to the present-day dominant role of motor vehicles.

How to modify driver behaviour (the most obvious characteristic of which is vehicle speed) will be a subject for the session on traffic engineering.

III. POINTS FOR DISCUSSION

1. Working according to a hierarchical planning process deals best with complicated and interrelated policy fields and provides the best scope for built-in safety in our traffic system.
2. It now appears that "normal" road design leads to a dominant position of motor vehicles (too many fast moving vehicles and extensive parking) and consequently to less safety for pedestrians and cyclists.
3. The purpose of introducing a classification of the road network according to function is to ensure that the three functions of a road: traffic function, access function and residential function are better balanced. Road classification necessitates a systematic approach in which areas are integrally designed or redesigned.
4. Considering the results of studies working with accident statistics, it seems to be hardly useful or possible to establish rigid criteria for lay-out and design of facilities for pedestrians and cyclists nor to give general statements on the priority of different (counter)measures. However, principles for designing and redesigning seem to be based on results from such safety research.
5. There is a fair chance of losing safety benefits in too small sized planning activities. Care should be taken in planning pedestrianised areas and cycle tracks, and in redesigning residential areas so as not to move the problems to the boundaries of the planning areas.
6. Design principles and design criteria (standards) should be developed with highest priority for those streets lying in the "grey middle area" on the scale of hierarchy of roads. In that area we meet the problem of the local distributor or collector. However, traffic function and access function are incompatible with one an other. Those streets have to perform both functions in the same space. Here street design needs to manage mixed traffic.
7. Design principles and design standards for all types of street (but with priority for local distributors) ought to be based on factual data coming from research and not only on opinions or common sense. In those data relationships need to be established between accident figures - behaviour of traffic - street characteristics and traffic pattern.

TABLES II.1.-II.3.

Table II.1. Comparison of results of different accident studies on town centres

Table II.2. Objectives of traffic and environmental management. (Source: Gilbert & Jowitt, 1976)

Table II.3. Accident rates by street type. (Source: Bennet & Marland, 1978)

Town	Year of introduction scheme	Effects scheme area	Effects in area surrounding scheme area	Effects control area	Specific effects on pedestrians	Length before/ after period
Reading[1]	end sixties	-29%	-	+ 7%	-	3/3 year
Uppsala[2]	1972/1973	-47%	+(4-12)%	-30%	-	3/2 year
Nottingham[3]	1973	-53%	+9%	-	-74%	3/5 year
Singapore[3]	1975	0%	-	-	0%	5/4 month
Stockholm[1]	1972	-31%		-	-	1/1 year
Nagoya central area[3]	1974	-32.8% (a)			-	-
		-45.0% (b)			-	-
		-50.9% (c)			-	-
64 zones[2]	1974	-31%		-	-	1/1 year
12 zones[3]	1976	-33%			-27%	1/1 year

[1] OECD, 1978B

[2] OECD, 1975

[3] Personal communication

(a) fatalities

(b) grave injuries

(c) slight injuries

Table II.1. Comparison of results of different accident studies on town centres

Traffic management	Environmental management
Increase flows (up to maximum traffic capacity)	Reduce flows (down to environmental capacity)
Reduce journey time	Reduce speeds
Reduce accidents (by controlling pedestrians)	Reduce accidents (by controlling vehicles)
Make best use of roads (by spreading and increasing load)	Make best use of roads (by inhibiting and reducing load)

Table II.2. Objectives of traffic and environmental management.
(Source: Gilbert & Jowitt, 1976)

Street type	9003-street sample			5474-street sample		
	No of streets	No of residents (thousands)	Pedestrian accident rate	No of streets	No of residents (thousands)	Non-pedestrian accident rate
Straight	5007	559	5.30	2805	279	3.31
Curved R 2500 ft	959	189	12.95	638	114	10.27
Curved R 2500 ft	3036	646	9.14	2031	419	9.63
Open-plan	1227	184*	7.21*	967	143*	7.15*
Not open-plan	7776	1210*	8.25*	4507	669*	7.63*
Bus route	700	243	25.66	495	166	26.64
No bus	8303	1150	4.41	4979	645	3.14
School access	636	181	20.08	352	99	18.72
No school	8367	1213	6.33	5122	712*	5.99
Shop access	490	158	25.65	253	89	24.51
No shop	8513	1236	5.87	5221	722*	5.47
Access to recreation	280	79	19.88	138	40	18.55
No access to recreation	8723	1314	7.41	5336	771	6.98
No open ends	69	11	4.06	49	4	2.60
One open end	3229	294	2.50	1980	185	2.51
Two open ends	5696	1088	9.67	3439	618	9.12
All	9003	1393	8.13	5474	811	7.55

Notes: Accident rates are quoted in personal-injury accidents per 10 000 residents per year. "Recreation" means recreational facilities suitable for children.

Table II.3. Accident rates by street type. (Source: Bennett & Marland, 1978)

*Printing errors in original report are corrected after communication with the authors

FIGURES I.1.-I.4. AND II.1.-II.4.

Figure I.1. Structure plan Almere-town; (A) Network for cyclists/ pedestrians and bus routes. (B) Road network for motorcars and railwayline. (Source: Diepenmaat, 1978).

Figure I.2. (Source: Colman, 1978).

Figure I.3. The traditional concept of the graded road hierarchy. (Source: Brindle, 1978).

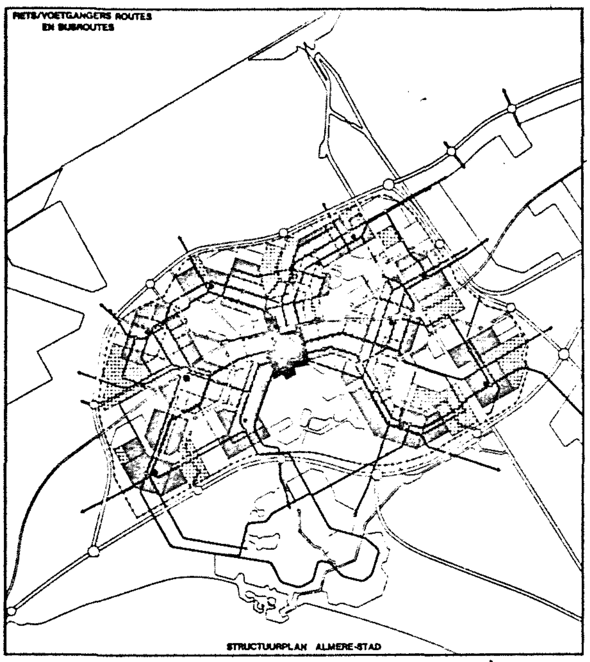
Figure I.4. What really happens in a hierarchy. (Source: Brindle, 1978).

Figure II.1. Average accidents per kilometer road length for different motor vehicle flows per day. (Source: DHV, 1979).

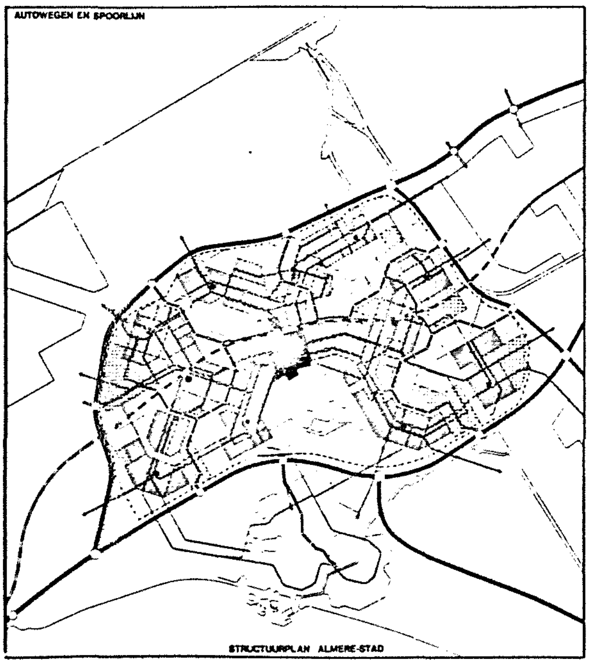
Figure II.2. Safety coëfficients (A = 1.00) for a combination of width of cycle path and width of verge; (I) for roads with two-way cycle paths on one side, (II) for roads with one-way cycle paths on either sides. (Source: DHV, 1979).

Figure II.3. The dependance of the accident rate of light traffic on the volume and speed of the motor vehicle traffic. (Source: Velhonoja, 1977).

Figure II.4. Location of accidents spots: Mannheim-Vogelstang. (Source: Pfundt et al., 1975).



(A) Network for cyclists/pedestrians and bus routes



(B) Road network for motorcars and railwayline

Figure I.1. Structure plan Almere-town. (Source: Diepenmaat, 1978).

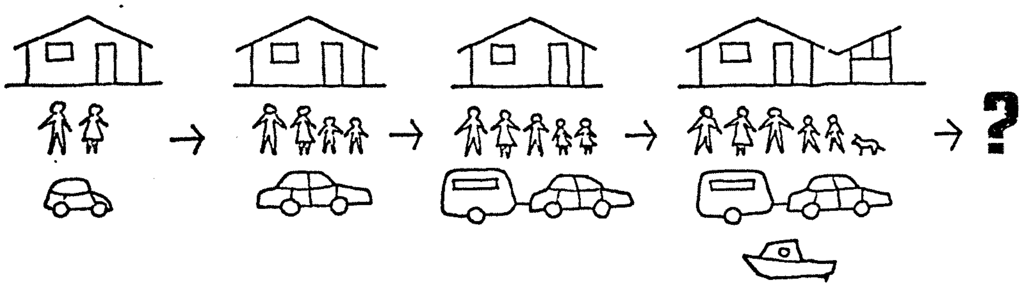


Figure I.2. (Source: Colman, 1978).

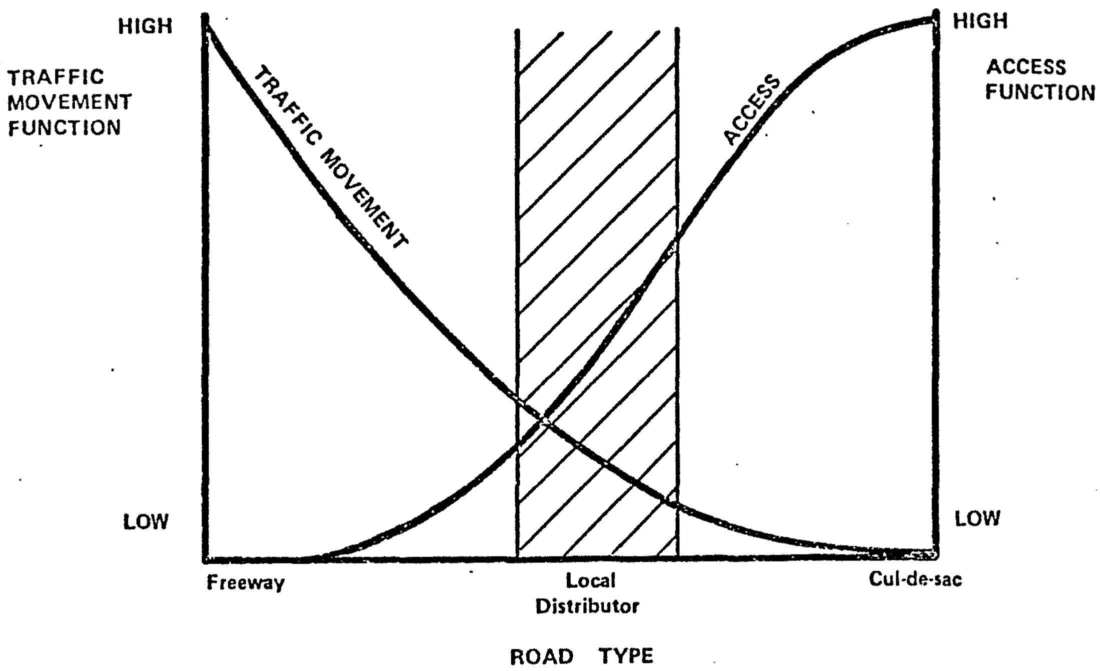


Figure I.3. The traditional concept of the graded road hierarchy. (Source: Brindle, 1978).

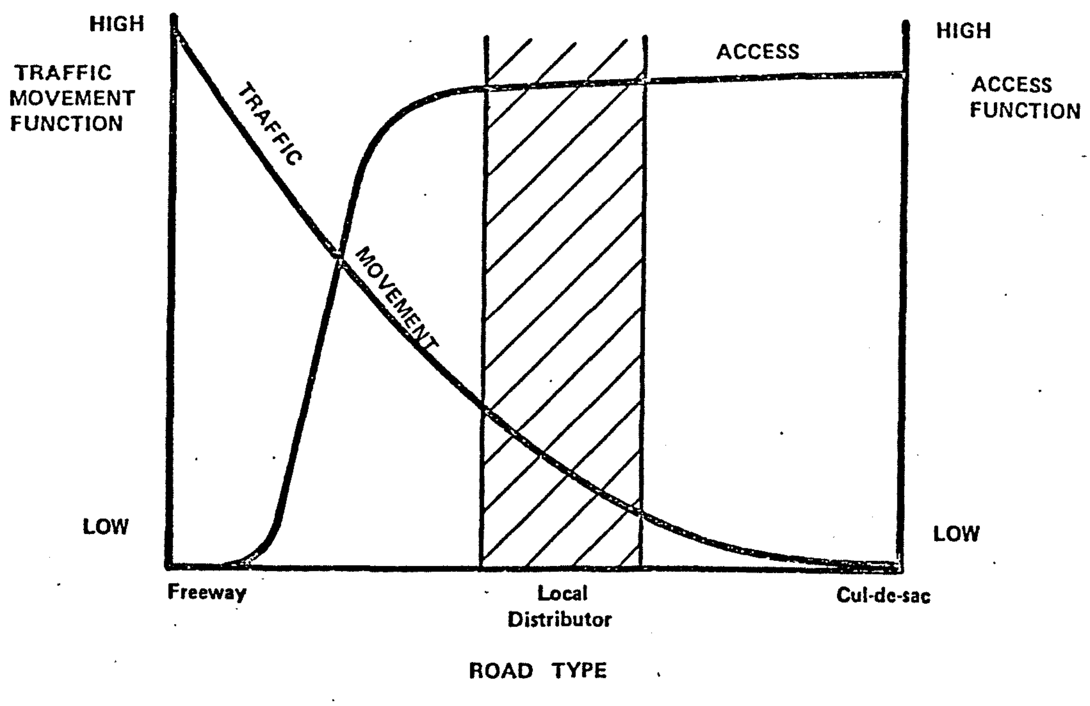


Figure I.4. What really happens in a hierarchy. (Source: Brindle, 1978).

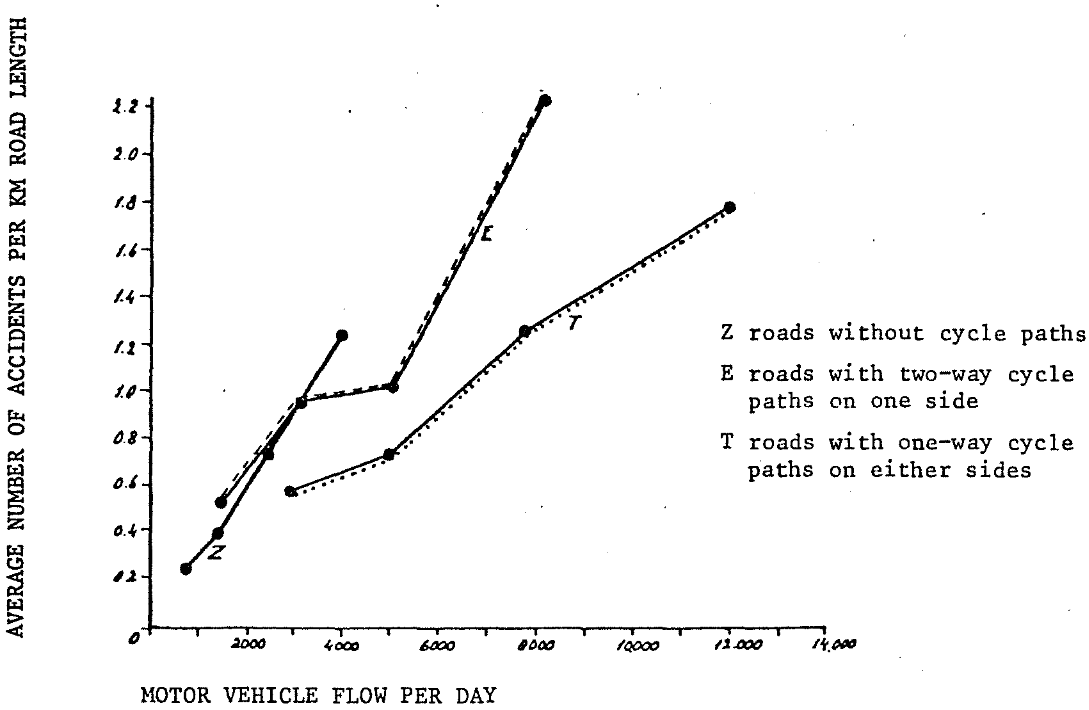


Figure II.1. Average accidents per kilometer road length for different motor vehicle flows per day. (Source: DHV, 1979).

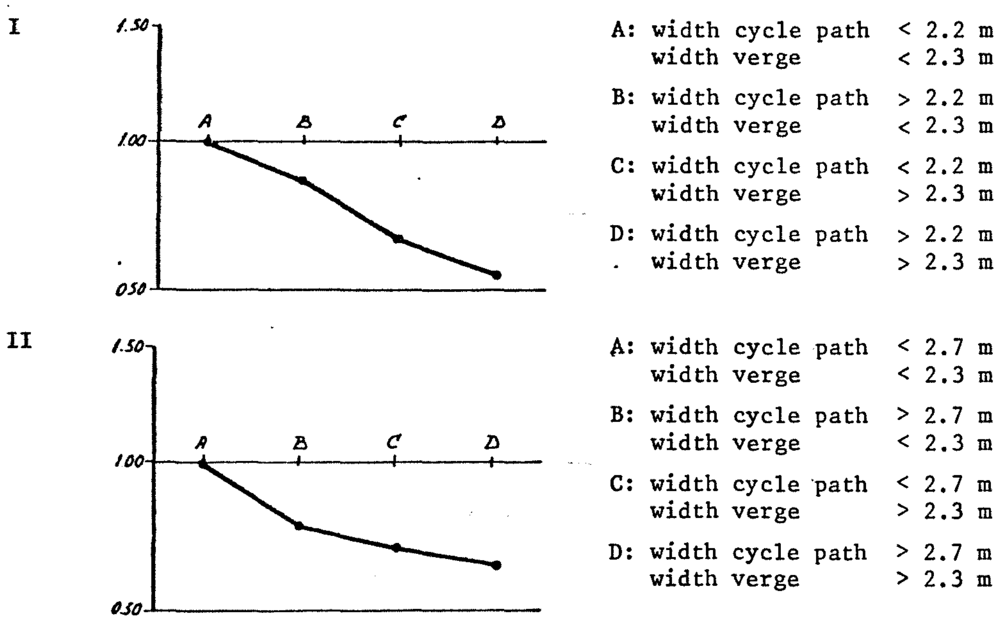


Figure II.2. Safety coëfficients (A = 1.00) for a combination of width of cycle path and width of verge; (I) for roads with two-way cycle paths on one side, (II) for roads with one-way cycle paths on either sides. (Source: DHV, 1979).

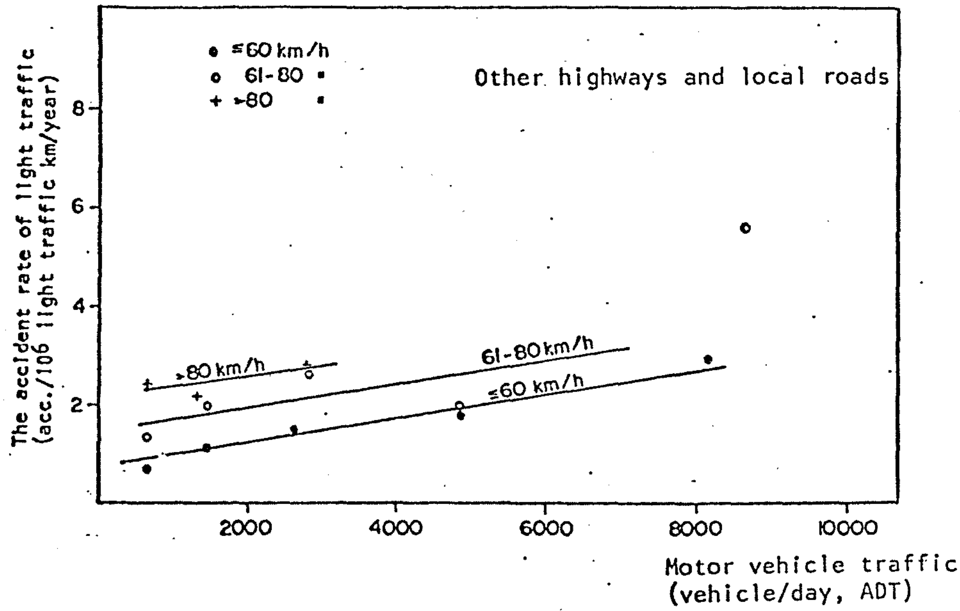


Figure II.3. The dependance of the accident rate of light traffic on the volume and speed of the motor vehicle traffic. (Source: Velhonoja, 1977).

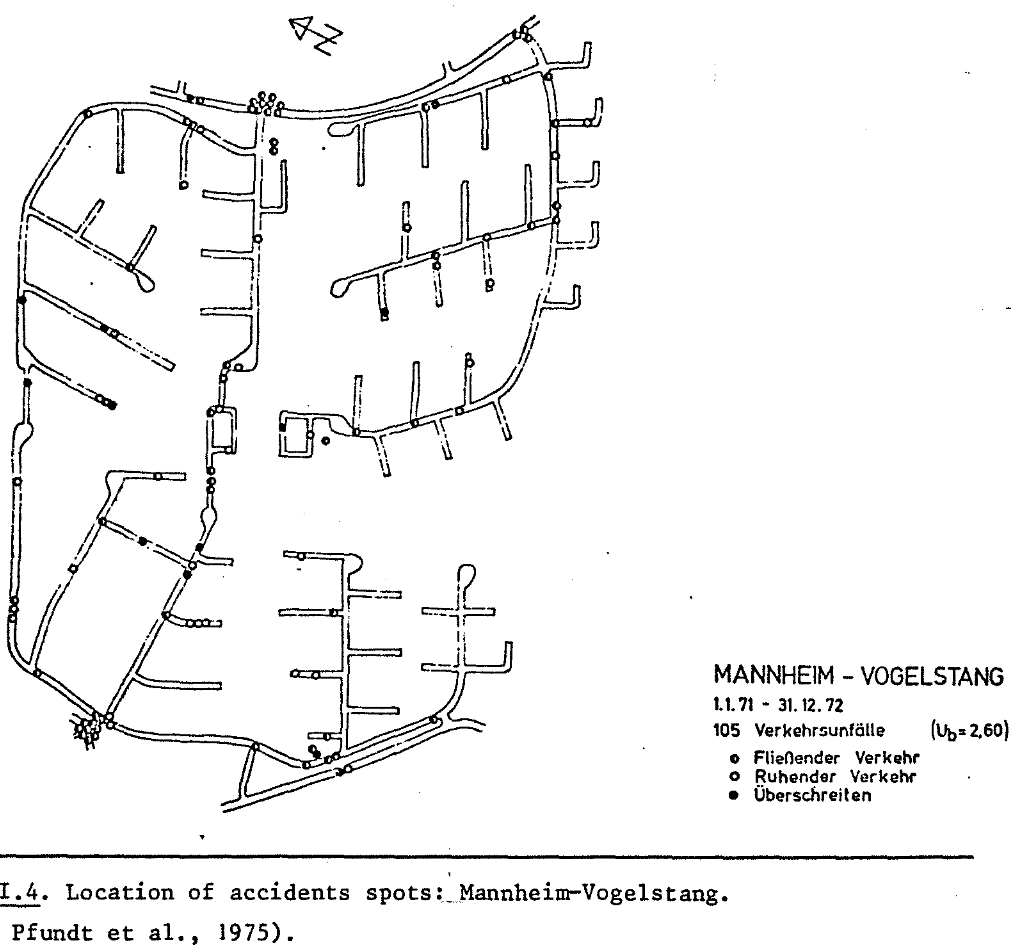


Figure II.4. Location of accidents spots: Mannheim-Vogelstang.
(Source: Pfundt et al., 1975).

REFERENCES

Appleyard, D. et al. (1976). Liveable urban streets: Managing auto traffic in neighborhoods. Report FHWA/SES-76-03. U.S. Department of Transportation, Washington, D.C., 1976.

Bennett, G.T. & Marland, J. (1978). Road accidents in traditionally designed local authority estates. TRRL Supplementary Report 394. TRRL, Crowthorne, 1978.

Beukers, B. (1978). Bicycle facilities in The Netherlands. Presented to 13th AIT/FIA/PIARC International Study Week on Traffic Engineering and Safety, Montreux, 11-16 September 1978.

Bosaeus, B. (1975). Case study Uppsala (Sweden). In: OECD (1975).

Brindle, R.E. (1978). Residential area planning for pedestrian safety. Paper presented to the Joint ARRB/DOT Pedestrian Conference, Sydney, 15-17 November 1978.

Colman, J. (1978). Streets for living; A guide to better Australian residential design practice. Special Report No. 17. Australian Road Research Board, Vermont, Victoria, 1978.

DHV Raadgevend Ingenieursbureau B.V. (1979). Onderzoek naar de relatie tussen weg- en verkeerskenmerken en de ongevallenkans van (brom)fietsverkeer langs wegvakken buiten de bebouwde kom (Research on the relationship between road and traffic characteristics and the accident risks of cyclists and moped riders along road sections outside built-up areas). (Concept). DHV, Amersfoort, 1979. (Only in Dutch).

Diepenmaat, E.W.G. (1978). Nieuwe stedelijke structuren (New urban structures). In: Congresverslag Nationaal Verkeersveiligheidscongres 1978 (Proceedings National Conference on Road Safety 1978), Amsterdam, 19-20 april 1978, pp. 26-31. ANWB, 's-Gravenhage, 1978. (Only in Dutch).

Eburah, J.W. (1976). Oxford Street accident study 1969-75. In: Proceedings of Seminar K on Traffic and Environmental Management, PTRC Summer Annual Meeting, University of Warwick, 12-16 July 1976. PTRC, London, 1976.

Gilbert, D. & Jowitt, P. (1976). Environmental evaluation of traffic management schemes: A review. In: Proceedings of Seminar K on Traffic and Environmental Management, PTRC Summer Annual Meeting, University of Warwick, 12-16 July 1976. PTRC, London, 1976.

Gunnarson, S.O. (1974). Efforts to increase pedestrian safety through urban planning measures: Swedish experiences. Presented to 12th International Study Week (in) Traffic Engineering and Safety, Theme 1, Beograd, 1974.

Hoekwater, J. (1978). Demonstration cycling-routes in The Netherlands. Paper presented to PTRC Spring Courses 1978 on Cycle Planning, 3-4 April 1978, Lecture 5B.

Hydén, C. (1973). Trafiksäkerhet via informationssystem; Utvärdering av Rosengårdsstråket i Malmö. Planfor Report No. 66, Part 2. University of Lund, 1973.

IFHP (International Federation for Housing and Planning) (1973). Goals for the development of the city centre. IFHF, The Hague, 1973.

ITTE (Institute of Transportation and Traffic Engineering) (1973). Proceedings of the Pedestrian/Bicycle Planning and Design Seminar, University of California, Berkeley, July 1973.

Janssen, S.T.M.C. (1976). Design and classification of roads from the viewpoint of driving task analysis. In: Proceedings OECD Symposium on Methods for determining geometric road design standards 1976, Helsingør, 10-12 May 1976.

Katteler, H.A. et al. (1978). Het gebruik van de fiets in Nederland (The use of the bicycle in The Netherlands). ITS, Nijmegen, 1978. (Only in Dutch).

Lea, N.D. et al. (undated). A study of measures to improve pedestrian and bicycle safety. TP 1004. Transport Canada, Ottawa.

Miyazaki, T. (1975). Case study Nagoya (Japan). In: OECD (1975).

Miyazaki, T. (1979). Nagoya. Personal communication.

Muhlrad, N. (1976). Introduction of the pedestrian and two-wheeler safety factor in the planning process. In: Hakkert, A.S. (ed.). Proceedings of the International Conference on Pedestrian Safety, Haifa, 20-23 December 1976, Vol. 1, Paper 3B. Michlol-Publishing House, Haifa, 1976.

NBPRW (National Board of Public Roads and Waterways, Finland). The safety effects of arrangements for light traffic. (Not published).

OECD (1975). Proceedings of the OECD Conference Better towns with less traffic, Paris, 14-16 April 1975. OECD, Paris, 1975.

OECD (1978A). Safety of two-wheelers. OECD, Paris, 1978.

OECD (1978B). Integrated urban traffic management. OECD, Paris, 1978.

OECD (1978C). Traffic safety in residential areas. (Draft report).

Pfundt, K. et al. (1975). Verkehrssicherheit neuer Wohngebiete. HUK-Verband, Köln, 1975.

Statens Planverk (1975). Cykeln i stadens trafiknät. Report No. 33, Del 1. Uppsala, 1975.

Tuohey, G.J. (1978). Traffic aspects of pedestrian malls. RRU Bulletin 36. National Roads Board, Road Research Unit, Wellington, New Zealand, 1978.

Velhonoja, P. (1977). The effect of road and traffic conditions on light traffic accidents. National Board of Public Roads and Waterways, Road Design Office, Helsinki, 1977.

Waller, P.F. & Reinfurt, D.C. (1969). Bicycles: An analysis of accidents in North Carolina. University of North Carolina, Chapel Hill, 1969.

Woodcock, N. (1979). Nottingham. Personal communication.

Yee, J. (1979). Singapore. Personal communication.