EVALUATION OF A NUMBER OF MEASURES FOR INCREASING PEDESTRIAN SAFETY

J.H. Kraay, Sociologist

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Institute for Road Safety Research SWOV, The Netherlands

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INTRODUCTION

Everybody, in town and country, is a pedestrian road-user almost daily. His behaviour is then governed by his optical impressions, habits and experience rather than by traffic-control regulations.

A pedestrian is often an unpredictable road user. In terms of vehicles, he is very manoeuvrable, accelerates fast and can stop very quickly. He can also move forward, backward or sideways.

Differences in age, sex and destination are reflected more clearly in pedestrian traffic than in wheeled traffic.

Because of all this, pedestrian traffic is more difficult to fit in a clear and simple pattern than wheeled traffic. There is an absolute lack of good methods for recording the characteristic features of pedestrian flows.

Measures for preventing or reducing the number of conflicts between vehicles and pedestrian traffic have taken the shape of pedestrian crossings.

A pedestrian crossing gives the pedestrian a certain measure of legal and/or physical protection.

Such crossings can be subdivided into various types:

1. Zebra crossings;
2. Light-controlled crossings; a variant of these is the crossing with push-button lights;
3. Pedestrian bridges and subways.

Measures for each of these three possibilities will be considered in succession.

1. Zebra crossings

1.1. Zebra crossings as a legal measure

In the Netherlands the first legal recognition of the pedestrians' status as road-users dates from 1st November 1961. Wheeled traffic was then required to give pedestrians free passage on a zebra crossing.

The regulations governing pedestrians and motorists applicable to zebra crossings are contained in the Traffic Rules and Symbols Regulations, a Royal Decree of 4th May 1966. Article 99 relates to pedestrians, and provides that:

(1) Pedestrians must cross a carriageway or a cycle path carefully, without unnecessary stops and straight over;

(2) Pedestrians must not cross the road within 30 metres of a zebra crossing;

(3) The rule in (2) does not apply if the pedestrian would first have to cross another road in order to reach the zebra crossing, nor if he walks to or from a public transport vehicle from or to the nearest pavement.

Article 100 concerns drivers of motor vehicles, and states that:

(1) Drivers must approach zebra crossings with care and must give free passage to pedestrians who are on the crossing.

(2) This obligation does not apply to police cars or fire engines, ambulances or motor vehicles of other emergency services designated by the Minister of Transport and carrying visible and audible signals as directed by the Minister under Article 58, nor to military convoys or funeral processions.

Article 37 contains a regulation about motor vehicles overtaking and roads (inter alia):

(3) Overtaking on the left or the right is forbidden if the vehicle being overtaken is stationary before a zebra crossing or is approaching it slowly.

It was at first thought that these regulations had reduced the number of pedestrians killed in road accidents. In 1960 there were 530 pedestrian deaths and a drop in 1961 to 471.

Table 1, however, shows that if 1960 is disregarded the number of pedestrian fatalities has risen steadily. It must be assumed therefore that the 530 deaths in 1960 were an exception to the trend over a number of years.

Year	Road Casualties	Of which pedestrians		Road deaths	Of which pedestrians	
	Number	Number	%	Number	Number	%
1950	20.554	4786	23,3	1021	356	34,9
1951	23.293	5171	22,2	1134	376	33,2
1952	25.230	5436	21,5	1097	346	32,5
1953	28.335	5976	21,1	1390	427	30,7
1954	31.961	6358	19,9	1520	437	28,8
1955	35.649	6658	18,7	1552	470	30,3
1956	38.263	7025	18,4	1628	467	28,7
1957	41.215	7221	17,5	1701	465	27,3
1958	41.386	7029	17,0	1604	439	27,4
1959	45.244	7324	16,2	1718	449	26,1
1960	50.284	7709	15,3	1926	530	27,5
1961	52.168	7689	14,7	1997	471	23,6
1962	52.602	7506	14,3	2082	485	23,3
1963	53.223	7459	14,0	2007	506	25,0
1964	61.562	8219	13,4	2375	520	21,9
1065	64.366	8561	13,3	2479	578	23,3
1966[x]	67.924	8906	13,1	2620	606	23,1
1967	63.964	7889	12,4	2862	601	21,0
1968	65.007	7618	11,7	2907	589	20,2

x) From the end of 1966 limited accident records were introduced.
This has influenced the number of recorded casualties.

Table 1

Number and proportion of pedestrians in recorded road casualties and deaths in period 1950-1968 (Source: Central Statistical Office)

This table also shows that the number of pedestrians among road casualties is increasing less rapidly than the total number of casualties recorded. It must not be concluded from this, however, that pedestrian traffic has become relatively safer. It is more likely to be due to the much quicker increase in the number of other road casualties. This in turn is largely due to the more rapid increase in the number of private cars (and their mileage) as compared with the increase in the number of pedestrians based on the growth in population.

It is also remarkable that the introduction in November 1961 of the zebra-crossing regulations hardly seems to have affected the pattern of accidents.

As is often customary, the places where pedestrians come into conflict with motor vehicles are now sub-divided into zebra crossings, light-controlled crossings and elsewhere. The international literature invariably shows the same differences, of which table 2 is an example.

Place		Relative risk
At, or within 20 yards of a junction	on light-controlled crossing	0,20
	on zebra crossing	0,65
	elsewhere	1,25
more than 20 yards from a junction	on zebra crossing	0,22
	elsewhere	1,00

Table 2. Relative risk when pedestrians cross roads (Source: R.R.L., 1965).

This table shows that zebra crossings involve three times the relative risk of light-controlled crossings. But zebras are comparatively safer than elsewhere.

There are no demonstrable indications that this pattern is different in the Netherlands. Nor is there any reason to suppose that the introduction of the regulations caused any movement in the relative safety figures.

Legal protection does not in fact mean accident protection.

It is pertinent to ask whether pedestrian safety <u>can</u> indeed be promoted by such regulations. If the ratios inside and outside built-up areas are first examined, it is found that 85% of pedestrian casualties occur in built-up areas (table 3).

In built-up areas		Outside built-up areas	
Pedestrians killed	Pedestrians injured	Pedestrians killed	Pedestrians injured
337	6368	264	920
85%		15%	

<u>Table 3</u>. Numbers of pedestrians killed and injured in traffic accidents inside and outside builtup areas in 1967 (Source: Central Statistical Office).

Accident statistics also show that about 10% of pedestrian casualties in built-up areas occur on zebra crossings. If zebra crossings could be made 100% safe (which is most doubtful) there would have been about 670 fewer pedestrian casualties in 1967. Or about 8.5% of the total in that year.

As interpretation of the zebra-crossing regulations causes constant problems for both pedestrians and motorists, while the police can hardly check these interpretations, it will be difficult to bring about even a low percentage in overall pedestrian safety.

1.2 Lighting zebra crossings

As a number of Dutch traffic experts doubt the safety effect of the November 1961 regulations, supplementary means are being sought of making zebra crossings more conspicuous after dark.

1. There are a number of possibilities of making zebra crossings more conspicuous such as: signal lights in the road surface, flashing lights, special lighting, or coloured light.

2. According to Schreuder (1964) it is essential to have good street lighting or good lighting of the zebra crossing itself. If street lighting is good there is no need to light the crossing as well.

3. With bright overhead zebra-crossing lighting limited to the zebra path, there is a danger of the pedestrian believing he is clearly visible when he is often not so. This gave rise to the idea of the silhouette effect.

Depending on the standard of street lighting, each zebra crossing should have either a negative contrast between pedestrian and background (i.e. pedestrian dark against the road surface) or a positive contrast.
The minimum contrast is a luminosity ratio between pedestrian and background, or vice versa, of at least 1.3[1].
If there is no continuous street lighting a positive contrast is cheaper to achieve in practice than a negative contrast. In the latter case, 150 metres of lighting on both sides of the crossing is necessary. And with a wet road surface the negative contrast is difficult because the background can hardly be made uniformly bright.

Giovanelli, Blevin and Wright (1962) propose that zebra crossings needing additional lighting should be provided with spotlights shining from the direction of oncoming traffic so that motorists see pedestrians in direct light. They want to improve the silhouette effect (positive contrast), which their system makes possible even in bad weather. They believe that special lighting is advisable for frequently used zebra crossings so that pedestrians will stand out more against the background.

In order to obtain proper lighting, the Street Lighting Committee[2] advises such a lighting system in which the lamps, seen from the direction of driving, are fitted before and over the crossing. The main thing is to provide enough horizontal illumination of the crossing so that the crossing itself is clearly recognisable. At the same time there must be enough vertical illumination to observe the pedestrian using the crossing.

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1) Report on Spa Conference of lighting experts, October 1967.

2) Meeting of Street Lighting Committee of Netherlands Illumination Association, 5th November 1965.

Another means of lighting is black and white posts (Siemens system). These 1.50-metre high posts are placed at the four corners of a zebra crossing; they cast light horizontally towards the centre of the crossing.

Visual assessment of a number of lighting installations by the Street Lighting Committee* members gave the following rating (from top down):

1. A.E.G. system: 4 posts; height 5 m; per fitting 2 x 65 Watts TL; arm length 2.5 m; (posts before and after crossing).
2. Philips system: 2 posts; height 7 m; per fitting 1 x SO 200 Watt; arm length 2.66 m; (posts before crossing);
3. Elektrostraling system: posts 4.5 m high; per fitting 2 x HPL 125 Watt; arm length 3 m; (before crossing).
4. Posts after crossing: height 9 m; per fitting 2 x 250 Watt HPL; arm length 1.5 m.
5. Siemens system: 4 posts each 1 x 60 Watt sodium; (at side of crossing).

The criteria were the extent to which the crossing and the pedestrian crossing over were visible and the extent to which a pedestrian still on the pavement is also visible.

It is not actually clear from the report whether the investigation examined the different lighting systems under the same conditions (such as road width, standard of street lighting etc.).

As already noted, road-surface illumination is very important in conjunction with crossing lighting. The Netherlands Illumination Association (1967) recommends an average road-surface illumination of at least 1 cd/m^2 over

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* Meeting of Street Lighting Committee of Netherlands Institute of Illumination, 5th November 1965.

a length of about 100 metres at both sides of the crossing. In order to make the crossing more conspicuous, other (i.e. additional) light sources besides street-lighting can be used with horizontal (E_H) and vertical (E_V) illumination. The E_H and E_V values depend on the strength of the street-lighting, the criterion for which is the average horizontal illumination ($\bar{E}_{H,OV}$). E_H and E_V should be at least equal to 5 x $\bar{E}_{H.OV}$ and certainly not less than 40 lx. If $\bar{E}_{H.OV}$ is greater than 20 lx lighting in situ is unnecessary.

The SWOV has already pointed out (in 1967) that additional zebra lighting is needed only if the crossing is relatively very dangerous and only if this danger is indeed due to the lack of adequate street lighting. The SWOV also pointed out the danger of additional lighting for some crossings, which may reduce the value of those without it.

It would be better if the entire road situation (crossing and junction) could be uniformly lighted. Most crossings are at junctions. Additional lighting for the crossing often worsens the lighting at the junction, which is not advisable. Additional lighting could, however, be provided for crossings not located at junctions.

2. "Green waves" for pedestrians

2.1 Introduction

The rapid growth of traffic will create an increasing need for additional facilities in the form of new roads and road improvements and for more efficient traffic control. In practice, however, such facilities are not always possible because of lack of space or shortage of funds.
It is possible however to improve the efficiency of the existing road system. As the efficiency of the road system is largely determined by the capacity of intersections, traffic control installations have been designed and operated in Delft which make the very most of the available traffic space.

2.2 Requirements for traffic control

The prime requirements for traffic control will be briefly indicated.

Performance[1)]

Traffic control performance must be maximal; it is at its maximum when lost time is at a minimum.

Lost time relating to the times when intersections are not in use by traffic is minimal if, with the correct green-phase combination and green-phase sequence, the position of each individual green phase is related solely to the end of the queue of the preceding conflict phase or phases[2)].

1) Hakkesteegt (1970) uses the term 'performance' for the notion of capacity. Performance of a traffic control system is defined as the number of vehicle (including pedestrians, cyclists) able to cross the intersection per unit of time.
2) Conflict phases are the green/amber phases of directions from which traffic flows are not admitted to the intersection at the same time.

With any other system a smaller number of vehicles will be able to cross the intersection owing to the lost time being greater.

Safety in relation to performance

Safe traffic movement is mostly achieved by "safeguarding" the conflict situations against each other and by choosing the times of the clearance phases so that no first vehicle collides with any last vehicle. In this context, a pedestrian is also considered as a vehicle.

2.3. The Delft flexible traffic-light system

Traffic control meeting these requirements is possible only with efficient division of the time and space factors for the benefit of the intersecting traffic flows. Owing to the big fluctuations in traffic patterns, in the form of traffic volume and its structure - which varies very greatly in the Netherlands - there are very many combinations of these factors. The possibility of reacting to these combinations determines traffic control efficiency. For every moment a traffic light is unnecessarily green for a given direction, cars and pedestrians are probably waiting unnecessarily for the other directions. All these possibilities and requirements are built into the Delft flexible traffic-light system, for cars, public transport (trams and buses), cyclists and pedestrians (Hakkesteegt, 1970). The system is adapted to the density, nature and behaviour of the various fluctuating traffic flows. In Delft, operation of the control equipment is not only traffic-related but is partly also provided with simple memory-decision elements for optimalising control and also for special priority facilities for public transport and pedestrians.

2.4. "Green waves" for pedestrians

The bigger and more complicated an intersection is for wheeled traffic, the more complex it becomes to cross it on foot. Thus the pedestrian is forced to cross in stages and to wait on refuges between the flows of traffic. Many of them will not tolerate this, ignore the traffic signs and simply cross. Pedestrian-crossing lights which these road users regard as remaining unnecessarily red encourage offences.
Within the Delft flexible traffic-light system priority is given to road-crossing pedestrians.
By pressing buttons the pedestrian reports to the traffic control equipment, which acts separately for each direction in order to synchronise the series of pedestrian crossing-lights and make one wait for the other if necessary. This not only cuts unnecessary waiting times for pedestrians, but also creates green waves for them so they can cross the complicated intersection in a single journey. The whole system is planned so that these pedestrian facilities do not adversely affect the capacity of the intersections. Having to "report" to the control equipment automatically distinguishes between: "pedestrians" and "no pedestrians". If there are no pedestrians, wheeled traffic can carry on with minimum waiting times.

This initial experiment with green waves for pedestrians has the following advantage for them.

1. As regards convenience, it is obviously more convenient for the pedestrian if waiting times are reduced to a minimum; this means even more to him in bad weather with rain or snow.
2. The impression is that familiarity with the system induces people to obey it more (by not crossing when the light is red and not

walking across near the pedestrian crossing) than they do at other controlled crossings, and therefore safety is also likely to become greater.

There is a definite impression that these green waves for pedestrians will have a favourable effect. The system will therefore be regularly extended in the future, especially where there are situations dangerous to pedestrians.

3. Pedestrian bridges and subways

In order to reduce the number of conflicts between pedestrians and vehicles to nil, the only (basic) solution is to separate pedestrian traffic spacewise from wheeled traffic. Separation timewise in the form of zebra crossings and light-controlled crossings has proved inadequate.

Examples of this principle can be found in the Netherlands in Lelystad, with its pedestrian bridges and in Bijlmermeer (an Amsterdam suburb) with subways.

Lelystad is a Dutch new town, built in the Easter Flevo Polder (formerly the Zuider Zee). It now has 4,000 inhabitants and will become a city with 100,000. The plans provide for four residential areas, each with its own neighbourhood centre and urban amenities, separated by zones reserved for special uses.

The traffic system on which the plans are based means that outside the actual residential areas three different kinds of traffic are almost completely segregated, i.e. motorised vehicles (including mopeds), cyclists and pedestrians.

The main roads, for mixed motorised traffic only, are 0.80 m lower than the street level in the residential areas. This depth reduces the difference in height for cyclists and pedestrians surmounting the bridge. In addition to traffic signs showing pedestrians that walking on main roads is prohibited, it is made physically impossible for them to cross such roads because there are ditches on both sides of them bounded by shrubbery reaching to the houses. This ensures 100% usage of the bridges.

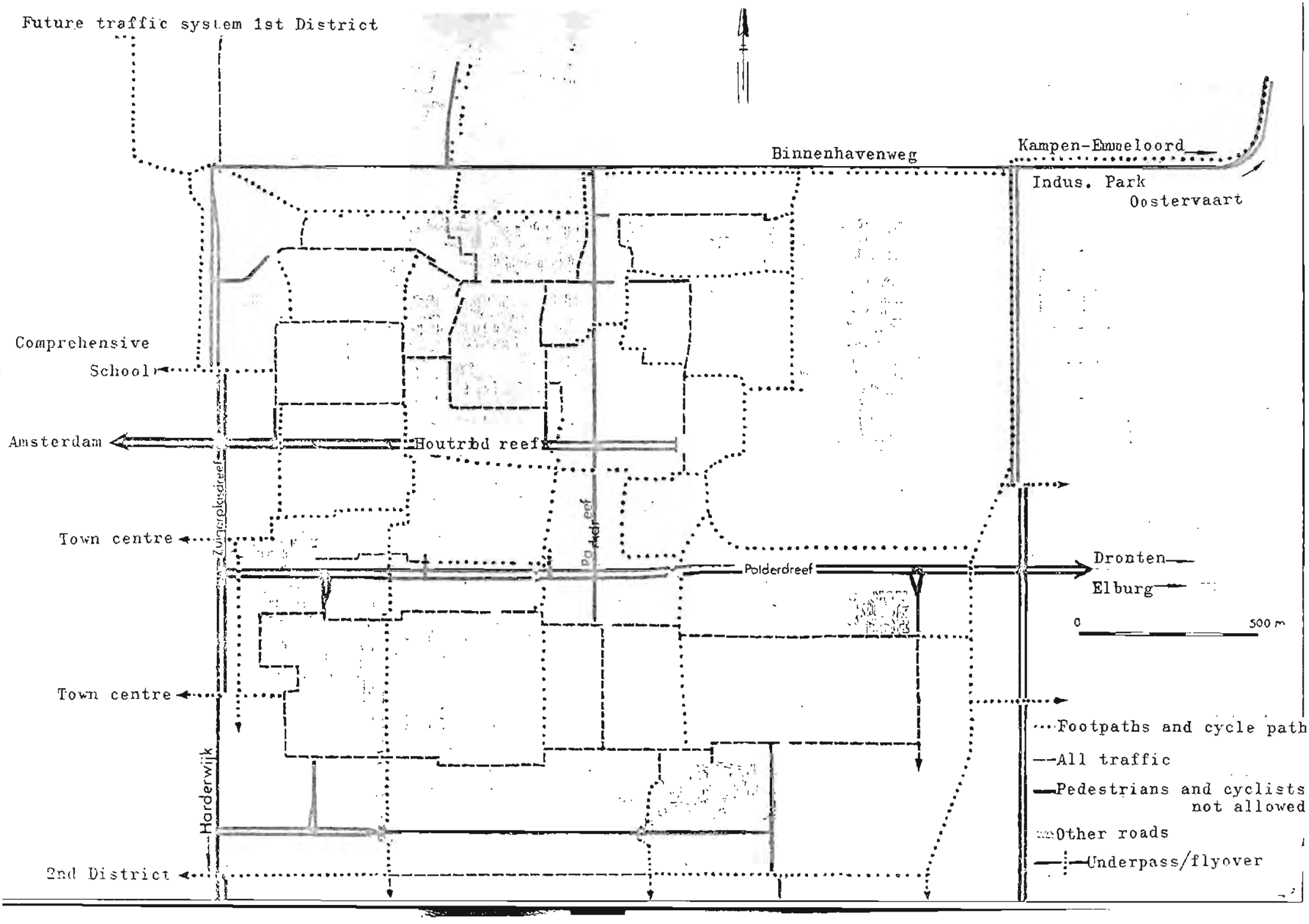
Connections for motor traffic from residential areas to through roads are based on about 500 houses per connection. Consequently, densities are unlikely to exceed 300 vehicles an hour, and in the heart of the area where motor vehicles and pedestrians do use the same routes conflict situations will be reduced to a minimum. At the same time, the road pattern has been planned so that high speeds are impossible.

The reason why pedestrian bridges instead of subways were chosen for Lelystad are:

1. It is simpler to keep the roads at ground level and if necessary sink them 0.80 m than to raise the road level with many flyovers, underpasses, etc.
2. The ground water system and drainage along the roads makes subways difficult and expensive.

In all cases the bridges have sloping approaches, which is convenient for cyclists and all classes of pedestrians (including mothers with prams and old people). The width for cyclists on the bridge is 3 metres and for pedestrians 2.5 metres.

Apart from the fact that nothing can be said statistically about accidents between pedestrians and wheeled traffic, it may nevertheless be noted that so far there has not been a single accident involving pedestrians.


Future traffic system 1st District
Binnenhavenweg
Kampen-Emmeloord
Indus. Park
Oostervaart
Comprehensive
School
Amsterdam
Houtrbd reef
Zuigerplasdreef
Town centre
Polderdreef
Dronten
Elburg
0
500 m
Town centre
Harderwijk
2nd District
Footpaths and cycle path
All traffic
Pedestrians and cyclists not allowed
Other roads
Underpass/flyover

4. Dutch Pedestrians Protection Association (NVBV)

Independently of the general organisation propagating road safety - the Dutch Road Safety Association - the Dutch Pedestrians Protection Association (NVBV) has had the specific objective since 1953 of promoting pedestrian safety. On the one hand it organises campaigns to educate pedestrians to act correctly; on the other it tries to develop (statutory) measures so as to help pedestrians.

A campaign and a measure by this organisation are discussed below.

4.1 "Walk left - Walk Safe" campaign

Following Switzerland's example, the Netherlands in 1963 started a "Walk left - Walk Safe" campaign by means of road signs. It was carried on in the Netherlands because of the favourable reports on the Swiss results; many signs were placed and it was noted that pedestrians did in fact follow the advice.

At first, the campaign was limited to the vicinity of barracks outside built-up areas. After soldiers proved to follow the advice, signs were placed at many other sites on roads outside built-up areas if the town concerned asked for them.

So far about 2000 of these signs have been installed in the Netherlands. There is a strong feeling that the response is very great. It is hoped that suitably evolved observational methods will disclose more in future about any change in habits. Although a change in habits is likely, it will be difficult to give scientific proof of any movement towards greater safety.

4.2 Civilian school-crossing wardens

The system of school-crossing wardens in the Netherlands has been growing for 25 years. The system aims at providing greater safety for children in the immediate vicinity of primary schools. It may be mentioned that Amsterdam was the first city in Continental Europe to try this system out, in 1947.

The system is not used for infant schools, because infants definitely cannot act responsibly in road traffic, and their parents are completely responsible for them. As regards safety for primary school pupils, it is fairly generally felt that care should be shared by parents, headmasters and the authorities.

The NVBV has sought for suitable clothing for crossing-wardens. At present, orange fluorescent jackets are worn (SWOV, 1970), while the patrols use a "lollipop" to stop vehicles.

The forms in which the system operates are as follows:

1. A group of school wardens consists of children from the top primary school classes (about 12 years old). A group can only be formed at the headmaster's written request and he must have signed statements by parents.

   The police instruct the children. Amsterdam even has seven different types of instruction depending on the location of the crossing, the number of children that use it, the existence of zebra crossings, traffic lights and/or pedestrian lights and specific local traffic conditions.

   Calculations for Amsterdam show that with this system three accidents a year occur involving road-crossing children guided by school wardens out of a total of about 14,000,000 crossings taking place at warden-controlled points (Veenstra, 1967).

2. Amsterdam has another solution in the form of young traffic assistants; these are girls between 17 and 21 employed by the Amsterdam Police but not yet qualified for a number of police duties which they will perform later.
   In the meantime they help children to cross at dangerous points.
3. Lastly there are the parent wardens. In The Hague they are paid (a small amount and with suitable insurance) and are recruited and trained by the police; in Amsterdam the schools recruit these (unpaid) wardens (they are insured), while the police instruct them.

The police and the **NVBV** , believe these methods work well and are on the whole completely accepted.

It must, however, be realised that such systems are merely a means of giving parents a helping hand with their own responsibilities.

5. Traffic training with model traffic-training areas (traffic gardens)

In the Netherlands about ten model traffic-training areas are in use to train children to cope with traffic conditions.

The basic idea is that children can be taught a number of rules of the road quicker and better in such a training area; it is also assumed that if proper behaviour (conforming to the traffic regulations) can be taught, the child will behave in the same way under actual traffic conditions.

Research in other countries, especially by Sandels (Sweden), however, clearly shows that these traffic-training areas are not such a successful training method. Prof. Sandels made two investigations into the effect of such instruction on children's actual behaviour.

1. Children, all aged 7, were divided into four groups:
   (a) a group taught in training areas;
   (b) a group taught in a school playground by simply marking lines on the ground and placing some traffic signs in position;
   (c) a group trained under actual traffic conditions in the street;
   (d) a group with no training at all.

Before being given any instruction, all the children were tested regarding their knowledge of relevant traffic situations and did a pedestrians' test in a simple situation in the street.
All the groups except (d) were taught by the same teacher for the same length of time and in the same words.
In the after-period they were interviewed and given practical pedestrians' tests.

2. The same experiment was made with infants aged 6.

Both studies showed that by far the best method of teaching correct pedestrian behaviour was in actual traffic conditions.
Next came the method in school playgrounds. The model training area was hardly better than for the control group with no training at all.

A number of obvious reasons why these areas are not a very successful training method are:

1. Children do not see the same things as adults (the eyes of 6-year olds are only about 110 cm from the ground). In the training area everything is at child-height, which is unrealistic.
2. Objects obstructing the view do not usually occur in such a training area, but do so in actual traffic conditions.
3. Children concentrate on one thing at a time. In a training area they do this in simple situations, but lack the scope for a good over-all view of a real (complex) situation.
4. Speeds in the training areas are very low. Research shows that children cannot estimate the speeds of approaching vehicles under actual conditions.
5. Adults often think that children will behave in actual conditions as they ought to after having travelled the route a few times in a training area under supervision.
6. There is a real possibility of children transmitting the game-playing conditions in the training area to actual traffic conditions, which is not desirable.

It follows that on the basis of present knowledge, model traffic-training areas are unlikely to make a pronounced, positive contribution to road safety; and certainly not for children up to, say, 8 or 9 years old. Nevertheless, if it cannot be proved that a measure is unsuccessful or if it is expected to be unsuccessful, its essential features will first have to be studied.

This is being done in Eindhoven, in a well-equipped training area where the element of playing a game has been eliminated and where there are suitable training programmes for children in the 1st to 6th forms of primary schools (both practical and theoretical). A TV camera records the children's behaviour in miniature cars, on bicycles and as pedestrians, for subsequent analysis. It is intended applying this observation method to a number of children as from the 1st form of primary school up to the 6th form; i.e. for six years. The children go to the area five times a year; i.e. thirty times in total for 1½ hours a time (3/4 hour practical and 3/4 hour theoretical).

Later, the information regarding acquired behaviour in the training area and the effect in actual traffic conditions will be compared with control groups who have not been trained by this method.

Conclusions

Following a discussion in this paper of a number of measures taken for pedestrian safety, the following conclusions can be drawn.

1. Apart from the facilities discussed in Section 3, none of the measures has produced the expected effect.
2. This does not mean these measures cannot have a positive effect: maybe an essentially good measure is not properly carried out or else the correct measurement methods have not been (or could not be) used.
3. The effect on overall pedestrian safety with 100% functioning of the measure discussed in 1.1.is at most marginal.
4. As many incidental measures can at most be expected to have a marginal effect, it is more advisable to seek pedestrian safety in combinations of measures.
5. Such combinations of measures should be based on scientific research.
6. So far there is little scientific knowledge of pedestrian behaviour and the ambient factors that (may) influence it.
   Present knowledge is reviewed by Schubert (1967) and in the O.E.C.D. Report on Pedestrian Safety (Biehl, 1970).
7. It is of prime importance for the authorities for scientific (theoretical) knowledge to be translated into terms of prospective measures; for the scientists it is important to do more towards formulating theories on pedestrian safety.

Literature

Biehl, B.M. Pedestrian behaviour; a survey of existing literature with proposals for further research. O.E.C.D., Paris, 1970.

Giovanelli, R.G.,Blevin, W.R.,Wright, K.A. Floodlighting of pedestrian crossings. Trans. Illum. Engng. Soc. 27 (1962) 3 : 139-142

Hakkesteegt, P. Flexibel verkeerslichtensysteem in Delft (Flexible traffic-light system in Delft). Verkeerstechniek 21 (1970) 9 : 483-494

Nederlandse Stichting voor Verlichtingskunde. Aanbevelingen voor de verlichting van voetgangersoversteekplaatsen. Verkeerstechniek 18 (1967) 7 : 306-307

Road Research Laboratory. Research on Road Traffic. H.M.S.O., London, 1965.

Schreuder, D.A. Marking and lighting of pedestrian crossings. Intern. Lighting Rev. 15 (1964) 2 : 75-77.

Schubert, H. Planungsmasznahmen für den Fuszgängerverkehr in den Städten. Hannover, 1967.

SWOV (Institute for Road Safety Research). Bijdragen voor de Nota Verkeersveiligheid (1965). Staatsuitg., Den Haag, 1967.

SWOV (Institute for Road Safety Research). Safety clothing for work on the road. Report 1970-3. Voorburg, 1970.

Veenstra, A. Klaarovers en moeder klaar-oversten. Alg. Politieblad 116 (1967) 7 : 387-391.

Recommendations

In my paper I have enumerated a number of measures relating to pedestrian safety.

The conclusions state that (apart from segregating different kinds of traffic) these measures hardly have any positive effect on pedestrian safety.

I am also convinced that a number of measures have been introduced based on ideas, hypotheses or theories, without these having been scientifically investigated.

Not that I am a priori opposed to this, but in such a procedure ideas, hypotheses and theories should form part of wider analytical approach.

In endeavouring to influence road safety in a positive sense, I should like to go into two aspects which I think are of importance in studying the problem:

1. a more fundamental approach to these problems in contrast to incidental measures based on disconnected ideas,
2. the behavioral rules for pedestrians and automobilists on and near zebra crossings.

As regards 1

In very many cases it will be impossible to avoid potential conflicts between pedestrians and vehicles [1]. In cases where potential conflicts occur, traffic conditions should have as little variety

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1) Further observations will be concerned only with motorists; motor cyclists, scooter riders and cyclists will be disregarded.

as possible. Less variety will make occurrences more predictable and there will be a bigger chance of getting information across to pedestrians and motorists regarding such occurrences. This means that the task of road users will become easier and potential conflicts will therefore emerge less often.

To limit obvious conflicts between vehicles and pedestrians, two principles can be adopted, based on the foregoing:

(a) make the movements of pedestrians and vehicles homogenous at places where these types of traffic intersect at the same level;

(b) make traffic conditions uniform where the routes of pedestrians and vehicles intersect at the same level.

These two principles are closely related.

I. The pattern of pedestrian movement can be made homogenous as follows:

(a) by making pedestrian crossings always at the same points in comparable traffic conditions or at places where pedestrians normally cross the road;

(b) by restricting the possibilities of crossing the road except at pedestrian crossings;

(c) by getting pedestrians to cross in groups instead of making individual decisions to cross over;

(d) by making an x number of pedestrian crossings per kilometre of road, per area of land, per number of intersections, etc.;

(e) by having rules for crossing the road at pedestrian crossings and at other places.

The movement pattern of motorists can be made homogenous as follows:

(a) by making pedestrian crossings always at the same places in comparable traffic conditions, or at places where pedestrians normally cross the road, or at places where motorists expect pedestrians to cross;

(b) by making an x number of pedestrian crossings per kilometre of road, per number of intersections, etc.;

(c) by having rules for approaching pedestrian crossings.

II. For making the traffic situations uniform, the very first thing is to choose between similarity in perceptibility of the situation and uniformity in its conception.

A. Similarity in perceptibility of pedestrian crossings and the pedestrians on them can be achieved with:

(a) conspicuousness of the pedestrian crossing and any (prior) warnings;

(b) recognisability of the pedestrian crossing and any (prior) warnings;

(c) expectation of the presence of a pedestrian crossing.

B. Uniformity in conception can be achieved with:

(a) uniform lighting;

(b) uniform marking;

(c) uniform (prior) indication.

Items A and B concern the motorist; they will play no significant part for pedestrians (except in expectation of the crossing's presence as regards perceptibility).

As regards 2

Based on the principles of homogeneity and uniformity, the homogeneity of pedestrian movements in the case of zebra crossings can be promoted, for instance, by the location of the crossings, their number, restrictions on crossing elsewhere than at the zebra, crossing in groups instead of individually, rules; homogencity in vehicle movements can be promoted, for instance, by the location of zebra crossings, their number, rules.
I should now like to go further into these rules.

On the whole one may say that if the rules are to meet their purpose of safe traffic regulation, they must satisfy the following requirements:

1. They must be informative, i.e. be intelligible, relate to concretely defined situations or behaviour, be capable of only one interpretation.
2. They must involve no contradictions, i.e. compliance with them must not conflict with other rules.
3. They must have validity, i.e. be significant to safe traffic regulation, and not be superfluous or incomplete.
4. It must be possible for the road user to obey them and for the police to enforce them. Obedience may be both psychological and physical. In its psychological form, the road user must not be inconvenienced too much.

If rules do not meet these criteria, they may cause problems for road users and make them uncertain of their legal position, and perhaps be detrimental to road safety.

The regulations in the Netherlands concerning pedestrians' and motorists' behaviour on and near zebra crossings (see appendix) do not completely satisfy items 1, 3 and 4.
I can give you the following examples to illustrate this. One of the regulations is that:
"Drivers must approach zebra crossings with care and must give free passage to pedestrians who are on the crossing".
If the pedestrian want to avail himself of his right to free passage he must already be on the crossing.
But he hardly dares to go on the zebra as long as fairly fast traffic is approaching, and he stands waiting on the kerb.
The motorist reacts by carrying on without reducing speed.
In this way, a zebra crossing is of little benefit to the pedestrian. Even stepping on to the crossing and standing there has little effect because this is still interpreted by the motorist as "waiting".
The custom is thus that:

- pedestrians only walk on to a zebra crossing when the approaching traffic is still fairly far away;
- if there is a line of traffic, the pedestrian waits until it has all passed by;
- the motorist approaches at normal speed and only applies his brakes if one or more pedestrians cross over and a slight swerve is no longer enough to avoid the pedestrian or pedestrians.

Other situations differing from these sometimes occur, but are not usually understood quickly and are thus dangerous; for instance:

- pedestrians cross just in front of an approaching car so that the motorist has to apply his brakes harder;
- motorists slow down and/or stop while the pedestrian is still standing on the pavement of the beginning of the zebra crossing (may cause front/rear collisions).

Accidents caused in this way generally have little to do with not seeing or seeing too late, but are due more to misunderstanding between the pedestrian and the motorist.

The situation becomes more complicated in the following cases, when there may be both misunderstanding and not seeing or seeing too late:

- the first car stops, the second car drives on past the first one. The pedestrian, encouraged to walk on by the first car stopping, now faces an additional hazard;
- the car stops, the pedestrian walks on, but forgets to watch the traffic coming from the other direction;
- the car stops, the second car sees this too late or is driving too close behind the first car and runs into it. If the first car is pushed on to the zebra crossing, there is a danger to crossing pedestrians.

As to the first mentioned case, a regulation has been made prohibiting overtaking of stationary vehicles before zebra crossings, but this still happens constantly.
As regards enforcement, the police generally apply too few sanctions in traffic offences by pedestrians; in particular, too little attention is paid to the rules about pedestrians

crossing roads and on and near zebra crossings.
This is probably because the police forces are understaffed.
The rules formulated by the authorities to limit motorist/pedestrian conflicts on and near zebra crossings are far from ideal.
The basic principles (of homogeneity and uniformity) are not served by this and there will be no positive effect on road safety.

To sum up:

What I have tried to make clear in the foregoing is that if pedestrian safety regulations are to have positive results, they will have to form part of a scientific approach to the problems. More analytical work will have to be done before appropriate regulations can be formulated.

<table>
<tr><td rowspan="4">Principles to diminish conflicts between motorists and pedestrians</td><td rowspan="2">homogeneity</td><td colspan="2">pedestrians</td><td>1. location of ped. crossing
2. number " " "
3. restrictions to cross elsewhere
4. to cross in groups
5. behavioral rules</td></tr>
<tr><td colspan="2">motorists</td><td>1. location of ped. crossing
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<tr><td></td><td rowspan="2">uniformity in the conception of ped-crossings</td><td>pedestrians</td><td></td></tr>
<tr><td></td><td>motorists</td><td>1. lighting of ped. crossings
2. marking
3. (prior) indication</td></tr>
</table>

Appendix

THE NETHERLANDS

Traffic Rules and Symbols Regulations. Royal Decree 4th May 1966 (Stb. 181).

Article 37

3. It is forbidden to overtake on the right or the left if the vehicle being overtaken is stationary before a zebra crossing or is approaching it slowly.

Article 79

If the traffic has to stop, drivers must keep clear the part of the road reserved for traffic from the opposite direction, zebra crossings and crossing for cyclists, and also allow free passage for intersecting traffic on intersections and junctions.

Article 81

2. It is forbidden in any event to stop a vehicle:
(b) on zebra crossings and crossing for cyclists;
(g) within a distance of 5 metres before zebra crossings and crossings for cyclists and, if there is no-stopping sign on the right side of the road, within 5 metres after this; this regulation does not apply to two wheeled motor vehicles;

Article 99

2. Pedestrians must not cross the road within a distance of 30 metres from a zebra crossing.
3. The regulation in para. 2 does not apply if, in order to

reach the zebra crossing, the pedestrian first has to cross another carriageway, nor if he is going to or from a public transport vehicle from or to the nearest footpath or pavement.

Article 100

1. Drivers must approach a zebra crossing with care and must give free passage to pedestrians on the crossing.
2. This obligation does not apply to police cars or fire engines, ambulances, or motor vehicles of other emergency services designated by the Minister of Transport and carrying visible and audible signals as directed by the Minister under Article 58, nor to military convoys or funeral processions.