INTEGRATION OF MOTOR TRAFFIC IN RESIDENTIAL AREAS: REQUIREMENTS FOR LIGHTING OF RESIDENTIAL YARDS

Contribution to IV World Transportation Engineering Conference, Mexico City, 2-6 October 1977

R-77-45
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Voorburg, 1977
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ABSTRACT

Until recently, all land transportation roads were roads for different modes of transportation (vehicles, pedestrians, etc.). The purpose might be different: roads for military use, commercial roads etc. The railroad presented the first modal split: a road exclusively for one mode of transport. In the 1920's this idea was pursued for motorways: roads exclusively for motor vehicles. And in the 50's and 60's the "New towns" had complete mode separation.

Old towns and cities could not be converted. It was sometimes suggested that it is better therefore to ban the motor vehicles altogether. Both the complete mode separation as the motor vehicle ban proved to be unacceptable and to be unworkable. The new towns could not be lived in, the old towns became slums.

In the early 70's the Government of the Netherlands undertook an ambitious programme: save the old and towns, realising that the auto is an essential part of to-day's social, cultural and economic pattern. The main idea was to make the town "liveable" with cars, compared with older ideas of make them liveable without (or: notwithstanding) cars.

The basic idea is that the common room between the houses is available for all inhabitants as a space for living. Living includes walking, sitting, playing, driving, riding, parking. A number of requirements have be been defined, and a number of specific measures have been indicated, which prevent that one particularly way of living (e.g. driving cars) can become predominant in residential areas. The requirements relate to road lay-out, signalisation and road marking, signing, road equipment, lighting, road surface, but also legal regulations as regards driving speed, parking etc.

Large-scale "demonstration" experiments are underway. It is to be expected that in the long run an important part of the residential areas (maybe even 30-40%) will be converted to "residential yards" as is the best translation for the Dutch term of "woonerf".

The paper concentrates on the lighting requirements both for public lighting as for vehicle lights.

1. INTRODUCTION

In the past, all roads for land transportation were roads for mixed traffic, in the sense that vehicles of different types made use of the roads, together with cattle, horseman and pedestrians. This was equally true in urban areas and on rural roads. We do not know whether this mixture of traffic modes resulted in a high accident rate; however, it is well-known that the resulting discomfort for pedestrians, particularly resulting from vehicles has been reason for millenia to restrict vehicle use in towns.

Roads, and particularly rural roads, could have different categories of users. Apart from the general purpose roads, many roads have been built for military purposes, the use being restricted exclusively to soldiers. Most streets, however, were of the general purpose type; with more noteworthly exceptions such as sacred roads that were to be used only in religous ceremonies.

This picture was changed in the 19th and 20th century. First, railroads required (or requested) a completely new network of tracks, fully independent of the existing road network. Even the intersections were eliminated either by grade separated crossings or by giving the train priority under all circumstances. A similar situation did develop as regards the motor vehicles. Again, the motorway (freeway) network is independent of the existing road network, and has complete grade separation. And finally, the villages, towns and cities were overgrown by cars; the urban areas became unpleasant and dangerous to live in as a result of noise, air pollution, land utilisation and, not the least, road accidents. The logical solution seemed to be to ban cars from old towns, and construct new towns for a car-free world.

In a number of cases, these principles have been executed to their extreme consequences. Apart from a small number of obvious exceptions, however, this complete mode-separation proved to be disastrous. The new towns became sterile and were silent and clean but very unpleasant to live in; old towns without cars became slums in the

same pace as those parts of towns that were still congested with cars. And finally, one had to accept the fact that the modern society requires the utilisation of cars, and more in particular requires the utilisation of passenger cars for private transportation. Viewed upon from a national or even international standpoint, the private car - in spite of its danger, environmental pollution and use of materials and energy - is an absolute necessity in order to maintain a state of affairs at a level even considerably lower than the present standard of living. And so the modern society, and more in particular the modern science meets the challenge to reduce or eliminate the adverse side-effects of mass transportation without curtailing too much its basic function: allowing people to travel and goods to be transported.

A major step foreward in the direction of a final solution is made by an ambitious plan of the Government of the Netherlands. In stead of banning the cars from residential areas, the plan is to integrate them in such a way that they can still be used, but that they will loose their predominant position. The areas where this integration are to take place are called "woonerven" which can be translated more or less by "residential yards" (living yeards also expresses the idea). It should be stressed that this approach is fundamentally different from the "new town" concept and its variants, that are based on complete mode separation. In residential yards , the basic idea is that the common room between the houses is available for all inhabitants as a space for living, which includes walking, sitting, playing, driving, riding, parking. Its main purpose is to relieve the inhabitants from the stress, the noise, the oppression and the pollution of cars. Creating residential yards is, therefore, not to be considered primarily as a road safety measure, but as a measure aimed at the improvement of the quality of life.

2. RESIDENTIAL YARDS

Residential yards is the indication used for urban areas where the inhabitants have the possibilities to live outdoors - in the more wide sense of the word. For this purpose, a number of requirements for living yards are formulated, together with a number of traffic regulations. Their main purpose is, as has been indicated in other presentations of this conference (De Jager, 1977a; Van den Bogaarde, 1977), to preclude through motor traffic, to reduce the local traffic, and to reduce driving speeds. All this has been combined in the Dutch word : leefbaarheid.
Probably the best translation in English is: amenity.

The amenity of urban regions is a complex concept. At least four different aspects seem to play an important rôle:
- the way the objective stress is restricted (noise, air pollution. visual intrusion, and other factors intruding the personal privacy)
- the way the subjective stress is restricted (expectation regarding road safety, particularly for children, and expectation regarding public safety - mugging and assault)
- the way social contacts can be established (notably the possibilities to play)
- the way the mobility is ensured (more in particular how the relation with the world outside can be maintained. This includes driving, parking easily and requires road safety).

There can be found a great number of measures that can improve the amenity of residential areas: many of them are in operation already many years, all over the world. The residential yard concept is new in the respect that it is a complete system, consisting of sets of engineering measures, and a completely different set of legal regulations especially set up for these residential yards. The major differences between the regulations for residential yards and other urban areas are
- motor vehicles should drive (and ride) at a walking pace, in stead of a speed limit of 50 km/h for cars and of 30 km/h for mopeds.
- vehicles are not allowed to cause hindrance to pedestrians; pedestrians

are not supposed to restrict the process of vehicles unnecessary; in stead of: cars have priority over pedestrians. Cars may be parked only on places marked as such, in stead of: cars may be parked except in places were it is prohibited.

- pedestrians may use all roads over the full width, in stead of only the side-walks.
- in[illegible] to express [illegible] future of their [illegible]

All residential yards must be indicated at their entrances and exits by means of special road signs.

Furthermore, a number of requirements are set up that are related to the technical design of residential areas.

The most important are the following:

- no separated side-walks
- narrow carriageway (some 2-2.5 m)
- straight stretches of carriageways not longer than 50 m
- physical and visual obstructions in the driving path.

It will be clear that particularly the obstructions in the driving path, applied to force the driver to drive more slowly because driving in more difficult, may have considerable repercussions on road safety in general. Furthermore, the mixture of traffic modes being the most important aspect of the improvement of the amenity, can be dangerous as well. Although the concept of residential yards was not introduced specifically as a road safety measure, these repercussions should be taken very seriously. This paper will mention two aspects of the question: how can the repercussion on the road safety (the change in the number of accidents) be established, and how far can the road lighting play a rôle in increasing the amenity and the road safety.

3. ASSESSMENT OF THE NUMBER OF ACCIDENTS

In most countries, pedestrians form a large part of the traffic casualties, and from these more in particular the children and the elderly people. The relevant data, and also the many countermeasures conceived to reduce the number of pedestrians casualties are reported widely in the literature.
A survey of this is given in the CCMS report (CCMS, 1974). In general, it usually is not easy to prove the net result of any road safety countermeasure on the basis of accident reduction alone. When one has to do with pedestrian accidents this problem is still more severe as the countermeasures are usually introduced locally, and they often differ considerably from place to place. Furthermore, the countermeasures themselves usually are - as a direct result of the character of the traffic participation of pedestrians - of a small scale. Therefore, if accident studies are to be used for pedestrian safety research, generalisation is difficult. When considering the introduction of residential yards, this problem will still be larger, because these yards are <u>not</u> primarily meant as a measure to improve pedestrian safety - the introduction of residential yards
may be considered as being cost-effective, even if the reduction in pedestrian accidents is only small. It is, however, important to know the effect of the introduction of residential yards on road safety (more in particular on the pedestrian and 'cyclists accidents) because it is to be expected that residential yards will be introduced on a large scale. Thus, it is required to be able to detect even small changes in the pedestrians accident pattern - changes, that might be considered as uninteresting when the cost-effectiveness of purely road safety measures is assessed. (See also de Jager, 1977). Oppe (1975) and Kraay (1975) argued that further development of the conflict analysis techniques may be useful in this respect.

Conflict analysis techniques are not new. The basic idea is that conflicts between traffic participants are very frequent as

compared with accidents, which are rare - in spite of the fact that many thousands die on the road each year. Furthermore, conflicts often are easy to observe. However, scoring and processing of conflicts can be difficult.

Hayward (1972) indicates that the number of accidents per year equals the number of conflicts per day; Harris & Perkins (1968) believe that it equals the number of conflicts per hour. These figures points directly to the advantages and to the weakness of the conflict analysis techniques. Many data in short time , but the results depend very largely on the definitions, and so do the reliability and the validity of the methods.

Conflicts usually are classified in a scale, varying from encounters at the one end and collisions at the other. In table 1 two current classifications are given (adapted from Spicer, 1971; and Kraay, 1976, respectively). Spicer's range is wider, but Kraay is more systematic. It is difficult, however, to correlate the two sets of classes: one will note easily that they are designed for different purposes. (Spicer for intersections in motorways, Kraay for pedestrians in residential areas) This suggests that neither of the two can be generally applied.

It is noted, that when one proceeds from serious to less serious conflicts, the number does increase, but the correlation with accidents becomes less pronounced: the reliability increases but the validity decreases. As indicated by Oppe (1975) a direct correlation between slight conflicts and accidents cannot be found. Now, in before - and - after studies, the conflicts of the past are in fact used as a prediction for accidents in the future. It is well-known that accidents in the past are not very good as a prediction for accidents in the future; one should not expect the conflicts doing much better. Further study, is justified in order to find out what exactly is the relation between conflicts and accidents (the validation of conflict studies). Probably this will require a more precise description or more applicable definition of conflicts and better systems for observing and scoring conflicts.

There is, however, another area in which conflicts and their analysis may be useful: conflicts may probably be used as a measure of the subjective experience of road safety. One may expect that the situation will be experienced as the more dangerous when one encounters more often conflicts. This idea needs further consideration.

4. LIGHTING REQUIREMENTS

4.1. General

The foregoing suggested two intermingling considerations, that both could have their repercussions on the requirements that should be formulated as regards the lighting in residential yards : amenity and road safety. In both instances, a number of aspects have been indicated, some of them having a direct bearing on the lighting. These aspects can be reformulated as follows:

- requirements as regards (objective) road safety
- requirements as regards (objective) public safety
- requirements as regards the lighting so that public areas can be used for the establishment and maintenance of social contacts - also at night
- requirements as regards the subjective experience of safety (both traffic safety as well as public safety)
- requirements as regards the restriction of lighting shining into the houses or otherwise infringing on privacy.

These points will be discussed systematically in the following sections. leading up to lighting requirements and recommendations.

4.2. Functional requirements

Generally speaking, the lighting (public lighting, street lighting) has the following functions, according to e.g. CIE (1977):

- promote the amenity
- promote the road traffic safety
- promote the travel performance (traffic volume, speed etc.)
- promote the public safety.

The requirements given in Sec. 4.1 can be classified along these lines as follows:

a. amenity
- a.1 allow the mixed usage of the public area
- a.2 promote the subjective safety
- a.3 promote the estetical impression of the surround

b. road safety

b.1 reduce the serious conflicts caused by cars

b.2 reduce the serious conflicts caused by mopeds

b.3 reduce the serious conflicts that confront pedestrians

c. travel performance

c.1 allow traffic into the residential yards (including traffic like fire brigades, ambulance, deliveries etc.)

c.2 reduce the traffic towards the residential yards

c.3 permit driving and parking, and leaving the area

c.4 obstruct through-traffic

d. public safety

d.1 promote that assailants can be recognised

d.2 improve conditions for police surveillance.

4.3. Technical requirements

The points indicated in the foregoing section can be systematically interpreted in terms of the technical requirements.

a.1 mixed usage
- a.1.1 uninterrupted road surface
- a.1.2 outfit for playing areas
- a.1.3 reduction speed of cars (thresholds, humps etc.)
- a.1.4 restrictions for parking (marking etc.)

a.2 subjective safety: for the time being promote the objective road safety (until a better definition is found)

a.3 aesthetical aspects
- a.3.1 trees and shrubs
- a.3.2 variations in road surfacing and pavement

b.1 conflicts from cars
- b.1.1 reduce speed of cars (as a.1.3)
- b.1.2 make cars visible
- b.1.3 make obstacles (b.1.1)"visible and non-agressive" (See SWOV,1976)

b.2 conflicts from mopeds
- b.2.1 reduce speed of mopeds

b.3 conflicts with pedestrians
- b.3.1 give pedestrians priority
- b.3.2 make pedestrians visible

c.1 entering traffic	c.1.1 leave entrances (also for fire engines etc.)
	c.1.2 allow for adequate parking
c.2 reducing entering traffic	
	c.2.1 excluding areas that attract much traffic (shopping centres, sports stadia)
	c.2.2 excluding areas with high housing and population density from "residential yards"
c.3 leaving the area	c.3.1 allowing for good traffic facilities with a high capacity to leave the area
	c.3.2 allow for adequate parking also for visitors
c.4 through traffic	c.4.1 allow for adequate through-routes outside the residential yard
	c.4.2 reduce driving speed (a.3.1)
	c.4.3. make residential yards easily recognisable
d.1 assault	d.1.1 no dark areas or hiding places
	d.1.2 adequate light and colour rendering
d.2 surveillance	d.2.1 adequate space for police control cars
	d.2.2 no dark areas or hiding places.

4.4. Lighting requirements

The technical requirements can be met to a large extent by adequate lighting, provided the lighting meets its own (lighting) requirements. These requirements will be subdivided in three groups: the road surface, the public lighting and the vehicle lighting and reflectorisation.

4.4.1. The road surface

The requirements quoted above can be regrouped as regards the road surface in the following way:

- the road surface is the background (the fore-ground) for many objects (pedestrians, traffic obstructions (a.1.1; a.1.3)
- differences in pavement aspect are essential (a.1.2; a.1.4; a.3.2)
- threshold, humps etc. are incorporated in the road (a.1.3)

- driving speeds are low (a.1.3)
- curb stones are absent (a.1.1)

These points give rise to the following requirements as regards the road surface in relation to the lighting requirements:

- light in colour (high light reflection at day and at night, contrasts)
- diffuse reflection, also when wet (otherwise the differences disappear)
- considerable differences in colour and aspect should be possible
- porous (drainage)
- separate elements (slabs, ducts and cables!)

It may be noted that the skidding resistance of the road surface is not very important.

Recommendation

I the road surface should consist of paving stones and/or bricks

II separate elements (notably humps etc.) should be standarized.

4.4.2. Public lighting

- All sorts of objects may present themselves at all different places, both moving and stationary. They must be very clearly visible. This requires a high luminance for adaptation and modelling of the light to acquire high contrasts (a.1.1; a.1.2; b.3.2)
- objects need to be recognised quite clearly and quite easily, particularly as long as humps, thresholds etc. are not standardised. It should be noted that these are meant to reduce the speed, and not meant to be traps. They must be clearly visible (a.1.2)
- optical guidance is a special problem here (a.1.3)
- discomfort glare is not critical (a.3)
- disability glare should be restricted (a.1.1)
- colour rendering should be good (a.3.2; c.4.3; d.1.2; d.2.2)

These points give rise to the following requirements are regards the public lighting

- road surface luminance $\bar{L}$ adequate for good and fast observation
- non-uniformity L_{min}/L_{max} not too great as regards dark areas - wet as well (therefore: the luminance technique is relevant here!)
- horizontal illuminance not too low, and its non-uniformity not too large in order to see road markings
- vertical illumination E_v rather high, because modelling is required.

In order to quantify the recommendations, the results of other lighting studies are used:

- the average value of the light level is established for adequate minimum safe traffic (CIE, 1977; NSvV, 1974/75, 1977) and for adequate public safety (Anon, 1976)
- the minimum value of the vertical illumination (and luminance) follows from the studies aimed at the minimum admissible values for face recognition in offices (Fischer 1972, 1973)
- the absolute minimum and the maximum non-uniformity of the illumination follow from the considerations of emergency lighting (CIE, 1977a; Simmons 1975).

Recommendations

From the abovementioned studies, the following suggestions for recommendations are derived:

- average illuminance $E_{hor} \geqq 5$ lux
- minimum horizontal illuminance $E_{hor\ min} \geqq 1$ lux
- $E_{max}/E_{min} \leqq 20$
- vertical illuminance at important locations $E_v \approx 20$ lux
- $3 < G < 5$
- T I $< 20\%$
- colour rendering $R_a \geqq 60$.

Note 1: the visibility of fixed objects, notably of thresholds, humps and other obstacles meant to reduce the driving speed should be ensured by an appropriate location of luminaires.

Note 2: the photometric recommendations cannot be translated into general geometric requirements, because residential yards may differ considerably. It is to be expected, that in most cases low mounted semi-cut-off lanterns with a low luminous output at rather short interdistances will satisfy most requirements. Monochromatic light sources should be avoided.

Note 3: The photometric and colorimetric terminology is explained in detai in CIE (1970) and CIE (1977).

4.4.3. Vehicle lighting and reflectorisation

It is not feasible to set up specific requirements for the lighting or reflectorisation of vehicles for residential yards. The lighting should be similar to that for residential areas in general.

Only one remark should be made. Glare from low beam car headlamps is generally considered as being objectionably strong (SWOV, 1969; Schreuder, 1971). For medium and high speed roads, there are few alternatives, so one has to accept this. For residential yards, however, where the driving speed is low, there is no particular need for low beam headlamps, particularly if the public lighting is adequate. The high luminance intensity is not required, and the glare is objectionable. The "town beam" concept, advocated in many cases, seems to be the ultimate solution (OECD,1976;CIE,1976).For the period required to install town beams on vehicles, it seems better to restrict the use of parking lights (side lights) rather than to prescribe low beam headlamps.

TABLE I

Classification of conflicts

After Spicer (1971)		After Kraay (1976)		
Type	Class	Type	distance	Class
precautionary braking	1 (slight)			
		non-sudden reaction	> 2m	contact
controlled braking	2	non-sudden reaction	~ 1m	intensive contact
		rather sudden reaction	> 2m	contact conflict
		rather sudden reaction	~ 1m	intensive contact conflict
		sudden reaction	> 2m	conflict
rapid deceleration near miss	3 (serious)	sudden reaction	~ 1m	serious conflict
very near miss or minor collision	4			
serious collision	5			

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