

ADVISORY SPEED LIMITS: SHOULD THEY BE EXPANDED OR NOT ?

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SUMMARY

Advisory speed limits are meant to be used in discontinuities, in situations which are perceived by the road user, while at the same time, not giving a clear suggestion as to the speed which should be sustained. At present advisory speed limits are almost exclusively applied in narrow road curves. This measure seems to be effective. However, suggestions as to wider application of advisory speed limits should be treated with some reserve.

Ineffective applications could lead to the devaluation of the measure and to more accidents at places, where advisory speed limits have a positive influence on the speed pattern.

1. INTRODUCTION

If traffic safety is endangered on some locations, because the speed of traffic is not satisfactorily adjusted to the road design, road authorities can take diverse countermeasures.

The first possibility, of course, consists of modifying the geometrical road design, thereby eliminating shortcomings. Authorities have to revert to other solutions only if no modifications are possible for ensuring a safe course of traffic. One of such possibilities is the application of advisory speed limits.

According to Dutch legislation, at present advisory speed limits should only be applied in curves with small radius.

In recent years there is an increasing demand for an extended application of advisory speed limits. Outside built-up areas, a wider application of advisory speeds means a replacement or complementing of existing speed limits. This could involve special circumstances and the application of advisory speed over road stretches of several kilometers length. In such situations advisory speed can be indicated on a sign board as, for ex. 60 km/h or as maximum and minimum speed, for ex. 50-70 km/h.

The usefulness of a wider application of advisory speeds can only be evaluated through a detailed analysis of their present mode of application and functioning. In other words, it is important to reveal the circumstances under which the advisory speed limit is an effective measure. It has to be taken into account, that a wider application may also have a negative influence, if the measures taken seem to be insufficiently effective. In such cases road users may be inclined to ignore the suggested speed, even in places where disregarding the suggested speed may increase the risk of accidents. The effectiveness of such measures should firstly be assessed by their influence of the correct speed behaviour, while it is also important to find out to what extent a modified speed pattern will promote traffic safety.

2. DRIVING BEHAVIOUR IN CURVES

The term "discontinuity" indicates in traffic jargon a sudden and considerable deviation in the appearance of the road from the expected characteristics. Such a discontinuity may lead to an unconsciously unsafe behaviour of the road user. This can also happen in a curve, with a radius, which is beyond the expectation pattern of the driver. Road users build up their expectations on the basis of road criteria, which they perceived on approaching the curve. In order to prevent unsafe driving in the curve, it is desirable to alert the driver and supply him with extra information by appropriate curve signs. If a driver deviates from the straight direction and turns into a bend, it is indispensable for him to know the entire situation in the curve, when he approaches it, in order to carry out the necessary manoeuvres (Mulder, 1974). For this reason it is necessary to ensure that - on changing on a straight-lined road the horizontal course direction - the driver perceives in time the change of course and that he is capable of assessing the radius of curvature and super-elevation, in order to adjust the required speed.

If a curve is early visible and if it is recognised as such by the driver, he will be able to react easily and, if necessary, to adjust suitably his driving behaviour. The adjustment of speed takes place on two levels: (a) a preliminary adjustment on approaching and entering the curve, and (b) a speed correction in the curve with regard to the preliminary speed adjustment.

Shinar et al. (1973) revealed, on the basis of experimental investigations, that a driver starts to assess the curvature of a curve about $2\frac{1}{2}$ seconds before entering it; the movements of his eyes display in this phase a distinct "scanning pattern". An essential factor is then the time he requires for adjusting (i.e. reducing) his driving speed. Shinar et al. calculate this time from a so-called preview index: $(V_N - V_B)/L_N$; wherein: V_N = the speed in the approaching zone; V_B = the speed in the curve; L_N = the length of the approaching zone.

Shinar et al. also studied the relationship between the preview index and the risk of accident. They found that the more time the driver has to

bridge-over the difference between the approaching speed and the speed in the curve, the smaller the accident liability of the curve. Probably the important thing is that the driver adjusts the driving speed gradually. In general it is accepted that a gradual speed reduction causes less disturbance in the traffic flow and, consequently, less accidents than a sudden speed reduction. Also, a second factor, based on driving performance and indicated by Shinar as "effective curvature", was in close correlation with the accident frequency in his investigation. According to Shinar et al. the "effective curvature" indicates the ratio of the maximum lateral acceleration experienced by the driver to the square of driving speed.

Thus, in this case, no geometrical elements and related dynamical magnitudes play a part, but rather more erroneous perceptions and decisions by the driver. Also according to Shinar et al. the difference between high and low accident-rate curves cannot be explained by geometrical criteria; less sharp curves are not safer than sharp ones. The essential factors are the errors in perceptions of curve characteristics. Consequently, Riemersma (1984) suggests that the design of curves should, in the first place, be based on the actual behaviour of the drivers and less on the mechanical characteristics of vehicles (road-vehicle interaction) and the assumed behaviour related to them.

These considerations permit the conclusion that it is of essential importance for the driver to perceive a curve early and to assess the actual curvature of the curve. In addition, he must have enough time for correcting erroneous decisions. Thus, geometrical criteria seem to be less important.

Brevoord (1974) recommends that:

- the curve must be in accordance with the general road characteristics;
- in the case there is a considerable difference between the road and the curve in this respect; the driver must be duly and in time informed about this;
- if the curve is poorly visible, its visibility must be improved.

3. THE FORCES WORKING ON THE VEHICLE AND ITS OCCUPANTS

There are three cases in which the forces working on the vehicle and its occupants become much too strong: skidding, turning over and exceeding the comfort limit (Pacejka, 1974). The limits of skidding and overturning can be determined objectively, based on assumptions as regards the road, the vehicle and various circumstances. On the other hand, the comfort limit requires the evaluation of accelerations which still can be tolerated by a person, thus this limit is of a subjective character.

The margin between the maximum speed (under given lateral forces) and the actual speed, determine to what extent a curve is safe for drivers, i.e. with minimum risk of overturning or skidding.

The Dutch State Road Laboratory RWL (Ten Cate, 1974) established on the basis of these conditions a safety limit. However, in the case of speeds between 50 and 90 km/h, the comfort limit is of overriding importance, because it is under the safety limit in the indicated speed range.

In evaluating the effectiveness of advisory speed limits, as means of influencing speed behaviour, the comfort limit has essential priority. The problem in this connection is whether the comfort limit, which is variable for various types of drivers, will not lead to considerable speed differences and, consequently, to more accidents. Investigations proved that drivers as a rule, on increasing speed, will comfortably tolerate continually decreasing lateral accelerations only.

In the Netherlands a simple linear relationship ($f_z = 0,237 - 0,001142 V$) has been accepted for establishing the standards of motorway designs. This relationship is in accordance with the range of maximum speeds as determined by investigations in other countries, like the Federal Republic of Germany, France and Switzerland. The Dutch standards for motorways are still under the so-called safe lateral acceleration ($f_z \text{ safe} = \frac{1}{2} f_z \text{ measured}$).

This means that advisory speeds, based on such comfort limit, will not lead to increased accident risks in the 50-90 km/h speed range. The ideas about advisory speed limits for non-motorways are in accordance with the standards set up for motorways (Westerduin, 1974).

4. EVALUATION OF ADVISORY SPEED LIMITS

It is possible to apply various advisory speed limits. Evidently, the advisory speed must be safe, but is difficult to determine the speed which is safe under various circumstances. In the Netherlands, undoubtedly, under the conditions prevailing at present (speed limits of 100 km/h and design speeds for motorways of 120 km/h) the advisory speed limits be based on the driver's comfort. The suggestion of a safe maximum speed, i.e. a speed at which the skidding or turning-over of the vehicle can just be prevented, is neither possible nor makes any sense, because, on the one hand, skidding and turning-over are closely related to the characteristics of the vehicle and the road surface, and on the other hand, advisory speed limits may encourage the drivers to exceed the advisory speeds.

In addition to a permanent advisory speed limit, a speed interval may be suggested as well. The application of such speed interval is not advisable at discontinuities, but should be made valid for longer road stretches. The measure is inspired by the idea that road users will be more inclined to follow a flexible advice, which permits the driver some degree of freedom, to take a decision and to choose a speed which he finds the best.

Another possibility consists of advising a comfortable maximum speed. This solution has the advantage that the driver will choose the speed on the basis of the personal discomfort caused by such speed. It has already been pointed out that such speed should in no case involve the risk of skidding or turning over. Certain problems, of course, may be caused by individual speed differences whereby fast cars have to brake suddenly in order to avoid contact with a slower car, driving before it.

Reports have been published in the Netherlands and other countries as well, over experiments on advisory speed limits on roads within and outside built-up areas. According to Ritchie (1972) the lateral acceleration experienced by the driver is the key variable in choosing the speed in a bend. He found that the test persons were capable of accepting a higher lateral acceleration in bends with advisory speeds than without

them. This phenomenon was independent of the actual speed. Thus, Ritchie concludes that advisory speed limits mitigate the feelings of uncertainty of road users.

In the United Kingdom experiments are being made on two-lane roads with advisory speeds in curves (indicated by the usual "dangerous curve" board) (Rutley, 1972). The experiments proved that the drivers were inclined to accept the suggested speeds. Decreases and increases were inconsiderable (max. 5 km/h) but nevertheless significant. In addition, the spreading of speed distribution did not seem to be lowered and, consequently, it could be concluded that advisory speed limits have the same effect on different driving speeds. The same investigation also revealed that setting up the standard triangular "dangerous curve" boards alone had no influence on the average driving speed. The use of the boards indicating advisory speeds resulted in a significant lowering of injury-related accidents, it was found.

In the Netherlands advisory speed limit experiments were carried out on several roads outside built-up areas. On some roads and road stretches speeds for example between 60 and 80 km/h were suggested while in several bends one fixed advisory speed was established. The people carrying out the investigation acknowledged that this form of advisory speed measure had no success. The failure may be explained by the speed advice not being specific enough over a longer stretch of the road so that drivers had to guess at the reason of the advisory speed.

The evaluating investigations into the effect of advisory speeds clearly indicate that they favourably modify the drivers' behaviour and display a positive effect on traffic safety.

5. EXPANDING THE APPLICATION OF ADVISORY SPEED LIMITS

According to Dutch legislation, advisory speed limits should only be established under the most stringent conditions, e.g. at discontinuities which are clearly recognisable by the road user, while the speed at which he can negotiate the discontinuity, is not unambiguously indicated by the road design.

In order to ensure that the individual road user can "learn" the places where advisory speeds are indicated and their reason as well, the placing of advisory speed limit boards must comply with the following requirements:

- the application of advisory speed must indicate such situations (locations), in which the driver will always be exposed to the same degree of discomfort if he disregards the suggested speed;
- on all locations, where the driver could encounter such discomfort, advisory speeds have to be indicated;
- wrong advisory speeds should never and nowhere be suggested.

Only under such conditions will the road user be able to learn what he must do if a certain speed limit is suggested. In addition, the difference between the advisory speed and the safe comfortable maximum speed should never be too great, otherwise the driver will not understand the reason of the advisory speed limit and will not be inclined to follow the advice.

One has the impression that the conditions formulated by law are complied with at the locations in the Netherlands where advisory speed limits are indicated. This means that the present mode of advisory speed adjusts the driving behaviour in the right direction, thereby having a beneficial effect on traffic safety.

On expanding the application range of advisory speeds, there is a chance that a driver, disregarding the suggestion, will not be immediately confronted with the consequences of this omission (for example an uncomfortable acceleration). The "teaching effect" will be nearly completely lost, if an advisory speed board does not clearly indicate to the road user a predictable situation. In such cases the effectiveness of the measure will be gravely weakened. However, there is no exact information at disposal in the Netherlands as regards the improper use of advisory speed limits. The road authorities in the Netherlands seem to show some reserve in view of the application of this measure.

In the following paragraphs some possibilities of expanding the application range of advisory speeds will be discussed.

5.1. Steep

The application of advisory speeds on steep slopes must not always meet the requirements formulated in the Dutch legislation. However, only when the driver drives downhill, will he realise that the braking distance is longer than the usual one, required on horizontal roads (a situation which is not expected in the Netherlands!). An advisory speed is certainly justified if immediately after the slope (for example before traffic lights or a roundabout) the car (nearly always) has to be stopped.

5.2. Extreme wind conditions

Advisory speeds can be applied to locations, where extreme wind conditions are likely to occur. Critical situations may develop if gusts of wind blow across the road and a wind-sensitive (unstable) vehicle, for example a small delivery van, overtakes a lorry or a bus. At small speed differences (8-17 km/h) between the two vehicles and a high absolute speed, it can happen that under the combined effect of wind, screening from the wind and air currents, the unstable vehicle will be forced to stray much too far from its right course. Such problems mainly arise during overtaking on motorways and two-lane roads, on bridges, crossing rivers or sea arms. On such roads an advisory speed limit of for example 70 km/h can be suggested under heavy wind conditions. There are no problems if the driver of the wind-sensitive vehicle does not exceed the suggested speed.

Advisory speed limits under such conditions differ considerably from those given for curves in one special aspect. Extreme wind conditions affect only wind-sensitive vehicles (small buses, caravans) which form a small part of the total number of vehicles moving on the roads. In addition, dangerous situations only arise when such vehicles try to overtake a lorry or a bus. On the other hand, in a curve all vehicles are driven under identical conditions and all drivers are exposed to the effect of lateral acceleration. For these reasons the application of advisory speeds in dependence on wind conditions is not an effective measure and not a proper use of advisory speed. In order to make the measure effective, it is also necessary to indicate its reason and purpose and the vehicle categories to which it applies.

5.3. Application of advisory speeds instead of speed limits

More recently opinions are voiced favouring the replacement of speed limits by advisory speeds. Such replacement could be effected in places where police is incapable of implementing the speed limit or in order to prevent the devaluation of the speed limiting measures. In such cases the application of advisory speeds would not be limited to discontinuities, but they would have to be valid for long road stretches. Most likely such replacement would reduce the large scale transgression of traffic rules, but driving speeds would not be lower, on the contrary, in some cases even higher. Should penalisation of speeding be abandoned, many drivers could get the idea that authorities do not attach so much importance to speed limits anymore. In addition, an advisory speed is only then effective if, on disregarding it, the driver is immediately confronted with harmful negative effects. Another possibility would be to reduce through advisory speeds the spreading of speed distribution, thereby also reducing the necessity of overtaking. On roads, where cars are frequently overtaken in a dangerous manner, the implementation of a minimum speed limit would be advisable. The Dutch law permits the implementation of minimum speed limits only on motorways. Experience in the Netherlands proved that advisory speeds with a minimum and maximum speed limit are not easily understood by the drivers. Under such conditions the prohibition of overtaking seems more effective.

6. CONCLUSIONS

Advisory speed limits are applicable at discontinuities in the road and traffic system, in cases where the road user is aware of a discontinuity, without being certain about the safe speed for negotiating it.

At present, advisory speeds are almost exclusively suggested at narrow curves. The general impression is that such mode of application in conformity with the Dutch standards, is a proper and effective measure. On driving through a bend it is essential that:

- the driver takes in time the correct decision in view of the bend and its actual curvature, and
- the driver has enough time for correcting erroneous decisions.

Where no correct decisions can be taken on the basis of the road design (bends do not fit into the road characteristics expected by the drivers and are badly visible), advisory speeds may be give indications as to the right speed behaviour. Based on these assumptions it can be expected that advisory speed limits will have under the aforementioned conditions, a positive effect on traffic safety.

Investigations confirmed that advisory speed limits reduce the uncertainty of road users as regards the choice of driving speed, thereby indeed improving traffic safety.

Another conclusion is that the expansion of the application range of advisory speeds should take place with due reserve under the following conditions:

- disregarding the advisory speed limit must always expose the driver to the same degree of discomfort;
- advisory speed limits have to be established on all locations where their application is necessary and justified;
- wrong advisory speed limits should never and nowhere be suggested.

Ineffective application of the advisory speed limits will inevitably lead to the devaluation of the measure. In this case more accidents can be expected on locations where at present advisory speed has a beneficial effect on speed behaviour (like in bends).

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