Assessing the safety of the road netword: A simple method

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Assessing the safety of the road network; a simple method

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In the beginning of the automobile era, the fear of an accident was so great that a man carrying a red flag walked ahead of the car to warn people of the impending danger. Later, police departments would use flags to literally mark road hazard on the map. The red flags indicated accidents with a fatal outcome. A study would be initiated at those points where many flags were concentrated. Although pin charts are still used, other measures have been developed since then to assist study into the causes of road accidents.

What has the SWOV realised in the Netherlands in this area? First we will sketch a broad outline of the road traffic situation in the Netherlands. Today, we have a fairly dense network of motorways: over 2000 kilometres covering a surface area of 33.500 square kilometres, to serve a population of almost 15 million. The total road network in the Netherlands is 100.000 kilometres long. Almost half this network lies inside the built up area. The rest is distributed over the area outside the built up zone. It is precisely these roads which demonstrate a large diversity in design and 'use' (meaning the traffic intensity on a particular road).

The Dutch road network is categorised such that utilisation by motor vehicles is roughly equivalent for the urban roads, the rural roads and the motorways. The distribution of traffic accidents over the three types of road network is quite different from the distribution of road use! In the Netherlands, there are over 30.000 injury accidents per year inside the built up area, and 12.000 outside the built up area. Of these injury accidents, 2000 occur on the motorway and 10.000 on the other roads outside the built up area. The measure which has been in use for many years to allow comparison of roads with respect to road safety is the 'accident rate': the number of accidents per million vehicle kilometres travelled. For the Dutch road network, a simple division sum offers us the following result:

The motorway is 6 times less 'hazardous' than other roads outside the built up area, and 17 times less 'hazardous' than the roads inside the built up area. Similar results are found virtually everywhere in the world. But is this a realistic comparison? Not if it leads us to conclude that the motorway is the safest road, followed by the decision that motorways should therefore be the only type of road we should construct.

Of course, we should consider additional factors if we are to arrive at a correct assessment of the road network and set the correct priority for road safety measures.

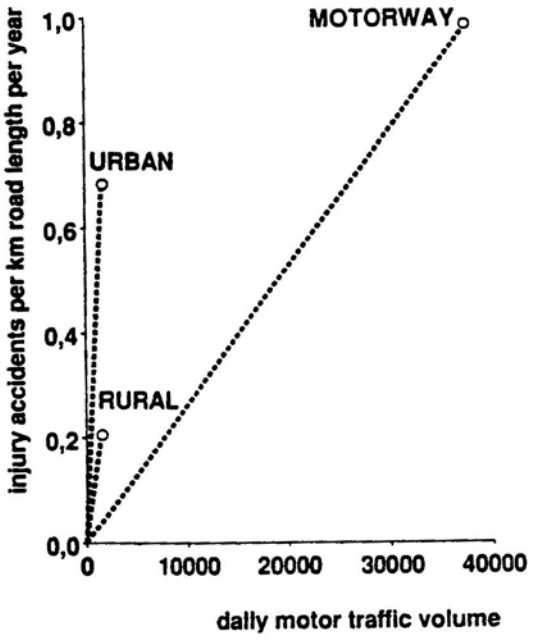

Diagram 1

In Diagram 1, the average values for the three road networks are shown using a coordinate system, with on the x axis the 'daily motor traffic volume', and on the y axis the number of 'injury accidents per kilometre road length per year'. The lines to the origin form an angle with the x axis.

The tangent of this angle - the number of accidents per kilometre road length, divided by traffic intensity - corresponds to the value for the accident rate: the number of accidents per million vehicle kilometres travelled. In this diagram, we see the various traffic functions of the three types of road network presented as the 'daily motor traffic volume'. In addition, a projection of the points on the y axis shows a ranking of roads based on accident density. This ranking - motorway/urban/rural - is clearly different to that for the 'accident rate' - urban/rural/motorway.

When comparing roads, we must remember the essential difference between the function of roads in terms of flow, access and even residential use. A motorway, for example, is not interchangeable with a road inside the built up area.

Even when roads belong to the same type of road network, there are still sufficient functional differences to justify a further distinction. In particular for the Dutch situation, we must realise that traffic inside the built up area represents other vehicle types besides motor vehicles - yet another important difference in traffic function which makes a comparison between roads more difficult, particularly when certain data are not available.

For roads outside the built up area, we have at least four main categories in the Netherlands:

The motorway is only accessible to drivers of a motor vehicle which can and may attain a speed of at least 80 kilometres per hour. It is prohibited to stop the vehicle, to turn it or to reverse it. The maximum speed for this road category is 120 kilometres per hour.

For the purpose of the SWOV study, a further division was made, based on the cross-section of the road. This led to two sub-categories of motorway:

- the standard motorway with two lanes per carriageway;
- the expanded motorway with more than four lanes.

The motor road only permits access to drivers of a motor vehicle which can and may reach a speed of at least 40 kilometres per hour. The same prohibitions as for the motorway apply in this case. The maximum speed is 100 kilometres per hour.

The categories which can be distinguished are as follows:

- the motor road with two main carriageways;
- the motor road with a single carriageway and in most cases two lanes.

The arterial rural road is prohibited to horses, cattle, and vehicles and motor vehicles which cannot or are not permitted to drive at speeds of over 25 kilometres per hour, as well as bicycles and mopeds. Sometimes the ban only applies to cycles and mopeds. This road category is subject to a speed limit of 80 kilometres per hour.

The sub-categories are as follows:

- the arterial rural road with dual carriageway;
- the arterial rural road with single carriageway.

The local rural road, which is in principle open to all drivers and pedestrians. Again, a speed limit of 80 kilometres per hour applies.

The sub-categories are:

- the local rural road, single carriageway with two lanes;
- the local rural road with one lane for both directions.

When comparing accident densities for these road categories, it is important to keep in mind the difference between traffic function and intensity.

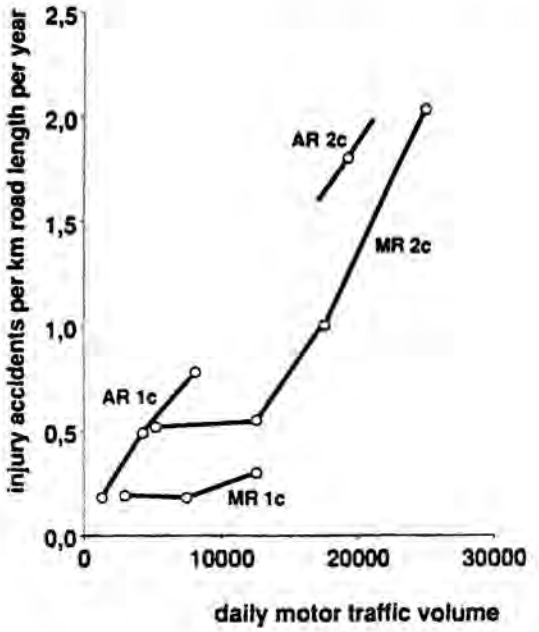

Diagram 2

Diagram 2 shows the relationship between accidents and traffic intensity per road category. Curiously enough, the number of injury accidents within the same intensity range is far higher for the 'motor road, dual carriageway', than for the 'motor road, single carriageway'. Later, we will compare the 'motor road, dual carriageway' in greater detail to the motorway. After all, there is a close resemblance between the two with respect to both the cross-section and the traffic intensity. The 'arterial rural road, dual carriageway' is - fortunately - rarely seen in the Netherlands. "Fortunately", because of the high accident density given the high traffic intensities. The 'arterial rural road, single carriageway' clearly scores less favourably than the 'motor road, single carriageway' at the same level of traffic intensity.

Now the promised comparison between the 'motorway with four lanes' and the 'motor road, dual carriageway', two road sub-categories from different main categories, for which a statement can be made about safety at the same intensity levels.

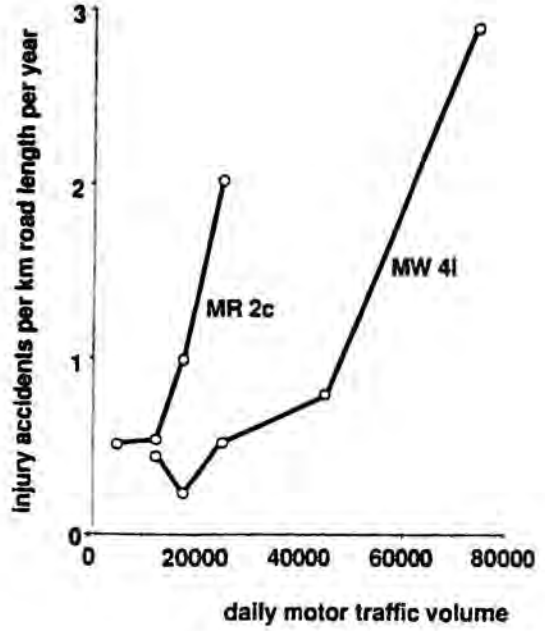

Diagram 3

In diagram 3, the 'motor road, dual carriageway' seems more hazardous than the motorway at an intensity of between 12.000 and 25.000 motor vehicles per day. In particular at high intensities, the motor road is more hazardous. In situations where a motor road could be replaced by a motorway, this graph offers a preliminary indication of the estimated effect in terms of injury accidents.
We would also like to show a different application of the measure 'accidents per kilometre of road length in relation to traffic intensity', based on road category. Imagine that study has given a reliable impression of a road category with respect to the number of accidents per kilometre road length per year for a number of intensity categories.

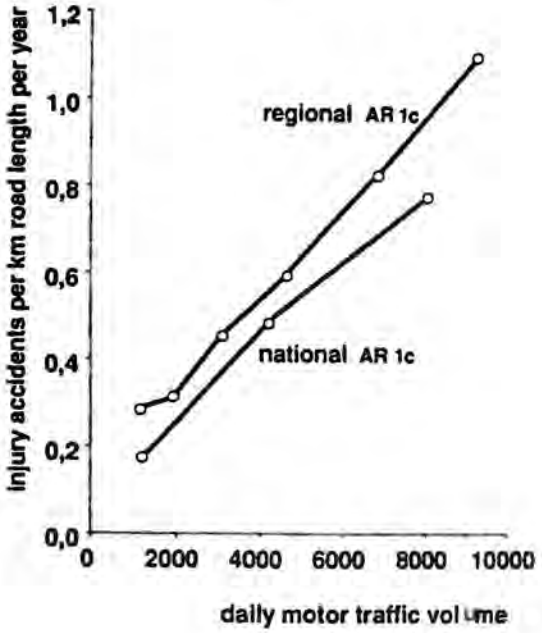

Diagram 4

The example selected for a Dutch, national gauge, the category 'arterial rural road', is shown in diagram 4. In a certain region of the Netherlands, accident and traffic intensity data were gathered for road sections belonging to the same category. The regional road sections were put in order of intensity and clustered into (in this case) six groups of roughly equivalent road length. The average number of injury accidents per group of road sections was compared to the average traffic intensity of the group. This has resulted in the 'regional' line, which can be compered to the national line. Although there are differences, it is doubtful whether these would be significant after statistical evaluation.

If a national standard is not available or not relevant, then the gauge can also be used for the selection of local road sections which are hazardous with respect to that group of road sections.

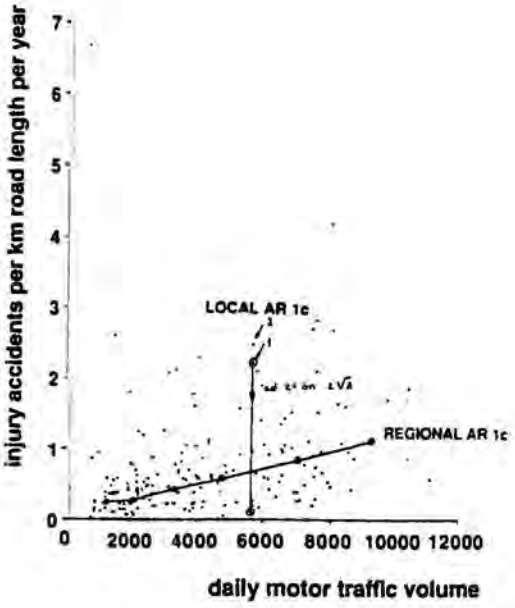

Diagram 5

Diagram 5 shows a group of local road sections through which the 'regional line' is drawn. Here we see all 267 road sections represented. The first group, for example, represents 73 kilometres of road length and 71 accidents over three years.
We have selected one location (nr 1) which will be assessed against the regional line; see diagram 5. How do we do that?
We assume that for small accident numbers, a Poisson distribution is applicable, i.e. each accident number has a standard deviation of twice its square root.
At the selected location, five injury accidents occurred over three years. The length of the location is 745 metres. If we reduce the number of injury accidents of the location by twice the square root of five and again compare the number of accidents per kilometre against the same intensity, then the road section comes to lie below the 'standard' of the regional line, just above the x axis. If we repeat this exercise for all local road sections, then only one point continues to lie above the line in this example. Does that mean that only that road

section is truly hazardous? Furthermore, a large number of accidents dip below the x axis, as though they had become 'negative' accidents.
Therefore, it would be preferable to apply a more practical method, even at the risk of being maligned by the methodologists amongst us.

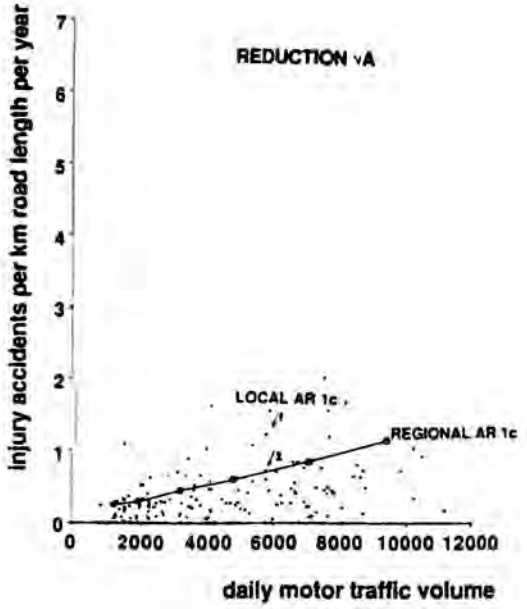

Diagram 6

In diagram 6, the number of injury accidents for each road section has been reduced by only the square root of the accident number. The point (nr.1) we used in diagram 5 for the purposes of illustration continues to lie above the standard line. A nearby point (nr.2) from diagram 5 - a road section where two injury accidents occurred over a length of 267 metres of road during a period of three years - is now located precisely on the line, and is therefore not included in the category of hazardous road sections with this method.
Of course, the SWOV is trying hard to find a selection criterium to enable the most hazardous roads and intersections to be pinpointed. We are developing an instrument - an interactive software package - to assess the degree of road hazard for a road network. We will issue a report as soon as new results become available.