ANNEX VII
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Road design standards of medians, shoulders and verges

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Notice to the reader

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Main report: Safety effects of road design standards
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Annex I: Road classification and categorization
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Annex II: Assumptions used in road design
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Annex III: Methods for investigating the relationship between accidents, road user behaviour and road design standards
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Annex IV: International organizations and road design standards
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1. Introduction

This report compares the road design standards of medians, shoulders and verges of different road types of EU and EFTA countries. The starting point is the survey conducted within the framework of the European Union DRIVE Programme (O'Cinnéide, McAuliffe & O'Dwyer, 1993). Fifteen European countries were involved in this project.

The results from the report by O'Cinnéide et al. are reproduced per section and provided with commentary (Chapter 3).
Subsequently, the design criteria of the countries which have devoted attention to this matter in their guidelines are discussed (Chapter 4).
Based on Chapters 3 and 4, the most suitable width of the various cross-sections is determined and an indication is given in table form of how many countries are able to concur on the basis of their guidelines and how many are unable to do so (Chapter 5).
With those parts of the cross-sections where there is minor agreement, proposals for further study are indicated (Chapter 6).

2. General principles

The design of the cross-section is relevant to:
- the prevention of accidents;
- the prevention of (serious) injury if a vehicle leaves the road;
- the interception of stranded vehicles and the accessibility of an accident location by emergency vehicles.

With respect to the *prevention of accidents*, the correct design of the cross-section can have a favourable influence on driving behaviour. To ascertain this, cross-sections should be uniform in order to be recognizable to the road user. It should be possible to compensate for slight, unintended changes in direction when negotiating the cross-section. There should be a continuity in the cross-section in a longitudinal direction. If discontinuities are nevertheless essential, the transitions must be of a gradual nature.

The safe design of the verges is also intended to *prevent* occupants of vehicles that leave the road from sustaining *(serious) injury*. This means that a zone with rigid obstacles (but also steep banks and canals) should be situated at a sufficient distance from the road, or that the zone should be shielded by means of a crash barrier.

Finally, the cross-section is of importance for the *interception of stranded vehicles*. It should be ensured that stranded vehicles do not come to a stop on the carriageway and hence create a hazardous situation there, while also obstructing traffic flow. For motorways, it is important that in case of an accident emergency vehicles are able to rapidly reach the accident site via the hard shoulder (emergency lane).

The above points represent general principles for the design of the cross-section. They form the basis for determining the dimensions of the cross-section. The dimensions are also determined by the vehicle characteristics, where the width and speed of a 'standard vehicle' represent the principal considerations.

Although such principles generally are not formulated in the guidelines of the European countries investigated, it must be (implicitly) assumed that these have been used as principles for design. The next step is to allocate the widths applicable to the various parts of the cross-section. It should be clear that every country has approached this in its own way, with the cost factor playing an additional role.

3. Survey of O'Cinnéide et al.

3.1. General

O'Cinnéide et al. (1993) have conducted a data collection of dimensions of cross-sections under the European Union DRIVE Programme. Fifteen European countries were involved in this project.
In the survey of O'Cinnéide et al. three categories are distinguished:
category 1: rural divided motorways;
category 2: rural non-motorway divided roads
category 3: rural undivided primary roads.
In 5 out of the 15 countries category 2 is not familiar.

In this chapter the frequencies of cross-section dimensions of the three road categories are given and discussed separately.
The following dimensions of the cross-sections are involved:
- median width
- lane width
- width of the paved inner shoulder
- width of the paved outer shoulder (emergency lane)
- width of the verge (unpaved)

N.B. The paved redressing strip between the left lane and the median is missing in the data of O'Cinnéide et al. This part of the road is added to Chapter 5.

When gathering data it is important to know whether the data are with or without the presence of crash barriers (guard rails or concrete barriers). In the survey of O'Cinnéide et al. this distinction is lacking. In the investigation of the cross-sections of the 15 European countries, it is not always clear whether the data are connected with shielded or with unshielded verges. We shall take this aspect into account.

3.2. Results of O'Cinnéide et al.

In the survey of O'Cinnéide et al. data of the three road categories mentioned before are given in the Tables 12 to 14: 'Standard cross-section dimensions'. The survey contents data of the following countries:

Austria	Netherlands
Denmark	Norway
Finland	Portugal
France	Spain
Germany	Sweden
Iceland	Switzerland
Ireland	United Kingdom
Italy	

The frequencies of the distinguished parts of the cross-sections in conformity with the survey of O'Cinnéide et al. are given below, with additional comments.

3.2.1. *Rural divided motorways (Road category 1)*

Median width

Width (m)	Frequency median width incl. paved shoulders	Frequency unpaved median width without shoulders
1.0 - 2.9	1	4
3.0 - 4.9	3	3
5.0 - 7.4	3	2
7.5 - 9.9	2	1
10.0 - 12.4	2	3
≥ 12.5	4	2
Total	15	15

Many countries have small dimensions of the median width, other have large. It seems that some countries have taken into account the presence of a crash barrier, others not.
A width up to 5 m for the unpaved median is given in the standards of 7 countries; too small for a unshielded median. Six contries have a width of 10 m and more for the median included the paved shoulders.

Lane width

Width (m)	Frequency
3.5	3
3.65	1
3.75	11
Total	15

Most countries have a lane width of 3.75 m. Data give a good impression of the agreement between the countries.

Paved inner shoulder

Width (m)	Frequency
0 - 0.5	4
1.0	9
2.0	1
no data	1
Total	15

Most of the 15 countries have stated a width of 1 m.

Paved outer shoulder (emergency lane)

Width (m)	Frequency
1.5 - 2.4	1
2.5 - 2.9	5
3.0 - 3.4	7
≥ 3.5	2
Total	15

Both the width of 2.5 - 2.9 m and 3.0 - 3.4 m are overrepresented within the 15 countries. With the notation of 3.0 ± 0.5 m, 12 countries agree with this width.

Verge (unpaved)
The verge is an unpaved zone besides the paved outer shoulder.

Width (m)	Frequency
0 - 0.4	2
0.5 - 0.9	3
1.0 - 1.4	2
≥ 1.5	4
no data	4
Total	15

In this data a small variation in width is found between 0,25 -1,5 m. Four countries have no data in their standards.
It is unknown whether besides the verge hazardous obstacles are allowed in the 15 countries or that the presence of crash barriers is obliged.

3.2.2. *Rural non-motorway divided roads (Road category 2)*

As told already, this type of road is not familiar at 5 of the 15 countries. Furthermore, data are missing from 1 or 2 countries.
In this chapter, firstly, frequencies are given according to the survey of O'Cinnéide et al. Because this type of road is rather similar to the above mentioned motorways, a comparison is made between the data of this two types of roads.

Median width

Width (m)	Frequency
0 - 4.9	6
5.0 - 7.4	0
7.5 - 9.9	1
10.0 - 12.4	0
≥ 12.5	1
no data	7
Total	15

In most of the standards a width up to 4 9 m is given.

Compared with road category 1:
- in 4 countries road category 2 has a similar width
- 2 countries have a somewhat smaller width (max. 2 m smaller)
- 2 countries have a much smaller width (more than 2 m)
- 7 countries: no data

Also the presence of a crash barrier at this road type is unknown.

Lane width

Width (m)	Frequency
3.25	1
3.5	4
3.65	1
3.75	3
no data	6
Total	15

Most countries have a lane width of 3.5 m.

In next table the difference with the motorways (category 1) is given.

Lane width (compared with category 1)	Frequency
same width	5
25 cm smaller	3
50 cm smaller	1
no data	6
Total	15

The lane width of this road category differs not much from category 1.

Paved inner shoulder

Width (m)	Frequency
0 - 0.5	5
1.0	4
no data	6
Total	15

All countries have a width of 1 0 m or less. The comparison with category 1 gives differences of maximum 1 m at the 9 countries with data.

Paved outer shoulder (emergency lane)

Width (m)	Frequency
0 - 1.0	3
1,75 - 2.4	2
2.5 - 2.9	2
3.0 - 3.5	2
no data	6
Total	15

Three countries have no emergency lane. The other contries have a width varying from the width of a passenger car to the width of an emergency lane of a motorway.

The next table gives the data of category 2, in comparison with motorways.

similar width to category 1 (2.5-3.5 m):	4
smaller width (maximum 1 m)	1
smaller width (more than 1 m)	4
no data	6
Total	15

Four countries have a width for the emergency lane which differs much from road category 1.

Verge (unpaved strip)

Width (m)	Frequency
0 - 0.90	2
1.0 - 1.9	3
2.0 - 2.9	1
≥ 3.0	2
no data	7
Total	15

Only 3 countries have a width of more than 2.0 m.
In comparison with road category 1:
- in 3 countries road category 2 has a larger width *)
- 4 countries have a similar width
- 1 country has a smaller width
- 7 countries: no data

*) The reason for a larger width has to be considered in the context of the absence of an emergency lane at road category 2 in these three countries (Denmark, Iceland and United Kingdom).

Also here, it is unknown whether besides the verge hazardous obstacles are allowed or that crash barriers are obliged.

3.2.3. *Rural undivided primary roads (Road category 3)*

This type of roads are primary roads with design speeds in the range of 80 to 100 km/h.

Lane width

Width (m)	Frequency
3.25	2
3.5	4
3.65	1
3.75	7
no data	1
Total	15

Most countries have a lane width of 3.75 m. Only 2 countries have a width of 3.25 m.
In comparison with road category 1:
- road category 3 has the same width in 11 of the 14 countries
- 3 countries have a smaller width (only 0.25 cm smaller)

The conclusion can be drawn that the difference from road category 1 is slight.

Paved shoulder (inner and outer)
With this road category, no difference is made between inner and outer paved shoulder.

Width (m)	Frequency
0 - 0.9	4
1.0 - 1.9	6
2.0 - 2.9	4
no data	1
Total	15

Most countries have a width of 1.0 - 1.9 m.

Verge (unpaved strip)

Width (m)	Frequency
0 - 0.9	5
1.0 - 1.9	2
2.0 - 2.9	1
3.0 - 3.9	2
≥ 4.0	1
no data	4
Total	15

Only 3 of the 14 countries have a width of 3 m and more.

Assuming that besides the verge hazardous obstacles are allowed (no presence of crash barriers), the obstacle free zone besides the road seems small.
To have insight in the width of the zone for vehicles leaving the road in an accident situation, the two zones (paved shoulder and verge) of the individual countries are added up (see next table).

Total width of paved shoulder and verge

Width (m)	Frequency
0 - 0.9	1
1.0 - 1.9	4
2.0 - 2.9	4
3.0 - 3.9	2
≥ 4.0	3
no data	1
Total	15

The difference with the previous table is slight: now only 5 of the 14 countries have an obstacle free zone of 3 m and more.

4. Important safety aspects in relation with dimensions

Background information and/or criteria about the dimensions indicated in the previous chapter are particularly scarce in the national guidelines. Generally, the explanations or supporting evidence are qualitative in nature. Chapter 2 has already entered into this in a summarizing form. This chapter will offer a quantitative basis, insofar this has been quoted in the guidelines of the countries in question.

The survey of O'Cinnéide et al. is based on cross-sections as they are likely to occur over long distances. Preferably, the same dimensions should be adopted for structural engineering works (viaducts, bridges). In order to reduce costs, however, the widths tend to narrow at the point of the engineering works. Due to the specific character of the works, which differs from one country to another, O'Cinnéide et al. have not entered further into the various designs for engineering works; neither will this report consider this aspect.

For the design aspects relating to the width of the lanes, we refer to Annex VI to the main report (Michalski, 1994).

The description of the safety aspects only distinguishes between road categories 1 and 3. Category 2 is not considered, because for this category, no data has been found in the literature to indicate the basis for the dimensions of the cross-section for the individual countries.

Section 4.1 first indicates the basic principle for the design of road verges as reported in the Dutch guidelines. This principle applies to both category 1 and 3 roads.
Sections 4.2 and 4.3 then cite the specific safety aspects applicable to categories 1 and 3. Various widths as noted in these sections can be found again under 'best practice' in Table 1.

4.1. Basic principle for the design of safe verges

For a strategy with respect to the design of verges, three basic designs can be distinguished which are applicable to both dual and single carriageway roads. These are listed below, in order of preference.

- In the first design, an *obstacle free zone* regarded as the safest of all, there are no hazard areas nor obstacles. Vehicles leaving the road can go on running freely or perhaps can be brought back under control.
- In the second type, a *zone with single obstacles*, roadside furniture and single rigid obstacles may occur. Roadside equipment like lighting poles and traffic signs have to be designed so that if hit by a car they do not endanger the occupants. If there is no way to remove the rigid obstacles, they must be protected separately (p.e. by a crash barrier of short length or by an impact attenuator).
- The relatively least safe area, a *full protected zone*, has a hazard area too close to the carriageway. This should be protected fully lengthwise by a crash barrier.

Both in the German and the Dutch standards, it is stated which obstacles must be shielded by a crash barrier (FGSV, 1989; RWS 1989a,b,c). Some of the most important are:

- water
- noise screens
- trees, poles, large signs, alarmposts (N.B. In the Netherlands, it is not necessary to shield the special constructed alarm posts because in case of an accident the posts will bend relatively easily at ground level)
- walls of buildings
- downward slopes steeper than 1:3 and:
  * in Germany: with a height difference > 3 m
  * in the Netherlands: with a top slope radius < 9 m
- upward slopes:
  * in Germany: steeper than 1:3
  * in the Netherlands: steeper than 1:2 and with a bottom slope radius < 6 m.

As stated before, specific constructions like bridges and viaducts are left out of consideration in this document.

According to the Dutch standards the following obstacles can be placed in a not shielded verge:

- steel lighting poles with a yielding construction
- aluminum poles with a maximum height of 10 m
- traffic signs and alarm posts
- curbs and ditches (< 7 cm)
- bushes.

To determine the widths of the carriageway and the emergency lane, the 'design vehicle' must be used as a basis. Both the German and Dutch guidelines adopt the dimensions of a lorry measuring 2.5 to 2.6 m in width and 4.0 m in height. For passenger cars, the Dutch guidelines apply a width of 1.75 m. Of course, the specified lorry width is the determining factor.

4.2. Safety aspects of road category 1

The most extensive support to the guidelines has been drawn up by the German and Dutch road traffic authorities (FGSV, 1989; RWS 1989a,b,c). An overview of this will be given below. Where road traffic authorities from other European countries have supplied an explanation in support of their guidelines, this will also be reported.

The width of the median can be defined as the total width between the two painted border lines to the left and right of the median. If the width of the border line itself is not included, one can consider the median as being made up of the paved redressing strips on either side and the unpaved median.

It is not known whether any study has been performed into the required width of paved redressing strips. However, in the Netherlands, category 1 roads were subjected to exploratory research where two widths were compared. From the accident frequency recorded it was shown that a width of 0.60 m did not present any disadvantages when compared to a redressing

strip measuring 1.10 m wide. The Dutch guidelines therefore stipulate a width of 0.60 m for roads with a design speed of 120 km/h, and a width of 0.30 m for roads with a design speed of 90 km/h.

The width of the unpaved median is dependent on the location of the crash barriers. According to the Dutch guidelines, a crash barrier is not essential if there is no risk that the median may be crossed. Also on the basis of American research, this width is set at a minimum of 20 m. Such a width will generally not be feasible in practice. It is proposed to investigate at which reduced width the same degree of safety can still be assured as with a median measuring 20 m in width (see Chapter 6).

A minimal median width can suffice if a crash barrier is placed. The German guidelines indicate the space required for the placement of crash barriers. If the barrier is flexible, a width of at least 2.50 m should be taken into account, representing the width of the barrier (0.80 m) and its possible deflection width. The Dutch guidelines specify a width of 2.30 m. For a less flexible or a rigid barrier, the German guidelines quote a width of at least 1.50 and 1.00 m, respectively.

If a width of 2.50 m is maintained for the flexible barrier, and with the presence of a redressing strip, the guard rails will be positioned at a sufficient distance away from the carriageway. With a rigid barrier, where the deflection width need not be taken into account, a certain distance from the barrier to the carriageway should be included in order to allow for the so-called 'obstacle apprehension distance' (safe driving distance). The Dutch guidelines indicate that for the obstacle apprehension distance the following spacing should be applied:
- for a design speed of 120 km/h : 1.50 m
- for a design speed of 90 km/h : 1.00 m.

For category 1 roads with a design speed of 120 km/h, this means that with the presence of a paved redressing strip of 0.60 m, an unpaved strip of 0.90 m remains. For a design speed less than 120 km/h, the safe driving distance is 1.00 m. With a width of 0.30 m for the redressing strip, the unpaved width will be 0.70 m. The German guidelines cite an unpaved width of 0.50 m, albeit that this is specified as a minimum.

This means that regardless of the type of barrier, the medians of motorways with a design speed $\geq$ 120 km/h should have a width of at least 4 00 m and motorways with a design speed $<$ 120 km/h a median width of at least 3.00 m.
The emergency lane is important for the correction of slight deviations in course, for stranded vehicles and for emergency vehicles. In addition, this space can be utilized for maintenance work. The French guidelines also include aspects such as comfort and recognition of the road category (SETRA, 1985). The Dutch guidelines base the minimal width of the emergency lane on the width of the design vehicle (= 2.60 m) and an alighting space of 0.50 m; a total of 3.10 m.

Those road categories which do not have an emergency lane do require an (unpaved) recovery zone for stranded vehicles. It is assumed that the majority of stranded vehicles will be passenger cars. The width of the recovery zone is then based on the width of a passenger car plus the

alighting width, is 1.75 + 0.50 m = 2.25 m, calculated from the outer edge of the border line. The French guidelines base the width of the emergency lane (including redressing strip) on the number of vehicles belonging to the category of heavy traffic:
< 1500 heavy vehicles per day: 2.50 m
> 1500 heavy vehicles per day: 3.00 m.

In the Netherlands road category 1 (rural divided motorways) is subject to an obstacle free zone of 10 m, calculated from the border line of the outside traffic lane. This distance is based on American and Dutch research, where a relationship is established between the obstacle distance and the percentage of vehicles which have collided with these obstacles in an accident situation or have run a certain distance on the verge.

The German guidelines cite obstacle free zones in flat verges at a minimum of 6 m to a maximum of 12 m from the border line. The minimum distance relates to rigid obstacles. The maximum distance is applicable if there is also a hazardous situation for other road users or if the danger zone is particularly hazardous, e.g. with open, deep water. If the verge is not flat but strongly inclined (steeper than 1:5), the minimum and maximum width are 10 m and 14 m, respectively.

The French guidelines quote an unpaved verge width of 0.75 m; if a crash barrier is placed, the width is 1.0 m. According to these guidelines, such widths also contribute to offering an unrestricted visibility distance.

If a sufficiently wide obstacle free zone is not feasible, a crash barrier should be placed. The Dutch guidelines determine that the barrier should be placed 0.50 m beyond the paved area. This area represents the margin required by stationary vehicles on the emergency lane. If the crash barrier is of a flexible construction, space should be reserved behind the barrier to allow deflection, amounting to 1.50 m. This additional space can be reduced as the construction becomes more rigid. The German guidelines reflect these requirements.

Some road traffic authorities take into account future road work activities during the construction of a road. The cross-section is then dimensioned such that if a lane needs to be closed off, sufficient room is still available to allow a diversion along the remaining paved area.

Based on an optimal distribution of the cross-section, a certain strategy can be adopted to arrive at a reduced width under certain conditions. In the Dutch guidelines, it is indicated that if necessary, the following elements can be reduced in width, in descending order:
- the margins intended for alighting from stranded vehicles
- the recovery zone along the median
- the emergency lane
- the redressing strip along the median
- the second lane
- the first lane

4.3. Safety aspects of road category 3

This section describes the safety aspect of single carriageway roads that

have the clear function to rapidly and safely process through traffic. The design speed of these roads is 80 to 100 km/h. In principle, these roads should not carry slow traffic, on the basis that separate cycle tracks or parallel roads to carry slow traffic are available, (not necessarily) located in the immediate vicinity of the main carriageway.

Although the Danish and Dutch guidelines describe the design and dimensions of single carriageway roads with cycle tracks and parallel roads in detail, this is not considered here, since standardization in a European context seems irrelevant for this subject at present (Danish Road Directorate, 1981; RONA, 1986).

With reference to verges on rural undivided primary roads, the following aspects are of relevance: obstacle-free width, paved redressing strip, unpaved verge and crash barriers.

As is true for motorways, it must be ensured that vehicles on single carriageway roads which go off course do not come into contact with rigid obstacles. For this purpose, an obstacle free zone should be created, or else the obstacles should be shielded. As indicated, the Dutch guidelines have determined the obstacle free zone for motorways to be 10 m wide (at a design speed of 120 km/h). For lower design speeds, a reduced width is sufficient. Based on American and Dutch studies, single carriageway roads with a design speed of 100 km/h should have a zone 6 m wide. If the design speed is 80 km/h, the width is 4.50 m. These widths are calculated from the inside edge of the border line. The width of the border line itself and the paved redressing strip therefore fall within the width of the obstacle free zone. The width of the redressing strip, according to the Dutch guidelines, is 0.45 cm (including border line).

The German guidelines indicate an obstacle free zone on flat verges for single carriageway roads varying from a minimum of 4.50 m (the distance to rigid obstacles) to maximally 9 m (hazard for other road users or particularly hazardous situations, such as open water). If the verge slopes down (steeper than 1:5), the minimal and maximal widths are 8 m and 12 m, respectively. As also indicated for category 1 roads, collision-safe traffic signs, aluminum light poles etc. can be placed in the obstacle free zone.

Although the Dutch guidelines state that the verges with rigid obstacles which are positioned too close to the carriageway can be shielded by means of a crash barrier, the guidelines on this subject are particularly conservative. The principal reason is the danger of rebound of vehicles that collide with the barrier. In contrast to divided motorways, there is a risk on undivided roads of a frontal collision if the vehicle rebounds from the barrier. Vehicles land after this on the opposite lane, meeting traffic travelling in the opposite direction.

According to the guidelines, crash barriers may only be placed if the risks have been weighed up: one the one hand, the risk to the occupants of the vehicle which has left the road, on the other the risk posed to others, e g. on roads situated adjacent or below.

If the road traffic authority decides to place a crash barrier, a recovery

zone should also be provided. Such a zone is important for stranded vehicles and to allow vehicles which have come off course to adjust their direction. The Dutch guidelines prescribe a width of 2.60 m for such a zone, with a minimum of 1.50 m (calculated from the inside of the border line).

In curves and near intersections, the presence of a crash barrier and obstacles can lead to a restriction of visibility. In such cases, the barrier (or obstacles) must be placed further from the roadway. The Dutch guidelines include a nomogram which indicates the relationship between the following three variables: horizontal arc, distance from obstacle to the road edge and the visibility distance. For an arc of, for example, 500 m and an obstacle distance of 3 m to the road edge, the visibility distance is 140 m.

In addition, the Dutch guidelines devote special attention to the quality of the verge. This must offer sufficient support to prevent the wheels from sinking down. In addition, the difference in height between the paved area and the verge must be minimal (no more than a few centimetres) to prevent the wheels from encountering excessive resistance when reversing, with an associated risk of overcorrection.

5. Consensus and differences between EU-countries

Based on the background to the guidelines set out in Chapter 4 and the frequencies cited in Chapter 3, Table 1 has been drawn up. This table first offers all parts of the cross-section as distinguished by O'Cinnéide et al., complemented by the following two elements:
- median paved redressing strip;
- obstacle free zone.

In the second place, the three road categories as distinguished by O'Cinnéide et al. are given.

The table also indicates per road category under the heading *Best practice* the dimensions of the elements of the cross-section, given on the basis of the results of Chapters 3 and 4. The given widths must be regarded as proposals, and are not fixed. Following this, it is indicated under *Agreement* how many countries have included corresponding widths in their guidelines according to the survey performed by O'Cinnéide, and under *Disagreement* for which number of countries this is not the case. Under *(Dis)agr. unknown*, the number of countries is cited which have not quoted a particular dimension.

The final two items give the dimensions as cited in two reports from 1987 and 1988 about the guidelines concerning European roads. The first report concerns an Appendix to the Agreement with respect to the Main International Traffic Arteries in Europe: the so-called E road network (AGR, 1988). This Appendix describes the conditions which this road network must satisfy. The second report is a survey of the Darmstadt Institute of Technology concerning a comparison of the guidelines for road design in countries of the European Community (Durth, 1987).

Neither report specifically discusses road category 2: rural non-motorway divided roads. Therefore, the table does not include a reference to either report with respect to this road category.

Question marks in the table indicate that it is uncertain how the relevant countries view the proposed *Best practice*, since the survey by O'Cinnéide et al. does not devote attention to this matter.

Both the elements of the cross-section where question marks have been placed and the elements where the number of countries showing *Agreement* is less in number than the number showing *Disagreement* are dealt with in detail in the next chapter. These elements are therefore suitable for further collection of data or for further research.

For the other elements, it can be stated that a majority of countries are able to concur on the basis of their guidelines. Those countries which do not concur with the proposed dimensions must make this known, preferably giving reasons why.

6. Knowledge and research to underpin guidelines

This chapter deals with the points on which there is less agreement between the countries concerned; it deals also with those parts of the cross-section which were not included in the survey by O'Cinnéide et al.

The lack of clarity about the widths of the verges, in particular, is due to the fact that the survey does not distinguish between verges with and verges without shielding provisions. Table 1 does make this distinction. This table proposes:
A. the width of the verge if a crash barrier is required;
B. the width of the obstacle free zone so that no crash barrier is required.

Both proposals are based on the German and Dutch guidelines. With respect to A, there is a high degree of agreement between the countries involved. With respect to B, it is uncertain how this is viewed in the various countries. It is assumed that the dimensions proposed in the German and Dutch guidelines are considered too generous.

Below, proposals for research with respect to B are given with a view towards realizing agreement between all countries involved.

Road categories 1, 2 and 3: obstacle free zones
The German and Dutch guidelines express a preference for obstacle free zones. With respect to width, these were determined for the Netherlands on the basis of an American study from the 1970s and a Dutch accident study dating from 1983 (SWOV, 1983).

As far as known the Dutch study concerning obstacle free zones, is the only one carried out in Europe with widths of more than approx. 3 m. In this study, the relation is determined between the number of accidents against trees and the distance of the trees to the edge of the pavement (see Figures 1 through 3). The tree accidents are related to the total number of accidents (= ratio tree accidents). As variable the motor vehicle volume (ADT) was used. The figures mentioned are related to the following three road types:
Figure 1: rural undivided *secondary* roads
Figure 2: rural undivided *primary* roads
Figure 3: rural divided *motorways*.

Based on these studies, Dutch guidelines stipulate widths varying from 10 m for motorways to 4.50 m for single carriageway roads with a design speed of 80 km/h (both calculated from the border line of the right lane). These guidelines are already being followed in the Netherlands when designing new roads. To date, no evaluation was undertaken. It would seem highly advisable to carry out such an evaluation. It is equally desirable that those countries which apply reduced verge widths should determine the proportion of obstacle accidents on these roads. It goes without saying that a distinction should be made according to road type. Such a study would be able to chart the problems associated with obstacle-related accidents, so that basic knowledge is gathered which can assist in the determination of the desired widths for obstacle free zones.

Road category 1: median unpaved and unshielded
If the median is sufficiently wide, there is no need for a crash barrier. The question is what width is considered sufficient. The Dutch guidelines quote 20 m. However, this distance is so large that only few countries can concur with this.

To arrive at a reduced width, the foremost criterium to be adopted should be that the median may not be crossed, neither in an accident situation nor with turning manoeuvres. It is therefore essential to realize a physical separation which does not lead to excessive impact deceleration for those vehicles that have left the road. This separation (possible in a natural way: sand ridge, planted) was to prevent also the crossing of heavy vehicles (lorries and buses). The dimensions such a physical separation should have and the distance it should be placed from the roadway are subjects for research.

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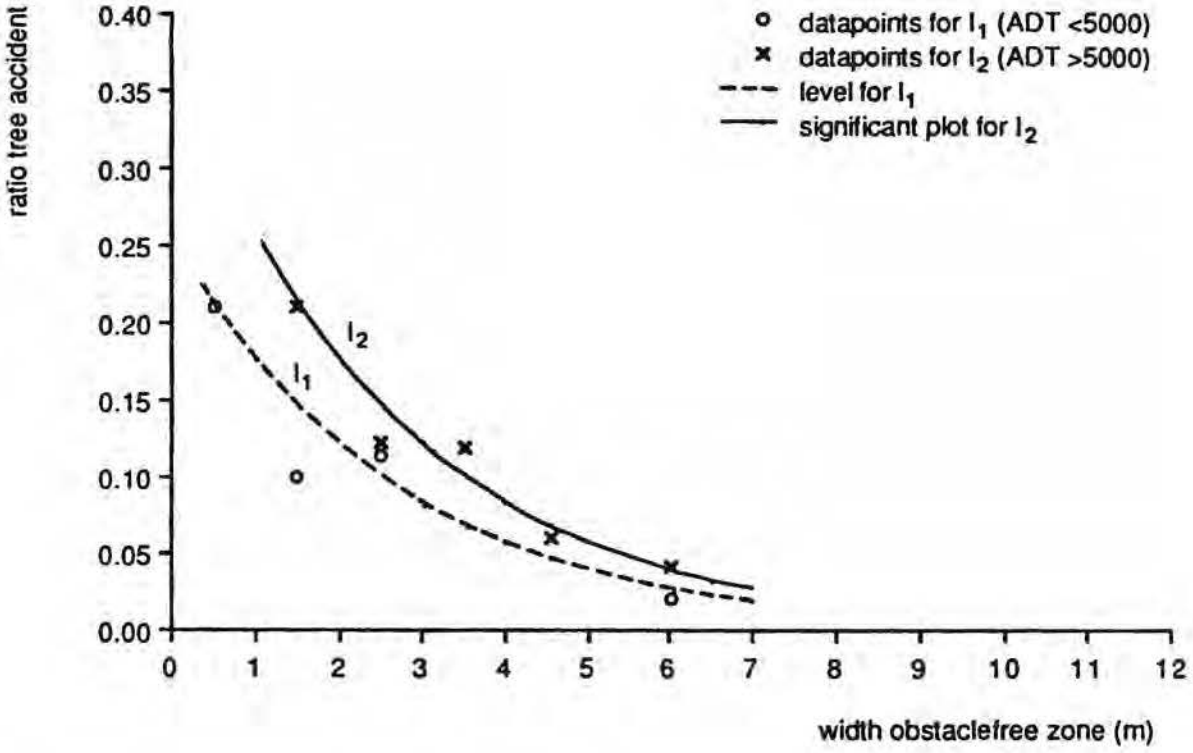

Figure 1. Regression plots for the rural undivided secondary roads (SWOV, 1983)

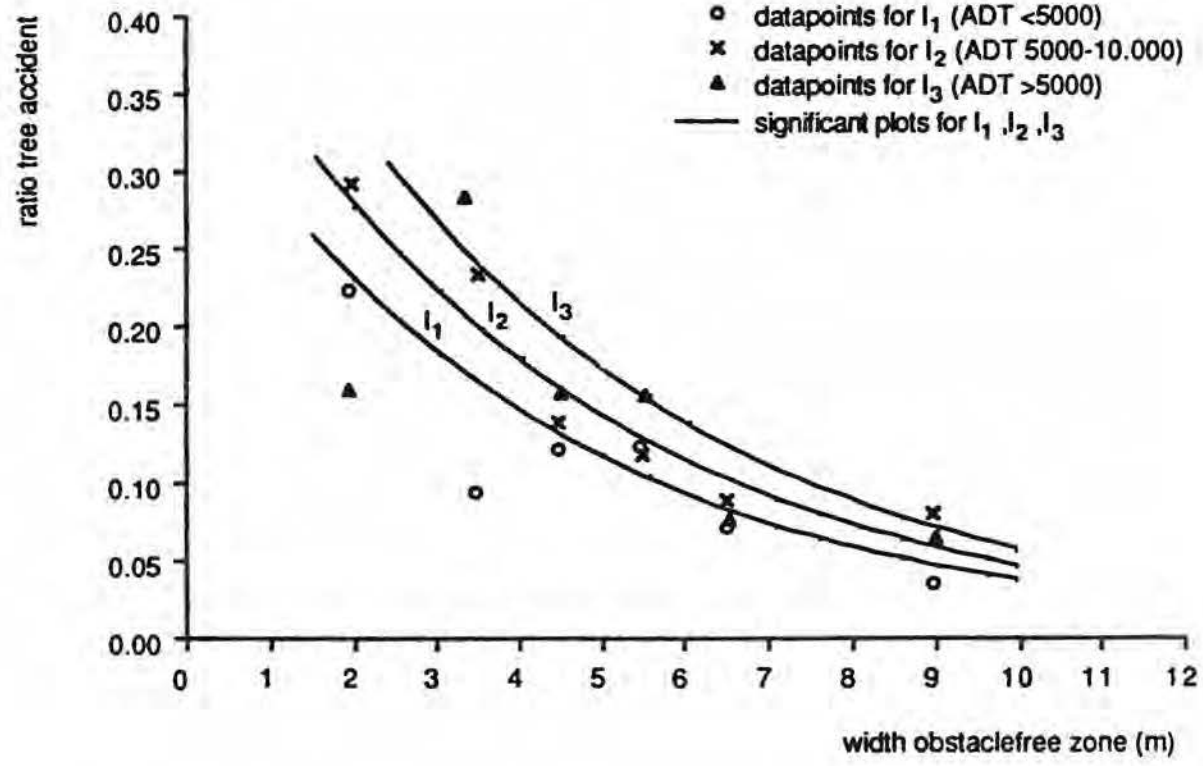

Figure 2. Regression plots for the rural undivided primary roads (SWOV, 1983)

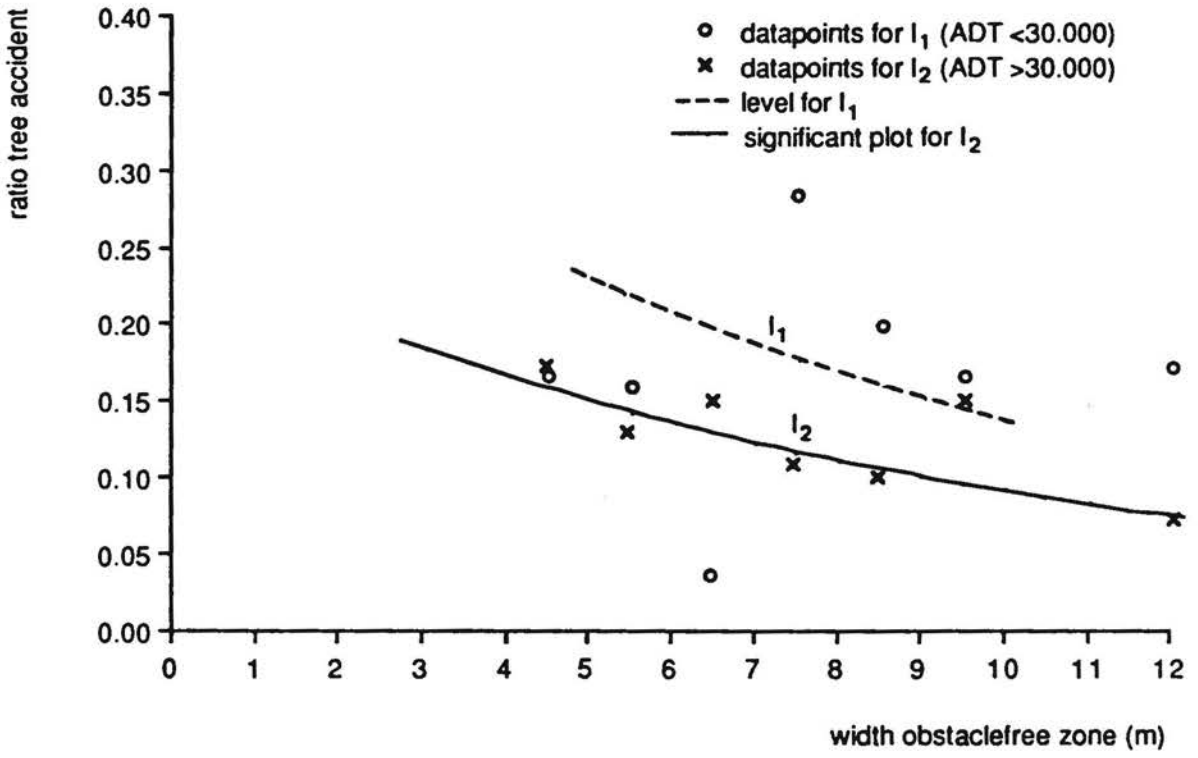

Figure 3. Regression plots for the rural divided motorways (SWOV, 1983)

TYPE ROAD/CONSENSUS	CROSS-SECTIONS [1]						
	Median [2]		Median redressing strip (paved)[3]	Lane	Outer shoulder (paved) (emergency lane) (redressing strip)	Verge (unpaved) protected	Obstacle free zone[4]
	protected	unprotec.					
road category 1: rural divided motorways							
Best practice	≥4m; 3m[6]	? >10m[7]	1m; 0.5m[8]	3.5-3.75m[9]	3+0.5m	≥0.5	? ≥7m
Agreement [5]	4m: 13 countries	5	1m: 9 countries	15	11	9	?
Disagreement	2	10	5	0	4	2	?
(Dis)agr. unknown	0	0	1	0	0	4	?
TERN-motorways (START) '94	3m	>>m[10]	-	≥3.5m[11]	≥2.5-3m[12] 0,75m[13]	-	
Comparison EG standards '87	3m	-	0,5m	3.5m	2.5m	1m	-
road category 2: rural non-motorways divided roads							
Best practice	3m[6A]	>6m[7]	0.5m[8A]	3.5m	2.5±0.5m	≥0.5m	? ≥5m
Agreement	7	2	7	8	6	8	?
Disagreement	1	6	2	1	3	0	?
(Dis)agr. unknown	7	7	6	6	6	7	?
road category 3: rural undivided primary roads							
Best practice	-	-	-	3.5m	≥1±0,5m	-	? 5m; 3,5m[14]
Agreement	-	-	-	12	12	-	3.5m: 3 countr.
Disagreement	-	-	-	2	2	-	1 1
(Dis)agr. unknown	-	-	-	1	1	-	1
START '94	-	-	-	≥3.5m	2.5m [15]	-	-
Comparison EG standards '87	-	-	-	3.75m	1.5m[16]	1 1.5m[17]	-

1) data are based on a survey and had to be simplified
2) protected or unprotected with a crash barrier
3) inner paved shoulder
4) the width of the obstacle free zone is counted from the edge (outside) of the emergency lane or redressing strip. There is no need for a crash barrier.
5) the number of countries (total 15) which agree on the dimensions given under "best practice" (according to their national standards; O'Cinnéide, Febr. 1993)
6) 4m for a design speed of ≥120 km/h; 3m for a design speed of <120 km/h (derived from a barrier width of 1m)
6A) design speed <120 km/h
7) criteria: median may not be crossed at accidents and turning manoeuvres. A study to determine a safe distance (> 10m, resp >6m) is preferable
8) 1m for a design speed of ≥120 km/h; 0.5m for a design speed of <120 km/h
8A) design speed <120 km/h
9) most of the countries have 3.75m; based on accident rates a lane width of 3.5 m can be recommended
10) Motorway working group START: "wide enough to result in little risk of vehicle cross-over accidents"
11) this minimum width of 3.5m must be kept as long as dimensions of vehicles are not altered.
12) 3m if heavy vehicle traffic so justifies
13) 3.25m shoulder width minus 2.50m emergency strip
14) 5m for a design speed of 100 km/h; 3.5m for a design speed of 80 km/h
15) shoulder width (paved and/or unpaved)
16) type "2S"
17) type "2S": 1m; type "2": 1.5m
"?" research is suggested