Safety effects of road design standards in Europe

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F.C.M. Wegman & M. Slop
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SWOV Institute for Road Safety Research, The Netherlands

SWOV Institute for Road Safety Research

Stichting
Wetenschappelijk
Onderzoek
Verkeersveiligheid
SWOV

Postbus 1090
2260 BB Leidschendam
Duindoorn 32
telefoon 070-3209323
telefax 070-3201261

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1. Introduction

Until now, road design standards and traffic regulations are a matter of national interest in Europe. As geographical, historical, psychological conditions differ, it is to be understood that road design is treated on a national level. But traffic tends to cross borders in Europe and with the increase of international traffic, international regulations and standards are becoming more expedient. From a road user perspective harmonization of design standards and traffic regulation is, and will be, of interest. Also for public authorities and network operators benefits can be of interest. However, a transition process from national standards towards international standards will be a very complex, time consuming and costly process. Due to its complexity rational decisions are required, based on cost-effectiveness considerations, but it is to be expected that political arguments will enter the arena as well.

The most important organization in this respect is the European Union. This has to do with its potential, because this international organization can enforce by legal means the decisions taken. As the Maastricht' treaty on the European Union entered into force on 1 November 1993, new fields of competence were attributed to the Union. A new provision on road safety was inserted in article 75 and a whole new chapter on Trans-European Networks (article 129) was added. Given the discussions about 'subsidiarity' in the European Union the Commission started to stimulate exchange of knowledge and commissioned several studies to identify the main points of interest, also in the field of road safety and infrastructure design. Later, the European Union can (and will) evolve towards the principle actor in this field, when Member States delegate power to the Union and the Union can (and will) enforce that power with legal means.

In the field of infrastructure, the EU is establishing a network, called the Trans-European Road Network (TERN). This network is formally approved by the Council of the EU (CEE, 1993), but the TERN will have to be approved once more along the newly introduced cooperation procedure. This new procedure, introduced by the Maastricht' treaty, gives more rights to the European Parliament. Meanwhile, working groups have to provide the necessary background for TERN and one of those working groups START (Standardisation of Road Typology) elaborates road design standards (START, 1994).

This contribution deals with the result of a study carried out for the European Commission by the SWOV Institute for Road Safety Research, in co-operation with a number of other European institutes, and which was reported in 1994. The title of the study is: 'Safety effects of road design standards' (Ruyters, Slop & Wegman (Eds.), 1994). The following aims for this study have been distinguished:

- Gathering of information about existing knowledge on the design of road infrastructure elements by:
  a. drawing an inventory of international treaties and recommendations, with information about their legal status;

b. drawing an inventory of national road design standards and the underlying knowledge.

- Analysing the role safety arguments have played when road design standards were compiled.
- Drawing a 'best practice' for road design standards in which considerations, background information and assumptions concerning road safety have been made explicit.

As a follow-up of this study a new study will start by the end of this year: *SAFESTAR (Safety standards for road design and redesign)*. The task is:

"To develop safety standards for highway design and redesign on all classes of road, including tunnels and bridges, taking account of the proposals for technical standards made in the TERN-report."

The second part of this contribution contains a short description of the different so-called workpackages in this study.

2. International and national road design standards in Europe; an overview

Road design standards play a vital role in road design in all EU Member States. But some important problems exist in this field nowadays. First of all Member States (for 12 Member States material have been collected, which means that no information on the three new Member States - Austria, Finland and Sweden - is available) do have their own national standard, as is indicated in the *Annex* to this paper (from Ruyters, 1994b).

Table 1 (from Ruyters, 1994a) gives a schematic representation of all international agreements or other cooperation forms, which are of relevance for road design and traffic operation (in chronological order).

Table 1:

Title:	Year:	Body:	Members:
Convention on Road Traffic	1949 and 1968	UN-ECE	UN-ECE members
European Agreement	1971	UN-ECE	UN-ECE members
Convention on Road Signs and Signals	1949 and 1968	UN-ECE	UN-ECE members
European Agreement	1971	UN-ECE	UN-ECE members
Protocol on Road Markings	1973	UN-ECE	UN-ECE members
"European Highway Code"	1975	ECMT	ECMT members
"European Road Traffic Rules"	1990	UN-ECE	UN-ECE members
European Agreement on Main International Traffic Arteries (AGR)	1975 (amended annexes 1988)	UN-ECE	UN-ECE members
TEM - Standards and Recommended Practice	1992	UN-ECE	UN-ECE members
TERN	1993 (and 1995?)	EU	EU members

Besides the 1968 Conventions on Road Traffic and on Road Signs and Signals as supplemented by the 1971 European Agreements and the 1973 Protocol on Road markings, the European Agreement on Main International Traffic Arteries (AGR) is of importance. The main text defines and establishes the international E-road network. In one of the Annexes to AGR, information can be found on classification of international roads and on geometric characteristics: general considerations, horizontal and vertical alignment, cross-section, intersections and 'equipment, environment and landscaping, maintenance'.

When comparing the AGR, *Annex II* of 1975 and 1988, the latter one is much looser, not very precise. Values given are less restrictive, strong limits are fewer. It seems that in this way, the annex can respond better to the diversity of national norms. A very weak point seems to be the classification: the category of motorways is clearly defined. Express roads not. The ordinary roads (in the E-road network!) are left almost without any values or standards.

Table 2 gives one example of the situation in Europe based on information collected by O'Cinnéide (O'Cinnéide et al., 1993).
For different design speeds the values are given per country for the minimum horizontal curve radius. Not for harmonization-sake, but for road safety reasons it is to be recommended to find out whether some form of agreement could be reached in Europe on design standards.
A common research programme to support compiling road design standards is recommended because it is expected to be more effective and productive.

TABLE 2	MINIMUM HORIZONTAL CURVE RADIUS (m)												
DESIGN SPEED (km/h)	140	130	120	110	100	90	85	80	70	60	50	40	30
AGR	1000		650		450			240		120			
AUSTRIA	1000		700		450			250	180	125	80	45	
BELGIUM			750			350				130			
DENMARK			872		492			265		130		50	
FINLAND			1100		650			350		170	110		
FRANCE			665		425			240		120			
GERMANY			800		500	380		280	200	135			
GREECE			500		350			200	140		75	50	30
ICELAND					450	350		250		125	80		
IRELAND			600		400			240		130		50	
ITALY	965		667		440			260		120		40	
NETHERLANDS			750		450*	350		260*	185	130*	85		
NORWAY					430	320		230	160	110			
PORTUGAL			700		450			230	170	120	80	40	
SPAIN	1000		650		450			250					
SWEDEN				625	500		350				160		
SWITZERLAND		780	650		420			240		120			
UNITED KINGDOM			720		510		360		255	180	127		
T.E.M.	1000		650		450			240					

MINIMUM HORIZONTAL CURVE RADIUS (m)

NOTE : Above values represent
'Absolute Minimum' for UK
and 'Minimum' for all other countries
* Non-Motorway Design Speeds (NL)

Besides the problem of different design standards for different European countries, we are confronted with different philosophies regarding the application of standards, when and how to depart and what are the safety consequences of these departures from design standards. This conclusion lead to the recommendation to look for the best practice concerning procedures of relaxations or departures from standards, whether they are mandatory or not. Secondly, this indicates a research programme in which safety consequences of design standards and departures from these standards are made as explicit as possible.

3. Safety effects of road design standards

3.1. Preliminary considerations for road design

Each year accidents are the cause of about 50,000 deaths and more than a million and a half injuries on the roads of the European Union. This high toll due to road accidents is considered as unacceptable, by all Member States of the European Union and by the European Union itself.

All countries have been taking and still take such kind of measures as legislation followed by police enforcement, improvement of road infrastructure and improving vehicle standards. Although it is hardly possible to assess the effects of individual measures on road accident trends, it can be stated road safety can be influenced.

Seldom the cause of a traffic accident is very simple. More often a combination of circumstances play a role, in which man, road and vehicle are of importance. Research reports from different countries have concluded that 95% of accidents are due to human error, 30% result from faults in road design and 10% are the result of mechanical defects (see Rumar, 1985). One conclusion that is sometimes drawn from this is that education (information, police enforcement, training) is the most important way of preventing accidents. This conclusion is erroneous and researchers have warned often enough about drawing such a conclusion. Is it not the case that road improvements, for instance, are intended to prevent human error? Information about the 'single' cause of accidents does not logically lead to a conclusion about the most effective way of preventing accidents, not counting the cost of measures. It is also possible to draw erroneous conclusions if one relies on police reports in which the question of guilt is settled only. One of the people involved in the accident has always violated the law in some way. However, this does not say anything about the most effective way of preventing accidents.

The key to a considerable safer road traffic lies in the concept to create an infrastructure that is adapted to the limitations and possibilities of human capacity through proper road design. Besides this, vehicles should simplify tasks of drivers and be constructed to protect the vulnerable human being as effective as possible. Last but not least, the road user should be adequately educated, informed and, where necessary, controlled.

Proper road design is crucial to prevent human errors in traffic and less human errors will lead to less accidents. Three safety principles have to be applied in systematic and consistent manner to prevent human errors:

- *Prevent unintended use of roads and streets*, after having defined the function of a street; flow or through function (rapid processing of through traffic), distributor function (rapid accessibility of residential and other areas) and access function (accessibility of destinations along a street while making the street safe as a meeting place).
- *Prevent large discrepancies in speed, direction and mass* at moderate and high speed, i.e. reduce the possibility of serious conflicts in advance.

- *Prevent uncertainty amongst road users*, i.e. enhance the predictability of the road's course and people's behaviour on the road.

This approach will lead logically to a road network with three functional road categories: roads and streets with a flow function, a distributor function or an access function. The three functions are of equal importance. Therefore, instead of classification, the term categorization is more appropriate. It is applicable to roads both inside and outside built-up areas. The frequency of properties alongside and in the immediate vicinity of the road does determine its design. So do traffic volumes of course, specifically with regard to the cross-section of the road. Depending on the frequency of properties and on vehicle volumes, several road types can be distinguished within one road category. The point is to keep the function of the road clear to road users, despite differences in design.

It is to be expected that proper road design, according to these principles, could reduce considerably the number of accidents and accident rates compared with the existing situation in Europe. However, it has to be admitted that the relationships between safety and road features are not well understood quantitatively. As indicated before, the relationships between road design and road safety is obscured by a variety of factors (driver, vehicle, risk increasing circumstances, traffic regulation).

Most European road design standards give definite instructions for the layout of the various elements of a road. Information on the background of these instructions is only rarely added. There is no indication of the relative importance that was given to road safety, in comparison with traffic flow, easy reach of destinations, environment, costs, etc. Moreover, it is often not very clear to what extent a certain standard was based upon factual figures and relations ant to what extent upon assumptions.

As underlying assumptions could be regarded assumptions of a universal nature; they are not likely to vary between countries because they refer to figures and relations with a predominantly objective character. At least, they should not vary. But assumptions of this kind are not at all identical in the national standards. This partly explains the differences in certain values for concrete design elements in the various standards.
This conclusion requires to harmonize firstly the underlying assumptions.

More generally speaking, when designing a road frequent use is being made of figures and relations, but not all figures and relations used are equally firm. A distinction has to be made between factual and assumed figures and relations. It is essential to have knowledge about this, when talking about harmonization. An attempt to classify the standards with regard to their firmness is made in Dutch standards for roads inside built-up areas. The facilities described are distinguished as follows:

- ***** regulations to be complied with;
- **** guidelines which can be deviated from only with a sound motivation;
- *** recommendations to be preferably followed because it is assumed that their effect is favourable;
- ** suggestions of which a favourable effect is expected;
- * possibilities of which a favourable effect is suspected only.

(nb. The acronym used for the research programme 'SAFESTAR' is carefully conceived!)

There is a need for a better understanding of the degree of technical firmness of respective standards, with special regard to the safety aspect. This information, reflected in a differentiation of the status of each standard, will enable the designer to make use of it in the most appropriate way. A practical possibility might be to indicate margins around certain values, which may be used by the designer 'in emergency'. As international harmonization is concerned, the question how to treat departures from standards will repeatedly be raised. This requires a set of well-founded instructions indicating when departures are tolerated.

3.2. Detailed studies; some results

3.2.1. *Cross-section design*

For the identification of the main reasons and criteria for road cross-section dimensions, three sources were taken into considerations (see also Michalski, 1994):
- the knowledge concerning the relationships between road geometry and operational, economical and safety aspects;
- conclusions from the comparison of dimensions provided in different standards;
- facts and assumptions presented in national guidelines.

The comparison of *motorway* cross-section width shows relatively great agreement of standards. The majority of EU countries uses a lane width of 3.75 m. The width of 3.25 is rarely used and only for a design speed of 90 km/h. For paved shoulders, only two countries use a width below 2.5 m, as recommended by START. From a safety point of view one can state that:
- widening a traffic lane over 3.5 m causes no significant improvement of the accident rates; so a lane width of 3.5 m can be recommended;
- safety effects of 3.25 m lane width for urban motorways should be investigated in order to determine safety consequences and using conditions;
- widening a paved shoulder (emergency stopping lane) over 2.5 m causes no significant improvement of the accident rates;
- the safety effects should be investigated of a total pavement width (11.5 - 12.0 m) of one carriageway for 2 x 2 lane motorways, which is required for maintenance reasons (to make temporary use of one carriageway as four lane two way road).

Non-motorway divided roads showing one or more motorway characteristics have high accident rates. The use of wide paved shoulders on these roads in different countries depends on some additional factors like road network structure, landscaping and multifunction of the road link. Even though, wide paved shoulders can have some advantages for safety, the possibility of emergency stopping is probably only a minor benefit. Therefore, a paved shoulder with a width comparable to the full width of an emergency stopping lane seems not to be necessary; safe bays (lay-bys) can be a cheaper and effective alternative.

Undivided rural roads have considerable different dimensions of traffic lanes and shoulders. In several cases two-lane roads with paved shoulders are used like four-lane roads. Based on safety research on can conclude:

- cross-section dimensions with environmental features should make the impression of 'narrow cross-section' being simultaneously a 'wide soft road space';
- four lane undivided roads should be avoided in rural areas;
- on higher speed roads of this kind, a paved shoulder can have a width of 1.8 - 2.0 m; a different colour or paving type should stress the special functions of these lanes, different from the functions of the main lanes;
- using of emergency lay-bys every kilometre and wide verges can be recommended to design practice.

For a strategy with respect to the design of *verges* (see Schoon, 1994) three general design principles can be distinguished which are applicable to both divided and undivided 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 or obstacles. Vehicles leaving the road can go on running freely and perhaps can be brought under control.
- In the second type, *a zone with single obstacles*, there are located roadside furniture and single rigid obstacles. Roadside equipment like lighting poles and traffic signs have to be designed in a way that, if hit by a motor vehicle, they do not endanger the occupants. The rigid objects, if there is no way to remove them, will have to be protected separately (i.e. with a crash barrier of short length or with 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 full lengthwise with a crash barrier.

A European survey on cross-section design standards shows an European agreement on how median and shoulders should be protected by crash barriers. However, it is unknown whether these guidelines are being followed. Moreover, a road safety assessment could indicate whether the new circumstances on the roads (higher mass, less space) have to result in new design standards for roadside features. Furthermore, less agreement exists between countries regarding a safe design of the unprotected medians and shoulders. Especially, the question remains to establish the widths of the obstacle free zones, so that no crash barriers are required.

3.2.2. *Curves in two-lane roads*

Statistical studies (see Brenac, 1994) show that the accident rate (accidents per vehicle kilometre) is high for low values of horizontal radius, and decreases when the radius increases. The alignment in which a curve takes place is very important in the determination of the safety at this curve, according to several studies. The accident rate at small radius bends is very high when the average curvature of the whole alignment is low, but relatively low when the average curvature is important. High accident rates are observed at a bend when it follows a long straight section, when its radius is smaller than the radii of preceding bends and when the number of bends per kilometre is low.

Other external factors have been found as relevant for road safety: severe bend in a steep down grade, short sight-distance (during the approach) on the bend or on the end of the curve.

Some studies show internal factors (depending on the design of the curve itself) also have important effects on safety, especially at bends having a small or medium average curvature. The main defect is irregularity of the curvature inside the bend itself, characterized by the presence of locally very small radii compared to the average radius of the curve. In bends with a transition curve the perception of the bend deteriorates and results in an over-estimation of the final radius and of the possible speed.

Regarding the curves, most standards in Europe have a sort of common basis which contains the design speed concept and rules concerning the minimal values of some main characteristics (especially the radius of the curve). Some countries are taking into account the actual speeds, and/or defining the conditions of the succession of the different elements of horizontal alignment. The conclusion is justified, from a safety point of view, that the definition of a minimal radius depending on the design speed is both insufficient and unnecessarily constraining. To introduce 'the actual speed approach' can be considered as an improvement, when properly implemented, but does not appear sufficient to avoid some alignment inconsistencies resulting in safety problems. Recommendations concerning the consistency of the succession of the different elements of the horizontal alignment (radius of a curve following a straight section, compatibility of radii of two near curves) seems necessary from the safety point of view. The use of complex curves containing a succession of circular curves and transition curves in the same direction may generate safety problems and should be avoided. Moreover the rules for the calculation of the length of transition curves should be re-analysed.

Concerning the signing of curves and its effects on safety, it seems that research results are still not sufficient to constitute a solid background for improving standards. Concerning the use of signing in relation with difficulty and situation of the bend, the lack of an homogeneous approach is also to be mentioned: in the national regulations, there are not always formal rules for using or not using signs (bend signs, chevron boards) at bends, and when they exist, they are rather different from a country to another, but even inside one country.

Vertical, regularly spaced elements of delineation along the outer side of the curve give information directly useful for the perspective task (estimation by the driver of distance, own speed, curvature). At less in the case where the delineation is provided on the entire road section, and not only at curves, perverse effects due to an increase of speeds are possible.

4. SAFESTAR: Safety standards for road design and redesign; an introduction

As mentioned before in order to obtain a structurally safe traffic system, road design should be optimally adapted to the human capabilities and limitations. In order to enhance road safety in Europe continued improvement of road design standards is required. In fact, it has been estimated that engineering improvements on the road have been one of the main factors behind the reduction in casualties on the roads of the EU countries in recent years. The objective of this research is to capitalize on this work and develop appropriate standards for road infrastructure. These standards would help to install good practice on all types of road throughout EU countries.

Final technical standards, or even proposals for these, cannot be produced from a safety perspective only. Therefore, the outcome of this research will be safety arguments for selecting certain design elements or for recommending certain dimensions. However, safety is usually among the criteria that are allowed for too implicitly: at every step in the design process, the designer is supposed to take decisions with safety in mind. Thus, at the end of the process, it is difficult to judge to which extent safety has been taken into account.

In general, safety can be considered at four different levels:
- safety achieved through specific attention paid during the detailed road design process;
- safety achieved through adherence to norms and standards of road design;
- the level of safety that can be achieved through road classification;
- the (explicit) amount of safety offered by the conceptual transport system satisfying the need for mobility.

The last three issues ask for a system of standards to be proposed as a result of this SAFESTAR-project. This system could at least be used as a reference, and at most as a official international agreement. Carrying out the project at the Community level will make it possible to promote uniformity in the best practice of safety standards throughout the EU countries, which is important in the efforts of fulfilling the Community policies, in particular the common transport policy.

According to the title of the research task, as indicated by the European Commission in the Framework Programme IV, Field VI: Transport, Section 7: Road Transport, Research Task 7.2/13:

> "Development of safety standards for highway design and redesign of all classes of road, including tunnels and bridges, taking account of the proposals for technical standards made in the TERN report".

By analysing the START report a research consortium, comprising nine research institutes, put together a programme, with 8 workpackages.
To introduce this research programme shortly, the following information can be given on the different workpackages.

Workpackage 1; Motorways: emergency lanes, shoulders and verges
Objectives: Based on an (in-depth) analysis of those accidents on (a selection of) TERN motorways that are related to the use of emergency lanes and/or to vehicles leaving the road, production of an accident typology and preparation of a first proposal how to prevent these types of accidents and/or the severity of the consequences of these accidents.

Two fields of activities are proposed:
- specific safety measures for emergency lanes on motorways;
- criteria for safety devices on motorways and express roads.

Workpackage 2: Tunnels on motorways
Objectives: To guarantee safety in longer tunnels with entries and exits, it is necessary to assess to what extent it is acceptable to deviate from standard motorway design criteria, and what additional criteria should be used.

Three fields of activities are proposed:
- literature review;
- tunnel design;
- validation of design features in a driving simulator.

Workpackage 3: Expressroads
Objectives: to produce safety standards for this road type, which have a poor accident record, often explained from their ambiguous character.

Three fields of activities are proposed:
- accident analysis;
- decision-making process in (some) EU Member States;
- formulation of safety standards for expressroads.

Workpackage 4: Cross-section of rural roads
Objectives: to find out the safety advantages of different kinds of rural single carriageway TERN cross-sections in different conditions.

Three fields of activities are proposed:
- safety evaluation of different kinds of cross-section;
- analysis of head-on and run-off accidents;
- alternative measures to prevent severe accidents.

Workpackage 5: Design of curves in rural roads
Objectives: The development of models to predict speed profiles in TERN two-lane single carriageway roads as a way to detect speed inconsistencies in curves and to develop a method to detect road geometric design inconsistencies, which create speed patterns and manoeuvres leading to accidents.

Five fields of activities are proposed:
- literature review;
- preliminary speed profile and design consistency models;
- validation of assumptions regarding constant acceleration and deceleration;
- verification and improvement of models;
- drafting a 'best practice'.

Workpackage 6: Marking of bends in rural roads
Objectives: By means of an experimental study testing different marking principles, i.e. by vertical signs and/or horizontal markings, to develop an efficient concept for the marking of bends in various danger categories.

Four fields of activities are foreseen:
- review of national rules and guidelines for marking bends and literature review;
- defining of danger categories for bends and development of marking principles;
- pre-testing in driving simulator;
- full scale tests in three European countries.

Workpackage 7: Junction design
Objectives: To establish basic knowledge and relationships between junction and traffic characteristics on the one hand, and safety indicators on the other hand. This knowledge should form the basis for establishing effective safety standards for junctions in the European countries. Special attention will be given to roundabouts and signalized junctions.

Four fields of activities are proposed:
- review on knowledge on rural junctions;
- review of knowledge on urban junctions;
- empirical studies of urban junctions;
- compiling the results in safety standards for junctions.

Workpackage 8: Safety audits
Objectives: To establish tools and procedures (strategical and practical) for a Road Safety Impact Assessment (RIA), including road safety audits, to be applied for new road schemes in the EU countries.

Fields of activities are proposed:
- compilation of existing tools and procedures and experiences with safety audits;
- testing in practice of promising tools and procedures;
- formulation of a 'best practice' regarding RIA (including safety audits).

The following research institutes are involved in the different work packages:
- SWOV Institute for Road Safety Research, Leidschendam (NL);
- TNO Human Factors Research Institute, Soesterberg (NL);
- Road Directorate, Copenhagen (DK);
- Swedish Road and Transport Research Institute, Linköping (S);
- Technical Research Centre of Finland, Espoo (FIN);
- Laboratório Nacional de Engenharia Civil, Lisbon (P);
- National Technical University of Athens, Athens (GR);
- Centre d'Etudes Techniques de l'Equipment Normandie Centre, Grand-Quévilly (F);
- Transport Research Centre, Brno (CZ).

The research programme will take 24 months. Twelve months after the start of the project partial reports will be produced and will be discussed with all partners, representatives of the European Commission, representatives of the START working group and from national road authorities. Such a meeting is foreseen as well, short before finalizing the project, in which an attempt to integrate all research results will be very crucial.

5. Conclusions and recommendations

Proper road design is crucial to prevent human errors in traffic and less human errors will result in less accidents. It is to be expected that proper road design, according to three safety principles, could reduce considerably the number of accidents and accident rates compared with the existing situation in Europe. These three safety principles are: prevent unintended use of roads - after having defined the function of each road; prevent large discrepancies in speed direction and mass at moderate and high speed; and prevent uncertainty amongst road users.

Road design standards play a vital role in road design in all Member States, but major problems exist in this field: not all countries have road design standards for all types of roads, road authorities do not always apply their standards, some space for interpretation is possible, road safety arguments are dealt with rather implicitly in design standards and there is no accordance between various countries. Underlying to this, the relationships between road features and safety are not always well understood quantitatively. The unavailability and non-accordance of road design standards for the road network in Europe increase risks and therefore contribute to the actual size of the problem on this continent. As the cross-bordering traffic increases, it becomes even more valid from a road safety point of view to harmonize road design standards on the level of the European Union ant to expand this harmonization to other countries (e.g. Central and Eastern European Countries) as well.

A lot of knowledge is available and it is recommended to draft 'best practices reports' about relevant topics (create 'Module Committees'). Member States of the European Union and from Central and Eastern European Countries could co-operate in this field and the European Commission (DG I PHARE/TACIS) and DG VII (Transport) are encouraged to stimulate this development.

The European Commission has taken the initiative to launch a research programme in the field of road design (standards) and road safety. This initiative will result in more international co-operation as can be seen in the SAFESTAR project. Other interested parties are invited to indicate their interest in this development and to join this initiative.

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Annex (from Ruyters, 1994b)

Conclusion

Conclusions for this chapter can merely be presented. This conclusion can only be seen as an attempt to give a more concise overview of geometric road design standards that differ so much from country to country. In a table, without mentioning the names of the standards themselves, the road design standards of the Member States of the European Union are regrouped in two categories: rural and urban. For each category, a distinction is made between mandatory and non-mandatory standards.

This table is concerning geometrical road design standards only. It is, given the amount of standards existing, likely to be incomplete, but the table has to be read in connection with the comments below.

	rural		urban	
	mandatory	non-mand.	mandatory	non-mand.
Belgium	X			
Denmark		X		X
France	X			
Germany	X			X
Greece				
Ireland		X		
Italy	X		X	
Luxemburg				
The Netherlands	X	X		X
Spain	X	X		
Portugal	X	X		
United Kingdom	X	X		X

Some further explanations have to be given for this table. In Greece and Luxemburg no specific standards are existing; both countries use standards of other countries. Greece is developping its own standards.

The other ten countries all have standards for rural roads. Only five countries have standards for urban roads, which are non-mandatory in four cases (Denmark, Germany, The Netherlands and the United Kingdom), but which are mandatory for Italy. This seems a matter of competence: the national state is in general responsible for the national network which is of reduced length and of "high" quality. It is relatively easy to motorways and express roads. The rest of the network is under the responsability of regional or local administrations. As there are many different administrations in one country, road design differs a lot from one to the other situation, which is mostly due to the surrounding conditions that are differing so much. The road design standards for urban roads are therefore in most of the cases guidelines or recommendations. It is not clear what the Italian situation for urban road design standards is like. In all ten countries, road design standards of the rural network apply to urban areas as far as urban roads form part of the national, state-owned, network.

The situation concerning road design standards for rural areas is even more complex. A common practice in all countries, also in Greece and Luxemburg, is the appliance of standards through project approval. If there are deviations from standards, the project approval assures there is some control. According to the owner of the road, this approval is ministerial or given by a regional or local administration.

Standards in Denmark and Ireland are non-mandatory. This is also the case concerning non-motorways in The Netherlands, for which a separate set of standards are existing, and concernig the rural roads of the local network in Portugal. There, the difference is that the same standards as for the national network are used, but then not on a mandatory base, but more as guidelines. For all four mentioned countries, deviations have to be well argued.

Belgium has mandatory standards for both the national road network and for the regional (Flamish and Walloon) networks. In France and Spain mandatory standards are existing for the national network. These standards are mostly used by the regional authorities (départements in France, the countries in Spain) as well. In Spain, standards have to be approved by the Ministry in a long legal procedure. Some standards remain (voluntary) guidelines only.

Two special situations are existing in Portugal and the United Kingdom. In Portugal, the standards for the national road network that are used for the local network have a special system for deviations. If "normal" maximum or minimum values can not be met, or only by engaging high amounts for construction costs, "absolute" maximum or minimum values are applied. This system is also used in the United Kingdom. There a three tier system is used: desirable minimum standards, relaxations and departures. For relaxations of the desirable minimum standards no ministerial approval is necessary, but conditions for relaxations are formulated in the standards. Departures have to be approved by the Ministry (Overseeing Department).

The discussion on the status of the standard is an essential one. A designer of a road relies upon an approved, mandatory standard. If the information contained in the standard is unsufficient to judge the consequences of deviations, it will be difficult to make a design in which the road safety component is well balanced.

In Europe, different approaches to this problem are existing: -project approval, but uniform application can not be garantueed in this way;

-status of the standard: mandatory standards, guidelines, recommendations, ..., but generally the designer is confronted to a lack of material to make a well balanced design;
-the two (Portugal) or three (United Kingdom) tier technique, which can give the designer more insight on the standard.

It can be recommended to look for a best practice concerning the existing approaches. The safety component would certainly be enhanced.