# RECENT DEVELOPMENTS IN HIGHWAY CROSS SECTION DESIGN IN GERMANY

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## ABSTRACT

The German guidelines for the design of roadway cross-sections (RAS-Q, 1982) are in a state of revision. In the discussions which are held among experts about this subject, not only do the various changes of technical details play an important role, but also the question of the basic philosophy of highway cross-section design. A scientifically based derivation of the dimensioning criteria is not possible because of a lack of corresponding investigations in the desired quantity. Due to this, the practice of a deterministic definition of measures for cross-section elements, which was usual in the past, will be retained in the future as well. An essential part of this procedure is the systematic graduation of the widths of cross section elements by which the total cross-section can be derived according to a modular assembly concept.

On the other hand, some research work on new projects was done, which offers a research-based platform for the determination of cross sections. For example, in the year 1994, an investigation of two-lane highways was finished, in which the frequencies of encounters between vehicles of different widths were investigated as well as the resulting effects on the traffic flow. Thus, there is a basis for decisions concerning the application of narrower cross-sections. Further developments of the model - which up to now mainly concentrated on urban streets - are possible with respect to the evaluation of traffic on two-lane rural highways.

Two other recent research projects have the objective to update the knowledge about speed-flow relationships as a basis for the dimensioning of highways. Due to current empirical research, more qualified regulations for multilane highways as well as for two lane rural highways can be expected in future. As a first step, the capacities of rural highways which in Germany are a component of the guidelines for cross section design have been increased by 25 %.

Another important aspect is that the necessary cost reductions for road construction in Germany can also affect the cross-section design. In the future, the six-lane "Autobahn-cross-section" will be built with a reduced width. Considerable savings of money for the Autobahn construction are to be expected as a result.

## INTRODUCTION

### Recent Development of the German Technical Regulations

In Germany there are different generations of technical regulations. The idea of the 80's was to develop regulations according to the main subject, for example cross sections, alignment, intersections and interchanges, economic aspects etc. (Figure 1).

| | CLASSIFICATION OF HIGHWAYS AND STREETS | | | | |
|---|---|---|---|---|---|
| | RURAL | | URBAN | | |
| ASPECTS | FREEWAY | HIGHWAY | FREEWAY | ARTERIAL | COLLECTOR |
| ALIGNMENT | RAS-L 1984 | | | | |
| CROSS SECTIONS | RAS-Q 1982 | | | | |
| INTER-SECTIONS | RAL-K-2 1976 / RAS-K-1 1988 | | | | |
| NETWORK DESIGN | RAS-N 1988 | | | | |
| ECONOMIC ASSESSMENT | RAS-W 1986 | | | | |

**FIGURE 1 Former System of Technical Regulations**

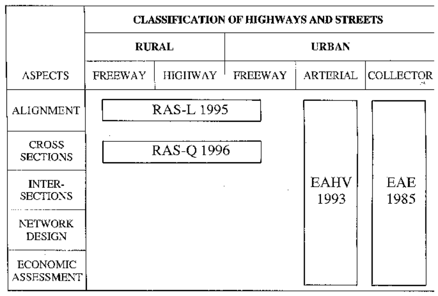



**FIGURE 2 Current System of Technical Regulations**

The new approach which gains more and more importance is to distinguish the single guidelines according to the type of the road and to put together regulations which cover the whole selection of aspects (Figure 2). Since 1993 there is one outstanding example for this new type of guideline. The Recommendations for the Design of Urban Arterials (*5*) can be looked upon as an integration of the former divided regulations, since they refer to cross-sections, intersections, signalization, facilities for pedestrians, bicyclists, public transport, parking cars etc.

Our new guideline for cross section is something like a mix between these concepts as it on the one hand refers only to highways and freeways with predominant flow function but on the other hand still concentrates on the special questions of cross section design.

Highways with predominant flow functions are roads and motorways which connect towns, parts of towns and major urbanizations with each other. Due to the covered distance and due to the regional importance, different ranks of connections are defined (I ... VI). In the German guidelines these ranks are combined with a code for the surrounding situation (e.g. A = rural freeways and highways, B = urban motorways and highways without access, C = urban arterials with access etc.). These combinations constitute the category of a road (cf. Figure 10). They are the first criterion for the selection of a suitable cross section. They also have an effect on the cross section elements and their dimensions. The new cross section guidelines are valid for the categories A I to A V, B I and B II.

Discussing the subject of cross section design, the basic theoretical concept used for the derivation of cross sections has to be defined. However, the design of cross sections cannot be based on one extensive theory. It is based - to say it in a sarcastic way - on a purely arbitrary act, or - to express it more politely - it is the result of a qualified compromise amongst experts; a compromise which is based on extensive experiences and know-how.

**Deterministic Concept**

In the past a general systematic framework was used as a protection against an excess of arbitrariness. The widths of the different elements of cross sections were differentiated in steps of 25 cm (Table 1). The application of these elements was regulated according to the importance and function of the highway.

This framework was useful as long as all streets and highways were regulated by one single guideline. Since 1993, however, the guidelines are again divided into guidelines for urban arterials and guidelines for rural highways, including freeways. Therefore, today the former wide range of widths of elements is not useful any more. While new guidelines for rural highways were developed, the intellectual background for the derivation of cross sections gained great importance again.

So far this background has a more or less deterministic character. We imagine that the whole cross section is divided into several elements. The basic idea is that wider elements provide a higher safety level. Thus, wider elements should be used for highways of higher functional classes or for higher speed levels.

These are the elements of a cross section :

- space for the standard vehicle
- allowance for lateral movements
- additional clearance for safe encounters with the oncoming traffic
- road verge
- paved shoulders
- lateral clearance

**TABLE 1 Widths [m] of Cross Section Elements (According to (*1*))**

| cross section "group" | number of lanes | lateral allowance | basic lane width | road verges | paved shoulders | soft verges |
|---|---|---|---|---|---|---|
| a | 4 - 6 | 1,25 | **3,75** | 0,50 - 1,00 | 2,50 | 1,50 |
| b | 2 - 6 | 1,00 | **3,50** | 0,25 - 0,50 | 1,50 - 2,00 | 1,50 - 2,00 |
| c | 2 - 4 | 0,75 | **3,25** | 0,25 - 0,50 | - | 1,50 |
| d | 2 | 0,50 | **3,00** | 0,25 | - | 1,50 |
| e | 2 | 0,25 | **2,75** | 0,25 | - | 1,50 |
| f | 2 | 0,00 | **2,50** | - | - | 1,00 |

Some of these elements should be explained in more detail:

As the standard vehicle, the largest vehicle allowed for regular traffic with a width of 2,50 m and a height of 4,00 m is used (Figure 3).

In the future, wider vehicles (up to 2,55m) will be allowed in Germany as well in the course of general European regulations. Nevertheless, a vehicle with a width of only 2,50 m will be maintained as the standard vehicle. This width doesn't include the rear view mirrors which can exceed the vehicle's profile by 0,25 m to both sides.

The allowance for lateral movements covers different aspects of inaccuracy of the driving mode for cars and trucks, e.g. the driver's imprecise steering abilities, needs for additional lane width in curves (additional swept path width in narrow curves leads to a widening of the lane only if it is above 0,50 m), dynamic lateral drift of the vehicles in curves (oversteering / understeering), space for mirrors or unallowed wide loads, and effects of cross winds. Some of these influences depend on the speed of the vehicles. Therefore it is obvious to relate these measures to velocity, e.g. to the design speed as it already had been regulated by the previous guidelines RAS-Q (1982) (*1*). It would be even more consequent to combine additional widths due to lateral inaccuracy of driving with the allowed maximum speed or the designed 85%-percentile of speeds.

As additional clearance for encounters with the oncoming traffic a fixed measure of 0,25 m had been introduced. This additional width had been added to those lanes of single carriageway highways, which bordered on the oncoming traffic. This measure is based on a survey (*2*) which showed that vehicles facing opposing traffic on a two-lane rural highway drive about 0,25 m more to the right than without oncoming traffic. The road verges have different purposes: On the one hand, they are meant to compensate for impreciseness of construction details which - nowadays - play a very minor role. On the other hand, they are supposed to carry lateral lane markings. They also have the purpose of keeping the driveway clean. On motorways, the inner road verge enables the passengers who had an accident to leave the car (emergency-function). Moreover the road verge extends the distance between the utilized track and the paved edge and thus improves the durability of the highway construction.

The paved shoulder is supposed to give space for cars which had a breakdown and it enables safer and easier operations of maintenance services.

The lateral clearance outside the paved carriageway provides a safety margin which has to be kept clear of solid obstacles. The size of this lateral clearance depends on the velocity. Only guard-rails may approach to a minimum distance of 0,50 m from the paved area. But the lateral clearance is not only a safety reserve. It is also needed due to the human senses of perception. For the approaching driver, obstacles situated aside the roadway occur under a certain lateral angle. Due to the vehicle speed, this lateral angle increases by a certain rate. Michaels (*3, 4*) has shown that this rate must be above a certain threshold in order to be perceived by the driver. A stress-free driving situation is only given when all lateral obstacles are perceived above this threshold. Since the rate of virtual lateral movement of an obstacle relative to the driver depends on the velocity of the vehicle and on the distance between the obstacle and the vehicle's trajectory, we need wider clearances for higher speeds.

**TABLE 2 Relation Between Allowed Maximum Speed And Minimum Lateral Clearance (Combination According to (*1*))**

| maximum allowed speed | minimum lateral clearance |
|---|---|
| ≤ 50 km/h | 0,75 m |
| ≤ 70 km/h | 1,00 m |
| > 70 km/h | 1,25 m |

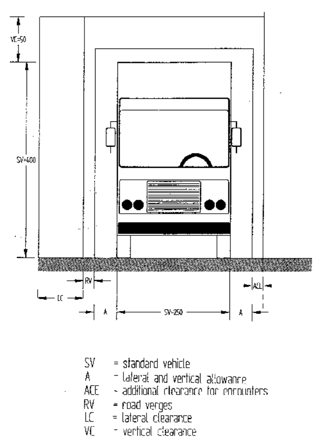



**FIGURE 3 Standard Vehicle and Elements of Cross Section**

Consequently, this relation has already been considered in the previous guideline RAS-Q (1982) (*1*). The lateral clearance was linked to the maximum allowed speed in steps of 0,25 m (Table 2).

These were elements of the traditional view of the derivation of highway cross sections, a view which can be called deterministic.

Regarding this subject, several points of criticism could be listed. First, the driver does not see any of the different defined elements. Instead, he uses the roadway by interpreting the highway as an integrated whole due to his general impression. Furthermore, all these ideas are based on the large truck which is used as the standard vehicle. The additional width elements, which partly depend on the velocity, are added to this truck width. But this disregards the fact that the maximum velocity permitted for trucks is 80 km/h (on rural roads even only 60 km/h). For fast passenger cars, however, a clearance of up to 2,00 m is available within one lane. We may assume that passenger car drivers use this large clearance for a faster ride.

Moreover, it has not been settled if smaller lateral clearances could become conceivable because of an improved vehicle construction, e.g. a decreased sensitivity against cross wind.

This is only a small part of a large sum of open questions which the traditional concept for the derivation of cross sections cannot answer. But what does the ideal concept for a derivation of cross sections look like?

## Integrated Concept

First of all it would be desirable to realize that the driver sees the entire road as an integrated whole. This causes a certain overall impression of the surrounding situation. For this general impression, the cross section plays an essential, but not the predominant role. This impression, however, provokes certain patterns of behavior of the driver. The main behavioral aspect is the chosen speed. This again has consequences on hazards, travel times and regional access qualities, environmental effects and economic costs. All these consequences have to be evaluated and taken into account.

Only after this comprehensive evaluation, that cross section could be chosen which is the best compromise for the respective purpose between positive and negative effects. Here social acceptance would also have an influence. Of course, interactions with other parameters of the road design - especially of the alignment - should be taken into account.

Such a procedure could be called an integrated approach in contrast to the deterministic derivation.

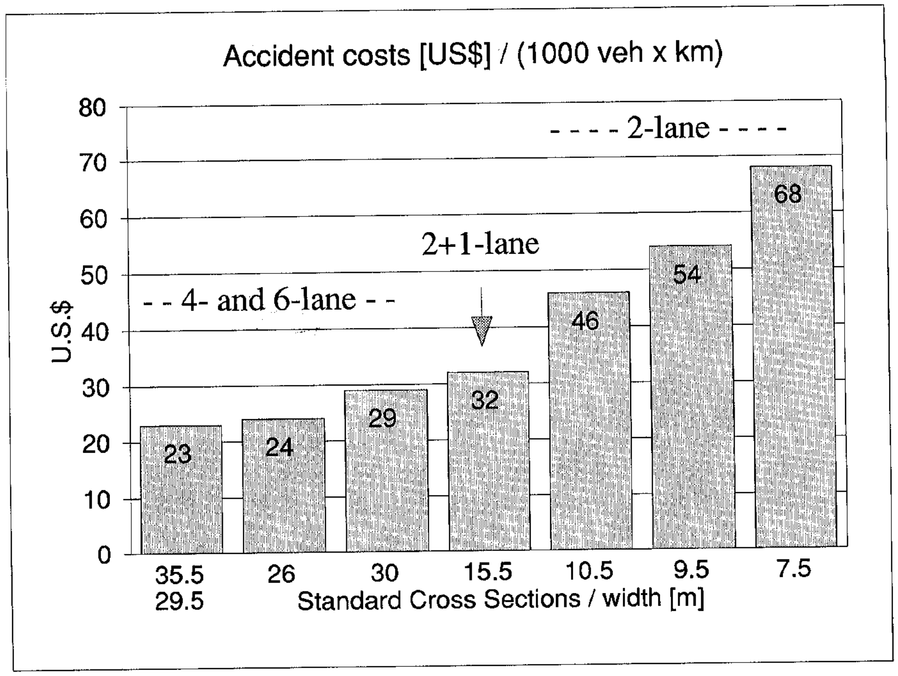



**FIGURE 4 Standard Cross Sections and Accident Costs on Rural Highways** (*7*)

The question comes up, are there enough reliable data at hand to pursue such a mode of procedure effectively? In the past several research projects have been performed on the dependence between the width of the roadway and the velocities of vehicles. For rural highways for example a slight increase of velocities on a wider roadway has been recognized (*6*). There are also several investigations about the relationship between width of roadway and accident occurrence.

Local speeds and accidents are, however, only isolated aspects of the entire range of consequences of cross section design.

A truly integrated investigation was carried out by the German Road Research Laboratory (Bundesanstalt für Straßenwesen, BASt): The project "Intermediate Cross Sections". Between 1984 and 1992, different types of cross sections were investigated with funds of several million DM. The starting point of this investigation was the gap in the efficiency between two-lane and four-lane roads which can be recognized in the range between 20.000 and 40.000 veh/day. Using a large set of existing test sections of two-lane, three-lane and four-lane (divided and undivided) rural roads, cross sections were studied by different empirical evaluations, e.g. concerning speeds, dangerously close headways and especially accidents.

The most important results of this extensive survey were

1. more detailed knowledge about the efficiency limits of two-lane and narrow four-lane highways
2. knowledge about the varying safety of different roadway cross sections (Figure 4)

Many of these research findings are to be integrated into the upcoming guidelines and, thus, will help to improve the performance of rural highways considerably.

But summarizing we must say: Even in the future, the design of highway cross sections will not be a discipline which gets its findings from scientific theory alone. The design of cross sections in the guidelines (that is the arrangement of standard cross sections) and in practical work is based on a qualified compromise amongst experts. In the medium or long term, a more research-based penetration of the mechanism of consequences of cross section design would be desirable. Especially in the field of perception of the roadway cross section by the driver and his reaction concerning velocity and lateral positioning within the lanes, interesting results are to be expected.

At the moment, we are still bound to a more conventional way. This is also the way the draft of the new standard for cross sections "RAS-Q 1996" was designed.

## REVISION OF THE GERMAN GUIDELINES FOR CROSS SECTION DESIGN

### Objectives and State of Investigation of the New RAS-Q

The previous guidelines for cross sections (RAS-Q) originated from 1982 (*1*). A revision was decided on in an agreement between the Federal Department of Transportation and the German equivalent to the TRB

(Forschungsgesellschaft für Straßen- und Verkehrswesen, FGSV) at the beginning of 1993. The authors were assigned with a research contract to perform the work. The main objective of this research assignment was the adaptation of the guideline to intermediate changes due to federal DOT advises as well as to latest findings from research and practice.

While working on the project, there was a close contact to the committee of experts of the FGSV. This committee contains practitioners from local authorities, state DOTs, consultants and members of universities. The current discussion about potentials for cost reduction in road construction was of considerable influence due to a visible lack of financial funds in Germany for the future. In addition to that, conceptional questions were considered as well and were put in the up-to-date results in the form of various smaller changes.

**The Important Improvements of the RAS-Q 1996**

The following list gives an overview of the most important features that have been improved:

- revision of the well tried standard cross sections
- integration of the so-called intermediate cross sections
- introduction of a new diagram for the pre-election of standard cross sections
- improved determination of cross sections with the help of traffic characteristics
- evaluation of sight distances in curves of dual carriageways
- consideration of safety aspects for the determination of cross sections

The new standard cross sections are illustrated in Figure 5 and Figure 6. Compared to the previous guidelines, several points should be illustrated in detail:

- The standard cross section RQ 35.5 needs, on the whole, 2 m less space than the previous 6-lane highway cross section. The center lane and the left lane have been reduced from 3.75 m to 3.50 m. The central reserve is now, as a minimum, 3.50 m wide. This width is needed to enable plantation, to provide space for columns of bridges and to provide clearance in case of deformations of the steel guard rails due to an accident. All these changes are a compromise between safety and quality of flow on the one hand and economic aspects on the other. This compromise was found in experts' discussions and on the background of the modular assembly concept which is the framework for all modifications. Thus, it was obvious to reduce the widths by steps of 0.25.
- The standard cross section RQ 29.5 for four-lane motorways has been widened by 0.50 m (+ 0.25 m for each carriageway). Here the reason is that at worksites a minimum carriageway of 11.50 m is necessary to allow four provisional lanes on one half side of the motorway.
- For special applications in the vicinity of large towns or as connector highways within urbanizations, narrow four-lane highways should be possible as well. The corresponding standard cross section (RQ 20. cf. Figure 5) has a width of 20.00 m, including a central reserve of 2,00 m. For the application under restricted conditions, the roadway has a minimum width of 17.00 m. As a protection against frontal collisions, a concrete barrier of at least 0.70 m width is necessary. These highways require a speed limit of 80 km/h or 100 km/h. They are also restricted to an ADT of 30,000 veh/day or below (cf. Figure 10). This limit has been set in order to take precautions for the case of vehicles stopped due to an emergency which could become a safety risk because of the lack of an emergency lane.
  The narrow type RQ 26 which is still operated without a general speed limit is restricted to a maximum predicted ADT of 30,000 veh/day as well. The reason is that, at construction sites, the traffic volume should allow a temporary single lane operation without too much congestion.
- Undivided 4-lane highways will not be allowed in the future due to bad safety experience (the accident costs had been twice the amount of the divided 4-lane highways (*7*)).
- For the first time, a three-lane cross section appears in German guidelines. The new standard cross section RQ 15.5 is an outcome of the project "Intermediate Cross Sections" (*7*). As a difference to the mode of operation in other European countries, a clearly defined assignment of the medium lane to one of the two directions is provided here. This new type of highway replaces the former extra-wide two-lane highway with paved shoulders (Figure 7).
  On this old type of cross section many severe accidents were caused by an unprecedented use of these highways: According to traffic rules, the paved shoulders were meant only as an emergency lane and as a reserve for agricultural traffic and bicycles. This cross section, however, was also used for roads which were allowed for fast motor vehicle traffic only. Here, under high traffic volume conditions, something like a four-lane flow occurred with trucks driving on the paved shoulders at high speed.

Experiments (7) showed clearly that the three-lane solution created a much safer traffic flow on a similar width of the roadway. Here the center lane is assigned to one of the two directions by lane markings. The direction of the center lane changes every 800 to 2000 m.

- The standard solution for the two-lane rural highway within the federal network now will be the RQ 10,5. Compared to the previous guidelines, this means a reduction of the paved carriageway width by 0,50 m down to 7,50 m, where only 7,00 m should be used by the traffic. The reason for this reduction is slightly better safety experiences with this smaller sized highway (7). Recently, however, new arguments came up saying that a 0,50 m verge might improve the durability of the pavement construction.

In addition to these improvements concerning the standard cross sections there are several aspects that should be pointed out:

- On multilane divided highways, the sight distance could be reduced in left curves. The reasons are the rather narrow central reserves which are used in Europe. In Germany, they will only be 3,50 m wide in the future. The installation of nearly 1,00 m wide steel guard-rails, of plantations or of noise abatement walls (cf. Figure 8) or anti-dazzle fences could impede sight distances of passenger car drivers on the left lane. This effect could be so strong that the sight distance is shorter than the emergency stopping distance, especially under wet weather conditions.

As a set of measures to improve safety in this situation, the following approaches could be recommended:

1. adjusted roadway alignment
2. adjusted speed limit for wet roadway conditions
3. widened central reserve with separate alignment for both directions.

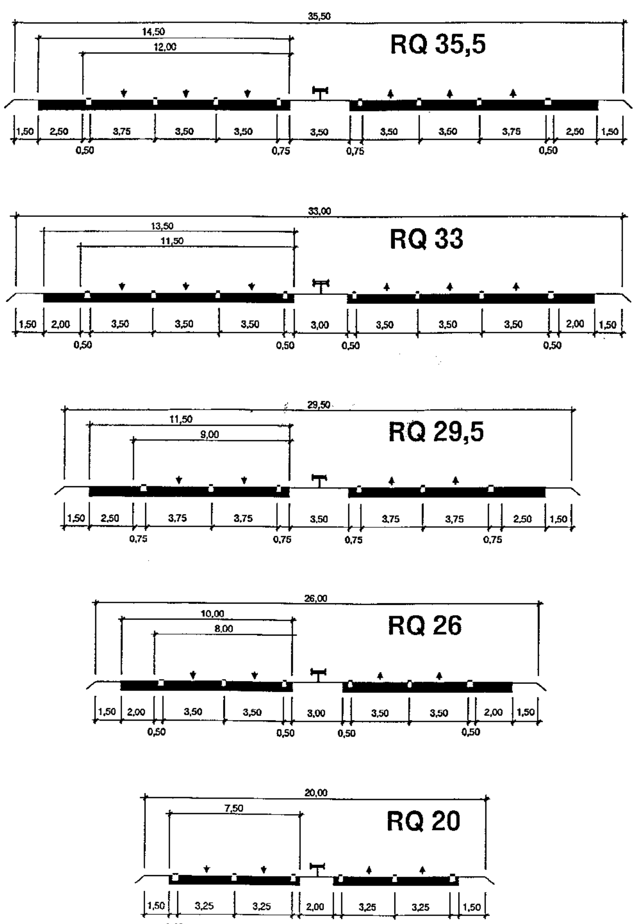



**FIGURE 5 Divided Standard Cross Sections [outline of a RAS-Q 1996]**

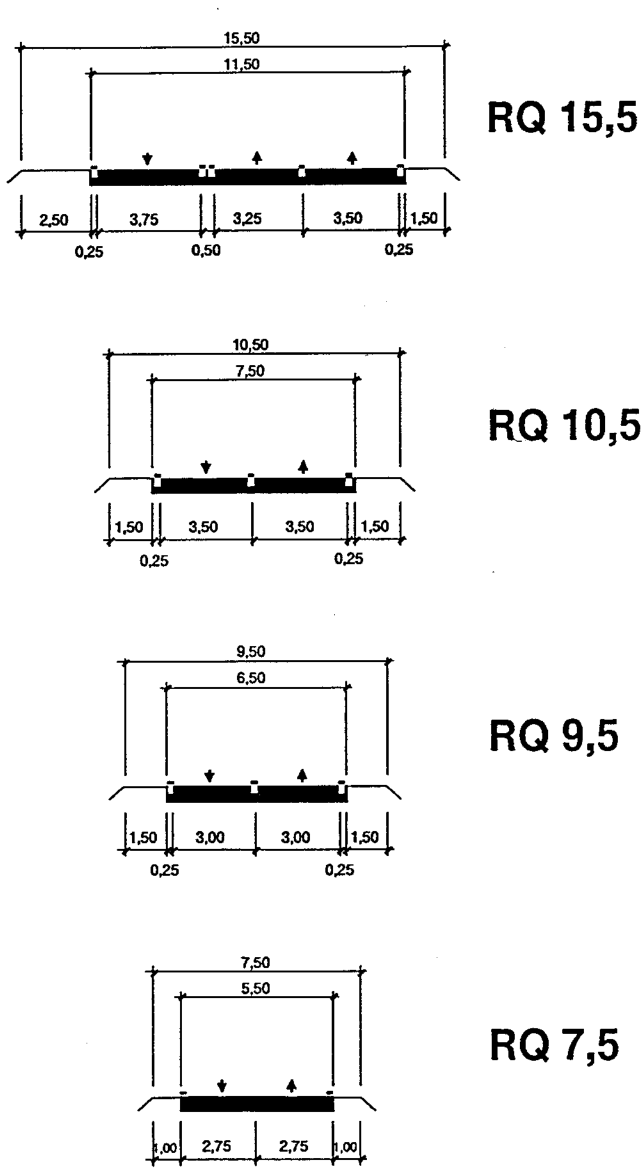



**FIGURE 6 Undivided Standard Cross Sections [outline of a RAS-Q 1996]**

The latter recommendation has been refused as a general recommendation by the responsible departments. This effect can be evaluated by the diagram in Figure 9. Here, on the right side, the standardized stopping distances for an emergency stop are given for wet and dry road surface. They are also depending on thegradient. Moving from these values over to the left diagram, the required distance "a" between the margin of the left lane and the sight obstacle located in the central reserve can be obtained. This, of course, depends on the curve radius "R". This diagram and its application is also new in the coming guidelines RAS-Q 1996.

- Special attention has to be paid to sufficient facilities for pedestrians and bicyclists. As an example, Table 3 gives the traffic flows above which separate bicycle paths along rural roads have to be provided.

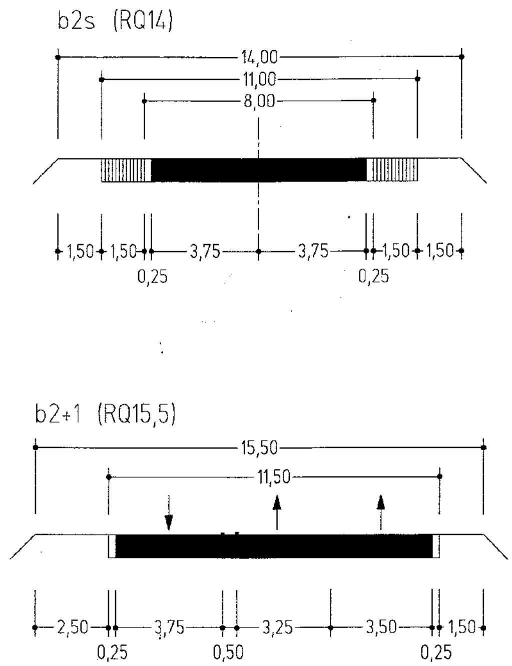



**FIGURE 7 Former Standard Cross Section RQ 14 and New Three-Lane Standard Cross Section RQ 15,5**

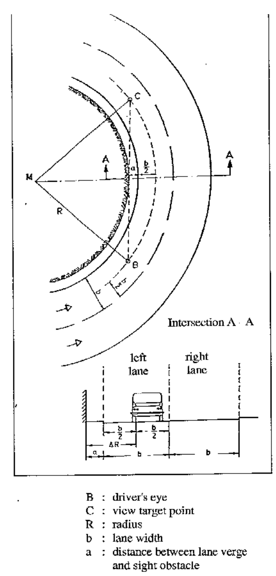
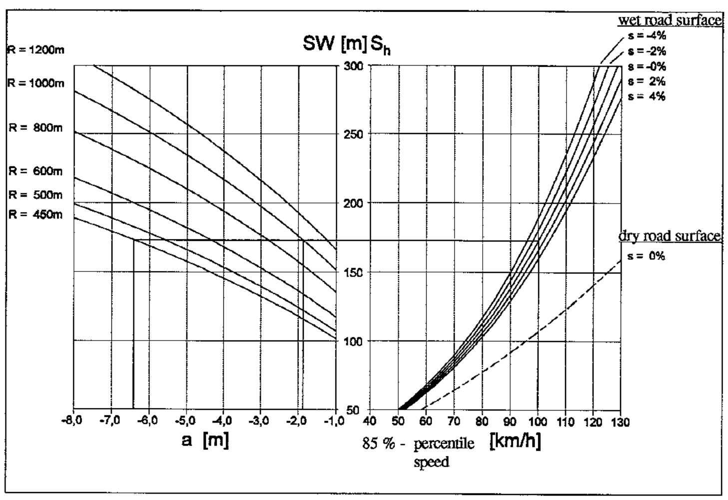



**FIGURE 8 Effects of Obstacles in Central Reserve on Stopping Sight Distance on Left Lanes of Carriageways**

**TABLE 3 Traffic Volumes for Application of Separate Paths for Pedestrians and Bicyclists**

| motorised traffic<br><br>[veh / day] | **separate paths for pedestrians**<br><br>traffic volume of pedestrians<br><br>[ped / peak hour] | **separate paths for bicyclists**<br><br>traffic volume of bicyclists<br><br>[bicyclists / peak h.] | **combined paths for pedestrians and bicyclists**<br><br>traffic volume of pedestrians and bicyclists<br><br>[ped. + bicycl. / peak h.] |
|---|---|---|---|
| < 2500 | 60 | 90 | 75 |
| 2500 - 5000 | 20 | 30 | 25 |
| 5000 - 10000 | 10 | 15 | 15 |
| > 10000 | 5 | 10 | 10 |
| When only daily traffic volumes for pedestrians and byciclists are available, the peak hour is 20 % of the daily volumes. | | | |




| | | |
|---|---|---|
| Sh | : | required stopping sight distance |
| SW | : | given sight distance |
| R | : | radius |
| a | : | distance between lane verge and sight obstacle |
| s | : | gradient |

**FIGURE 9 Diagram for Evaluation of Stopping Sight Distance and Effects of Geometric Design on Left Lanes of Carriageways**

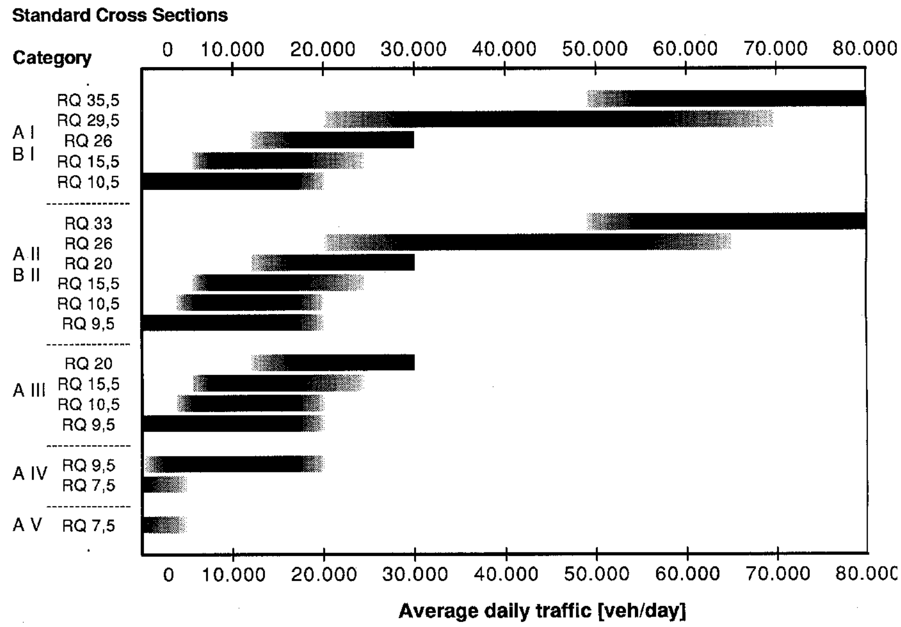



**FIGURE 10 Diagram for the Preelection of a Standard Cross Section [Outline of a RAS-Q 1996]**

- As a new feature, a diagram for the preelection of standard cross sections has been introduced (Figure 10). This graph should give a first idea about suitable types of highways in relation to the ADT (average daily traffic in veh/day). The solid parts of the bars indicate traffic volumes (given ADT on the x-axis) which always apply for the standard cross section under consideration. The shaded parts cover ADT-volumes, where the highway types can only be applied under special external conditions, e.g. type of terrain, gradient, curvature, percentage of trucks or level of desired travel velocities for cars. (An explanation of the categories on the y-axis is given in the Introduction.

  But the details of the determination of cross sections still depend on the typical speed-flow relationships for each cross section. As there is no Highway Capacity Manual in Germany, up till now, these speed-flow diagrams are an element of our cross section guideline's appendix. (As a matter of fact a German equivalent to the HCM was elaborated during the last years and was introduced to the community of German traffic engineers in September 1995 (*8*).)

  In Germany the decisive parameter for the traffic flow quality is traditionally the mean travel speed of the passenger cars. Overall, the guidelines contain a set of 100 graphs for undivided highways to account for gradients, curvature and percentage of trucks. For divided highways and motorways, only gradients and trucks are taken into account as additional influences. Here the consequences of gradients are estimated by a method given by Brannolte (*10*).

  But the guidelines do also require a minimum degree of utilization of the new highway. Normally, the predicted traffic should at least be half of the maximum capacity.

  The range between this minimum traffic volume and a defined maximum volume which is close to capacity is represented by the white area in Figure 11 (which explains the principle of traffic flow assessment) as well as by the black bars in our new diagram for the preelection of standard cross sections (Figure 10).

The expected traffic volumes should be obtained from traffic master plans, preferably for both the morning and afternoon peak hours of normal week days. There are other guidelines available to translate traffic flows between ADTs and hourly volumes based on typical patterns over the time of the day and depending on the prevailing travel purpose of traffic on the highway under concern. Only under very clear network conditions, traffic counts and successive multiplication by prediction factors to account for the further general traffic increase are allowed as well.

- The consideration of safety aspects when choosing the cross section is an important completion of the RAS-Q. With this, the user is able to estimate the economic costs due to accidents on different cross sections. The average accident cost rates are to be projected on a period of 20 years and on the whole length of the section under concern. The designer is urged to compare these accumulated accident costs with the estimated costs for construction. The optimum type of highway under this rough economic assessment of accidents has to be chosen. It must be assumed that, in future, this new safety argument will have more impact on the definite type of highway than the traffic flow arguments being discussed above.

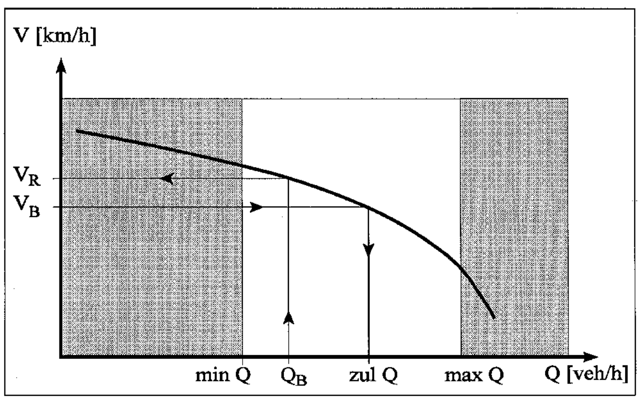
## CONCLUSION

The new set of German guidelines for the design and evaluation of cross sections for rural highways and motorways is based on the latest set of research results. However, in its fundamental structure it is still based on a deterministic approach. The transition into an integrated justification is solved only for the so-called intermediate types of highways. Here, as the most innovative idea for German conditions, a three-lane highway appears, whose center lane changes its direction every few kilometers.

For motorways, the trend towards reduction of investment costs governed some of the new details. But the necessity to operate the motorways under roadwork conditions determines several details of the design, too. Details of the construction also play an important role.

For the selection of highway cross section types the desired traffic flow conditions as well as the optimum traffic safety are to be evaluated. As a new feature of the guidelines the sight conditions in left curves of multi-lane highways have to be observed as well.

We should also point to the fact that the European Community so far didn't have any impact on the cross section design. In this field, each of the European countries still tries to develop its own optimum solution based on its specific traditions. An international comparison of cross sections (cf. Figure 12, 13) shows that the German roads are positioned in the center of the range within the European countries concerning their road width.




$V_B$ = desired average travel velocity of passenger cars[km/h]
zul Q = corresponding service flow[veh/h]
$Q_B$ = expected hourly flow[veh/h]
min Q = minimum traffic volume[veh/h]
max Q = maximum traffic volume[veh/h]
$V_R$ = corresponding average travel velocity of passenger cars [ km/h ]

**FIGURE 11 Speed-Flow-Diagram (Dummy), Principle of Assessing the Traffic Flow Quality for a New Highway**

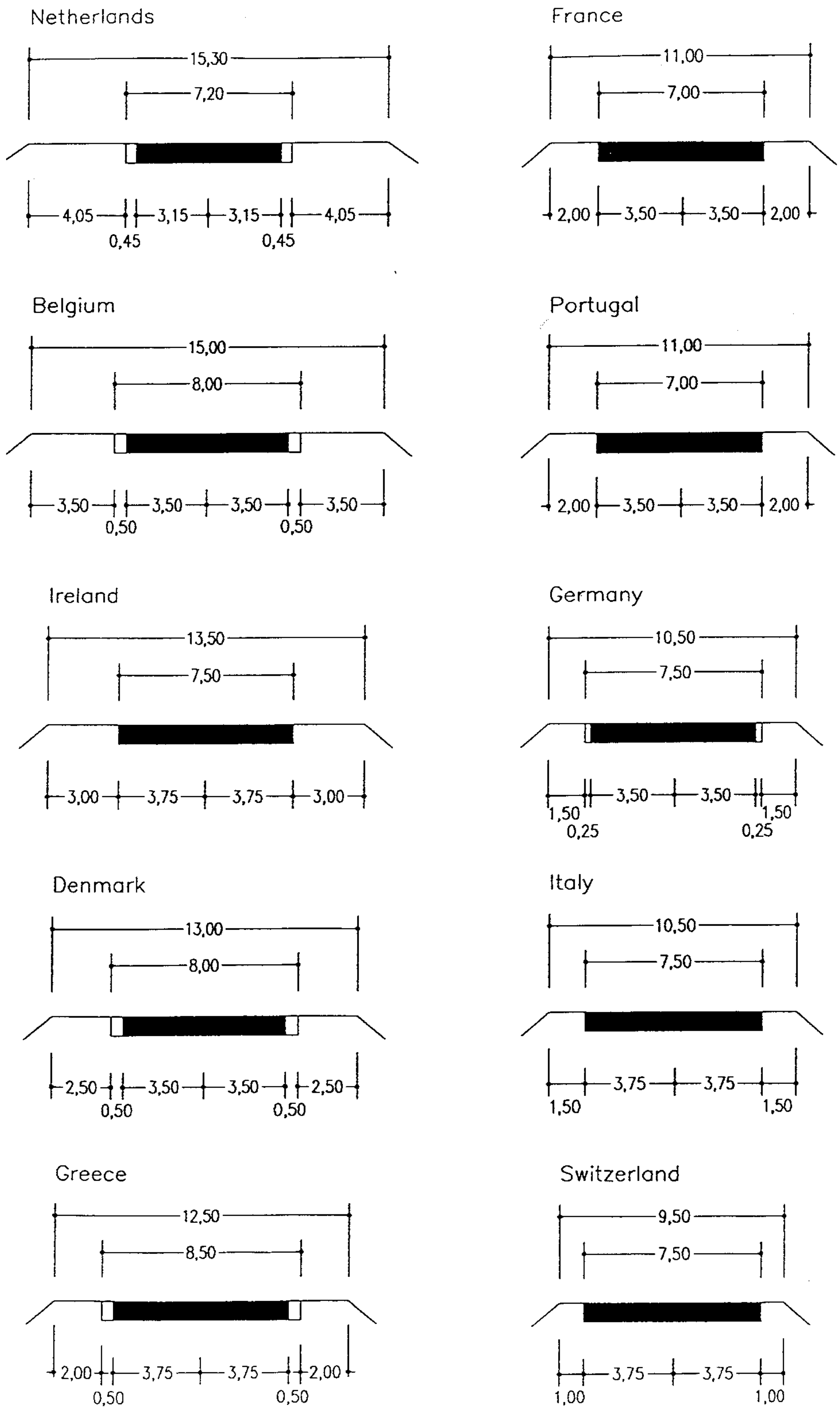



**FIGURE 12 European Cross Sections for Two-Lane Rural Highways**

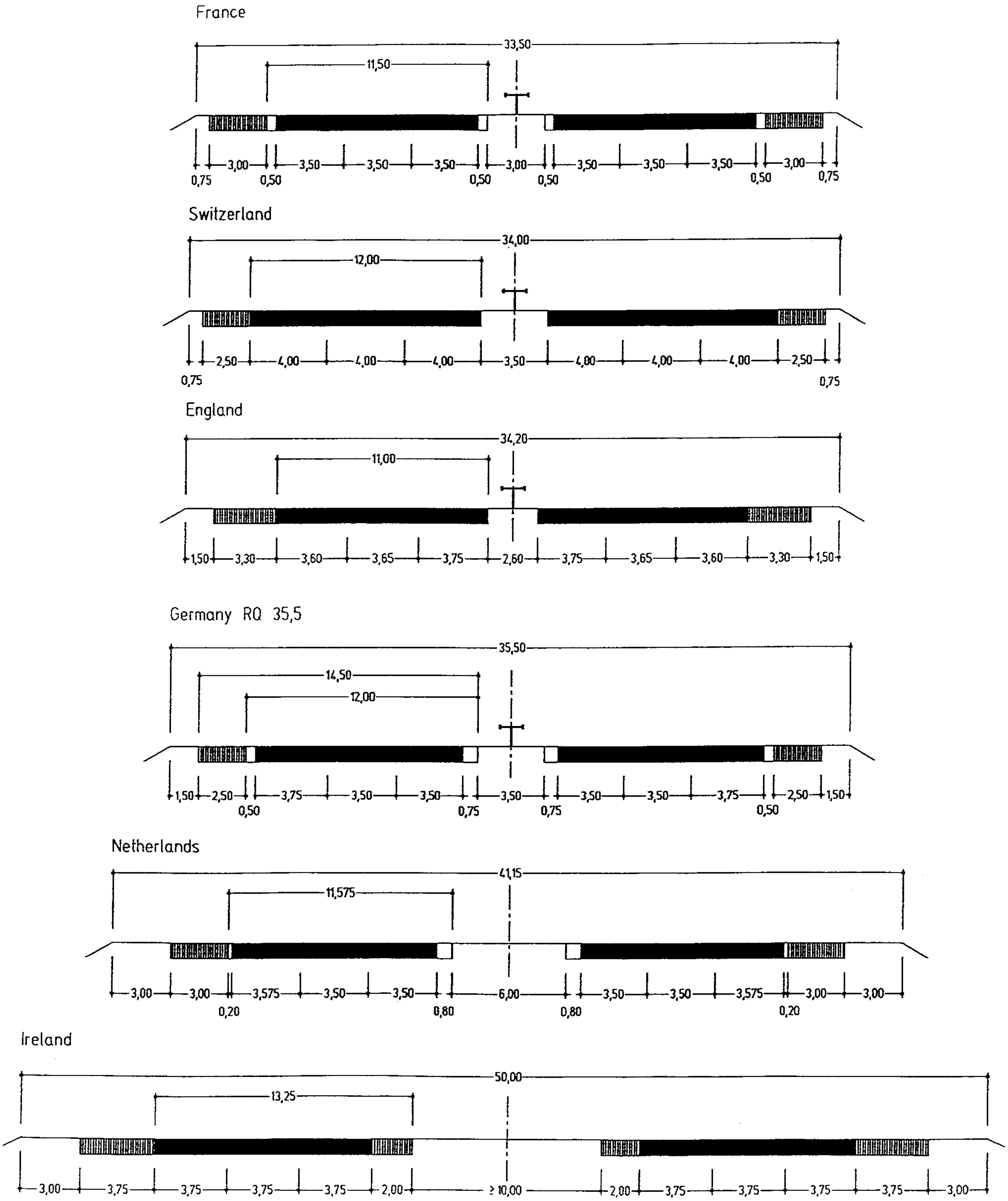



**FIGURE 13 European Cross Sections for Motorways**

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