Road and Transportation Research Association
Working Group Highway Design

FGSV

RAL

Guidelines for the Design of Rural Roads

Edition 2012/Translation 2024

R 1

Road and Transportation Research Association
Working Group Highway Design

FGSV

RAL

Guidelines
for the Design of Rural Roads

Edition 2012/Translation 2024

R 1

Working Group Highway Design
Committee Rural Roads

Chair (2012): Director and Professor (em.) Dipl.-Ing. G. Hartkopf, Rösrath

Members (2012): Professor Dr.-Ing. A. Bark, Giessen
Ltd. RBDir. a.D. Dipl.-Ing. M. Bartz, Berlin
Ltd. BDir. Dipl.-Ing. G. Grafwallner, Weilheim
Ltd. RBDir. Dipl.-Ing. D. Griepenburg, Coesfeld
Professor Dr.-Ing. Wolfgang Haller, Hanover
Professor Dr.-Ing. W. Kockelke, Giessen
MR'in Dipl.-Ing. I. Kralack, Potsdam
University Professor Dr.-Ing. habil. W. Kühn, Plauen
RDir'in Dr.-Ing. K. Lemke, Bergisch Gladbach
Professor Dr.-Ing. V. Meewes, Cologne
Ltd. RBDir. a.D. Dipl.-Ing. H. Nikolaus, Rheinbach
Dr.-Ing. T. Räder-Großmann, Erfurt
University Professor Dr.-Ing. T. Richter, Berlin
TRDir. Dr.-Ing. R. Stöckert, Bonn
Professor Dr.-Ing. R. Weber, Darmstadt
University Professor (em.) Dr.-Ing. habil. G. Weise, Dresden
Dr.-Ing. F. Weiser, Bochum
Dr.-Ing. M. Zimmermann, Karlsruhe

Task Group Design of New Roads

Director (2012): University Professor (em.) Dr.-Ing. habil. G. Weise, Dresden

Members (2012): Professor Dr.-Ing. A. Bark, Giessen
Ltd. RBDir. Dipl.-Ing. D. Griepenburg, Coesfeld
Director and Professor (em.) Dipl.-Ing. G. Hartkopf, Rösrath
Dr.-Ing. T. Räder-Großmann, Erfurt
University Professor Dr.-Ing. T. Richter, Berlin
TRDir. Dr.-Ing. R. Stöckert, Bonn
Dr.-Ing. F. Weiser, Bochum
Dr.-Ing. M. Zimmermann, Karlsruhe

Preliminary remarks

The "Guidelines for the Design of Rural Roads" (RAL), Edition 2012, have been worked out by the Task Group "Design of New Roads", assisted by the Task Group "Improvement of Existing Roads" and have been discussed in the Committee "Rural Roads". In addition to the members of the Task Group, Dr.-Ing. E. Bakaba, ORBR M. Forster, Dipl.-Ing. A. Hegewald as well as Dr.-Ing B. Zierke were involved. Moreover the work was assisted by the staff members of the Institute for Design of Road Facilities of the Technical University of Dresden (Dr.-Ing. T. Jährig, Dipl.-Ing. V. Kuczora, Dipl.-Ing. A. Vetters). The integration of the comments by the state DOTs (highway administration and legal regulation for traffic management) on the draft 2008 of RAL as well as the final version of the guideline text was carried out by an editorial group consisting of the members of the Task Group "Design of New Roads" under the supervision of Director and Professor Dipl.-Ing. G. Hartkopf, Rösrath

For the range of rural roads, RAL, Edition 2012, replaces the following technical regulations:
- "Richtlinien für die Anlage von Landstraßen (RAL), Teil Knotenpunkte (RAL-K), Abschnitt 2: Planfreie Knotenpunkte" (RAL-K-2), Edition 1976 (FGSV 290/5)
- "Aktuelle Hinweise zur Gestaltung planfreier Knotenpunkte außerhalb bebauter Gebiete (Ergänzungen zu den RAL-K-2)" (AH RAL-K-2), Edition 1993 (FGSV 290/6)
- "Entwurfshinweise für planfreie Knotenpunkte an Straßen der Kategoriengruppe B (Ergänzungen zu den RAL-K-2)" (RAS-K-2-B), Edition 1995 (FGSV 290/7)
- "Richtlinien für die Anlage von Straßen (RAS), Teil Querschnitte" (RAS-Q), Edition 1996 (FGSV 295)
- "Richtlinien für die Anlage von Straßen (RAS), Teil Linienführung" (RAS-L), Edition 1995 (FGSV 296)
- "Richtlinien für die Anlage von Straßen" (RAS), Teil Knotenpunkte (RAS-K), Abschnitt 1: Plangleiche Knotenpunkte" (RAS-K-1), Edition 1988 (FGSV 297/1)

Table of contents

Page

1 Introduction 11

1.1 Content 11

1.2 Purpose 11

1.3 Scope 11

2 Objectives 12

2.1 General aspects 12

2.2 Traffic safety 12

2.3 Traffic flow quality 12

2.4 Environmental compatibility 14

2.5 Costs for investments and operation 14

3 Basic principles 15

3.1 Planning process 15

3.2 Road categories and design classes 17

3.3 Design classes and distinctive design features 18

4 Cross-sections 21

4.1 General aspects 21

4.2 Fundamentals for the dimensions of the cross-sections 21

4.2.1 Standard vehicle dimensions 21

4.2.2 Roadway components 21

4.2.3 Component parts of the standard cross-section 22

4.2.4 Footpaths and bicycle paths 22

4.2.5 Slopes 23

4.3 Standard cross-sections 23

4.4 Verification of the traffic flow quality of the standard cross-section 26

4.5 Overtaking lanes 26

4.5.1 Principles 26

4.5.2 Roads of design class EKL 1 26

4.5.2.1 Usage criteria 26

4.5.2.2 Arrangement 26

4.5.2.3 Intersections 27

4.5.3 Roads of design class EKL 2 27

4.5.3.1 Usage criteria 27

4.5.3.2 Arrangement 27

4.5.3.3 Intersections 27

4.5.4 Roads of design class EKL 3 27

4.5.4.1 Usage criteria 27

4.5.4.2 Arrangement 28

4.5.4.3 Intersections 28

4.6 Cross-sections for building structures 28

4.7 Consideration of other types of traffic 30

Page

5 Alignment . . . 31

5.1 General aspects . . . 31

5.2 Horizontal alignment . . . 31

5.2.1 Straights . . . 31

5.2.2 Circular curves . . . 31

5.2.3 Transition curves . . . 32

5.2.4 Site plan curves . . . 34

5.3 Vertical alignment . . . 35

5.3.1 Longitudinal gradients . . . 35

5.3.2 Crest and sag vertical curves . . . 35

5.4 Three-dimensional design . . . 35

5.4.1 General aspects . . . 35

5.4.2 Standard spatial elements . . . 36

5.4.3 Deficits . . . 36

5.4.4 Verification of the three-dimensional alignment . . . 41

5.5 Sight distance . . . 41

5.5.1 Required stopping sight distance . . . 41

5.5.2 Existing sight distance . . . 42

5.5.3 Verification of the stopping sight distance . . . 42

5.5.4 Overtaking sight distance . . . 42

5.6 Design of roadway surface . . . 42

5.6.1 Transverse gradient . . . 42

5.6.2 Superelevation . . . 43

5.6.3 Carriageway widening on sharp curves . . . 46

5.6.4 Carriageway widening . . . 47

5.7 Special features of alignment of bridges and tunnels . . . 47

6 Intersections . . . 48

6.1 General aspects . . . 48

6.2 Planning intersections . . . 48

6.2.1 Basic requirements . . . 48

6.2.2 Distance between intersections . . . 49

6.2.3 Higher priority road . . . 49

6.2.4 Alignment . . . 49

6.3 Types of Intersections . . . 51

6.3.1 Traffic management and types of intersections . . . 51

6.3.2 Warrants for intersection types . . . 52

6.3.2.1 Grade-separated intersection . . . 52

6.3.2.2 Partially grade-separated intersection . . . 53

6.3.2.3 Partially at-grade intersection . . . 55

6.3.2.4 At-grade intersections or crossings with traffic signals 56

6.3.2.5 At-grade intersections or crossings without traffic signals . . . 56

6.3.2.6 Roundabouts . . . 57

6.4 Elements of Intersections . . . 57

6.4.1 Through lanes . . . 57

6.4.2 Exits . . . 57

6.4.3 Entries . . . 58

6.4.4 Ramps . . . 59

6.4.5 Left-turn lane . . . 61

Page

6.4.6 Right-turn lane 63
6.4.7 Crossing and turning 65
6.4.8 Carriageway dividers 66
6.4.9 Triangular island 68
6.4.10 Central island/pedestrian crossings 68
6.4.11 Swept path design 70
6.4.12 Roundabout carriageways 70
6.4.13 Roundabout island 71
6.4.14 Exit from and entry to roundabouts 71
6.4.15 Bypass 72

6.5 Design of the road surface 72

6.6 Sight Distances 73
6.6.1 General aspects 73
6.6.2 Stopping sight distance 73
6.6.3 Starting sight distance 73
6.6.4 Approach view 73

6.7 Verification of traversability 75

6.8 Management of bicycle and pedestrian traffic 75
6.8.1 General aspects 75
6.8.2 Intersections or crossings without traffic signals 75
6.8.3 Intersections or crossings with traffic signals 76
6.8.4 Roundabouts 76

6.9 Management of public transport 76

7 Equipment 77

7.1 General aspects 77
7.2 Road Marking 77
7.3 Vertical traffic signs 77
7.4 Direction signs 77
7.5 Traffic signals 78
7.6 Traffic guidance systems 78
7.7 Vehicle restraint systems (safety barriers) 78
7.8 Road surface drainage 78
7.9 Stationary lighting system 79
7.10 Anti-glare and wildlife protection equipment 79
7.11 Emission protection equipment 79
7.12 Planting 79
7.13 Car sharing parking spaces 80
7.14 Roadside rest areas 80
7.15 Cables 80

Page

Appendices 81

Appendix 1: Markings and signs of overtaking lanes 82

Appendix 2: Emergency lay-bys 85

Appendix 3: Geometry of clothoid curves 86

Appendix 4: Calculation of crest and sag curves 88

Appendix 5: Sight distance on crests model 89

Appendix 6: Construction notes on intersection elements 90

Appendix 7: Exemplary solutions for intersections 105

Appendix 8: Technical regulations 129

List of illustrations

Page

Figure 1: Lineaments and network segments in the sense of a connection (example) . . . 17
Figure 2: Basic dimensions for traffic space and clearances . . . 21
Figure 3: Position and dimensions of a joint foot/cycling path . . . 23
Figure 4: Standard formation of slopes . . . 23
Figure 5: Standard cross-section RQ 15.5 . . . 24
Figure 6: Standard cross-section RQ 11.5+
(a) with overtaking lanes
(b1) without overtaking lanes with lane limiter
(b2) without overtaking lanes with lane marking . . . 24
Figure 7: Standard cross-section RQ 11 . . . 25
Figure 9: Standard cross-section RQ 21 . . . 25
Figure 8: Standard cross-section RQ 9 . . . 25
Figure 10: Standard cross-sections on bridges . . . 29
Figure 11: Standard cross-section in tunnels RQ 11t . . . 30
Figure 12: Relationship of successive radii . . . 32
Figure 13: Radii following straights . . . 32
Figure 14: Shapes of transition curves . . . 33
Figure 15: Example for the arrangement of a route in standard space elements (SRE) . . . 36
Figure 16: Standard spatial elements with a horizontal straight . . . 37
Figure 17: Standard spatial elements with a horizontal curve . . . 38
Figure 18: Critical concealed vision area . . . 38
Figure 19: Concealed vision – hidden dips/“roller coaster” . . . 39
Figure 20: Expansion and compression of a horizontal curve with the same radius . . . 39
Figure 21: Design deficits - breaks . . . 40
Figure 22: Design deficit – flattening and bulging . . . 41
Figure 23: Required stopping sight distance S_H depending on the EKL and the longitudinal gradient . . . 42
Figure 24: Transverse gradient depending on the circular curve (see text for further explanation) . . . 43
Figure 25: Rotation axis of the carriageway in superelevation development sections . . . 43
Figure 26: Forms of superelevation development sections (unidirectional cross fall) . . . 45
Figure 27: Forms of superelevation development sections (bidirectional cross fall crowned road) . . . 46
Figure 28: Connection of intersecting lower ranked roads in plan . . . 49
Figure 29: Connection of intersecting lower ranked roads in elevation . . . 50
Figure 30: System sketch of a cloverleaf . . . 53
Figure 31: System sketch of a left-lying trumpet . . . 53
Figure 32: System sketch of half a cloverleaf . . . 53
Figure 33: System sketch of partially at-grade intersection (EKL 2 / EKL 3) . . 55
Figure 34: Diverging lane with island tip. . . . 58
Figure 35: Merging lane with island tip . . . 58
Figure 36: Carriageway divider on entries and crossings . . . 69
Figure 37: Centre island used as crossing for bicycle and pedestrian traffic . 69
Figure 38: Corner rounding with three-part circular curve sequence . . . 70
Figure 39: Bypass in roundabout . . . 72
Figure 40: Visual range to be kept free for stopping sight distance in sub-ordinate intersection access . . . 74
Figure 41: Visual range to be kept free for starting sight distance in sub-ordinate intersection access . . . 74
Figure 42: Visual range to be kept free for approach view in sub-ordinate intersection access . . . 74

Page
Figure 43: Dimensions of bus bay for a standard service bus 76
Figure 44: Marking and signs of overtaking lanes on roads of EKL 1 83
Figure 45: Marking and signs of overtaking lanes on roads of EKL 2 84
Figure 46: Example for an emergency stop bay on a single-lane EKL 1 road 85
Figure 47: Points of clothoid curves 86
Figure 48: Geometry of clothoid curves 87
Figure 49: Model for crest and sag curves 88
Figure 50: Sight distance model 89
Figure 51: Construction of a small divider island at a crossing angle of α = 80 to 120 gon (72 to 108°) 91
Figure 52: Construction of a small divider island with a crossing angle of α < 80 gon (72°) 92
Figure 53: Construction of a small divider island at a crossing angle of α > 120 gon (108°) 93
Figure 54: Construction of a large divider island at a crossing angle α = 80 to 120 gon (72 to 108°). 94
Figure 55: Construction of a large divider island at a Crossing angle α < 80 gon (72°) 95
Figure 56: Construction of a large divider island at a crossing angle of α > 120 gon (108°) 96
Figure 57: Construction of a right-turn alignment with edge length of the triangular island 98
Figure 58: Construction of a right-turn alignment with edge length of the triangular island 99
Figure 59: Construction of a corner rounding 100
Figure 60: Construction of a right-turn alignment without triangular island . . 101
Figure 61: Construction of a right-turn entry rounding 102
Figure 62: Construction of a carriageway divider in a roundabout 104
Figure 63: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road ramp RRQ 2 106
Figure 64: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road EKL 3. 107
Figure 65: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road EKL 3. 108
Figure 66: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road EKL 3. 109
Figure 67: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road EKL 3. 110
Figure 68: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp RRQ 2. 111
Figure 69: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road EKL 3. 112
Figure 70: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road EKL 3. 113
Figure 71: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3 114
Figure 72: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3 115
Figure 73: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3 116
Figure 74: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3 117
Figure 75: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 4 118
Figure 76: Example for an intersection with traffic signals, higher priority road EKL 4 / lower priority road ramp EKL 4 119
Figure 77: Example for an intersection with traffic signals, higher priority road EKL 4 / lower priority road ramp EKL 4 120

Page

Figure 78: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3 121
Figure 79: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3 122
Figure 80: Example for an intersection without traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3 123
Figure 81: Example for an intersection without traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 4 124
Figure 82: Example for an intersection without traffic signals, higher priority road EKL 4 / lower priority road ramp EKL 4 125
Figure 83: Example for a roundabout, higher priority road EKL 3 / lower priority road ramp EKL 3 126
Figure 84: Example for a roundabout, higher priority road EKL 3 / lower priority road ramp EKL 4 127
Figure 85: Example for a partially at-grade intersection, higher priority road EKL 2 / lower priority road ramp EKL 3. 128

List of tables

		Page
Table 1:	Road categories as defined by RIN and the scope of RAL (surrounded in bold print)	11
Table 2:	Traffic safety	13
Table 3:	Traffic flow quality	13
Table 4:	Environmental compatibility	14
Table 5:	Public authority costs	14
Table 6:	Planning stage for rural roads	15
Table 7:	Design classes for rural road depending on the road category	18
Table 8:	Reference values for deviations of the design class rendered in Table 7	18
Table 9:	Design classes and fundamental design features	19
Table 10:	Additional width in the tunnel with square cross-section depending on the transverse crossfall	28
Table 11:	Approximate values for usefulness of a joint foot/cycling path on roads of EKL 3	30
Table 12:	Recommended radii and minimum lengths of circular curves	31
Table 13:	Site plan curves	34
Table 14:	Maximum longitudinal gradients	35
Table 15:	Recommended crest and sag curve radii and minimum length of tangents in longitudinal section	35
Table 16:	Required movement of the start of the in the transition from straight section before the start of crest for different clothoid circular curves	36
Table 17:	Effects of deficit of the spatial alignment	37
Table 18:	Limiting values of superelevation transition	44
Table 19:	Taper length of carriageway widening	47
Table 20:	Basic design characteristics of intersections	48
Table 21:	Standard fields of application of intersection types in four-leg intersections	51
Table 22:	Standard fields of application of intersection types in three-leg intersections	51
Table 23:	Management of traffic flows in at-grade partial intersections of partially grade-separated intersections	54
Table 24:	Areas for the smallest radii used depending on the type of intersection and ramp	59
Table 25:	Fields of application of the ramp cross-sections	60
Table 26:	Limiting values for draft ramp elements	60
Table 28:	Fields of application of the left-hand turns	61
Table 27:	Left-turn types	61
Table 29:	Right-turn types	64
Table 30:	Fields of application of the right-turn types	65
Table 31:	Types of access for crossing and turning off	67
Table 32:	Width of roundabout carriageways (including shoulders) depending on the outside diameter	70
Table 33:	Values for points of clothoid curves	86
Table 34:	Turning radii and drop shadows at crossings	94
Table 35:	Intersection elements of the exemples shown	105

1 Introduction

1.1 Content

The “Guidelines for the Design of Rural Roads” (RAL) deal with rural roads with at-grade or grade-separated intersections outside of built up areas. Short[1)] non-built up two-lane road sections are also considered rural roads. Longer two-lane sections are planned in accordance with the “Guidelines for the Design of Motorways” (RAA).

In terms of legal categorisation they may be federal, state, district or local roads.

1.2 Purpose

RAL are the basis for the construction of safe and functional rural roads. The specifications pursue the goal to standardise the design of rural roads as far as possible. For this purpose four design classes have been defined. Rural roads are decisively defined by the function of a road in the network expressed by the road category in accordance with the “Guidelines for Integrated Network Design” (RIN). The design classes are used to ensure the uniformity of roads of one category as well as to clearly differentiate between roads of different categories. In this way a suitable driving style according to the network function should be supported.

The prerequisite for the construction of safe and functional roads is the simultaneous consideration of design, traffic and legal matters (conformity of construction and operation). For this reason, RAL deal with the legal facts to permit them to be included in the development and assessment of design and technical solutions at an early stage already. The framework for the legal facts presented in RAL is the German Road Traffic Regulations (StVO) and the General Administrative Regulations of the Road Traffic Regulations (VwV-StVO) as amended.

RAL are directed to the designers and the road administration. As the road regulations are in the competence of the road traffic authorities, the planning process of traffic matters has to be harmonised with the road traffic authorities at an early stage.

RAL offer no final solution for road design in fact they offer the designer scope for discretion, which shall be used when balancing various utilisation requirements and targets. In this respect deviations from the standard values are possible, but have to be justified in individual cases.

1.3 Scope

RAL are applicable for rural roads of road category LS I to LS IV according to RIN (Table 1).

RAL contain principles, design elements and road furnitur for new construction as well as reconstruction and widening of rural roads.

RAL can be applied in the various stages of the planning process with the respectively different depth. In all planning stages, it has to be ensured that a section planned according to RAL is compatible with the characteristics of the adjacent road section and the transition can clearly be identified by the road users.

1) up to about 15 km in length

Table 1: Road categories as defined by RIN and the scope of RAL (surrounded in bold print)

Category group / **Link function level**		Motorways	Rural roads	Open arterial roads	Built-on arterial roads	Access roads
		AS	**LS**	**VS**	**HS**	**ES**
Continental	**0**	**AS 0**		–	–	–
Sub-continental	**I**	**AS I**	**LS I**		–	–
Inter-regional	**II**	**AS II**	**LS II**	**VS II**		–
Regional	**III**	–	**LS III**	**VS III**	**HS III**	
Sub-regional	**IV**	–	**LS IV**	–	**HS IV**	**ES IV**
Local	**V**	–	**LS V ***	–	–	**ES V**

LS I	unproblematic, designation of the category
	problematic
–	not occurring or not justifiable

* if necessary, design in referring to RAL.

2 Objectives

2.1 General aspects

Rural roads shall fulfil their assigned spatial planning with a high level of traffic safety and a suitable quality of traffic flow. They shall protect the essentials of life, shall be integrated into the environment as far as possible, with less utilization of land as possible. Rural roads shall pass environmentally sensitive areas at a suitable distance and should affect the demands of settlement areas as little as possible. They shall be planned in such a way that they fit into the terrain and should be constructed, maintained and operated as cost-effective as possible.

The demands mentioned above have to be weighed against each other during the planning process. As a rule the basis are the variants available for discussion in the different planning stages. By weighing

- traffic safety
- traffic flow quality
- environmental compatibility

with regard to the targets, advantageous variants can be developed while considering the public authority costs. The goal is to work out a solution that provides the greatest benefit for the society at the lowest possible cost considering the targets mentioned above.

Cost-benefit analyses are required in the entire planning process in order to determine the economic efficiency of a measure, to compare variants and to prioritise measures. On the basis of the methods introduced for examining economic efficiency, the costs of a variant (building, maintenance and repair costs divided up over the useful life) are compared with the benefits (advantages and disadvantages for the society in total). Rural roads have to be designed and operated so that the benefit to cost ratio is as high as possible.

Certain environmental influences cannot be given a definitive monetary value. Such effects have to be assessed in addition to the benefit - cost analyses with respect to the targets mentioned above and have to be included in the overall assessment.

Depending on the extent and effect of a project, specialist contributions may be required and included in the different planning stages.

The following targets for designing rural roads and potential influences help in this respect. In justified exceptional cases, deviations may be required from the provisions in sections 3 to 7 with as part of this assessment.

2.2 Traffic safety

Rural roads have to be designed in such a way that a high level of traffic safety is achieved when used as intended.

The behaviour of the road users is influenced considerably by the design and operating characteristics of routes and intersections. This has an effect on road safety.

For this reason a rural road shall have a cross-section, alignment, intersection design and equipment that causes the driver to drive at the speed defined by the respective network's function. For reasons of traffic safety, rural roads should be designed identically as far as possible ("standardised") and should clearly differ from roads with another network function ("recognition"). As driving error cannot be ruled out completely, roadsides should be designed in such a way that accident consequences are as low as possible when leaving the carriageway.

Roads with higher ranked linked function level use several network sections in general. Continuity principles apply for them especially for reasons of traffic safety. For this reason, consecutive network sections of rural roads shall be designed as uniformly as possible

The protection of vulnerable road users has to be given special consideration.

Targets and possibilities of influence are listed in Table 2.

2.3 Traffic flow quality

In conformity with spatial planning, the system of central locations is the basis for determining the network function of rural roads. On the basis of the German Regional Development Act (ROG), a target for the accessibility of central locations is developed in RIN. They are the basis for determining the travelling speed and are thus an important quality specification for the design of roads.

For this purpose, each network section is allocated to a category. This is determined by the importance of connections that pass through this network section and demands of the roadside environment in the area of the network section. With increasing importance of the connection, higher travelling speeds have to be planned.

The different network functions also result in different requirements for the connection-related service quality. These requirements are manifested in the RIN in category-specific target values for the required average private car travel speeds that should be achievable during the measurement hour on the network section of the planned road.

The extent to which the planned road is able to achieve the required traffic flow quality (QSV) level in the measurement hour on the road section and at the intersections will be checked using the process described in the "German Highway Capacity Manual" (HBS).

Targets and possibilities of influence are listed in Table 3.

Table 2: Traffic safety

Targets	Possibility of influences
Suitable speeds	– Ensured by clear characteristics, which reflect the respective network functions – The behaviour of influencing design features ensures that vehicle drivers drive at an appropriate speed for the network function
Safe progress	– Sufficient stopping sight distances are guaranteed – Good relations among consecutive radii for constant driving style – Preferably use recommended element ranges – Indicate unavoidable changes in the road characteristic – Clearly warn of sudden curves – Sufficient lateral slopes in straights and curves – Drain surface water along short routes – Avoid poorly draining zones – Coincident horizontal and vertical curves
Safe encounter and overtaking	– Safeguard overtaking with overtaking lanes – Avoid critical sight distances for overtaking processes – In the case of wide lanes and at high speeds, separation of slow and fast traffic from one another
Safe alignment in intersections	– Clear notification of structural design and operating mode of intersections – Design intersections to be recognisable, clearly, fully comprehensible and useable for road users – Create sufficient visual contact with other road users at intersections
Safe use by vulnera-ble road users	– In heavy traffic or at high speeds plan separate traffic areas for motor vehicle traffic, agricultural traffic and non-motorised traffic – Separate cyclists and pedestrian traffic from motor vehicle traffic – Clear guidance of cycle traffic at intersections – Permit visual contact between motorists and cyclists at intersections – Should cyclists and pedestrians need to cross, use structural and/or technical safety measures
Lateral spaces	– Clearly show the course of the road with appropriate planting – Provide obstacle-free side spaces or measures to protect against collision with unavoidable obstacles by the side of the road – Provide sufficient width of unattractive planting for game

Table 3: Traffic flow quality

Targets	Possibility of influences
Appropriate traffic flow quality in motor vehicle traffic Good connection and access quality in cycle and if necessary in pedestrian traffic Effective flow quality in the public transport network Sufficient access from adjacent areas	– Adequate dimensioning of cross-section – Select a suitable alignment for the design class – At high speeds provide a separate route network for slow road users – Create sufficient overtaking opportunities at regular intervals – Limit the number of intersections – For roads with highly significant connections, avoid intersections requiring road users to wait – Prevent unreasonable waiting times for all traffic flows even in peak periods – Design heavily used intersections as partial grade-separated or partial at-grade – Traffic light signal control systems should be traffic dependent and closely spaced traffic light signals should be coordinated – Separate cycle traffic from motor vehicle traffic – Avoid steep slopes for cycle traffic – Provide direct routes for cyclists and pedestrians – Create requirement-appropriate crossing opportunities – In roads with a high linkage function level, ensure that there is no access to the agricultural route network – In roads with a low linkage function level, create sufficient diversion-free accesses to agricultural areas – Reserve adequate space for maintenance services

2.4 Environmental compatibility

Rural roads impact both on the immediate and the wider environment. They shall be designed such that those assets specified in the German Act on the Assessment of Environmental Impacts (Gesetz über die Umweltverträglichkeitsprüfung) (UVPG) are affected as little as possible. The UVPG specifies the framework for proper description, evaluation and consideration of worth protecting assets in the planning. The Federal Nature Conservation Act (Bundesnaturschutzgesetz) (BNatSchG) and corresponding nature conservation acts include requirements with respect to species and regional protection (for example the risk assessment for Natura 2000 regions), the impact mitigation regulation with specifications for preventative and compensatory measures and statutory nature conservation consideration that have to be incorporated into the planning. In areas of transition to built-up areas, high density usage frequently results in competition of use amongst the different modes of transport and with the urban built environment requirements. Therefore the planning has to basically incorporate the specific aims of the urban built environment and natural environment and be agreed with the regional development and nature conservation authorities.

In spring and groundwater catchment areas and in reservoir catchment areas the water laws require measures to prevent contaminants from normal road traffic use or road traffic accidents (see also "Guidelines for construction measures on roads in water protection areas" (RiStWag)).

Targets and possibilities of influence are listed in Table 4.

Table 4: Environmental compatibility

Targets	Possibility of influences
Minimum use of conservation areas, minimum dissection of important surface functions for prevention of negative influences on – wildlife migration routes – habitat networks (biotope network) – species variety – water flow Minimum pollution from noise and air impurities, good microclimate Good integration of the road into the landscape, minimum impact on settlement structures Minimum impact on previously un-dissected low-traffic areas Minimum impact on water and soil	– Minimum use of valuable areas – Little change to the natural environment – Keep a distance from elements which would be harmed – Limit negative effects to a few affected elements – Keep embankments and cuttings low – Provide lateral protective planting – Check crossing aids for animals – Install roadside noise protection means

2.5 Costs for investments and operation

The budget laws of the Federal State and the Laender obligate the public authorities to carry out investments with economic efficiency and austerity

The public authority need to consider the investment costs including the costs for necessary compensation and replacement measures as well as the costs for maintenance. The total costs for the public authority should be as low as possible.

Targets and possibilities of influence are listed in Table 5.

Table 5: Public authority costs

Targets	Possibility of influences
Low investment costs	– Road to be adapted to terrain – Avoidance of areas worthy of protection with high compensation – Avoidance of long connecting links, adjustments and transfers – Civil engineering work as short as possible – Make noise protection measures superfluous by alignment – Provide open drainage into the terrain
Low maintenance and operating costs	– Design roads easy to maintain – Minimise outlay for periodic control, maintenance and repair work on the road and side space as well as use of worn or damaged parts – Make roads, ancillary facilities and roadsides easily accessible for services – Ensure that maintenance can be carried out without traffic obstruction as far as possible – Ensure trafficability of all road parts by the reference vehicle to prevent damage to lanes and roadsides

3 Basic principles

3.1 Planning process

The planning for new-builds, renovations and expansion of rural roads shall be an iterative process over several planning stages. The results of the individual planning stages are documented in planning documents (Table 6). Graphical displays will be used increasingly for better illustration of the planning results and for planning purposes.

Before a final planning project is accepted, the **requirement planning** shall be based on the principles of the corresponding legislation on developing rail and major roads at a federal or state level. The requirements plan for Federal highways is decided based on the Federal Transport Infrastructure Plan (appendix to the Federal Transport Infrastructure Building Plan (FStrAbG)). For interstate, regional and municipal roads that are comparable, planning documents in the public easement of states, regions and municipalities. All requirement planning is based on traffic investigations, the analysis of the deficits in the existing road network and economic considerations. The requirement planning is not part of RAL.

The "Guidelines for the Planning Process and for the Unified Design of Draft Documents for Road building" (RE) contain the planning stages and the respective subsequent process steps. The RE give the breakdown and contents of all draft documents of the planning process from the preliminary planning stage to the approval planning stage.

The descriptions of the planning stages are based on the definitions of the "Official Scale of Fees for Services by Architects and Engineers" (HOAI) and of the "Manual for Contract Awarding and Execution of Freelance Services of Engineers and Landscape Architects in Road and Bridge Building" (HVA F-StB). In the various guidelines, different terms are occasionally used for the same planning content.

The level of detailing and the scale of the draft documents to be produced shall be selected such that the requirements of the individual planning stage are satisfied and the effects on the environment and the local constraint points in the site plan and longitudinal sections and cross-section are recognisable.

Table 6: Planning stage for rural roads

Planning and design stages	Documents	Usual processes	Service phases (Lph) in accordance with German Fee Regulations for Architects and Engineers (HOAI) and HVA F-StB
Requirement planning	Federal road plan / requirement planning (federal trunk roads) Requirement plans on federal and/or regional level and comparable plans	Federal road plan comparable procedures for main and district roads	
Preliminary planning stage (according to RE)	Preliminary investigation	Regional planning procedure – land development plan – line determination	Initial conceptual design (Lph 1) Preliminary planning (Lph 2)
Design planning stage (according to RE)	Preliminary draft	technical and budgetary verification of in-authority approvals	Design planning (Lph 3)
Approval planning stage (according to RE)	Assessment draft	Plan approval procedure Plan authorisation procedure Development plan procedure	Approval planning (Lph 4)
Final planning stage (implementation)	Final design / construction design	Construction release	Implementation procedure (Lph 5)

Preliminary planning as a conceptual planning level, is primarily designed to determine the route when building new rural roads. It is generally carried out within the context of a regional planning procedure and can be carried out with the route determination. The preliminary planning begins, generally based on a requirement plan, with the delineation and analysis of the planning area, which should incorporate all practical variants from the traffic perspective and must be large enough such that the significant effects of all variants of the future road on the environment can be determined.

For the subsequent determination of low conflict areas and for the legally prescribed environmental compatibility inspections an Environmental Impact Assessment (EIA) is required. In accordance with the "Guidelines for the preparation of environmental compatibility studies in road construction" (Richtlinien für die Erstellung von Umweltverträglichkeitsstudien im Straßenbau) (RUVS) the geographical and variant specific effects of the project on the environment are determined, described and evaluated within the EIA.

In addition, plans which may affect a site of community importance, in accordance with the FFH Guidelines or a European bird sanctuary in accordance with the regulations for the protection of birds (Natura 2000-Gebiete) must be checked at this point for compatibility with the conservation aims of such a site. The methodology is outlined in the "Manual for Compatibility Checking in Federal Highway Building" including associated sample cards.

At the preliminary planning stage it may also be necessary to carry out an investigation for the extension and widening of existing rural roads. In any case, there will be an investigation of options within a narrow corridor as determined by the existing highway. Deviations will be subject to considerable environmental constraints.

The preliminary planning stage is concluded with the documentation of the preliminary investigation. The basic design and operating features in the preliminary investigation shall be preselected depending on the design class (see also section 3.2) in order to develop the corridor options in the site plan and longitudinal section. The number of intersections, their location and type shall also be illustrated in the preliminary investigation. The same applies for the civil engineering works with their basic dimensions. The investigations shall incorporate transitions to existing systems.

All options from the preliminary investigation are then appraised with respect to the achievable traffic flow quality on the basis of the HBS process.

Taking into account these and all other aims (see also section 2) a preferred option is then generally determined. This forms the basis for the regional development and route determining process and for the processing of the subsequent planning stages.

A check based on the "Guidelines for the Traffic Safety Audit" (Richtlinien für das Sicherheitsaudit von Straßen) (RSAS) should be undertaken for the preliminary investigation.

The preliminary investigation materials shall be prepared to a scale of 1:10,000 or larger depending on the scope, type of extension and environmental conditions. For the summarising presentation within the framework of the regional planning and routing regulations, the scale of 1:25,000 shall be suitable as well

The **design planning** shall involve the definitive realisation of the preferred option in terms of the horizontal and vertical alignment for the preliminary design. In this case the design class (see also section 3.2) determines the design standard (standard cross-section, alignment, intersection type). The preliminary design shall include dimensioning of civil engineering works and take into account the subgrade conditions.

This planning stage shall also involve a more detailed analysis of the environmental and nature conservation requirements. For this purpose, the landscape conservation plan shall be prepared according to the "Guidelines for the Preparation of Environmental Compatibility Studies in Road Construction" (Richtlinien für die landschaftspflegerische Begleitplanung im Straßenbau) (RLBP). Investigations on drainage and emissions protection shall be carried out and if necessary other required appraisals prepared.

The preliminary draft is designed for internal administration budget and expert checking.

The costs of the road building project are determined and broken down into specified structures. Required cost sharing (e. g. in the case of interfaces with other traffic carriers and at intersections) shall be indicated.

The traffic flow quality has to be demonstrated based on the method described in the HBS.

A safety audit in accordance with the RSAS shall be conducted for the preliminary design.

The documents for the preliminary draft have to have scale of 1:5,000 as a rule. Particularly in the case of extension and widening projects, activities in the built environment and on a small scale, a larger scale is desirable.

In the **approval planning** stage the preliminary design is refined and expanded for the land use plan for the planning permission process. In this case all relevant aspects shall be illustrated in the detail required for the legal decision. The land use plan shall clearly communicate and illustrate the type and scope of the impacts for all those participating in the process. It is the basis for the overall appraisal of all public and private requirements.

The preliminary design documents are augmented by the land procurement documents and the directory for public law provisions.

When producing the assessment draft the Federal Highways Act (FStrG) and the "Guidelines for the Land Use Planning Procedure According to the Federal Highways Act" (PlafeR) and/or the road acts of the federal states shall be taken into account.

The documents for the assessment draft are prepared at a scale of 1:1,000.

The **implementation procedure** involves incorporating the conditions and provisions of the land use planning decision and further development of the design for the technical approval.

The implementation plan shall include all necessary details and plans for the invitation to tender and the building project (e.g. layout plan, cross-sections, road surface vertical layout). Further components of the implementation plan are the signage and road marking plans, supply line plans and landscape conservation compliant execution plans in accordance with the "Recommendations for Landscape Conservation-Compliant Implementation in Road Construction" (ELA) and further technical plans as required.

A safety audit in accordance with RSAS shall be carried out for the implementation plan.

The documents for the implementation draft are prepared as a scale of 1:1,000 or in greater detail.

3.2 Road categories and design classes

For reasons of traffic safety and traffic flow quality, as far as possible rural roads should be designed so that road users can drive consistently and at an appropriate speed for the respective road network function. This speed derives from the category of the road and the journey distance range associated with that category.

Rural roads are assigned to specific design classes (EKL 1 to EKL 4) to clarify to the road user which design features should be expected on a journey and at what speed it is possible to drive. Roads in different design classes should clearly differ in their appearance. Roads within a design class shall as far as possible resemble the standard road appearance (to be recognisable).

Road sections shall be assigned to a single design class as far as possible. Road sections in terms of RAL are the parts of the network between intersections to which a planned highway is linked with another road of the same or higher-ranking linkage function level (Figure 1). In special cases it can be practical to downgrade a road section at an intersection with a lower ranking road category if the parts, which are so formed have significantly different traffic demands.

The road category in accordance with RIN is the starting point for determining the design class for rural roads (Table 7). This also applies for existing roads linking to the planned highway. The road law designation has no influence on the determination of the design class.

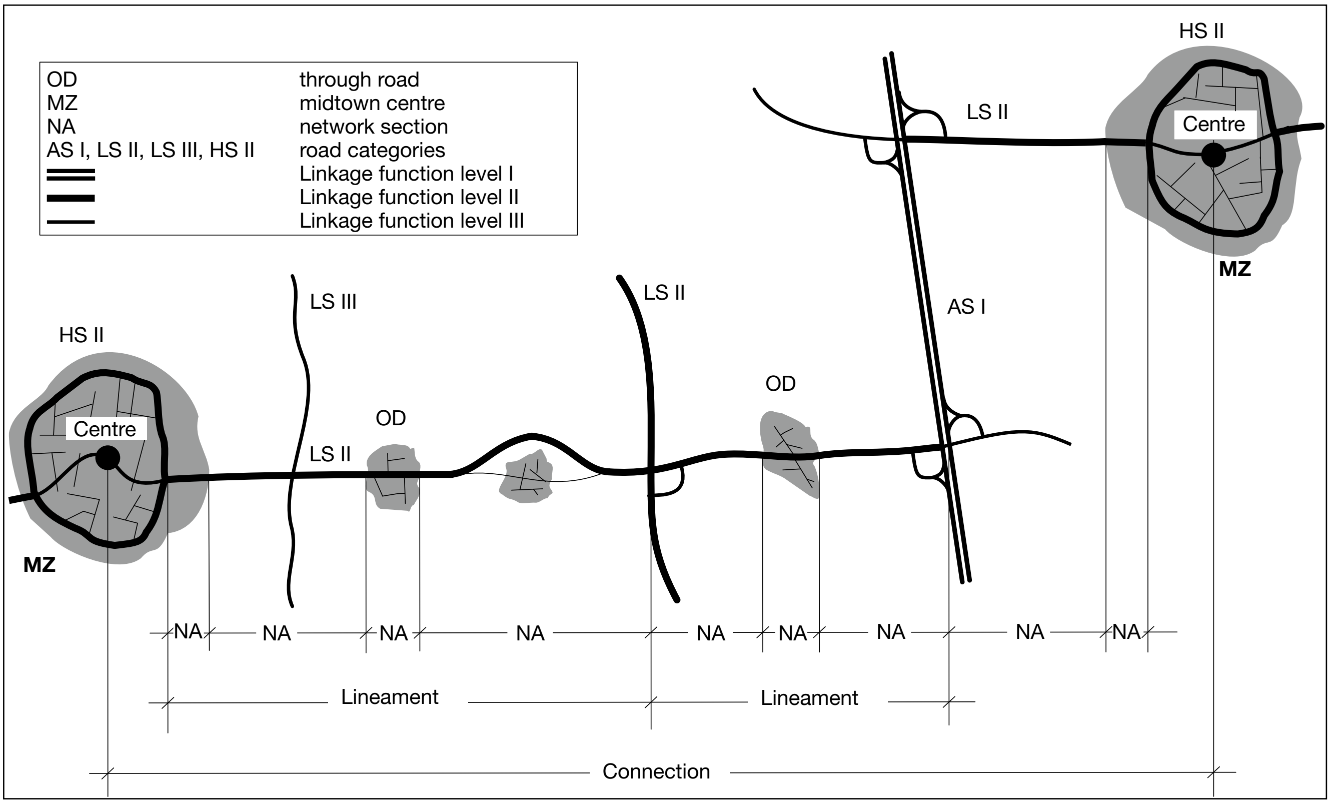


Figure 1: Lineaments and network segments in the sense of a connection (example)

Table 7: Design classes for rural road depending on the road category

Road category	Design class
LS I	EKL 1
LS II	EKL 2
LS III	EKL 3
LS IV	EKL 4

In general the assignment of a road section of a highway to a design class is based on the road category.

In the case of very high traffic demand on a road section, from the perspective of the traffic flow quality, a higher-ranking design class than that given in Table 7 may be planned.

In the case of very low traffic demand on a road section, from the perspective of the public authority costs, a lower ranking than the design class in Table 7 might also be planned. This does not apply to rural roads in category LS III.

Exceptions apply if high or low traffic demand exists only on short sections of a road section or if a change of design class in terms of a reduction in length means that the required equivalent highway design cannot be guaranteed.

Table 8 shows the target values for traffic demand which, if exceeded or undershot, would require checks to be carried out as to whether, taking into account the targets cited in section 2 (traffic safety, traffic flow quality, environmental compatibility and public authority costs) an alternative to Table 7 is reasonable when allocating the design class of a road section.

Also when selecting a design class other than that specified in Table 7 it has to be demonstrated using the HBS method that the road sections and intersections of the planned road guarantee the desired level of traffic flow quality (QSV) (see also Section 4.4). It should also be checked whether, if the design class is changed, the target proposals of the RIN with respect to the desired vehicle travelling speed for the road category are achieved overall on the network sections.

Table 8: Reference values for deviations of the design class rendered in Table 7

	Traffic demand on the lineament $\mathbf{DTV}_{\text{cross-section}}$ [Vehicles/24h]	
Road category	**Verification of a lower-rank EKL**	**Verification of a higher-rank EKL**
LS I	< 12,000	
LS II	< 8,000	> 15,000
LS III		> 13,000
LS IV		> 3,000*)

*) higher-rank EKL required as a rule
(applies also for SV > 150 Vehicles/24h)

3.3 Design classes and distinctive design features

Rural roads shall be driven at a speed suitable for each network function. The important design and operating characteristics influencing the speed are determined for the design classes.

A design speed, based on the network function, shall be assigned to the rural roads within a design class with the aim of standardised implementation. This shall determine the dynamic driving based limit values of individual design parameters. The planning speed is not identical to the permissible maximum speed according to the road traffic legislation (speed limit).

Both the uniformity of roads in a design class and the difference from roads in different design classes should be clearly and fully comprehensible to the road user. This task is particularly assisted by the differentiated implementation of the longitudinal markings, which are continuously recognisable by the driver.

In addition, the design class directly determines

- operating mode
- standard cross-section including the overtaking principle involved
- the elements of alignment
- the routing of the traffic in junctions
- the other operating characteristics

Since it is the practical combination of all elements, which defines the character of a road, these features are reconciled with one another within a design class ("standardised"). At the same time there shall be sufficient clarification between the roads in different design classes ("recognisable").

Table 9 shows the basic design features of rural roads of different design classes.

Roads in design class EKL 1 are single carriageway three-lane roads with the standard cross-section RQ 15.5. They have grade-separated intersections. Both directions of travel are separated from one another by a "technical" central reservation. The regular interchange of one and two lane sections provides the road section with technical overtaking opportunities for each direction of travel of around 40 % of travel in each direction.

Roads in EKL 1 shall be operated as rural roads restricted to motor vehicles. Agricultural and non-motorised traffic travel in this case on a special route network. Junctions with equivalent ranking or lower ranked networks should be designed as grade-separated or partially grade-separated intersections.

Based on the network function and the generally associated long to very long journeys, the design is based on a planning speed of 110 km/h. Travel in each direction is consistently technically separated. The alignment should be correspondingly "very extended".

Roads in design class EKL 2 are single carriageway two-lane roads with standard cross-section RQ 11.5+, which incorporate overtaking lanes, sometimes in one direction and sometimes in the other direction. As far as possible therefore overtaking should be confined to technically secured overtaking sections and overtaking involving oncoming traffic lanes should be avoided as far as possible. Both directions of travel in the three lane sections should always be technically separated by two lane markings (unbroken double line). The same applies for two-lane sections where overtaking is prohibited due to particular risks. In the remaining sections, both directions of travel are separated by a double broken centreline (dashed line).

The concentration of overtaking in safe overtaking areas is most acceptable if a sufficient number of three-lane sections are available to satisfy the overtaking demand. Therefore, for each direction of travel as far as possible at least 20 % of the road section should provide this kind of technically secured overtaking opportunity. A higher proportion of such overtaking sections are desirable for traffic safety and traffic flow. If a sufficient quantity of overtaking lanes is not possible it should be investigated at which points in the two-lane sections, particularly with adequate sight distance, overtaking, with use of the oncoming traffic lane, may be permitted and at which points, particularly in the case of inadequate sight distance, this should be prohibited (see also section 5.5.4).

In the case of roads in class EKL 2, agricultural traffic should be directed to separate routes as far as possible. Non-motorised traffic should be excluded from the carriageway and should travel independently of the road on separate routes or on cycle paths or footpaths alongside the carriageway.

On the basis of the network function and the generally associated length of average to long journeys the design speed is set as 100 km/h. The directions of travel are therefore technically separated as far as possible. The routing should also be extended as far as possible.

Links with equivalent ranking or lower priority road networks shall be designed preferably as partly at-grade intersections or as at-grade intersections, respectively with traffic light signals. Otherwise controlled crossroads with traffic light signals should be planned.

Roads in design class EKL 3 are single carriageway two-lane roads with the standard cross-section RQ 11. The lanes are separated by a single line in the centre of the carriageway in which overtaking with use of the carriageway of oncoming traffic is permitted if geometric and traffic conditions allow.

The lanes are separated by a single lane marking in the centre of the highway where overtaking with use of the lane of the oncoming traffic due to insufficient sight distance or other hazards should be prohibited (see also section 5.5.4).

Table 9: Design classes and fundamental design features

Design class	Design/operating characteristics					Alignment of the carriageway				Layout of intersection elements
	Planning speed [km/h]	Operating mode	Cross-section	Safe overtaking sections in each direction	Routing for cycle traffic	Routing	Recommended radii R [m]	Maximum longitudinal gradient max s [%]	Recommended crest radius Hk [m]	Standard solution for higher priority road*)
EKL 1	110	Motor road	RQ 15,5	~ 40 %	Independent of road	very extended	≥ 500	4.5	≥ 8,000	merging
EKL 2	100	Gen. traffic	RQ 11,5+	≥ 20 %	Independent of the road or following carriageway	extended	400 – 900	5.5	≥ 6,000	Entering/leaving/crossing with traffic signals
EKL 3	90	Gen. traffic	RQ 11	no	Following carriageway or on the lane	confined	300 – 600	6.5	≥ 5,000	Entering/leaving/crossing with/without traffic signals
EKL 4	70	Gen. traffic	RQ 9	no	on the lane	very confined	200 – 400	8.0	≥ 3,000	Entering/leaving/crossing without traffic signals

*) Other possible applications of junction types dependent on design class are presented in section 6.3.3.

In the event of major overtaking pressure, particularly in heavy traffic or on grades, the creation of overtaking lanes may be considered (see also section 4.5.4).

The cycle traffic may travel on the carriageway or in two directions along one side of the highway on a combined and foot/cycle path (see also section 4.7).

Links with equivalent ranking or lower priority road networks shall be via at-grade intersections or roundabouts. In the case of at-grade intersections it shall be checked whether a traffic signal control system is required for reasons of traffic load or traffic safety. In this case note that intersections without traffic signals offer a significantly lower level of traffic safety than those with traffic signals. Offset intersections without traffic signals are preferable to crossroads without traffic signals.

On the basis of the network function and the generally associated short to medium-length journeys and the relative frequency of at-grade intersections, the planning speed is 90 km/h. This enables better reconciling of the horizontal and vertical alignment.

Roads in design class EKL 4 are single carriageway roads with the standard cross-section RQ 9, used for short-range travel. Because of the low traffic demand and the related infrequent encounters, the road is designed to a fixed width, which does not permit the marking of two lanes. Rather than a lane marking in the centre of the carriageway, lane markings are applied on either side. These may be traversed since in the case of an encounter with a heavy goods vehicle it may be necessary to use the entire fixed width. These lateral lane markings and the lack of a central carriageway marking signal to the road user that increased caution is required.

Reduction of speed during an encounter is therefore in line with the desired lower vehicle speeds for this network function.

The roads are primarily used by agricultural traffic and non-motorised traffic. Separate footpaths and cycle paths alongside the carriageway may be recommended if the composition of the traffic (e.g. schoolchildren travelling) or the network function poses particular demands on cyclists or pedestrian traffic links.

Due to the low traffic demand, the link with the equivalent ranking and lower priority road network with at-grade intersections without traffic light signals is sufficient. Roundabouts are not necessary as a rule.

On the basis of the network function and the generally associated short journeys the planning speed is set as 70 km/h. The alignment in vertical and horizontal alignment can therefore be very well reconciled to the respective conditions.

Due to the terrain-reconciled alignment and the particular situations encountered due to the narrowness of the roads, it is desirable for the purposes of traffic safety that road users do not exceed the planning speed. It should be checked therefore if a corresponding limit of the maximum speed is required for traffic safety reasons.

Roads in design classes EKL 1 to EKL 3 with very high traffic demand

Particularly in the vicinity of major conurbations or due to the combining of connections in certain parts of the network, one or more consecutive network sections in the EKL 1 to EKL 3 may be subject to a very high traffic demand. In such cases, on the basis of the HBS it should be checked whether the traffic flow quality is adequate in the usually planned single carriageway cross-section for the respective road category under the actual local circumstances (see also section 4.4).

If a short dual carriageway cross-section (up to around 15 km) is required in the course of an otherwise single-lane road and if in this case the traffic volume amounts to a max. 30,000 vehicles /24h, the cross-section shall be planned as per the specifications of RAL (see also section 4.3). In this case the remainder of the design features (operating mode, alignment, type of junction) corresponding to the higher-ranking design class of the adjacent single-carriageway roads, at least however corresponding to EKL 2.

In other cases the dual carriageway cross-section shall be planned as per specifications of the RAA.

4 Cross-sections

4.1 General aspects

The principle of standardised and recognisable road types for the road user is manifested in a particular way by the road cross-section. Therefore a single-carriageway standard cross-section is defined for each design class.

The HBS method shall be used to check whether the traffic flow quality is adequate on all sections of the planned road in the case of the defined standard cross-section. Moreover, using the method of the HBS, the traffic flow quality shall be demonstrated in all intersections.

It shall also be checked whether the target proposals of the RIN with respect to preferred vehicle speed for the road category are achieved on the network sections of the planned road (see also Section 4.4).

For the defined standard cross-section the compatibility of planned sections with the adjacent sections should also be checked in order to guarantee, as far as possible, a unified road characteristic. The transitions shall be designed to be recognisable to the motorist and to be equally safe.

4.2 Fundamentals for the dimensions of the cross-sections

4.2.1 Standard vehicle dimensions

Motor vehicles have a maximum admissible width of 2.55 m and a maximum admissible height of 4.00 m in accordance with the Road Traffic Licensing Regulations (StVZO). These dimensions are used as a basis for the calculation of component parts of the driving space.

4.2.2 Roadway components

The **traffic space** for motor vehicles comprises the space occupied by the standard vehicle, the clearances required for movement above and to the side and the spaces above the edge markings and/or load-bearing drainage channels (Figure 2).

The **lateral movement clearance** is the space required to compensate for driving and steering accuracy and the safety distance required for projecting parts (e. g. mirrors). For lanes regularly used by heavy goods traffic it is 0.95 m and for lanes not regularly used by heavy goods traffic it is 0.70 m.

The upper movement clearance is 0.25 m.

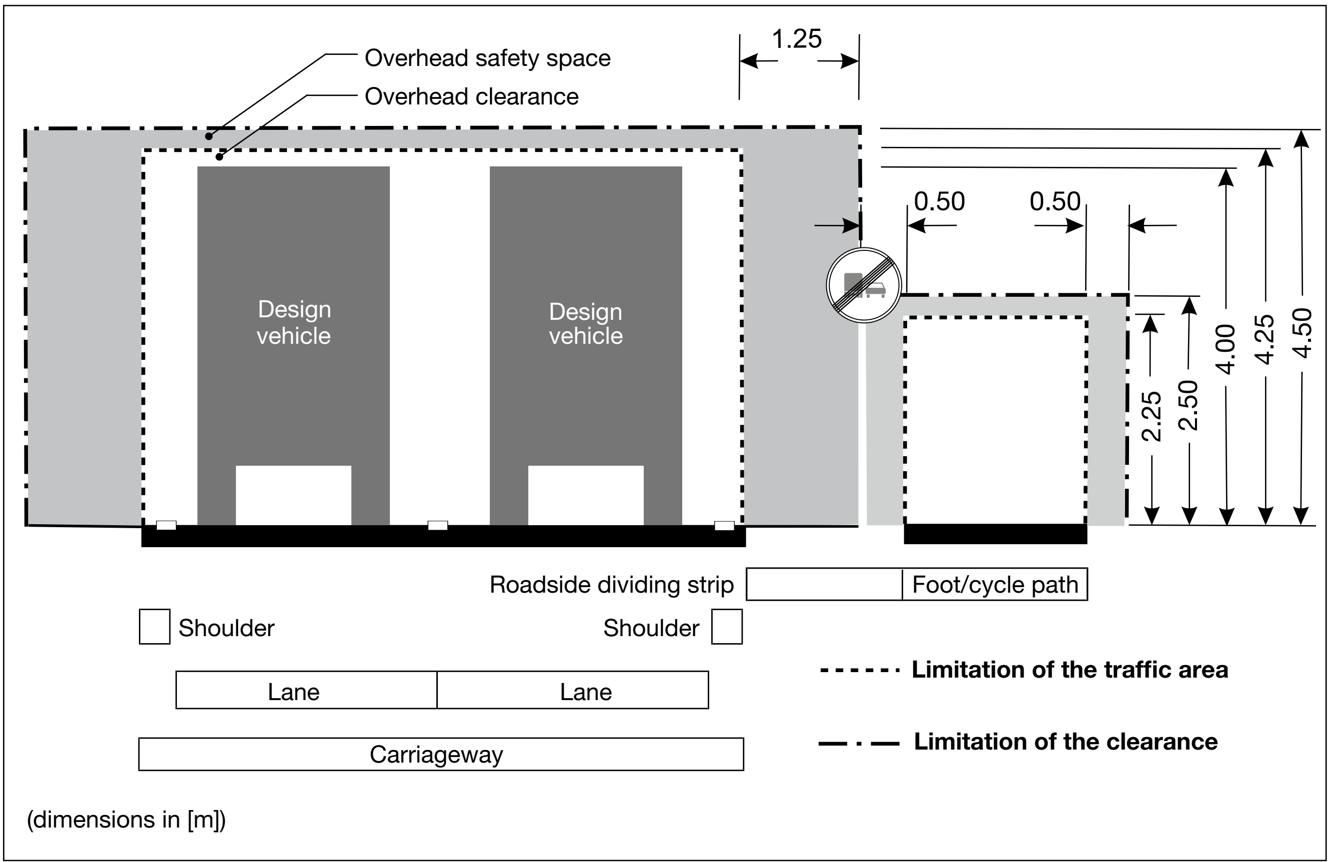


Figure 2: Basic dimensions for traffic space and clearances

The width of the **traffic space** for **cycle- and pedestrian traffic** is generally 2.50 m. The traffic space height is 2.25 m.

The **clearance** comprises the traffic space and the upper and lateral safe stand-off distances. The lateral limitations of the clear space are vertical to the lane.

The width of the **lateral safety clearance of lanes** is 1.25 m. This measurement may be reduced by 0.25 m if the maximum speed is limited to 70 km/h. On central reservations of dual carriageway roads the lateral safety width is 1.00 m.

The clearance has to be kept from solid obstacles. Traffic sign posts may stand on the border of the clearance. Safety installations and easily deformable parts of traffic control installations may project into the clear space and up to 0.50 m into the traffic space. In the case of safety installations this measurement may be reduced in justified exceptional circumstances to 0.25 m. Kerbs may project into the clear space up to the limit of the traffic space.

The measurement of the **upper safety clearance of lanes** is 0.25 m. The **height clearance** is 4.50 m. An increase may be required to enable the superstructure to be renewed with above ground building.

The width of the **lateral safety clearance** of **footpaths** or **cycle paths** is 0.50 m. The height of the **upper safety clearance** is 0.25 m. The height clearance is 2.50 m.

The **clearance** of **footpaths** or **cycle paths** shall be kept clear of fixed obstacles (e. g. buildings, fences, walls, traffic signs and trees). Traffic signs may project into the clear space up to the limit of the traffic space.

4.2.3 Component parts of the standard cross-section

The **carriageway** consists of the lanes, the shoulders and in some cases the technical central reservations.

Lanes, which are regularly used by heavy goods traffic, are 3.50 m wide. Overtaking lanes, since they are not regularly used by heavy goods traffic, are 3.25 m wide.

Shoulders serve to stabilise the road construction and accommodate carriageway boundaries. They are 0.50 m wide. This measurement is increased to 0.75 m in three lane road sections to increase the space for parking highway maintenance vehicles.

Kerbs shall be avoided where possible. If this is not possible in justified exceptional circumstances, their standard height shall be 0.12 m and 0.15 m on structures. The maximum measurement is 0.20 m and 0.25 m in tunnels. The height is limited to 0.07 m upstream from traffic-stopping systems.

Outside structures, according to “Guidelines for the design of Motorways: Drainage” (REwS) extensive leaching of water from the road surface via the embankment or via the **grassed channels** is desirable. If this is not possible, the road surface water should be drained collectively. Open gutters on rural roads in the form of **kerb, drainage or gravel channels** are suitable. They are in principle placed next to the carriageway at the expense of the verge and/or of the central reservation.

Central reservations are divided into structural central reservations and technical central reservations. They are used to separate the directions of travel in the road cross-section.

Structural central reservations in dual carriageway roads separate the carriageways for opposite travel directions and accommodate traffic restraint systems, traffic signs and anti-dazzle systems. They are generally 2.50 m wide and not usually planted. They may need to be designed to accommodate drainage systems, installations (e.g. supports for overpassing structures) and traffic restraint systems (safety barriers) as well as highway maintenance.

Technical central reservations on the EKL 1 roads separate the directions of travel on a carriageway. They are 1.00 m wide including lane boundaries and should by visually highlighted by a striking coloured surface design (see also section 7.2). The separation of the directions of travel may be supported by the installation of technical equipment such as small guide beacons (Reference 605 StVO).

Verges serve to accommodate system elements (traffic signs, guidance systems and traffic restraint systems) and act as working areas for the highway operating services. Verges must be strong enough to carry merging traffic and operating personnel for traffic safety reasons. Hard shoulders are 1.5 m in width. In some sections they can be reduced to 1.00 m along with 2.00 m wide ditches.

4.2.4 Footpaths and bicycle paths

Footpaths and bicycle paths alongside carriageways are generally designed as combined foot/cycling paths for two way traffic on one side of the road (reference 240 StVO) (Figure 3). They are 2.5 m in width.

Footpaths and bicycle paths alongside carriageways should be planned using the natural terrain – if necessary at varying distances from the carriageway. The position should be selected such that cyclists are not unreasonably dazzled by motorised traffic. The roadside dividing strip should be at least 1.75 m wide. Depending on the traffic load, the foot-and cycle paths designed to the specifications of the “Guidelines for Passive Protection on Roads using Vehicle Restraint Systems” (RPS) should take into account vehicle restraint systems. Verges next to footpaths and cycle paths are 0.50 m wide. In justified exceptional circumstances (e. g. in the case of kerbs) the width depends on the lateral safety clearance between the carriageway and the foot/cycling path.

The width of footpaths and cycle paths on bridges is regulated in “Code Drawings for Civil Engineering Structures” (RiZ-ING).

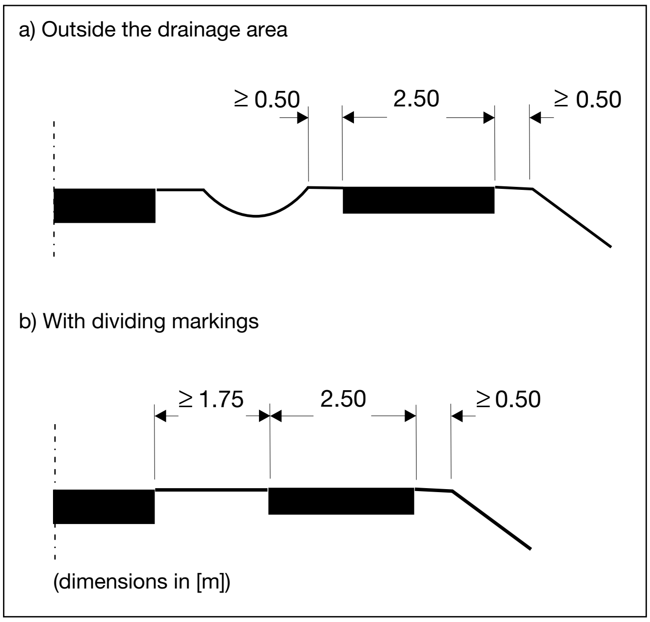


Figure 3: Position and dimensions of a joint foot/cycling path

4.2.5 Slopes

Slopes are designed according to Figure 4.

The slope gradient is generally 1: n for embankments and cuttings is generally 1: 1.5.

A different slope gradient may be required

- for geotechnical reasons
- for integration of the highway into the landscape
- to avoid safety systems
- for Federal Imissions Control reasons
- for avoidance of snowdrifts or
- for accommodation of supply lines.

In the case of high slopes (h ≥ 5.00 m) load-bearing berms may be needed to facilitate maintenance.

The transition between a slope and the terrain is rounded.

Drainage ditches are formed as per REwS. In the case of embankments and cuttings these shall be accommodated at the foot of the slope in natural soil. At the transition between a cutting and an embankment the ditch, due to its different arrangement in the cutting and/or on the embankment should be tapered out.

4.3 Standard cross-sections

A single-lane standard cross-section is defined for each design class. Should the HBS test (see also section 4.4) indicate that the single-carriageway standard cross-section does not guarantee sufficient traffic flow quality, a dual carriageway standard cross-section may

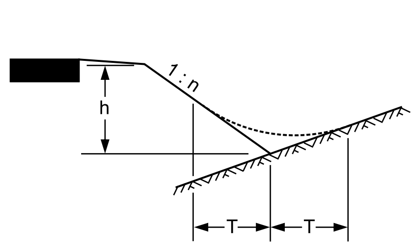
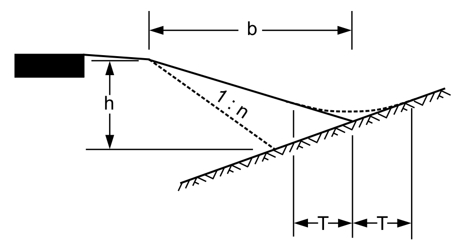
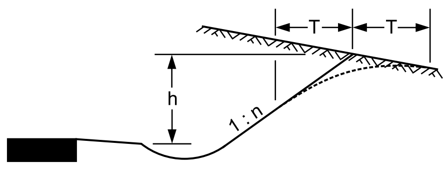
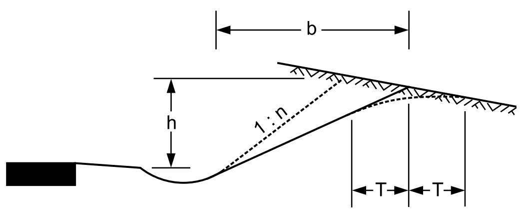
	Slope height h	
	h ≥ 2.00 m	h < 2.00 m
Embankment		
Cutting		
Slope	Standard slope gradient1 in n = 1 in 1.5	Standard slope width b = 3.00 m
Tangential length of the rounding T	T = 3.00 m	T = 1.5 h

Figure 4: Standard formation of slopes

be used (see also section 3.3) in the course of otherwise single-carriageway roads on one or more consecutive network sections (up to an overall length of around 15 km).

The standard cross-sections may be augmented by footpaths and cycle paths according to Figure 3.

Standard cross-section for roads of EKL 1

The **standard cross-section RQ 15.5** (Figure 5) is a single carriageway cross-section with overtaking lanes added alternately in both directions of travel, thus comprising three lanes (continuous three lane road). Therefore for each direction of travel, up to around 40 % of the route has technically secured overtaking opportunities. The two directions of travel are separated by a technical central reservation (see also section 7.2).

The RQ 15.5 should be operated as a road restricted to motor vehicles (motor road).

Rules for the arrangement and formation of the overtaking sections are given in section 4.5.2. Emergency lay-bys shall be placed in the single lane sections. Appendix 2 contains instructions on the location and formation of the emergency lay-bys.

Standard cross-section for roads of EKL 2

The **standard cross-section RQ 11.5+** (Figure 6) is a single carriageway with a two-lane cross-section, which is widened by an additional overtaking lane to 3 lanes in individual sections for one direction of travel (temporarily three lane road). The overtaking shall be concentrated in these technically secure sections to prevent as far as possible overtaking in sections where the lane for the oncoming traffic will be used.

The two directions of travel in the three lane sections shall always be technically separated by two lane limit markings (continuous double line). This also applies for two-lane sections where overtaking is to be prohibited due to particular risks (e.g. insufficient overtaking sight distance). In the remaining sections, both directions of travels are separated by a double centreline (dashed line). The dimensions of the cross-section are not changed.

There should be an adequate succession of overtaking sections to create overtaking opportunities for approximately 20 % or more of the road section in each direction of travel. Higher proportions are preferable for traffic safety and traffic flow. If it is impossible to create a sufficient number of overtaking lanes, it should be checked where in the two-lane sections, particularly with sufficient sight distance, overtaking should be allowed with the use of the oncoming traffic lane or should be prohibited in sections with insufficient sight distance, this should be prohibited (see also. section 5.5.4).

Rules for the arrangement and formation of the overtaking sections are given in section 4.5.3. Emergency lay-bys may be effective.

Operation is as a motor road is appropriate. Traffic not approved for such rural roads should be directed to a special travel network if possible. Cycle traffic on the carriageway shall be prevented in principle.

Standard cross-section for roads of EKL 3

The **standard cross-section RQ 11** (Figure 7) is a single carriageway two-lane cross-section. Both directions of travel shall be separated from one another by a single lane marking line where overtaking with use of the on-

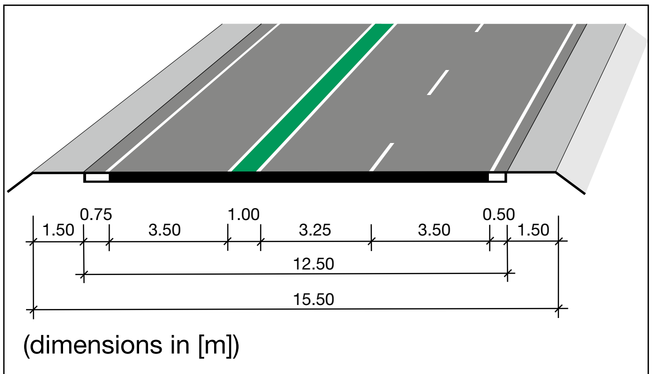


Figure 5: Standard cross-section RQ 15.5

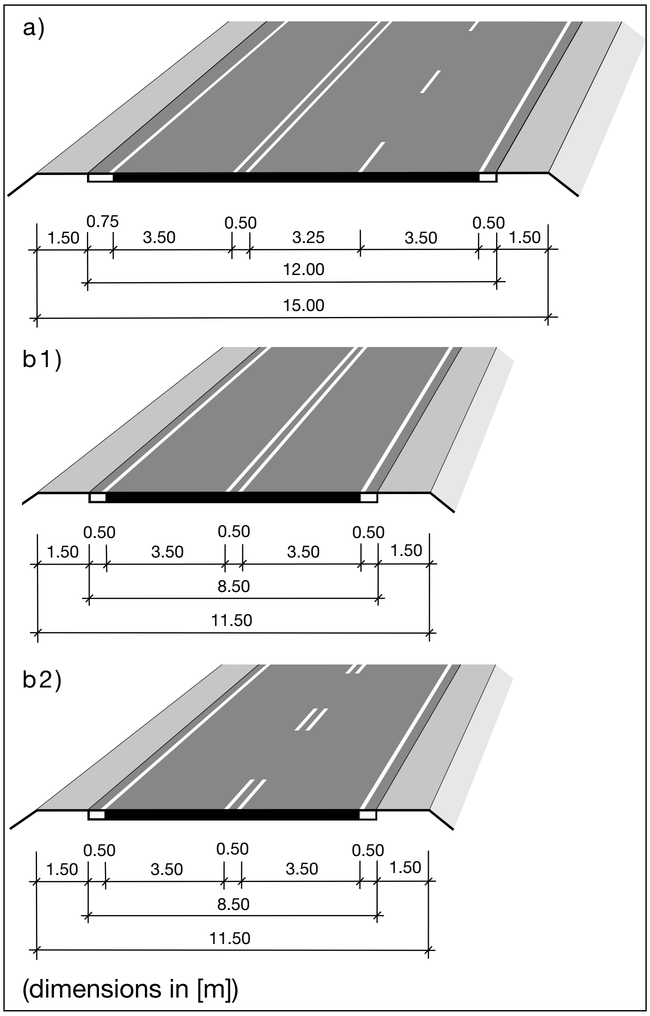


Figure 6: Standard cross-section RQ 11.5+
(a) with overtaking lanes
(b1) without overtaking lanes with lane limiter
(b2) without overtaking lanes with lane marking

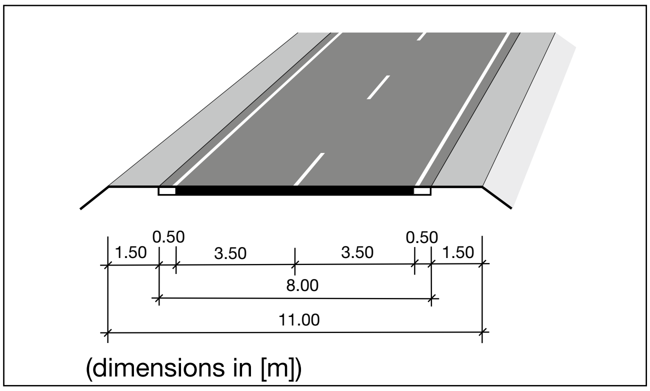


Figure 7: Standard cross-section RQ 11

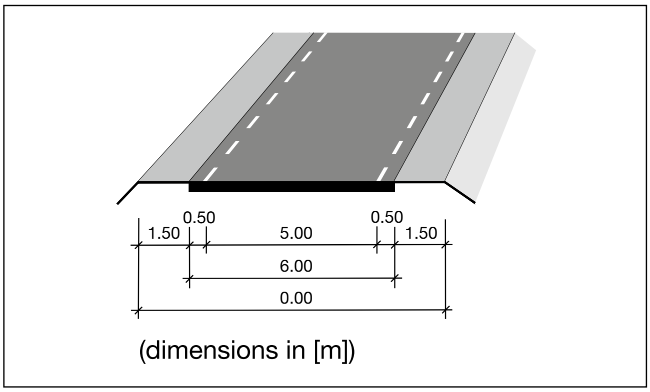


Figure 8: Standard cross-section RQ 9

coming traffic lane should be allowed. Where the use of the oncoming traffic lane is to be prohibited on safety grounds, lanes should be separated by a single lane limit line.

In justified exceptional circumstances where the density of heavy goods traffic is low (up to 300 vehicles/24h) the lane width may be reduced. In this case it should be checked whether such a reduction of the lane would result in safety disadvantages[2)]. Maintenance measures with continuation of the traffic may then no longer be possible. Even if the lane width is reduced, the width of the shoulders must be unchanged at 0.50 m.

Standard cross-section for roads of EKL 4

The **standard cross-section RQ 9** (Figure 8) is a single-carriageway cross-section without a marking for separation of the two directions of travel.

The cross-section is generally considered for traffic loads of up to 3,000 vehicles/24h and heavy goods traffic loads of up to 150 vehicles/24h.

Lane indicating lines are marked on both sides of the fixed width at a distance of 0.50 m. The dash-space ratio is 1: 1 (1 m dash /1 m space).

[2)] With the average cost rates it should be assumed that in the case of lanes narrower than 3.50 m the additional accident costs during the service life, even in very light traffic, will exceed any savings in building and operating costs.

The absence of central lane marking indicates to the driver that in the event of encounters with heavy goods vehicles the width between the two lateral lane markings is inadequate and therefore the entire fixed width may have to be used.

Standard cross-section for roads of EKL 1 to EKL 3 with very high traffic demand

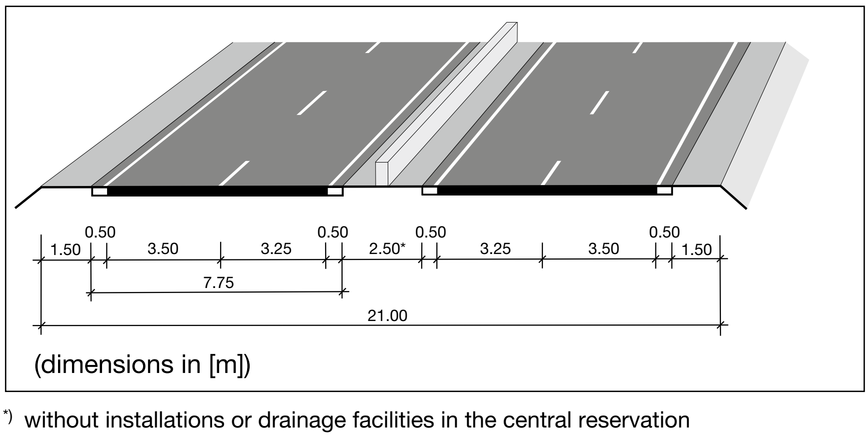
The **standard cross-section RQ 21** (Figure 9) is a dual carriageway cross-section.

This cross-section is considered for traffic densities of up to 30,000 vehicles/24h however for short network sections only (up to around 15 km) in the course of otherwise single carriageway roads.

The cross-section should be operated as far as possible as a motor road. Non-motorised traffic shall be basically excluded.

For reasons of traffic safety, emergency lay-bys shall be provided in each carriageway direction. Appendix 2 contains instructions on the location and formation of the emergency lay-bys.

The design width of the structural central reservation assumes that no installations or drainage facilities need be accommodated in the central reservation. Otherwise the central reservation must be widened. The design width furthermore places special requirements on the vehicle restraint systems (safety barriers).



*) without installations or drainage facilities in the central reservation

Figure 9: Standard cross-section RQ 21

4.4 Verification of the traffic flow quality of the standard cross-section

Based on the single carriageway standard cross-section for the design class according to Table 7 (see also section 4.3) including any planned overtaking sections, on the basis of the HBS method it must be checked whether the intended standard cross-section guarantees an adequate traffic flow quality.

If, according to HBS, it is indicated that the traffic flow quality on the single carriageway standard cross-section, planned according to Table 7, is inadequate, it should be checked whether the traffic flow quality on EKL 3 roads could be improved by changing the lane markings or by the addition of overtaking lanes, particularly on gradients.

In the single carriageway standard cross-section planned in accordance with regulations for EKL 2 roads it should be checked in such cases whether the target could be achieved by increasing the density of overtaking lanes.

If such a planning change does not achieve the desired traffic flow quality level according to HBS, the road must be designed to the requirements of the next higher design class. Should the deficits in the traffic flow quality only occur on a short length, as an alternative to a plan involving the next design class up it should also be checked whether a dual carriageway standard cross-section is expedient in this section.

Should the proof in accordance with the HBS indicate that the traffic flow quality on the single carriageway standard cross-section of EKL 1, planned according to Table 7, is inadequate, a dual carriageway cross-section should be planned. If this requirement is confined to a short stretch of an otherwise single carriageway road (up to around 15 km), the dual carriageway standard cross-section in accordance with RAL shall be planned (see also section 3.3).

If there is a need for a dual carriageway standard cross-section of a greater length or if the traffic density is more than 30,000 vehicles/24h, the dual carriageway cross-section shall be planned according to the specifications of RAA.

If the high traffic demand for a LS IV-category road requires a higher quality standard cross-section than RQ 9, as specified in Table 7, the road should be planned according to the specifications of EKL 3 due to the fundamentally different layout.

Furthermore, it should be checked whether the RIN targets with respect to the desirable car travel speed for the road category are achieved with the cross-section planned for the design class, including the relevant intersections on the individual network sections of the planned road.

If this is not the case in one or more network sections based on the distances or the traffic rules on at-grade intersections, the average car travel speed can be improved by the addition of further overtaking lanes, particularly on gradients, or by increasing the intersection spacings and or by selecting another type of intersection.

4.5 Overtaking lanes

4.5.1 Principles

Overtaking lanes are planned for single carriageway cross-sections on the basis of traffic safety and traffic flow quality. By the temporary allocation of a second travel lane in any one direction, overtaking should be possible to separate fast from slow traffic without using the oncoming traffic lane. The criteria for use, as well as the arrangement (location and length of overtaking sections), are determined by the design class. This also applies for the configuration of the junction areas. The geometric design of the widening and narrowing and the traffic rules governed by markings and signs are sometimes independent of the design class (see also Appendix 1).

4.5.2 Roads of design class EKL 1

4.5.2.1 Usage criteria

Constantly available overtaking lanes, which regularly swap between the two directions of travel are a distinguishing element of single carriageway roads in class EKL 1. The location and length of the overtaking lanes is determined by the link with the rest of the road network and the topography. The overtaking lanes should be distributed evenly as far as possible over the length of the road section.

The overtaking sections shall be long enough to satisfy the overtaking requirement. The single lane sections however may not be so long that the overtaking prohibition is ignored. The overtaking sections shall therefore be at least 1,000 m long, with 1,200 m is desirable and the maximum is 2,000 m.

EKL 1 roads do not require separate verification of the traffic volume requirements for overtaking lanes.

4.5.2.2 Arrangement

In EKL 1 roads the sections with overtaking lanes follow immediately after one another for each direction of travel. The widening of the carriageway in one direction of travel therefore coincides with the narrowing of the carriageway in the other direction of travel which means that the assignment of the lanes in any one direction changes at any one of these points. Narrowing from 2 to 1 lane is a "critical" changing point. Widening from 1 to 2 lanes is a "non-critical" changing point.

The following applies for the arrangement of overtaking lanes:

– Changing points should be in areas of good visibility with elongated lane guidance and not in, or near, areas of poor water drainage and or potentially slippery areas (e.g. on bridges).

- overtaking lanes should not be placed immediately before the end of a section if the road characteristics change substantially at that point.

Overtaking lanes on hilly or mountainous terrain should be as far as possible arranged on an ascent.

Emergency lay-bys shall be provided in the single lane sections. Instructions on the location and formation of emergency lay-bys are contained in Appendix 2.

4.5.2.3 Intersections

EKL 1 design class roads are planned as standard with grade-separated/partial grade-separated intersections (see also section 6). In this case the following applies:

- A section with an overtaking lane can be designed by adding to the lane from a merging lane. This kind of lane addition is not recommended in areas of a high proportion of heavy goods traffic or on longitudinal gradient because it makes overtaking of heavy goods vehicles difficult. These kinds of introduced overtaking sections should also therefore not be implemented at minimum lengths. The marking between the two lanes should be formed over a length of 40 m.
- The right lane of an overtaking section should not be converted into a diverging lane by means of lane subtraction.
- If the intersection areas in justifiable exceptions cannot be combined with non-critical changing points, the overtaking lane passing through the intersection upstream from the diverging lane must be at least 800 m long and at least 600 m downstream from the merging lane. An intersection in the vicinity of an overtaking lane can therefore have a slightly larger section length than specified in sections 4.5.2.1. In the case of an intersecting overtaking lane it is expedient to indicate the technical central reservation in the region of the merging lane by structural elements such as small guide beacons (reference 605 StVO).

4.5.3 Roads of design class EKL 2

4.5.3.1 Usage criteria

The temporary widening of the two-lane RQ 11.5+ cross-section by an overtaking lane is a distinguishing feature of EKL 2 roads. In order to concentrate the overtaking demand to overtaking sections, their number and length should be great enough that safe overtaking is possible in each direction of travel over at least 20 % of the road section. A greater percentage improves traffic safety and the traffic flow.

Overtaking behaviour is improved when the start of overtaking lanes are recognised in good time with the sign 542-10 StVO (lane addition sign) in combination with the additional sign 1004-35 (“2 km”).

EKL 2 roads do not require separate verification of the traffic warrant for overtaking lanes due to insufficient traffic flow quality. It must be checked nevertheless whether the desired traffic flow quality is achieved in accordance with the HBS method and the combined target specifications of RIN for the desired car travel speed for the road category with the cross-section including the planned overtaking lanes. Further overtaking lanes may be beneficial.

4.5.3.2 Arrangement

The section should be evenly distributed as far as possible and road users should be notified in good time. The overtaking lanes may also be shorter than in the case of EKL 1 roads, particularly in low traffic demand. However they should not be shorter than 600 m and generally not longer than 1,500 m.

Otherwise the definitions in section 4.5.3.1 apply substantially for the location of overtaking lanes. Note in addition:

- As far as possible, overtaking lanes on hilly or mountainous terrain should be arranged on the ascent slope. Should two overtaking lanes overlap at the top, check first whether one of the overtaking lanes (generally the one with the lessor longitudinal gradient) can be moved or omitted altogether to permit the continuation of the other. If this is not possible or is impractical, in the resulting four-lane section the separation of directions of travel should be clearly and physically indicated by control equipment such as small guide beacons (reference 605 StVO).
- Overtaking lanes should not be placed upstream from urban through-roads nor before the end of an extension if the road characteristic substantially changes at that point.
- Overtaking lanes should not be placed on sharp right-hand bends due to the danger of collision with oncoming traffic.

4.5.3.3 Intersections

Roads in the design class EKL 2 are generally designed with partially at-grade intersections or with at-grade intersections, which are operated with traffic signals. In this situation the following applies:

- Overtaking lanes should be placed outside intersections as far as possible.
- Overtaking lanes should never end in or just before the intersection. The left-turn lane is then placed downstream from the prohibited area at the end of the overtaking lane.
- Overtaking lanes may start within the intersection in justifiable exceptional circumstances. In this case the widening should take place in the approach to the intersection as far as possible.

4.5.4 Roads of design class EKL 3

4.5.4.1 Usage criteria

Overtaking lanes are not a standard element of EKL 3 roads. In the case of severe overtaking pressure, particularly due to high traffic demand or on ascents, individual overtaking lanes maybe beneficial. These can be designed in the same way as overtaking lanes on EKL 2 roads.

The precondition for creating an overtaking lane on EKL 3 roads is that in accordance with the HBS method the desired traffic flow quality is not provided on the RQ 11 two-lane standard cross-section or particular safety deficits exist. It must be clarified whether the creation of an overtaking lane is more economical than an adjustment of the vertical and/or horizontal alignment. It should be furthermore checked whether the target specifications of RIN with respect to the desired average car travel speed will be achieved without an overtaking lane.

On the basis of a verification of the traffic flow quality according to HBS, in some cases an overtaking lane may also be required on long descending gradients.

4.5.4.2 Arrangement

An overtaking lane should be at least 600 m long.

An overtaking lane in the region of an ascending gradient should start as soon as possible before the section with the greatest longitudinal gradient and should continue beyond the crest.

Should in exceptional cases, two overtaking lanes overlap at the crest of a hill, the requirements in section 4.5.3.2 apply.

4.5.4.3 Intersections

EKL 3 roads are designed with at-grade intersection (with and without traffic signals) and/or roundabouts. The following applies:

- Overtaking lanes should be placed outside intersections as far as possible. If this is not possible or is impractical, the intersections should be operated with traffic signals.
- Overtaking lanes should never end in or just before the intersection. The left-turn lane is then placed downstream from the prohibited area at the end of the overtaking lane.
- If an overtaking lane starts in the region of an intersection with a traffic light system, the widening as far as possible should take place in the approach to the intersection.
- Should an overtaking lane start in the region of an at-grade intersection without a traffic light system, the overtaking lane should start beyond the prohibited area for oncoming left-hand turners.

4.6 Cross-sections for building structures

In the region of built structures, the cross-sections shall substantially agree with those of the adjacent road sections. Special specifications however apply for the individual cross-section components for cross-sections in the region of bridges and tunnels. Figure 10 shows the standard cross-sections for rural roads on bridges.

The drainage on bridges generally occurs within the minimum 0.50 m wide shoulder. In the case of three-lane EKL 1 roads and three-lane sections of EKL 2 roads, the shoulder for the single lane traffic direction is increased to 1.25 m in the vicinity of bridges.

When planning bridges for dual carriageway roads with a separate superstructure, the central reservation should generally be increased to 3.00 m. Note that, dependent upon the vertical and horizontal alignment there may be a height difference due to the transverse gradients between the central parapets which limits the suitable traffic restraint system (safety barrier system).

If this height difference cannot be avoided by re-alignment, a wider central reservation may be required.

Vehicle restraint systems (safety barriers) in the vicinity of built structures are designed according to the RPS and the corresponding reference drawings. A width of 2.50 m is required between vehicle restraint systems and the structural railings, where foot/cycle paths are provided (see also RiZ-ING (engineer's reference drawings). Otherwise in accordance with the regulations of the RPS an emergency footpath of width at least 0.75 m is required.

Tunnels are long enclosed underground traffic crossings (L > 80 m), but also partly covered underground or over ground traffic routes, over ground road enclosures and gallery structures. Figure 11 shows the standard cross-section for rural roads in tunnels.

The standard cross-section RQ 11t is used for all single carriageway roads in tunnels (RQ 15.5, RQ 11.5+, RQ 11 and RQ 9). In the case of roads with standard cross-sections RQ 15.5 and RQ 11.5+ the overtaking lanes should end well before the tunnel.

Tunnels in the course of dual carriageway roads (RQ 21) are planned in accordance with the RAA specifications.

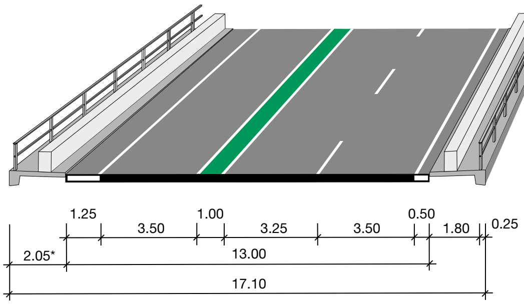
Due to the substantially higher building and operating costs, the dimensions in the tunnel are less than the standard cross-sections of open-air roads. Emergency footpaths in tunnels are 1.00 m wide.

The required height clearance in the tunnel is 4.50 m.

Table 10: Additional width in the tunnel with square cross-section depending on the transverse crossfall

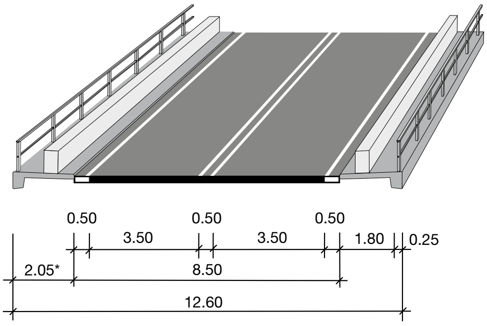
Transverse crossfall q [%]	**Additional width of hard shoulder** [m]
> 3.5 to 4.5	0.05
> 4.5 to 5.5	0.10
> 5.5 to 6.5	0.15
> 65	0.20

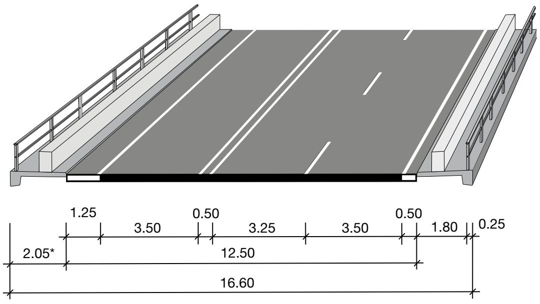
It is generally assumed that the lateral border of the traffic space runs vertically upwards. If the carriageway is cambered towards the tunnel wall, tall vehicles may pro-



EKL 1

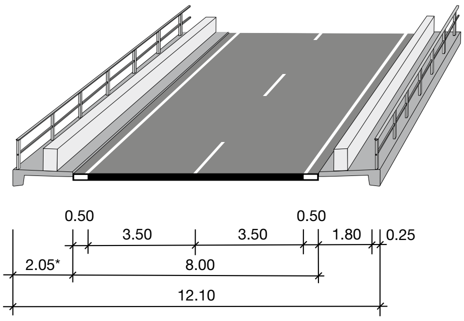
RQ 15.5B





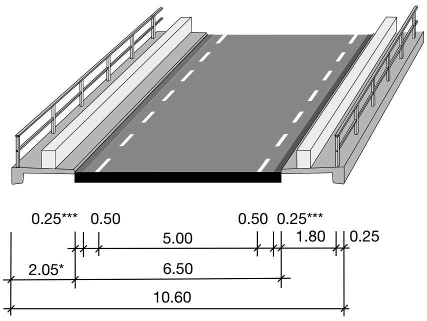
EKL 2

RQ 11.5B



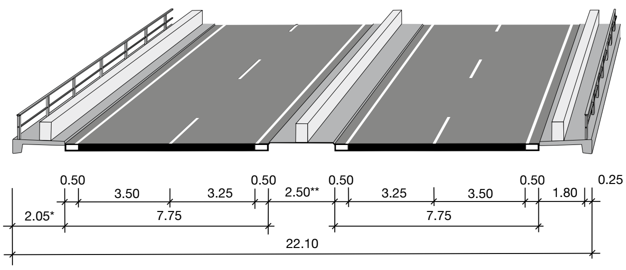
EKL 3

RQ 11B



EKL 4

RQ 9B



EKL 1 – 3

RQ 21B

(dimensions in [m])

*) depending on the selected system of safety equipment, the width of the parapets and therefore the overall width of the bridge may change according to RiZ-ING.

**) depending on the selected system of safety equipment and the height differences when designing superstructures with a saw tooth cross-section, the width of the parapets and therefore the overall width of the bridge may change according to RiZ-ING.

***) additional safety strips

Figure 10: Standard cross-sections on bridges

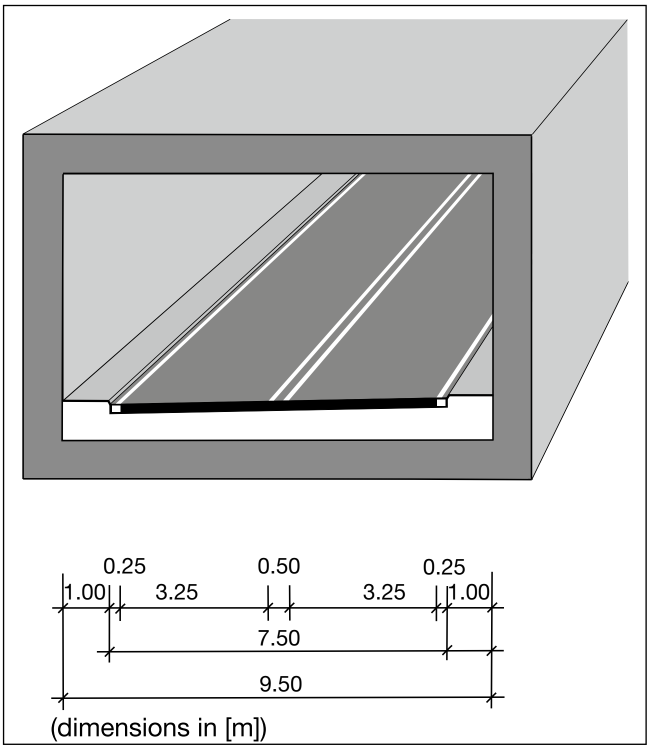


Figure 11: Standard cross-section in tunnels RQ 11t

ject into the clear space over the emergency footpath. If the lateral camber q is more than 3.5 % the hard shoulder should therefore be widened according to Table 10.

In the case of curved cross-sections it may be economical to tilt the surface of the emergency footpath in line with the carriageway camber. The lateral limit lines can then be assumed to be perpendicular to the carriageway surface. In this case there is no need to widen the traffic space.

In the planning and design of tunnels, the "Guidelines for the Equipment and Operation of Road Tunnels" (RABT and EABT) shall be observed.

4.7 Consideration of other types of traffic

In the case of EKL 1 and EKL 2 roads, cycle traffic should not be permitted on the carriageway. In the case of EKL 3 roads cycle traffic may be allowed on the carriageway. In the case of EKL 4 roads cycle traffic on the carriageway is the standard solution.

If it is found during planning that in future there will be a regular demand for the use of parts of an EKL 3 highway as a cycle link, it must be checked whether the cycle traffic may travel on the carriageway or whether for reasons of traffic safety it should be directed to a foot/cycling path alongside the carriageway.

This type of check shall consider the density and speed of the car traffic, the proportion of heavy goods traffic and the visibility of the road along with the density of cycle traffic and the proportion of cyclists requiring protection.

Table 11 gives guideline values for this kind of test at a maximum permissible driving speed for cars of 100 km/h, a heavy goods traffic proportion around 10 %, and extended routing and a low proportion of cyclists and pedestrians requiring protection.

Table 11: Approximate values for usefulness of a joint foot/cycling path on roads of EKL 3

average daily vehicle traffic [vehicles/24h]	**daily load in cycle and pedestrian traffic** [C and P/24h]
2,500 – 4,000	> 200
4,000 – 7,000	> 100
7,000 – 10,000	> 50

In the case of vehicle loads of over 10,000 vehicles/24h cycle traffic is not generally permitted on the carriageway for safety reasons.

Cyclists and pedestrians may be directed alongside the carriageway on two-way paths (see also section 4.2.4), at a distance from the road or, also in suitable cases, on other parts of the road network.

Planning and design instructions for consideration of cycle traffic are contained in the "Recommendations for Cycle Traffic Installations" (ERA).

Planning and design instructions for consideration of public local transport are contained in the "Recommendations for Public Transport Installations" (EAÖ). These regulations apply substantially for urban roads. Bus traffic is allowed on rural roads appropriately.

5 Alignment

5.1 General aspects

The design of the road in profile, site plan and longitudinal section is carried out according to the principles of spatial alignment (see also section 5.4). The overlap of the design elements in the site plan and longitudinal section should be checked to ensure that the sequence of spatial elements guarantees adequate recognition of the road progression and a satisfactory overall visual impression of the road structure. Where doubt exists in any particular area, these sections shall be visualised in perspective images and/or sequences of perspective images.

Particular attention shall be directed to the transitions between the planned and the adjacent road sections.

Engineering structures shall be added to the spatial carriageway depiction as they occur taking into account the costs and constructive perspectives.

The design elements shall be decided on the basis of safety audits, driving dynamic calculations and empirical findings.

Requirements for alignment of carriageway-accompanying foot/cycle paths are included in the ERA.

5.2 Horizontal alignment

5.2.1 Straights

Straights are well suited to level terrain and wide valleys. They align well with other linear structures such as railway lines, canals and building plot stockades, offer good visibility at intersection areas and provide overtaking opportunities on two-lane roads

Long straights (above all with constant longitudinal gradient) have disadvantages as follows:

– They are difficult to place in a varying topography,

– They make distances and speeds of oncoming vehicles and vehicles in front and behind difficult to judge

– There is increased headlight dazzle at night.

Therefore the length of straights should be limited to a max. LG = 1,500 m. In individual cases longer straights may be expedient to fit the environment or if conditions require it.

To achieve safe transitions, the radii adjacent to the straights shall be at a suitable ratio to the length of the straights. In the process both directions have to be analysed (cf. section 5.2.2).

5.2.2 Circular curves

In terms of size (radii) and sequence of circular curves should permit consistent travel at the planned speed for the design class. The circular curves should also be in harmony with the topography.

Table 12 shows recommended values for circular curve radii R. Larger radii may be selected if the road fits better into the landscape or is better suited to the local circumstances. It should be noted however that an extended alignment in design classes EKL 3 and EKL 4 may suggest overtaking opportunities in areas in which safe overtaking is not possible. Large radii may also affect the overall impression of this road type.

In order for motorists to perceive circular curves as independent elements within the curves, these should feature minimum lengths as given in Table 12.

Table 12: Recommended radii and minimum lengths of circular curves

Design class	**Radius ranges R** [m]	**Minimum length of circular curves min L** [m]
EKL 1	≥ 500	70
EKL 2	400 – 900	60
EKL 3	300 – 600	50
EKL 4	200 – 400	40

For reasons of traffic safety, the radius of successive circular curves should be similar. Figure 12 shows the permissible ratio of radii for adjacent circular curves. The ratio of the successive radii should be in a useful range at least. The good range should be attempted in roads of EKL 1 to EKL 3.

In case of justified exceptions, the recommended radii can be reduced by up to a maximum of 15 per cent in case of EKL 2 to EKL 4 roads. The prerequisite is, however, that ratio of successive radii is in a good range.

Accompanying traffic measures have to be established, if, in case of justified exceptions, the ratio of successive radii according to Figure 12 has been chosen to be outside the useful range, On EKL 1 to EKL 3 roads, for example, chevrons are used to assist the visual approach to curves (sign 625 StVO), potentially supplemented by the curve hazard sign (sign 103 StVO). In individual cases such measures are recommended for EKL 4 roads as well. An increased probability for accidents occur when there are unfavourable ratios of the radii of the successive circular curve. In this case the use of such traffic control equipment has also to be evaluated. When such traffic control equipment is used, a check on whether a restriction of the permissible maximum speed is required.

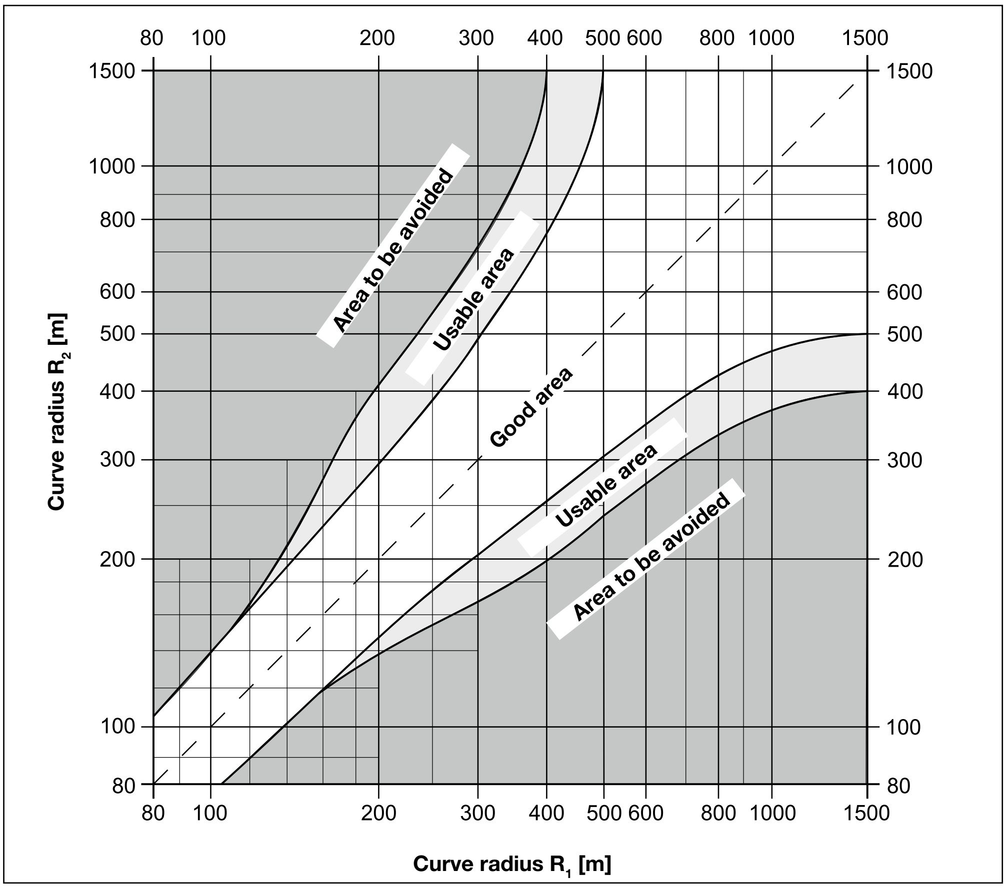


Figure 12: Relationship of successive radii

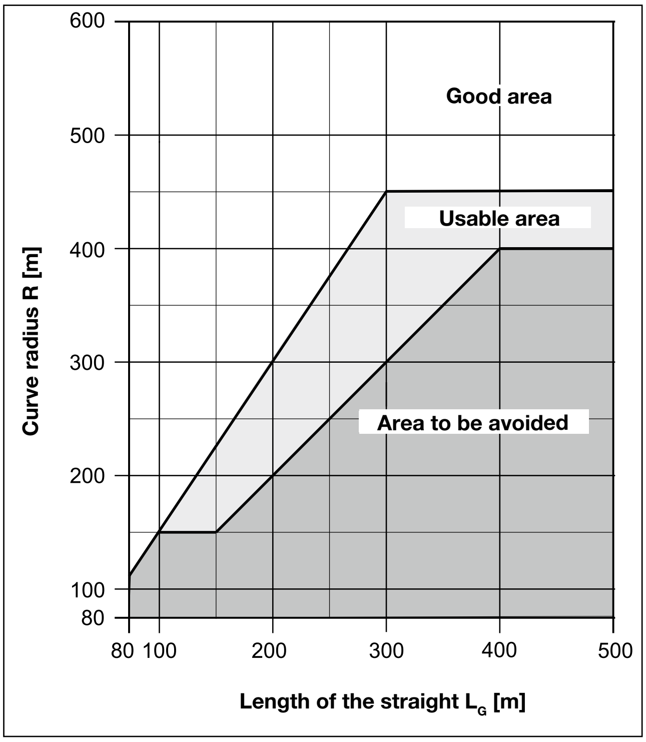


Figure 13: Radii following straights

Figure 13 shows the permissible minimum radii of circular curves following straights. The radii of circular curves following straights should be in a useful range at least. The "good range" should be attempted in roads of EKL 1 to EKL 3. In case of straights with a length of LG < 300 m, it has to be ensured, in addition, that the two successive circular curves have radii that are within the required range of the radius relation shown in Figure 12.

Straights between curves in same direction (broken back curves) should be avoided. If this is not possible, their length in EKL 1 to EKL 3 roads shall be at least 600 m and at least 400 m in EKL 4 roads. After such straights, the conditions in Figure 13 have to be observed as well.

5.2.3 Transition curves

As a matter of principle, transition curves are required between straights and circular curves.

In exceptional cases to be justified, transition curves can be dispensed with, if the differences between two elements are insignificant. A transition may be waived in a transition from a straight section to a radius with R ≥ 1,000 m or a S-type clothoid (reverse clothoid) between two radii with R ≥ 2,000 m.

Transition curves are designed as clothoids (cf. Enclosure 3). The following applies:

$$A^2 = R \cdot L \quad (1)$$

A [m] = Clothoid parameter
R [m] = Radius at the end of the clothoid section
L [m] = Length of the clothoid from the tangent alignment to Radius R

The clothoid parameters should be within the range

$$\frac{R}{3} \leq A \leq R \quad (2)$$

In this respect, the A/R ratio tends to be in the upper permissible area in case of small radii, in the lower permissible range for large radii. Clothoid parameter A < 100 m should be avoided, if possible.

A clothoid parameter A ≥ R/3 ensures that the transition curve has a visually satisfactory appearance (deflection angle of clothoids t > 3.5 gon or 3.15°).

Figure 14 shows the usual shapes of transition curves.

In case of flat curves (deflection angle of curves γ ≤ 10 gon or 9°) transition curves are not required. Such flat curves should be at least 200 m for EKL 1 and EKL 2 roads, at least 150 m for EKL 3 roads and at least 100 m for EKL4 roads. A crest clothoid can be shaped under the same operating conditions.

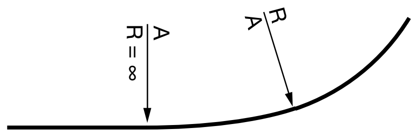
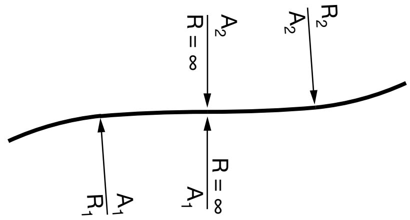
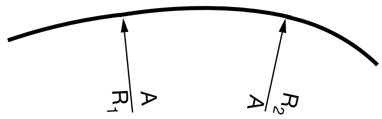
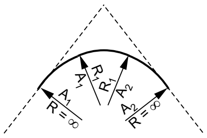
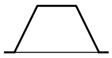
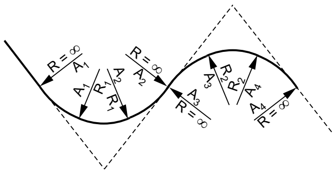
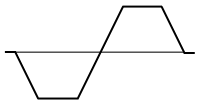
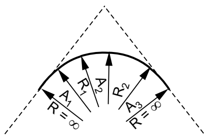
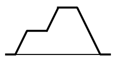
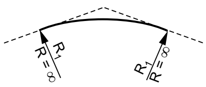
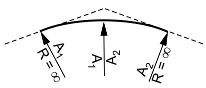
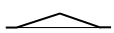
Connection	**Shapes**
Straight with circular curve	simple clothoids 
two circular curves	S-type clothoids 
	egg-shaped clothoids 

Figure 14: Shapes of transition curves

5.2.4 Site plan curves

The combination of the individual site plan elements with each other produces the following suitable site plan curves (Table 13).

Table 13: Site plan curves

Designation Image	Element sequence curvature band	Conditions of use	Evaluation
compound circular clothoid curve 	$R = \infty - A_1 - R_1 - A_2 - R = \infty$ 	They should be shaped symmetrically ($A_1 \approx A_2$). In case of unsymmetrical shapes the ratio should be $A_1 : A_2 \leq 1.5$.	very good
S-type clothoid 	$R = \infty - A_1 - R_1 - A_2 - A_3 - R_2 - A_4 - R = \infty$ 	The radius sequence should be determined as stipulated in section 5.2.2. Both branches of the S-type clothoid should have the same parameters ($A_2 \approx A_3$). In case of unsymmetrical shapes the ratio should be $A_2 : A_3 \leq 1.5$. Intermediate straights between the two branches of the S-type clothoid should not exceed the length $L_Z \leq 0.08 \cdot (A_2 + A_3)$ – Otherwise both curves are considered independent compound curves.	very good
egg-shaped curve 	$R = \infty - A_1 - R_1 - A_2 - R_2 - A_3 - R = \infty$ 	The circular curves are inside each other, are of different size, must not touch each other, and have to be concentric to each other. The radius sequence should be determined as stipulated in section 5.2.2. The deflection angle of egg-shaped curves should be at least ≥ 3.5 gon (3.15°).	good (observe the conditions of use)
flat curve 	$R = \infty - R_1 - R = \infty$ 	They are permissible only in small deflections (γ < 10 gon or 9°) and/or for circular curves with large radii. The curve length should not go below 200 m in EKL and EKL 2, 150 m in EKL 3 and 100 m in EKL 4. The transverse gradient should remain constant in the crest zone along a length of 60 metres.	satisfactory (observe the conditions of use)
crest clothoid 	$R = \infty - A_1 - A_2 - R = \infty$ 	They are permissible only in small deflections (γ < 10 gon or 9°) . They should be shaped symmetrically ($A_1 \approx A_2$). The curve length should not go below 200 m in EKL and EKL 2, 150 m in EKL3 and 100 m in EKL 4. The transverse gradient should remain constant in the crest zone along a length of 60 metres.	satisfactory (observe the conditions of use)

5.3 Vertical alignment

5.3.1 Longitudinal gradients

Small longitudinal gradients

- improve traffic safety,
- increase capacity and traffic quality,
- reduce operating costs and road user costs and
- cut emissions.

Longitudinal gradients s ≤ 4.0 % are advantageous.

More pronounced longitudinal gradients may, under some circumstances, permit

- better adaptation to terrain,
- less intervention in the environment and
- lower construction costs.

For traffic safety reasons the maximum longitudinal gradients set out in table 14 should not be exceeded.

Table 14: Maximum longitudinal gradients

Design class	**max s** [%]
EKL 1	4.5
EKL 2	5.5
EKL 3	6.5
EKL 4	8.0

If the maximum longitudinal gradient is exceeded in justified exceptional cases, the maximum resultant slope should not be above 10.0 % (see section 5.6.1).

In tunnels longer than 400 m the longitudinal gradient should not exceed 3.0 %.

In areas of at-grade intersections, small longitudinal gradients (s ≤ 4.0 %) should be targeted; longitudinal gradients s > 6.0 % should be avoided.

To avoid zones providing inadequate water drainage, in superelevation development sections a longitudinal gradient of s ≥ 1.0 % (better 1.5 %) shall be observed (see section 5.6.2). If this is not possible in justified exception cases, the minimum longitudinal gradient must be s = 0.7 %.

In unusual situations, if the carriageway is exceptionally bordered by kerbstones, all gutters should have a longitudinal gradient of at least s = 0.5 %. Otherwise drainage of the surface water must be assured by special technical measures (e.g. variable-angle channels).

On long bridges (clearance ≥ 100 m) and in tunnels a minimum longitudinal gradient of s = 0.7 % should be observed in order to ensure drainage. To avoid pumping installations, the gradient in the tunnel section should not contain a sag, if possible.

5.3.2 Crest and sag vertical curves

The changes in longitudinal gradient in longitudinal section are rounded. Crest and sag curve radii should be selected such that they

- create a balanced spatial alignment together with the horizontal alignment elements,
- ensure the necessary stopping sight distances,
- adapt to the topography and
- preserve the landscape.

The crestsand sags vertical curves are designed by circular curves. They are calculated approximately with quadratic parabolas (see appendix 4).

Table 15 shows the recommended values of the crest and sag curve radii and the minimum tangent lengths; the later apply to vertical curves.

Table 15: Recommended crest and sag curve radii and minimum length of tangents in longitudinal section

Design class	**Crest radius H_K** [m]	**Sag radius H_W** [m]	**Tangent length min T** [m]
EKL 1	≥ 8,000	≥ 4,000	100
EKL 2	≥ 6,000	≥ 3,500	85
EKL 3	≥ 5,000	≥ 3,000	70
EKL 4	≥ 3,000	≥ 2,000	55

Values may vary below those recommended in table 15 in justified exceptional cases by as much as 15 %. Then special care must be taken to co-ordinate site plan and longitudinal section elements by size and mutual relationship. Small sag radii should not be overlaid with small horizontal curve radii. Recognition and spatial alignment should be checked according to section 5.4 in such cases. The required stopping sight distance as per section 5.5 must be maintained everywhere.

In hilly terrain the crest radius should be greater than the sag radius (see section 5.4.2). However, for reasons of recognition and spatial alignment the sag radius should not be less than half the adjoining crest radii. Where there are small differences in height and in flat terrain the sag radii should be substantially larger than the crest radii, to maintain a visually balanced carriageway course.

5.4 Three-dimensional design

5.4.1 General aspects

The spatial alignment of a road has a major influence on driving behaviour and traffic safety.

The roadway as seen by the driver comprises the carriageway and the road side area. It must be readily recognisable, comprehensible, consciously perceivable, clearly defined and unambiguous for motorists. The road features supplementing the information offered by the spatial impression of the carriageway itself must also meet these requirements. The road should also fit as harmoniously as possible into the landscape.

The course of the road and the visual guidance of motorists should be improved by the design of the surrounding environment and the road features (traffic guidance and signage, terrain modelling, plantation etc.). High-rise structures especially highlight the course of the road on crests and in curves offering poor visibility. This is provided primarily by lateral plantation installed at a sufficient distance.

The combination of the horizontal and vertical design elements creates spatial elements and sequences of spatial elements. The sequencing of these spatial elements results in a satisfactory three-dimensional alignment if standard spatial elements are used and the following basic rules are observed in their sequencing. The recommended values of the design elements (see sections 5.2 and 5.3) must also be observed.

The three-dimensional alignment is generally satisfactory when the points of intersection of curves in the site plan and longitudinal section are roughly in the same place and the numbers of intersection points in the site plan and longitudinal sections match. An unfavourable situation occurs, in particular, if the number of vertical intersection points is not in balance with the site plan. If a differing number cannot be avoided, the turning points in a plane should not converge with tangential points of junction of the other plane. In this the longitudinal section element (vertical) should be enclosed by the site plan element (horizontal).

5.4.2 Standard spatial elements

Standard spatial elements are created if the start and end of curves in the site plan converge with the start of crests and sags in longitudinal section. Straights in the site plan are treated as horizontal curves with radii $R = \infty$ and constant longitudinal gradients in longitudinal section are treated as crest or sag radii with $H = \infty$. The standard spatial element also occurs in principle when these start and end points in the site plan and longitudinal section are shifted slightly (up to roughly 20 % of the length of the site plan element).

Figure 15 illustrates the division of a stretch of road into standard spatial elements.

Figures 16 and 17 show the effects of standard spatial elements.

A standard spatial element occurs only when the following conditions are met:

Where **crest vertical curves, converge with horizontal curves,** it may be necessary to move the start of the horizontal curve before the start of the crest in order to ensure that the start of the horizontal curve is easily recognisable. The values specified in table 16 cover the worst-case sequence of straight (with constant longitudinal gradient) – clothoid (with crest curve) – circular curve. Approaches from an opposite curve produce virtually identical values.

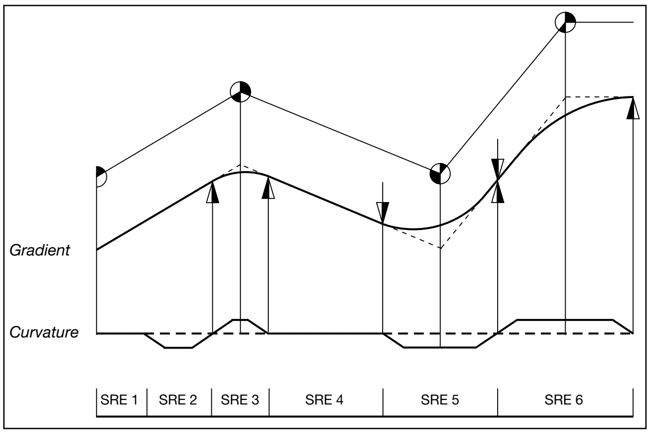


Figure 15: Example for the arrangement of a route in standard space elements (SRE)

Table 16: Required movement of the start of the in the transition from straight section before the start of crest for different clothoid circular curves

Crest radius H_K [m]	**Clothoid parameter A** [m]			
	150	**200**	**250**	**≥ 300**
3,000	25	50	65	80
4,000	15	35	55	75
5,000	No displacement required	25	50	70
6,000		15	40	60
7,000			30	55
8,000			20	45
9,000			10	40
10,000				30

To avoid critical elongation at the start of **horizontal curves converge with vertical sags** with a ratio R : H > 1 : 10, the start of the horizontal curve shall, in this case too, not be located after the start of the sag curve That is to say, moving a curve is only permissible if the longitudinal section (vertical) element is enclosed by the site plan (horizontal) element.

Bridge structures should integrate into the course of the road. To avoid the plateau effect created by a straight bridge between two sags, particularly large sag radii with long lengths should be selected.

5.4.3 Deficits

Errors in the creation of spatial elements and sequences of spatial elements lead to deficits in spatial alignment.

Table 17 sets out the deficits broken down by their effects on driving behaviour and traffic safety.

When constructing new roads, deficits in all categories shall be avoided. On redevelopment projects this applies at least to areas of obstructed vision and to concealed starts of curves.

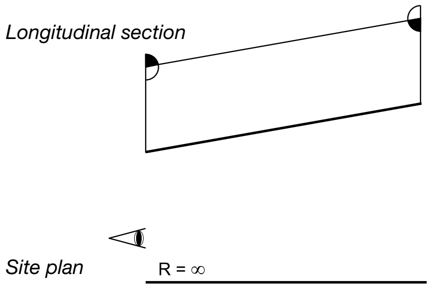
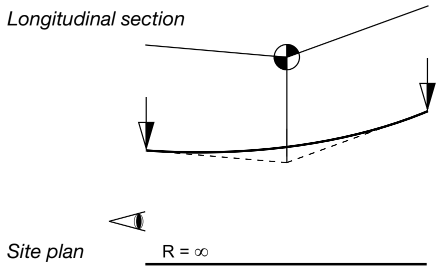
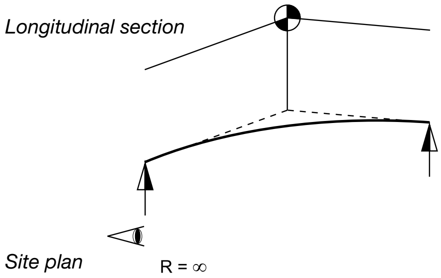
Site plan/longitudinal section	Perspective	Evaluation
Straight with constant longitudinal gradient		
		– has a monotonous effect over substantial length – frequently has a rigid effect in the landscape – promotes glare – is suitable for less varying land-scapes – good for intersections
Straight sag		
		– ensures good visibility and visual guidance – with large radii provides an alter-native to level straights – suitable for intersections – favourable for overtaking
Straight crest		
		– limits sight distance – worsens the optical guidance – not suitable for at-grade intersec-tions

Figure 16: Standard spatial elements with a horizontal straight

Table 17: Effects of deficit of the spatial alignment

Deficit	Influence on driving behaviour and traffic safety
Obstructed vision (hidden dips/”roller coaster”)	High
Concealed beginning of curve	High
Expansion	Medium
Compression	Low
Design deficits	Low

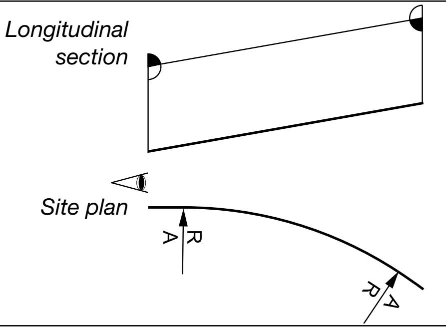
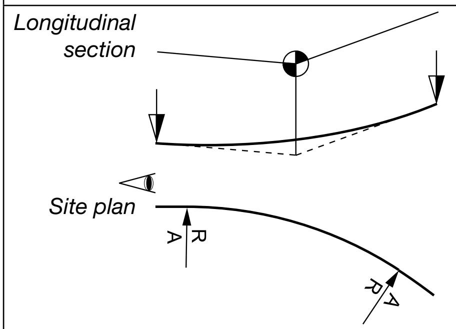
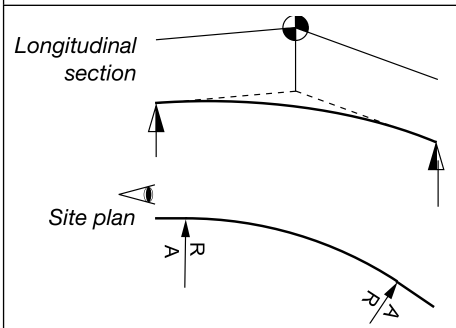
Site plan/longitudinal section	Perspective image	Assessment
Curve with constant longitudinal gradient		
		– is unproblematic if there is sufficient sight distance – permits an adaptation to the environment – suitable for overtaking lanes and transition areas
Curved sag		
		– unproblematic if there are sufficiently large design elements – tends to lead to lower speeds – permits an adaptation to the environment – improves the optical guidance – is critical for overlaps with small site plan radii
Curved crest		
		– unproblematic if there are sufficiently large design elements – improves the optical guidance – tends to lead to lower speeds – is not suitable for at-grade intersections

Figure 17: Standard spatial elements with a horizontal curve

Obstructed vision area

An obstructed vision area is where the near-ahead carriageway is hidden for the motorist (eye height h_a = 1.00 m), such as due to a crest or slope, and becomes visible again after it. Such an area is problematic if the obstruction extends over a length of more than 75 m and the carriageway becomes visible again within a distance of less than 600 m (figure 18). This situation becomes critical and extremely hazardous if the obstructed vision area is additionally more than 0.75 m deep. This applies especially where the oncoming carriageway can be used for overtaking.

If critical concealed vision areas cannot be avoided in such cases, a check should be made as to whether overtaking needs to be prohibited.

Concealed vision areas may occur due to a hidden dip or "roller coaster" type of profile (figure 19).

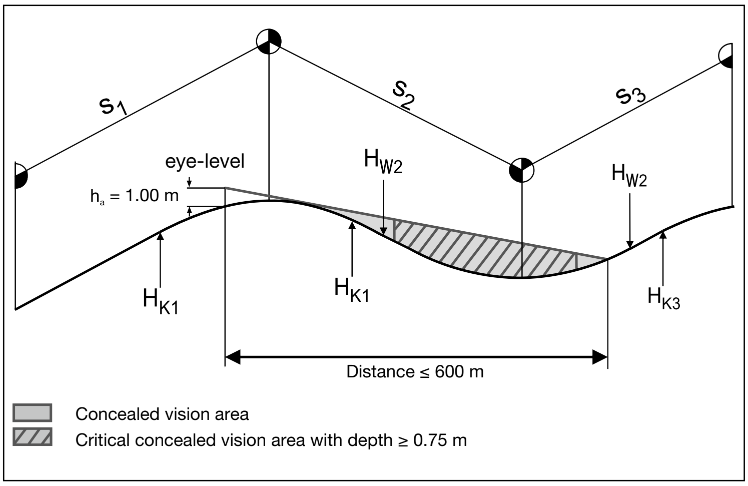


Figure 18: Critical concealed vision area

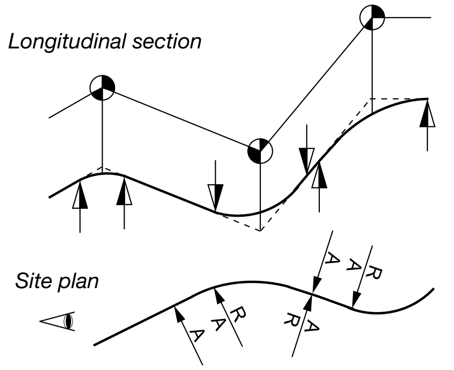
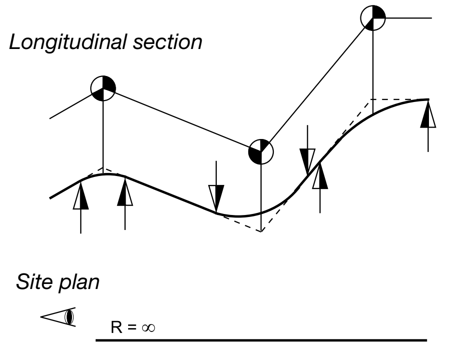
<table>
<tr><th>Site plan/longitudinal section</th><th>Perspective</th><th>Notes</th></tr>
<tr><td colspan="2">Hidden dip in a curve (“roller coaster”)</td><td rowspan="4">– Avoidance of multiple longitudinal section elements in a site plan element
– Selection of largest possible rounding radii
– Selection of radii greater than 5000 m (without constant longitudinal gradients between vertical curves)
– The smaller the first crest radius, the longer and deeper is the obstructed vision area
– Avoidance of constant longitudinal gradients between vertical curves in case of changes in longitudinal gradient less than approximately 8 %
– Check (e.g. with perspective images) in area of high point of first crest in short zones with constant longitudinal gradient in longitudinal section</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td colspan="2">Hidden dip on a straight</td></tr>
<tr><td>
</td><td></td></tr>
</table>

Figure 19: Concealed vision – hidden dips/”roller coaster”

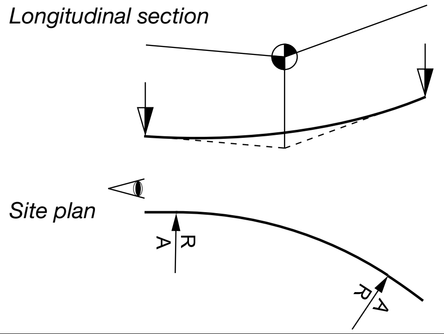
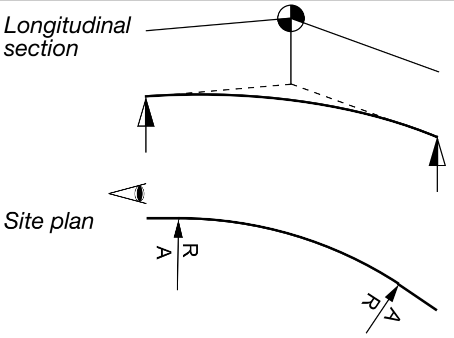
<table>
<tr><th>Site plan/longitudinal section</th><th>Perspective</th><th>Notes</th></tr>
<tr><td colspan="3">Expansion due to sag</td></tr>
<tr><td>
</td><td></td><td>– at R : H > 1 : 10:
safety-reducing increase of speed level</td></tr>
<tr><td colspan="3">Compression due to crest</td></tr>
<tr><td>
</td><td></td><td>– R : H ≤ 1 : 10:
safety-increasing decrease of speed level
– R : H > 1 : 10
Reduction of the speed-reducing effect</td></tr>
</table>

Figure 20: Expansion and compression of a horizontal curve with the same radius

Concealed beginning of curve

A concealed start of a curve is where the road ahead is not visible at least as far as the point of a change in direction (deflection) of 3.5 gon (3.15°) from a distance of 75 m before the start of the horizontal curve. Consequently, it must be ensured that the start of the part of the crest curve invisible to the driver is further away from the driver than the point of the relevant change in direction. In case of large clothoid parameters (A ≥ 300 m) it is sufficient if the clothoid is visible along a length of at least 100 m (table 15).

Elongation and compression

In a sag the radius of the circular curve appears more elongated (figure 20 top), and on a crest more compressed (figure 20 bottom), than on a curve with a constant longitudinal gradient. The magnitude of the elongation/compression is influenced by the ratio of the horizontal radius to vertical radius (R : H).

Design deficits

Inconsistencies in the carriageway convey an incongruous alignment to motorists (figures 21 and 22).

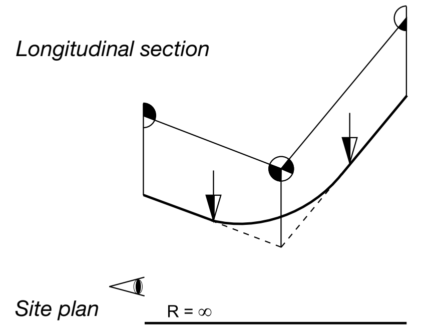
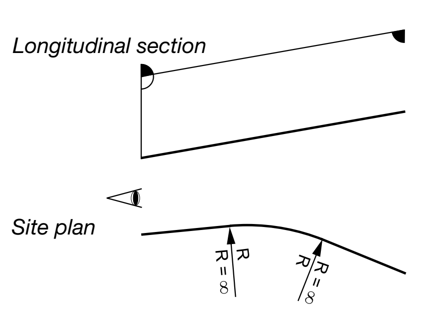
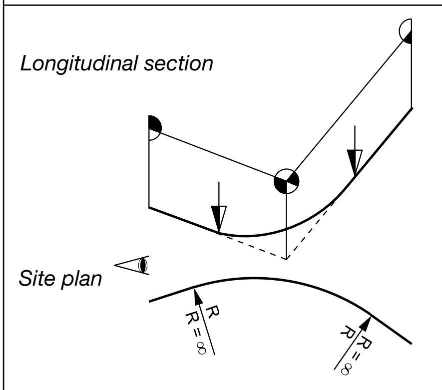
<table>
<tr><th>Site plan/longitudinal section</th><th>Perspective</th><th>Notes</th></tr>
<tr><td colspan="2">vertical break “sykline horizont”</td><td rowspan="6">– Avoid long straights with constant longitudinal gradient
– Avoid vertical sags with short tangent lengths between long straights with constant longitudinal gradient
– Avoid minimum vertical curve radii in case of change in longitudinal gradient greater than approximately 10 %
– Plan minor change of direction (> 3 gon) in the site plan
– Avoid small horizontal curve radii in case of minor changes of direction in the horizontal alignment</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td colspan="2">horizontal break</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td colspan="2">horizontal and vertical break</td></tr>
<tr><td>
</td><td></td></tr>
</table>

Figure 21: Design deficits - breaks

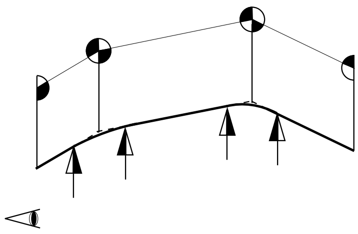
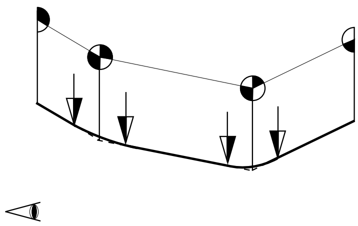
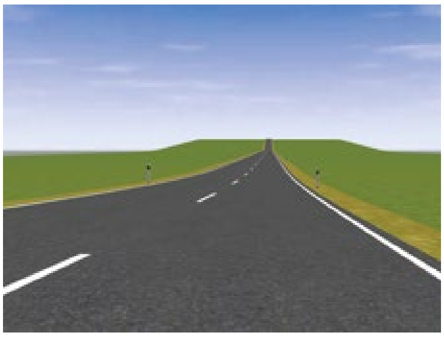
Site plan/longitudinal section	Perspective	Notes
Flattening		– Avoid straights with a constant longitudinal gradient between two vertical curves in the same direction (crests or sags) – Integrate engineered structures smoothly into the grade line design and as far as possible also in the horizontal alignment
Longitudinal section  *Site plan* R = ∞		
Bulging		
Longitudinal section  *Site plan* R = ∞		

Figure 22: Design deficit – flattening and bulging

5.4.4 Verification of the three-dimensional alignment

The three-dimensional alignment of a road is verified by a three-stage procedure.

In the first stage a check is made whether adequate co-ordination of horizontal and vertical alignments (intersection points) is possible by redesign on stretches not conforming to standard spatial elements.

In a second stage, a check is to determine if the start of a curve, on stretches still not conforming to standard spatial elements, is recognisable in good time and adequately. Additionally, the entire route is checked as to whether the course of the carriageway is recognisable in good time and adequately, and there are no stretches of obstructed vision.

Such safety-critical deficits should, as a matter of principle, be eliminated, by modifying the horizontal and vertical design elements. This can be avoided, however, if perspective images, or sequences of perspective images, can be used to verify that the road ahead is clearly recognisable and consciously comprehensible by the motorist.

In a third stage, the road design is checked for design deficits by qualitative analysis of the horizontal and vertical alignment based on calculated perspective images. Section 5.4.3 serves as an aid in this task. Design deficits can be accepted if modifications to the design are not possible at reasonable effort and expense.

Details on perspective image calculation and the verification methodology are contained in the "Notes on the Visualisation of the Design of extra-urban Roads" (H ViSt).

5.5 Sight distance

5.5.1 Required stopping sight distance

Obstacles on the carriageway must be recognisable at every point at least from a distance enabling the motorist to stop in time when driving at the planning speed applicable to the design class, even on a wet road (required stopping sight distance).

Figure 23 shows the required stopping sight distance dependent on design class and longitudinal gradient.

Greater sight distances than the required stopping sight distances are desirable to allow drivers orientation to the road ahead in good time and so enable driving without excessive demands on their attention (decision sight distance).

For this reason the available sight distances along most of the road should be at least 30 % above the required stopping sight distances.

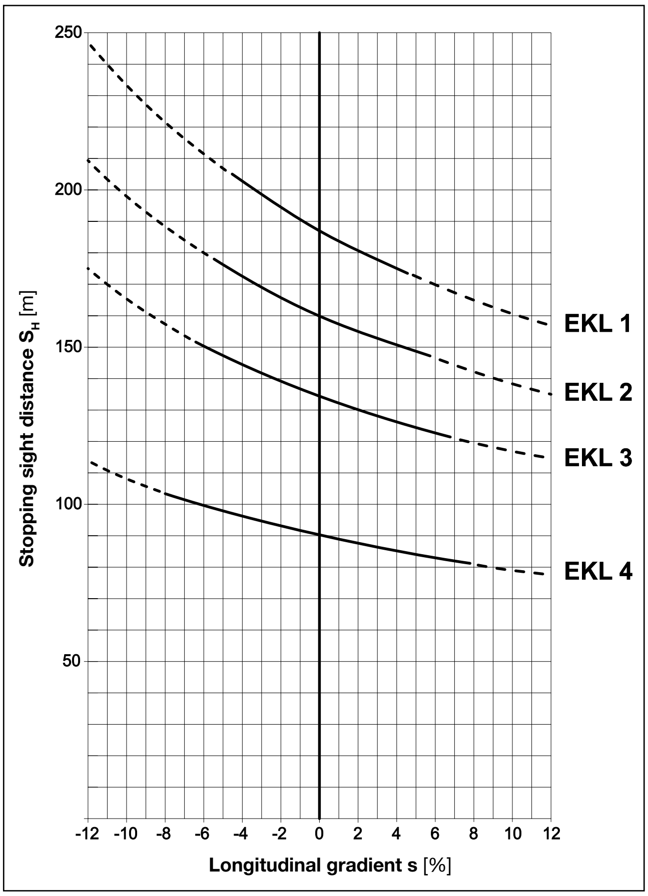


Figure 23: Required stopping sight distance S_H depending on the EKL and the longitudinal gradient

It is advantageous for the traffic flow and for traffic safety if vehicles travelling at different speeds can overtake safely. Stretches with adequate overtaking sight distances assist this endeavour. However, in view of the fact that on roads used for long and very long journeys, overtaking should be undertaken preferentially on stretches with appropriate overtaking lanes, explicitly no minimum stretches with adequate overtaking sight distances are specified for roads of design classes EKL 1 and EKL 2. This also applies to roads of design class EKL 3, because on those roads the journey lengths are only in the short to mid-range, and the dense sequencing of at-grade intersections restricts overtaking opportunities over large stretches of the route. This also applies particularly to roads of design class EKL 4, on which the narrowness of the carriageway additionally impedes overtaking.

5.5.2 Existing sight distance

The available sight distance is the result of the route's vertical and horizontal alignments, the cross-section and the design of the road side environment. It is described by a line of sight between the eye height and a target height. The eye height and a target height are at a height of 1.00 m above the middle of the right-hand lane, or on roads of design class 4 above the middle of the carriageway (see appendix 5). On left-hand bends on divided carriageways the available sight distance for the left lane must also be checked. Then the eye height and target height are at a height of 1.00 m above the middle of the left lane.

The available sight distances must be spatially determined, separately for each driving direction, and displayed in sight distance strings, taking into account the course of the carriageway and the adjoining terrain, overpasses, and road features (such as vehicle restraint systems, noise insulating walls, fly-over aids) as well as the vegetation.

5.5.3 Verification of the stopping sight distance

For safety reasons, it must be verified that the available sight distance is greater than the required stopping sight distance at every point. This is done section by section. When comparing available sight distances with required stopping sight distances, the average longitudinal gradient within the required stopping sight distance should be assumed for each section. If the available sight distance is less than the required stopping sight distance, and if that deficit cannot be eliminated due to local conditions, it must be checked whether it is necessary to limit the permissible maximum speed.

5.5.4 Overtaking sight distance

To be able to initiate and safely complete overtaking of a truck, a sight distance of at least 600 m is required.

If the available sight distance on two-lane sections is between 300 m and 600 m, motorists cannot always decide unambiguously whether they are able to overtake, taking into account the possible oncoming traffic. If this critical zone cannot be avoided by planning measures, it should be checked whether overtaking needs to be prohibited for safety reasons, or if only overtaking of slow vehicles can remain allowed by additional sign 1049-11 VzKat. For safe overtaking of slow vehicles, a sight distance of at least 300 m is required.

5.6 Design of roadway surface

5.6.1 Transverse gradient

On straights the carriageway is constructed with a transverse gradient (cross fall) on one side. The minimum transverse gradient of the carriageway is q = 2.5 %.

Overtaking lanes as well as merging and diverging lanes should have the same transverse gradient as the carriageway in terms of direction and magnitude.

For reasons of driving dynamics and better curve identification, circular curves are configured with a transverse gradient to their insides. The maximum transverse gradient is q = 7.0 % and the minimum transverse gradient is q = 2.5 % also.

Figure 24 shows the transverse gradient dependent on the radius. The values shall be rounded up to 0.5 %.

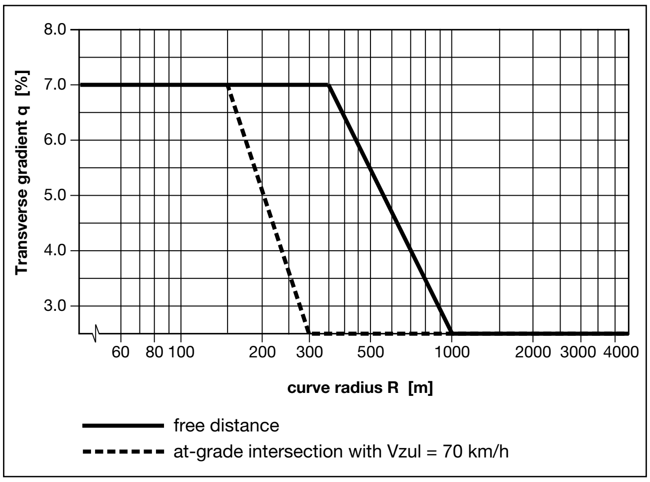


Figure 24: Transverse gradient depending on the circular curve (see text for further explanation)

To avoid problems where secondary roads join at at-grade intersections due to a large transverse gradient in the higher-level road, the curve radii should where appropriate be planned for a permissible maximum speed of 70 km/h. For this case the transverse gradient dependent on the radius as per the dotted line in figure 24 applies (see sections 6.2.4, 6.3.3.4 and 6.3.3.5).

The dotted line can also be applied to the transverse gradient in tunnels.

The curve radii should be planned so that the transverse gradient on bridges is limited to q = 5.0 %.

At radii R > 3000 m, a negative transverse gradient of q = – 2.5 % may be configured if there is a zone of poor drainage or, on dual carriageways, so as drainage on the central reservation can be avoided.

To avoid vehicles skidding on winter ice, the resultant gradient should be limited to max p = 10.0 %.

$$p = \sqrt{s^2 + q^2} \qquad (3)$$

p [%] = resultant gradient
s [%] = longitudinal gradient
q [%] = transverse gradient

Verges and shoulders that are used for carriageway drainage have a cross-fall at q = 12.0 %, otherwise at q = 6.0 %.

5.6.2 Superelevation

Changes in carriageway transverse gradient usually occur within the transitional circular curve, regardless of the axis around which the road surface rotates.

If there is no transitional curve (see section 5.2.3) the superelevation is developed half before and half after the point where the two elements meet.

In exceptional cases, the transverse gradient is changed on a straight, and should be done so at the start or end of the straight.

Changes in transverse gradient on structures should be avoided as far as possible.

On single-lane roads the carriageway is usually rotated around its own axis (on two-lane roads around the axis of the main directional lane) (figure 25). For better adaptation to local conditions, in justified exceptional cases the rotation may also be around the inner or outer edge of the carriageway.

Where single overtaking lanes merge on one side into a two-lane cross-section (roads of design class EKL 2 and EKL 3), it is useful to leave the centre of rotation where it would be without the widening in the cross-section.

Superelevation transition

The relative grade Δs [%] is the difference between the longitudinal gradients of the carriageway edge and the axis of rotation. This results from:

$$\Delta s = \frac{q_e - q_a}{L_V} a \qquad (4)$$

q_e [%] = transverse gradient at end of development length
q_a [%] = transverse gradient at start of development length (q_a negative when sloping upwards from the control line)
LV [m] = superelevation development length
a [m] = distance of carriageway edge including shoulder from axis of rotation

In order to avoid an excessive rapid increase in transverse gradient within the superelevation development section, the maximum relative grade max Δs should not exceed the values in table 18. Applying the recommended radii ranges as per table 11 and the cor-

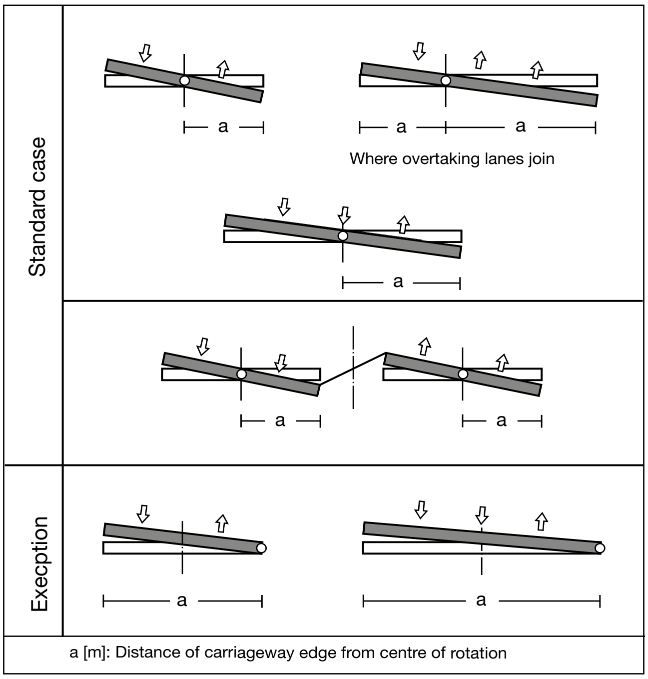


Figure 25: Rotation axis of the carriageway in superelevation development sections

responding clothoid parameters, these values are automatically met. If max Δs is exceeded, then higher clothoid parameters should be selected.

If min Δs as per table 18 is greater than max Δs the axis of rotation off centre, min Δs is used.

Table 18: Limiting values of superelevation transition

Design class	**max Δs** [%]	**min Δs** [%] **at q ≤ 2,5 %**
(EKL 1)/EKL 2	0.8	0.10 · a
EKL 3	1.0	
EKL 4	1.5	
a [m] Distance of carriageway edge from axis of rotation		

The minimum superelevation development length results from:

$$\min L_V = \frac{q_e - q_a}{\max \Delta s} \cdot a \qquad (5)$$

$\min L_V$ [m] = minimum length of superelevation development length
q_e [%] = transverse gradient of carriageway at end of development length
q_a [%] = transverse gradient at start of development length (q_a negative when sloping upwards from the control line)
max Δs [%] = maximum relative grade
a [m] = distance of carriageway edge from axis of rotation

Superelevation standards are presented in figure 26.

Consideration of dewatering

In order to minimize zones with poor drainage, the relative grade in superelevation development sections may not fall below the minimum relative grade (min Δs) in table 18 in the area from + 2.5 % (min q) through 0 % to – 2.5 % (– min q). Each transition curve must be checked for Δs < min Δs. In such a case the superelevation transition had to be divided. On the stretch in the range from q = + 2.5 % to q = – 2.5 % a relative grade of min Δs has to be adopted. On the remaining stretch of the superelevation transition the relative grade has the residual constant Δs until the transverse gradient at the start of the circular curve is reached.

To ensure adequate carriageway drainage, the difference should be between the longitudinal gradient and the relative grade.

$$s - \Delta s \geq 0{,}2\ \% \qquad (6)$$

s [%] = longitudinal gradient

Δs [%] = relative grade

This also avoids carriageway edges with absolute longitudinal gradients opposite to the gradient.

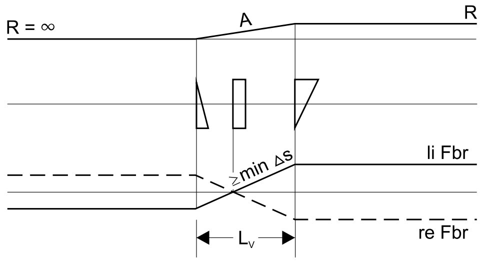
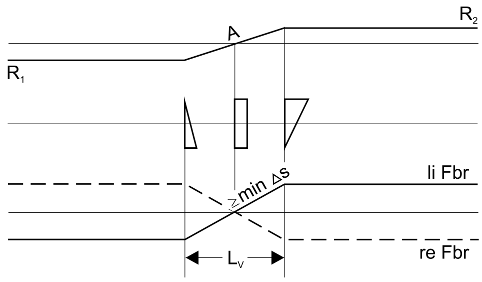
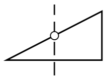
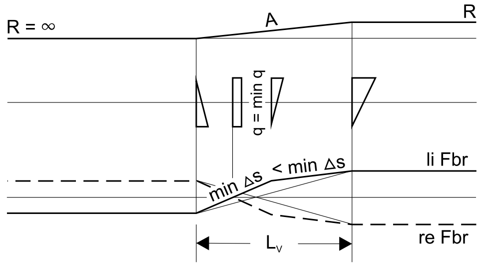
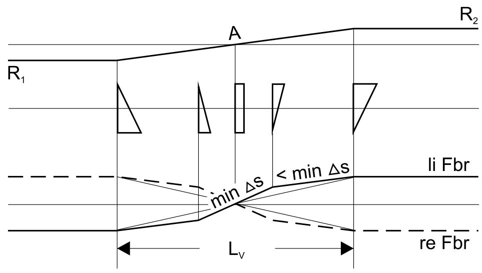
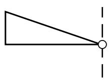
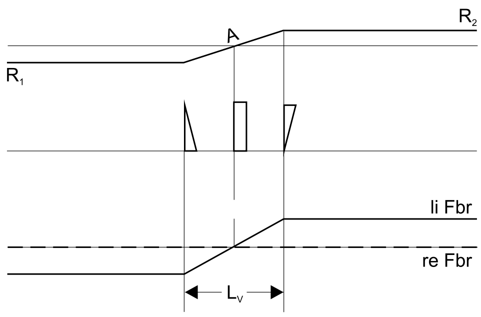
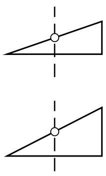
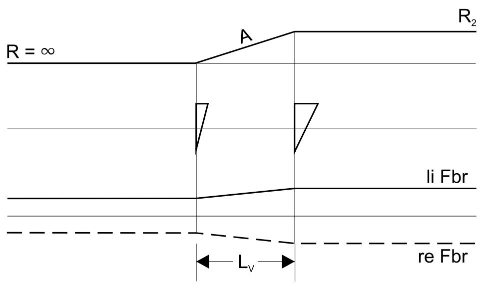
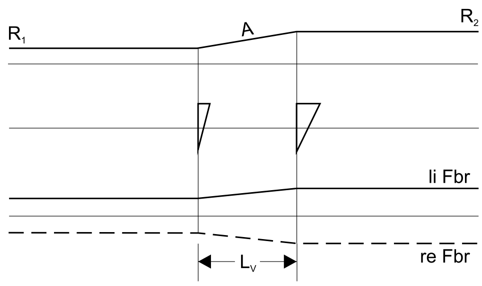
The requirement for a resultant slope of p ≥ 0.5 % as per REwS may result in higher values.

If no adequate longitudinal gradient can be ensured in the area of the horizontal alignment point of intersection due to special constraints, the point of zero cross-fall can be shifted relative to the beginning of the transition curve (clothoid) by the length L = 0.1 · A.

Changes in the transverse gradient on straights are only permissible if zones of poor drainage can be avoided elsewhere as a result.

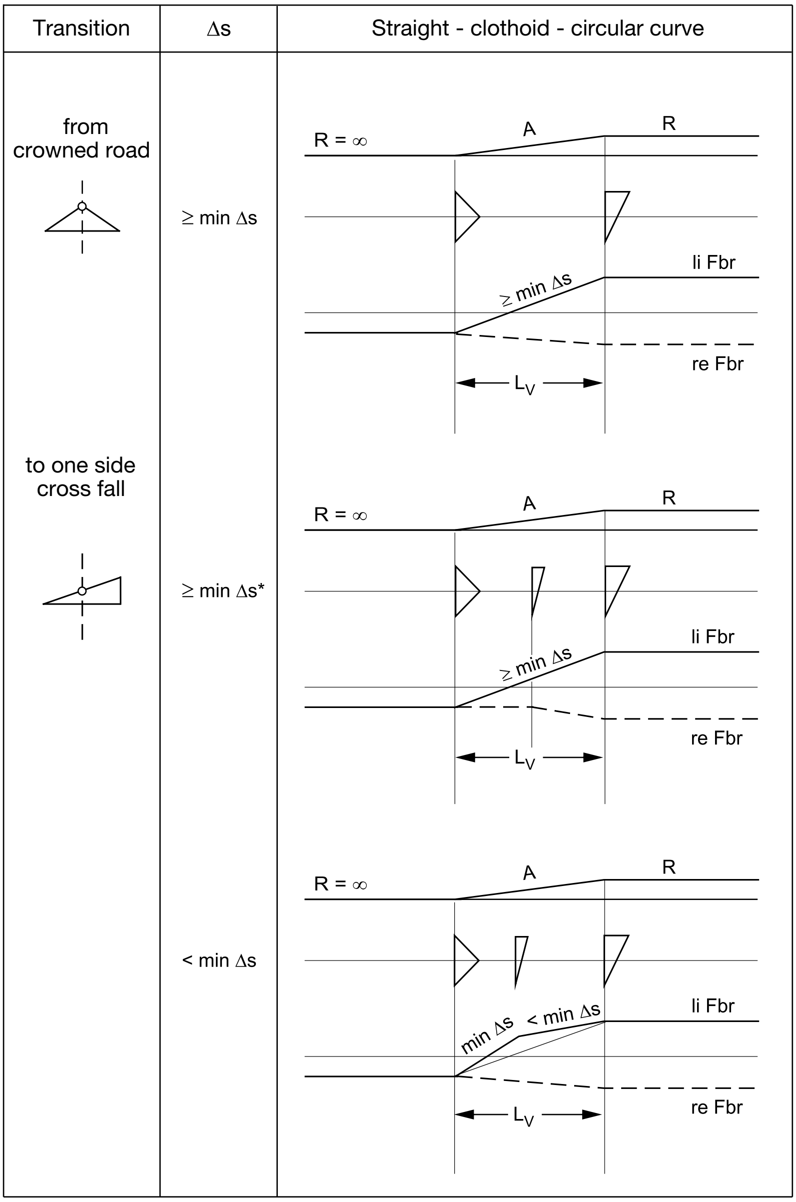
For superelevation transitions with simultaneous carriageway widening or installation of an additional lane, the relative grade of the un-widened carriageway is determinative.

The transition of a planned road on an existing road with a transverse gradient on two sides (crowned road) should be designed as per figure 27.

Transition	Δs	Straight - clothoid - circular curve	circular curve - clothoid - circular curve
between differently large or equally large transverse gradient in opposite direction	≥min Δs		S-type clothoid 
	< min Δs		
	≥min Δs		Turning around a carriageway edge 
between differently large transverse gradient in the same direction 	random		egg-shaped lines 

○ Axis of rotation
L_v Superelevation development lenght
min Δs Minimum relative grade
li Fbr Left carriageway edge
re Fbr Right carriageway edge

Figure 26: Forms of superelevation development sections (unidirectional cross fall)



*	Shorter crown in the axis of rotation, but longer section with min q in clothoid
o	Axis of rotation
L_v	Superelevation development length
min Δs	Minimum relative grade
li Fbr	Left carriageway edge
re Fbr	Right carriageway edge

Figure 27: Forms of superelevation development sections (bidirectional cross fall crowned road)

5.6.3 Carriageway widening on sharp curves

In horizontal curves with radii R < 200 m the carriageway must be widened by the measure i. The widening is effected all along the length of the circular curve on the inner edge.

$$i = \frac{100}{R} \qquad (7)$$

i [m] = carriageway widening
R [m] = radius of the curve to be widened

The trasition to the widened cross-section should usually be done in the transition curve (clothoid).

In the case of very short clothoids, such as in the course of tight lines-type curves, the linear transition may be longer than the clothoid length. In these cases the transition has to be designed with a roughly even overlap into the straight and the circular curve.

Separate alignment of the carriageway's inner edge and maintaining the full extent of the widening on a parallel circular curve may then be more useful.

5.6.4 Carriageway widening

The carriageway edges are tapered to create overtaking lanes and divider islands. In curves with R < 300 m the carriageway widening should be established on the inner edge of the curve, otherwise on both sides. Carriageway widenings for overtaking lanes are usually established on the side of the overtaking lane.

The carriageway edges can be tapered with two square parabolas combined to form an S-curve or by independent alignment with elements of lines-type clothoids with usually two circular curves. Independently aligned alignment should be preferred if the driving path is closely to the carriageway edge. To avoid reverse circular curves on open road sections, the taper length should be enlarged or the carriageway edge independently aligned.

Carriageway widenings, where the width of the central reservation changes, should be executed by seperate alignment of the carriageway edges independent of the road axis.

Carriageway widening to taper continuous lanes due to the creation of left-turning lanes is established adequately (see section 6.4.5).

Table 19 contains recommended taper lengths.

Table 19: Taper length of carriageway widening

Carriageway widening i [m]	**taper length l_Z** [m]		
	EKL 1 EKL 2	EKL 3	EKL 4
≤ 1.50	80	60	50
> 1.50 to ≤ 2.50	100	80	60
> 2.50 to ≤ 3.50	120	100	70
> 3.50	170	140	–

5.7 Special features of alignment of bridges and tunnels

Bridge structures must be coordinate with the alignment.

The structure's length and the construction engineering requirements can be reduced by configuring bridge crossings with other traffic routes to be as perpendicular (right-angle) as possible. An angle between 80 gon (72°) and 120 gon (108°) is recommended.

Straight alignments are advantageous for economic reasons. If bridge centreline is curved, the radius should possibly be selected so as to limit the transverse gradient to

$$\max q = 5{,}0\,\%$$

Transition curves in the course of bridges shall be avoided.

There should be no superelevation transitions on bridges.

There should preferentially be a constant longitudinal gradient on bridges. On longer bridges a constant horizontal curvature in the longitudinal section is required in order to apply the incremental launch technique.

To ensure adequate road drainage, a minimum longitudinal gradient of s = 0.7 % on long bridges (clearance ≥ 100 m) should be observed.

Small longitudinal gradients occurring in the area of unavoidable low or high points necessitate short spacing of the road segments and so entail higher construction and maintenance expenditure. Low points shall be avoided as far as possible due to the drainage in the centre of the structure and also for safety reasons.

Tunnels shall be dimensioned with as generous horizontal and vertical design elements as possible. The longitudinal gradient in tunnels shall be limited to max s = 3.0 %. At lengths of more than 500 m max s = 2.5 % should be desirable.

6 Intersections

6.1 General aspects

Intersections on rural roads are designed according to the importance of the intersecting roads. The intersections are differentiated by basic design characteristics and operational characteristics. Basic design characteristics are grade-separated, partially grade-separated and partially at-grade intersections, at-grade intersections and crossings, and roundabouts (table 20). Grade-separated, partially grade-separated and partially at-grade intersections consist of multiple subsidiary intersections (entry/exit zones and T-intersections, crossings or roundabouts) and the associated ramps. The operational characteristics are differentiated by signage and signalization.

6.2 Planning intersections

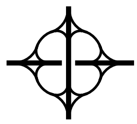
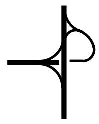
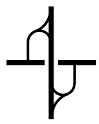
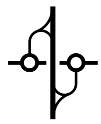
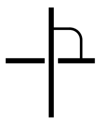
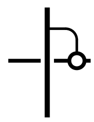
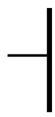
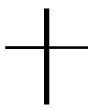
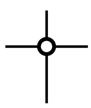
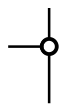
6.2.1 Basic requirements

Intersections should be designed to ensure safe guidance of the traffic passing through, entering/exiting and crossing them. To that end, for all traffic categories coming from all directions they should be

- readily recognisable
- clearly visible
- consciously comprehensible in terms of traffic routing and priority, and
- be easy and safe to use for vehicle traffic to traverse and for pedestrians.

Additionally, the numbers and layout of intersections should be such that the driving speed targets as per RIN can be attained on the higher priority road across multiple consecutive network segments.

Table 20: Basic design characteristics of intersections

Engineered basic form	**traffic management at partial intersections or intersections**		**Examples (higher priority road shown vertically)**	
	higher priority road	**lower priority road**		
Grade-separated intersection	Merging/ Diverging	Merging/ Diverging		
Partially grade-separated intersection	Merging/ Diverging	Turning into/out of roundabout	 *)	 *)
Partially at-grade intersection	Turning into/out	Turning into/out of roundabout		
At-grade intersection				
T-intersection	Entry/exit	Turning into/out		
Crossing	Turning into/out/ crossing	Turning into/out/ crossing		
Roundabout	Roundabout			
*) May also be executed as a diamond. The road with right of way is shown as a broad line.				

To attain the desired standardisation, it is useful to design the intersections in the course of a road in a uniform way.

Intersections between roads of design classes EKL 1 and EKL 4 should be avoided. Intersections between roads of design classes EKL 2 and EKL 4 are also not advisable. Links to agricultural tracks from roads of design classes EKL 1 and EKL 2 should be avoided. From roads of design class EKL 3 such links should be kept to the essential minimum.

The traffic flow quality of intersections must be verified according to HBS procedures. It must additionally be checked whether, in the case of a sequence of intersections with traffic signals or roundabouts on the network segments of the higher priority road, the average car speed as per RIN for the road category can be maintained.

6.2.2 Distance between intersections

For reasons of road safety and in order to comply with the targeted network speeds, the distance should be as large as possible. On roads of design class EKL 1 distances between intersections of less than three kilometres should be avoided, and on roads of design class EKL 2 distances of less than two kilometres.

If shorter spacing is unavoidable for network-related reasons, it should be investigated whether two closely adjacent intersections can be consolidated to create a single one.

6.2.3 Higher priority road

At at-grade crossings the road of the higher design class has priority. Where roads of the same design class are linked, the road with the heavier traffic load should generally be assigned priority.

At at-grade intersections the continuous road normally has priority right of way.

6.2.4 Alignment

The axes of the roads being linked should as far as possible intersect at right angles, or at least within an angle range of 80 gon (72°) ≤ α ≤ 120 gon (108°). Otherwise the axis of the lower priority road should be offset. A crossing may be split into two adjacent intersections (filter) (figure 28). A filter to the right is more favourable. The left-exiting lanes may be located successively or adjacent to each other depending on the required length and size of the filter. Such a split can

- increase capacity
- reduce waiting times
- make waiting obligation clear and
- increase the traffic safety.

It should therefore be investigated whether a filter to the right can be implemented instead of a crossing.

It is important for road safety that intersections are readily identified. The ability of motorists to consciously perceive the rights of way early is of particular importance. This applies especially to lower priority approach roads without traffic light control, and to higher priority roads in particular when traffic is exiting, entering or crossing without traffic light control. There must be early recognition of the traffic light installation from all approaches.

Consequently, intersections on roads of design classes EKL 1 and EKL 2 should be identifiable from distances of ≥ 300 m and intersections on roads of design classes EKL 3 and EKL 4 from distances of ≥ 200 m.

An intersection is clearly identifiable when the linked roads are routed in a valley topology.

Recognition of intersections can be improved by signage (especially advance direction signs), guidance systems and the engineering of the roadside.

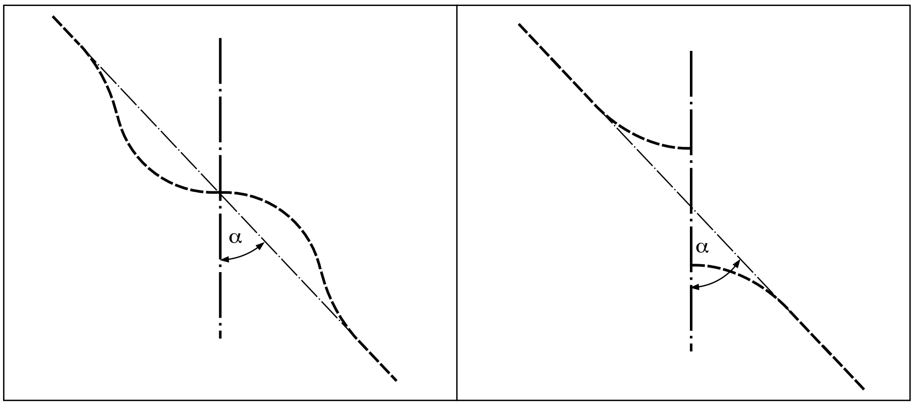


Figure 28: Connection of intersecting lower ranked roads in plan

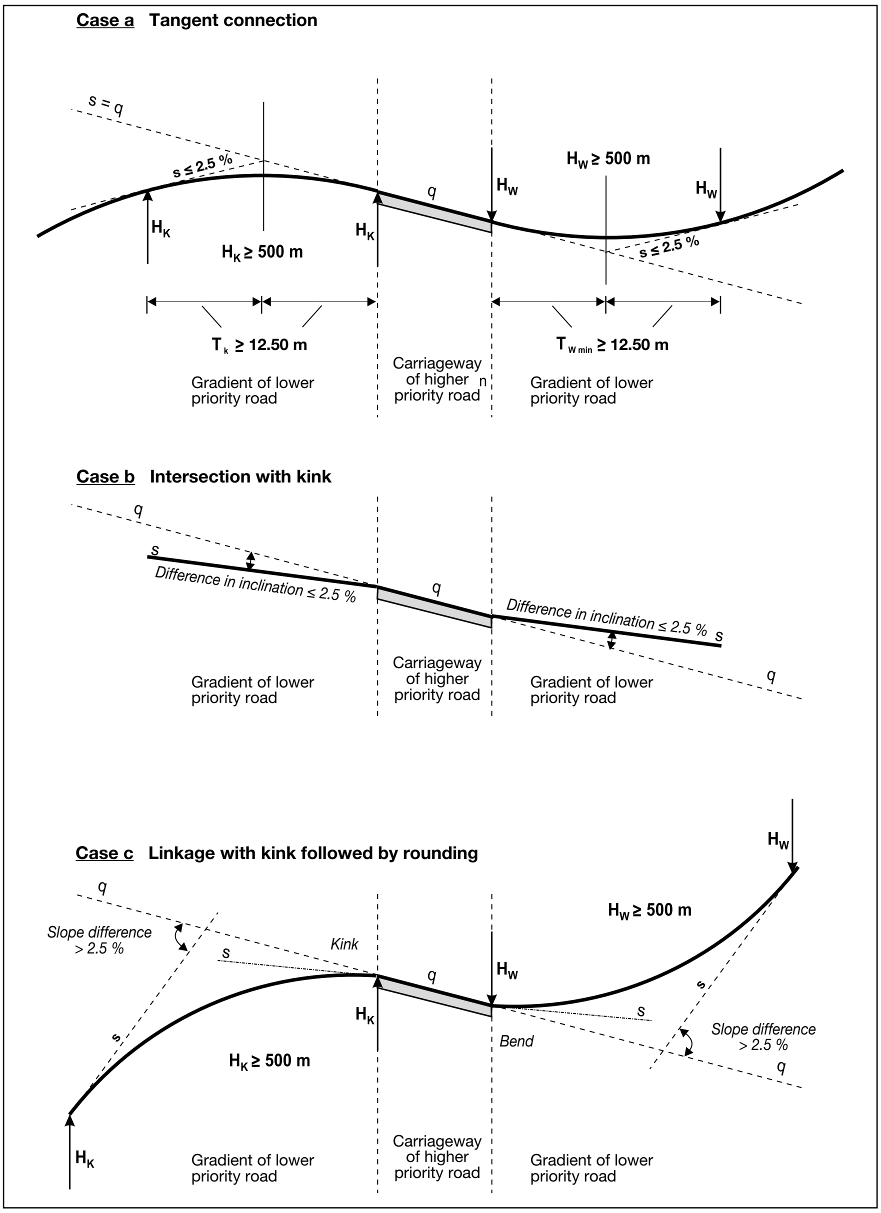


Figure 29: Connection of intersecting lower ranked roads in elevation

The requirements for higher priority roads in the vicinity of intersections are as per the general requirements for the vertical and horizontal alignments set out in sections 5.2 and 5.3. The transverse gradient is configured as per section 5.6.1.

Gradients and carriageway surfaces of the lower priority intersection approach roads must be adapted to the geometry of the higher priority roads.

The longitudinal gradient should be kept as low as possible on all intersection approach roads. On the higher priority approach roads it should not exceed 4 % (max 6 %).

To ensure recognition of the intersection and maintain the necessary braking and acceleration actions, the longitudinal gradients of the lower priority roads should be below the permissible maximum values set out in table 14. In the immediate approach to the intersection at a distance of L ≥ 25 m from the edge of the higher priority carriageway, a longitudinal gradient of max. 2.5 % should be targeted.

The gradients of the lower priority approach roads may be linked differently to the transverse gradient of the higher priority carriageway. At intersections with higher priority roads of design classes EKL 2 and EKL 3 a tangential linkage (figure 29, case a) should be implemented. The slope transitions should be rounded with radii $H_K/H_W \geq 500$ m. The tangent length should be T ≥ 12.50 m.

If particular constraints mean a tangential linkage is not possible, a kink can be inserted at the edge of the higher priority carriageway (figure 29, case b and case c). After the kink measuring > 2.5 % a rounding with $H_K/H_W \geq$ 500 m should be implemented (case c). Differences between the longitudinal gradient of the lower priority road and the transverse gradient of the higher priority road of ≤ 2.5 % do not have to be rounded (case b).

6.3 Types of Intersections

6.3.1 Traffic management and types of intersections

The basic design forms derive from the traffic management on the linked road within the intersection zone (table 20). Combining the basic design form with the operational form produces the intersection type.

Only certain intersection types are specified for roads of a given design class in the standard case.

– Tables 21 and 22 show the standard applications of the intersection types.

Table 21: Standard fields of application of intersection types in four-leg intersections

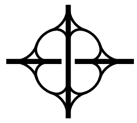
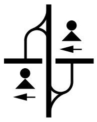
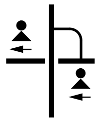
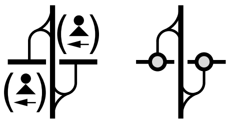
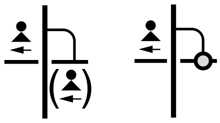
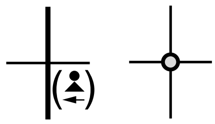
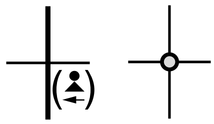
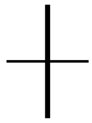
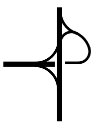
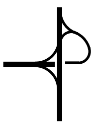
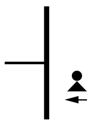
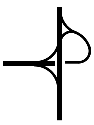
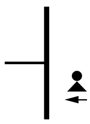
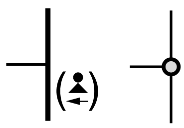
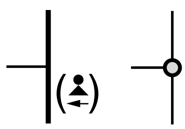
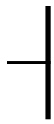
higher priority road / lower priority road	EKL 1	EKL 2	EKL 3	EKL 4
EKL 1		**Key:** Traffic lights with left turn protection; (…) Check use of traffic lights. The higher priority road is shown vertically. The road with right of way is shown as a broad line. For more applications of intersection types see section 6.3.3		
EKL 2				
EKL 3				
EKL 4	**not acceptable**	**not recommended*)**		

Table 22: Standard fields of application of intersection types in three-leg intersections

higher priority road / lower priority road	EKL 1	EKL 2	EKL 3	EKL 4
EKL 1		**Key:** Traffic lights with left turn protection; (…) Check use of traffic lights. The higher priority road is shown vertically. The road with right of way is shown as a broad line. For more applications of intersection types see section 6.3.3		
EKL 2				
EKL 3				
EKL 4	**not acceptable**	**not recommended*)**		

*) If in justified exceptional cases a road of design class EKL 4 has to be linked, the linkage should be implemented as that of an EKL 3 road.

– In justified exceptional cases, it may be investigated whether a different intersection type is more beneficial based on traffic requirements and local conditions, taking into account the objectives set out in section 2.1 (road safety, traffic quality, environmental compatibility and public authority cost).

The choice of intersection type and the configuration of the intersection must be adapted to traffic requirements and local conditions in the planning process for each individual intersection. This process must consider:

– the direction and volume of traffic flows
– neighbouring intersection types
– availability of space
– constraint points and
– surface inclinations.

Heavily used property entrances are treated in the same way as intersections of EKL 4 roads.

Other possible applications of intersection types dependent on design class are presented in section 6.3.3.

6.3.2 Warrants for intersection types

6.3.2.1 Grade-separated intersection

Grade-separated intersections connect roads in two levels. They comprise the entry and exit zones on both roads and the connecting ramps. They are used where a road of design class EKL 1 is linked to a motorway or another EKL 1 road. Three-leg grade-separated intersections are also created where an EKL 1 road linked to a motorway or another EKL 1 road.

The standard solution for a four-leg intersection is the "clover leaf" (figure 30), and for a three-leg intersection the "left-sided trumpet" (figure 31).

Grade-separated intersections are planned in accordance with RAA standards. No filter lanes are employed. The exits and entries are single-lane. They are planned as per sections 6.4.2 and 6.4.3. The ramp alignment is normally adjusted to them (with counter-curves). See section 6.4.4 for ramp planning.

At grade-separated intersections on otherwise single-carriageway roads (RQ 15.5) the need for engineering measures to separate the directions, such to improve drainage, needs to be investigated.

6.3.2.2 Partially grade-separated intersection

Partially grade-separated intersections connect roads on two levels. They comprise the entries and exits on the higher priority road and at-grade secondary intersections (intersections with or without traffic signals or roundabouts) on the lower priority road as well as connecting ramps between them. The exits and entries are single-lane. They are planned as per sections 6.4.2 and 6.4.3. The ramp alignment is adjusted to them (with counter-curves). See section 6.4.4 for ramp planning.

Partially grade-separated intersections are usually used where a road of design class EKL 1 links to a road of design class EKL 2 or EKL 3. In justified exceptional cases, they are considered where a road of design class EKL 2 links to another EKL 2 road or an EKL 3 road, where high vehicle speeds are desired because of the long journeys undertaken on them. Continuity must be ensured in configuring sequences of intersections. When linking to an EKL 2 road, traffic signals are needed at at-grade intersections for safety reasons. At links to EKL 3 roads other solutions may also be employed. The entry and exit zones are planned in accordance with RAA standards. The configuration instructions set out in section 6.3.3.1 apply accordingly.

At partially grade-separated intersections on otherwise single-carriageway roads (RQ 15.5) the need for engineering measures to separate the directions, such to improve drainage, needs to be investigated. Table 23 shows possible configurations of at-grade secondary intersections. The standard solution for a four-leg intersection is the "half clover leaf" (figure 32). The connecting ramps (asymmetrical or symmetrical) should as far as possible be configured so that the heaviest main flows do not have to enter from the left. The location of the ramps in the various quadrants influences the spacing and configuration of the at-grade secondary intersections on the lower priority road (table 23).

A further solution is the diamond shape, which is suitable particularly for heavily used interchanges on the approaches to built-up areas because it takes up little space and the intersection zone on the lower priority road is kept compact. The connections of the ramps to the lower priority network should be configured as detailed above as at-grade crossings with traffic signals or as roundabouts. At at-grade secondary intersections the in-flowing ramps should be treated in the same way as roads of design class EKL 3.

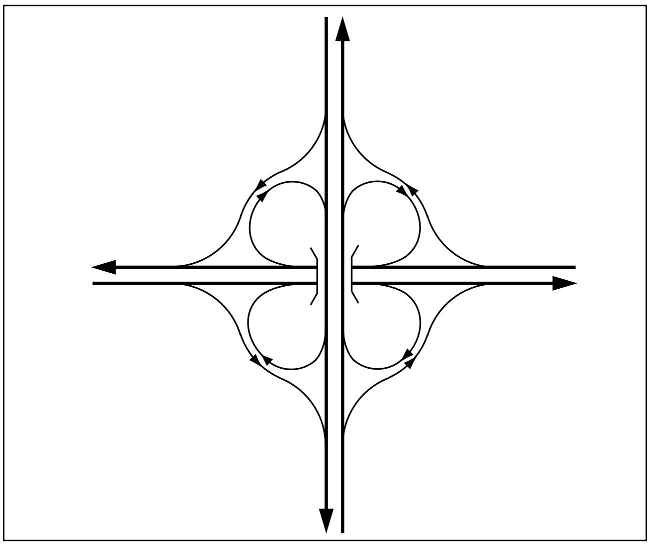


Figure 30: System sketch of a cloverleaf

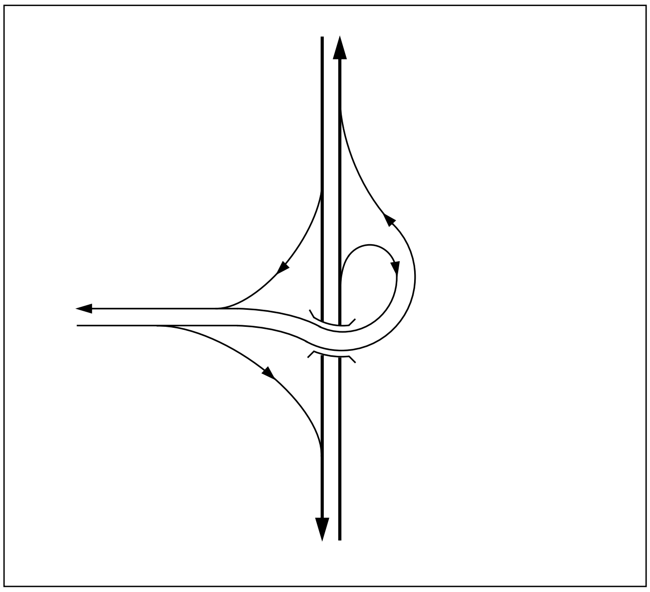


Figure 31: System sketch of a left-lying trumpet

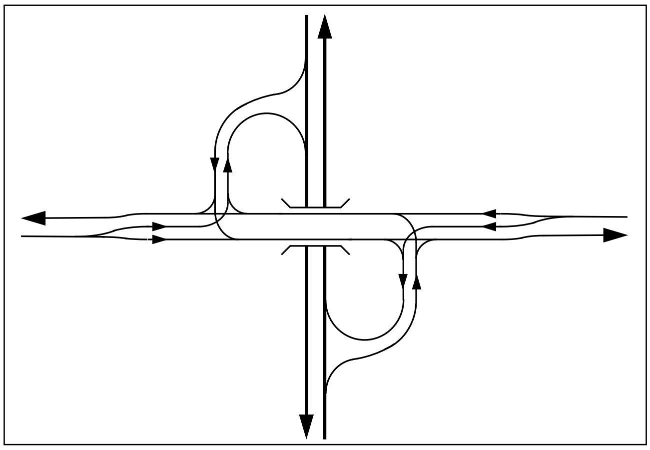


Figure 32: System sketch of half a cloverleaf

Table 23: Management of traffic flows in at-grade partial intersections of partially grade-separated intersections

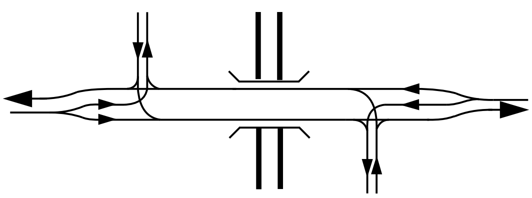
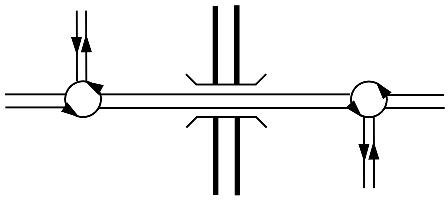
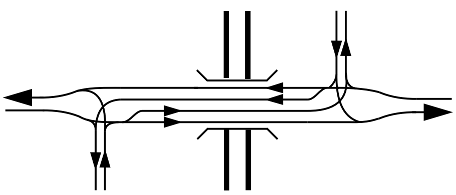
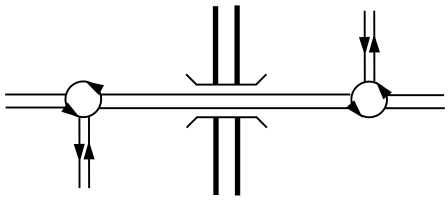
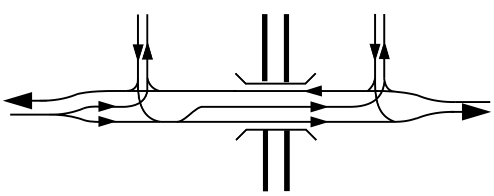
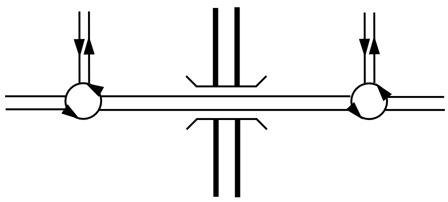
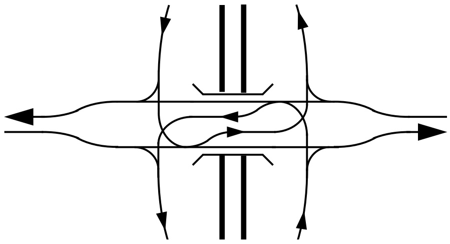
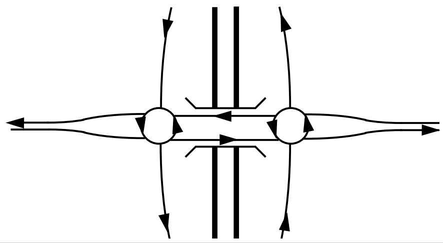
diagonal half cloverleaf with exit in front of the building (unsymmetrical)	
	
Advantages: – Possible to extend the left exit lane on the lower priority road – Useful in managing high-volume traffic links – Relatively narrow bridge Disadvantage: – Extensive intersection zone on the lower priority road	Advantages: – Avoidance of left exit lane – Short intersection zone on the lower priority road – Minimum bridge width Disadvantage: – Complex routing of through-passing secondary traffic flow
diagonal half cloverleaf with exit in front of the building (unsymmetrical)	
	
Advantages: – If no right exit lane, intersection zone on lower priority road is kept compact – Useful in managing high-volume traffic links Disadvantages: – Unfavourable in terms of driving dynamics – Possibility to extend the left exit lane on the lower priority road limited – Very wide bridge	Advantages: – Avoidance of left-turn lane – Short intersection zone on the lower priority road – Minimum bridge width Disadvantages: – Unfavourable in terms of driving dynamics – Possibility of tailback on exit ramp – More space required – Complex routing of through-passing secondary traffic flow
symmetrical half cloverleaf	
	
Advantage: – Useful where space is restricted along one side of the lower priority road Disadvantages: – No preferential link in either direction – One exit ramp unfavourable in terms of driving dynamics – Relatively wide bridge	Advantages: – Avoidance of left-turn lane – Minimum bridge width Disadvantages: – One exit ramp unfavourable in terms of driving dynamics – Possibility of tailback on exit ramp – More space required – Complex routing of through-passing secondary traffic flow

Table A 23 (continued)

Diamond	
	
Advantages: – Favourable in terms of driving dynamics (fast, ascending exit ramps) where the lower priority road is elevated – Needs less space than half clover leaf – Short intersection zone on the lower priority road Disadvantages: – Relatively wide bridge – High speed in the ramps – Poor visibility at the partial intersections – Susceptible to wrong-way travel	Advantages: – Favourable in terms of driving dynamics (fast, ascending exit ramps) where the lower priority road is elevated – Avoidance of left-turn lane – Minimum bridge width Disadvantages: – More extensive intersection zone on the lower priority road – Parting parallel ramps required – More space required – Complex routing of through-passing secondary traffic flow – Susceptible to wrong-way travel
The higher priority road is shown vertically.	

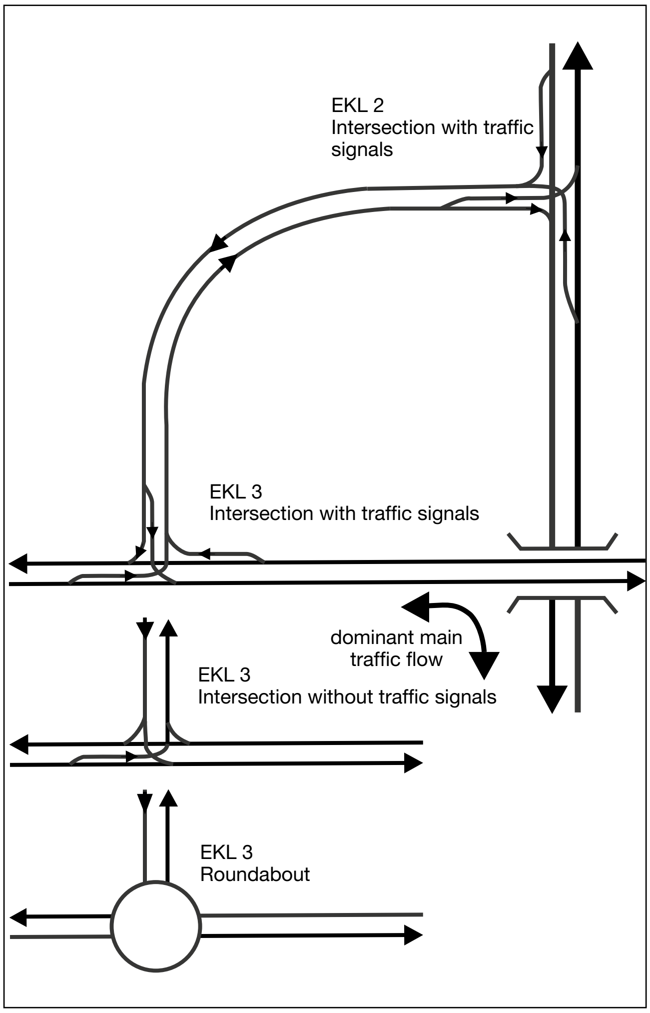


Figure 33: System sketch of partially at-grade intersection (EKL 2 / EKL 3)

6.3.2.3 Partially at-grade intersection

Partially at-grade intersections connect roads at two levels. They comprise two at-grade partial intersections with a connecting ramp between.

Partially at-grade intersections are used where a road of design class EKL 2 links to another EKL 2 road or an EKL 3 road. Where the ramp links to an EKL 2 road, traffic signals are needed for safety reasons. Where the ramp links to an EKL 3 road, other solutions may also be considered.

The ramp should as far as possible be located so that the heaviest main flow does not have to enter from the left (figure 33) The partial intersections should where possible be drawn apart far enough so that widening is avoided on and beneath the bridge.

Intersections with and without traffic signals and roundabouts should be planned as per sections 6.3.3.5 and 6.3.3.6.

Figure 33 shows a system sketch for a partially at-grade intersection and the beneficial location of the ramp to handle a dominant main traffic flow.

6.3.2.4 At-grade intersections or crossings with traffic signals

At-grade intersections (and, where appropriate, crossings) with traffic signals at partially grade-separated or partially at-grade intersections are routinely used where a road of design class EKL 2 links to a road of the same or higher priority.

At-grade intersections with traffic signals are routinely used where a road of design class EKL 3 or EKL 2 links to an EKL 2 road.

In justified exceptional cases, at-grade crossings with traffic signals may also be used where a road of design class EKL 2 or EKL 3 crosses an EKL 2 road.

If an at-grade crossing/intersection is chosen to link EKL 3 or EKL 4 roads to EKL 3 roads, a decision as to the installation of traffic signals must be made after checking the traffic flow quality and road safety criteria (see section 6.3.3.5). This must also consider the traffic management at neighbouring intersections.

Traffic signals should as far as possible be controlled according to traffic flows. For safety reasons, traffic turning left should be protected by a dedicated filter phase. The signalling design is in accordance with the criteria of the “Guidelines for Traffic Signals” (RiLSA). In accordance with VwV-StVO road traffic regulations, the permissible speed in the intersection zone is limited to 70 km/h.

According to RiLSA, the number of through-flowing lanes in the intersection zone may be increased in order to extend capacity, whereby the additional lane should end approximately 250 m after the intersection (point of intersection of the road axes) in the same way as an overtaking lane on a road of design class EKL 2 (see appendix 1).

Intersections or crossings with traffic signals should also be created with a crossing angle of 80 gon (72°) to 120 gon (108°). Locations on crests or in tight curves should be avoided.

With regard to longitudinal gradients, proceed according to section 6.2.4. At intersections or crossings with traffic signals, linkage of the lower priority intersection approach road with a kink (figure 29, case b) should be avoided.

Appendix 7 presents examples of intersections and crossings with traffic signals.

[3] When applying average cost rates, it should be assumed that an intersection with a traffic volume for the whole intersection above approximately 5,000 vehicles per 24 hours, the higher construction and operating costs of a intersection with traffic signals will be balanced by the accident costs avoided during its useful life. This applies to both crossings and intersections.

6.3.2.5 At-grade intersections or crossings without traffic signals

At-grade intersections or crossings without traffic signals may be used where a road of design class EKL 3 links to another EKL 3 road or an EKL 4 road. This is the standard solution where an EKL 4 road links to another EKL 4 road.

In justified exceptional cases, an intersection without traffic signals may also be used where a road of design class EKL 3 links to an EKL 2 road.

In doing so, it must be investigated whether the safety disadvantages resulting from the lack of traffic signals are acceptable.[3]

Intersections without traffic signals may also be used where a road of design class EKL 3 links to a partially grade-separated or partially at-grade intersection on a higher ranking road.

Intersections are more advantageous than crossings. It should be investigated whether a filter to the right can be implemented instead of a crossing.

Intersections and crossings without traffic signals in tight curves should be avoided. If the lower priority road feeds in to the inside of the curve, visibility for the waiting motorists is unfavourable. If it feeds in to the outside of the curve, the intersection is not clearly identified by motorists on the lower priority approach road and judging speeds in the higher priority traffic flow is problematic. If such a location is unavoidable in justified exceptional cases, special measures may be helpful (see section 6.6).

The location of intersections or crossings without traffic signals on crests or in obstructed vision areas should be avoided. If this is not possible for the lower priority road in justified exceptional cases, separate measures should be implemented for the lower priority approach roads in order to improve intersection recognition, such as extended carriageway dividers and plantation of the surrounds, or the installation of walls (see section 6.6).

At intersections or crossings without traffic signals, lower priority approach roads requiring drivers to give way should be configured as single lanes.

Especially where visibility is a problem for the approaching traffic or where the priority traffic has difficulty detecting the situation, as well as where cyclists and pedestrians are routed over the priority road, it should be investigated whether the permissible maximum speed should be limited. This also applies where a central island is planned as a crossing refuge for cyclists and pedestrians.

Appendix 7 presents examples of at-grade intersections and crossings without traffic signals.

6.3.2.6 Roundabouts

Roundabouts are considered where a road of design class EKL 3 links to another EKL 3 road or an EKL 4 road. They may be used in justified exceptional cases where a road of design class EKL 2 links to another EKL 2 road or an EKL 3 road.

Roundabouts are also considered where a road of design class EKL 3 links to a higher-ranking road at a partially grade-separated or partially at-grade intersection.

Roundabouts are particularly suitable where the traffic loads of the linked roads roughly match. The traffic volume on the less heavily used intersection approach roads at three leg roundabouts should account for at least 15 % of the total entering traffic load, and at four leg roundabouts for at least 20 % (sum of the traffic volumes of both intersection approaches on the less heavily used stretch of road).

The traffic flow quality must be verified according to HBS procedures.

If the traffic flow quality of a single-lane roundabout is not adequate, and there is heavy traffic exiting to the right, the quality can be improved by engineering a separate right-hand exit (bypass) lane (see section 6.4.15).

If the traffic flow quality of a single-lane roundabout is not adequate even when a bypass is installed, it should be investigated whether the quality can be improved by a two-lane roundabout, or whether a different intersection type should be selected.

If the traffic flow quality of an existing two-lane roundabout is not adequate, it can be improved by installing two-lane approach roads when carrying out redevelopment work. Details on the configuration of two-lane roundabouts and two-lane approach roads are contained in the “Fact sheet for the construction of roundabouts”.

The axes of the linked roads should be aligned radially to the centre point of the circle.

Examples of correct configuration of roundabouts are presented in appendix 7.

6.4 Elements of Intersections

6.4.1 Through lanes

Continuous lanes within the intersection zone are equal in width to the lanes on the adjoining stretches not forming part of the intersection. In justified exceptional cases the width before the intersection may be reduced by 0.25 m if that is the only way to create the required lanes for exiting traffic flows.

If continuous lanes must be offset in order to create left-exit lanes or carriageway dividers, the procedure as per section 5.6.4 should be applied.

In circular curves the necessary widening of the lanes is produced as per section 5.6.3.

At grade-separated and partially grade-separated intersections with merging and diverging lanes, a crown is permissible between them and the continuous carriageway within the cross-section if the ramp and the change in transverse gradient cannot otherwise be accommodated in the transitional bend of the ramp. However, the difference between the transverse gradients of the continuous carriageway and the exit or entry filter lane at the start of the carriageway limitation (sign 295 StVO) before the island tip on the exit or at the end of the carriageway limitation after the island tip of the entry must not exceed Δq = 5.0 %. If necessary, the carriageway limitation must be extended relative to the standard as per section 6.4.2 or section 6.4.3 as appropriate.

The longitudinal gradient should be at least high enough such that zones of poor drainage in the stretches with changing transverse gradient are avoided. If the longitudinal gradient is adequate, the stretch with changing transverse gradient may be advanced a distance into the diverging/merging lane such that the transverse gradient q = 0.0 % is already reached at the start/end of the transitional circular curve. A maximum ramp slope of 2.0 % must be observed.

6.4.2 Exits

Exit zones should be configured with a parallel diverging lane (figure 34).

Diverging lanes are 3.50 m wide (including the interrupted carriageway limitation). The shoulder in the vicinity of exit lanes is 0.50 m wide.

The length of the diverging lane l_A on single-carriageway roads is 150 m, and on dual-carriageway roads 200 m. The diverging lane ends at the tip of the no-entry zone. The tip of the no-entry zone is located where the surface width of 5.25 m (lane width of RRQ 1 at 4.50 m and width of right-hand shoulder at 0.75 m) is attained through the alignment of the carriageway edge. The length of the carriageway limitation before the tip of the no-entry zone is usually $0.1 \cdot l_A$.

The measure of the island head perpendicular to the higher priority road between the carriageway edges is 2.00 m. Details on marking of the exit zone are contained in the “Guidelines for Road Markings” (RMS).

The length of the offset l_Z is a uniform 30 m.

An exit should not be combined with the end of an overtaking lane as a lane subtraction (see section 4.5.2.3).

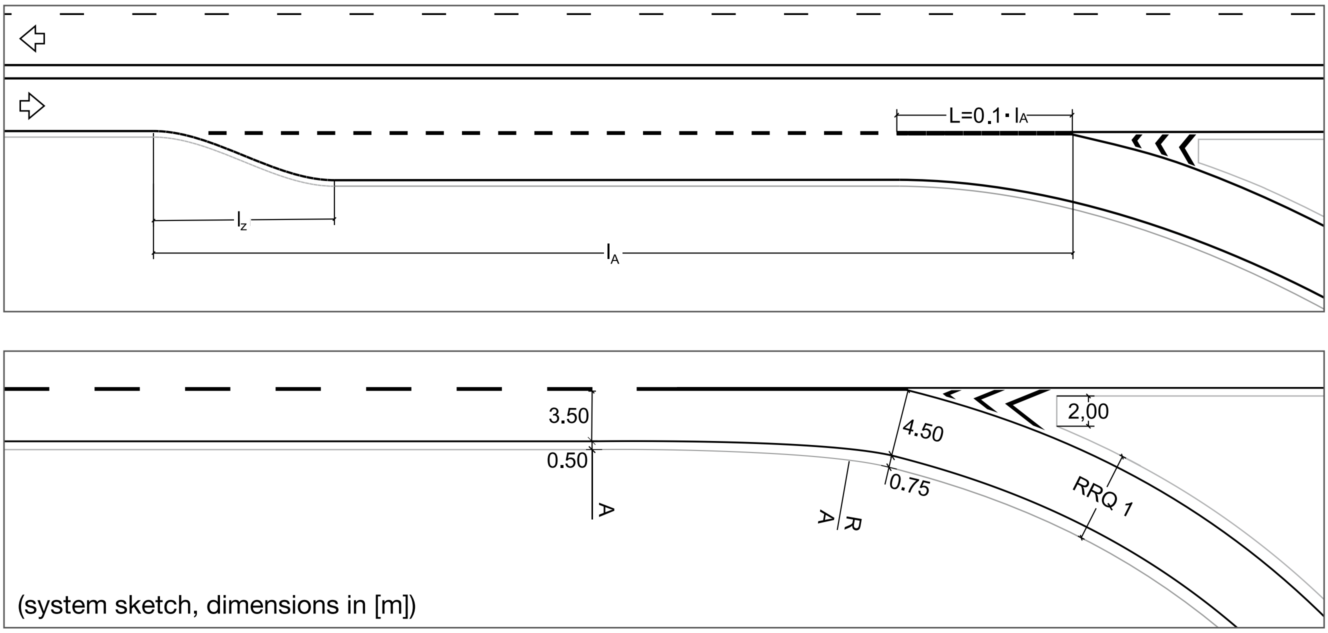


Figure 34: Diverging lane with island tip.

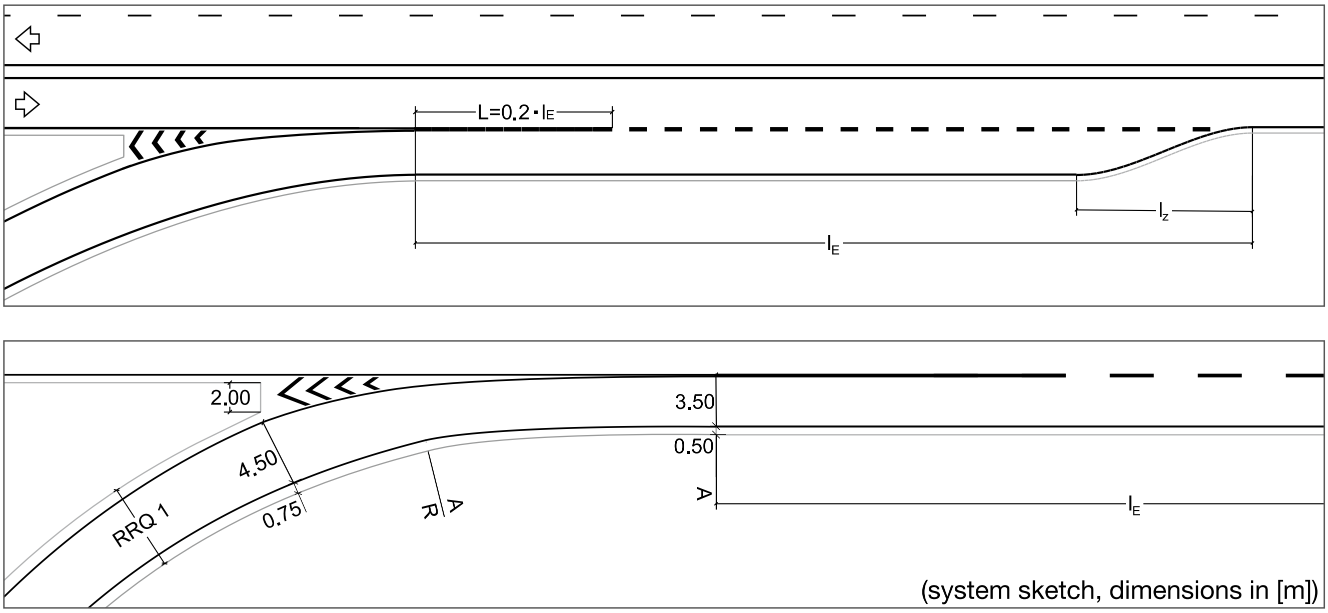


Figure 35: Merging lane with island tip

6.4.3 Entries

Entry zones should be configured with a parallel merging lane (figure 35).

Merging lanes are 3.50 m wide (including the interrupted carriageway limitation). The shoulder in the vicinity of entry filter lanes is 0.50 m wide.

The offset of the width of the lane and of the right-hand shoulder based on the dimensions stipulated by RRQ 1 is obtained solely by means of marking as from the island head. The measure of the island head perpendicular to the higher priority road between the carriageway edges is 2.00 m. Detail on marking of the entry zone are contained in the RMS.

The length of the merging lane l_E on single-carriageway roads is 150 m, and on dual-carriageway roads 200 m. The merging lane starts where the clothoid of the ramp transitions into the alignment parameter of the continuous stretch of road. The length of the carriageway limitation after the start of the merging lane is usually 0.2 l_E.

The length of the offset l_Z is a uniform 30 m.

An entry can also be combined with the start of an overtaking lane as a lane addition (see section 4.5.2.3).

6.4.4 Ramps

Connecting ramps are differentiated according to their alignment in the site plan as direct, semi-direct and indirect.

All ramps are normally configured with adapted alignment. Table 24 shows ranges for the smallest radii to be used. The reference line for the radius is the inner edge of the carriageway.

Connecting ramps must not incorporate any additional intersections or crossings. There should be no land use requiring development within the intersection. The only exceptions to this are rural roads agency and police facilities.

At intersections, crossings and roundabouts, the intersection approach roads of ramps are treated in the same way as roads of design class EKL 3.

Table 25 shows cross-sections for connecting ramps and their applications.

The design elements of the ramps are reduced relative to the stretch of road outside of the intersection. The following conditions must be met:

- Adequate sight distances (stopping sight distance, view of direction signs) are required.
- Ramps before at-grade partial intersections should be extended in the site plan and longitudinal section so that a reading distance of at least 50 m is available in advance of the direction signs.
- The ability for a driver to detect small radii has priority over the visual appearance of the carriageway.
- The length of the ramp should enable pre-filtering and arrangement of any necessary queuing lanes (see section 6.4.7) before the at-grade secondary intersection with traffic signals.

Table 26 shows the limit values of the ramp design elements dependent on the configured radii.

Table 24: Areas for the smallest radii used depending on the type of intersection and ramp

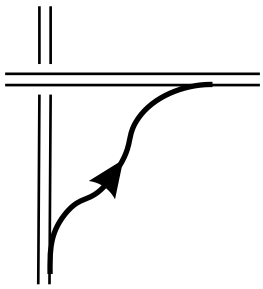
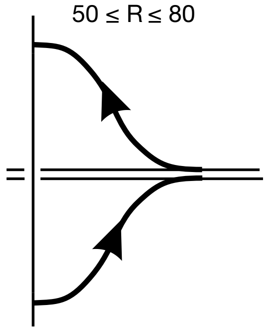
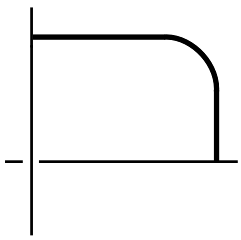
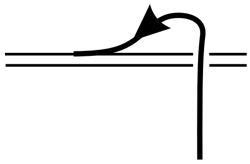
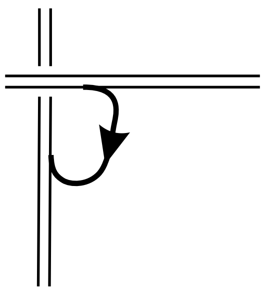
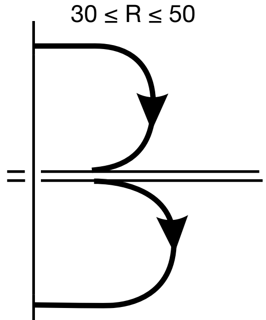
Type of intersection / Type of ramp	Grade-separated intersection	Partially grade-separated intersection	Partially at-grade intersection
direct	60 ≤ R ≤ 80 	50 ≤ R ≤ 80 	40 ≤ R ≤ 50 
semi-direct	50 ≤ R ≤ 80 		
indirect	40 ≤ R ≤ 50 	30 ≤ R ≤ 50  40 ≤ R ≤ 50	
(system sketch, dimensions in [m])			

Table 25: Fields of application of the ramp cross-sections

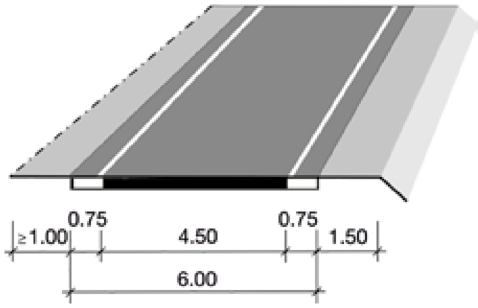
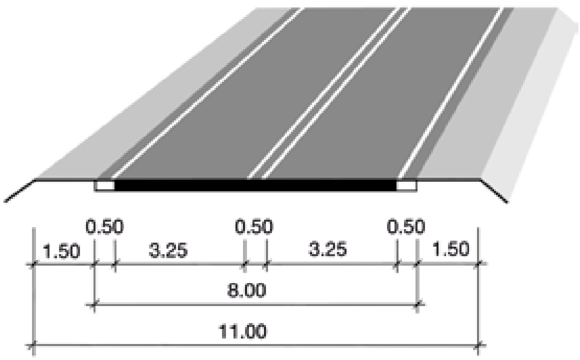
Ramp cross-sections		Applications
RRQ 1		Grade-separated intersections and partially grade-separated intersections with short sections of parallel routed entry and exit ramps
RRQ 2		Partially grade-separated intersections with shared entry and exit ramp routing and partially at-grade intersections
(dimensions in [m])		

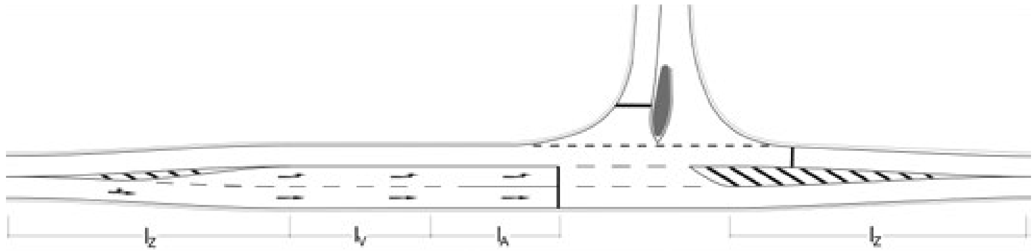
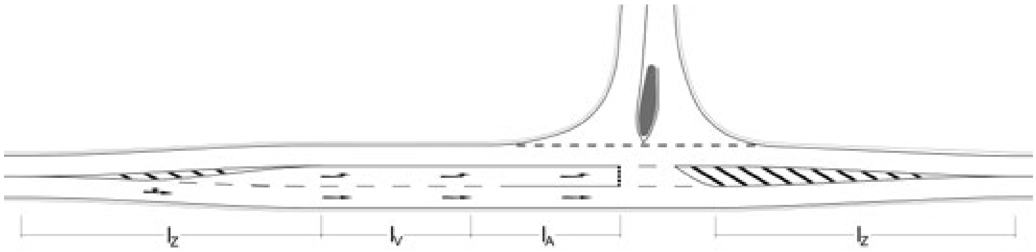
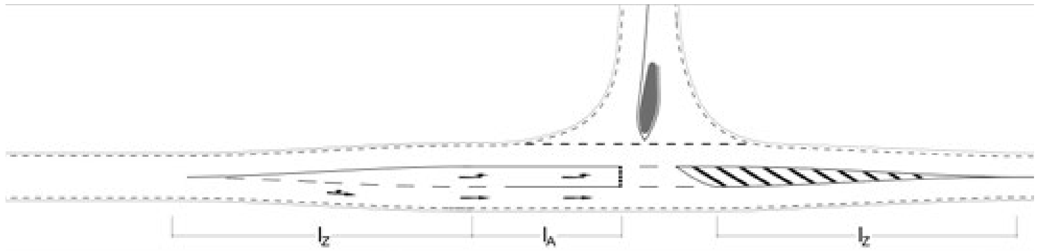
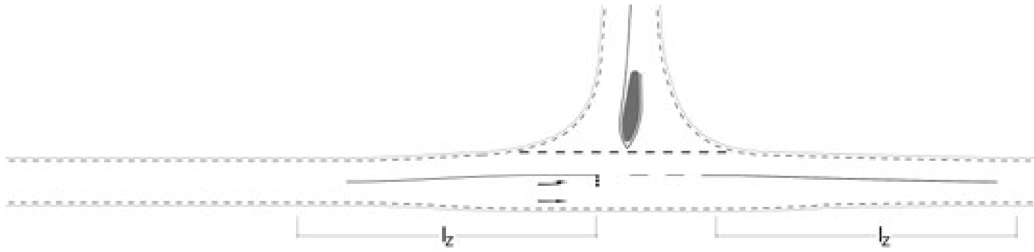
Table 26: Limiting values for draft ramp elements

each realigned radius	**R**	[m]	**30**	**40**	**50**	**60**	**80**
Minimum crest radius	min H_K	[m]	1,000	1,250	1,500	1,750	2,000
Minimum sag radius	min H_W	[m]	500	625	750	850	1.000
Limiting values of the longitudinal gradient	max s	[%] (rise)	+ 6.0				
	min s	[%] (drop)	- 7.0				
Stopping sight distance	S_H	[m]	30	35	40	45	55
Minimum transverse gradient outside offset zones	min q	[%]	2.5				
Maximum transverse gradient	max q	[%]	6.0				
Minimum ramp slope	min Δs	[%]	0,1 · a a [m]: Distance from centre of rotation to carriageway edge				
Maximum ramp slope	max Δs	[%]	2.0				
Maximum camber	max p	[%]	10.0				
Curve widening	i in RRQ 2	[m]	2.00	1.00	0.50	–	–

The following special features have to be observed.

- On exit ramps the smallest possible clothoid parameters should be applied to ensure early detection of the curve radii in the vicinity of the island tip. The reference line for the radius is the right-hand edge of the carriageway.
- The clothoid parameter should be selected such that the ramp slope of 2.0 % is not exceeded and the change of transverse gradient can as far as possible be executed within the transitional circular curve (see section 6.4.1).
- Sequential radii should be oriented to the principle of relational alignment. A subsequent radius should, as far as possible, not be substantially smaller than the previous radius. In the case of sequential radii with interim straights of more than 100 m in length, the subsequent radius should as far as possible be substantially larger than the previous radius (the target is a ratio $R_2 : R_A = 1.5 : 1$).
- In case of steep longitudinal gradients of the linked roads and so-called following longitudinal gradients of the connecting ramps, exceeding of the limit values stipulated in table 26 is permissible provided the maximum camber of 10.0 % is maintained. The minimum camber of 0.5 % also applies to ramps.

Table 27: Left-turn types

Left-turn type	Sketch
LA1	
LA2	
LA3	
LA4	
System sketch	

Lane widening in curves should be executed as per table 26.

With small radii, a greater usable width than 6.00 m is required for a truck to pass a broken down truck or parked rural roads agency vehicle. Consequently, in the ramp cross section RRQ 1 an additional emergency escape space of 1.00 m must be provided beyond the surfaced area at radii of R = 50 m, and at radii of R = 30 m a similar space of 2.00 m. The vehicle restraint systems (safety barriers) should be moved away as necessary.

6.4.5 Left-turn lane

Four types of left turn are differentiated (Table 27).

Table 28 shows the applications of the left exit types dependent on the design class of the road being exited, the operational form of the intersection and the design class of the road being turned into.

Table 28: Fields of application of the left-hand turns

Design class of road exited	Operational form of intersection	Design class of road turned into	Types of left turn
EKL 2	with traffic signals	(EKL 2)/EKL 3	LA1
EKL 3	with traffic signals	(EKL 3)/EKL 4	LA1
	without traffic signals	EKL 3, EKL 4	LA2
EKL 4	without traffic signals	EKL 4	LA3
EKL 4	without traffic signals	EKL 4*) LS V**)	LA4

*) With little left-exiting traffic
**) Also main agricultural roads, factory access roads

Left-turn type LA1 is routinely used on roads of design classes EKL 2 and EKL 3 at intersections with traffic signals.

Type LA1 consists of a left exit lane composed of a queuing section l_A, a deceleration section l_V and an offset section l_Z.

The left exit lane is 3.25 m wide. On roads of design class EKL 2, taking into account the double line, this entails a widening of the carriageway by 2.75 m.

When specifying the stop lines, necessary crossing points for cyclists and pedestrian and the locations of signal units should be considered where appropriate. This applies especially to the location of a signal unit on the left hand side of the road. If it is to be installed on the carriageway divider on the lower priority approach road, the stop line can be moved closer into the intersection zone.

The trajectory curves of entering or exiting vehicles must also be taken into account when specifying the stop lines. This applies in particular to vehicles which may be entering or exiting simultaneously. A truck-trailer combination is the benchmark vehicle.

The calculated tailback as per HBS[4] defines the length of the queuing section l_A. It should be at least 20 m.

The length of the deceleration section l_V is 40 m on EKL 2 roads and 20 m on EKL 3 roads.

The length of the offset section l_Z is 70 m with single side offset and 50 m with offset on both sides. The left exit lane is initiated by a no-entry zone. The offset back towards the left exit lane starts after 40 m with widening on one side and after 30 m with widening on both sides.

Left-turn type LA2 is routinely used on roads of design classes EKL 3 at intersections without traffic signals.

Type LA2 consists of a left exit lane composed of a queuing section l_A, a deceleration section l_V and an offset section l_Z.

The left exit lane is 3.25 m wide.

The location of the stop or give way line should be specified as per figure 36. The stop or give way line should be moved as necessary due to the trajectory curve of entering vehicles. A truck-trailer combination is the benchmark vehicle. It must additionally be ensured at crossings that the trajectory curves of vehicles possibly exiting to the left simultaneously do not overlap.

The calculated tailback as per HBS[5] defines the length of the queuing section l_A . It should be at least 20 m.

The length of the deceleration section l_V is 20 m.

4) The 90 % tailback calculated for the rated traffic volume is used.

5) The 95 % tailback calculated for the rated traffic volume is used.

If no significant tailback of traffic turning left is to be expected according to HBS, no deceleration section is required.

The length of the offset section l_Z is 70 m with single side offset and 50 m with offset on both sides. The left exit lane is initiated by a no-entry zone. The offset back towards the left exit lane starts after 40 m with widening on one side and after 30 m with widening on both sides. In justified exceptional cases, the offset back towards the left exit lane may start after 30 m with widening on one side and after 20 m with widening on both sides.

Left-turn type LA3 is routinely used on roads of design class EKL 4 where roads of design class EKL 4 join them.

It may also be used on EKL 3 roads where EKL 4 roads, roads classified under LS V, main agricultural roads or factory access roads join them and no significant tailback[6] of left-exiting traffic is to be expected.

Type LA3 consists of a left exit lane composed of a queuing section l_A and an offset section l_Z with open feed-in.

The left-turn lane has a width of 2.75 m. The continuous lanes are widened to 2.75 m on the offset section. The width of the shoulder remains unchanged at 0.50 m.

When specifying the stop or give way lines, the trajectory curves of entering and exiting vehicles must also be taken into account. This also applies to vehicles, which may be simultaneously exiting to the left. A truck-trailer combination is the benchmark vehicle.

Where there is little heavy traffic (< 2 vehicles per h), the adjacent lanes may additionally be used when verifying driveability with the aid of trajectory curves, applying driving style 2.

The calculated tailback as per HBS[5] defines the length of the queuing section l_A . It should be at least 10 m.

The length of the offset section l_Z is 70 m with single side offset and 50 m with offset on both sides. The offset starts with no no-entry zone. The lane limitations adjacent to the left exit lane and to the opposite no-entry zone start and end where the carriageway width due to the widening is 6.50 m.

Left-turn type LA4 is used on EKL 4 roads where EKL 4 roads, roads classified under LS V, main agricultural roads or factory access roads join them and no significant tailback[7] of left-exiting traffic is to be expected as per HBS.

Type LA4 consists of a queuing section l_A and an offset section l_Z.

6) This applies with a 95 % tailback of $N95 \leq 1$ vehicle.

7) This applies with a 95 % tailback of $N95 \leq 1$ vehicle.

To create the 10 m long queuing section, the carriageway is widened such that a lane 4.75 m wide can be marked out for the direction of travel from which the turning traffic is coming. The length of the offset section l_Z is 70 m with single side offset and 50 m with offset on both sides. The offset starts without a no-entry zone. The lane in the opposite direction is 2.75 m wide. The width of the shoulders remains unchanged at 0.50 m.

The lane limitation to mark out the queuing section starts where the carriageway width due to the widening is 6.50 m.

Left exit with no engineering modification

On roads of design class EKL 4, low-load agricultural roads or property access roads are routinely linked with no engineering modification. In justified exceptional cases, this can also be done on roads of design class EKL 3 if such access roads cannot be avoided.

6.4.6 Right-turn lane

Six types of right turn are differentiated (Table 29).

Table 30 shows the applications of the right exit types dependent on the design class of the road being exited, the operational form of the intersection and the design class of the road being turned into.

Right-turn type RA1 is routinely used on roads of design class EKL 2. There it is combined with approach road type KE1 or KE2 (see section 6.4.7).

Type RA1 consists of a right exit lane running parallel to the higher priority carriageway, a triangular island and a large teardrop (see sections 6.4.8 and 6.4.9).

The right exit lane is composed of a queuing section l_A, a deceleration section IV and an offset section l_Z.

The calculated tailback[8] as per HBS defines the length of the queuing section l_A before the stop line. It should be at least 20 m.

The length of the deceleration section IV is 40 m on EKL 2 roads and 20 m on EKL 3 roads.

The length of the offset l_Z is 30 m.

The right exit lane is 3.25 m wide (including the interrupted carriageway limitation line). The shoulder adjacent to the right exit lane is 0.50 m wide.

The width of the carriageway between the triangular island and the corner rounding is at least 5.50 m. Driveability must be verified with trajectory curves as per section 6.7. The corner rounding is effected with a simple circular curve. Its radius is derived from the prevailing geometric conditions (carriageway edge of right exit lane and minimum distances to the triangular island and to the large teardrop). The triangular island is configured as per section 6.4.9.

[8] The 90 % tailback calculated for the rated traffic volume is used.

Right-turning traffic should be integrated into the signal control. This also applies where it would not be necessary to create a right exit lane according to HBS procedures.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road should be implemented close to the higher priority carriageway (normally up to 4.00 m away) by way of the triangular island and the large teardrop.

Right-turn type RA2 is routinely used on roads of design class EKL 3 where other EKL 3 roads join at a signalised intersection. It may also be used at low-volume intersections on EKL 2 roads where a triangular island is not necessary or not possible. In both cases it is combined with approach road type KE1 or KE2 (see section 6.4.7).

The corner rounding is executed with a sequence of three circular curves and a small teardrop (see section 6.4.8). The main circular curve radii are configured as per section 6.4.11.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road should be implemented close to the higher priority carriageway (normally up to 4.00 m away) by way of the small teardrop.

Type RA2 is assigned a right exit lane running parallel to the higher priority carriageway if so required according to HBS procedures.

The right exit lane is composed of a queuing section l_A, a deceleration section l_V and an offset section l_Z.

The calculated tailback as per HBS[8] defines the length of the queuing section l_A before the stop line. It should be at least 20 m.

The length of the deceleration section l_V is 40 m on EKL 2 roads and 20 m on EKL 3 roads.

The length of the offset l_Z is 30 m.

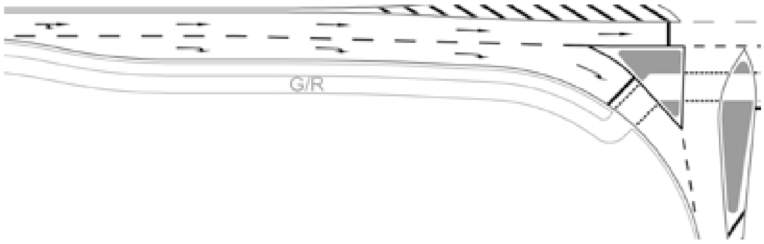
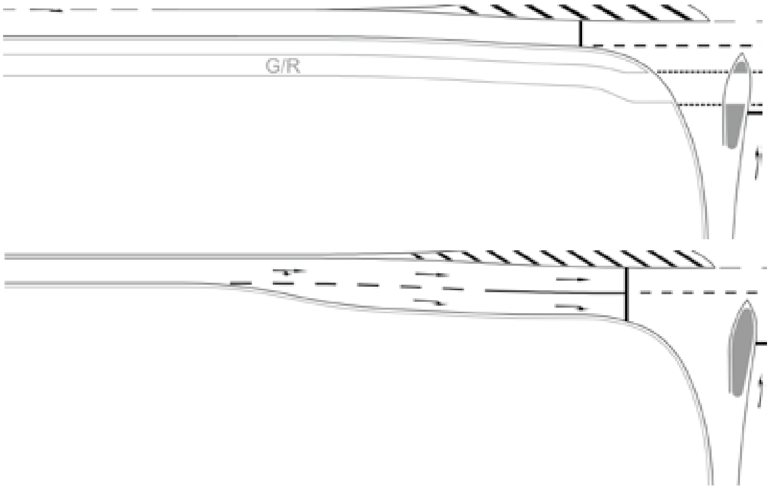
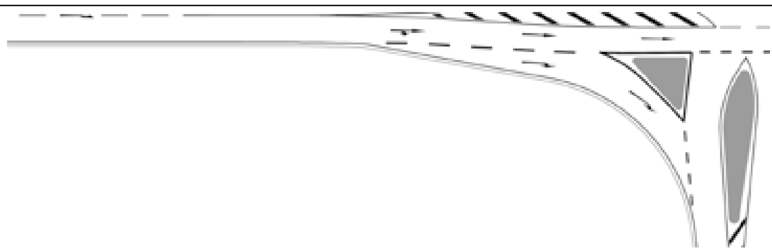
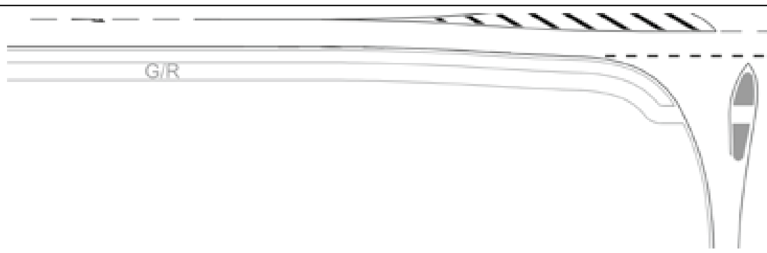
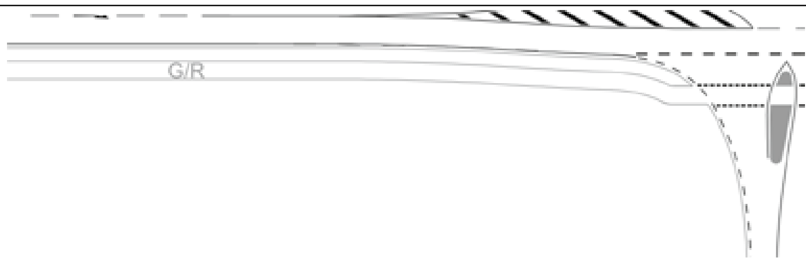
The right exit lane is 3.25 m wide (including the interrupted carriageway limitation line). The shoulder adjacent to the right exit lane is 0.50 m wide.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway , the crossing over the lower priority approach road should be implemented by way of the small teardrop even if there is a right exit lane.

Right-turn type RA3 is considered for roads of design class EKL 3 where EKL 3 roads join at an intersection without traffic signals and right-turning traffic needs to be cleared rapidly due to the high traffic load on the higher priority road. It is combined with approach road type KE3 (see section 6.4.7).

The corner rounding is executed with an circular curve, a triangular island and a large teardrop. The circular curve of the corner rounding has a radius of 25 m. The triangular island is configured as per section 6.4.9. The

Table 29: Right-turn types

Right-turn type	Sketch	Allocated access type
RA1		KE1/KE2
RA2		KE1/KE2
RA3		KE3
RA4		KE4
RA5*		KE5*
RA6*		KE6*

*) If left exit with no engineering modifications is possible as per section 6.4.5, the small teardrop can be omitted, provided perception of the obligation to wait is assured by signage and/or plantation.

Table 30: Fields of application of the right-turn types

Design class of road exited	Operational form of intersection	Design class of road turned into	Separate routing of cyclists/pedestrians: Parallel to higher priority road via lower priority approach road	Separate routing of cyclists/pedestrians: Across higher priority road	Right-turn type	Associated approach road type for crossing/ entry
EKL 2	with traffic signals	**(EKL 2)/EKL 3**	Yes	Yes	RA1	KE1/KE2
(EKL 2)/EKL 3	with traffic signals	**(EKL 3)/EKL 4**	Yes	Yes	RA2	KE1/KE2
EKL 3	without traffic signals	**EKL 3**	No	No	RA3/RA4	KE3/KE4
	without traffic signals	**EKL 3**	Yes	Yes*	RA4	KE4
	without traffic signals	**EKL 4**	Yes	Yes*	RA5	KE5
EKL 4	without traffic signals	**EKL 4**	–	–	RA6	KE6

() Exceptions
*) Only applicable at intersections. The crossing is effected by way of a refuge in the vicinity of the no-entry zone opposite the left exit lane.

width of the carriageway between the triangular island and the corner rounding is at least 5.50 m. Driveability must be verified with trajectory curves as per section 6.7.

The requirement for right-turning traffic to wait behind the triangular island, should be indicated by sign 205 StVO (Give way!) and sign 340 StVO (interrupted carriageway limitation line).

Type RA3 is not suitable if cyclists and pedestrians have to cross the right-turning traffic.

Right-turn type RA4 is routinely used on roads of design class EKL 3 where other EKL 3 roads join at an intersection without traffic signals. It is combined with approach road type KE4 (see section 6.4.7).

The corner rounding is executed with a sequence of three circular curves and a small teardrop. The main circular curve radii are configured as per section 6.4.11.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road should be implemented away from the higher priority carriageway (normally at least 6.00 m away) by way of the small teardrop, with mandatory queuing (without surface marking) (see section 6.8.2).

Right-turn type RA5 is routinely used on roads of design class EKL 3 where other EKL 4 roads join at an intersection without traffic signals. This also applies to joining of roads categorised under LS V, main agricultural roads or factory access roads. Type RA5 may also be used where low-volume EKL 3 roads join at an intersection without traffic signals. In both cases it is combined with approach road type KE5 (see section 6.4.7).

The corner rounding is executed with a sequence of three circular curves and a small teardrop. The main circular curve radii are configured as per section 6.4.11.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road should be implemented close to the higher priority carriageway (normally up to 4.00 m away) by way of the small teardrop on a (red coloured) surface marking prioritised for cyclists (see section 6.8.2).

Type RA5 is only suitable if the traffic on the higher priority road is so light and the intersection so clearly laid-out that oncoming cyclists are seen in good time by right-turning motorists.

Right-turn type RA6 is routinely used on roads of design class EKL 4 where other EKL 4 roads, roads categorised under LS V, main agricultural roads or factory access roads join. It is combined with approach road type KE6 (see section 6.4.7).

The corner rounding is executed with a sequence of three circular curves and a small teardrop. The main circular curve radii are configured as per section 6.4.11.

6.4.7 Crossing and turning

Separate lanes for entering and crossing traffic flows with at at-grade intersections or crossings and at-grade partial intersections of partially grade-separated and partially at-grade intersections increase the capacity of the intersection and provide space for queuing vehicles.

Carriageway dividers (teardrops) should routinely be installed to indicate the stop or give way requirement. These are configured as per section 6.4.8. Additionally, to indicate the requirement to wait and in order to improve visibility to the left, the corner rounding should be as small as possible taking into account the driving geometry demands of the standard benchmark vehicle. The corner rounding is therefore executed with a sequence of three circular curves. The main circular curve radii of the corner roundings are configured as per section 6.4.11. The width of the carriageway between the carriageway divider and the corner rounding (including the shoulders on both sides) is at least 4.50 m.

The lanes for the crossing traffic should be routed so that the crossing vehicles can negotiate the intersection without major changes of direction.

Six approach road types for crossing and entry are differentiated (table 31).

Approach road type KE1 is used in combination with right exit types RA1 or RA2 on roads of design classes EKL 2 and EKL 3 in order to attain high capacity at signalised intersections.

Type KE1 for intersections comprises separate lanes for the traffic entering from the left and right. At crossings, as well as the lane for the crossing traffic it comprises additional lanes for traffic entering from the left and right. If additional lanes are not required for both entering traffic flows, the crossing traffic and the traffic entering from the right are usually consolidated.

Lanes for traffic entering from the left and right are 3.25 m wide. The lengths of the associated queuing sections are produced in accordance with the HBS procedure.

The carriageway widening necessary to create separate or additional lanes should usually be developed to the right starting from the axis of the lower priority intersection approach road. Details on the construction are contained in appendix 6.

The carriageway divider in combination with right-turn type RA1 is a large teardrop, and in combination with right exit type RA2 a small teardrop. The shoulders on the right-hand carriageway edge are 0.50 m wide. The shoulders on the teardrop are 0.25 m wide. They can be widened to 0.50 m if necessary for surface water drainage.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road is implemented as in the case of right exit type RA1 or RA2.

Approach road type KE2 is used in combination with right exit type RA1 or RA2 on roads of design classes EKL 2 and EKL 3 at intersections with traffic signals where a single-lane queuing section is sufficient according to HBS procedures.

The carriageway divider in combination with right-turn type RA1 is a large teardrop, and in combination with right exit type RA2 a small teardrop.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road is implemented as in the case of right exit type RA1 or RA2.

Approach road type KE3 is used in combination with right-turn type RA3 on roads of design class EKL 3 at intersections without traffic signals.

A large teardrop is installed as a carriageway divider.

If the right-entering traffic flow including a lot of heavy vehicles turns into a carriageway on a steep incline, it may be useful to install a merging lane with a length lE of at least 150 m. In these cases the right-entering traffic should be routed behind a triangular island.

Approach road type KE4 is routinely used in combination with right-turn type RA4 where a road of design class EKL 3 joins another EKL 3 road at an intersection without traffic signals.

A small teardrop is installed as a carriageway divider.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road is implemented as in the case of right-turn type RA4.

Approach road type KE5 is routinely used in combination with right-turn type RA5 where a road of design class EKL 4 joins another EKL 3 road at an intersection without traffic signals.

A small teardrop is installed as a carriageway divider. The lane limitation (sign 295 StVO) before the teardrop starts where the carriageway width due to the widening is 6.50 m.

If cyclists and pedestrians are on a separate path parallel to the higher priority carriageway, the crossing over the lower priority approach road is implemented as in the case of right-turn type RA5.

Approach road type KE6 is routinely used in combination with right-turn type RA6 where a road of design class EKL 4 joins another EKL 4 road. It is not suitable if cyclists and pedestrians have to be guided parallel to the higher priority carriageway on a separate path across a lower priority approach road.

A small teardrop is installed as a carriageway divider. The lane limitation (sign 295 StVO) before the teardrop starts where the carriageway width due to the widening is 6.50 m.

In configuring the main circular curve radii for the corner rounding as per section 6.4.11, it is accepted that heavy vehicles entering from the right will briefly occupy the road space of the oncoming traffic.

Other approach roads

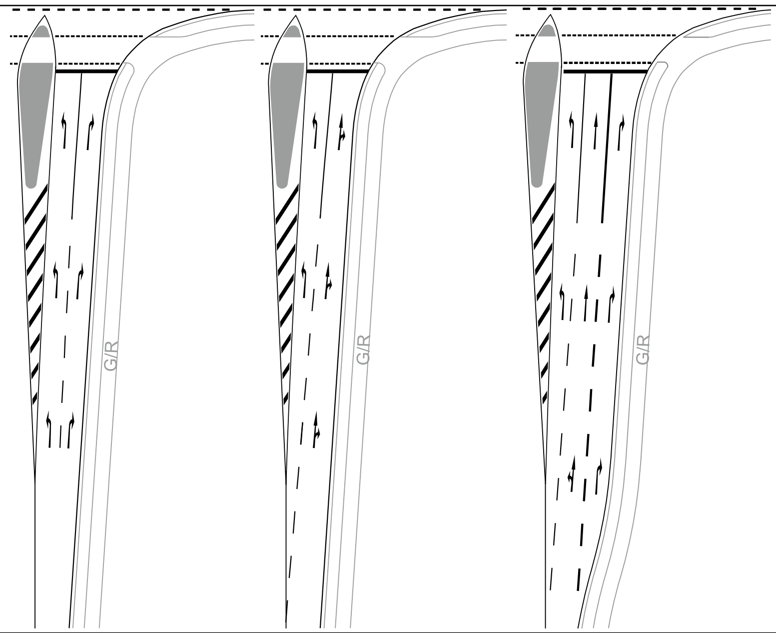
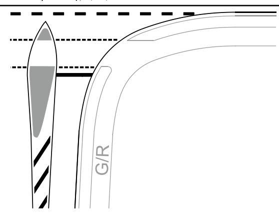
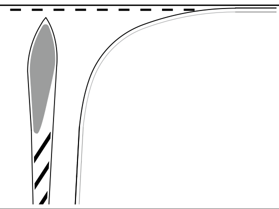
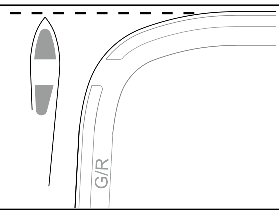
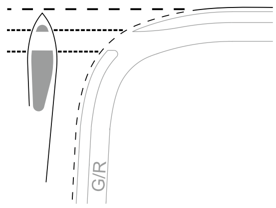
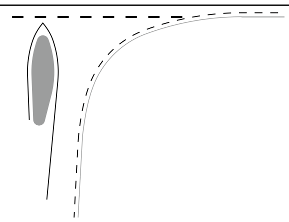
Roads categorised under LS V, main agricultural roads, factory access roads etc. link to roads of design class EKL 3 or EKL 4 in the same way as EKL 4 roads.

6.4.8 Carriageway dividers

On the lower priority intersection approach roads carriageway dividers should be installed as a matter of principle in order to tell motorists that they must wait.

If the left exit lane as per section 6.4.5 is configured with no engineering modification, carriageway dividers at intersections are not needed, provided the right of way situation is clearly identifiable by means of traffic signs and/or vegetation.

Table 31: Types of access for crossing and turning off

Approach road type	Sketch	Associated right-turn type
KE1*		RA1/RA2
KE2*		RA1/RA2
KE3		RA3
KE4		RA4
KE5		RA5
KE6		RA6**

*) Configuration in combination with RA2 and small teardrop

**) If left exit with no engineering modifications is possible as per section 6.4.5, the small teardrop can be omitted, provided perception of the obligation to wait is assured by signage and/or plantation.

Carriageway dividers are configured with sloped kerbs. The crossing points for cyclists and pedestrians should be configured in accordance with the “Notes on Barrier-Free Traffic Installations” (H BVA).

Carriageway dividers at intersections and crossings are configured as large and small teardrops (figure 36).

The **large teardrop** is used in combination with right exit types RA1 and RA3. In all other cases the **small teardrop** is used.

Methods of constructing large and small teardrops are contained in appendix 6.

At crossings, simultaneous left exit should be possible, though the freedom of movement of the standard benchmark vehicles must not be allowed to overlap. Whether the carriageway dividers must be moved further away from the carriageway edge of the higher priority road should be checked with trajectory curves as per section 6.7.

If simultaneous entry from the left is to be possible at crossings with traffic signals, the freedom of movement of the standard benchmark vehicles must not be allowed to overlap. This must be checked as per section 6.7 with trajectory curves.

On the lower priority intersection approach road a lane limitation (sign 295 StVO) should be installed before the carriageway divider.

The recognition of the carriageway divider and the perceptibility of the traffic routing configuration should be checked, where appropriate also with perspective images. The carriageway divider should be extended as necessary such that the line of sight passes through the carriageway divider (see appendix 6).

6.4.9 Triangular island

Triangular islands are configured with sloped kerbs. The edges of triangular islands are normally configured parallel to the respective lane edge. With shorter length they may also be straight. They should not be shorter than 5.00 m and not longer than 20 m. As a result the area in which right and left exiting traffic meet remains limited and clearly defined.

If a cycle or pedestrian path runs over a triangular island (only with right-turn type RA1), the remaining island edges adjacent to the path crossings should be at least 1.50 m long. Instructions for the design of crossing points for cyclists and pedestrians are contained in H BVA.

Recognition of triangular islands can be improved by

- advance markings
- signage (e.g. direction signs)
- light signals or
- reflectors.

Instructions for constructing triangular islands are contained in appendix 6.

6.4.10 Central island/pedestrian crossings

Cyclists and pedestrians on separate paths must be safely routed when crossing carriageways. The crossing point should be identifiable from a distance that enables motorists to react in good time to crossing cyclists and pedestrians. For cyclists, the fields of view necessary for safe crossing must be free of obstructions (direction signs, foliage) (see section 6.6).

Crossing points should normally be installed in the vicinity of intersections (see section 6.8).

If in special cases, crossing points are required outside of intersections, constructional and/or technical safeguards may be useful, depending on the volume of motor vehicle traffic, the number of heavy vehicles on the road, and the volume and composition of the cycle and pedestrian traffic. Then note the following points:

- The crossing point must not be surface marked or coloured. Cyclists and pedestrians must be made aware of the requirement to wait by sign 205 StVO (Give way).
- The crossing point should be quickly and clearly identifiable for approaching cyclists and offer waiting cyclists or pedestrians adequate space to wait.
- If the volume of the crossing cycle and pedestrian traffic is high, or, if the crossing point is routinely used by vulnerable people (such as schoolchildren), it may be useful to install a central island (figure 37).
- The central island must be clearly identifiable for the motor vehicle traffic from both directions, day and night. Stationary lighting may be required. The posts of stationary signals must not be located on the central island.
- Visual contact between the non-motorised traffic and the motor vehicle traffic must not be impeded by traffic signage and vegetation.
- A lane limitation (sign 295 StVO) should be installed before the island. It should further be investigated whether the permissible maximum speed should be limited in the vicinity of the crossing point.
- The lanes should not be narrowed in the vicinity of the island. They should be offset before and after the island as per table 19.

Shared pedestrian and cycle paths used in both directions of travel outside of built-up areas require a facility to cross the carriageway safely at the start and end of the built-up area. The configuration of crossing points at the entries to built-up areas is stipulated in the RASt guidelines.

On busy roads it may be necessary to install traffic signals at crossing points.

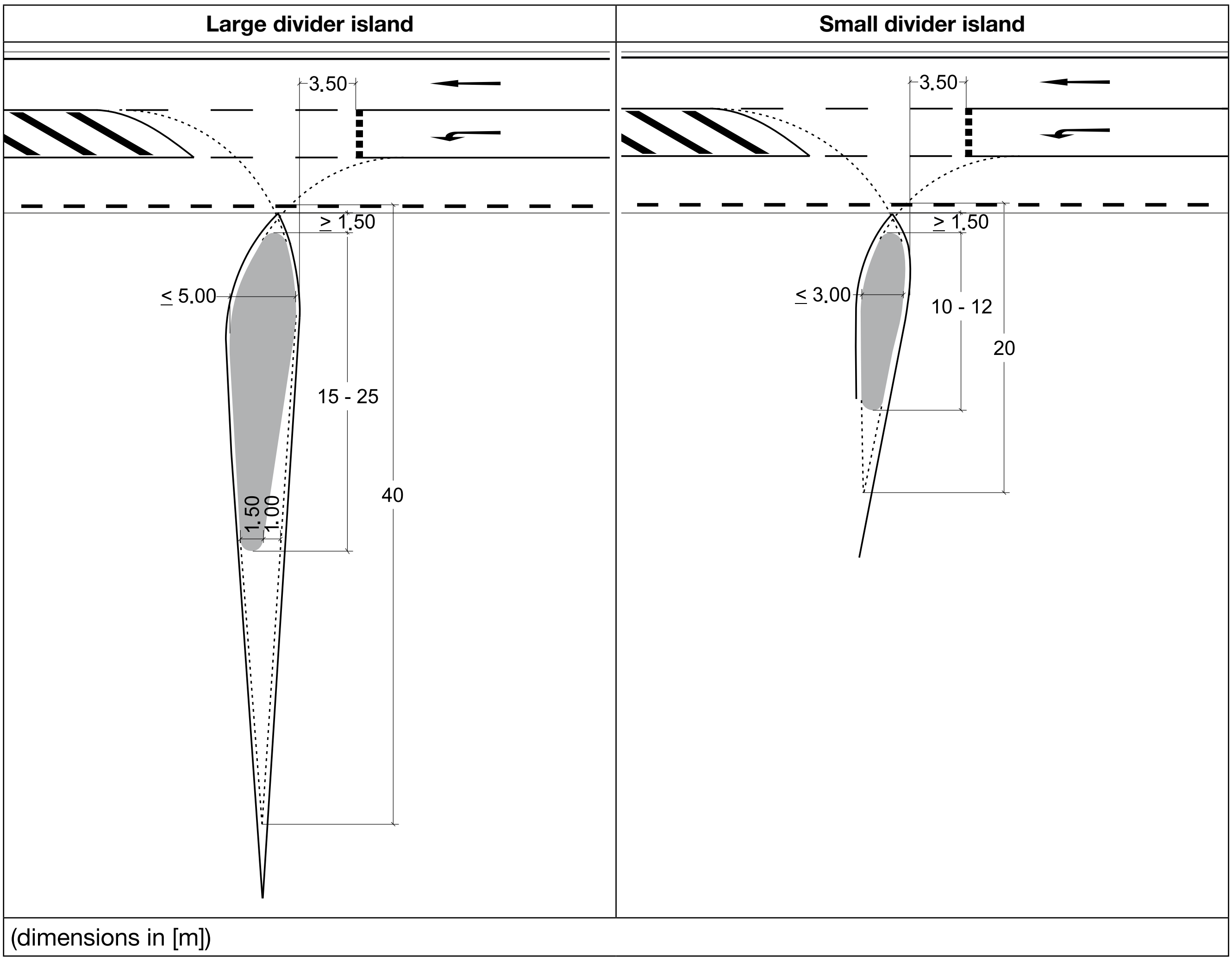


Figure 36: Carriageway divider on entries and crossings

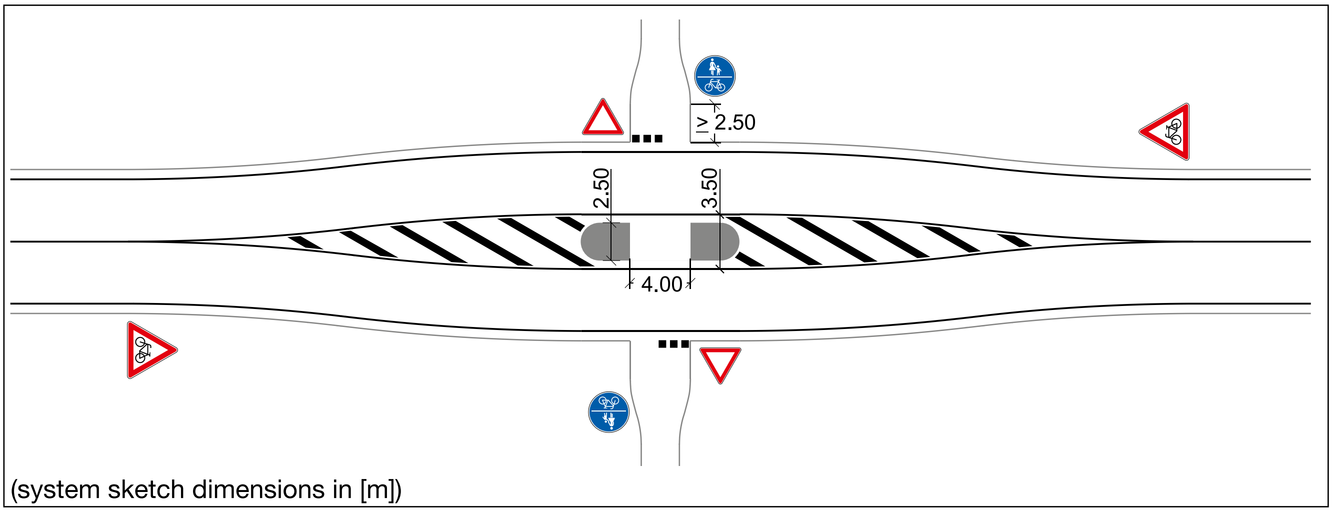


Figure 37: Centre island used as crossing for bicycle and pedestrian traffic

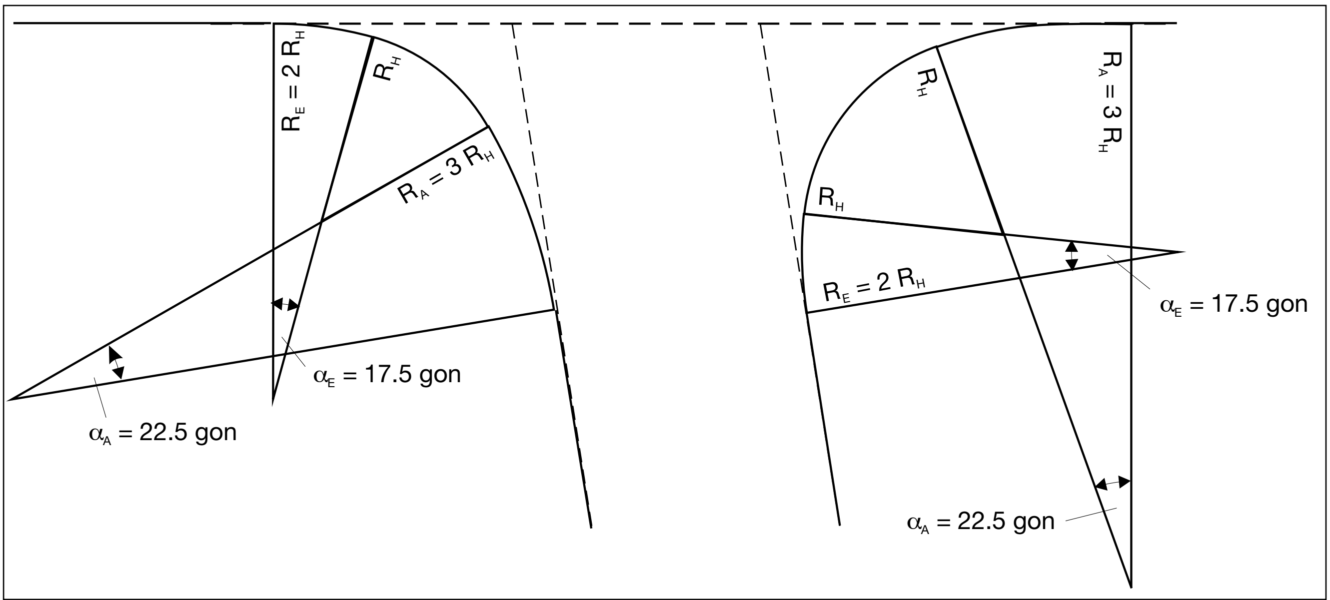


Figure 38: Corner rounding with three-part circular curve sequence

6.4.11 Swept path design

As a rule, corner roundings are three-part circular curve sequences (torispheres) (Figure 38). They are advantageous in particular in the case of larger swept paths, because they are more closely adapted to the trajectory curves of the motor vehicles and take up less space while providing comparable quality of driveability.

The main circular curve radius R_H should be selected such that exiting and entering traffic do not normally have to use the oncoming traffic lane.

The three-part circular curve sequence is configured with a radius ratio

$$RE : RH : RA = 2 : 1 : 3 \quad (8)$$

RE [m] = entry radius
RH [m] = main circular curve radius
Ra [m] = swept outer radius

The entry radius R_E and the exit radius R_A always have constant centre angles (α_E = 17.5 gon (15.8°) and α_A = 22.5 gon (20.3°)) regardless of the overall change of direction angle.

To avoid the impairment of approach visibility associated with a large corner rounding, minor infringements of the left exit lane by trucks entering from the right can be accepted.

For nodes with a crossing angle of 100 gon (90°) and a carriageway divider, the main arch radius R_H for the right-hand turn types RA2, RA4 and RA5 15 m and for the access types KE1, KE2, KE3, KE4 and KE5 should be 12 m. For the right-turn type RA6, the main arch radius R_H should be 12 m and for the access type KE6 it should be 10 m.

The width of the carriageway between the corner rounding and the divider island is at least 4.50 m. If this measure is significantly exceeded with the local circumstances, it should be checked whether safe travel is possible with a main arch radius R_H < 15 m (see section 6.7).

Construction procedure for the corner rounding with a three-part circular curve sequence can be found in Annex 6.

6.4.12 Roundabout carriageways

The roundabout carriageway must be executed with a consistent radius and width as a single-lane carriageway (see section 6.3.3.6).

Table 32 shows the width of the roundabout carriageway depending on the external diameter. The shoulders with a width of 0.50 m each are included in the dimensions specified.

Table 32: Width of roundabout carriageways (including shoulders) depending on the outside diameter

Type	Small roundabout	
Outside diameter D [m]	35 ≤ D < 40	40 ≤ D < 50
Width of the roundabout lane B_K [m]	7.50	7.00

Greater outer diameters aid traversability for heavy traffic.

The roundabout carriageway must be designed as an independent carriageway. It is designed for drainage as a rule with a transverse gradient outwards of 2.5 %. This also improves the identifiability of roundabout traffic.

With a design of the banking deviating from this, the transverse gradient should not exceed 6.0 % at any location.

6.4.13 Roundabout island

The roundabout island must be designed in such a way that it cannot be driven over in normal operation. No obstacles may be placed on it, which may result in severe consequences when being hit by a vehicle.

The roundabout island should be delineated by oblique kerbs or other oblique-angled segregating elements and not by horizontal walls or high kerbs.

The design of the roundabout island is beneficial as a slightly rising hill, as the visual relations going beyond the intersection are thereby interrupted. This effect should be checked from all access routes with perspective images, if applicable.

Notes on the design of roundabout islands as part of routes for heavy-duty and major transports can be found in the Fact sheet for the layout of roundabouts (Merkblatt für die Anlage von Kreisverkehren).

6.4.14 Exit from and entry to roundabouts

Entries to roundabouts should be designed in single lanes; this also applies for entries with two-lane circular carriageways.

Roundabout exit roads should always be single lane.

The entries to roundabouts must be directed to the roundabout traffic in a radial fashion, in as much as possible.

The entries to and exits from roundabouts must be separated by carriageway dividers, their axes should be aligned towards the centre of the circle.

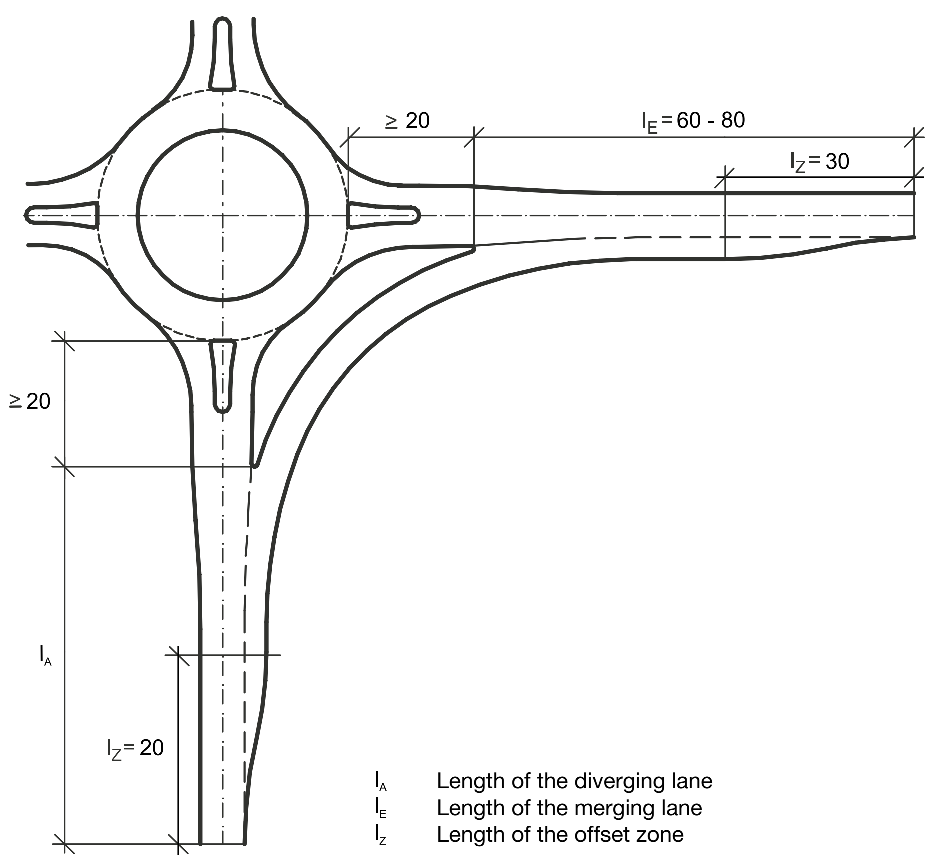
The width of the carriageway next to the carriageway divider should be at least 4.50 m but no more than 5.00 m at the narrowest position in the access route, in the exit at least 4.75 m but no more than 5.50 m. The shoulders on the edge of the lane are 0.50 m wide. The shoulders on the carriageway dividers are 0.25 m wide; they can be widened up to 0.50 m if this is required due to the surface drainage. The traversability of the roundabout entries and exists must be shown with trajectory curves in accordance with section 6.7.

The construction procedure for carriageway dividers can be found in Annex 6.

The carriageway divider should be delineated by mountable kerbs. At crossings for cyclists and pedestrians, they should be at least 2.50 m wide. Design notes are included in H BVA.

If a roundabout access route is in a right corner or crest, the identifiabiilty of the carriageway divider and the clarity of the traffic management should be verified with perspective images, if applicable. The carriageway divider may need to be extended (see section 6.4.8 and figure 36).

The corner roundings of roundabout entries and exists are designed as simple circular curves. The radius at roundabout entries is 14 to 16 m and at roundabout exits 16 to 18 m. If a roundabout exit is not crossed by cyclists or pedestrians, these values may be exceeded by up to 30 %.



(System sketch, dimensions in [m])

Figure 39: Bypass in roundabout

6.4.15 Bypass

With a bypass, cars turning right in roundabout traffic are directed directly and outside the roundabout carriageway.

In doing so, the cars turning right are directed with a diverging lane to the bypass and brought together with the neighbouring roundabout exit via a merging lane. The individual elements are displayed in Figure 39.

The diverging lane is 3.50 m wide including the interrupted carriageway delimitation line. It is initiated with an offset zone. The length of the offset zone l_Z is 20 m. The shoulder next to the diverging lane is 0.50 m.

The length of the diverging lane should be defined in such a way that the start of the diverging lane is not blocked by the tailback[9], calculated in accordance with the HBS for the roundabout entry.

The bypass should be structurally separated from the roundabout carriageway and routed without a counter circular curve. Its carriageway width is 5.50 m. The traversability must be shown with trajectory curves.

Cyclists and pedestrians need to wait before being guided across the bypass.

The merging lane is 3.50 m wide including the interrupted carriageway delimitation line.

Its length is 60 to 80 m, including an offset zone with a length of lz = 30 m. The shoulder next to the merging lane is 0.50 m wide.

If the evidence in accordance with HBS shows that more than one bypass will be necessary, it must be checked whether another intersection element type is more favourable.

6.5 Design of the road surface

Coordinating the longitudinal and transverse gradients as well as the slope transitions in the node access routes, should ensure that the drainage of the surface water is on as shortest possible drainage paths. The following usage criteria have to be observed:

– The slopes of the higher priority road remain unchanged, Those of the lower priority roads must be adjusted to the geometry of the higher priority road.

[9] Authoritative is the 95 % tailback calculated for the measurement traffic density.

– The surface water occurring on the carriageway surface of a route should not reach the node surface or other access routes.
– For the lower priority roads of the same rank to nodes, the drainage aspects are the focus rather than the driving issues.
– Low points of sags and peaks of crests should only be arranged in areas with sufficient transverse gradient ($q \geq 2.5$ %).
– As a rule, a transverse gradient of $p \geq 2.0$ % should be aimed at. In areas where the transverse gradient changes, it may be reduced, but not below 0.5 %.

Carriageway dividers and triangular islands can facilitate the drainage of the carriageway surface, as they:
– Structure the node surfaces
– Favour the design of the positive transverse gradients and
– Enable the arrangement of low points with carriageway drainages on the edges of the carriageway dividers or triangular islands.

The construction of the slope transitions is the basis for determining surface height plans and, where applicable, necessary contour line plans. Contour line plans with slope lines are used, in addition to checking the surface height plans, for determining the low points and determining the necessary road street outlets.

The design of the slope transitions and the low points is influenced by the fact whether
– the gradients of the lower priority road are to be connected to the transverse gradient of the higher priority road with or without the slope difference (kink) (see Figure 29)
– in the lower priority, carriageway dividers or triangular islands are planned.

The guidance of the surface water and the correct position of the road outlets can be checked by processing the carriageway edge as an independent grading plan.

6.6 Sight Distances

6.6.1 General aspects

Nodes and crossings must be identifiable from a distance, which enables drivers to stop before any vehicles as well as cyclists and pedestrians crossing or turning off or on.

In addition, certain visual ranges must be kept free from permanent visibility obstacles (including signposts) and shrubbery for drivers, cyclists and pedestrians who need to wait. In such visual ranges, only necessary traffic facilities, such as light masts, traffic light encoders or traffic light posts are permissible.

The determination of the sight distances should be carried out in three dimensions. The following parameters must be taken into account in doing so:
– Eye height for car drivers: 1.00 m
– Eye height for lorry drivers: 2.50 m (only to be observed for subways, signposts and traffic signs) and
– Target height on the higher priority carriageways: 1.00 m

The required clear sight distance is guided by the design category or by the maximum speed permissible as arranged in the intersection. In particular, the visibility must be provide for the:
– stopping sight distance
– starting distance and
– approach view.

6.6.2 Stopping sight distance

In all node access routes, the stopping sight distances S_H must be observed as stated in Figure 23. As such, it is also ensured, as a rule, that the right of way regulation can be identified in good time (Figure 40). If the visual range required for identifying the right of way regulation cannot be observed in justified exceptions, the right of way regulation must be announced. In addition, it must be verified whether a restriction of the permissible maximum speed is required.

6.6.3 Starting sight distance

The starting sight distance is understood to be the sight distance that is visible on both sides for a driver waiting 3 m from of the edge of the higher priority carriageway (Figure 41). A higher priority footpath/cycling path located close to the carriageway is not considered here.

The starting sight distance range must be sufficiently wide enough so that drivers can turn into the higher priority road from a stop with an acceptable hindrance of the priority vehicles. This applies both for intersections and crossings without traffic signals as well as for intersections and crossings with traffic signals.

The necessary side length L of the starting sight distance is 110 m is for a restriction of the permissible maximum speed to 70 km/h. At intersections or crossings, where the permissible maximum speed is not limited to 70 km/h, the side length L is 200 m.

At intersections where the relevant starting distance range cannot be kept free due to local mandatory conditions, it must be verified whether a restriction of the permissible maximum speed is required.

6.6.4 Approach view

The approach view is considered to be the visual range that is visible for a driver on the lower priority road at a distance of 15 m (with a high number of heavy-duty vehicles turning in 20 m) from the edge of the higher priority carriageway in both directions. A higher priority footpath or cycling path located close to the carriageway is not considered here.

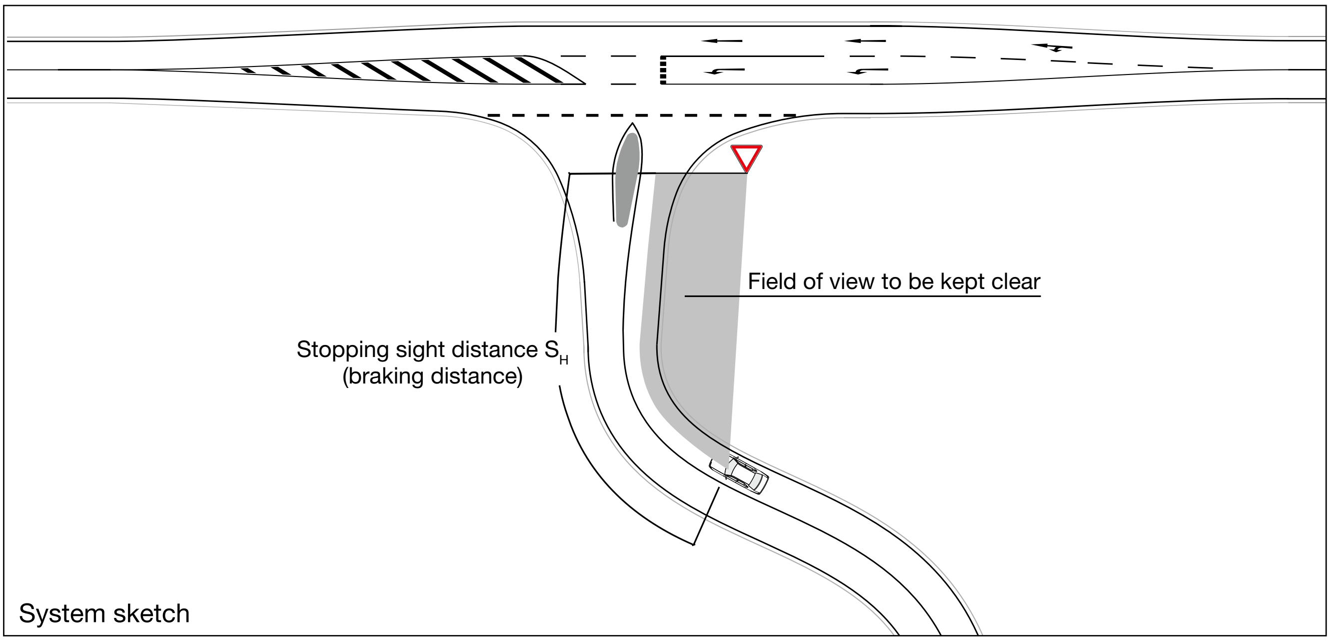


Figure 40: Visual range to be kept free for stopping sight distance in sub-ordinate intersection access

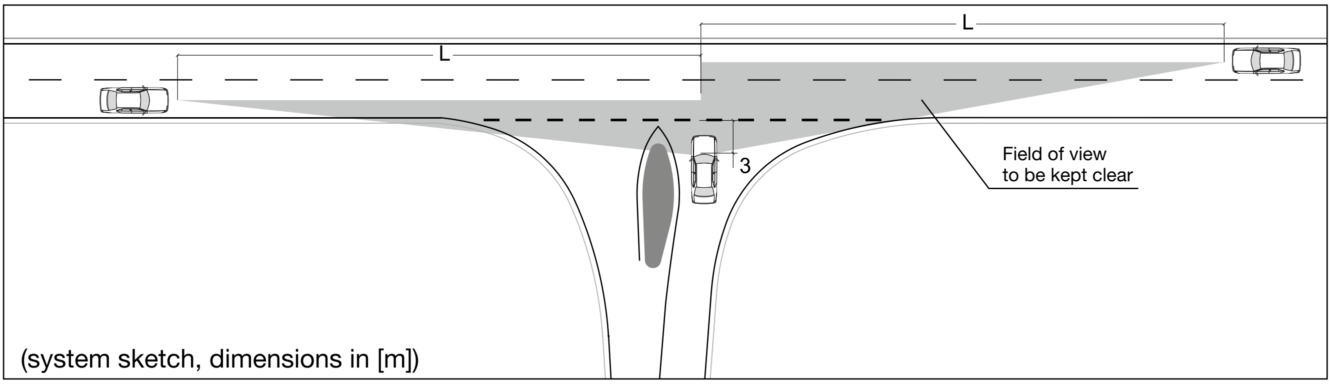


Figure 41: Visual range to be kept free for starting sight distance in sub-ordinate intersection access

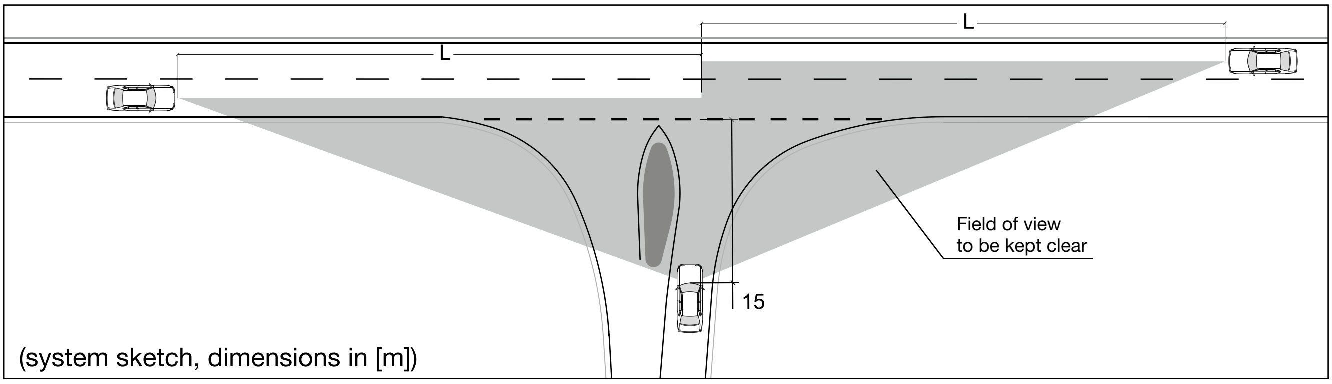


Figure 42: Visual range to be kept free for approach view in sub-ordinate intersection access

If the approach view is sufficiently clear, the driver can turn into the higher priority street without stopping if applicable (Figure 42). For reasons of traffic safety, this option is, however, not applicable if the permissible maximum speed in the higher priority road is limited to 70 km/h. The necessary side length of the approach view is then 110 m.

At nodes where the approach view cannot be kept free or where the permissible maximum speed is not limited to 70 km/h, the arrangement of Item 206 Highway Code (Stop. Grant right of way) and a stop line (Item 294 Highway Code) is suitable.

6.7 Verification of traversability

At nodes of the same plan, the traversability for all manoeuvres of turning on or off the approach must be verified with trajectory curves (see Standard vehicles and trajectory and swept path curves for verification of traversability of traffic areas, RBSV). In doing so, way of driving 1 (the steering wheel is turned while driving) must be used as a rule.

Basically, the combination vehicle is the most unfavourable. If an intersection needs to be regularly used by special transport or military vehicles, this needs to be taken into account by selecting a corresponding measurement vehicle.

In addition to the minimum surface requirement specified by the trajectory and swept path curves, lateral tolerances of 0.50 m should be taken into account.

If trajectory and swept path curves are determined with CAD, the selection of sensible guiding lines, on which the guiding point of the vehicle (centre of the guiding front axis) is conducted, has special significance. The radii underlying the guiding lines must be at least 12.50 m.

6.8 Management of bicycle and pedestrian traffic

6.8.1 General aspects

For cyclists and pedestrians, one sided special paths operated in dual direction traffic are intended as a rule. Due to the high speeds, unambiguous guides and right of way regulations as well as good visual conditions for the non-motorised and the motorised road users are required at nodes.

Examples of the correct guidance of the cycling and pedestrian traffic at nodes of the same plan with and without traffic signals are shown in Appendix 7.

Cyclists and pedestrians crossing a higher priority carriageway or a lower priority road must be taken into account by using corresponding node elements (see sections 6.4.5, 6.4.6 and 6.4.7).

6.8.2 Intersections or crossings without traffic signals

If cyclists and pedestrians are on a separate path parallel with the higher priority carriageway that crosses a lower priority road of EKL 3, they should not have priority for safety reasons as a rule. In doing so, it must be noted that the joint footpath and cycling path is used in both directions as a rule. The crossing of the lower priority road should, in this case, be located away from the higher priority carriageway (as a rule at least 6.00 m) requiring the cyclists and pedestrians to wait. The waiting area in the divider island is 2.50 wide as a rule. The obligation to wait must be made clear with traffic signs; a ford marking or red colouring are not permissible.

If cyclists are on a separate path in parallel to the higher priority carriageway that crosses a lower priority road to a road of EKL 4, they can have priority for reasons of traffic flow quality for the cyclists[10)]. This also applies to access routes of roads of EKL 3 if their use is comparatively low. In doing so, it must be noted that the joint footpath and cycling path is also used by pedestrians. The crossing should in this case be close to the higher priority carriageway (as a rule up to 4.00 m in distance) and across the divider island. To clarify the right of way for cyclists, a ford is marked that should be highlighted in red for safety reasons. The ford is 2.50 m wide.

This solution is only suitable if the traffic on the higher priority road is so low and the intersection is so clearly visible that cyclists, moving in the opposite direction, are identified by drivers turning right in good time. If pedestrian traffic, on the joint footpath and cycling path runnng in parallel to the higher priority road, is not very low, it should be directed on a separate path detached from the higher priority road via the carriageway divider with the obligation to wait.

Non-motorised traffic turning left should be guided indirectly when on a joint footpath and cycling path (Item 240 Highway Code).

If cyclists or pedestrians need to cross the higher priority road, e.g.

- between a separate road in parallel to the carriageway of the lower priority road and an opposite footpath and cycling path in parallel to the higher priority road,
- on a footpath and cycling path as part of the lower priority crossing road or
- on a one-sided footpath and cycling path as part of the higher priority road, which changes the side of the road in the area of the node,

[10)] Highway Code note: The ford indicates the priority of cycling traffic compared to motorised traffic, which turns into the lower priority road or arrives from it. The obligation to wait compared to pedestrians is limited only to the motorised traffic turning into the lower priority road despite the ford (see Section 9 Highway Code).

A central island is effective in controlling the crossing (see section 6.4.10). This can be installed at intersections with left-turn types LA2 and LA3 in which blocking zones opposite the left-turn lanes are integrated. The structural width of the central island is 2.50 m. In the area of the central island, the shoulder of the direction towards the intersection has a width of 0.25 m, the shoulder of the direction moving away from the intersection a width of 0.50 m. The waiting area usable by crossing cyclists or pedestrians in the area of the central island is 4.00 m wide as a rule.

In addition, it must be verified whether a restriction of the permissible maximum speed is required.

At crossings, safe movements by the non-motorised traffic can only be ensured by traffic signals. Otherwise, another node must be selected.

6.8.3 Intersections or crossings with traffic signals

For intersections or crossings with traffic signals, the cycling and pedestrian traffic should be included in the signal controls in accordance with the RiLSA. As a rule, the path over the lower priority road is installed close to the higher priority carriageway (as a rule up to 4.00 m away) on a ford (highlighted in red) via the carriageway divider. As a rule, the ford is 4.00 m wide.

When using the right-turn type RA1, the vehicles turning right should be given an own phase in the signal control and coordination with the signalisation of the non-motorised traffic.

6.8.4 Roundabouts

At roundabouts, where in at least one node access route a carriageway accompanying joint footpath and cycling path is created, the non-motorised traffic is directed outside the roundabout on a joint footpath and cycling path.

When crossing the roundabout entries, the cycling and pedestrian traffic should be detached from the roundabout (as a rule at least 6.00 m) and guided via the carriageway divider with the obligation to wait. The obligation to wait applicable to the non-motorised traffic must be shown with traffic signs.

6.9 Management of public transport

The issues of public transport must be taken into account in particular by the position and design of stops. Separate lanes for the public transport vehicles are not required as rule.

Waiting zones for stops must be visible for drivers with the necessary stopping distance. The waiting zones should be connected to the footpath network.

For roads of EKL 1, the stops should not be made directly on the carriageway, but with a structural separation from it.

For roads of EKL 2 and heavily used roads of EKL 3, the stop should be created as a bus lay-by. The dimensions for barrier-free entry and disembarking are shown in Figure 43. Further indications for designing bus lay-bys can be found in the EAÖ.

For intersections or crossings without traffic signals, the stop should be made beyond the intersection. For intersections or crossings with traffic signals, the position is freely selectable as a bus lay-by when designing the stop. The position after the intersection makes it easier for public transport to file out.

The position is freely selectable for roundabouts. The stop should end in the roundabout entry before the crossing for cyclists and pedestrians or behind it in the roundabout exit.

The position of the stops must be coordinated with the guidance of cyclists and pedestrians.

Bus lay-bys should not be created in the area of right corners, if possible. Otherwise, sufficient visual range for public transport when filing in must be shown.

In lower priority roads of roads of EKL 3, stop control can be used depending on the operation frequency and the level of traffic also as a carriageway side stop.

For roads of EKL 4, the design is carried out as a carriageway side stop as a rule. Carriageway side stops should not be created after the intersection.

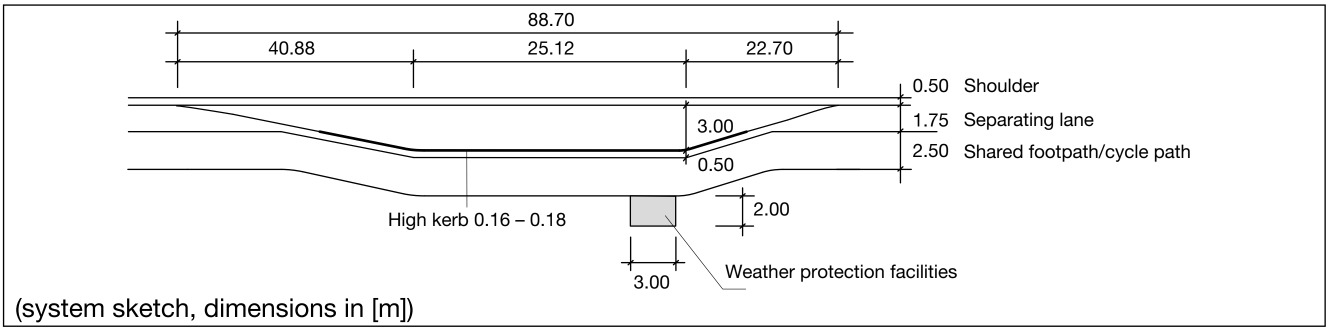


Figure 43: Dimensions of bus bay for a standard service bus

7 Equipment

7.1 General aspects

The equipment of rural roads and roadsides is part of the draft in all draft stages, because it has a major influence on driving behaviour and road safety.

Signs, marking and other equipment and plants influence the desired unit of draft, construction and operation.

The Highway Code and German General Administrative Rule for the Highway Code forms the legal foundations for the equipment of roads with road signs, traffic equipment and traffic signals.

The road signs include the directional signs and road marking.

Road signs, traffic equipment and traffic signals require arrangement by the traffic authorities in charge in coordination with the public authority and police. The basis is the marking and sign plan; it contains all necessary road signs, traffic equipment and traffic signals in accordance with the Highway Code and German General Administrative Rule for the Highway Code.

The equipment and operation of tunnels are regulated in the RABT and EABT.

7.2 Road marking

Carriageway markings are used to control and order the traffic by uniquely assigning the traffic directions and the traffic guidance at nodes. They are a key element of visual guidance. They support the driver in distinguishing between roads of various design categories and should therefore also promote driving on the road with a speed appropriate for the relevant network function.

Carriageway markings must be clearly identifiable during the day and at night. They constitute the key guidance element in the close area in particular at night. The task of remote guidance is performed by reflector posts.

The bases for the geometrical design of carriageway markings are the RMS.

For roads of EKL 1 and EKL 2, as a rule, carriageway markings with increased night time visibility on a wet road should be used. Lane delineations that separate the two directions of travel should also have a profile so that driving over them becomes clearly felt by the driver.

Also for roads of EKL 3, in particular in the event of heavy traffic, carriageway markings with increased night time visibility when wet should be used where there are increased requirements for drivers to identify the markings during darkness and when wet.

The continuous double lines planned for single-lane roads of EKL 1 to separate the two directions should be arranged at a distance so that a central paved area of 1.00 m in width is created, including the carriageway delineations. The area between the lane delineations should be highlighted in an optically conspicuous green. The paint applied must correspond to the material requirements of carriageway markings. It should be in the colour Traffic green (RAL 6024) and not retro-reflecting. To support the direction separation, traffic elements can also be applied, such as small beacons or delineators (Item 605 Highway Code).

Also for roads of EKL 2, where overtaking is not prohibited, two continuous lane delineations (double line) should be planned to separate the two directions. They should be arranged to give a separating area of 0.50 m wide including the lane delineations. This area should not be highlighted in colour to clearly distinguish roads of EKL 1. In sections where overtaking is to be prohibited, two interrupted guiding lines with a line/gap ratio of 1: 2 (4 m line / 8 m gap) also in a total width of 0.50 m will be applied to separate the two directions instead of the continuous lane delineation.

Roads of EKL 4 are not given a guide line in the centre of the carriageway. Here, the carriageway edge is indicated by guide lines applied 0.50 m from the edge of the pavement. These guiding lines can be driven over when cars meet, where necessary. They should be applied with a line/gap ratio of 1:1 (1 m line / 1 m gap).

7.3 Vertical traffic signs

Vertical traffic signs must comply with the Highway Code or be approved by announcement in “Verkehrsblatt”. Details on the installation of traffic signs are included in the German General Administrative Rule for the Highway Code.

Positive and negative right of way signs are always required in the intersection elements of the same plan. At entries (see section 6.4.3), a “do not enter” sign is sufficient, if no lane addition is made.

7.4 Direction signs

For the information of the road users and to prevent hazardous driving manoeuvres, the direction signs must give the road users indications of necessary driving decisions early. Directions are therefore required at all access routes of nodes. Here, the number of target indications must be kept to the absolute minimum in order to avoid excessive visual demands on the road user.

The breakdown and design of the direction signs are guided by the Guidelines for route-indicating signage away from motorways (Richtlinien für die wegweisende Beschilderung außerhalb von Autobahnen) (RWB). Indications on the creation of a special direction sign for cycle traffic can be found in the Fact sheet for route-indicating signage for cycle traffic (Merkblatt zur wegweisenden Beschilderung für den Radverkehr).

On roads of EKL 1, EKL 2 and EKL 3, advanced warning signs for intersections must be installed as a rule, so that timely driving decisions can be made.

An overhead sign may be favoured for multiple-lane node access routes seeing heavy traffic for better traffic guidance.

7.5 Traffic signals

The signal draft is carried out in accordance with RiLSA. The quality of the traffic movement must be shown in accordance with the HBS.

To protect road users turning left, in higher priority roads and in lower priority roads of crossings with continuous alignment, own signal phases should be planned. This is the only way that a high level of road safety can be ensured with a traffic light system.

Traffic light systems should be controlled depending on the traffic to limit delays. In doing so, the issues of the public transport network and non-motorised traffic must be taken into account.

The sites of the signal masts must be taken into account in the junction design. Furthermore, there must be sufficient space to install signalisation equipment. For that reason, the planning of the traffic light system should be carried out simultaneously with the node design.

7.6 Traffic guidance systems

Vertical guidance systems are used for the visual guidance of the road users in the remote area; it therefore supplements the effect of carriageway markings. For that reason, the roads of all design classes should be comprehensively fitted with reflector posts at a distance of 50 m. In narrow bends and crests, the distance should be reduced in accordance with the Code of Practice for the Positioning and Design of Vertical Traffic Guidance Equipment (HLB).

Chevrons in bends (Item 625 Highway Code) may become necessary in accordance with the provisions of the German General Administrative Rule for the Highway Code if the visual guidance needs to be supported due to a direction change outside the usable area for the relation of consecutive curves (see Figure 12 and Figure 13).

7.7 Vehicle restraint systems (safety barriers)

The road environment should be designed in such a way that vehicles leaving the carriageway do not incur a severe accident (principle of the mistake-forgiving road environment). If such a design is not possible, vehicle restraint systems are required. They are used

- for the protection of uninvolved persons or areas/components requiring protection next to the road or on the opposite carriageway of two-lane roads and
- for the protection of the vehicle passengers, for instance, against a fall or impact on hazardous obstacles next to the carriageway.

The scope of using vehicle restraint systems are defined in the RPS. In doing so, the restraint systems are distinguished by the criteria of restraint level (penetration safety), effect class (flexibility) and impact severity level (severity of injury).

For the flexibility of the vehicle restraint system (effect), sufficient areas should be available at the edge of the carriageway so that systems with a low impact severity level can be used.

Protection devices should be installed in accordance with the RPS at a minimum distance of 0.50 m from the edge of the paved surface. To prevent insufficient sight distance, a larger distance may be necessary.

Kerbs in front of vehicle restraint systems should not be any higher than 0.07 m.

Vehicle restraint systems in central reservations can in narrow bends result in the necessary stopping distance no longer being provided. This can be avoided outside of crests if the protection devices are no higher than 0.95 m. If visual distance (sight distance) determinations show that the stopping sight distances are not obtained, the central reservation must be widened. Otherwise, it must be verified whether the permissible maximum speed should be restricted.

The demands for penetration resistant road restraint systems with low impact force levels can (in particular if drainage is planned in the central reservation) necessitate a widening of the central reservation beyond the standard measure intended in section 4.

7.8 Road surface drainage

For ecological and commercial reasons, rural roads should often be drained by discharging the surface water via the shoulders and seeping away through cavities or the natural soil.

A closed drainage system can be used if

- a discharge cannot be obtained with an open drainage,
- the route crosses a drinking water protection zone,
- further demands from water management require this or
- a direction carriageway is cross-banked to the central reservation.

The surface water collected at the edge of the carriageway is, as a rule, directed via an open drain system to the outfall ditch via special equipment (rain retention basin, rain processing basin, etc.). Further details on road drainage can be found in the REwS.

The RiStWag and the Rulebooks of the German Association for Water Management, Waste Water and Waste (DWA) set conditions for the type of the drainage of rural roads and the design of the verge areas in accordance with the requirements to protect the collection areas.

7.9 Stationary lighting system

Rural roads are not illuminated on the open section. If for special reasons (e.g. to increase drivers' ability to better identify intersections) a stationary lighting system is to be planned, it must have dimensions in accordance with DIN 13201.

7.10 Anti-glare and wildlife protection equipment

On single-lane roads, anti-glare measures can, as a rule, only be necessary for a traffic route running in parallel.

On two-lane roads, anti-glare protection is only planned for car traffic as a rule. For this reason, vehicle restraint systems with a height of h ≥ 0.80 m without technical fixtures are sufficient in central reservations for anti-glare purposes. In the event of an unfavourable gradient guidance, additional anti-glare equipment may be necessary. See section 7.7 for possibly arising sight distance problems.

Game protection fences may be required on roads of EKL 1, where frequent deer crossing can be expected. It must also be verified for roads of EKL 2 whether these special conditions apply.

It must be verified whether sufficient stopping distances are ensured (see section 5.5.2) when game protection equipment (e.g. flyover help) is installed close to the carriageway,

7.11 Emission protection equipment

The Traffic Noise Protection Ordinance (Verkehrslärmschutz-Verordnung) (16 BImSchV) forms the legal basis for protection measures in accordance with the principles of noise prevention. The sound examinations must be carried out in accordance with Annex 1 to 16 BImSchV or in accordance with the Guidelines for Noise Protection on Roads (Richtlinien für den Lärmschutz an Straßen) (RLS).

Active noise protection measures (for example noise protection banks, noise protection walls) are, as a rule, preferred ahead of passive noise protection measures on the property frontage requiring protection.

If sufficient surface is available, noise protection banks are more beneficial than noise protection walls for environmental and commercial reasons. As a rule, they are executed with a bank slope of 1: 1.5 and a 1.00 m wide crown.

The ZTV Lsw and the Recommendations for the design of noise protection systems on roads (Empfehlungen für die Gestaltung von Lärmschutzanlagen an Straßen) contain information on design and integration in the environment.

Impacts from air pollutants can be estimated in accordance with the Guidelines for the Determination of the Air Quality on Roads without or with loose frontage development (RLuS).

Emission protection equipment can also be considered in accordance with the requirements of RiStWag.

7.12 Planting

The Federal Nature Conservation Act (BNatSchG) in connection with the state law regulations requires the conservation of the character, variety and beauty of the landscape as well as of historic cultural area. There is an obligation to restore or redesign the landscape appearance in the event of intervention.

To support the spatial alignment, bush plants must be included in the side areas of the road.

As a rule, it must be noted that the necessary stopping distances (see section 5.5) are not to be permanently restricted by vegetation. This also applies to the central reservation of two-lane roads.

The RLBP and ELA are authoritative for plants. Assistance in integrating the road in the landscape can be found in the Recommendations for Integrating Roads in the Landscape (ESLa).

For vegetation next to carriageways, road safety issues must be evaluated. The side areas therefore need to be designed in such a way that the consequences of accidents for cars coming off the carriageway remain small.

Shrubs are not considered to be hazardous obstacles within the meaning of the RPS, if they are cut when a stem diameter of 0.08 m.is exceeded. They should stand at least 3.00 m from the edge of the paved surface and must not impact on the sight distance.

When planting new trees near the carriageway, it must be recognised that they grow to become hazardous obstacles within the meaning of the RPS. Trees should therefore only be planted in areas that cannot be hit by vehicles coming off the carriageway (e.g. behind vehicle restraint systems or on cut slopes. Even behind vehicle restraint systems, they should be planted at least 3.00 m from the edge of the paved surface so that the effectiveness of the vehicle restraint system is not compromised.

7.13 Car sharing parking spaces

In particular near motorways and roads of EKL 1, the creation of car sharing parking spaces may be desirable.

For the design and dimensioning of car sharing parking spaces, the Recommendations for Parking Traffic Installations (Empfehlungen für die Anlagen des ruhenden Verkehrs) (EAR) must be observed. As new car sharing parking spaces are, as a rule, optional, the possibility of a later expansion in line with requirements must be taken into account.

The connection should be treated like a road of EKL 3.

7.14 Roadside rest areas

Roadside rest areas should be created in accordance with the Recommendations for Service Areas on Roads (Empfehlungen für Rastanlagen an Straßen) (ERS). They should be made on both sides at a sufficient distance from intersections. For roads of EKL 1, the exits and entries should be made with merging and diverging lanes.

7.15 Cables

Underground lines should be laid sufficiently far from the edge of the paved surface or the adjoining drainage devices and at a sufficient depth, as they are at risk in the verge due to the installation of road signs or protection devices.

Appendices

Page

Appendix 1: Markings and signs of overtaking lanes 82

Appendix 2: Emergency lay-bys 85

Appendix 3: Geometry of clothoid curves 86

Appendix 4: Calculation of crest and sag curves 88

Appendix 5: Sight distance on crests model 89

Appendix 6: Construction notes on intersection elements 90

Appendix 7: Exemplary solutions for intersections 105

Appendix 8: Technical regulations 129

Appendix 1

Markings and signs of overtaking lanes

A 1.1 Overtaking lanes on roads of EKL 1

To separate the two directions, for roads of EKL 1 a continuous road traffic central reservation 1.00 m wide is used, which is designed in addition to the lanes.

The changeover positions are marked and signposted in accordance with Figure 44.

The blocking zones should be at least 180 m in length for “critical” changeover positions and 30 m for “non-critical” changeover positions. Both section changes should be designed in an abrupt and clearly identifiable way for drivers’ perception. The “critical” changeover positions must also be indicated by three “End of the lane” arrows applied diagonally to the driving direction in the middle of the ending lane.

A 1.2 Overtaking lanes on roads of EKL 2

Overtaking lanes are separated from the opposite direction by a continuous double line 0.50 m in width. This is designed in addition to the lanes.

Overtaking lanes are marked and signposted in accordance with Figure 45.

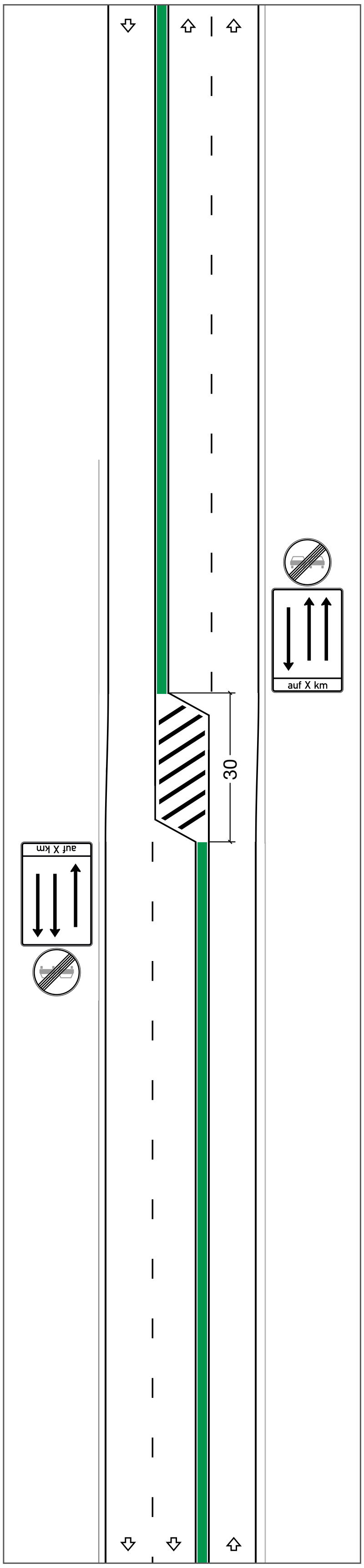
The widening of the carriageway at the start of the overtaking lane and the narrowing of the carriageway at the end of the overtaking lane should be 120 m in length. The section changes should be designed in an abrupt and clearly identifiable way for drivers’ perception. The narrowing must also be indicated by three “End of the lane” arrows applied diagonally to the driving direction in the middle of the ending lane.

The traffic guidance board at the start of the overtaking lane should show its length. The traffic guidance board can, if an intersection is created in the area of the overtaking lane, in an exceptional case to be justified, be repeated after this intersection, stating the remaining length. Both traffic guidance boards are only on the right side of the road.

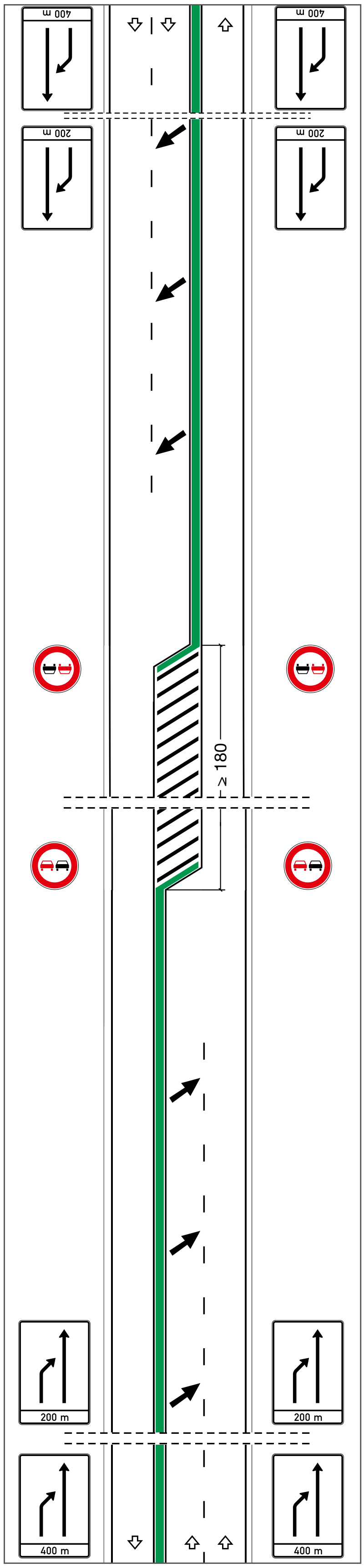
The traffic guidance boards announcing the end of an overtaking lane are also on the left side of the road, where possible.

To reduce passing pressure, it is preferably to announce the overtaking lane for roads of EKL 2 with an information board in the two-lane section. This is not required for roads of EKL 3 as a rule.

It may be favourable to the support the traffic flow in ascending sections by setting a minimum speed for the overtaking lane.



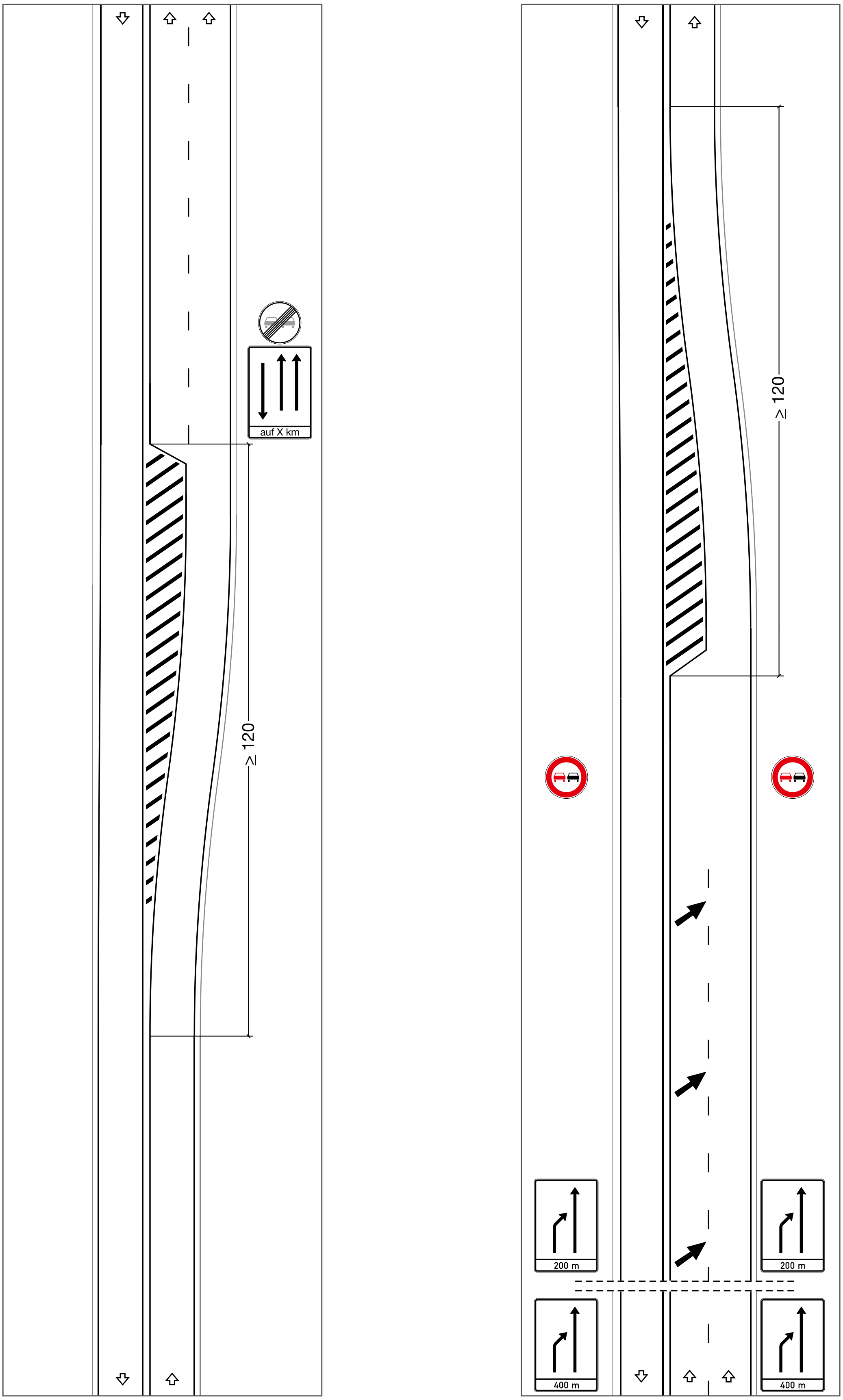
with “non-critical” changeover



with “critical” changeover position

(system sketch, dimensions in [m])

Figure 44: Marking and signs of overtaking lanes on roads of EKL 1



(system sketch, dimensions in [m])

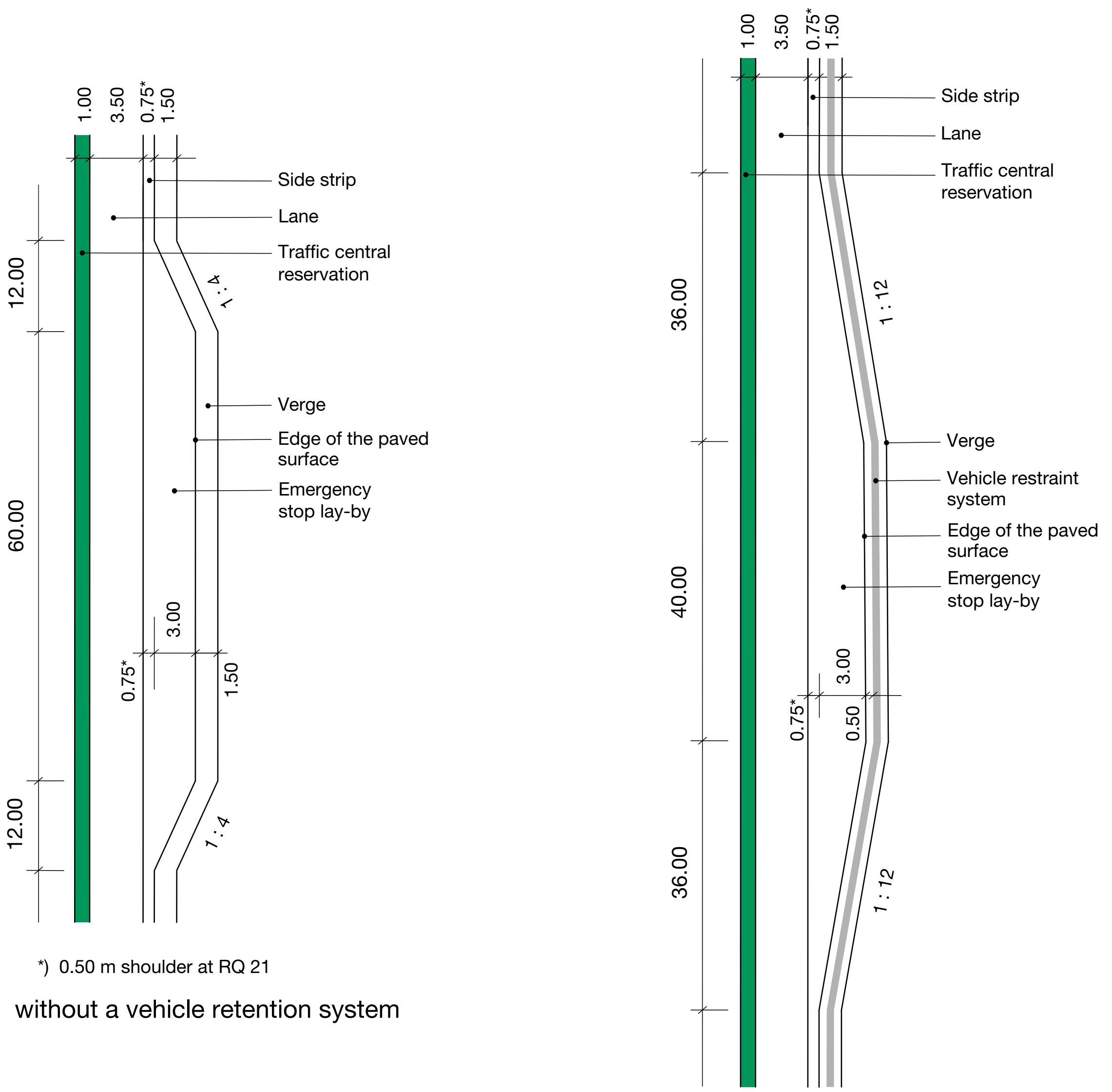
Figure 45: Marking and signs of overtaking lanes on roads of EKL 2

Emergency lay-bys

On three lane roads with a wide centre line treatment, emergency stop lay-bys are required for reasons of road safety on a regular basis. They must be preferably created in the middle of the single lane sections. The position must be coordinated with the operating requirements (e.g. near bridges).

On two-way four lane roads without shoulders, emergency stop lay-bys on the carriageways for both directions are required for road safety reasons. They must be arranged at regular intervals of about 500 m to 1,000 m. The position must be coordinated with operating requirements (e.g. near bridges).

Emergency stop lay-bys are 3.00 m wide and 84 m long including the wedge shaped distortions on both sides. Vehicle restraint systems in the area of an emergency stop lay-by require a length of 112 m (Figure 46) due to the then narrower distortion in accordance with the RPS.



*) 0.50 m shoulder at RQ 21

without a vehicle retention system

*) 0.50 m shoulder at RQ 21

with a vehicle retention system

(system sketch, dimensions in [m])

Figure 46: Example for an emergency stop bay on a single-lane EKL 1 road

Appendix 3

Geometry of clothoid curves

All clothoid curves are geometrically similar. For that reason, the same direction change angles and the same form or ratio values r/a = R/A, etc., occur at the same form position. These characteristic form positions are called points. They are uniquely defined by the radius r of the unit clothoid curves (a = 1) for all clothoid curves (Figure 47 and Table 33).

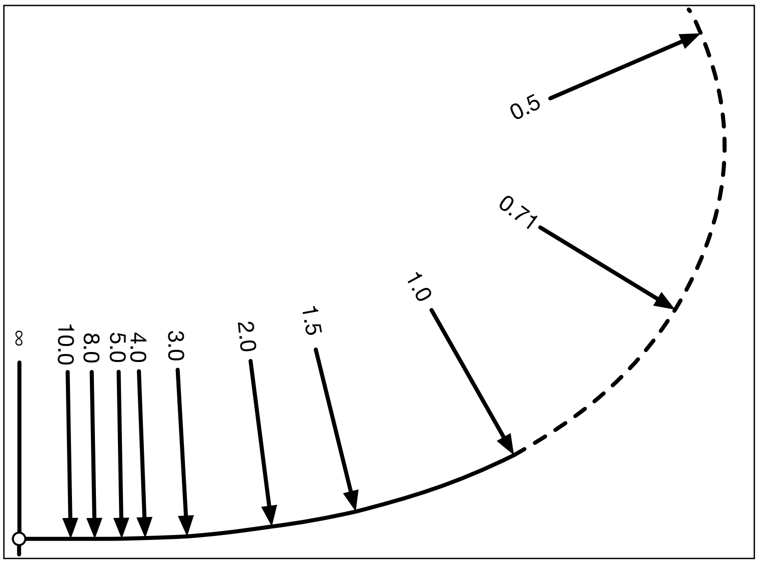


Figure 47: Points of clothoid curves

Table 33: Values for points of clothoid curves

Points r	τ [gon]	τ [rad]	A [m]		R [m]		L [m]	
1	31.83	0.50	1.00R	1.00L	1.00A	1.00L	1.00A	1.00R
1.5	14.16	0.22	0.67R	1.50L	1.50A	2.25L	0.67A	0.45R
2	7.96	0.13	0.50R	2.00L	2.00A	4.00L	0.50A	0.25R
3	3.54	0.06	0.33R	3.00L	3.00A	9.00L	0.33A	0.11R
4	1.99	0.03	0.25R	4.00L	4.00A	16.00L	0.25A	0.06R
5	1.27	0.02	0.20R	5.00L	5.00A	25.00L	0.20A	0.04R
6	0.89	0.01	0.17R	6.00L	6.00A	36.00L	0.17A	0.03R
∞	0.00	0.00	0.00	0.00	∞	∞	0.00	0.00
$\frac{R}{A}$	$\frac{100}{r^2 \cdot \pi}$	$\frac{1}{2r^2}$	$\frac{R}{r}$	$r \cdot L$	$r \cdot A$	$r^2 \cdot L$	$\frac{A}{r}$	$\frac{R}{r^2}$

Figure 48 applies for the geometry of the clothoids.

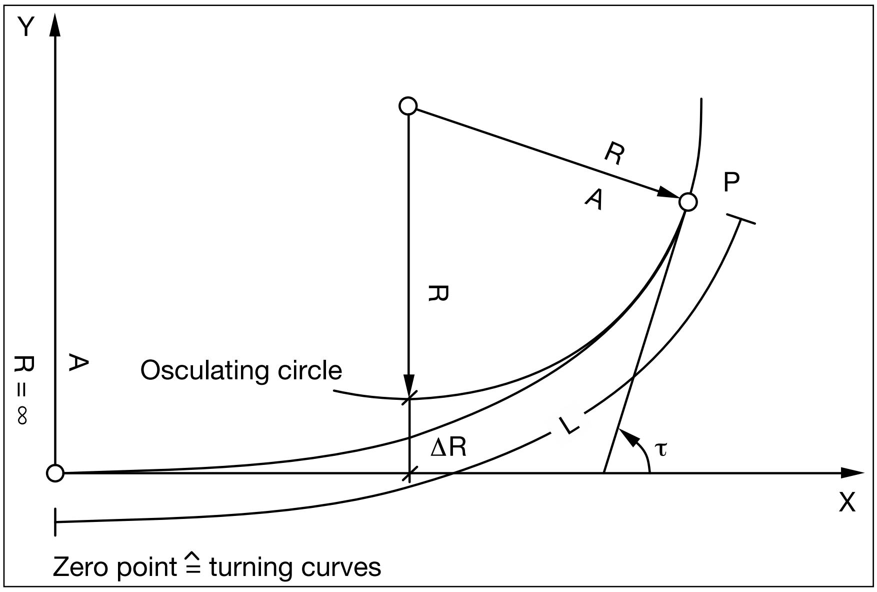


Figure 48: Geometry of clothoid curves

The setup law of the clothoid is:

$A^2 = R \cdot L$

$\tau\,[\text{rad}] = \frac{L}{2 \cdot R}$

$\tau\,[\text{gon}] = \frac{L}{2 \cdot R} \cdot \frac{200\ \text{gon}}{\pi}$

$X = \int_0^L \cos \frac{L^2}{2 \cdot R^2}\, dL$

$Y = \int_0^L \sin \frac{L^2}{2 \cdot R^2}\, dL$

with:

R [m] = Radius of an circular curve at the point P of the clothoid curves
A [m] = Clothoid parameter
L [m] = Length of the clothoid curves from the zero point to point P
τ = Angle between the tangents at the starting point and at point P
X,Y = Rectangular coordinates of point P
X_M = Abscissa of the centre of the circle
ΔR [m] = Offset of the osculating circle from the line in the zero point

For X, Y and ΔR, in rough calculations the approximation formulas expressed via L and R are sufficient:

$R \approx L$

$Y \approx \frac{L^2}{6 \cdot R}$

$\Delta R \approx \frac{L^2}{24 \cdot R}$

Appendix 4

Calculation of crest and sag curves

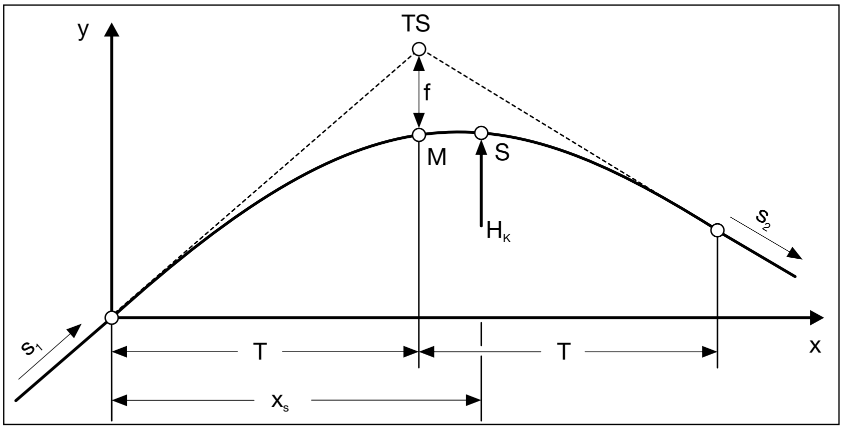


Figure 49: Model for crest and sag curves

For the calculation of crest and sag curves the following equation applies:

$$x_S = \frac{s_1}{100} \cdot H$$

$$s(x) = s_1 + \frac{x}{H} \cdot 100$$

$$y(x) = \frac{s_1}{100} \cdot x + \frac{x^2}{2 \cdot H}$$

$$T = \frac{H}{2} \cdot \frac{s_2 - s_1}{100}$$

$$f = \frac{T^2}{2 \cdot H} = \frac{T}{4} \cdot \frac{s_2 - s_1}{100} = \frac{H}{8} \cdot \left(\frac{s_2 - s_1}{100}\right)^2$$

with:

H	[m]	=	Vertical curve radius (radius of the crown curve radius of the square parabola)
T	[m]	=	Line length of the rounding
s_1, s_2	[%]	=	Longitudinal gradient of the two tangents
s(x)	[%]	=	Longitudinal gradient at a random point within the rounding
y(x)	[m]	=	Ordinates at a random point within the rounding
x_S	[m]	=	Abscissa of the peak of the rounding
f	[m]	=	Gauge from the tangent intersection to the rounding circular curve
M		=	Centre of low point
S		=	Peak (corresponds to the maximum point for crests or the low point for sags)
TS		=	Tangent intersection point

and the sign rules:

longitudinal gradient as incline	[%]	positive	(+)
longitudinal gradient as fall	[%]	negative	(–)
sag radius H_W	[m]	positive	(+)
crest radius H_K	[m]	negative	(–)

Appendix 5

Sight distance on crests model

The calculations of the necessary stopping distances in Section 5.5.1 are based on a safety model.

According to this model, a car stationary on a crest should be identified in sufficient time to allow a driver driving at the planned speed to still be able to stop his vehicle before this obstacle if the carriageway is wet.

The eye height as the key parameter for the approaching driver of a car is set as h_A = 1.00 m.

The height of the top of the standing car is set at 1.50 m. For vehicle height to be identifiable from the distance required for the stopping sight distance procedure, however, the hazard must protrude 0.50 m above the carriage surface in the area of a crest. For this reason, compared to the existing sight distances with the necessary stopping distances, an eye height of h_z = 1.00 m is used for crests.

Also when comparing the existing visual ranges with the desired orientation sight distances, eye height and target height are defined as 1.00 m.

The context in accordance with Figure 50 applies.

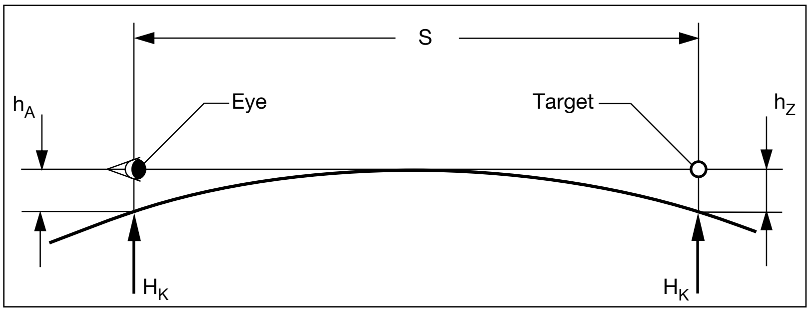


Figure 50: Sight distance model

with:

S [m] = Sight distance
h_A [m] = Eye height (1.00 m)
h_Z [m] = Target height (1.00 m)
H_K [m] = Crest radius

The values recommended in Table 14 of the crest radius are based on experience. Their observance ensures that both the required stopping distances and the required orientation sight distances are given in the area of straight crests (Figure 16).

Appendix 6

Construction notes on intersection elements

A 6.1 Divider (splitter) island

A 6.1.1 Fundamental aspects

The construction of divider islands is, as a rule, based on the axis of the lower priority road. If additional lanes are planned for left turning traffic from the lower priority roads at crossings with traffic light systems, a parallel axis line must form the basis instead of the axis of the lower priority road for the divider island, on one of the two lower priority road approaches. This results in a right offset of about 3 m for both divider islands.

The following line types are used in the following construction drawings (scale 1:500):

Legend of line types of the construction drawing:

Carriageway edges
Axes
Construction lines
Front edge of divider islands and triangular island
Corrected front edge of divider islands in accordance w
Marking as a narrow line
Marking as a broad line

A 6.1.2 Small divider island

Crossing angle α = 80 to 120 gon (72 to 108°).

In this angle area, a construction in keeping with Figure 51 is recommended.

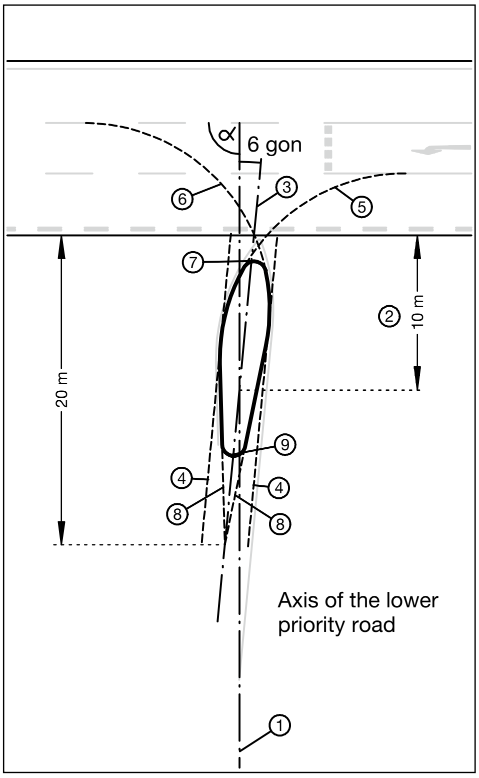


Figure 51: Construction of a small divider island at a crossing angle of α = 80 to 120 gon (72 to 108°)

① Define the axis of the lower priority road.

② Identify a point on the axis of the lower priority road at a distance of 10 m from the carriageway edge of the higher priority road.

③ Draw a divider island axis turned by 6 gon (5.4°) to the right against the axis of the lower priority road by the point determined in accordance with ②.

④ Construct two auxiliary lines at a distance of 1.50 m on the right and left in parallel with the divider island axis.

⑤ Construct an circular curve for road users turning left with R = 12 m. This circular curve touches the left edge of the lane for road users turning left with the left-turn types of LA1, LA2 and LA3 and the left auxiliary line of those lines specified under ④. For the LA4 left-turn type, the circular curve begins on the axis of the higher priority road. For crossings with the KE1 access route type, it may be necessary to increase the radius to up to 15 m in order to ensure the simultaneous turning left.

⑥ Construct an circular curve for road users turning in left with R = 12 m. For the LA4 left-turn type, the radius can be reduced to up to 10 m. With the LA1, LA2 and LA3 left-turn types, this circular curve touches the right auxiliary line of those lines specified under ④ and the left edge of the lane of the higher priority road, which is to be turned into. For the LA4 left-turn type, the circular curve ends on the axis of the higher priority road. With a crossing angle of α ≤ 100 gon (90°), the radius may need to be reduced to 8 m in order to achieve the divider island shape intended.

⑦ Round the front divider island head between the two circular curves for the road user turning left and the road user turning in left with R = 0.75 m.

⑧ Integrate the two lines such that they, on the one hand, touch the circular curves for the road user turning left or for the road user turning in left and, on the other hand, jointly intersect the divider island at a distance of 20 m from the carriageway edge of the higher priority road.

⑨ Round the rear divider island head with R = 0.75 m.

Crossing angle α < 80 gon (72°).

In this angle area, a construction in keeping with Figure 52 is recommended.

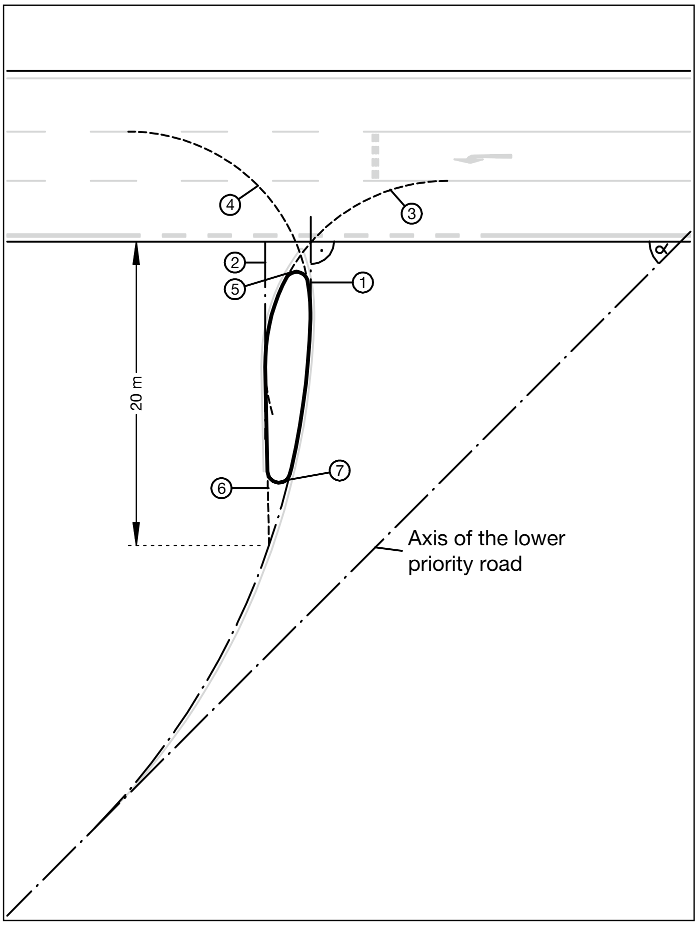


Figure 52: Construction of a small divider island with a crossing angle of α < 80 gon (72°)

① Bend the axes of the lower priority road with R ≥ 50 m in such a way that the curved axis comes into perpendicular contact with the carriageway edge of the higher priority road. At crossings, the axes of the two legs of the lower priority road need to be offset by about 3 m from one another so that the divider islands are pitted against one another.

② Draw two lines perpendicular to the axis of the higher priority road at a distance of 3.00 m left of the intersection of the bent axis of the lower priority road with the carriageway edge of the higher priority road.

③ Construct an circular curve for road users turning left with R = 12 m. This circular curve touches the left edge of the lane for road users turning left with the left-turn types of LA1, LA2 and LA3 and the line drawn under ②. For the LA4 left-turn type, the circular curve begins on the axis of the higher priority road. For crossings with the KE1 access route type, it may be necessary to increase the radius to up to 15 m in order to ensure the simultaneous turning left.

④ Construct an circular curve for road users turning in left with R = 12 m. For the LA4 left-turn type, the radius can be reduced to up to 10 m. At the LA1, LA2 and LA3 left-turn types, the circular curve touches the curved axis of the lower priority road and the left edge of the lane of the higher priority road into which it is to be turned into. For the LA4 left-turn type, the circular curve ends on the axis of the higher priority road.

⑤ Round the front divider island head between the two circular curves for the road user turning left and the road user turning in left with R = 0.75 m.

⑥ Integrate the lines such that they, on the one hand, touch the circular curve for the road user turning left and, on the other hand, intersect the curved axis of the lower priority road at a distance of 20 m from the carriageway edge of the higher priority road.

⑦ Round the rear divider island head between the lines drawn in accordance with 6 and the curved axis with R = 0.75 m.

Crossing angle α > 120 gon (108°).

In this angle area, a construction in keeping with Figure 53 is recommended.

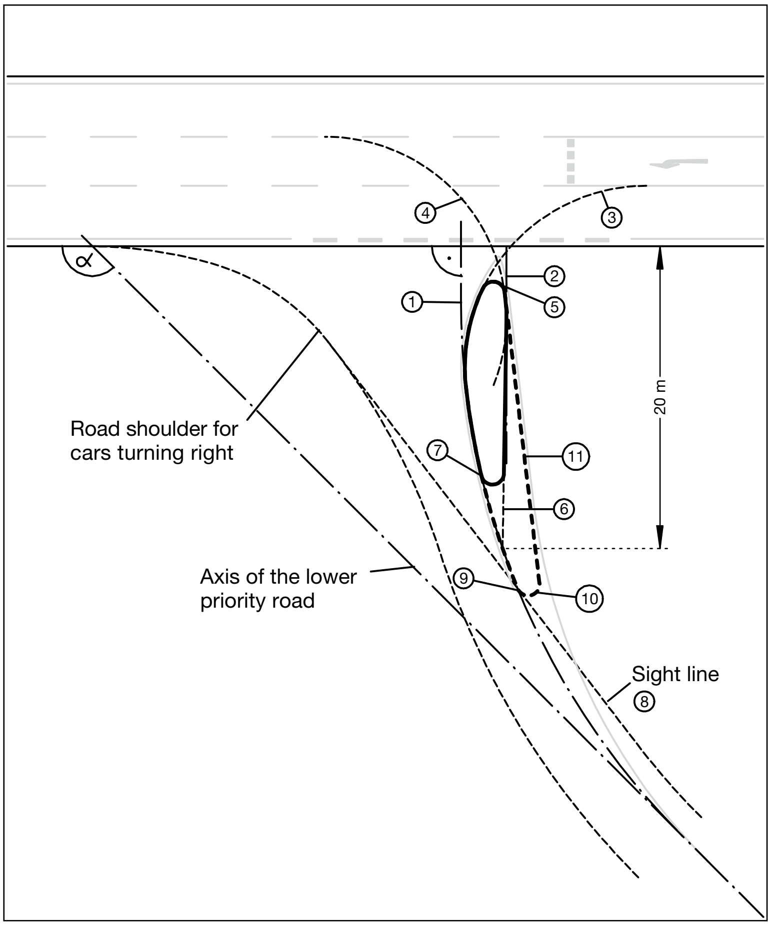


Figure 53: Construction of a small divider island at a crossing angle of α > 120 gon (108°)

① Bend the axes of the lower priority road with R ≥ 50 m in such a way that the curved axis comes into perpendicular contact with the carriageway edge of the higher priority road. At crossings, the two axes of each leg of the lower priority road need to be offset by approximately one divider island width from one another so that the divider islands are pitted against one another.

② Draw two lines perpendicular to the axis of the higher priority road at a distance of 3 m right of the intersection of the bent axis of the lower priority road with the carriageway edge of the higher priority road.

③ Construct an circular curve for road users turning left with R = 12 m. This circular curve touches the left edge of the lane for road users turning left with the left-turn types of LA1, LA2 and LA3 and the curved axis of the lower priority road. For the LA4 left-turn type, the circular curve begins on the axis of the higher priority road. For crossings with the KE1 access route type, it may be necessary to increase the radius to up to 15 m in order to ensure the simultaneous turning left.

④ Construct an circular curve for road users turning in left with R = 12 m. For the LA4 left-turn type, the radius can be reduced to up to 10 m. At the LA1, LA2 and LA3 left-turn types, this circular curve touches the line drawn in accordance with ② and the left edge of the lane of the higher priority road in which it is to be turned into. For the LA4 left-turn type, the circular curve ends on the axis of the higher priority road.

⑤ Round the front divider island head between the two circular curves for the road user turning left and the road user turning in left with R = 0.75 m.

⑥ Integrate the lines such that they, on the one hand, touch the circular curve for the road user turning in left and, on the other hand, intersect the curved axis of the lower priority road at a distance of 20 m from the carriageway edge of the higher priority road.

⑦ Round the rear divider island head between the lines drawn in accordance with ⑥ and the curved axis with R = 0.75 m.

⑧ Create a tangent for sight line check between the middle of the (curved) lane approaching the higher priority road and the right carriageway edge for road users turning right. If this tangent does not intersect the divider island constructed in accordance with ⑥ and ⑦ the divider island must be extended by ⑨ to ⑪. As the precise position of the carriageway edge for road users turning right also depends on the construction of the divider island, an iterative sight line check may be necessary.

⑨ Extend the left divider island edge on the curved axis of the lower priority road at least to the position where the curved axis intersects with the relevant view beam.

⑩ Round the rear divider island head from position determined in accordance with ⑨ with R = 0.75 m.

⑪ Integrate a line such that it touches the circular curve of the road users turning in left and the round the rear divider island head determined in accordance with ⑩.

A 6.1.3 Large divider island

Crossing angle α = 80 to 120 gon (72 to 108°).

For this angle area, a construction in keeping with Figure 54 is recommended.

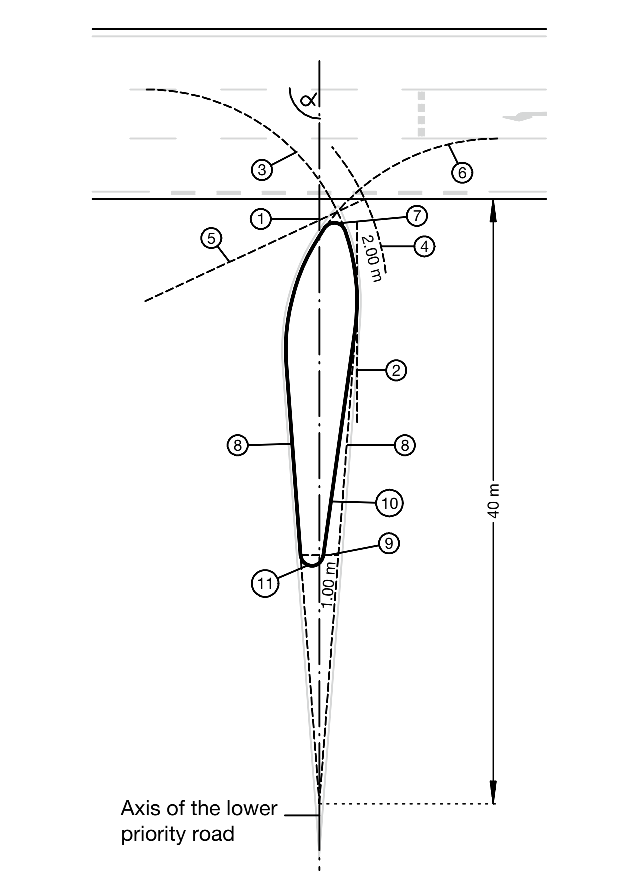


Figure 54: Construction of a large divider island at a crossing angle α = 80 to 120 gon (72 to 108°).

① Define the axis of the lower priority road. Identify the intersection between the axis of the lower priority road and the carriageway edge of the higher priority road. At crossings with the KE1 access route type, it must be ensured that the axes of the lower priority roads are offset to the right in accordance with Table 24.

② Construct a parallel on the right next to the axis of the lower priority road. Their distance is 2.50 m for a perpendicular intersection (α = 100 gon (90°)). It is reduced per gon of absolute deviation of the intersection angle compared to 100 gon by 0.05 m. [It is reduced per degree of absolute deviation of the intersection angle compared to 90° by 0.055 m.] If for crossings with the KE1 access route type simultaneous turning left should be possible, it may be necessary to reduce the distance of the parallel also for a crossing angle of α = 100 gon (90°) to about 2 m. With swept path curves it must be proven that a simultaneous turning left is possible (see ⑥).

③ Construct an circular curve for drivers turning left. This circular curve touches, on the one hand, the parallel to the axis of the lower priority road constructed under ② and, on the other hand, the left edge of the lane of the higher priority road, in which it is to be turned into. For intersections, the radius of the circular curve for the road user turning in left is 2.50 m larger than the lane width of the higher priority road; at crossings, it must be chosen to ensure the simultaneous turning in left in accordance with Table 34.

④ Draw an circular curve with a radius increased by 2.00 m around the same centre as with the circular curve for the road user turning in left as drawn in accordance with ③.

⑤ Connect the circular curve centre with the point where the circular curve increased by 2.00 m as drawn in accordance with ④ intersects with the carriageway edge of the higher priority road. Identify the point where this connecting line intersects the circular curve for the road user turning in left as drawn in accordance with ③.

⑥ Construct an circular curve for the road user turning left such that it runs through the intersection determined in accordance with ⑤ and simultaneously touches the left edge of the lane of the higher priority road from which it is turned into. This circular curve, and the circular curve drawn in accordance with ③ form part of the front divider island head. The radius of this circular curve for the road user turning left at the junction is, as a rule, as large as the radius for the road user turning in left, but is to be selected such that a divider island width of between 3 m and 5 m results. At crossings, this results in a radius for the road user turning left in accordance with Table 34. If a verification with trajectory curves at crossings shows that it is not possible to simultaneously turn left with the radii selected, a larger distance between the circular curve drawn in accordance with ③ for the road user turning in left and the parallel radius drawn in accordance with ④ (e.g. 3 m to 4 m) can ensure that the distance between the two circular curves is sufficiently large for the road user turning left.

④ to ⑥ are called a 2 m construction.

⑦ Round the front divider island head with R ≥ 0.75 m such that the front divider island head is at least 2 m and no more than 4 m from the carriageway edge of the higher priority road.

⑧ Draw two lines such that they, on the one hand, touch the circular curves for the road user turning left or for the road user turning in left and, on the other hand, intersect the axis of the lower priority road at a distance of 40 m from the carriageway edge of the higher priority road.

⑨ Determine the location of a line that is perpendicular to the axis of the lower priority road and is 2.50 m between these two lines drawn in ⑧.

⑩ Remove a dimensions of 1.00 m from the line lying to the right of the axis towards the left. Draw a new line from this point such that it touches the circular curve for the road user turning in from the left as drawn in accordance with ③.

⑪ Round the remaining 1.50 m wide rear divider island head with R = 0.75 m.

Table 34: Turning radii and drop shadows at crossings

Crossing angle [gon]	**Turning in radius** [m]	**Turning off radius** [m]	**Right offset at LSA** [m]
80	10	18	1.00
100	15	15	3.00
120	20	11	3.00

Crossing angle α < 80 gon (72°).

For this angle area, a construction in keeping with Figure 55 is recommended.

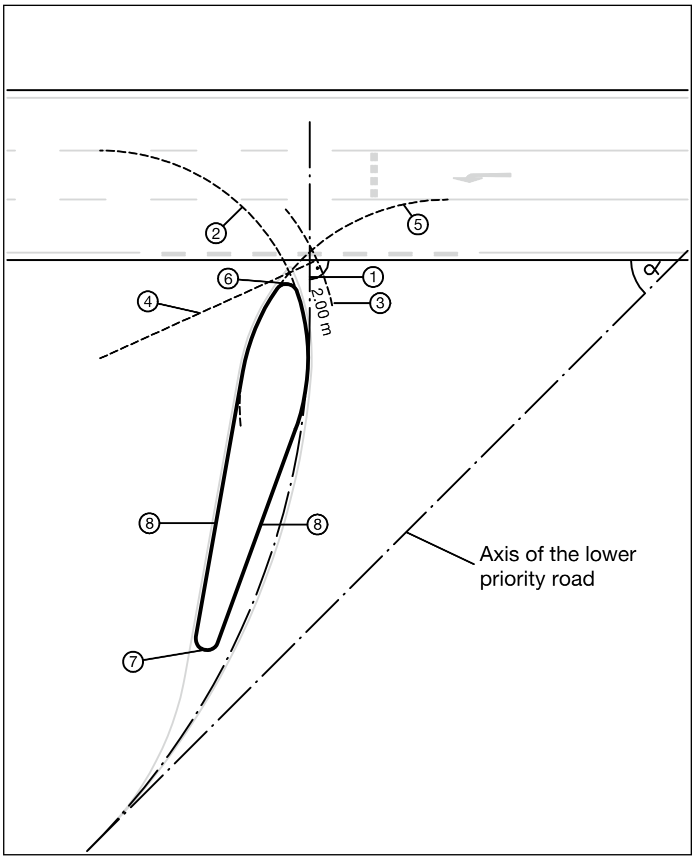


Figure 55: Construction of a large divider island at a Crossing angle α <80 gon (72°)

① Bend the axes of the lower priority road with R ≥ 50 m in such a way that the curved axis comes into rectangular contact with the carriageway edge of the higher priority road. At crossings, the axes of the adjoining node access routes need to be offset by about one divider island width so that the divider islands are pitted against one another.

② Construct an circular curve for drivers turning left. This circular curve touches, on the one hand, the curved axis of the lower priority road and, on the other hand, the left lane edge of the lane of the higher priority road, in which it is to be turned into. For intersections, the turning-in radius is 2.50 m larger than the lane width of the higher priority road; at crossings, it must be chosen to ensure the simultaneous turning in left in accordance with Table 34.

③ Draw an circular curve with a radius larger by 2.00 m around the same centre as with the circular curve for the road user turning in left as drawn in accordance with ②.

④ Connect the circular curve centre with the point where the circular curve increased by 2.00 m as drawn in accordance with ③ intersects with the carriageway edge of the higher priority road. Identify the point where this connecting line intersects the circular curve for the road user turning in left as drawn in accordance with ②.

⑤ Construct an circular curve for the road user turning left such that it runs through the intersection determined in accordance with ④ and simultaneously touches the left edge of the lane of the higher priority road from which it is turned into. This circular curve and the circular curve drawn in accordance with ② form part of the front divider island head. The radius of this circular curve for the road user turning left at the intersection is, as a rule, as large as the radius for the road user turning in left, but to be selected such that a divider island width of between 3 m and 5 m results. At crossings, this results in a radius for the road user turning left in accordance with Table 34. If a verification with swept path curves at crossings shows that it is not possible to simultaneously turn left with the radii selected, a larger distance between the circular curve drawn in accordance with ② for the road user turning in left and the parallel radius drawn in accordance with ③ (e.g. 3 m to 4 m) can ensure that the distance between the two circular curves is sufficiently large for the road users turning left.

⑥ Round the front divider island head with R ≥ 0.75 m such that the divider island head is at least 2 m and no more than 4 m from the carriageway edge of the higher priority road.

⑦ Offset the rear divider island head at a distance of about 25 cm from the carriageway edge of the higher priority road by 1.00 m to the left from the curved axis. Round the rear divider island head in this position with R = 0.75 m.

⑧ Draw two lines such that they, on the one hand, touch the two circular curves for the road user turning left or for the road user turning in from the left and, on the other hand, the rounding of the read divider island head constructed in accordance with ⑦.

Crossing angle α > 120 gon (108°).

For this angle area, a construction in keeping with Figure 56 is recommended.

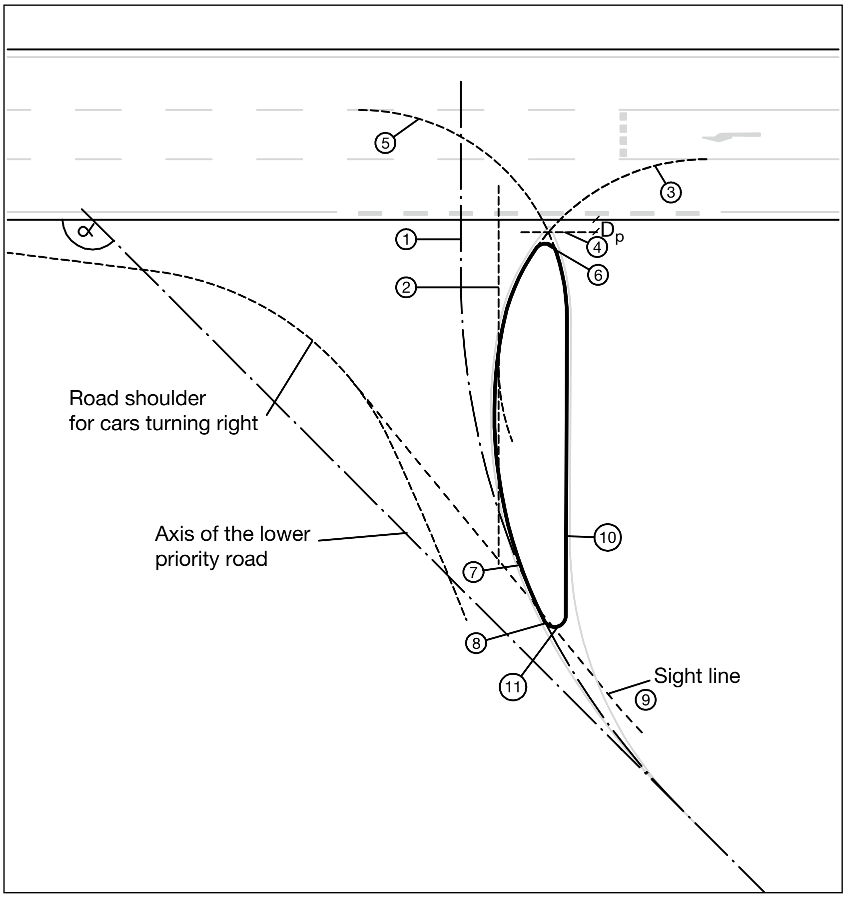


Figure 56: Construction of a large divider island at a crossing angle of α > 120 gon (108°)

① Bend the axe of the lower priority road with R ≥ 50 m in such a way that the curved axis comes into perpendicular contact with the carriageway edge of the higher priority road. At crossings, the two axes of the lower priority roads need to be offset by about one divider island width from one another so that the divider islands are pitted against one another.

② Draw two lines rectangular to the axis of the higher priority road at a distance of 2.50 m right of the intersection of the bent axis of the lower priority road with the carriageway edge of the higher priority road.

③ Construct an circular curve for road users turning left with a radius R_i. This circular curve touches, on the one hand, the line constructed in accordance with ② and, on the other hand, the left edge of the lane of the higher priority road from which it is to be turned into. For intersections, the turning-off radius is 2.50 m larger than the lane width of the higher priority road; at crossings, it must be chosen to ensure the simultaneous turning in left in accordance with Table 34.

④ Draw a parallel to the carriageway edge of the higher priority road at a defined distance D_p. This distance D_p is 0.825 m for a standard carriageway width (11.25 m) of the higher priority road. The distance D_p can be calculated for carriageway widths deviating from the standard dimensions of the higher priority road as follows:
$D_p = (B_{FS} + 3.00 \text{ m}) \bullet (1 - (B_{FB} + 2.50 \text{ m}) / (B_{FB} + 4.50 \text{ m}))$
(with B_{FS} = carriageway width of the higher priority road,
B_{FB} = carriageway width of the higher priority road)

⑤ Construct an circular curve for drivers turning left. The radius of this circular curve is at intersections, as a rule, as large as the radius for the road user turning left. This circular curve intersects at the distance D_p calculated under ④ from the carriageway edge of the higher priority road; the circular curve constructed in accordance with ③ for the road user turning left and touches the left edge of the lane of the higher priority road, which is to be turned into. This construction ensures that the point of intersection between the circular curves for the road user turning in left and for the road user turning left is about where it is for divider islands with other crossing angles that are constructed in accordance with the 2 m construction.

⑥ Round the front divider island head with R ≥ 0.75 m such that the divider island head is at least 2 m and no more than 4 m from the carriageway edge of the higher priority road.

⑦ Construct an circular curve (R = 30 m), which touches, on the one hand, the circular curve for the road user turning left and, on the other hand, the axis of the lower priority road.

⑧ Define the rear divider island head on the left divider island edge constructed in accordance with ⑦ such that it comes to lie at a distance of about 25 m from the carriageway edge of the higher priority road.

⑨ Create a tangent for view beam check between the middle of the (curved) lane approaching the higher priority road and the carriageway edge for the road user turning right. If this tangent does not intersect the constructed divider island, the left divider island edge must be extended accordingly.

⑩ Round the rear divider island head from the point defined in accordance with ⑧ or ⑨ with R = 0.75 m.

⑪ Draw a line such that it touches, on the one hand, the circular curve for the road user turning in from the left and, on the other hand, the rear divider island head rounded in accordance with ⑩.

A 6.2 Right-turn types with triangular islands

A 6.2.1 Fundamental aspects

For the following constructions of triangular islands, the requirements of the RAL on the various right-turn types (see Table 29) as well as on the various access route types (see Table 31) must be observed.

A construction with a set edge length is usually applied for the RA1 right-turn type (with joint footpath and cycling path).

A construction without a set edge length is usually applied for the RA3 right-turn type (without joint footpath and cycling path).

A 6.2.2 Construction with defined edge lengths

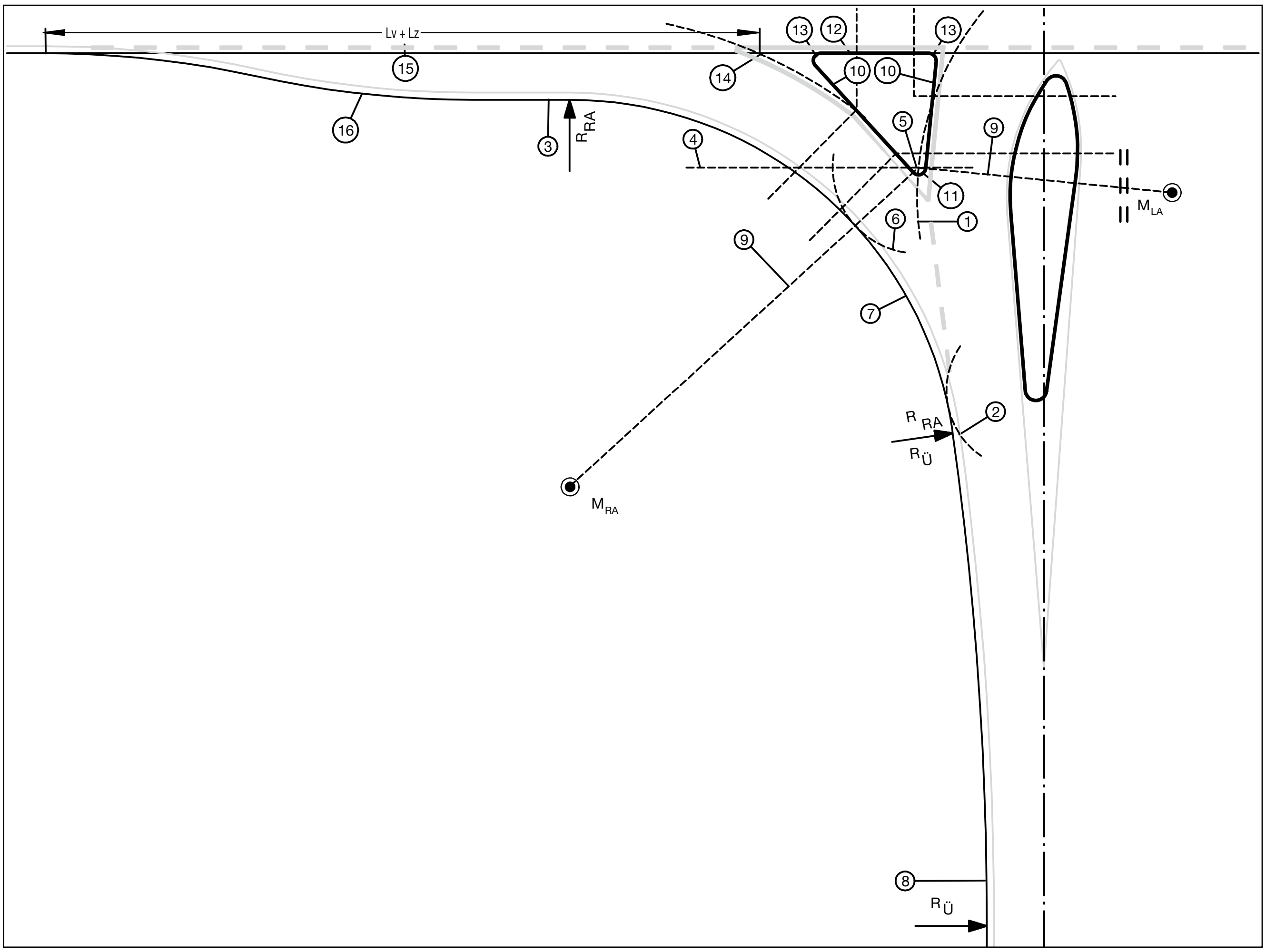


Figure 57: Construction of a right-turn alignment with edge length of the triangular island

① Construct an auxiliary circle around the centre of the circular curve for the road user turning left from the associated divider island construction (M_{LA}) with a radius that is 6.00 m + 0.50 m bigger than the corresponding radius of the circular curve for the road user turning left (R_{LA}).

② Construct an auxiliary circle around the end point of the straight divider island edge that connects to the circular curve with R_{LA} (start of the rounding radius of the rear divider island head) with a radius R = 5.50 m.

③ Draw two parallels to the carriageway edge of the higher priority road at a distance of 3.25 m.

④ Draw a parallel to the carriageway edge to the higher priority road at a distance that approximately corresponds to the desired length of the edge of the triangular island, which is opposite the divider island. As a rule, this edge length is to be selected such that crossings over the lower priority road are at a consistent distance to the carriageway edge of the higher priority road whether on the triangular island or the divisional island.

⑤ Identify the intersection of this parallel with the auxiliary circle constructed in accordance with ① as the centre of the rounding radius (R = 0.50 m) of the rear divider island head.

⑥ Construct an auxiliary circle around the centre found in accordance with ⑤ with the radius R = 5.50 m + 0.50 m.

⑦ Adjust or factor in an circular curve with a radius to be determined on an iterative basis that touches the parallel in accordance with ③ and the auxiliary circles in accordance with ② and ⑥. The radius determined can be rounded, where necessary. This requires a fresh adjustment or factoring in.

⑧ Adjust a suitable circular curve $R_{Ü}$ between the circular curve in accordance with ⑦ and the carriageway edge of the lower priority road.

⑨ Draw a connecting line between the centre of the rounding of the rear island head of the triangular island and the centres of M_{LA} and M_{RA}.

⑩ Identify the side edges of the triangular island as a vertical on the two connecting lines in accordance with ⑨. For crossings, it must be ensured that the triangular side directed towards the divider island is adjusted to the crossing driving relationship. If the edge conditions result in edge lengths of the triangular island of more than approx. 8 m to 10 m, it may be conducive the execute the side of the triangular island faced towards the right-turn guidance as a parallel to the carriageway of road users turning right at a distance of 5.50 m.

⑪ Round between the rear island head of the triangular island arising between the two verticals in accordance with ⑩ R = 0.50 m.

⑫ Identify the edge of the triangular island at the carriageway edge of the higher priority road.

⑬ Round the front island heads of the triangular island arising between the verticals in accordance with ⑩ and the line in accordance with ⑫ R = 0.50 m.

⑭ Identify the intersection point of the auxiliary circle drawn in accordance with ⑤ and the carriageway edge of the higher priority road.

⑮ Remove the exit opening from the point determined in accordance with ⑭ the length of the exit opening (lv + lz) for the right-turn lane.

⑯ Connect the intersection point determined in accordance with ⑮ the parallels in accordance with ③ by introducing the distortion at the start of the exit opening for the right-turn lane.

A 6.2.3 Construction without defined edge lengths

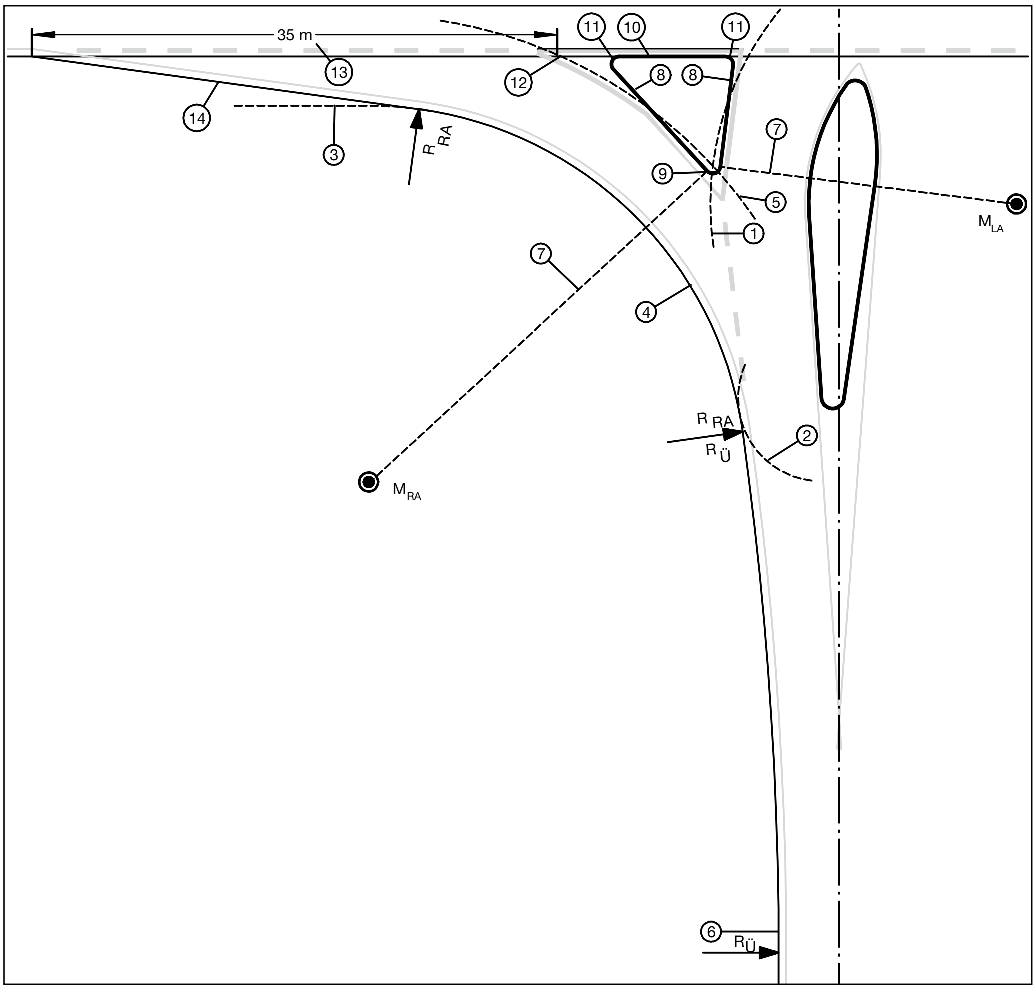


Figure 58: Construction of a right-turn alignment with edge length of the triangular island

① Construct an auxiliary circle around the centre of the circular curve for the road user turning left from the associated divider island construction (M_{LA}) with a radius that is 6.00 m + 0.50 m larger than the corresponding radius of the circular curve for the road user turning left (R_{LA}).

② Construct an auxiliary circle around the end point of the straight divider island edge that connects to the circular curve with R_{LA} (start of the rounding radius of the rear divider island head) with a radius R = 5.50 m.

③ Draw a parallel to the carriageway edge of the higher priority road at a distance of 3.25 m.

④ Adjust an circular curve for the road user turning right (R_{RA}), which touches the auxiliary circle in accordance with ② and the parallel in accordance with ③. The circular curve radius R_{RA} is, as a rule, for crossing angles $\alpha < 80$ gon 20 m and for crossing angles $\alpha \geq 100$ gon 25 m.

⑤ Construct an auxiliary circles around the centre of the circular curve constructed in accordance with ④ for the road user turning right (M_{RA}) with a radius that is 5.50 m + 0.50 m bigger than the circular curve for the road user turning right (R_{RA}). The intersection point with the auxiliary circle in accordance with ① is the centre for the rounding (R = 0.50 m) of the rear island head of the triangular island.

⑥ Adjust or factor in the circular curve $R_{Ü}$ at the circular curve in accordance with ④ and at the carriageway edge of the lower priority road.

⑦ Draw a connecting line between the centre of the rounding of the rear island head of the triangular island and the centres of M_{LA} and M_{RA}.

⑧ Identify the side edges of the triangular island as a vertical on the two connecting lines in accordance with ⑦. For crossings, it must be ensured that the triangular side directed towards the divider island is adjusted to the crossing driving relationship. If the edge conditions result in edge lengths of the triangular island of more than approx. 8 m to 10 m, it may be preferable to have the side of the triangular island faced towards the right-turn guidance to be parallel to the carriageway for road users turning right at a distance of 5.50 m.

⑨ Round the rear island head of the triangular head arising between the two verticals in accordance with ⑧ with R = 0.50 m.

⑩ Identify the edge of the triangular island at the carriageway edge of the higher priority road.

⑪ Round the island heads of the triangular island arising between the verticals in accordance with ⑧ and the lines with ⑩ R = 0.50 m.

⑫ Identify the intersection point of the auxiliary circle drawn in accordance with ⑤ and the carriageway edge of the higher priority road.

⑬ Remove the exit opening from the point determined in accordance with ⑫
– 35 m at the exit wedge or
– the length of the exit opening (lv + lz) with a right-turn lane.

⑭ Connect the intersection established in accordance with ⑬ on the carriageway edge
– with the circular curve R_{RA} through a line with an exit wedge or
– with the parallel in accordance with ③ through the introduction of the distortion at the start of the exit opening for a right-turn lane.

A 6.3 Three-part circular curve sequence of a corner rounding

The three-part circular curve sequence of a corner rounding is constructed in accordance with Figure 59.

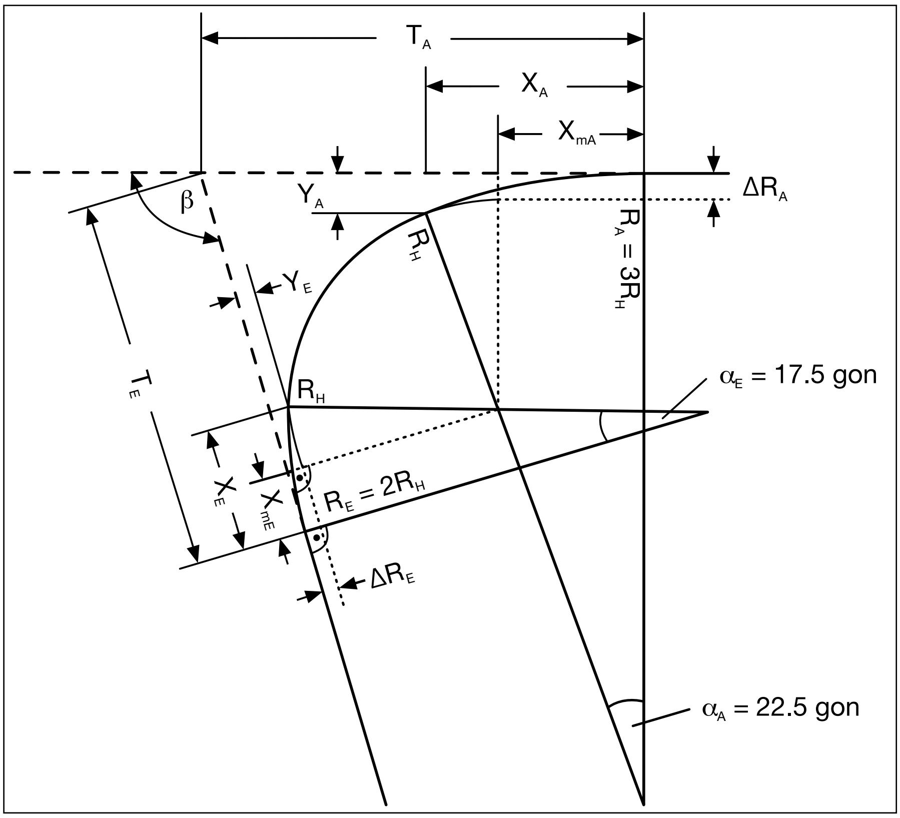


Figure 59: Construction of a corner rounding

The following connections apply for the construction:

$R_E : R_H : R_A = 2 : 1 : 3$

$\Delta R_E = R_H \cdot 0.0375$	$Y_E = R_H \cdot 0.0750$	$X_{mE} = R_H \cdot 0.2714$	$X_E = R_H \cdot 0.5428$
$\Delta R_A = R_H \cdot 0.1236$	$Y_A = R_H \cdot 0.1854$	$X_{mA} = R_H \cdot 0.6922$	$X_A = R_H \cdot 1.0383$

$T_E = R_H \cdot (0,2714 + 1,0375 \tan\frac{\beta}{2} + \frac{0,0861}{\sin\beta})$ $\quad$ $T_A = R_H \cdot (0,6922 + 1,1236 \tan\frac{\beta}{2} - \frac{0,0861}{\sin\beta})$

with the entry parameters (see Section 6.4.11):

- main arch radius R_H
- entry radius R_E
- exit radius R_A
- radii relations $R_E : R_H : R_A = 2 : 1 : 3$
- change of direction angle of the entry radius R_E α_E = 17.5 gon (15.8°)
- change of direction angle of the exit radius R_A α_A = 22.5 gon (20.3°)
- section angle of the carriageway edge of the lower priority road with the carriageway edge of the higher priority road β

A 6.4 Right-turn types without triangular islands

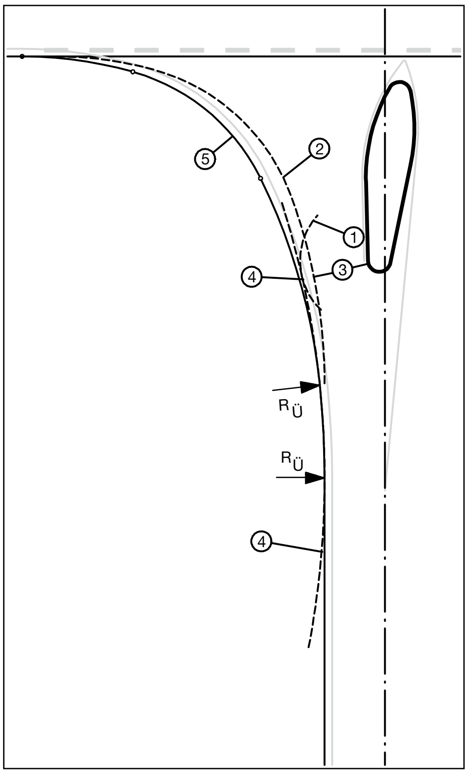


Figure 60: Construction of a right-turn alignment without triangular island

The carriageway edges for road users turning right are constructed for right-turn types without triangular islands by factoring in a corner rounding in the form of a three-part circular curve sequence (see Section A.6.3) between the carriageway edge of the higher priority road and the right carriageway edge leading away from the node of the lower priority road. In doing so, it may be necessary to integrate an additional circular curve $R_Ü$ between the three-part circular curve sequence and the carriageway edge of the lower priority road.

For intersections with a crossing angle of α = 100 gon (90°) and a carriageway divider, the main circular curve radius is R_H = 15 m.

① Construct an auxiliary circle around the end point of the straight divider island edge (at the same time the start of the rounding radius of the rear divider island head) with a radius of R = 4.50 m.
② Adjust or factor in a three-part circular curve sequence for the corner rounding in accordance with Section A 6.3 between the right carriageway edge of the higher priority road and the right carriageway edge of the lower priority road leading away from the node with a main circular curve radius of R_H = 15 m.
③ Verify the compliance with the necessary minimum distance of 4.50 m between the start of the rounding radius of the rear divider island head and the right carriageway edge of the corner rounding. If this distance is far greater than 4.50 m due to the local circumstances, a swept path curve proof should verify whether safe traversability is also possible with a main circular curve radius R_H < 15 m.
④ If the distance in accordance with ③ falls below the minimum distance of 4.50 m, adjust or factor in an additional circular curve $R_ü$ between the auxiliary circle in accordance with ① and the right carriageway edge of the lower priority road leading away from the node.
⑤ Adjust or factoring in of a three-part circular curve sequence for the corner rounding in accordance with Section A 6.3 between the right carriageway edge of the higher priority road and the additional circular curve $R_Ü$ in accordance with ④ with a main circular curve radius of R_H = 15 m.
⑥ When necessary, iterate ④ and ⑤.

A 6.5 Right-turn types

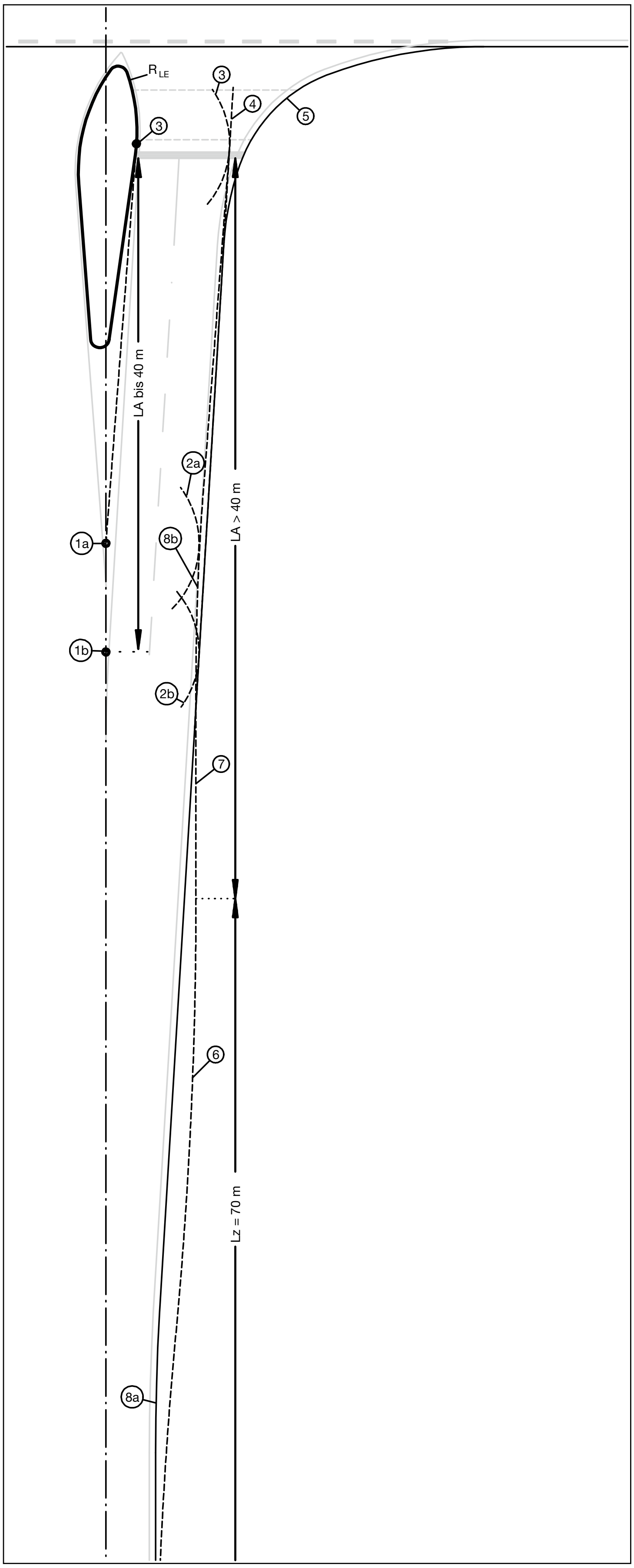


Figure 61: Construction of a right-turn entry rounding

At intersections with two separate lanes or at crossings with only one additional lane, the right carriageway edge of the lower priority road is, as a rule, designed as a straight guidance without distortion if the necessary installation area is no longer than 40 m. If the installation area is longer, the right carriageway edge is initiated with a distortion of 70 m.

The carriageway edges for road users turning in from the right are constructed by factoring in a corner rounding in the form of a three-part circular curve sequence (see Section A 6.3) between the right carriageway edge of the lower priority road leading towards the node and the right carriageway edge of the higher priority road. The right carriageway edge of the lower priority road aligned to create the necessary number of lanes in the installation.

For nodes with a crossing angle of α = 100 gon (90°), the main circular curve radius R_H for the access types of KE1, KE2, KE3, KE4 and KE5 12 m and for the access rout type of KE6 is 10 m.

The construction described below is applicable for a carriageway edge with a single-lane installation area and a two-lane installation area.

① Construct an auxiliary point on the axis of the lower priority road.
a) If a single-lane installation area is planned or if a double-lane installation area of more than 40 m in length is required in accordance with the HBS, this auxiliary point is on the intersection point of the construction line of the right divider island with the axis of the lower priority road.
b) If according to the HBS a double-lane installation area of up to 40 m in length is required, the distance of the auxiliary point to the carriageway edge of the higher priority road corresponds to the length of the installation area required in accordance with the HBS plus the distance of the stop line from the carriageway edge of the higher priority road. This auxiliary point may, however, not be any closer to the carriageway edge of the higher priority road than the intersection point of the construction line of the right divider island edge with the axis of the lower priority road.

② Construct an auxiliary circle around the auxiliary point determined in accordance with ① with a radius of R = 4.50 m with a single-lane installation area or the necessary carriageway width at the rear divider island head with a double-lane installation area (sum of the lane widths, plus the shoulder widths of 0.50 m on the carriageway edge and at least 0.25 m on the divider island).

③ Construct an auxiliary circle around the starting point of the construction line of the right divider island edge, which connects to the circular curve with R_{LE}, with a radius of R = 4.50 m with a single-lane installation area or the necessary carriageway width with a double-lane installation area (sum of the lane widths, plus the shoulder widths of 0.50 m on the carriageway edge and at least 0.25 m on the divider island).

④ Adjust or factor in a line between the auxiliary lines in accordance with ② and ③.

⑤ Adjust or factor a three-part circular curve sequence in accordance with Section A 6.3 between the lines in accordance with ④ and the right carriageway edge of the higher priority road.

⑥ With a double-lane installation area of more than 40 m in length, construct a smooth right edge of the lower priority road over L_Z = 70 m between the right carriageway edge and a parallel offset of the required carriageway width of the lower priority road.

⑦ Extend this right hand edge to the lower priority road in the direction of the intersection..

⑧ Adjust or factor in of an additional circular curve $R_Ü$:
a) with a single-lane installation area or with a double-lane installation area of up to 40 m in length between the line in accordance with ④ and the right carriageway edge of the lower priority road.
b) with a double lane installation area of more than 40 m in length between the line in accordance with ④ and the right carriageway edge in accordance with ⑦ widened by distortion.

If at a crossing on the right next to the lane for the crossing traffic an additional lane is planned for road users turning in from the right, the above construction for the right carriageway edge of a double-lane installation area applies in the same way for the edge of the lane for the crossing traffic. The right carriageway edge of the additional lane for road users turning in from the right must be directed in this case as a parallel to the right edge of the lane for the crossing traffic and initiated with smooth edge line that is 30 m in length.

A 6.6 Carriageway divider at the roundabout

When constructing in accordance with Figure 62, the definitions in Section 6.4.14 must be observed.

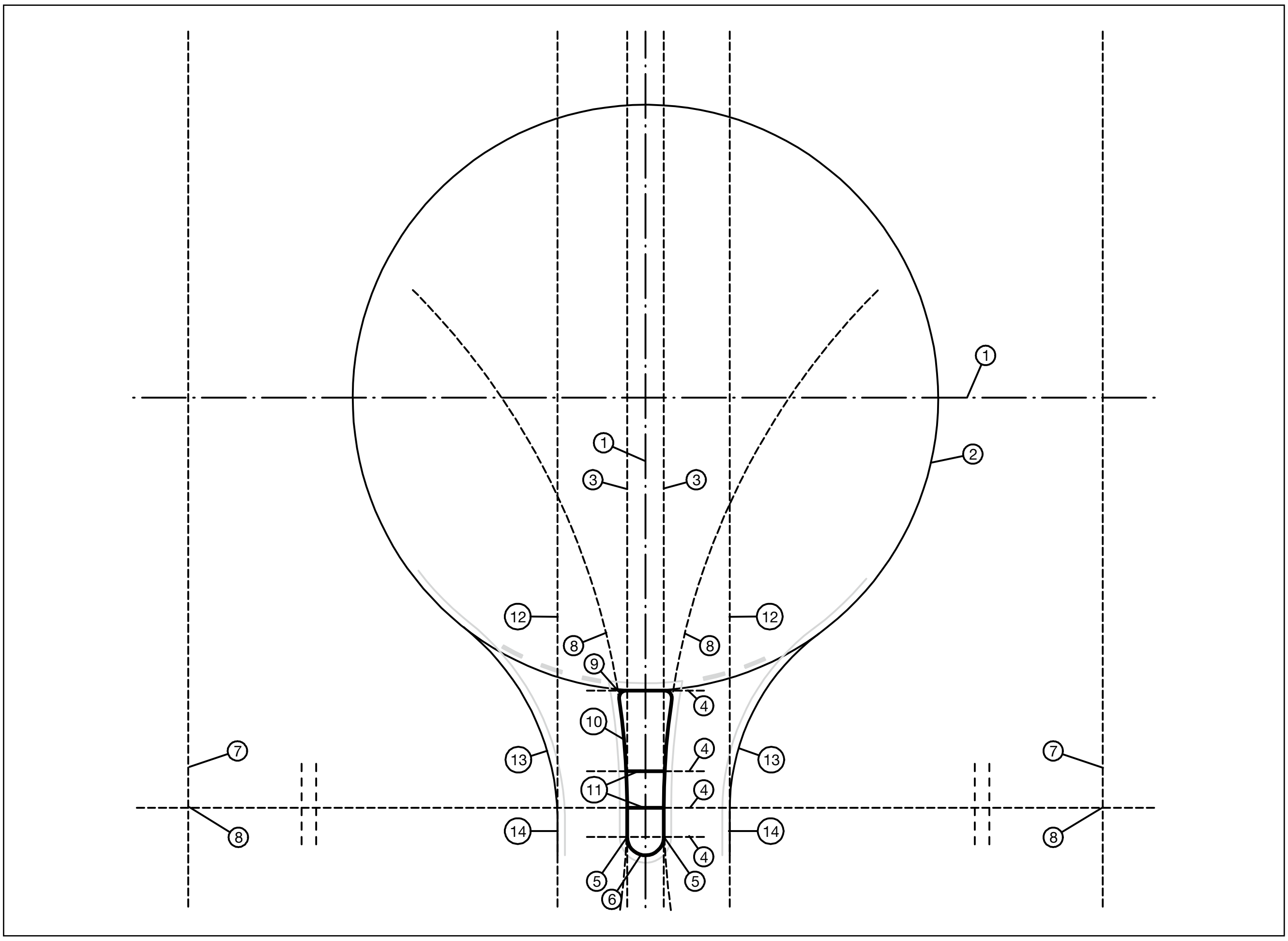


Figure 62: Construction of a carriageway divider in a roundabout

① Define the axes of roundabout entries.
② Draw the external radius for roundabout traffic.
③ Construct two auxiliary lines on the right and left in parallel at a distance of 1.25 m to the axis of the roundabout entry.
④ Construct an auxiliary line through the intersection between the external radius drawn in accordance with ② of the roundabout and the axis of the roundabout entry vertically to the front head of the carriageway divider. Draw parallels to this auxiliary line at a distance of 5.50 m, 8.00 m and 10.00 m (5.50 m, 8.00 m and 10.00 m lines) to define the crossing position for the joint footpath and cycling path as well as the construction of the rear head of the carriageway divider.*)
⑤ Define the intersection points of the axis parallels drawn in accordance with ③ the 10.00 m line.
⑥ Round the rear head of the carriageway divider between the intersection points determined in accordance with ⑤ with a radius of R = 1.25 m.
⑦ Draw two further auxiliary lines to the axis parallels constructed in accordance with ③ at a distance of 50 m.
⑧ Draw an circular curve with a radius of 50 m around the intersection points of the 8 m line with the auxiliary parallels drawn in accordance with ⑦ (circle centres) such that they touch the axis parallels drawn in accordance with ③.
⑨ Round the front corners of the carriageway distributor through two circular curves with a radius of R = 0.50 m between the circular curves drawn in accordance with ⑧ and the auxiliary line constructed in accordance with ④ for the external radius of the roundabout.
⑩ Construct the external edges of the carriageway divider by the circular curves drawn in accordance with ⑧ between the roundings created in accordance with ⑥ and ⑨.
⑪ Define the crossing position for the joint footpath and cycling path between the 5.50 m and the 8.00 m line.
⑫ Draw a further auxiliary parallel to the axis parallels drawn in accordance with ③ at a distance of 4.50 m to 5.00 m for the roundabout entry and at a distance of 4.75 m to 5.50 m for the roundabout exit; therefore, determination of the carriageway edges.
⑬ Construct circular curves for entries and exits with radii of between 14 m and 18 m such that they touch the external radius of the roundabout drawn in accordance with ② and the auxiliary parallels in accordance with ⑫.
⑭ Create the relevant right carriageway edges of the roundabout entry and exit through the parallels in accordance with ⑫ between the transition into the radii in accordance with ⑬ and the rear head of the carriageway divider. From the rear head of the carriageway divider, distort the carriageway edges to the dimension of the carriageway width of the roundabout entry.

*) The dimensions may differ in individual cases.

Exemplary solutions for intersections

Table 35: Intersection elements of the exemples shown

Figure No.	Higher priority road	Lower priority road	Intersection/ crossing	Traffic signals	Types of left turn	Types of right turn	Types of access	Divider islands	Right turn lane	G/R crossing of the higher priority road	G/R crossing of the lower priority road
63	EKL 2	RRQ2	Intersection	Yes	LA1	RA1	KE1	large	Yes	No	Yes
64	EKL 2	EKL 3	Intersection	Yes	LA1	RA1	KE1	large	Yes	Yes	No
65	EKL 2	EKL 3	Intersection	Yes	LA1	RA1	KE1	large	Yes	No	Yes
66	EKL 2	EKL 3	Intersection	Yes	LA1	RA2	KE1	small	Yes	Yes	No
67	EKL 3	EKL 3	Intersection	Yes	LA1	RA2	KE1	small	No	No	Yes
68	EKL 3	RRQ2	Intersection	Yes	LA1	RA2	KE2	small	Yes	No	Yes
69	EKL 3	EKL 3	Intersection	Yes	LA1	RA2	KE2	small	No	Yes	No
70	EKL 3	EKL 3	Intersection	Yes	LA1	RA2	KE2	small	Yes	No	Yes
71	EKL 3	EKL 3	Intersection	No	LA2	RA3	KE3	large	No	No	No
72	EKL 3	EKL 3	Intersection	No	LA2	RA4	KE4	small	No	No	Yes
73	EKL 3	EKL 3	Intersection	No	LA2	RA4	KE4	small	No	Yes	No
74	EKL 3	EKL 3	Intersection	No	LA2	RA4	KE4	small	No	Yes	Yes
75	EKL 3	EKL 4	Intersection	No	LA2	RA5	KE5	small	No	No	Yes
76	EKL 4	EKL 4	Intersection	No	LA3	RA6	KE6	small	No	No	No
77	EKL 4	EKL 4	Intersection	No	LA4	RA6	KE6	small	No	No	No
78	EKL 3	EKL 3	Crossing	Yes	LA1	RA2	KE1	small	No	Yes	Yes
79	EKL 3	EKL 3	Crossing	Yes	LA1	RA2	KE1/KE2	small	No	Yes	Yes
80	EKL 3	EKL 3	Crossing	No	LA2	RA4	KE4	small	No	No	Yes
81	EKL 3	EKL 4	Crossing	No	LA2	RA5/RA6	KE5/KE6	small	No	No	Yes
82	EKL 4	EKL 4	Crossing	No	LA3	RA6	KE6	small	No	No	No
83	EKL 3	EKL 3	Roundabout	No						Yes	Yes
84	EKL 3	EKL 4	Roundabout	No						Yes	Yes
85	EKL 2	EKL 3	Partially at-grade intersection	Yes/No							

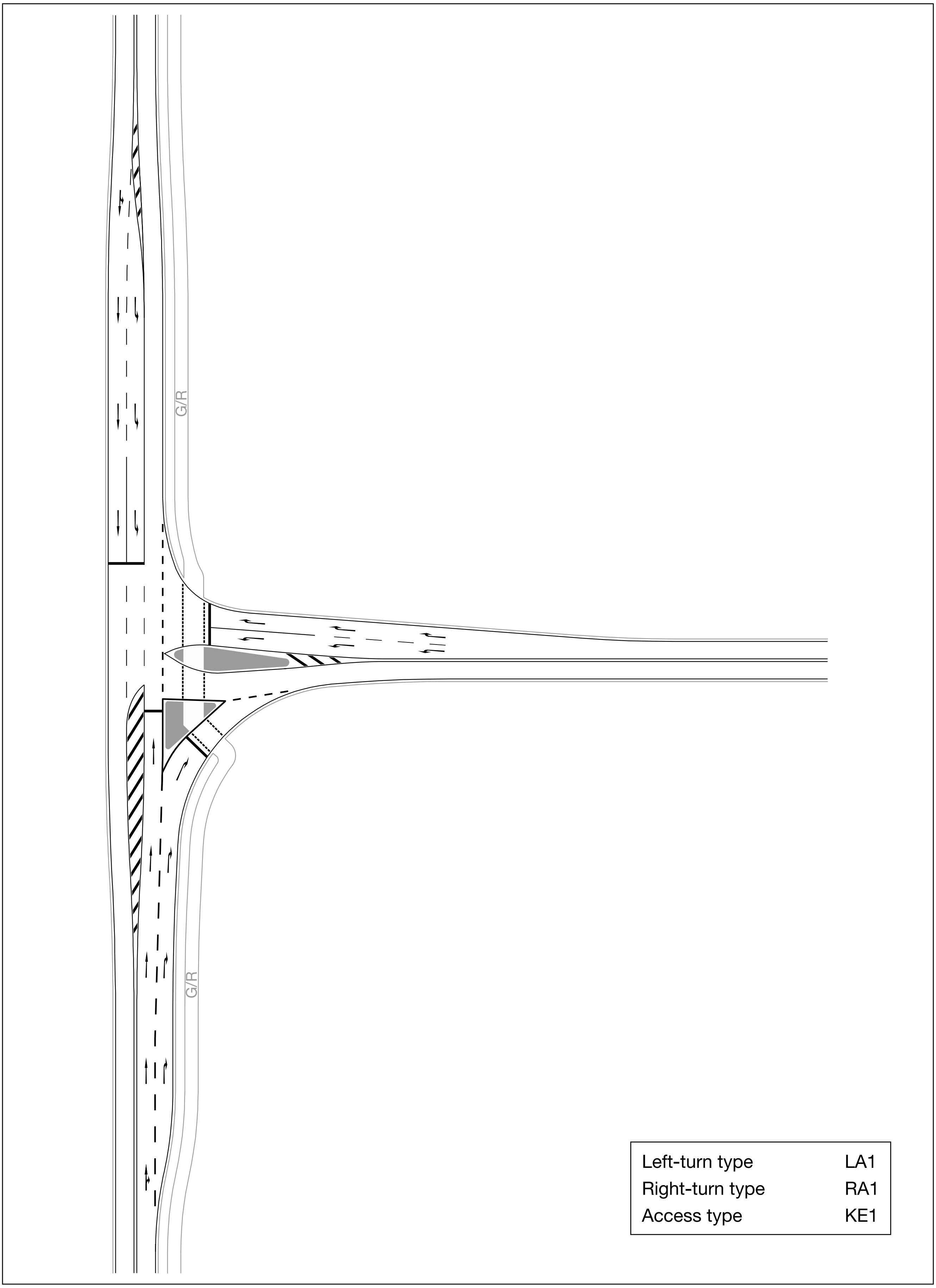


Figure 63: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road ramp RRQ 2

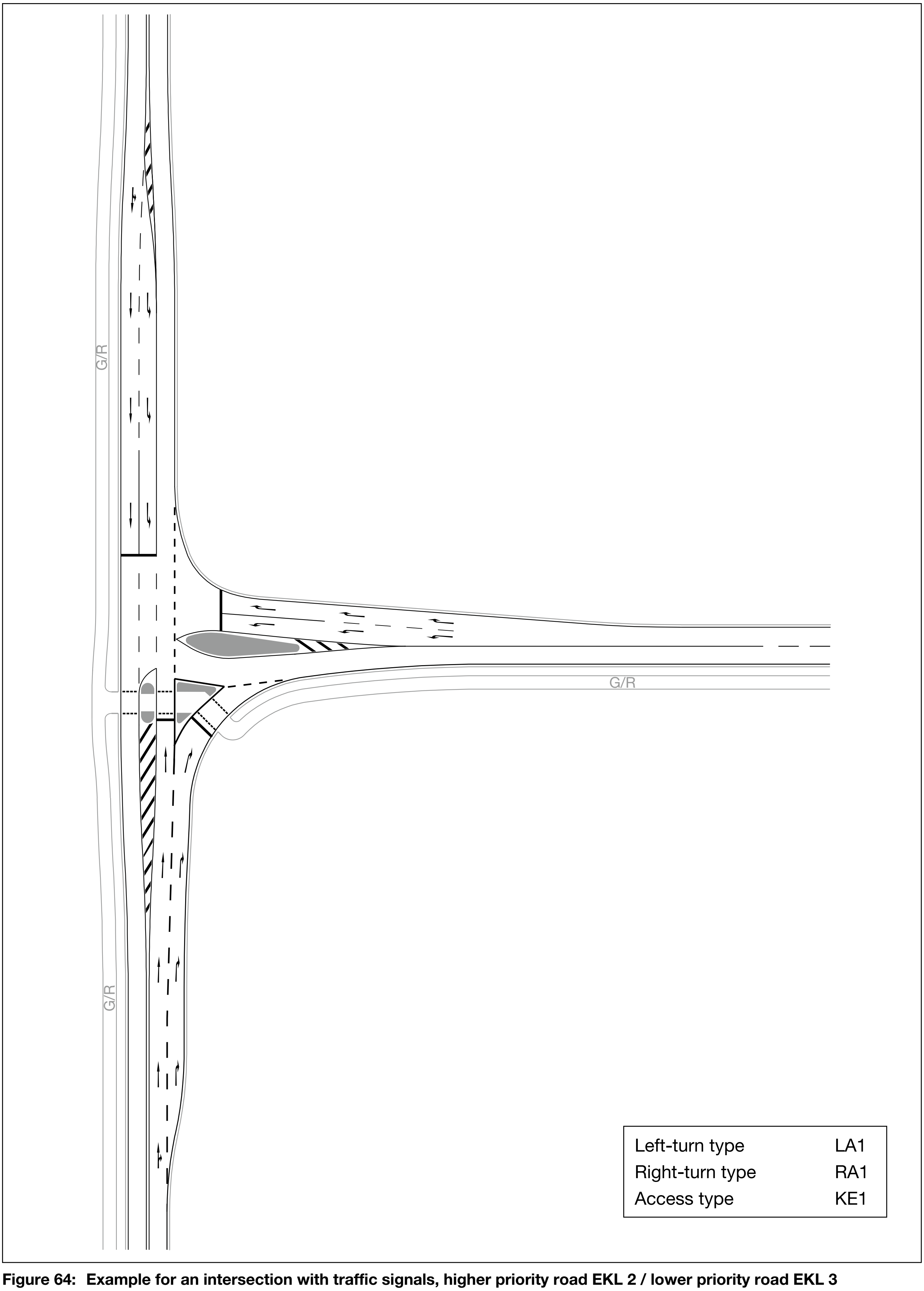


Figure 64: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road EKL 3

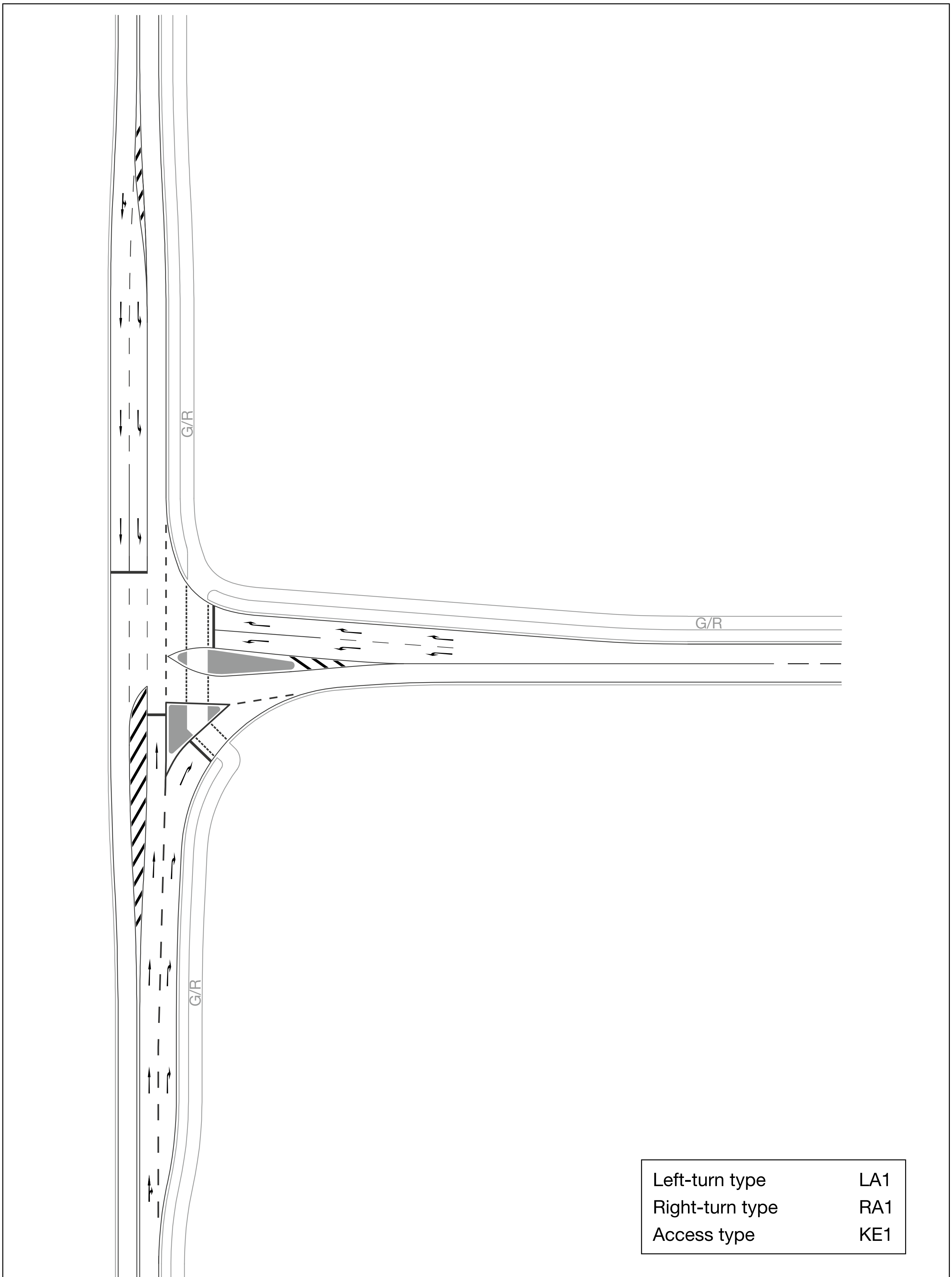


Figure 65: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road EKL 3

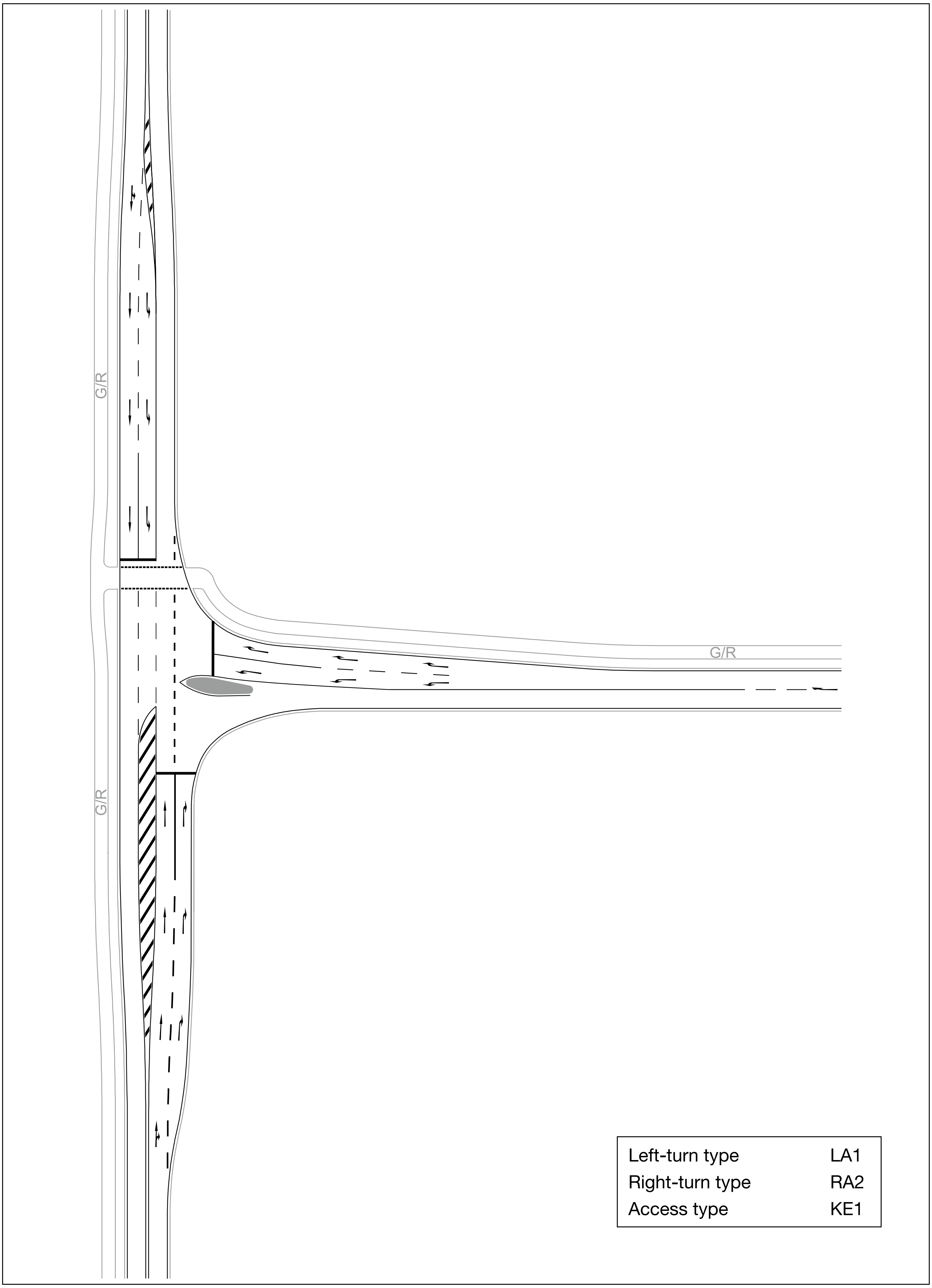


Figure 66: Example for an intersection with traffic signals, higher priority road EKL 2 / lower priority road EKL 3

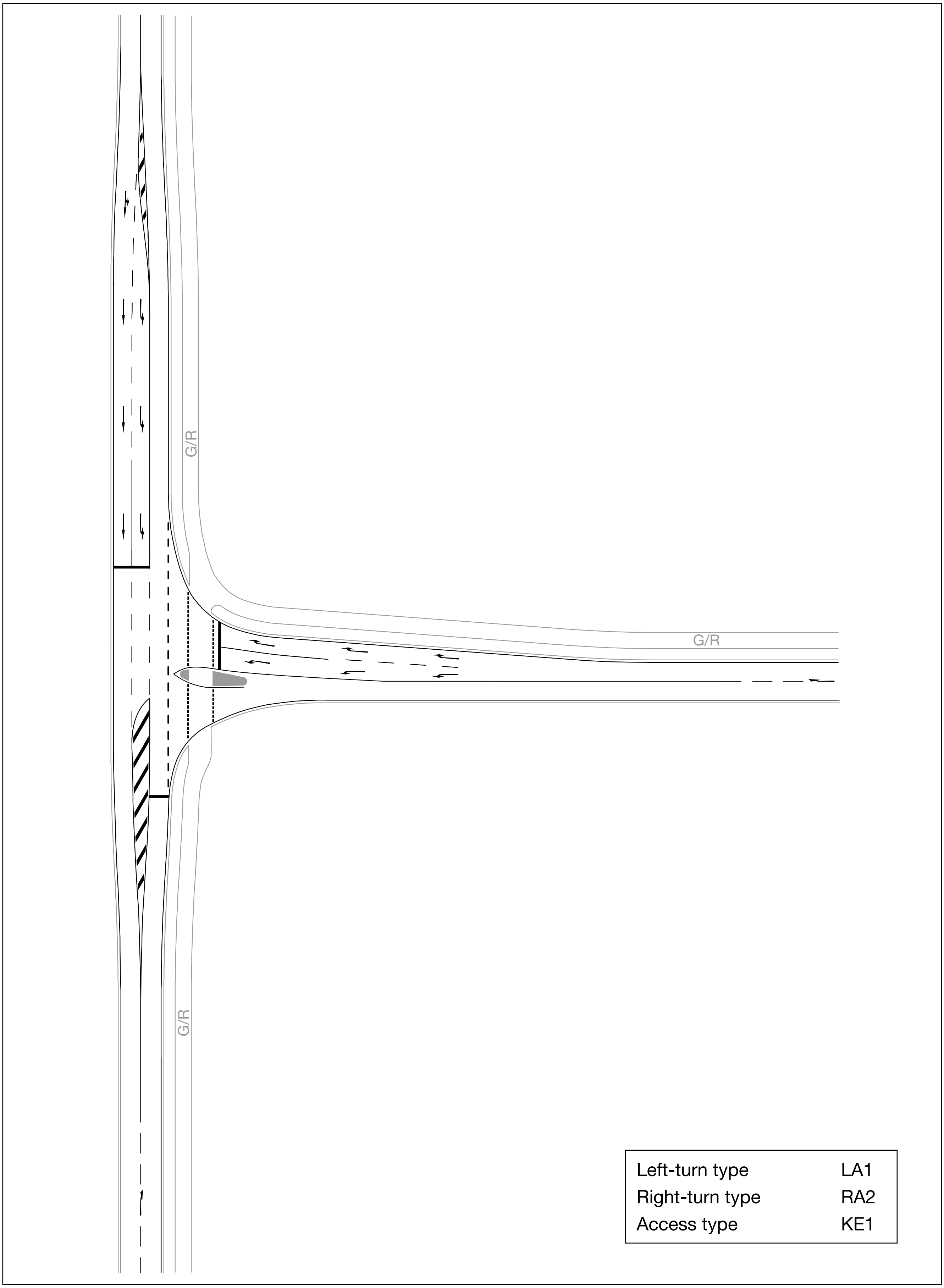


Figure 67: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road EKL 3

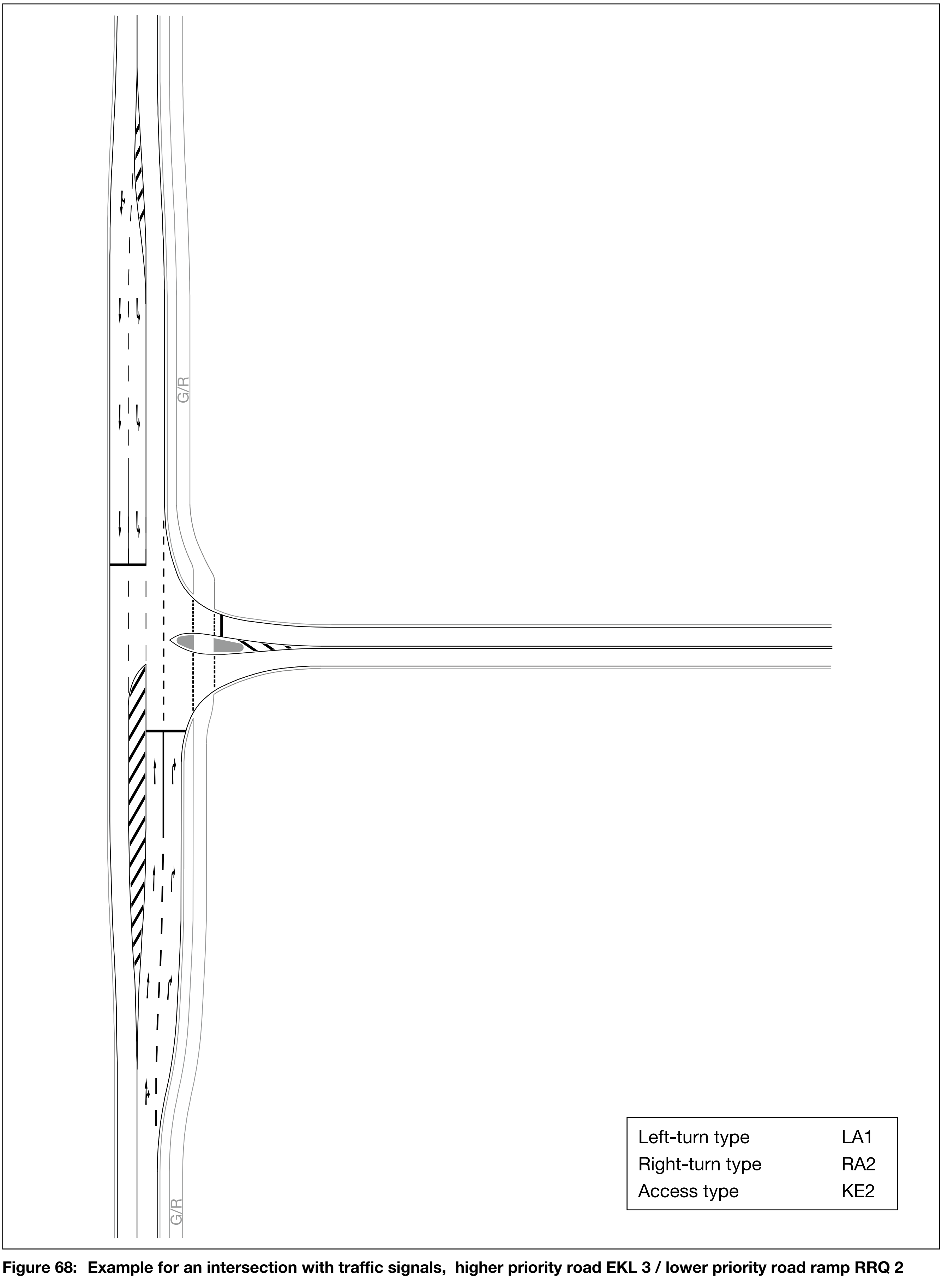


Figure 68: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp RRQ 2

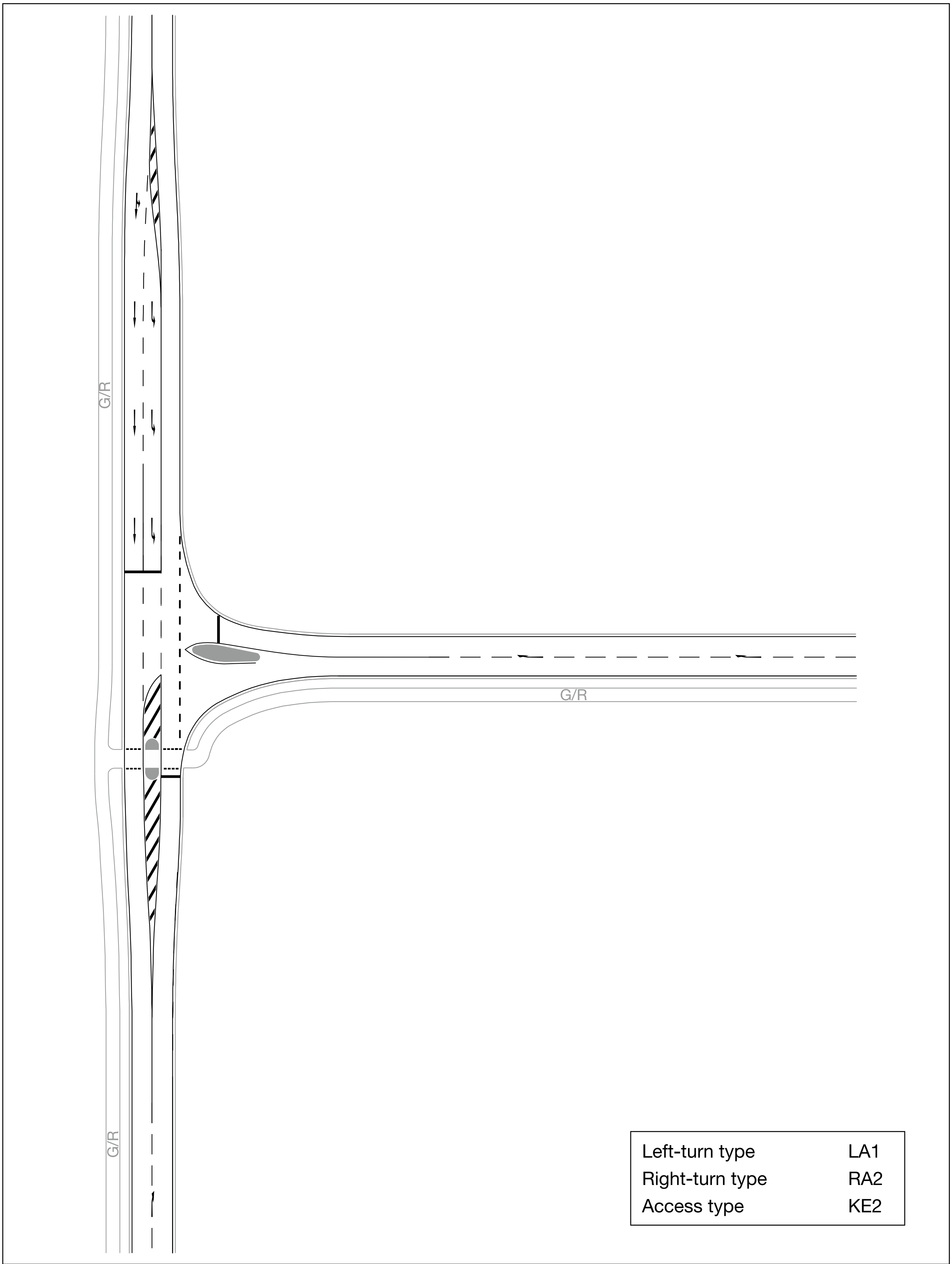


Figure 69: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road EKL 3

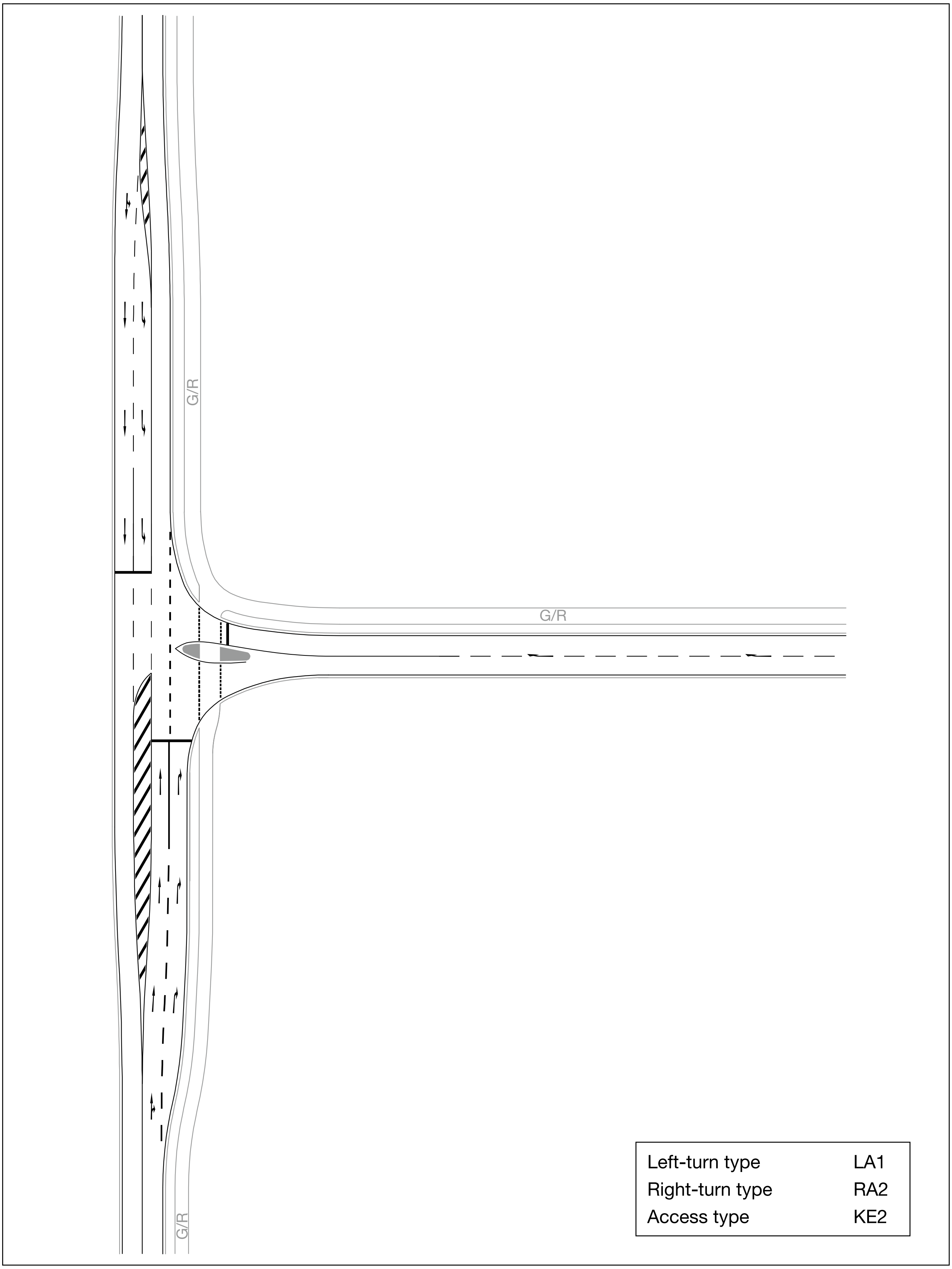


Figure 70: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road EKL 3

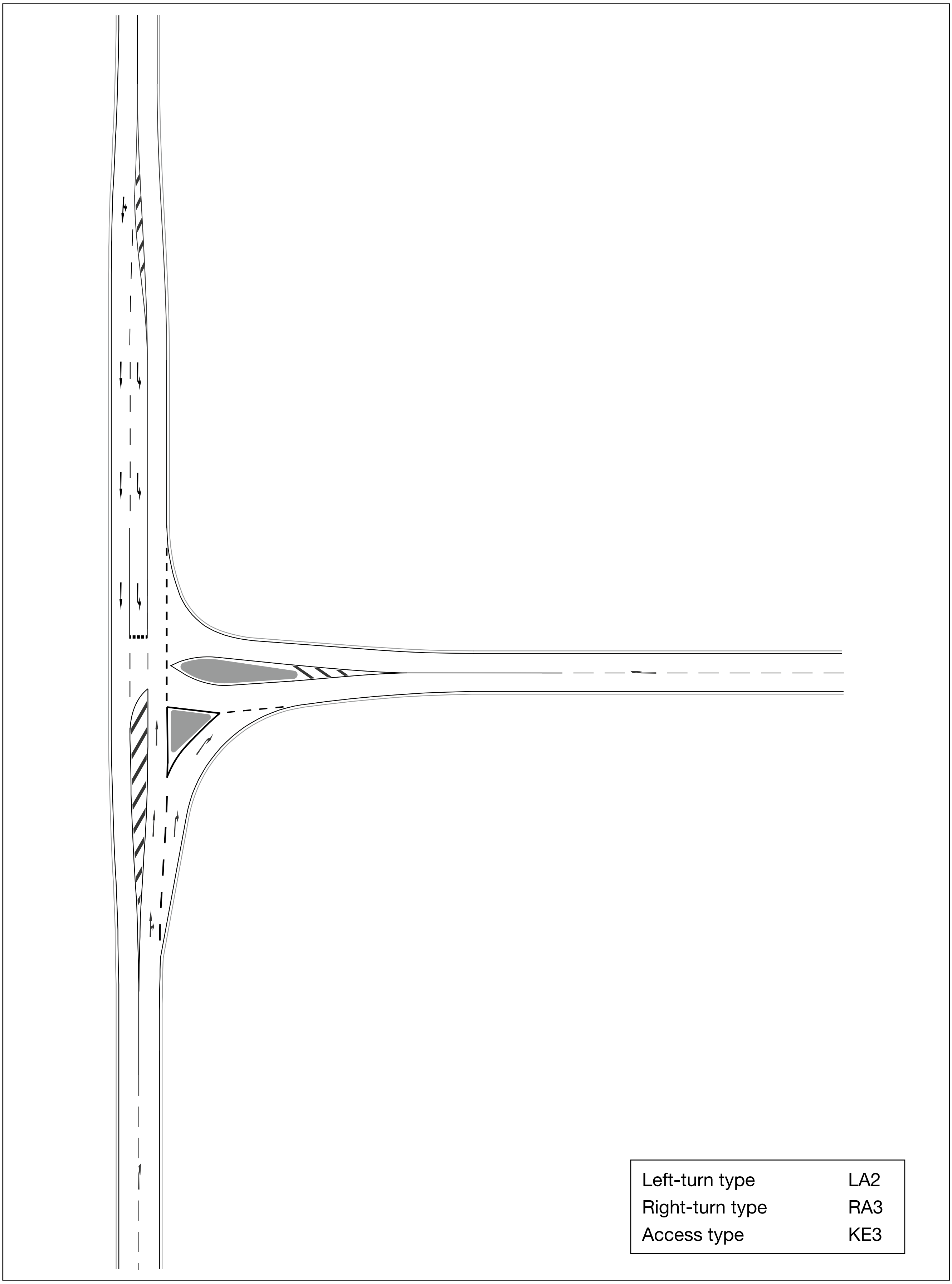


Figure 71: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3

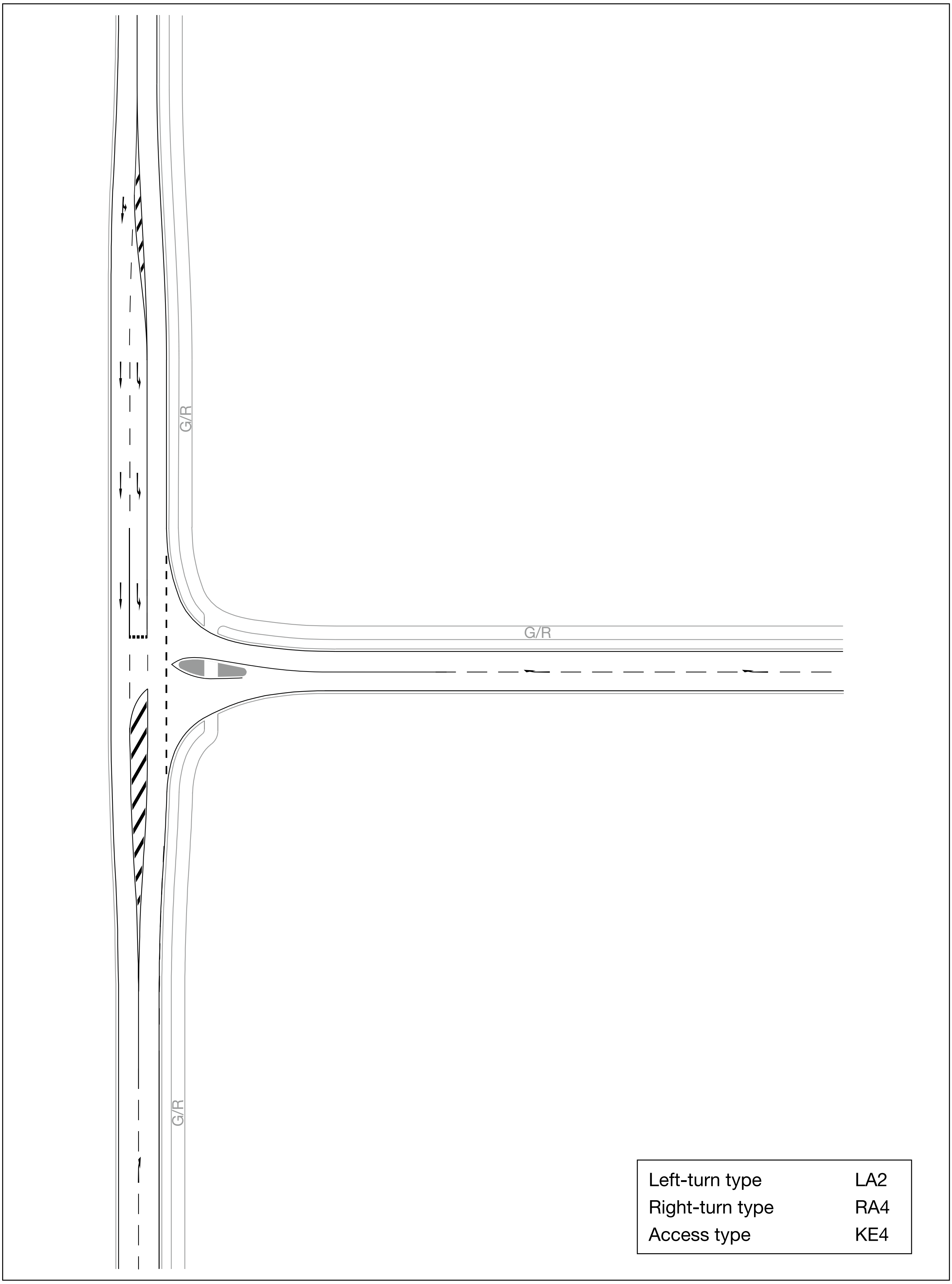


Figure 72: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3

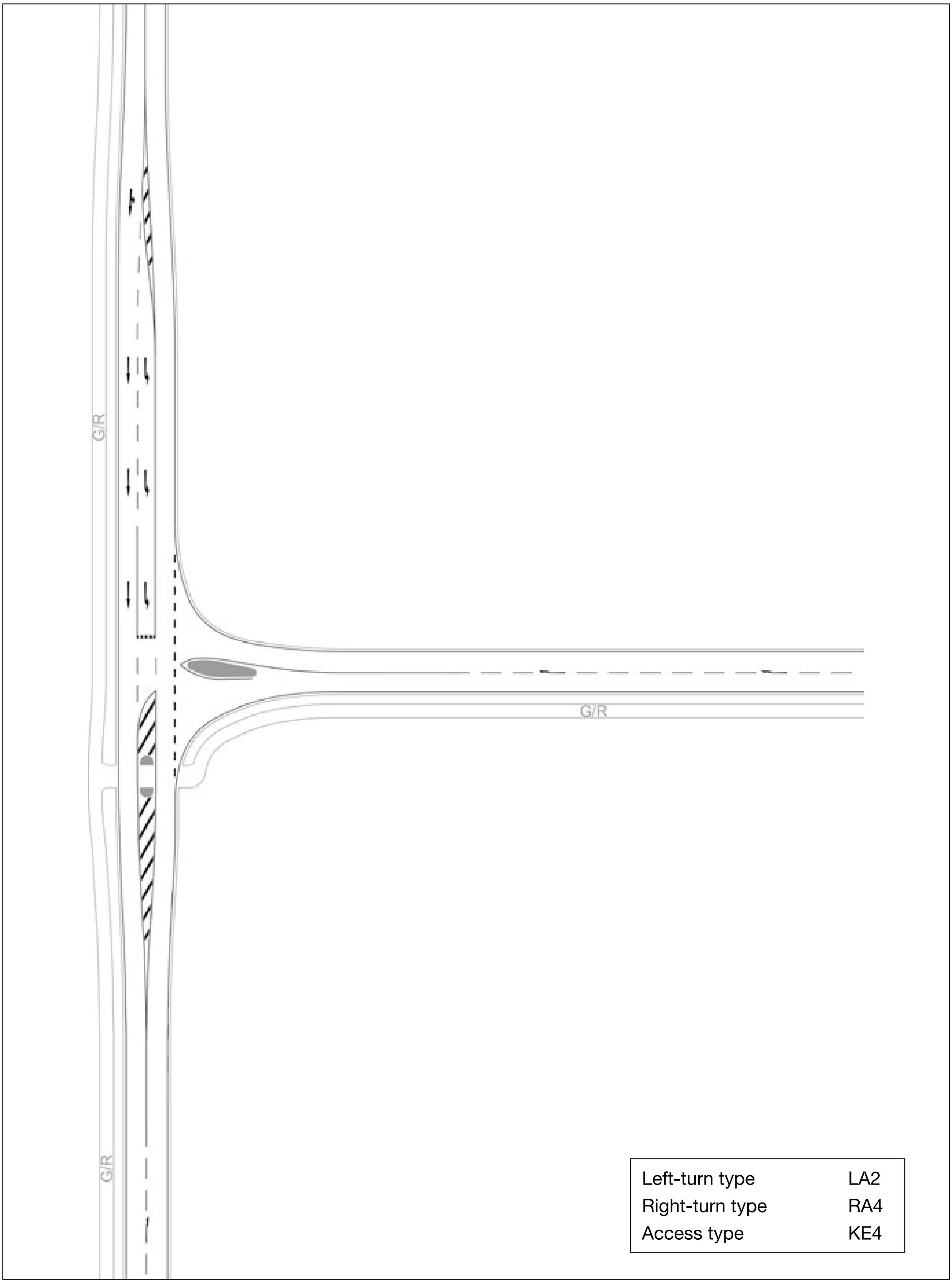


Figure 73: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3

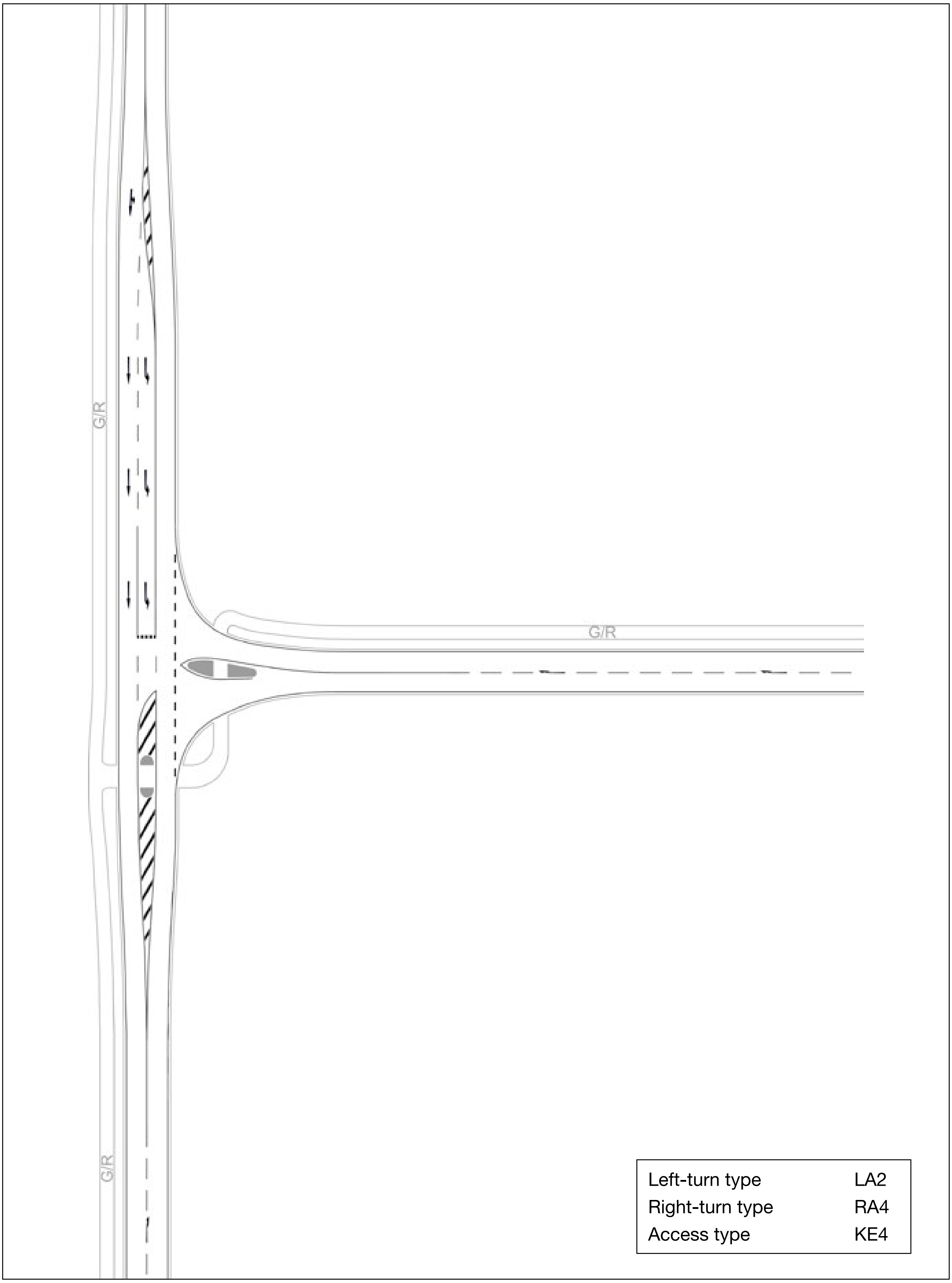


Figure 74: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3

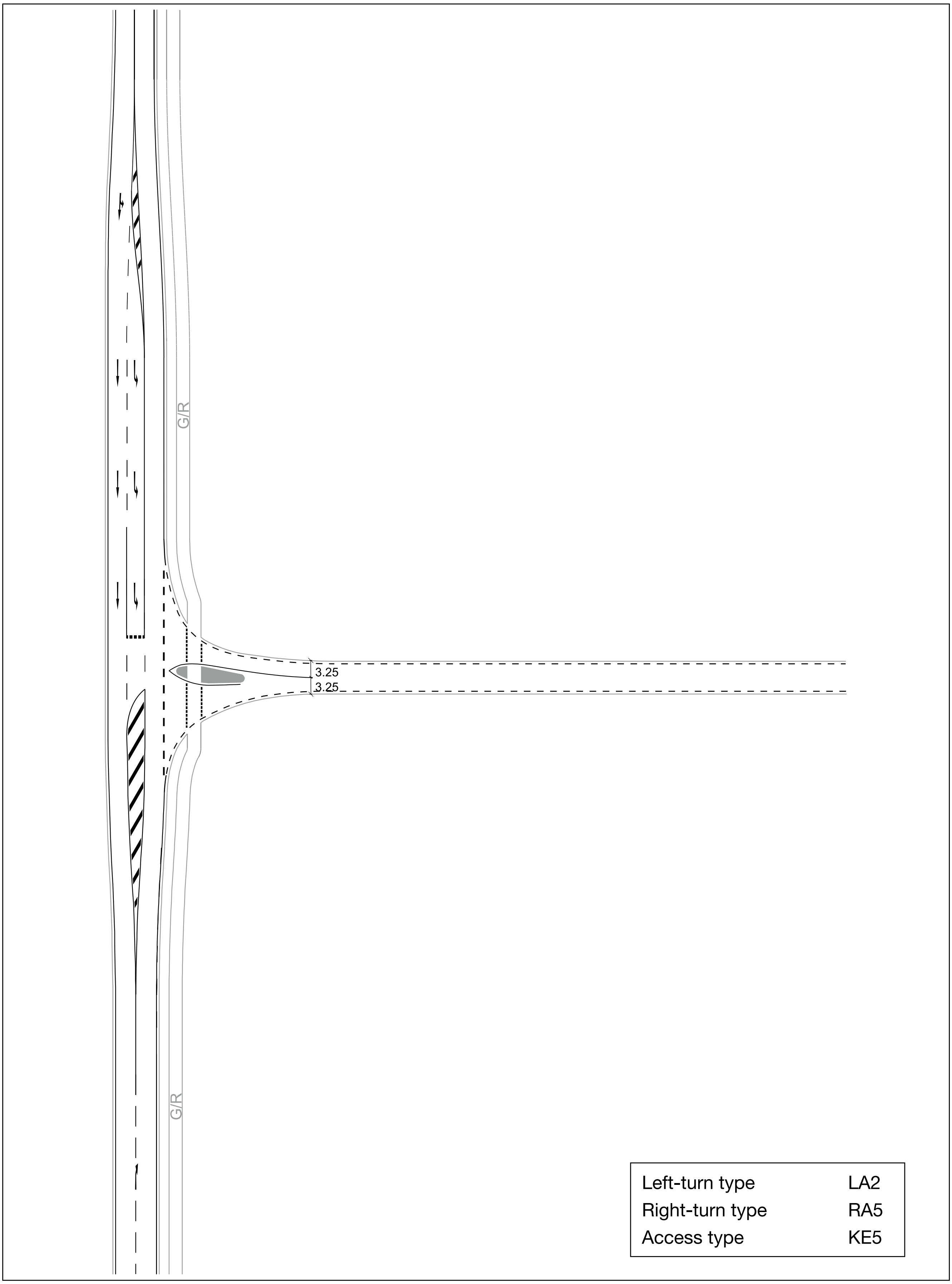
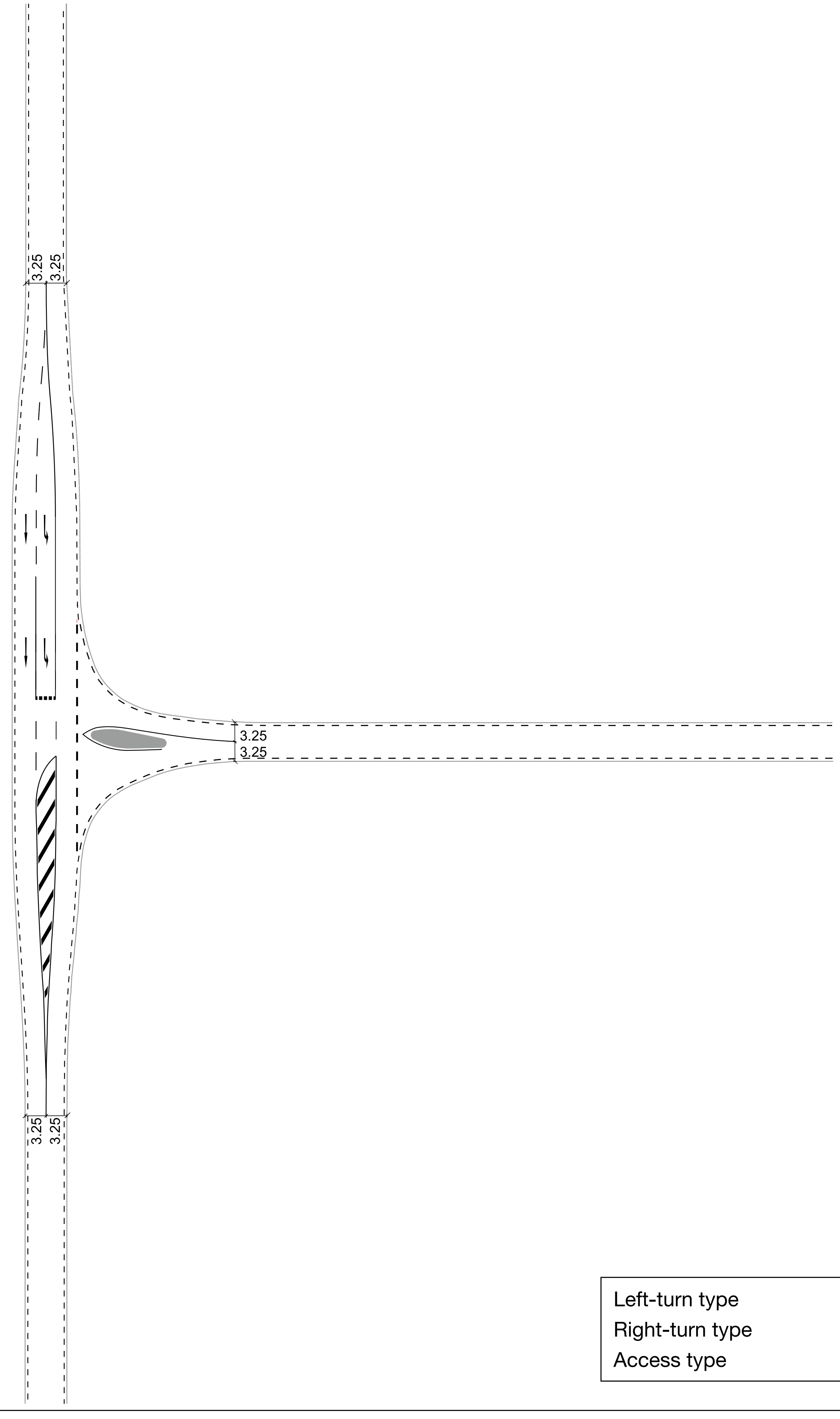


Figure 75: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 4



Left-turn type	LA3
Right-turn type	RA6
Access type	KE6

Figure 76: Example for an intersection with traffic signals, higher priority road EKL 4 / lower priority road ramp EKL 4

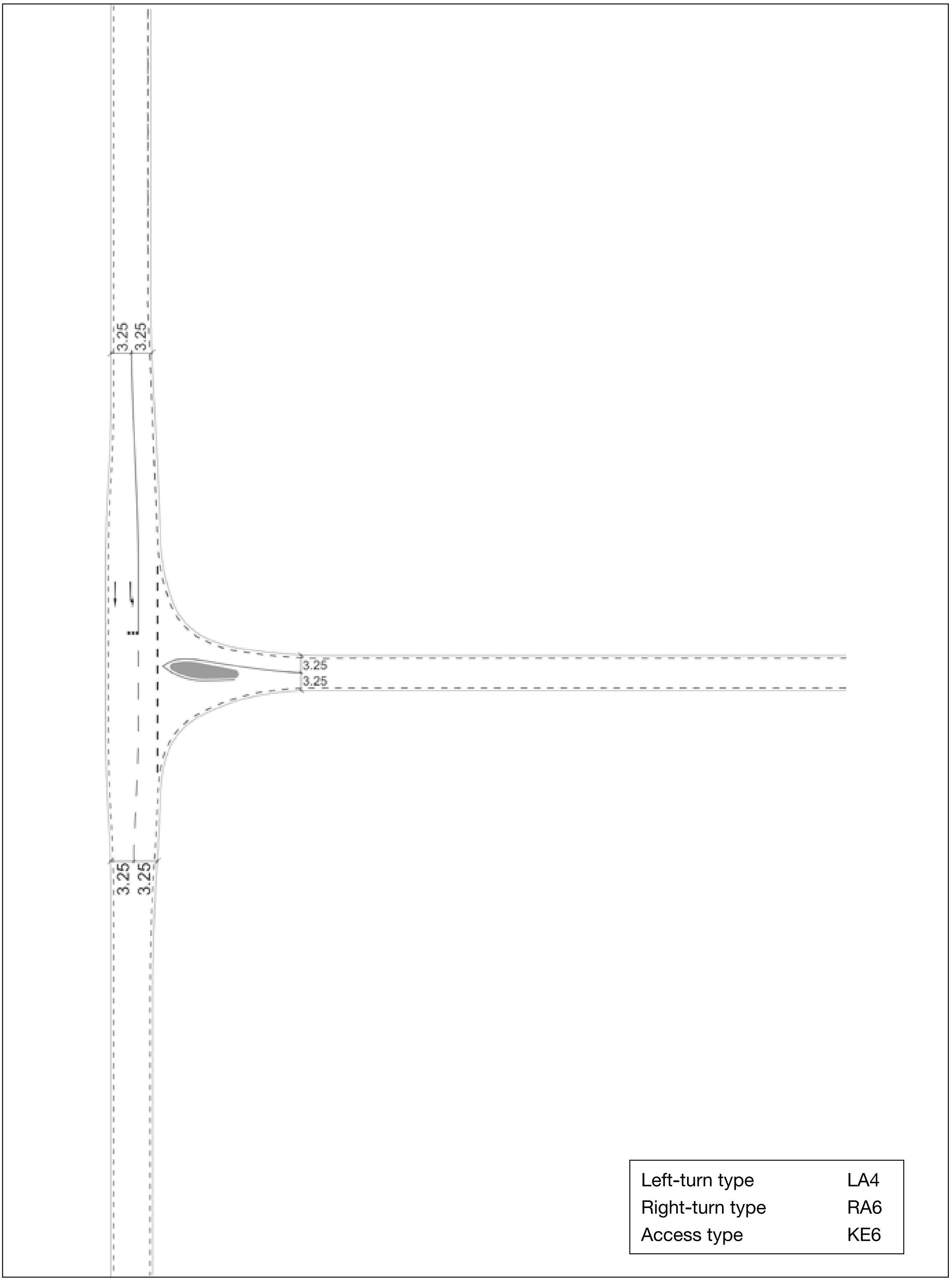


Figure 77: Example for an intersection with traffic signals, higher priority road EKL 4 / lower priority road ramp EKL 4

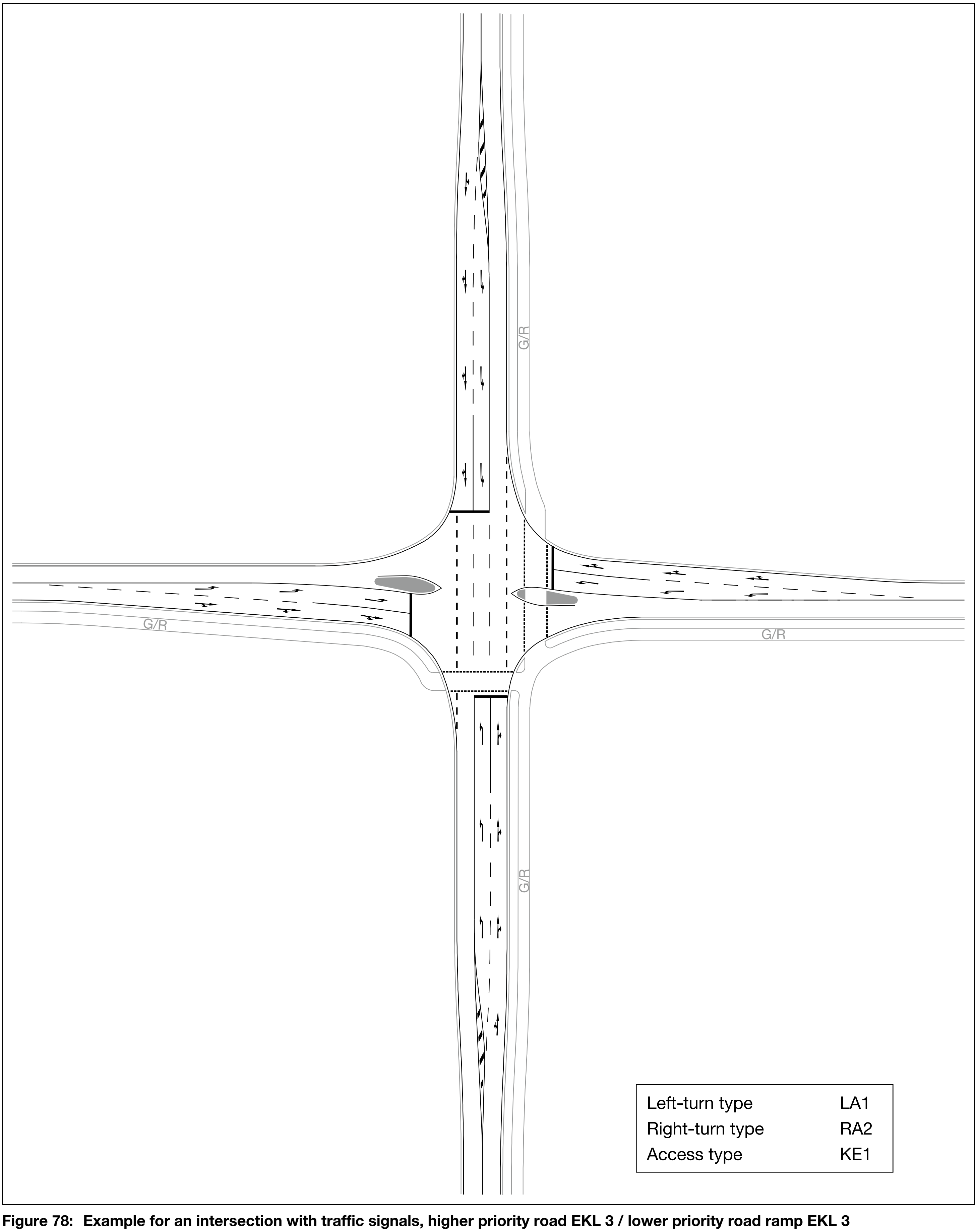


Figure 78: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3

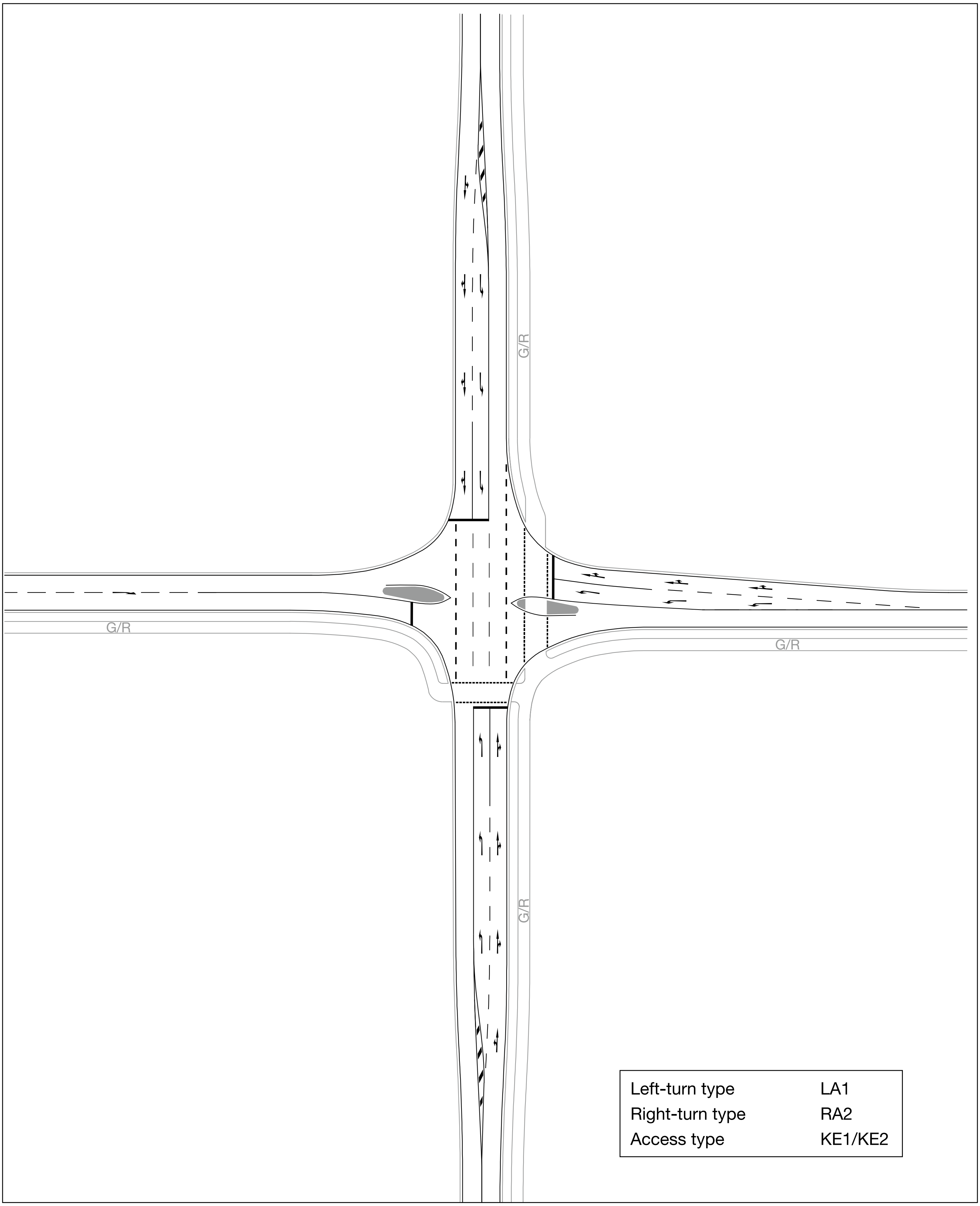


Figure 79: Example for an intersection with traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3

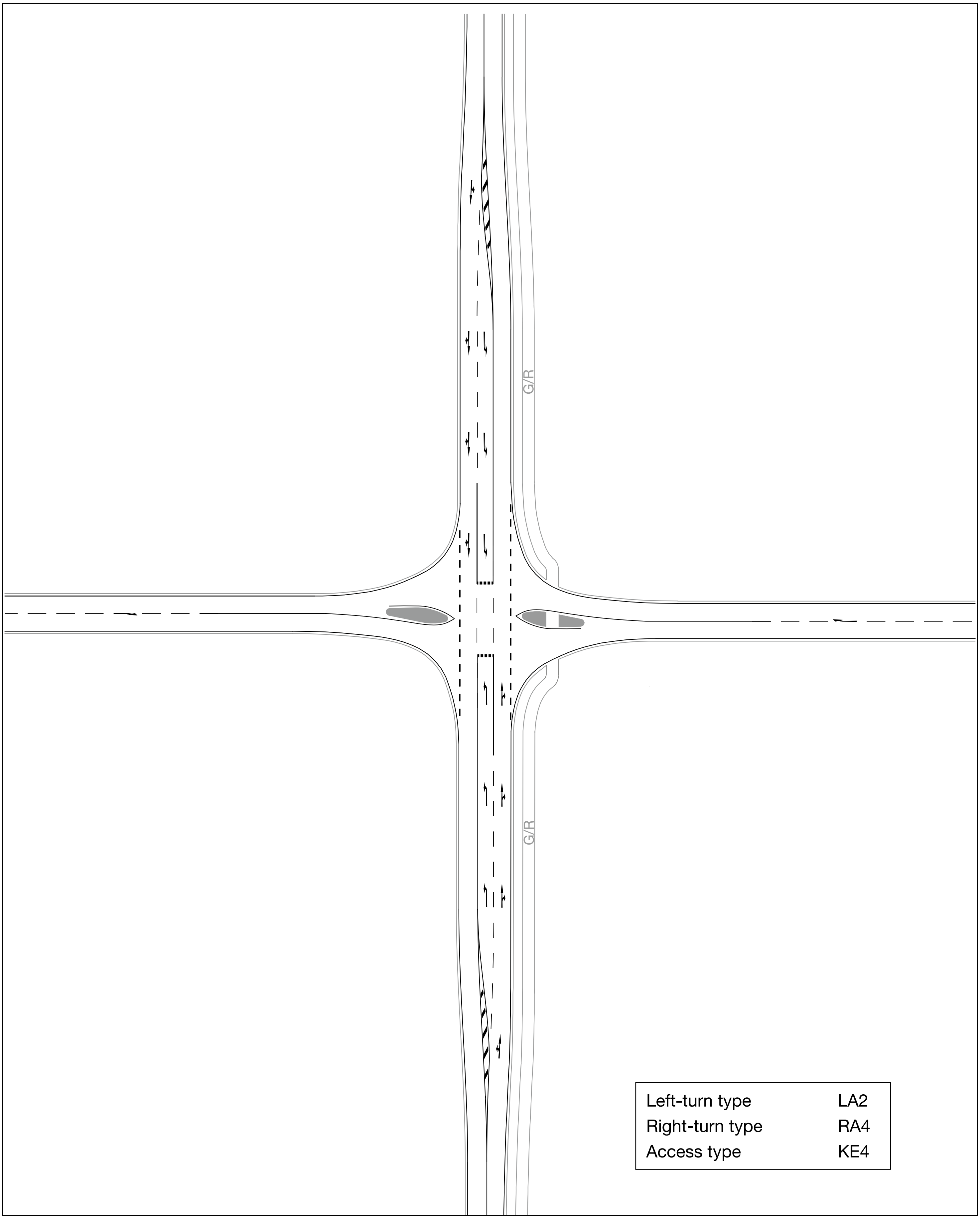


Figure 80: Example for an intersection without traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 3

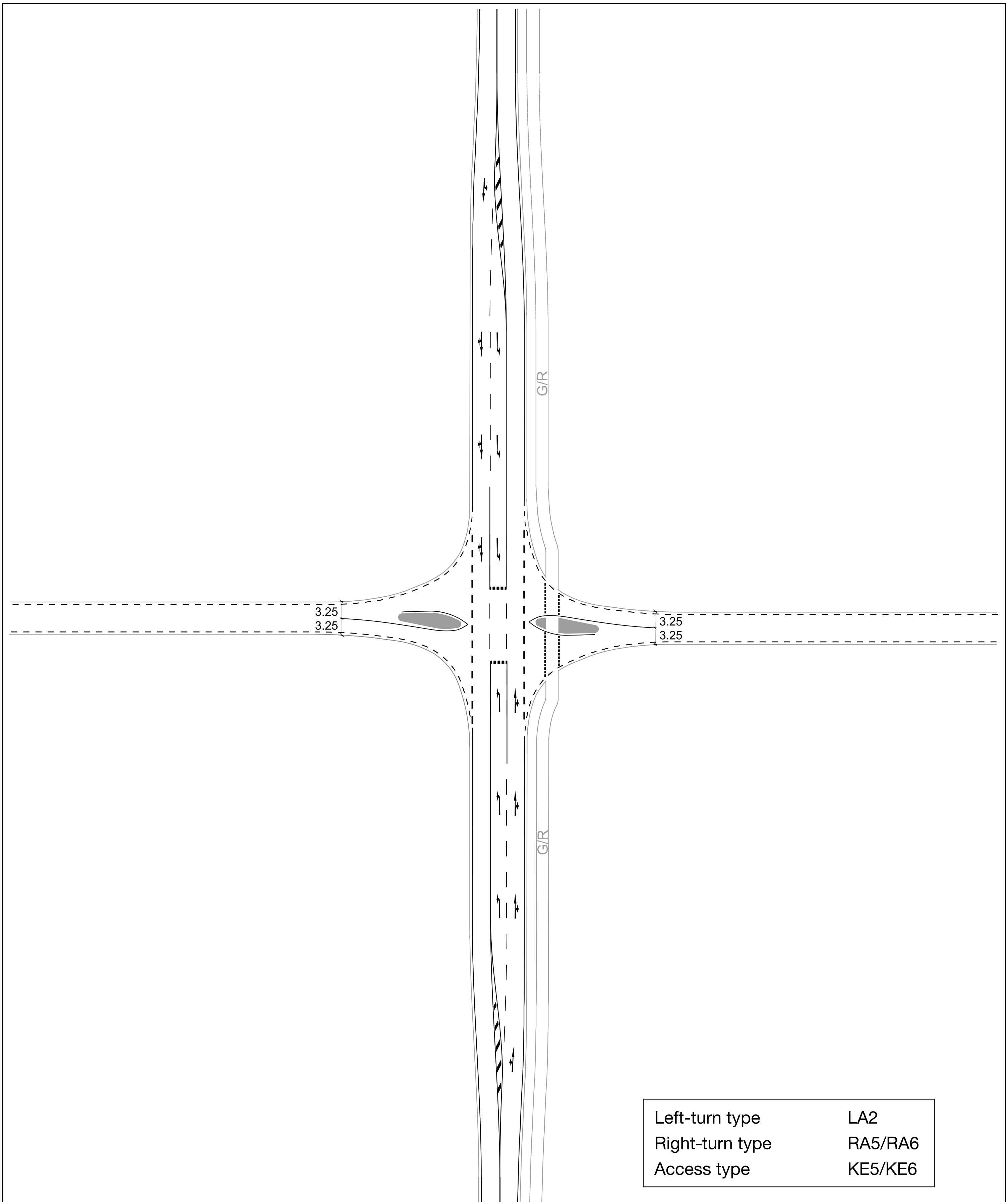


Figure 81: Example for an intersection without traffic signals, higher priority road EKL 3 / lower priority road ramp EKL 4

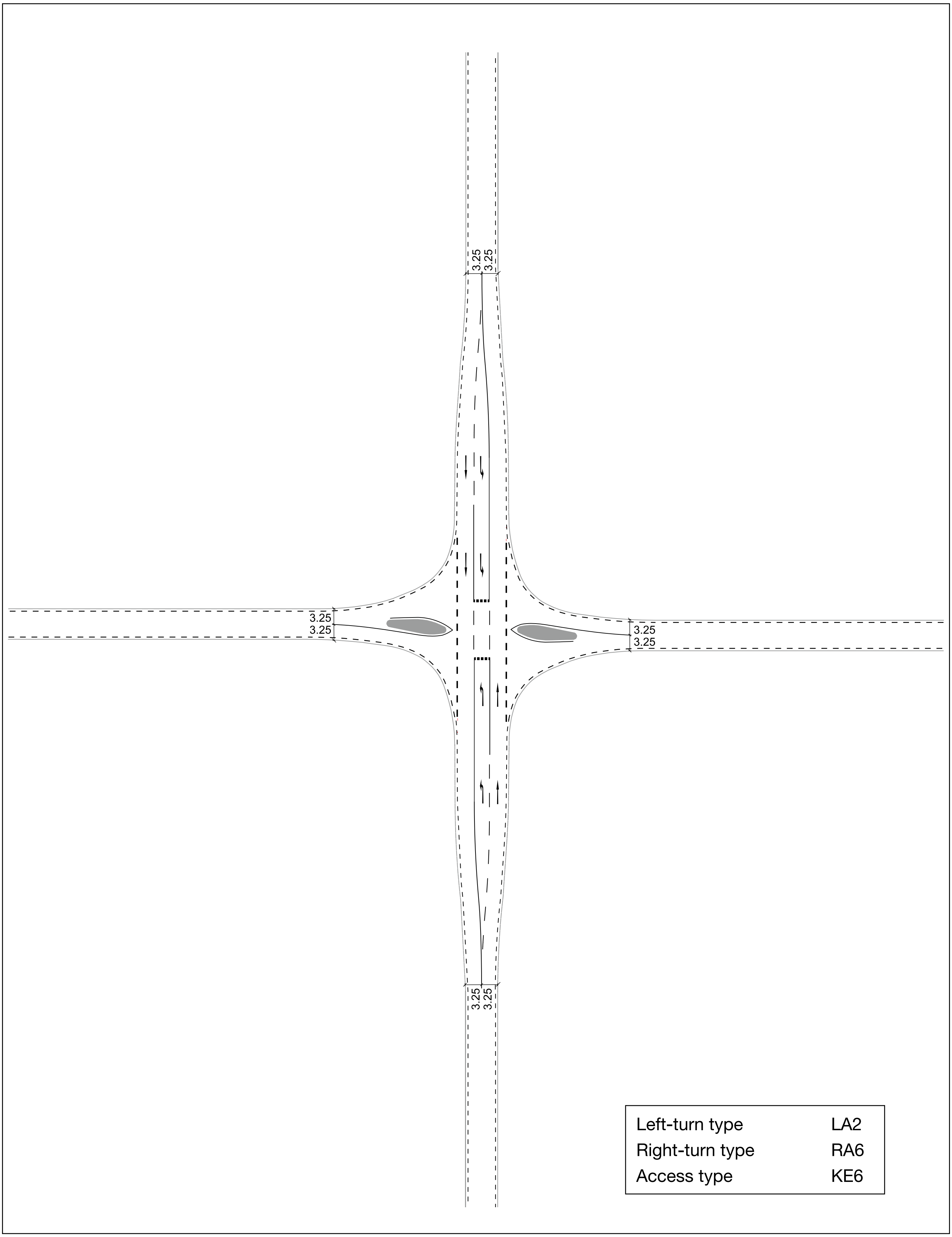


Figure 82: Example for an intersection without traffic signals, higher priority road EKL 4 / lower priority road ramp EKL 4

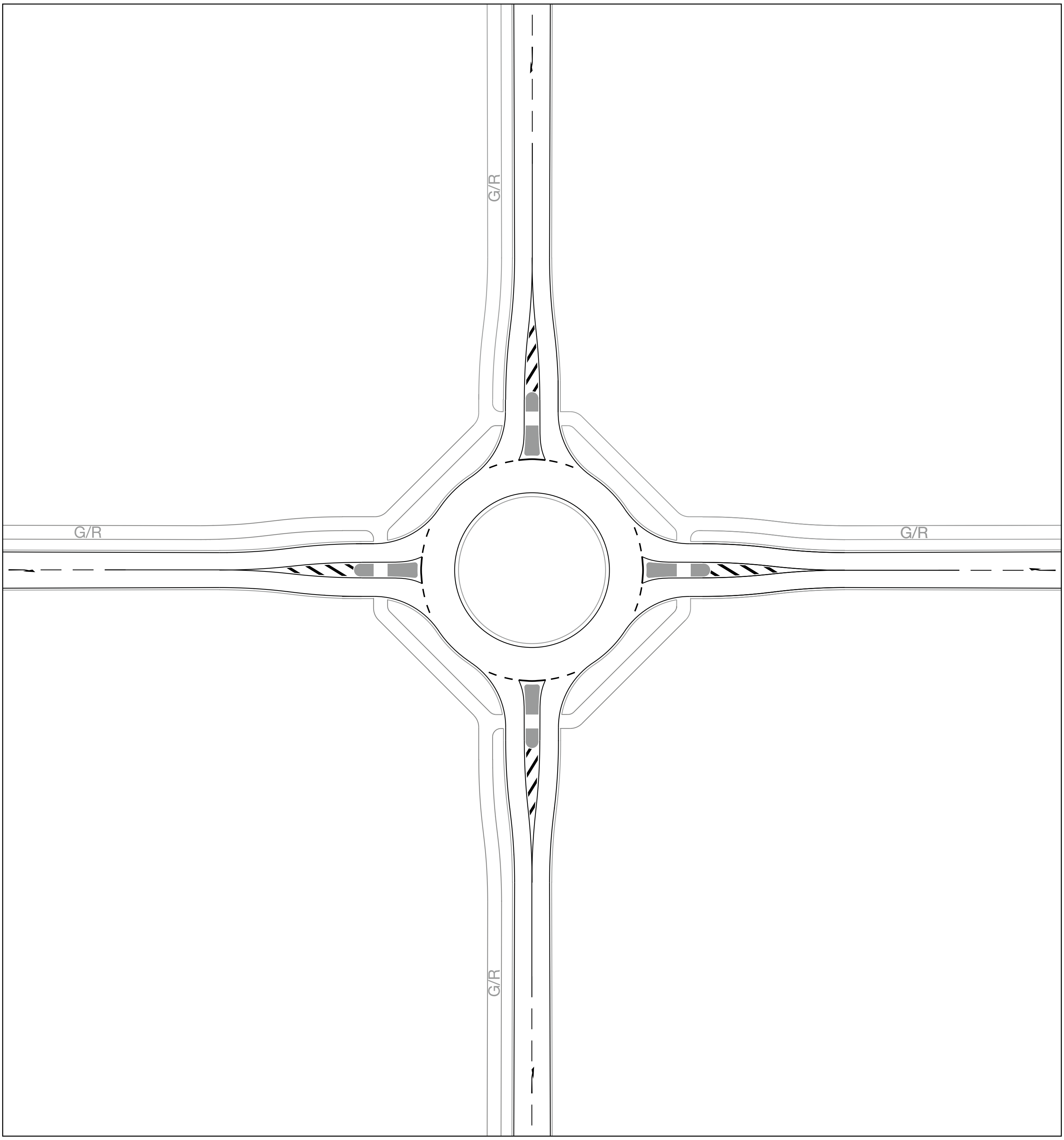


Figure 83: Example for a roundabout, higher priority road EKL 3 / lower priority road ramp EKL 3

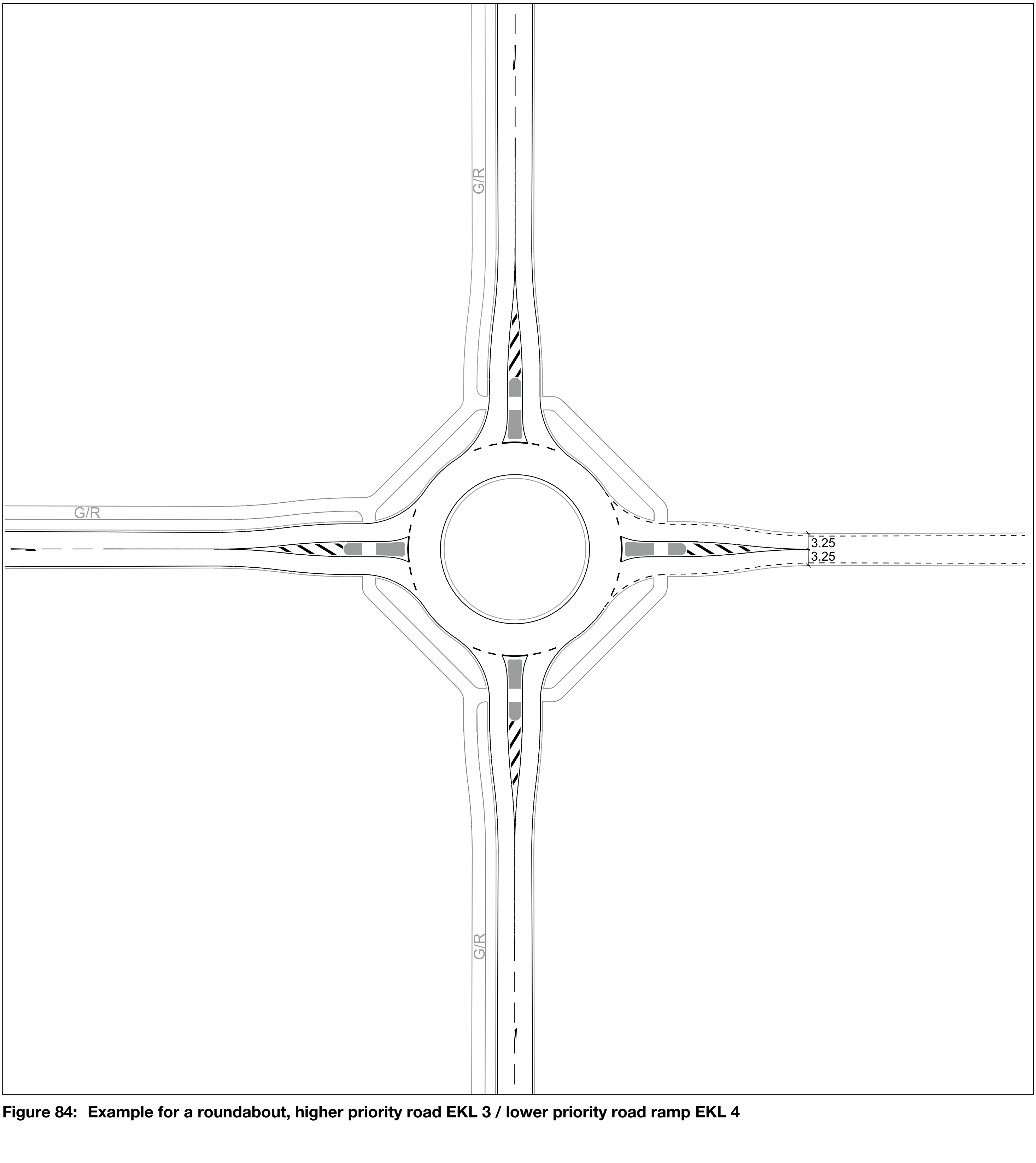


Figure 84: Example for a roundabout, higher priority road EKL 3 / lower priority road ramp EKL 4

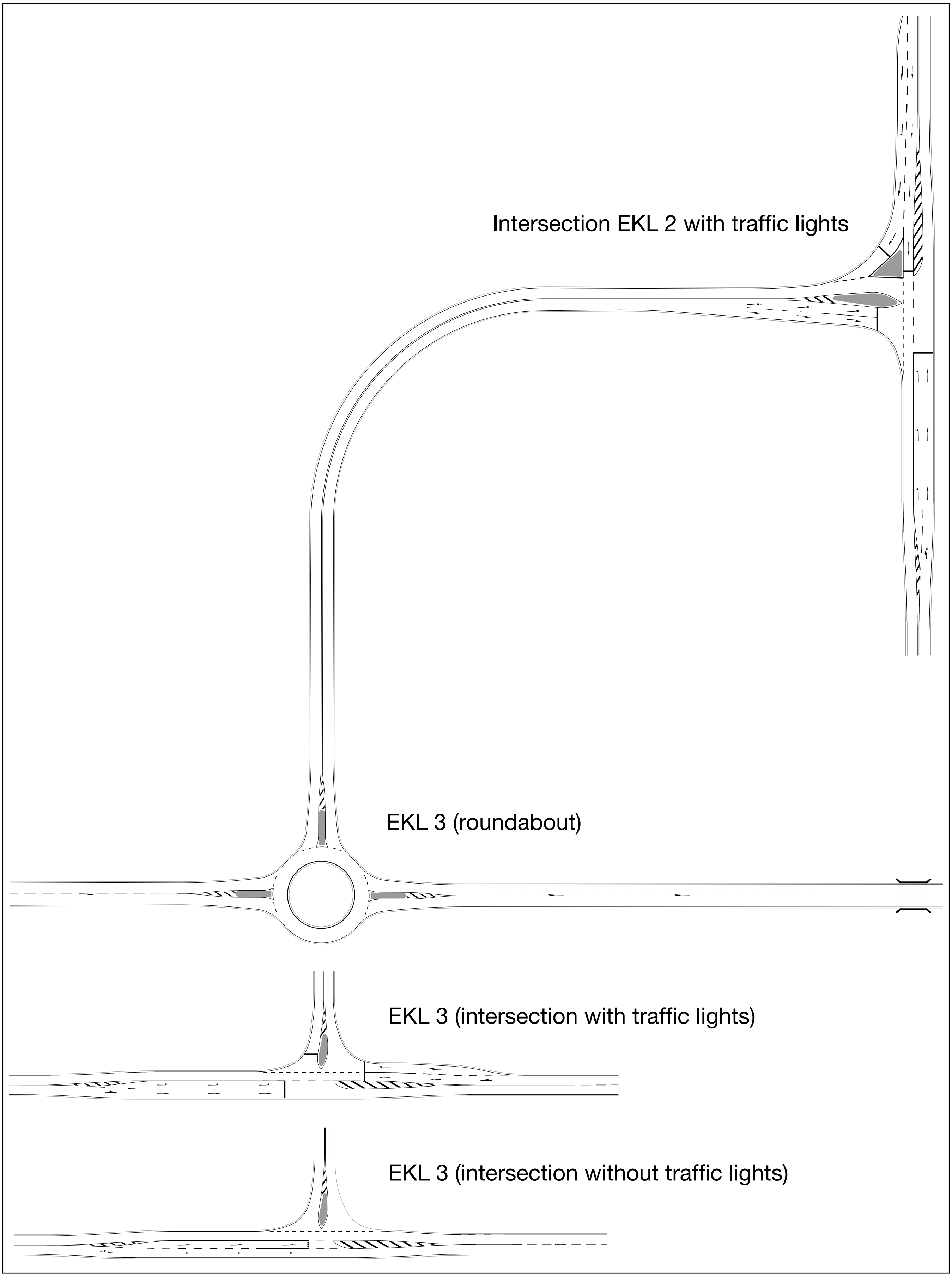


Figure 85: Example for a partially at-grade intersection, higher priority road EKL 2 / lower priority road ramp EKL 3

Appendix 8

Technical regulations

BMUV[1)]	FFH Guidelines	Directive 92/43/EEA of the Council of 21 May 1992 on conserving the natural habitats and wild animals and plants (Fauna-Flora-Habitat directive)
DIN[2)]	DIN 13201-1	Road lighting – Part 1: Selection of lighting class
	DIN EN 13201-2	Road lighting – Part 2: Quality characteristics
	DIN EN 13201-3	Road lighting – Part 3: Calculation of quality characteristics
	DIN EN 13201-4	Road lighting – Part 4: Methods of measuring the quality characteristics of street lighting installations
FGSV[3)]	RBSV	Standard vehicles and tractrix curves for checking of the traversability of traffic areas (FGSV 287)
	EAÖ	Recommendations for Public Transport Installations (FGSV 289)
	EAR	Recommendations for Parking Traffic Installations (FGSV 283)
		Guidelines for designing noise protection facilities on roads (FGSV 227)
	ELA	Recommendations for the landscaping designs in road building with the sample cards for the standard design of landscaping execution plans in road building (sample cards LAP) (FGSV 2932)
	ERA	Recommendations for Cycle Traffic Installations (FGSV 284)
	ERS	Recommendations for Service Areas on Roads (FGSV 222)
	ESLa	Recommendations for the integration of roads in the landscape (FGSV 254)
	HBS	Manual for the measurement of road safety facilities (FGSV 299)
	H BVA	Notes on Barrier-Free Traffic Installations (FGSV 212)
	HLB	Notes on the arrangement and execution of vertical guidance systems (HLB), Section 5: reflector posts. In: Straße und Autobahn 8 (1957) H. 6, pp. 219–222
	HVA F-StB	Handbook for awarding and execution of construction contracts in road and bridge construction (FGSV 941)
	H ViSt	Notes on the Visualisation of the Design of extra-urban Roads (FGSV 262)
		Information sheet for the Design of roundabouts (FGSV 242)
	RAA	Guidelines for the Design of Motorways (FGSV 202 E)
	RABT/EABT	Guidelines on the equipment and operation of road tunnels
	REwS	Guidelines for the Design of Motorways: Drainage
	RASt	Directives for the Design of Urban Roads (FGSV 200)
	RE	Guidelines on the planning process and for the standard design of draft documents in road building (FGSV 2070)
	RiLSA	Guidelines for Traffic Signals - Traffic Lights for Road Traffic (FGSV 321)
	RIN	Guidelines for Integrated Network Design (FGSV 121)
	RiStWag	Guidelines for construction measures on roads in water protection areas (FGSV 514)
	RLBP	Guidelines for the landscaping accompanying planning in road building (RLBP) and the sample cards for the standard design of landscaping accompanying plans in road building (FGSV 2931)
	RLS	Guidelines for noise protection on roads (FGSV 334)
	RLus	Guidelines for the determination of the air quality on roads without or with loose frontage development (FGSV 210)
	RMS	Guidelines for Road Markings - Part 1: Dimensions and geometrical arrangement of marking indications (RMS-1) – part 2: Application of carriageway markings (RMS-2) (FGSV 330/1 and 330/2)
	RPS	Guidelines for passive protection on roads by vehicle retention systems (FGSV 343)
	RSAS	Guidelines for the Road Safety Audits (FGSV 298)
	RUVS	Guidelines for the preparation of environmental compatibility studies in road construction (FGSV 229) (in preparation)
	RWB	Guidelines for the directing signposting outside of motorways (FGSV 329)

Technical regulations – continued

FGSV[3]	ZTV Lsw	Additional technical contractual terms and directives for the execution of soundproofing walls on roads (FGSV 258)
VkBl[4]	RiZ-ING	Installation drawings for engineering structures
	PlafeR	Directives for the plan determination in accordance with the Federal Highway Act (plan determination directives)
	VzKat	Catalogue of traffic signs
Cartography[5]	(Sample cards FFH-VP)	Guidelines for a FFH compatibility test in federal highway construction with the sample cards for the standard illustration of FFH compatibility tests in federal highway construction

Laws and regulations

16. BImSchV Traffic Noise Protection Ordinance
– sixteenth ordinance for carrying out the Federal Emissions Protection Act,
www.bundesgesetzblatt.de, www.bmdv.bund.de

BNatSchG Bundesnaturschutzgesetz – Gesetz über Naturschutz und Landschaftspflege,
(Federal Nature Conservation Act – act on nature conservation and landscaping)
www.bundesgesetzblatt.de, www.bundesrecht.juris.de

FStrAbG Fernstraßenausbaugesetz – Gesetz über den Ausbau der Bundesfernstraßen,
(Highway Expansion Act – act on the expansion of the federal highways)
www.gesetze-im-internet.de

FStrG Federal Highways Act (Bundesfernstraßengesetz),
www.gesetze-im-internet.de

HOAI Ordinance on the Fees for Architects and Engineering Service,
(Verordnung über die Honorare für Architekten- und Ingenieurleistungen)
www.gesetze-im-internet.de

ROG Regional Planning Act (Raumordnungsgesetz),
www.bundesgesetzblatt.de, www.bmdv.bund.de

StVO German Road Traffic Regulations (Straßenverkehrs-Ordnung)
www.bundesgesetzblatt.de, www.bmdv.bund.de

StVZO Road Traffic Licensing Regulations (Gesetz über die Umweltverträglichkeitsprüfung)
www.bundesgesetzblatt.de, www.bundesrecht.juris.de

UVPG Act on the Environmental Compatibility Test, (Gesetz über die Umweltverträglichkeitsprüfung),
www.bundesgesetzblatt.de, www.bmdv.bund.de

VwV-StVO General Administrative Regulations of the Road Traffic Regulations
(Allgemeine Verwaltungsvorschrift zur Straßenverkehrs-Ordnung)
www.bundesanzeiger.de, www.verwaltungsvorschriften-im-internet.de

Reference sources

[1] **Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection**
Address: Stresemannstrasse 128-130, D-10117 Berlin, Germany
Tel.: +49 (30) 18 305-0, Fax: +49 (30) 18 305-2044
Internet: www.bmuv.de

[2] **DIN Media**
Address: Burggrafenstrasse 6, D-10787 Berlin, Germany
Tel.: +49 (30) 58 88 57 00-70
E-Mail: kundenservice@dinmedia.de, Internet: www.dinmedia.de

[3] **FGSV Verlag GmbH**
Address: Wesselinger Strasse 15-17, D-50999 Köln, Germany
Tel.: +49 (22 36) 38 46 30, Fax: +49 (22 36) 38 46 40,
E-mail: info@fgsv-verlag.de, Internet: www.fgsv-verlag.de

[4] **Verkehrsblatt-Verlag**
Address: Schleefstrasse 14, D-44287 Dortmund, Germany
Tel.: +49 (231) 12 80 47, Fax: +49 (231) 12 80 09
E-mail: info@verkehrsblatt.de, Internet: www.verkehrsblatt.de

[5] **Verlags-Kartographie GmbH**
Address: Virchowstrasse 7, D-36304 Alsfeld, Germany

All FGSV regulations listed are also available digitally for the FGSV Reader and are included in the comprehensive “FGSV - Technical Regulations - Digital” subscription.

Remarks on the system of technical publications of the FGSV

R stands for regulations:

These publications either specify the technical design or realization (R1) or give recommendations on the technical design or realization (R2).

W stands for information documents:

These publications represent the current state-of-the-art knowledge and define how a technical issue shall be practicably dealt with or has already been successfully dealt with.

Category R1 indicates 1st category regulations:

R1-publications contain the contractual basis (Additional Technical Conditions of Contract and Directives, Technical Delivery Forms and Technical Testing Regulations) as well as guidelines. They are always coordinated within the FGSV. R1-publications – in particular if agreed on as integral part of the contract – have a high binding force.

Category R2 indicates 2nd category regulations:

R2-publications contain information sheets and recommendations. They are always coordinated within the FGSV. Their application as state-of-the-art technology is recommended by the FGSV.

Category W1 indicates 1st category documents of knowledge:

W1-publications contain notes. They are always coordinated within the FGSV but not with external parties. They represent current state-of-the-art knowledge within the respective responsible boards of the FGSV.

Category W2 indicates 2nd category documents of knowledge:

W2-publications contain working papers. These may include preliminary results, supplementary information and guidance. They are not coordinated within the FGSV and represent the conception of an individual board of the FGSV.

FGSV 201 E

FGSV
DER VERLAG

Published by:
FGSV Verlag GmbH
D-50999 Cologne/Germany
Wesselinger Strasse 15-17
Phone: +49 (0) 22 36 / 38 46 30
E-Mail: info@fgsv-verlag.de · Internet: www.fgsv-verlag.de

2024 December