Guidance for Local Road Design

2022.

Guidance for Local Roads Design

(GLRD)

1. DESIGN ROAD ELEMENTS

[COMPANY NAME] | [Company address]

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1 INTRODUCTION

1.1 General

These Guidance GLRD (Guidance for Local Road Design) are envisioned for designing of local roads. According to their function and in technical term, local roads are public roads, as a rule, with one carriageway, outside and inside the area with organized lateral construction[1], and with intersections at one level. Most commonly, the local roads serve to connect settlements, parts of settlements, and they represent connection of settlements or some urban area with the state road network. They are regarded by a slighter traffic volume with participation of vehicles with a higher axle load. Shorter sections with dual carriageway can appear in the category of local roads and are primarily part of local road network of large agglomerations (Belgrade, Novi Sad, Niš, etc.)

Sections with dual carriageway are classified as highways and they are envisaged and designed in compliance with the methodology and regulations intended for state roads of first category.

In accordance with the Law on Roads (Official Gazette of RS, no. 41/2018 and 95/2018), roads are divided into state and municipal roads:

- State roads IA category – highways
- State roads IB category – arterial roads
- State roads II A category – regional roads
- State roads II B category – regional roads
- Municipal roads

Municipal roads are roads under jurisdiction of the local administration, in terms of planning, construction, exploitation and maintenance. In general, they can be classified into the following groups

- Municipal roads – streets in settlements
- Municipal roads – outside settlement
- Municipal roads – uncategorized roads, agricultural roads.

Following the statistical data for 2020, the traffic road network in the Republic of Serbia consists of the following lengths according to road categories (Table 1).

Table 1 Road network in the Republic of Serbia in accordance with the statistical data

	Road network 2020. (km)								
Region	Total	Contemporary carriageway	Highway	State road I category		State Roads II category		Municipal roads	
				Total	Contemporary carriageway	Total	Contemporary carriageway	Total	Contemporary carriageway
Republic of Serbia	**44,908.81**	**30,519.88**	**929.00**	**3,864.52**	**3,864.52**	**9,662.36**	**9,422.50**	**30,452.93**	**16,303.86**
Belgrade region	**5,892.29**	**3,219.24**	**142.00**	**190.62**	**190.62**	**454.01**	**453.46**	**5,105.66**	**2,433.16**
Vojvodina region	**6,195.23**	**5,670.87**	**258.50**	**1,023.90**	**1,023.90**	**1,961.93**	**1,961.93**	**2,950.90**	**2,426.54**
Sumadija and Western Serbia region	**19,199.97**	**12,411.11**	**160.50**	**1,609.39**	**1,609.39**	**3,824.59**	**3,652.02**	**13,605.49**	**6,989.20**
South and East region	**13,621.33**	**9,218.67**	**368.00**	**1,040.62**	**1,040.62**	**3,421.83**	**3,355.09**	**8,790.88**	**4,454.96**
Kosovo and Metohija Region	...	...		...	...	...	...	...	...

1) Highways are not included in the total length of roads of first category Source: Municipalities and regions in the Republic of Serbia 2021, Republic Institute of Statistics, ISSN 2217-7981

Although the local roads are not mentioned under the current Law on Roads, a definition of local roads can be derived from the municipal roads definition as subcategories of municipal roads, i.e. Local roads are all municipal roads apart from streets in the settlement.

In practice, municipal roads are designed in the same manner as state roads, due to the fact that specific technical regulations and regulations are not defined for this. Until now, this has led to doubts as to what designing measures are appropriate and economically acceptable for

[1] A local road within an area with lateral construction, when there are no street elements

this special group of roads, particularly when it comes to different approaches from one local administration to another. It is certain and generally established that these roads have not been treated in an adequate manner, including that the general condition of the local road network under the jurisdiction of the municipalities is unsatisfactory. If we take a look at Table 1, it could be perceived that the length of the municipal road network is 67.8% of the total road network of the Republic of Serbia and that only 53.5% is with contemporary road surface.

According to the World Bank Study (*Improving the Management of Secondary and Tertiary Roads in the South East European Countries Feb 2008*), this road network is designated as a tertiary road network, while for the Republic of Serbia the following facts were recognized:

- Constraints in planning
- Inadequate staff potential of Road managers
- Insufficient funds for maintenance
- Delays in maintenance interventions
- Inadequate designing standards (most commonly standards with excessively high requirements with regard to the level of the road and the traffic load are applied. Designing and construction should correspond to the road class to avoid irrational consumption of resources).

The Study indicates that this road network condition in Serbia is considered as mainly unsatisfactory and at lowest rank with regard to the region. On 74% of the local road network the condition is considered as poor, on 18% acceptable and good on only 8% of the local roads length. A low level of capital investment through capital and current costs is also observed, and based on the same study, financial needs are covered by only 16% of funds that are specifically provided for financing.

The conclusions and recommendations of this Study can be briefly pointed to the following suggestions and measures for implementation:

- Raising the technical and management capacities of local administration,
- Decentralization of local administration aimed at attaining a balance between the political, institutional and fiscal responsibility,
- Adopting a strategy and policy for development of the local road network,
- Establishing an updated roads database, road inventory and contents that gravitate towards that road, as well as mechanisms for maintenance and updating over the next period of time,
- Establishing a functional classification for all levels of the local road network.
- Adopting an appropriate legislation that governs the field of local road network (law, regulation, rules, etc.), and defining the competence for its implementation
- Establishment of local road management bodies in accordance to one of the well-known models:
    - Through the central Agency by transferring the competences of the local administration to the relevant state bodies
    - Through the Project Implementation Agency, by assigning the competences of the local administration to specialized agencies
    - Through the joint service committee of several local administrations
    - Involving the private sector through consulting services in terms of planning and management
- Revision of national designing standards through preparation of specific guidelines for local roads.

In the specific case of preparing guidelines for local roads design, the problems above-mentioned comes down to the analysis of practice in the EU countries based on similar documents, comparison with local regulations and adoption of representative models from the field of designing regulations.

A key initial step is preparation of proposal for functional division, through categorization of the local road network in Serbia and allocation of appropriate regulations for designing according each category.

Given the above said, the following relevant local roads designing guidelines, as well as state roads designing guideline are being selected for the purposes of comparative analysis and preparation of this guidelines GLRD:

- Richtlinien für die Anlage von Landstraßen - Forschungsgesellschaft für Straßen- und Verkehrswesen (RAL) FGSV (Guidelines for the construction of rural roads)
- Rural Road Link Design – Transport Infrastructure Ireland
- Pravilnik o projektiranju cest – Slovenia
- SRDM – Smernice za projektovanje državnih puteva u Republici Srbiji - PERS

1.2 Aim

As a basis for designing, the GLRD aims to produce safe and functional local roads designs with appliance of technical solutions suitable for the road category. The key objective is to standardize the local road network to the greatest extend. In that context, four designing classes are defined according to the local road function within its category.

1.2.1 To whom are the SPLP guidelines intended?

These guidelines are primarily intended for Designers, but also for other participants in the process of planning, designing, construction, maintenance and local roads managing, and this primarily refers to:

- Local authorities responsible for planning and managing the local road network:
    a. When preparing programs and plans for the development and improvement of the local road network.
    b. For the purpose of preparation of Terms of References (TOR).
    c. Technical control and Supervision of the realization of the process of design, construction and maintenance of the local road network.
- Design organizations engaged in the preparation of local road designs, i.e. the preparation of different levels of design documentation during:
    a. Preparation of designs of brand new local roads
    b. Reconstruction of existing local roads
    c. Rehabilitation of existing local roads
    d. Maintenance of local roads, preparation of reports in terms of improvement of operating conditions, and traffic safety improvement.
- Consultants, engaged in the services of technical control of designs, and construction supervision, and in other services issued by the local road authorities.
- Operators responsible for the maintenance of local roads.

1.2.2 Content and abstract of the SPLP guidelines

The guidelines are divided into six books in accordance with specific areas of local road design, namely:

Book 1. Road Design Elements
Book 2. Pavement Structure
Book 3. Drainage
Book 4. Design of Bridges and Engineering Structures
Book 5. Environmental and Social Requirements
Book 6. Geotechnical Investigations and Testing

Each of the mentioned books contains customized guidelines for the respective area of local road design.

Book 1. Road Design Elements

In the Book 1, the design elements of the road are covered in chapters 3 - 7.

Chapter 3 Four design classes have been established in accordance with the road function, category and traffic load.

Chapter 4 Overview of the basic traffic profile elements in accordance with dimensions of the relevant vehicles, as a ground for the necessary dimensions of local road cross-section, sorted in accordance with the corresponding design class. Checking the required service level and ensuring the conditions for overtaking.

Chapter 5 Local road alignment. Determining the limit values of the local road plan and profile. Determining the relevant speed. Visibility determination. Principles that apply when leveling and widening roadways.

Chapter 6 Traffic junctions – Intersections. Planning and selection of the structural form of intersections in accordance with the traffic function of the roads that form the intersection. Determination of the type of intersection in accordance with design class K (rules and recommendations). Elements of intersections, ramps, traffic lanes, islands, determination of their lengths and widths, and boundary elements of the plan and profile in accordance with their function, as well as the sort and type of turns.

Roundabouts, application in accordance with the traffic function. The method of shaping and determining the elements of the roundabout in accordance with the traffic function.

Visibility within intersections, determination of the field of vision and checking of traffic flow through intersections, and selection of geometric elements in accordance with the relevant vehicle. Managing the bicycle traffic through intersections.

Chapter 7 Road equipment. Horizontal marking and vertical signalization and road equipment in the function of safe traffic flow. Determining the technical parameters for traffic signs in a function of the design class. Other road equipment, vehicle retention systems, lighting, noise protection. Functional elements of the road (parking lots, rest areas and gas stations).

Book 2. Pavement Structures

Within the book 2, the design of pavement structures on local roads is covered.

Chapter 2 Traffic load. Relevant traffic load calculation according to the current regulations of Serbia and the EU and the specifics that characterize local roads

Chapter 3 Climatic and hydrological impacts. The impact of climatic conditions on the deterioration of the pavement and the overall pavement structure (PS), especially due to extreme temperature oscillations, as well as measures to increase the resistance of PS. The impact of hydrological conditions on PS and measures to prevent negative impact.

Chapter 4 Substrate of the pavement structure. The required bearing capacity of the substrate and the required quality of the materials. Testing and measurement methods and procedures and their application. Measures to improve material characteristics and bearing capacity.

Chapter 5 Materials for pavement structures construction. Binders, aggregates, reclaimed materials and application of appropriate materials.

Chapter 6 Types of pavement structures. Division of road constructions according to the type of construction, according to the characteristics of binders, production technology, etc. Practical recommendations for choosing the appropriate construction.

Chapter 7 Dimensioning of pavement structures. Phases of road construction design, determination of structure and dimensioning procedures with a recommendation for the development and application of the catalog design method as a special benefit for application on local roads.

Chapter 8 Evaluation of the functional and structural condition of pavement structures. Methodology of the procedure for carrying out the assessment of the situation and determining the PCI index. Management of pavement structures.

Chapter 9 Durability of pavement structure. The life cycle of pavement construction and pavement rehabilitation procedures.

Book 3. Drainage

Book 3 refers to the design of drainage of local roads using a system for collecting and draining surface and seepage water.

Chapter 2 Legislation and technical documentation. Review of valid legal and technical regulations and procedures for obtaining conditions and consents from competent institutions for appropriate levels of projects. Overview of applicable standards and regulations.

Chapter 3 Planning. Drainage system planning, drainage system selection and appropriate drainage measures.

Chapter 4 Concept of road drainage. Open and closed drainage system.

Chapter 5 Presentation of road drainage in projects. Contents of the drainage design

Chapter 6 Designing. Design process through stages:

- Hydrology, Hydrological analyzes based on relevant parameters:
    - Precipitation quantity, calculation of relevant precipitation for the area of the local road
    - Rainwater runoff, calculation of the amount of runoff from the road and the surrounding road surface into the drainage system
    - Infiltration rates, infiltration of water into the surrounding terrain
    - Retention capacity, provision of retention capacity
- Dimensioning of the drainage system
    - Criteria for designing, determining the return period and reference values for dimensioning the drainage system
    - Surface drainage, Pavement surface runoff, open channels, curbs and gutters.
    - Systems of closed collectors. Culverts
    - Retention. Types of retention basins,
    - Sedimentation. Precipitators, principles and types.

Chapter 7 Structures

- Surface structures. Pavement and road surface, canals, ditches
- Underground facilities. Collectors, inspection shafts.
- Subsurface drainage, pavement structure drainage, other drainage
- Culverts, types
- Structure drainage (bridges, retaining walls, tunnels)
- Water retention facilities
- Water treatment,
    - Retention basins
    - Infiltration basins and drainage trenches
    - Sedimentation facilities. Sedimentation tanks, oil separators

Chapter 8 Greening of the drainage system
Chapter 9 Drainage of roads during construction
Chapter 10 Precautionary measures
Chapter 11 Maintenance, review procedures and interventions during maintenance.

Chapter 12 References
Chapter 13 Appendix, drawings and details

Book 4. Design of Bridges and Engineering Structures

Book 4 refers to the design of bridges and other engineering structures as a part of the road alignment structure or as a part of supporting structures in the function of the road.
Chapter 2 Maps, plans and relevant data as a ground for bridge design

- Spatial urban ground, according to the size and importance of the structure
- Traffic data, traffic load, type and intensity of traffic,
- Geodetic plans
- Road data, plan, profile and cross section elements
- Geological geomechanical data, type and scope of research and collection of necessary data
- Hydrological - hydrotechnical data
- Meteorological - climatic data
- Seismological data
- Terms of references

Chapter 3 Road Alignment elements on bridges

- Choice of Angle of the bridge crossing over obstacle
- Choice of vertical alignment
- Choice of direction

Chapter 4 Bridge Traffic Profile

- Cross section, bridge width, cross section profile elements, pavement, sidewalks, fences.

Chapter 5 Bridge design concept on local roads network

- Load-bearing structures of bridges
    - Beam structures
    - Frame structures
- Types of cross section structure on local roads
    - Slab section
    - Ribbed section
    - Ribbed beam
    - Precast prestressed beams

Chapter 6 Design development data

- Traffic load
- Loads on bridge from atmospheric influences
- Seismic loads
- Waterproffing
- Bridge drainge
- Pavement structure on bridge
- Expansion joints
- Edge beams
- Bearings
- Vehicle restraint systems
- Pedestrian, cycle fences
- Water sprinkle protection
- Noise barriers

- Lighting

Chapter 7 Anex – Integral bridges. Recommendations for the application and specifics of integral structure bridges design.

Chapter 8 Engineering structures

- Retaining structures
- Backfilled retaining structures
- Mass gravity retaining wall
- Gabion retaining structures
- Precast retaining structures
- Reinforced earth „terre armée“ retaining structures
- Built-in retaining structures

Chapter 9 Design of retaining structure in accordance with EC7

Book 5. Environmental and Social Requirements

Book 5 contains guidelines for identifying, assessing, and managing the risks of a local road's potentially negative environmental and social impact.

Chapter 1 Meaning of expressions

Chapter 2 Terminology

Chapter 3 Purpose and scope of the document

Chapter 4 Classes of local road design and environmental protection requirements

Chapter 5 Institutional responsibilities

Chapter 6 Assessment and management of environmental and social risks and impacts

Chapter 7 Efficient use of resources and prevention of pollution

Chapter 8 Climate resilience

Chapter 9 Community health and safety

Chapter 10 Land acquisition, land use restrictions, and forced relocation

Chapter 11 Biodiversity conservation and sustainable management of living natural resources

Chapter 12 Cultural heritage

Chapter 13 Stakeholder engagement and information disclosure

Chapter 14 ES procedure during the preparation of local road projects

Chapter 15 Institutional implementation and reporting arrangements

- Grievance management
- Access to information and public discussions

Annexes: Types of forms of questionnaires, reports, objections, etc. for environmental and social impact assessment and verification procedures, for the purposes of design, and execution of works, as well as for appeal procedures.

List of legal regulations and relevant institutions for environmental protection

Book 6. Geotechnical investigations and testing

Book 6 contains guidelines for conducting geotechnical investigations and tests required for the design preparation for local roads.

Chapter 2 Stages of Geotechnical Investigations. Determining the phases of investigation works depends on the purpose for which they are carried out, and the type of structure for which the design has to be prepared or construction works are going to be carried out.

Chapter 3 Execution of geotechnical investigations

- Preparation of geotechnical investigations
- Collection of existing data
- Field investigation works

Chapter 4 Laboratory tests

Chapter 5 Geotechnical Investigation Procedures

Chapter 6 Contents of Geotechnical Reports

Chapter 7 Type of investigations

Chapter 8 Annex

- Report content
- Scope of field investigations in accordance with SRPS EN1997-2
- Standards

1.3 Framework

The local roads categories are not defined within the general regulations and legal acts of the Republic of Serbia, as is the case with the state roads (Regulation on criteria for categorization of public roads Official Gazette 38/19). This document proposes classification of the local roads as part of municipal roads, hereinafter, local roads, within the following categories:

Table 2 Roads categorization in compliance with the Rulebook

Category / Type		Remote connection		Connection	Flow collecting	Serving
		Remote road Highway	Remote road	Connecting inter regional roads, roads through settlements	Collecting roads, regional roads, roads through the settlement with lateral construction	Access road towards settlements and property
Functional connection		**DP-AP**	**DP**	**VP**	**SP**	**PP**
International	**0**	**IA - 0**			**-**	**-**
Arterial	**I**	**IA - I**	**DP IB**	**VP IB**		**-**
Regional	**II**	**-**	**-**	**VP IIA**	**SP IIA**	**-**
	III	**-**	**-**	**VP IIB**	**SP IIB**	**-**
Local I - between local traffic centers or state roads	**IV**	**-**	**-**	**-**	**SP IV** (SP-r) *	
Local II - between urban contents and Local I or state roads	**V**	**-**	**-**	**-**	**SP V** (SP-p)*	**PP V** (PP-p)*
Local III – between local and Local I or Local II	**VI**	**-**	**-**	**-**	**-**	**PP VI** (PP-l)*

DP IB	Correct assignment of category
	Problematic assignment of category
-	Unjustified or not applicable

* Type of road based on the Rulebook on the conditions that road structures and other elements of the public road must fulfill, from traffic safety point of view.

There are six groups of connection functions:

- 0 – international - are part of the international European roads (E roads), connected by traffic with the roads of neighboring countries.
- I – arterial – connections between macro regional, i.e. macro regional and regional traffic centers
- II – regional A – connections between macro regional and regional, i.e., between regional traffic centers
- III - regional B – connections between regional traffic centers
- IV – Local I, connections between local traffic centers
- V – Local II, connections between urban and state roads / local and roads
- VI – Local III, connections between properties and local I / local II roads.

Categories are divided in o five sub-categories:

- AP – Highway – State road of IA category, as a rule, remote road outside agglomerations,
- DP – State road of IB category, remote road outside and infrequently inside agglomerations / centers,
- VP – State roads IB, IIA and IIB category, connection road outside and inside regional centers
- SP – State roads IIA and IIB category and local I roads, collector road outside and inside traffic centers
- PP – Local II and local III roads, access roads to minor urban contents.

2 Aims

2.1 General

Local roads should meet the spatial and planning function while ensuring a high level of traffic safety, traffic flow, as well as an adequate management of level of service. It should be necessary to ensure environmental protection and adequate embedding into the environment, with minimal occupation of valuable areas. By their nature these roads lead towards sensitive environment areas, hence they need to be routed at a sufficient distance, while the function of connecting the settlement suffers minimally. The said roads should be planned in such a manner to adapt well to the site conditions and at the same time to achieve maximum economic effect during construction and maintenance, as well as min. operational costs.

Based on the present impacts caused by climate change and future predictions, it is recommended that the local road authority support development of the greater resistance of local roads to climate change when planning and designing roads. This goal can be achieved by preparation and the adoption of the action plan by the local government, especially for the areas that are at increased risk of impact including local infrastructure.

The above requirements are balanced during the planning process. The basis to attain these goals is preparation of multiple variants that are evaluated during different planning phases, while the key objectives are:

- Traffic safety
- Level of service
- Sustainable environmental protection
- Climate resilience

While optimal variant is being selected, construction costs should also be taken into regard. The best solution is the one that, while satisfying the above objectives, the greatest social benefit at the lowest cost are provided.

Therefore, an economic (cost benefit) analysis shall be done, i.e. Feasibility Study shall be prepared. The local road should be designed in such a way to achieve the greatest possible utility index.

The objectives that must be accomplished by the local road design are elaborated further below. In exceptional cases, deviation from the regulations specified in chapters 3 to 7 are possible, however, a valid clarification shall be provided.

2.2 Traffic safety

Local roads shall be designed in a way to ensure a high level of traffic safety; within the function they are intended to.

While designing, particular attention shall be paid to the traffic participants behavior, given that this has high impact factor to the traffic safety.

While designing local roads, particular focus should be devoted to the cross-section, plan and profile elements, intersections and road equipment, so the driver's speed is in line with the speed envisaged for that road. Local roads with same functions within the network should be standardized, i.e. designed elements should be similar, and therefore recognizable with respect to roads that have different function within the network of local or other roads. As driving errors cannot be ruled out, the free zone along the road shall be designed so that the consequences of traffic accidents, in the event of vehicles running-off the road, are minimized.

Roads that have a higher level of connection function, as a rule, are extended over several sections. Primarily, for the reasons of sustainable traffic safety, given that the principle of continuity is applied in the course of designing. Therefore, the adjacent sections of the local road in a row shall be designed in the most uniformed manner possible. Particular attention should be paid to the participation of recreational drivers and their behavior on the road.

The objectives and applicable measures are summarized in Table 3.

Table 3 Traffic safety

Aim	Possible and preferably applicable measures
Basic speed	• Achieved through appliance and observation of clear characteristics for the appropriate function of the local road • Such design elements should be applied that effect the driver to drive at a speed appropriate to the function of the local road within the network.
Safe traffic flow	• Sufficient stopping visibility provided. • Uniform driving through a favorable radius size ratio (adjacent) curves. • An inevitable change in the characteristics of the road route announced. • Dangerous curve in vicinity is clearly announced • Adequate transverse slope of the road and in the curve ensured. • Quick water evacuation of from the road ensured. • Zones with poor drainage shall be avoided.
Safe passing and overtaking	• Overtaking zones shall be designed for safe overtaking, while critical overtaking locations with poor overtaking visibility should be avoided. • Slow from fast traffic should be separated on longer sections with high vehicle speed
Safe traffic flow through traffic nots	• Clearly announce the basic structural form and operational shape of the approaching node • Intersections should be designed to be clear, recognizable, understandable, passable / accessible. • Ensure sufficient visual contact with other road users within the intersection/node (internal and external visibility at the intersection). • Traffic participants shall be sorted.
Safe participation of vulnerable road users	• Special traffic areas for motor and agricultural vehicles and non-motorized traffic participants shall be envisaged, in case of high traffic volume or high speeds. • Separate pedestrian and bicycle traffic from traffic areas for motor vehicles, with clear guidance of bicycle paths in intersection zones. • Enable unhindered visual contact between drivers and cyclists in intersection zones • Use structural or technical safety measures at pedestrian and bicycle crossings.
Free zones along the road	• Point up the alignment with appropriate lateral planting • Provide a free zone without obstacles or establish measures to protect side obstacles in case of collision. • Provide an area of sufficient width for planting appropriate vegetation.

Also, with the updated Roads Law from 2018 and with sets of By-Law acts and Technical Guidelines referring to road safety tools, Serbia fully meets the European Directive 96/2008 (upgraded version Directive (EU) 2019/1936).

As per Roads Law (Official Gazette of Republic of Serbia no. 41/2018 and 95/2018), RSA (Road Safety Audit) needs to be performed for all road projects for new – construction or reconstruction of state roads and in all phases of projects implementation:

1. Preliminary design stage;
2. Detailed design (Design for construction permit) stage;
3. Design for construction stage;
4. Pre-opening stage (As-built drawings);
5. Early operation stage;

RSI (Road Safety Inspection) refers to roads and streets in operation and it is executed with the aim of checking the elements of the existing road from the aspect of road safety, the possible impact of road works on road safety, as well as the prevention of road collisions and their consequences.

RSI can be:

1. periodic
2. targeted RSI.

Periodic RSI is executed on first class roads in a period of five years. Targeted RSI ис executed on parts of public roads and streets where road collisions or higher risk of injury has been recorded.

Law and By-law act - Rulebook for RSA&RSI (Official Gazette of Republic of Serbia no. 52/2019), defines that the road safety auditor (inspector) needs to be an independent party involved in project implementation (separate from the Designer, Technical Control, Contractor).

For the local roads, RSA and RSI are NOT an obligatory step as per Roads Law (Official Gazette of Republic of Serbia, no. 41/2018 and 95/2018). Even though RSA and RSI is not required by local legislation it would be beneficial to conduct the RSA. Also, the recommendation is to executed targeted RSI before writing the Terms of Reference (ToR), in order to form requirements for design from the aspect of road safety.

Roads Law provides for another road safety tool - risk mapping (determining the areas of greatest risk). Risk mapping is executed on the basis of:

1) data on road collisions and consequences of road collisions by sections of roads or

2) analysis of road safety characteristics assessment by road sections.

It is recommendeed mapping sections of local roads from the aspect of increased risk of road collisions, and to execute RSI in order to define measures to eliminate the risk.

2.3 Level of service in traffic flow

The function of local roads is determined in accordance with the regional and spatial plans of the Local Government units and the layout of local centers. Planning documents are prepared in accordance with the Rulebook on the Content, Method and Procedure for Preparation of Spatial and Urban Planning Documents (Official Gazette of RS, No. 32/2019).

Based on the defined function of the local road in the network, the target values are determined in accordance with the function of the local road and access to the centers. This is the basis for determining the basic speed of movement in the traffic flow, as a basic parameter in function of the level of service.

In accordance with the defined function and basic speed, each section is assigned a corresponding category. The category is established by the importance of the connectivity function and the traffic service requirement with regard to the environment around that section within the network. The increase in demand and the significance of connectivity, the tendency for a higher base speed comes as well.

Different functions within the network are resulting in different requirements for establishing the quality and level of service.

Aims and applicable measures are summarized in Table 4.

Table 4 Level of service in traffic flow

Aim	Possible and preferably applicable measures
Adequate level of service of motorized vehicles **Good connectivity and a high level of service for bicycle and, if necessary, pedestrian traffic** **High level of public transport service** **Harmonized level of service and development of traffic in the neighboring local unit - traffic center**	• **Dimensioning of appropriate cross elements** • **Selection of appropriate crosses according to design class** • **Provide separate traffic lanes for slow vehicles within the network, at high-speed sections.** • **Provide safe overtaking zones at regular intervals** • **Limit the number of traffic nodes (intersections)** • **Avoid intersections with mandatory waiting to pass and turn at roads with a significant connecting function, even in peak periods** • **Minimize waiting hours** • **At intersections with a particularly high traffic volume, provide crossings that are off-level or partially off-level** • **Depending on the traffic intensity, traffic flow control at intersections should be regulated by traffic lights, with synchronized operation of signals at nearby nodes.** • **Separate bicycle from motor traffic.** • **Enable direct management of bicycle and pedestrian traffic** • **Align intersections with the principles of demand for traffic movements.** • **Exclude the connection of agricultural roads to roads with a significant connection function.** • **Enable a sufficient number of accesses to agricultural land from roads that have a low level of connection function** • **Ensure sufficient maneuvering space when driving**

The basic speed (V_0) is an important input program parameter, as important indicator of the road direction service level under relevant traffic load. The required basic speed is governed by the function and road category, as well as by the terrain characteristics.

On two-lane roads, the required basic speed (V_0) can be achieved provided that sufficient overtaking visibility is ensured.

The level of service is an indicator of the overall traffic quality on the road under relevant traffic load. The service level is inspected for different road sections and different traffic flow conditions:

- On open alignment (route Management on the observed section)
- On gradients (the size and length of slope are considered)
- On connections (on disconnection, connection, realignment lane)
- On intersections

The procedure to determine the level of service on a road with one carriageway and two traffic lanes is based on:

- Calculation of vehicle speed in free traffic flow V_s in function: V_0 (speed in idyllic conditions or basic speed), $F_Š$ (traffic lane width factor), F_{BS} (distance factor of lateral immovable obstacles) F_{PS} (frequency factor of access points of connections and intersection).
- Calculation of equivalent capacity PA-tveh/h function: Qm (relevant traffic load), F_{KV} (heavy commercial vehicle factor) and F_{NU} (longitudinal slope factor).
- Level of Service calculated for two alternative procedures:
    - o With an average travel speed Vp which is equal to the speed Vs reduced by the effect of the equivalent capacity qp and the effect of the percentage (%) share of the road length where overtaking is not possible, or
    - o With the percentage share of the increase in travel time due to driving in a queue with regard to the time spent in free traffic flow, with the possibility of overtaking on the entire road length. The procedure is intended for roads where the speed is of secondary importance (II class roads according to HCM)

With respect to two - traffic lanes roads (class II), the lower level of service obtained according to the above procedures is selected.

Calculation of the level of service shall not be carried out in the following cases:

- On local roads with one carriageway and two traffic lanes and traffic flow PGDS < 3500 veh/day
- In case of functional type PP of the local road

On two-lane roads, the required basic speed (V0) may be achieved if sufficient overtaking visibility is provided.

Program conditions are shown in Table 5.

Table 5 General program conditions for movement of vehicles

	ACCESS ROAD		COLLECTION ROAD	
	PP-l	PP-p	SP-p	SP-r
Traffic flow conditions	With no significance		Discontinuous flow	
Relevant level of service	Not applicable		E (D)	
Basic speed V_0	Plain 60 Hilly 40 Mountainous 30		Plain 80 Hilly 60 Mountainous 40	
Overtaking (%) length	Plain 40% Hilly 20% Mountainous 10%		Plain 60% Hilly 40% Mountainous 20%	
Minimum intersection distance	400m (200m)		1000m (500m)	
Stopping	Allowed on carriageway			Regulated
Parking	Regulated on carriageway		Regulated on and outside carriageway	Outside carriageway

2.4 Environmental sustainability

Sustainability is the ability to meet our needs without compromising the ability of future generations to meet their own. This concept integrates economic, social and environmental aspects.

Sustainable road designs should meet the functional requirements of the life cycle of the road, but also social development and economic growth while reducing negative impacts on the environment and the consumption of natural resources. The characteristics of a sustainable local road designs are recognized and considered throughout its life cycle, from the planning stage through design to construction, exploitation and maintenance.

The roads sustainability should recognize that roads are a part of the transport infrastructure, while transport is an aspect of satisfying human needs.

While observing the current practice, it may be concluded that it is a great challenge to achieve sustainability in road construction since this activity, according to its nature, generates a lot of energy and consumes a lot of fossil resources.

The road sector produces the highest level of greenhouse gases, directly, through fossil energy used in mining, transport, paving, and indirectly through emissions from vehicles. Road construction requires a lot of energy at different levels: for production of asphalt and cement intended for pavements and excavation materials, for road maintenance, and for the vehicles that slow down the traffic flow due to wrong road planning and design. Finally, the constant increase in the number of road vehicles - and therefore traffic - leads to a significant increase in pollution and noise disturbance.

In addition, the road construction sector faces vast challenges such as cheaper and better production, construction and maintenance, but also bearing in mind that raw materials are getting less and less, while laws on environmental protection are getting stricter in terms of air pollution and noise disturbance. As all other sectors, the road construction sector have to face the challenge of sustainability.

In order to protect natural resources, reduce energy consumption, reduce emissions of harmful gases, and noise reduction, it is recommended to apply contemporary road construction technologies and methods that involve greater use of recycled materials. The goal is to use a minimum of 10% recycled material during the construction, reconstruction, and rehabilitation of roads, so the local road authority is encouraged to implement programs and action plans for the achievement of such targets. One of the most commonly applied measures is the recycling of the lower bearing layers of the pavement structure in situ with the use of hydraulic binders and additives.

In addition to recycled materials, there are other sustainable practices such as the use of new materials, for the construction of long-life cycle pavements, the application of specific measures in the management of stormwater with the implementation of surface water treatment to eliminate contents coming from dangerous pollution, the use of rubber in asphalt mixtures for the construction of silent pavements. A detailed overview of these technologies is given in Book 2, Pavement Structure.

The aims and applicable measures are summarized in Table 6

Table 6 Environmental sustainability

Aim	Possible and preferably applicable measures
Avoid locations under any form of protection, and if this is not possible, use them as min.as possible **Protection of cultural assets and archaeological sites** **Protection of soil and soil prevention against erosion** **Ensure migratory movements of animal species on the site** **Protection of ecosystems and habitats** **Ensure smooth surface waters flow, especially torrential streams** **Adequate protection against dust and noise with materials that fit into the natural environment** **Water protection against pollution** **Retain existing hydrology in the vicinity of the road** **Forest protection from uncontrolled weekend settlements** **Landscape protection, especially in**	• **Preparation of hydrological, geological and geomechanical studies,** • **Potentially problematic areas shall be avoided to the furthest extent,** • **Define precise measures for protection of cultural assets and archaeological sites with lists and maps,** • **Apply shallow cuts and low embankments, wherever possible with slope protection along with planting native vegetation,** • **Check measures for the crossing of animals, especially amphibians,** • **Adequate drainage of the local road surface,** • **On roads in mountainous and steep terrains, respect the slopes gradients,** • **Construction of lateral drainages to receive heavy rains,** • **Prevent silting of watercourses,** • **For roads in embankments through wetlands, special attention shall be paid to construction of culverts,** • **Construction of drainage channels along the road line to remove underground water from marshes and wet lands** • **Adequate forest management in the vicinity of the road,** • **Construction of drainage channels above the cut of a large slope to receive surface water and protect slopes,** • **Analyze alternative solutions "without action" and assess the long-term road impact for 20-30 years,** • **Preparation quarries management plans, borrow**

protected and tourist locations **Positive impact on the local population and preservation of the structure of the existing settlement** **Protection of the existing greenery around the road** **Safety of the local population** **Protection of the microclimate**	**pits, extraction of gravel material from rivers/streams in cooperation with the local community,** • **Special attention should be devoted to single-lane roads and safety improvement for drivers, pedestrians and cyclists.** • **Planting vegetation as part of landscaping, however, it also has an effect to improve soil stability, microclimate and the environment**

2.5 Construction and maintenance costs

In accordance with the Law on Budget of the Republic of Serbia, the participants in investment construction (road infrastructure), budget and public funds users are obligated to manage investments with due care in order to achieve the principles of economy and efficiency.

With respect to costs, investment costs shall be taken into account, including the costs of required reconstructive and rehabilitation measures, plus the current costs of road and operational maintenance. The total cost calculated in this manner, should be as low as possible.

Aims and possible and preferably applicable measures are summarized in Table 7.

Table 7 Construction costs

Aim	Possible and preferably applicable measures
Low level of investment	• **The road alignment shall be adjusted to the field conditions.** • **Zones with high protection requirements and high compensation costs shall be avoided.** • **long routes for connections, dislocation measures and adaptations shall be also avoided.** • **Apply as short engineering constructions as possible.** • **Use local materials.** • **The required necessary noise protection measures shall be directed towards the source of noise.**
Low maintenance costs and low operational costs.	• **Open drainage systems shall be used for drainage.** • **Designs shall be adjusted to the road users.** • **The processes of periodic inspection, maintenance work, replacement of worn or damaged parts of road equipment, etc. shall be simplified.** • **The road and road facilities shall be adjusted to be easily accessible for works. The streets, utility facilities and side road locations shall be easily accessible for work.** • **Ensure that works can be carried out with as few obstacles and traffic disruptions as possible.** • **Ensure clearance on all parts of the road for inspection and service vehicle in order to prevent damage to the road and equipment.**

2.6 Climate Resileance

Local roads are roads that, according to their function, are significantly adapted to geographical, terrain, and urban conditions, and thus pass through areas that are exposed to increased risk. Within these zones, roads are particularly exposed to risks caused by climate change, primarily in regard to the following risks:

- Flood risks due to external and internal high waters, especially in the areas of river courses

- Risks of erosion and landslide occurrence, particularly in torrential flow zones
- Wildfire risks in forest zones during longer periods of drought and elevated air temperatures
- Risks of snow drifts and avalanches in areas of sparse vegetation at high altitudes.
- Risks of the negative impact, caused by exposure to extreme temperatures for the long period, on the pavement with the effect of permanent deformations and damage.

Climate changes over a long period of time affect the increase of the above-mentioned risks, and thus are reflected in:

- Socio-economic conditions of the local population
- Unforeseen costs of local government in extreme climate situations
- Difficulties in planning the construction and maintenance of local road infrastructure.

2.6.1 Methodology

For the reasons stated chapter 2.6, it is necessary to develop a Methodology of climate resilience to the negative impact of climate change, which is based on the recognition of:

- Hazards due to extreme natural events, which can affect the loss of life, injuries, loss of property, damage to infrastructure, supplies of goods to the population, damage to the ecosystem and natural resources, etc.
- Road infrastructure exposures in areas with high hazard
- Vulnerabilities in terms of the predisposition of certain parts of the road to be extremely affected and damaged
- Risks of negative socio-economic impact as a result of extreme damage caused to the road infrastructure

All the above-mentioned facts are of great importance when planning the local road network, in order to provide alternative routes in areas with higher traffic flow.

It is recommended that a database with cadastral data, road infrastructure inventory, climate data, and data on climate change be established within the local road authority administration, which would be periodically updated. Such a database would play a key role in planning to increase the climate resilience of the local road infrastructure.

A particularly important segment of the methodology for increasing the climate resilience of roads is the identification of future climate scenarios. In order to achieve this, it is necessary to obtain historical data for all types of natural hazards:

- Floods
- Landslides
- Flash floods (torrential area)
- Wildfires
- Snow drifts and icing

By monitoring these natural hazards, it is possible to make future predictions and the extent of their future impact.

This methodology is detailed in the document "Guidelines for assessing the vulnerability of the road network to climate change and natural hazards" PE "Roads of Serbia", May 2021.

2.6.2 Impact Assessment

After determining the methodology, it is necessary to assess the impact of climate change on the road infrastructure. The impacts on local roads caused by climate change are twofold:

- Impacts caused by short-term effects of extreme climate events, with immediate negative consequences on infrastructure and difficulties in traffic.
- Impacts caused by long-term negative effects on road infrastructure, which occurred during the process of climate change, resulting in increased road maintenance costs.

The impacts that are of particular importance on the degree and speed of deterioration of road infrastructure, especially roadways and drainage systems, are shown in Table 8

Table 8 Climatic events and corresponding risks to road infrastructure*

Critical climatic event	Impact on road infrastructure
Extreme precipitation (showers or prolonged rainfall)	• **Road flooding** • **Pavement substructure erosion, landslides** • **Overloading of the drainage system which causes erosion and flooding** • **Traffic disruptions and impact on traffic safety**
Average rainfall at the season or year level	• **Impact on soil moisture level, which further affects bearing capacity and structural integrity of roads, bridges and tunnels** • **The negative impact of high water levels on the road base** • **Risk of flooding caused by surface water runoff, landslides, slope instability and road damage if there are changes in the type of precipitation (e.g. rainfall instead of snow during winter and spring ice melting)**
Sea level rise	• **Flooding of roads in coastal areas** • **Erosion of road base and bridge supports** • **Reduced free passage height under bridges** • **Increased demand for the use of roads used in case of emergency evacuation**
Maximum temperature and number of consecutive warm days (heatwave)	• **The question of the integrity of the pavement structure: reduction of stiffness of asphalt layers, rutting caused by traffic loading, cracking, bitumen bleeding** • **Thermal expansion of joints on bridges and in rigid pavement structures** • **Impact on vegetation in the right-of-way**
Drought (consecutive dry days)	• **Sensitivity to wildfires that can directly endanger traffic infrastructure** • **Possibility of landslides in cleared areas affected by wildfires** • **Pavement substructure consolidation with (uneven) settlement as a consequence** • **Increased smog** • **Lack of water for earthworks**
Snowfall and snowdrifts	• **Traffic disruptions and impact on traffic safety** • **Snow removal costs** • **Impact of avalanches on road closures or endangering vehicles** • **Flooding as a result of snow melting**
Freezing (number of icy days)	• **Traffic disruptions and impact on traffic safety** • **Ice removal costs**
Melting (number of days with a temperature around zero)	• **Permafrost melting that can result in the settlement of buildings and roads** • **Reduced usability of temporary roads on icy ground**
Ekstreme wind speeds	• **Stability of bridges** • **Damage to signalling, lighting and poles**
Fog	• **Traffic disruptions and impact on traffic safety** • **Increased smog**

* Table 8 is taken from RIMAROCC Risk Management for roads in a changing climate – A Guidebook to the RIMAROCC Method 2010

In the course of 2014 alone, the damages caused by excessive rainfall and consequent floods in the Republic of Serbia exceeded the value of 1.5 billion euros in all sectors, of which the damage to the road infrastructure was about 160 million euros.

Based on the "*Report on the impact of climate change on road infrastructure, with a proposal for adaptation measures*", from 2021, research was conducted in the Republic of Serbia, based on which road infrastructure is most exposed to the following impacts caused by climate change:

- Floods (activation of landslides, occurrence of unstable slopes, damage to the drainage system, soil erosion in the zone of bridge piers)
- Snow storms and snowdrifts (traffic disruption and negative impact on traffic safety)
- Increase in maximum temperatures (Decreasing the bearing capacity and duration of the pavement structure)

Expected climate changes in the forthcoming period until 2100. in the Republic of Serbia are the following:

- An increase in the average temperature on the ground surface of 3 - 4°C, with a pronounced increase during the summer months.
- A decrease in the amount of precipitation in the summer months and an increase in the amount of precipitation in the rest of the year with approximately the same total amount of precipitation, which indicates an increase in the risk of droughts and floods.

Based on the conclusions presented above and in accordance with the methodology defined by the RIMAROCC project and the guidelines for road infrastructure from the ROADAPT program, the impacts characteristic of considering the effects of climate change stand out. The risk of a critical event is calculated as the product of the probability of occurrence of the event and the corresponding effects.

The probability of occurrence of a critical event can be qualitatively defined within one of four categories:

- Very rare (once in 50 years or less)
- Rare (once in 10 to 50 years)
- Occasionally (once in 3 to 10 years
- Often (more than once in 3 years)

When the risks are defined, it is also important to compare them in accordance with the importance of each section of the road network, and in this way it is possible to see the road network as a whole.

The importance of the road section is seen through the following parameters:

- Road category
- Traffic load
- Alternative routes
- Development of the region in the area of the road section in terms of population, industry, tourism, cultural and historical significance, etc.

2.6.3 Road infrastructure adaptation measures in relation to risks and vulnerability in the future time prospectus

Climatic changes first of all require the modification of design guidelines in order to ensure sufficient capacity for road drainage and prevention of erosion and landslides, defining qualitative requirements for increasing soil stability, the resistance of the pavement structure to greater temperature fluctuations, and more rigorous application of environmental protection measures. In order to implement these measures, it is necessary to outline and oblige, first of all, the designer, to implement and process them within the design documentation. The local road administration is responsible for this process.

When rehabilitating the existing road network, it is necessary to carry out a risk assessment, identify vulnerable parts of the road and propose measures related to the impacts caused by climate change. The reliability of the impact assessment mostly depends on the data collected within the road database, which is the responsibility of the local road administration, so it is recommended that the existing databases be periodically updated or new ones created in case they do not exist. It is possible to obtain methodology and forms from PERS.

In addition to the creation and adaptation of design guidelines, it is necessary to adapt the existing legal and technical regulations related to road infrastructure.

It is recommended that the following documents be used for the purpose of adaptation of local road infrastructure designs:

1. *Guidelines for assessing the vulnerability of the road network to climate change and natural hazards,* PE Roads of Serbia, May 2021
2. *Report on the impact of climate change on road infrastructure, with a proposal for adaptation measures*, 2021, Prof. dr. Goran Mladenovic
3. *RIMAROCC Risk Management for roads in a changing climate* – A Guidebook to the RIMAROCC Method 2010
4. *ROADAPT Roads for today, adapted for tomorrow*, Guidelines 2015

3 Basis

3.1 Planning process

Planning a new construction, adaptation or extension of a local road is an iterative process that takes place through several planning stages. The results of each planning phase are documented within the prescribed procedure.

In accordance with the Law on Planning and Construction, a public road is a linear infrastructural structure, whose construction, as well as the construction of structures in its function, is envisaged by the corresponding planning document. For the purposes of construction, appropriate design documentation shall be provided, respecting the procedures set under the Law.

Spatial basis

The Local Self-Government unit adopts a spatial plan for its territory, under which the spatial development of traffic and infrastructure systems is particularly processed.

Based on the General Urban Plan for cities, the general corridors of infrastructure systems are defined, and therefore the general regulation plans including the location of entry of state and local roads into settlements.

Detailed regulation plans are prepared following the adoption of the General Plans, which contain regulation and construction lines, as well as traffic infrastructure capacities.

Preparation of planning documents is carried out in accordance with points 8-16 of the Law on Planning and Construction.

Design- technical documents

Prior the preparation of design documents for local road, the investor addresses to the Local administration unit. If the urban planning conditions are in place, the Investor shall obtain location conditions for the infrastructure structure from the Local Government unit authorities. The conditions apply to the subject parcels or their parts, which the Investor is obliged to integrate before the usage permit is issued and prepare appropriate subdivision design.

Depending on the type of design (construction, reconstruction, rehabilitation...) design - technical documentation is prepared in quite a few stages, as follows:

- Conceptual Design
- Preliminary solution
- Preliminary Design
- Design for construction permit
- Design for construction
- As-build Design

The procedure establishing the designing stages and conditions under which design is carried out is provided under the Law on Planning and Construction (LoPaC), Part V CONSTRUCTION OF STRUCTURES.

In compliance with Article 134 of the LoPaC, based on the prepared design for construction permit for a local road, the local administration unit issues a construction permit.

Terminology and important definitions of the LoPaC related to Municipal roads

According to the Law on Roads (LoR), amongst others, the following definitions apply

- Municipal road is a public road that forms links within the territory of one municipality and/or one city and connects the municipal or city areas with the national road network;
- Street is a public road in settlement linking parts of an urban area;
- Road outside urban area is a section of a public road outside urban area borders;
- A road in a settlement is part of a public road within the boundaries of the settlement, which are determined by the planning document of the local self-government unit;

The municipal road as a public road under the full jurisdiction of the local self-government, in practice is divided into:

- **Streets** (a municipal road within the settlement, which is not designated by a municipal decision for the passage of the state road through the settlement)
- **Local roads** (municipal road outside settlement)

LoR does not recognize the term local road, but in practice this term is used for a municipal public road outside the settlement, i.e. a municipal road with no street elements.

In absence of adequate terminology and categories for the municipal road outside the settlement - local road, within these guidelines a proposal is given for adequate division and categorization with regard to the functional and traffic importance of the local road on the territory of the municipality.

Article 5 of the LoR obliges the local self-government to issue the following act:

- The Municipal assembly or the city council shall issue an act on the classification of municipal roads and streets based on the criteria under paragraph 2 of this Article.

Article 12 of the LoR obliges the local self-government to issue the following planning act:

- The public road manager shall prepare a medium-term plan for construction, reconstruction, maintenance and protection of roads, annual program of works on the construction, reconstruction, maintenance and protection of public roads, individual studies, with the previously obtained opinion by the Ministry, i.e. the body of the autonomous province responsible for the traffic work, that is, the authority of the Local Self-Government unit responsible for traffic affairs.

In Part VII of the LoR - PROTECTION OF PUBLIC ROADS AND SPECIAL TRANSPORTATION, the following parameters are defined for ensuring the function of the Municipal Road:

- Width of protected area on both sides of the road 5m
- Boundary of expropriation 1m
- one of controlled construction 5m

In Part X LoR - SPECIAL CONDITIONS FOR CONSTRUCTION AND RECONSTRUCTION OF PUBLIC ROADS - PLANNING, DESIGN AND CONSTRUCTION, the following stipulations are provided in Article 78:

- Public roads shall be envisaged, designed and constructed in a manner so that planning and technical solutions are harmonized with the latest knowledge of public road design and construction techniques, traffic safety requirements, demographic and economic needs, economic principles and justification assessment criteria for their construction, regulations on environmental protection and regulations governing agricultural land. An integral part of the design documentation of public road construction and reconstruction designs are assessment reports on road's impact on traffic safety and reports on the revision of designs from the aspect of road safety characteristics, in accordance with Art. 88 and 89 of this Law.

The determinants from Article 78 are mostly incorporated in the Guidelines for Design of Local Roads, GDLR with special reference to the specifics that distinguish local from state roads.

Procedure for preparation of planning and design documents

Within the road design Manual in the Republic of Serbia SRDM 1.0 Planning, technical and investment documentation, a detailed overview of planning and design technical documentation and their content is given.

Figure 1, presents the general algorithm of the stages and process related to preparation of design and technical documentation for preparation of design and technical documentation of roads outside the settlement.

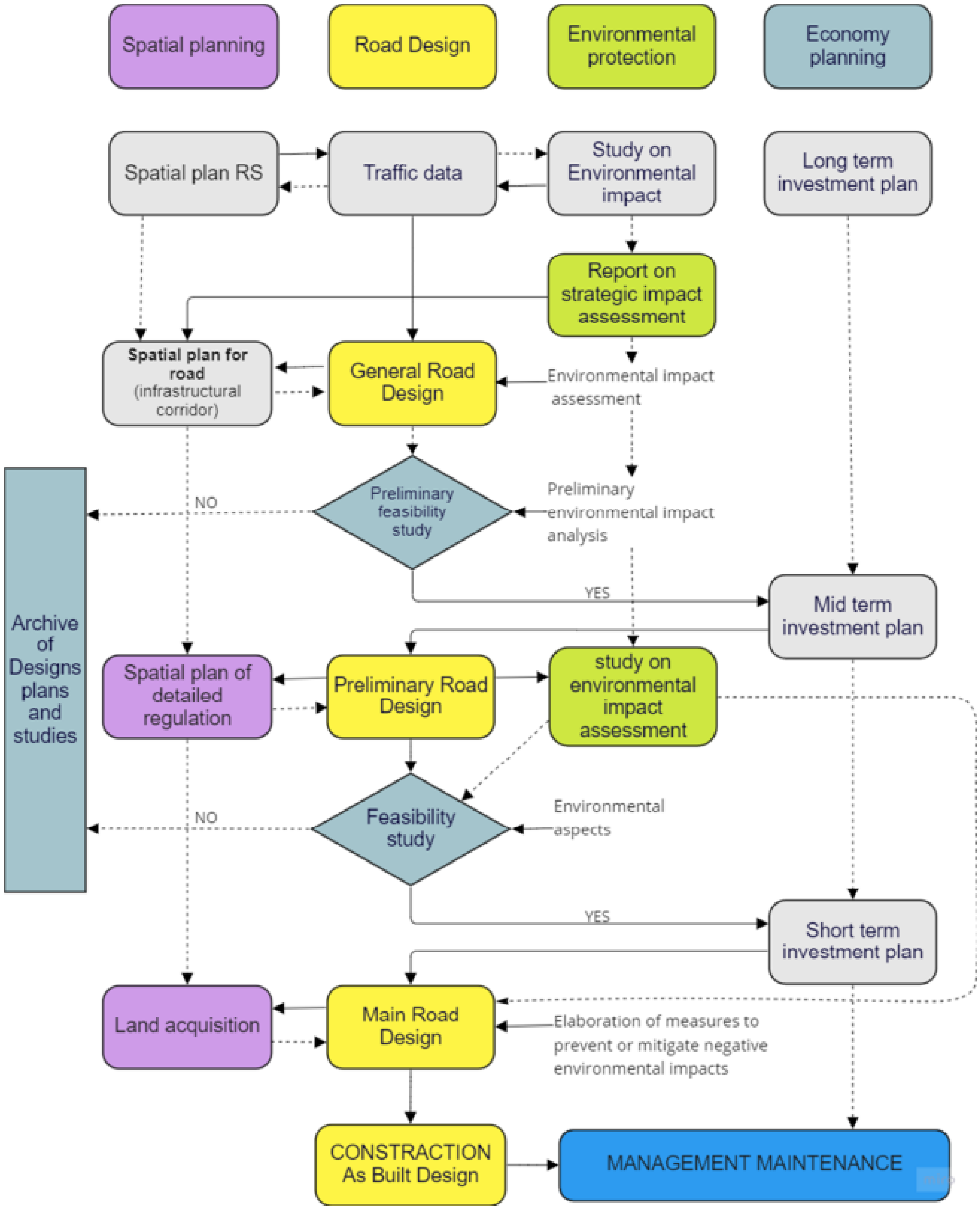


Figure 1 Algorithm of the road designing process outside the city

Legal basis for the field of planning, design and construction of roads in the RS

The legal basis relevant for the field of local road design is primarily based on the following legal documents:

LAW on Public Roads ("Official Gazette RS", no. 41/2018 and 95/2018)

LAW on planning and construction (Official Gazette of the RS", no. 72/2009, 81/2009 - amended, 64/2010 - US decision, 24/2011, 121/2012, 42/2013 - US decision, 50 /2013 - US decision, 98/2013 - US decision, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - other laws, 9/2020 and 52/2021)

RULEBOOK on content, manner and the procedure for drawing up planning documents (Official Gazette of the RS No. 31/2010, 69/2010, 16/2011) - based on Article 201, item 5) of the Law on Planning and Construction (Official Gazette of the RS No. 72/09, 81/09 -correction)

RULEBOOK on the content of information about the location and content of the location permit (Official Gazette of the RS No. 3/2010) - based on Article 201, point 8) - of the Law on Planning and Construction

RULEBOOK on the conditions that must be fulfilled by road structures and other public road elements from the aspect of traffic safety (Official Gazette of the RS No. 50/2011)

RULEBOOK on the content, scope and method of preparation of the previous Feasibility Study and the Feasibility Study for construction of structures (Official Gazette of the RS, No. 1/2012)

RULEBOOK on the content and manner of issuing Construction permit (Official Gazette of the RS, No. 4/2010, 26/2010, amended 93/11)

OTHER documents relevant to the preparation of planning and technical documentation

SRDM Guidelines for road designing in the Republic of Serbia 2012
SPLP Guidance for Local Road Design 2022 – this document

3.2 Local road categories and corresponding design classes

In order to attain a high level of traffic safety and level of service, local roads should be designed in such a way that the movement of users along the road is homogeneous as much as viable, with a speed that corresponds to the function of the road within the network. This speed is determined according to the road category and the section length.

Design classes are introduced to harmonize design elements depending on functional and capacitive requirements, therefore clearly indicating to traffic users what they can expect while driving and at what speed they can move. Design classes for local roads K1 to K4 are introduced. In accordance with the design classes, the roads clearly differ in their appearance and characteristics. Within one design class the road should be uniformed and homogeneous (recognizable).

With respect to longer sections of local road with several sections, the design class should be selected so to ensure a uniform perception of the route along the entire section. Local road sections in this sense are local road routes between nodes where the local road connects to another road of the same or higher rank (Figure 2). In particular cases, division of one local road section, at the node may further receive a lower rank, if the traffic requirements are being considerably changed.

The road category is input data to determine the design class for local roads (Table 9 Design classes of local roads with regard to the road category).

In case of high traffic service requirement on the local road route, while respecting the requirements for a sustainable level of service in the traffic flow, it is possible to switch to a higher design class than the one assigned to that road in Table 9.

Otherwise, if traffic service requirement is low, and if the principles given for construction costs are followed, a lower design class than shown in Table 9 can be applied.

These principles are not applied when low or high demand for traffic service appears on short lengths of local road sections, i.e. when change of design class on a short length of road is not rational to.

The reference values of the traffic flows volume that should be checked on site prior making decision on the design class to be applied on the section are shown within Table 10 below. The traffic flows values obtained in the planning phase can often be overestimated or underestimated, thus in such cases it makes sense to deviate from the defined classes of local road design from Table 9, while respecting the objectives indicated in chapter 2 (traffic safety, level of service, environmental compliance and construction costs).

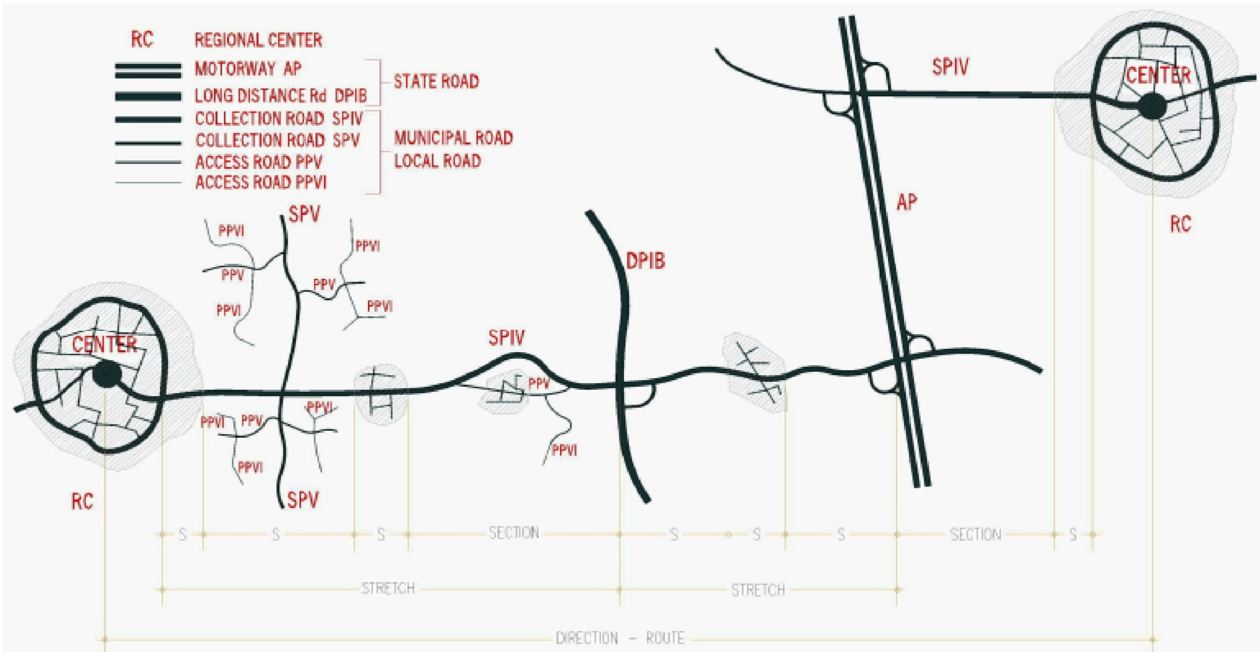


Figure 2 Directions and sections of the road network in connection function of (example)

Table 9 Design classes of local roads with regard to the road category

Road category	Recommended level of service	Design class
SP IV	D (E)	K 1
SP V	E	K 2
PP V	Not applicable	K 3
PP VI	Not applicable	K 4

Table 10 Reference values of possible deviation from design class from Table 9

	Traffic demand on direction, PGDS (veh/24)	
Road category	Check for application of a lower design class K	Check for application of a higher design class K
SP IV	< 5000	
SP V	< 1000	>5.000***
PP V	< 150	>1000**
PP VI		>150*

*Appliance of higher class K is recommended
**In participation of commercial vehicles KV>10%, adopt a higher design class
*** In participation of commercial vehicles KV>15%, adopt a higher design class

3.3 Design classes and definition of design characteristics

The vehicle should move on local road at a uniform speed corresponding to the function of the local road within the network. In this regard, all parameters affecting the vehicle speed are defined according to the corresponding design class K.

In order to standardize the design procedure for a certain design class K of local road, a basic speed is assigned, depending on the road function within the network. This further determines the limit values of individual design parameters, which are based on driving dynamics. The planned speed is not identical to the maximum permitted speed on that road in accordance with traffic regulations.

The homogeneity of driving conditions on a road of one design class, including the differences between roads of different design classes, should be recognizable for the road users. Specifically, the difference in the horizontal marking is one of the recognizable road features for the user.

The design class directly determines the following specific characteristics and parameters:

- The method of preparation of design
- Normal cross-section, including the adequate principle of overtaking
- Plan and profile elements (axis)
- Method of traffic arrangement within intersections
- Other operational characteristics

Given that grouping of all design elements leads to a recognizable road characteristic, these elements are standardized and assigned to each design class. At the same time, a clear distinction between roads designed with different design classes is made. The primary recommendations of local roads design elements according to different design classes are presented within Table 11.

Table 11 Design classes and basic values of designed elements

Design class	Design / Functional elements					Plan and profile elements				Nodes / Junctions
	Basic speed [km/h]	Type of traffic	Normal cross section	Overtaking visibility is ensured for both directions	Cycling traffic	Axle	Recommended range of horizontal curves R [m]	Max cross slope max s [%]	Min. and Recommended vertical curve Rv [m]	Road connection with a lower or equal rank *
K 1	80 (100)	Only motorized vehicles	PP 10.0+ str32below	>= 40%	Independent with regard to the road	Very streched	>= 250	6 (7)	>= 2500 (8000)	access / turning with interweaving / crossing with or without traffic light
K 2	60	General traffic	PP 9.0 str33	>= 20%	Independent or within the frames of separate path in the road profile	Streched	120 - 700	8 (9)	>= 1250 (4000)	access / turning /crossing with or without traffic lights
K 3	50 (40)	General traffic	PP 7.5 str33	–	Within a special path in the road profile or on the road	Adjusted	75 - 400	9 (10)	>= 900 (2500)	access / turning /crossing without traffic lights
K 4	40 (30)	General traffic	PP 6.0 str34	–	On the road	Very adjusted	45 - 250	10 (12)	>= 550 (2000)	access /turning /crossing

*possible appliance of the node type, depending on the design class K, is shown in point 6.3.3)

Local road design class K1 shall be applied on two-lane roads with a standard PP 10.0 cross-section. Directions of vehicle movements are separated by horizontal traffic signals in the central part of the carriageway. Nodes are designed at one level. Exceptionally, when a local road of design class K1 connects to a state road of a higher rank (moto road), a grade separated crossing type is applied. Overtaking implies use of traffic lanes envisioned for movement of vehicles in the opposing direction. Overtaking should be allowed uniformly on at least 20% of the route per direction of movement (40% in total).

When the need for overtaking is high, particularly when the number of heavy vehicles on gradients is increased, introduction of an additional traffic lane on the inclines should be considered (see chapter 4.5.4).

The agricultural traffic (machines) should be allowed on separate traffic surfaces. The same applies for non-motorized traffic (pedestrian and cycling). Pedestrian and cycling traffic should be physically divided on separate paths outside the road surface.

In conformity with the function of the said roads within the network, a basic speed V_0 of 80 km/h is established for mid-distance trips. The alignment should be designed as streched route as much as viable.

Connections with roads of the same class (category) or with roads of a lower class (category) shall be designed as surface intersections, with or without traffic lights, i.e. as roundabouts.

Local road design class K2 shall be applied on two-lane roads with a standard PP 9.0 cross section. Directions of vehicle movements are separated by horizontal traffic signals in the central part of the carriageway. Overtaking means use of traffic lanes intended for movement of vehicles from opposing direction. Overtaking should be allowed homogeneously on at least 10% of the route per direction of movement (20% in total). On this road the agricultural traffic (machines) is possible, provided that the prescribed traffic safety measures are met. Cycling traffic shall take place on the carriageway or a separate lane shall be formed on one side of the road for both, cycling and pedestrian traffic in both directions (see chapter 4.7). Formation of separated areas for cyclists, i.e. pedestrians, should be considered depending on the requirements (e.g. locally increased pedestrians or cyclists traffic)

In accordance with the function of these roads within the network, for shorter distances, with relatively short distances between intersections, a basic speed V_0 of 60 km/h is established. The route should be designed as a streched route adapted to the terrain.

Connections with roads of the same class (category) or with roads of a lower class (category) shall be designed as surface intersections, typically without traffic lights, i.e. as roundabouts. In case of possible traffic jams, installation of traffic lights shall be considered.

The local road design class K3 shall be applied for single-lane roads with a standard PP 7.5 cross section. Given that minor traffic volume is expected, the carriageway shall be designed in a width on which is not possible to mark two traffic lanes. Rather than division line on the carriageway, two broken edge lines are envisaged, along both edges of the carriageway. Edge lines are intended to be driven over, particularly in cases of passing by a truck or bus. When dividing line is missing, the road user shall be alerted to drive with much more attention.

Given the road function within the network, i.e. very short length of movement, the speed on this road shall be reduced to the basic speed of 50 km/h. Movement of agricultural vehicles and non-motorized traffic is possible on this road. Separated pedestrian and cycling paths could be considered in case of special requirements, such as traffic intended for school needs, or locally increased intensity of pedestrian and cycling traffic.

Connections with roads of the same class (category) or with roads of a lower class (category) are designed as surface intersections, without traffic lights. Construction of roundabouts is not common.

The alignment should be designed as alignment adjusted to the terrain.

The local road design class K4 shall be applied to single-lane roads with a standard PP 6.0 cross-section. Given that particularly low traffic volume is expected, the carriageway shall be designed in a width where marking of two traffic lanes is not possible. Rather than a dividing line, two dashed edge lines shall be envisaged along both edges of the carriageway. Edge lines are intended to be driven over, particularly in cases of passing another passenger vehicle. For the purposes of passing by heavy vehicles or buses the carriageway shall be widened at certain locations. The construction of bypasses should be adjusted to the terrain, i.e. to the road visibility conditions. The lack of a dividing line and a very narrow road should be an alert to the road users to drive with significantly increased attention.

Taking into regard the road function within the network i.e. the particularly short length of movement from the property to the road connection the same or higher rank, a reduced basic speed of 40 km/h is envisaged for this road. On these roads movement of agricultural machinery and non-motorized traffic is possible.

Connections with roads of the same class (category) or with roads of a higher class (category) are designed as surface intersections.

The alignment should be designed as alignment adjusted to the terrain.

Road design class K1, with high traffic volume

Particularly, when the road is located in the immediate vicinity of larger settlements or parts of settlements with accumulated indirect and direct road connections and high traffic load roads, thus the cumulative traffic is exceptionally high, a high-capacity profile could be applied for shorter sections. With an inspection of the required capacity and the level of service envisaged for a local road with one carriageway, the need to introduce a profile with a separated carriageway in each direction could arise, on shorter lengths (up to 15 km), provided that the traffic volume is very high and that PGDS is 12 – 15,000 vehicles/24h. All other design elements shall be adjusted to the highest design class K1, along with appliance of the PP 21 profile.

4 Cross-section

4.1 General

The principle of appliance of a standard road type that is recognizable for the users is mostly reflected through the cross section. A standard cross section with one carriageway is assigned to each design class K.

With respect to the envisaged road, it shall be verified if sufficient traffic quality is attained with the assigned standard cross section, including for all intersections on the section in question.

In addition, it shall be verified if the speed V_0 is achievable on the envisaged section for the road category to which it belongs (see chapter 4.4).

With regard to the standard cross section assigned to the envisaged road direction, it shall be inspected if all characteristics of the adjacent sections are sufficiently harmonized. Transitional changes are easily noticed by drivers, hence, the design shall be adjusted according the traffic condition changes.

4.2 Basic dimensions of cross section

4.2.1 Basic dimensions of vehicles

Following with the REGULATION ON THE REQUIREMENTS THAT THE STRUCTURES AND OTHER PUBLIC ROADS ELEMENTS MUST FULFILL FROM THE ASPECT OF TRAFFIC SAFETY, hereinafter referred to as the REGULATION, point 3.4.2, the motor vehicle has a limited width of 2.55 m, and limited height of 4.00 m. These dimensions are used as a basis for dimensioning the driving spaces elements.

Relevant parameters of the static gauge of vehicle types on the outside urban road network are given in Figure 3.

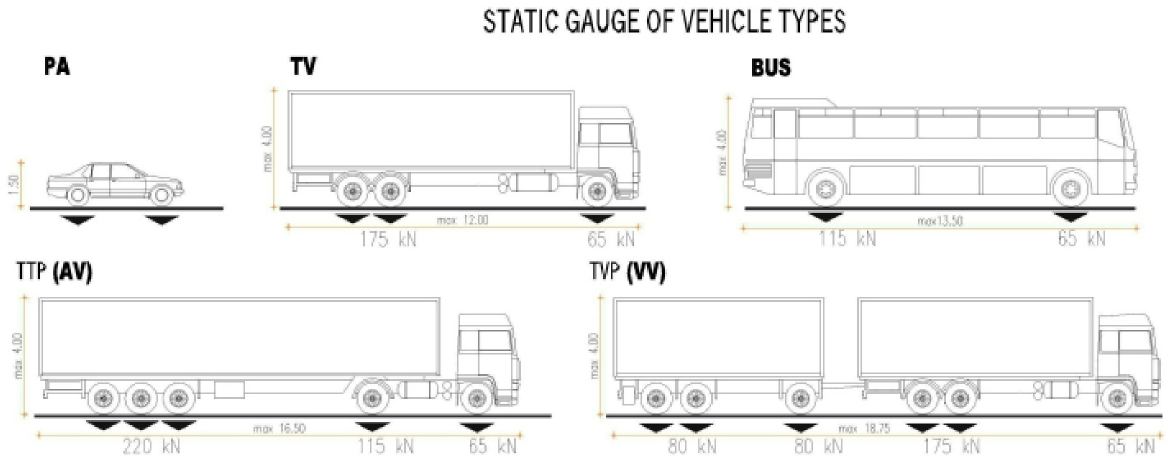


Figure 3 Static dimensions of vehicle types

4.2.2 Traffic profile elements

The traffic profile for a motor vehicle refers to the space occupied by the observed vehicle, plus the lateral and height occupation of space due to dynamic oscillations during the movement of vehicle, and the space for side edge strips or drainage gutters. (Figure 4).

Lateral space occupation due to dynamic oscillations in free movement of vehicle, is the space that is a compensation for imprecise driving of vehicle as well as a reserve space occupied by vehicle elements that deviate from the basic dimensions, such as rear-view mirrors, etc. This additional occupancy is 0.95 m for traffic lanes that are regularly (exclusively) used for movement of heavy vehicles or 0.70 m for traffic lanes, that are not regularly used for heavy vehicles.

The height reserve due to oscillation is 0.20 m.

The width of the traffic profile for mixed cycling and pedestrian two-way traffic is 2.50 m, while the width for cycling traffic only is 2.25 m, the height is 2.25 m.

Loading gauge is an extended traffic profile for a safety area. In the vertical direction it is 0.3 m, i.e. a total of 4.5 m. In lateral direction, it depends on the profile type, while for local roads it is 1.25 m, and this can be narrowed to 1.0 m, if the allowed speed is 50 km/h.

Solid obstacles cannot be found within the loading gauge, while traffic signals could be installed on the road edge. The guardrail, as a deformable obstacle, could be located inside the loading gauge, at a distance of 0.5 m from the traffic profile. Protective rail elements, in confirmed exceptional cases, could be installed at 0.25m.

The height of the loading gauge is 4.5m. This height can be increased if upgrading of the carriageway is required.

The side protection zone for the loading gauge, along the traffic profile of the cycling path, is 0.5m, while the upper zone is 0.25m, defining the loading gauge of 2.5m height. Solid obstacles cannot be found within the free cycling and pedestrian profile, while traffic signals could be a part of the loading gauge, but not within the traffic profile.

4.2.3 Standard cross section's components

Road profile is consisted of carriageway, shoulder, and on some roads, median.

Traffic lanes, which are mostly frequently used by heavy vehicles are 3.25m wide on local roads.

Marginal strips are an integral part of the carriageway and they serve to stabilize the edge of the pavement structure. Their width on local roads is 0.25m.

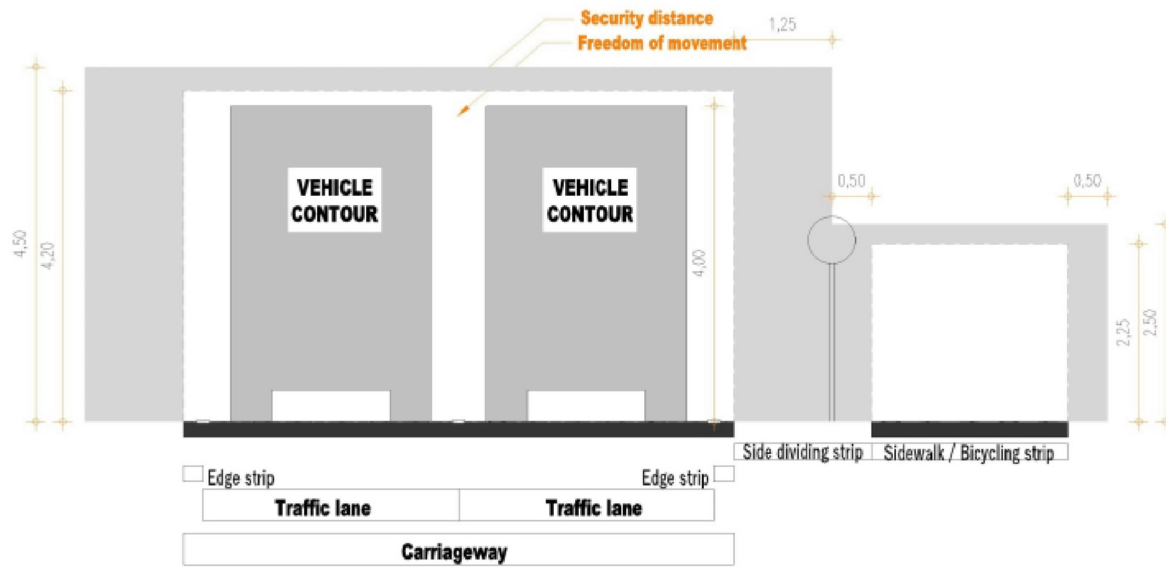


Figure 4 Basic dimensions of gauge and traffic profile

In general, **kerbs** shall not be installed along the edge of local road. In a case of justified need, the height of installation is 12 cm above the edge of the carriageway, or 15 cm on structures. The maximum height of kerbs is 20 cm on open alignment, while 25 cm in tunnel.

Drainage elements. Outside structures, the water from the road generally drains freely over shoulders, road slopes and grassed canals, and thereafter absorbs into the soil. However, in some cases when the above is not possible, drainage is carried out through open channels and the water is drained to the recipient. The channels that are directly formed along the carriageway are gutters with or without a longitudinal slope towards the discharge point outside the road base. Gutters are constructed in the width of the road shoulder. In special cases, the water drainage from the road to the recipient can be done through a closed sewage system, however these cases must be proven and justified.

In the case of formation of a road section with separate carriageways, a median is formed.

Median splits the carriageway in different directions and in general is 2.5m wide on local roads. A guardrail, or other systems for stopping vehicles, traffic signals, drainage elements, lighting and possibly structures pillars that cross over the road are placed within the median. Planting of vegetation is not typical for medians widths. The width of median could be more than 4.0m, if necessary.

The median can be formed for the purposes of splitting the traffic directions on roads with one carriageway as well, width 1.0m for roads of K1 design class. (see chapter 7.2)

Shoulders are formed on the side of the carriageway and serve for, amongst other: stabilization of the carriageway from the lateral side, installation of guardrail on the surface, traffic signals and as a working surface during maintenance or other road works. For safety purposes, shoulders are made with a stable surface in case a vehicle runs off the carriageway. The width of the shoulders is established according to the road category, i.e. design class (1.5m, 1.25m, exceptionally 1.0m).

4.2.4 Pedestrian and cycling paths

Most commonly the pedestrian and cycling paths are designed laterally on one side of the road and used for two-way traffic. In a case of combined pedestrian and cycling traffic, the carriageway is 2.5 m wide (Figure 5).

Pedestrian and cycling paths, along the carriageway, are routed to adjust the terrain, with a variable distance as necessary, with respect to the carriageway, taking into regard to protect the cyclists against lights from vehicles. The median between two carriageways should be at least 1.75m wide. Depending on the intensity of pedestrian and cycling traffic, installation of guardrail shall be considered. The shoulder along the cycle and pedestrian path is 0.5 m wide, but for the safety purposes, with an adequate explanation it could be wider.

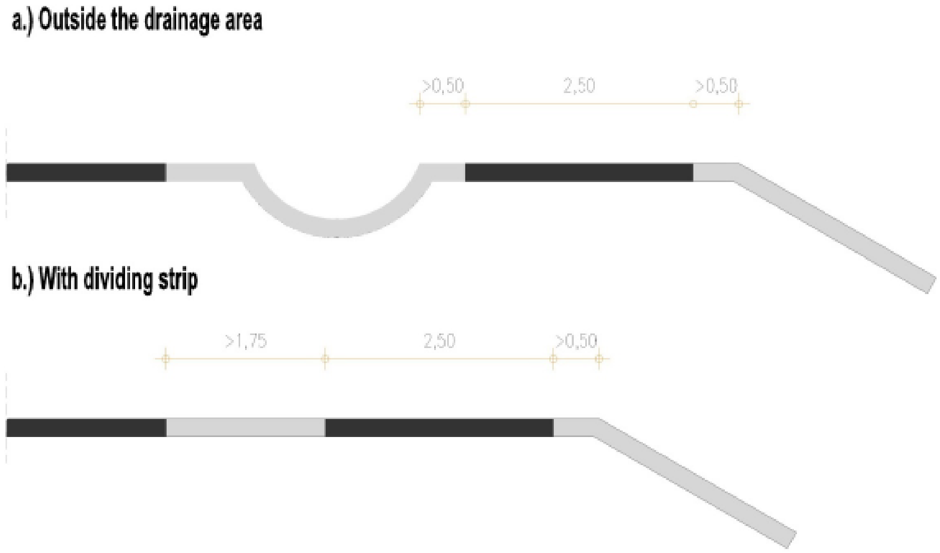


Figure 5 Location and dimensions of mixed pedestrian cycling paths

4.2.5 Embankments

Embankments shall be designed as described in Figure 6**.**

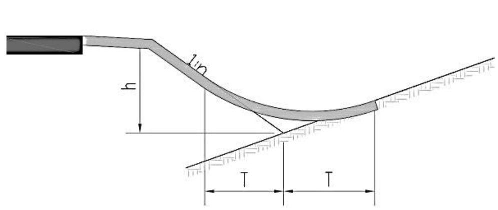
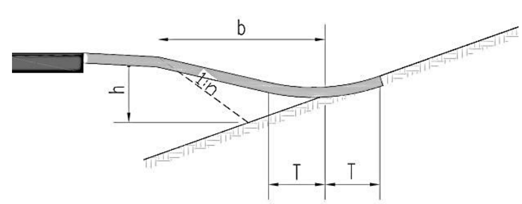
Slope gradient 1: n is typical 1: 1.5 for embankment slopes and cuts. It is possible to apply different slopes, according to the requirements.

- Slope stability
- Integration of the local road into the landscape
- To avoid guardrail
- To reduce the noise impact
- To prevent snowing on the road
- For easier installation in the road base

In case of high embankment heights of more than 5.0 m, it is possible to construct load-relief berms so to facilitate road maintenance.

The transition between the slope and the autochthon soil is rounded.

Drainage channels are constructed along the bottom of the embankment slope or cut.

	Height of slope [m’]	
	h>=2.0 m	H<2.0 m
Embankment		

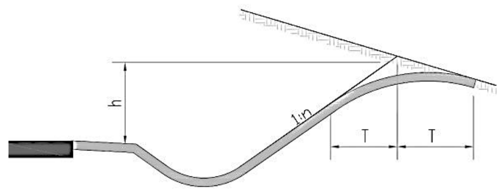
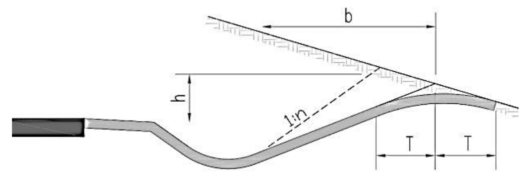
Cut		
Embankment	Standard Slope gradient 1:n=1:1.5	Standard slope width b=3.0 m
Length of the rounding tangent	T=3.0m	T=1.5 *h

Figure 6 Standard embankment/cutting slope treatment

4.3 Standard normal cross section

A standard normal cross section is defined for each K design class for a local road with one carriageway. If the required level of service is proved to be insufficient, then the higher class and category within the network is taken into regard, i.e. a profile with a double carriageway could be applied for design class K1 (it can be applied on a local road up to 15 km long, see chapter 3.3).

The standard cross section could be widened with pedestrian and cycling paths, if required.

Standard cross section for roads class K1

Standard cross section PP 10.0 (Figure 7) is a single carriageway profile with two traffic lanes. On sections of local road category Local I - collector road IV, design class K1 is assigned and the possibility of safe overtaking is provided on it for at least 40% of the road length in both directions. The traffic lane intended for movement of vehicles in the opposing direction is used for overtaking.

Pedestrian and cycling traffic should be physically divided on separate pathways outside the carriageway.

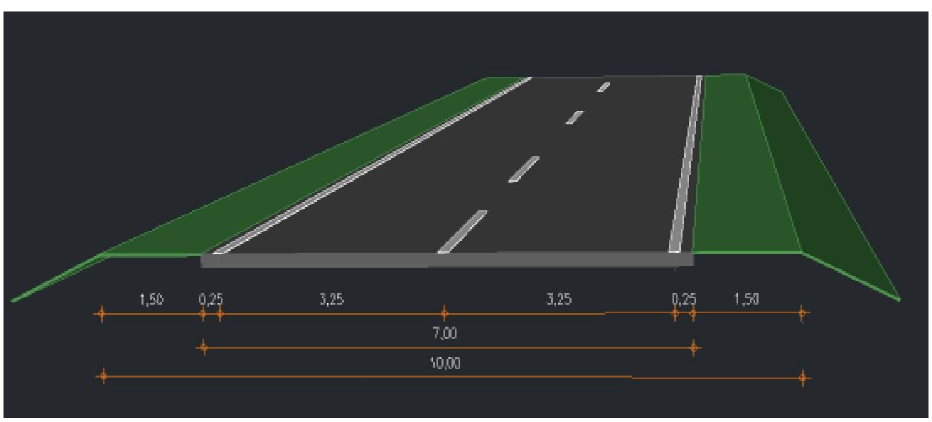


Figure 7 Standard cross section PP 10.0

Standard cross section for roads class K2

Standard cross section PP 9.0 (Figure 8) is a single carriageway profile with two traffic lanes. On local road sections of category Local II - SP V, which is assigned design class K2 and on which the possibility of safe overtaking is provided for at least 20% of the road length in both directions. The traffic lane intended for movement of vehicles in the opposing direction is used for overtaking.

If significant participation of heavy vehicles on local road traffic is confirmed, pedestrian and cycling traffic should be physically divided on separate pathways.

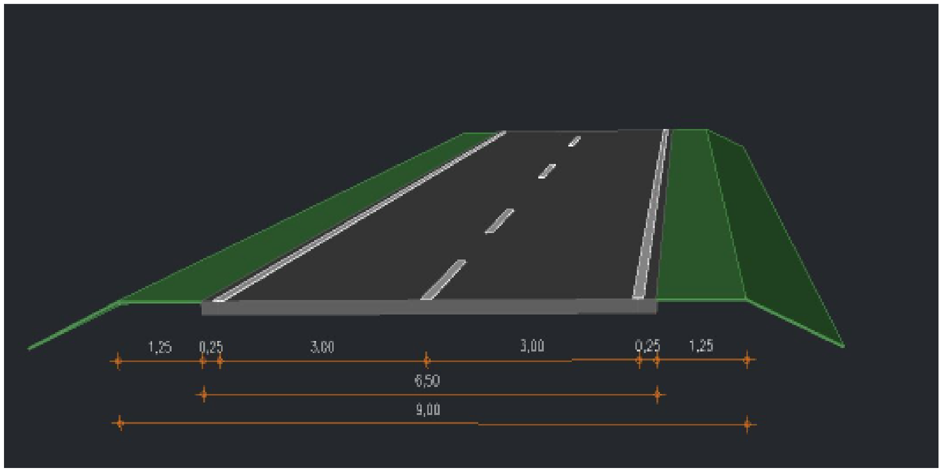


Figure 8 Standard cross section PP 9.0
Standard cross section for roads class K3

Standard cross section PP 7.5 (Figure 9) is a profile with one carriageway. On local road sections of Local III - PP V category, design class K3 is assigned and due to reduced width its carriageway is not marked with traffic lanes. Marginal strips marked with a broken line are formed on both sides.

A minor traffic volume is expected on this local road with a proportionally insignificant share of freight traffic and public transportation.

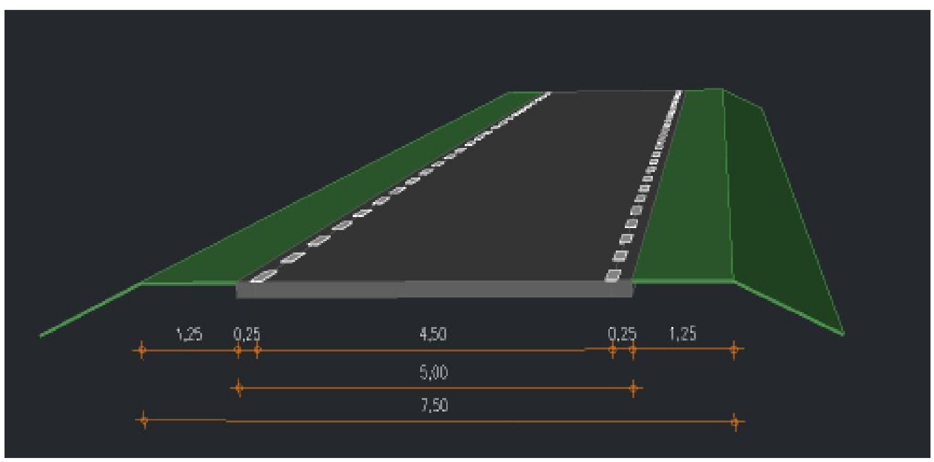


Figure 9 Standard cross section PP 7.5
Standard cross section for roads class K4

Standard cross section PP 6.2 (Figure 10) is a local road profile with one carriageway. On the local road sections of category Local IV - PP VI, design class K4 is assigned and traffic lanes are not marked on due to the reduced width of the carriageway. Marginal strips marked with a broken line are formed on both sides.

No frequent traffic is expected on this class of local road with sporadic participation of freight vehicles.

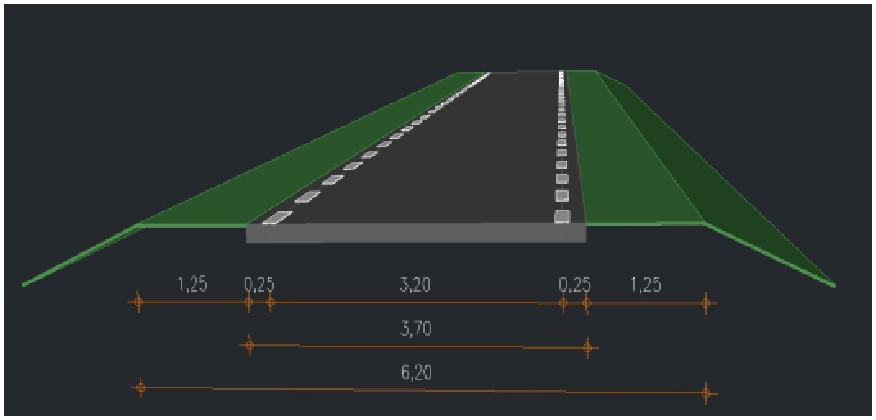


Figure 10 Standard cross section PP 6.2

Standard cross section for road class K1 with a great heavy traffic load and a proportionately large share of freight vehicles and public transport vehicles

When there is a particularly increased request for traffic service on a part of a local road section of category Local I - SP IV, with traffic load exceeding the PGDS of 15,000 vehicles/24 h, and with a relevant traffic load qm>1800 vehicles/h, a road profile with one carriageway is replaced by the PP 21 profile with two carriageways separated by a median in each direction (Figure 11). Appliance of this profile is typical at the entrance/exit from larger agglomerations with high cumulative traffic within the zone of high concentrations of inflows and is applied on shorter road sections on the network, in length of up to 15 km. These road sections are solely intended for motorized traffic. Given the assumption that a significant and continuous participation of freight and public transport vehicles (>12%), a lane width of 3.5 m is applied, while the overpassing lane remains at a width of 3.25 m. For the safety purposes and public transport needs, service area at the side of the road for stopping shall be envisaged on these road sections.

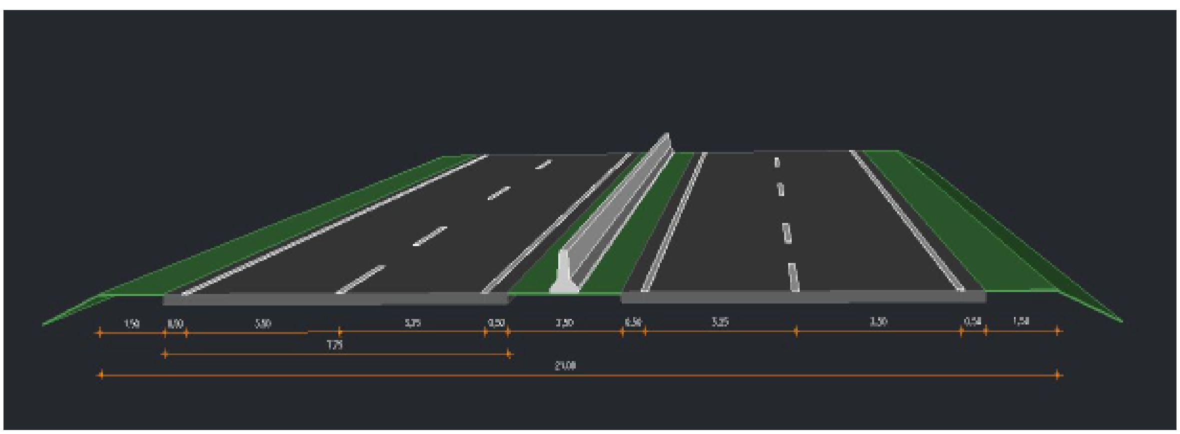


Figure 11 Standard cross section PP 21

4.4 Check of the road level of service with standard cross section.

For each standard cross section assigned to the design class K1 and K2, based on a profile with a single carriageway, according to Table 9 and Table 10, it should be verified whether the required level of service is provided, including the envisaged overtaking zone.

If, however, the verification indicates that the required level of service for one carriageway road section has not been attained in accordance with Table 8 and Table 9, introduction of overtaking zones shall be considered, particularly on inclines. All the above is aimed at improvement of the traffic quality.

If introduction of overtaking lanes in alternating zones and on gradients does not meet the required level of service, a higher design class should be considered i.e the possibility of appliance of a standard cross section with separate carriageways on that section should be checked (up to 15 km long), where such profile is needed.

The envisaged traffic must be based on PGDS over 15,000 vehicles/24h, if appliance of normal cross section with separate carriageways is required on longer lengths or on the entire route.

With respect to roads of design class K3 and K4, the transition to a higher class and category is related the increase in PGDS traffic in accordance with Table 10.

4.5 Overtaking traffic lanes

4.5.1 Principle

Overtaking lanes are envisaged for single carriageway roads, with requirement of achieving a higher level of service and increasing traffic safety. With regard to roads having separated carriageways in each direction, continuous overtaking is possible for both traffic directions, with a clear separation of the fast and slow traffic.

The criteria for introduction of overtaking lane, its arrangement (location and length for overtaking), shall be harmonized with design class K. The same applies for intersections. Geometric shaping, widening and narrowing, pavement markings and signaling are not depended on the design class.

4.5.2 Design class of Local roads K1

4.5.2.1 Setting criteria

When the need for introduction of overtaking lanes on local roads of class K1 with one carriageway is confirmed due to established insufficient level of service, the said lanes are constructed by widening the cross section PP10.0 for the overtaking lane. The number and length of overtaking traffic lanes constructed in such a way, should together with other possibilities for overtaking enable at least 20% of the route length (road direction) safe overtaking per direction. The location and length of the overtaking lane mostly depends from the connections with other roads on the network and the terrain topography.

4.5.2.2 Schedule

Overtaking sections shall be evenly arranged along the local road route, with timely advance notice of such a possibility. Overtaking sections should have sufficient length for safe traffic flow, min. 600m, optimal 800m and max. 1500m.

While arranging the overtaking lanes, the following procedures shall apply:

- On hilly and mountainous terrain, overtaking lanes should be constructed towards gradient direction.
- Overtaking lanes should be avoided at sharp right curves, due to the risk of collision with the opposite direction traffic.
- Traffic redirection points in the overtaking lane should be placed on rather safe locations, such as open roads, while unsafe zones such as inflection surfaces, on which slippery pavement can occur due to hindered drainage or bridges in their vicinity should be without a doubt avoided.
- Overtaking lanes should not be constructed immediately before a point after which the road characteristics are significantly changed.

4.5.2.3 Zone of connections and intersection

Local roads of class K1 shall be envisaged with intersection at one level, with an exception when the local road intersects with the state road of category I or highway, in which case it is possible to envisage a full or partial grade-separated junction. Traffic could be regulated with traffic lights at these intersections. While designing intersection, the following rules shall apply:

- Overtaking lanes should be constructed outside intersections,

- Overtaking lanes should never end just before the intersection, but before approaching it, so that a left-turn traffic lane is formed behind the restricted zone after the end of the overtaking traffic lane,
- In some exceptional cases overtaking lanes could be constructed directly behind the intersection, however, for such case a special clarification shall be provided. In that case, the widening of the carriageway shall take place before the intersection.

4.5.3 Design class of Local roads K2

4.5.3.1 Setting criteria

Overtaking lanes are not envisaged for local K2 roads. Exceptionally, in a case of great traffic service request, particularly on gradients, single construction of overtaking traffic lanes could be foreseen. In that case, the design principles as for class K1 shall apply. The decision on introduction of overtaking lane on local roads K2 implies a previous inspection if the expected level of service for the local road route is met.

4.5.3.2 Schedule

When introducing overtaking lane, the min. length should be 600 m.

The overtaking lane on gradient should start before the critical slope and shall be left after crossing the ridge.

4.5.3.3 Intersection zone

Local roads of class K2 are envisaged with intersections in levels without traffic lights, or as roundabouts. In some exceptional cases installation of traffic lights is possible, if such a need is proven. While designing intersections, the following rules apply:

- Overtaking lanes are constructed outside the intersection,
- Overtaking lanes never end in the intersection zone. If there is an overtaking lane before the intersection, then the left-turn lane is formed after the restrictive zone and after the overtaking lane ends.

4.6 Normal cross section of local roads on structures

Within the structures zone, the cross section should mostly correspond to the cross section on the primary route. Some cross section elements on the structures and in tunnels have specific characteristics. Figure 10 shows normal cross section of local roads in accordance with the design classes on bridges.

Drainage on bridges is carried out within the edge strip where the gullies are placed, and therefore the edge strip on the bridges is extended to 0.5m.

Car stopping devices on bridges are compulsory on local roads with a basic speed V0 > 50 km/h. Pedestrian paths on these bridges are elevated 7 cm with regard to the carriageway.

Car stopping devices are not required for local roads with a base speed of V0 <= 50 km/h, Pedestrian paths on these bridges are elevated 15 cm with regard to the carriageway.

Bridges on K1 roads class shall be designed with normal cross section (Figure 12).

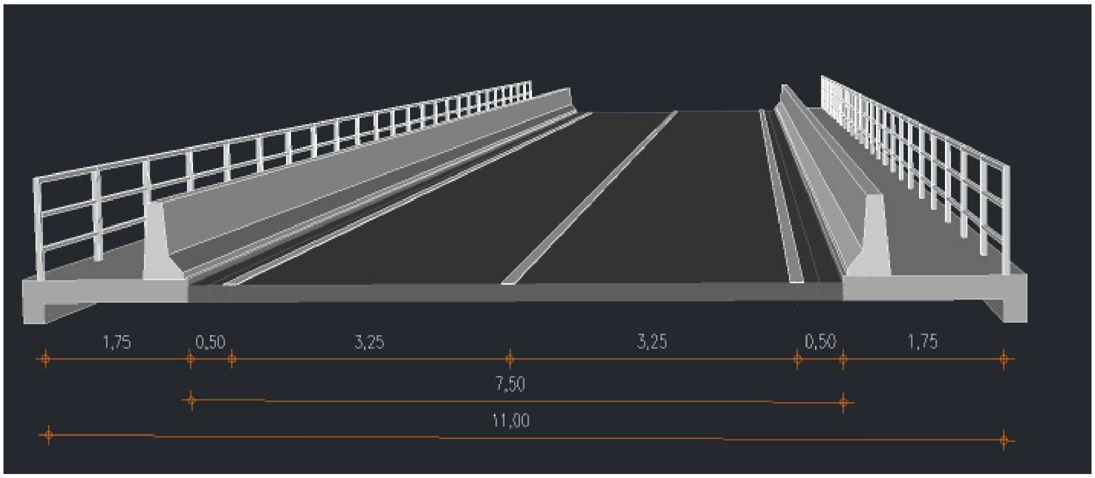


Figure 12 Normal cross section PP11M

Bridges on K2 roads class shall be designed with normal cross section PP10.5M (Figure 13)

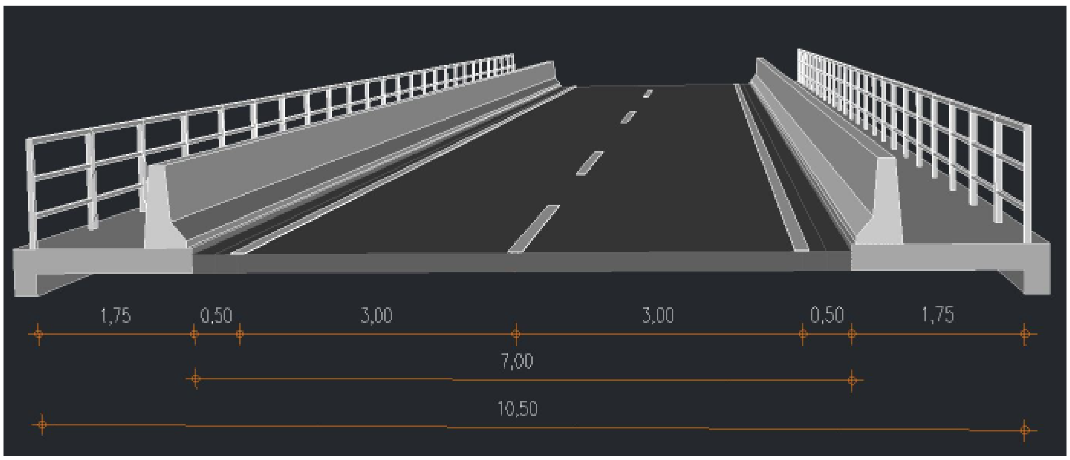


Figure 13 Normal cross section PP10.5M

Bridges on K3 and K4 roads class shall be designed with normal cross section PP8M (Figure 13)

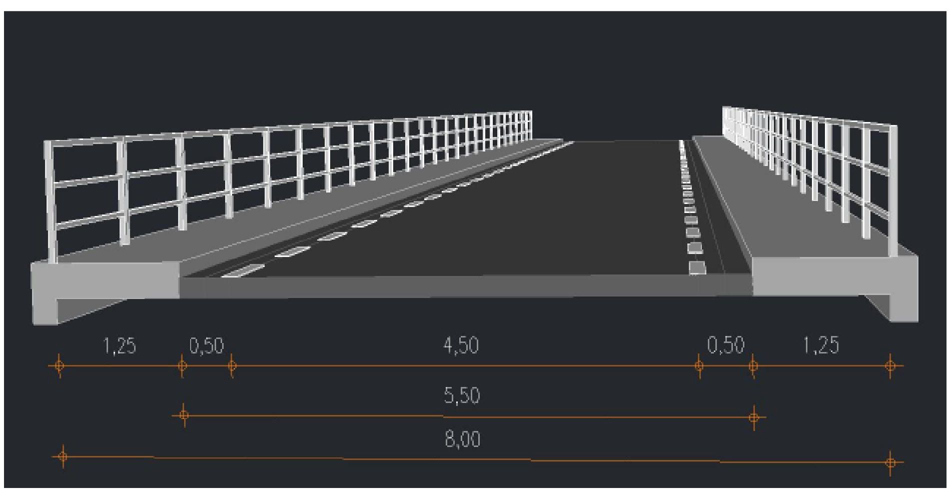


Figure 14 Normal cross section PP8M

On class K1a roads on sections with separated carriageways bridges are designed with a cross section PP21.5M

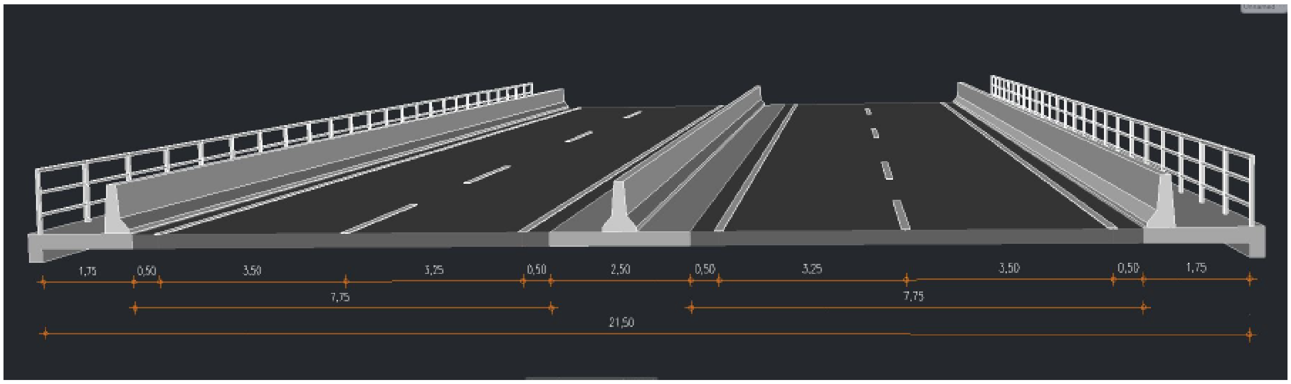


Figure 15 Normal cross section PP21.5M

Tunnels, underpasses longer than 80m and galleries on local roads of class K1 and K2 are designed with standard cross section elements as shown in Figure 16. The required height of the free profile in tunnels is 4.50m.

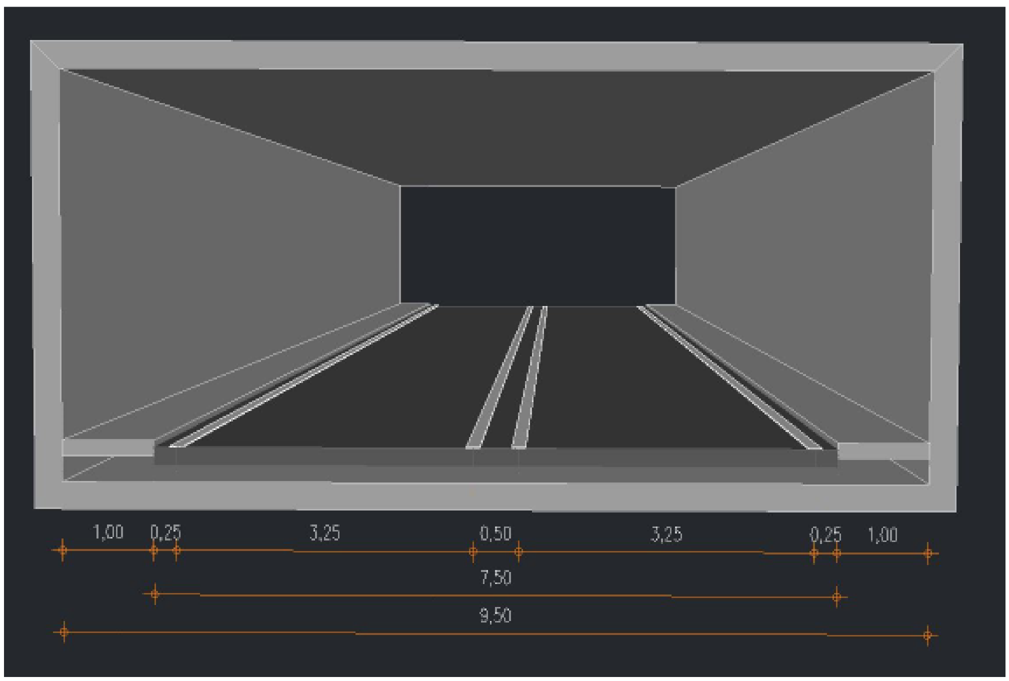


Figure 16 Normal cross section in tunnel PP9.5T

Table 12 Extension of the edge strip in tunnel depending on the size of cross slope

Cross slope [%]	Extension of edge strip [m]
> 3,5 to 4,5	0,05
> 4,5 to 5,5	0,10
> 5,5 to 6,5	0,15
> 6,5	0,20

With respect to a square tunnel cross section, the lateral side of the free tunnel profile is vertical. If the carriageway is inclined towards the tunnel wall, high vehicles can endanger the free profile, above the service path. In cases where the carriageway cross slope is greater than

3.5%, the traffic lane from the lower side should be widened in accordance with the values given in Table 12.

4.7 Non-motorized traffic

On roads of class K1, cycling traffic should not be moving along the carriageway traffic lanes. On roads of class K2, cycling traffic within the carriageway is possible. On carriageway of class K3 and K4 roads, cycling traffic is considered as standard solution.

Regarding the roads of class K2, in accordance with the structure and intensity of the motorized traffic, it should be checked if the cycling traffic is safe within the carriageway, or separate cycling and pedestrian paths shall be constructed for safety purposes.

While inspecting the above indicated safety, the intensity and speed of motorized traffic shall be established, including the proportion of freight traffic, visibility, as well as the cycling traffic intensity and the vulnerability of cyclists as traffic participants.

Table 13 Indicative values for introduction of an autonomous pedestrian-bicycle paths on a local road of class K1 and K2

PGDS [Vehicles / 24 h]	Daily stress in bicycle (B) and pedestrian (P) traffic [B and P / 24 h]
2.500 – 4.000	> 200
4.000 – 7.000	> 100
7.000 – 10.000	> 50

Table 13 shows the reference values of the stress test at a motorized traffic speed of min. 80 km/h, with participation of heavy traffic of app. 10%, on a local road section with a minor proportion of vulnerable participants in non-motorized traffic.

With PGDS over 10,000 vehicles / 24 h, the participation of bikers in traffic is not acceptable due to safety reasons.

Bicycle and pedestrian traffic may be carried out in both directions on a separate independent path along the carriageway.

5 Local road alignment

5.1 General

The designing procedure for the road alignment over cross section and plan and profile elements is based on the principle of alignment optimization in spatial conditions (see point 5.4). The superimposition of vertical and horizontal design elements with the terrain conditions must be checked, in terms of whether the visibility requirements are sufficiently met. In addition, it must be verified if the road visually suites into the natural environment to a sufficient extent. For the purposes of checking the critical points, design tools with visual perspective representation are used.

Special attention shall be paid to the transition between the planned and existing road sections.

Engineering structures are processed as a continuous part of road structure, with particular attention to costs and structural details.

The applied design elements shall be established based on provision of the safety conditions, vehicle dynamic characteristics and previous experience of designers.

5.2 Plan design elements

5.2.1 Direction

Direction as a design element of the plan fits well into the landscape of plain and wide valleys. It relates well to other linear infrastructure facilities, such as railways, channels, power and other lines with good general visibility, particularly to intersections, with good overtaking conditions.

The following disadvantages are detected for long directions, particularly the ones with continuous longitudinal slope:

- Difficult embedding into varying topography
- Hindered estimate of distance and speed of oncoming vehicles, as well as those moving ahead and behind.
- Unfavorable from the aspect of glare in night driving conditions

Based on the above, direction as a plan design element should not be unambiguously applied, while the length of direction should not exceed the length of Lp=1500 m.

To ensure a safe transition from a straight to a circular curve, the applied radius of the circular curve should be in balance with the previous length of length of direction. (see point 5.2.2).

5.2.2 Circular curve

The circular curve as a design element in scope and relation with other alignment curve elements should enable uniform driving at the envisaged basic speed, which is assigned to the design class K. The selected circular curves should also fit within the terrain topography.

Table 14 shows the recommended values for the circular curves radius. Appliance of greater values of circular curves radius is possible, if a better relation between the alignment and terrain, or a better fit dictated by local conditions is achieved. The particular requirement that must be underlined is that the route of local road of class K1 should be very streched, while the route of local road K2 should be streched. For local roads of class K3, the sprung alignment should be applied on locations where overtaking is foreseen. For local roads of class K3, especially K4, the appliance of larger radius may bring into question the intended functional effects of the class assigned to them.

The length of circular curve arc must be perceived by the driver, and therefore, as a design independent element, it must have a length greater than the minimum as provided within Table 14.

Table 14 Recommended circular curves radius and appropriate min. length of circular arcs

Designing class	**Range of curve radius** [m]	**Min. length of circular arc** **L** [m]
K1	> 250	60
K2	120 –700	50
K3	75 – 400	40
K4	45 – 250	25

Due to safety reasons, the adjacent radius of adjacent curves should have an optimal ratio between them. Figure 17 Radius ratio of adjacent circular curves - adjacent circular curves ratio shows a chart with the permissible limits of the adjacent radius. According to the given chart, the radius of the adjacent curves ratio can exceptionally move forward within the zone of usable ratio. The chart should be applied in selection of the radius for classes K1 to K3.

In exceptional justified cases, the adjacent radius ratios that deviate from the bounds values up to max 15% may be applied, assuming that optimal values are applied further along the route. This exception must be decreed by appropriate signaling (dangerous curve). The appliance of such solutions should be convoyed by a safety analysis and possible introduction of speed limits on that section.

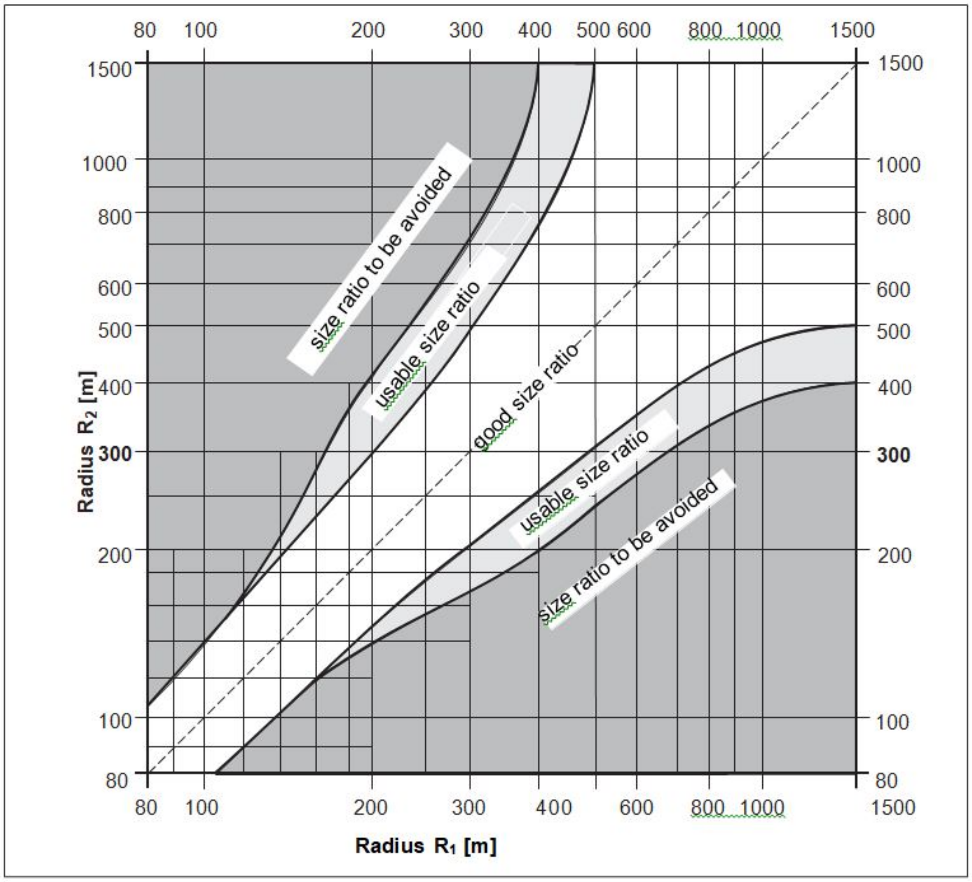


Figure 17 Radius ratio of adjacent circular curves

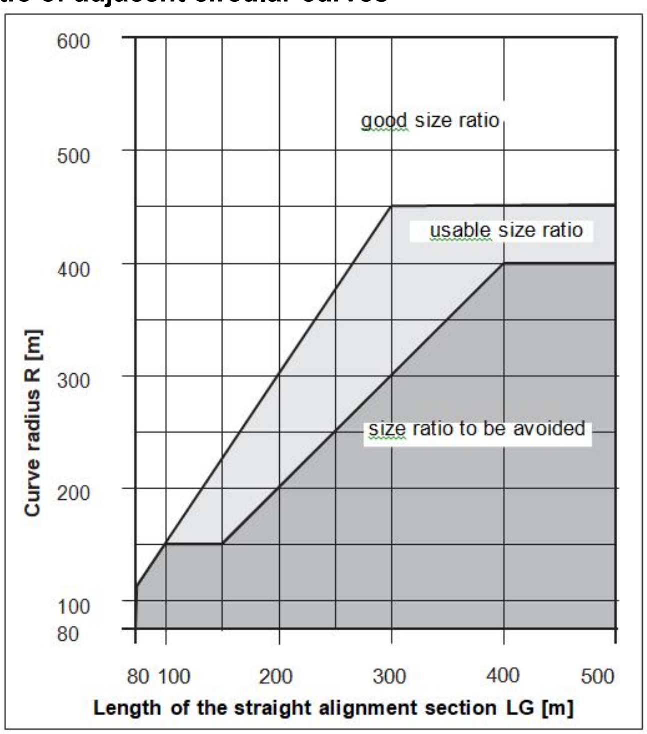


Figure 18 Curve radius in the continuation of direction of a certain length

Figure 18 Curve radius in the continuation of direction of a certain length shows the recommended range of size of circular curve radius, which follows the route depending on its length. In the most unfavorable case, the limiting size of the radius should be within the range of the usable length direction ratio and the radius size. A good relation should satisfy the values of direction length and circular curve radius for class K1 and K2. When the length of the line is Lp< 300m it is recommended that the radius of the following two circular curves are in the recommended ratio values, in compliance with the chart presented within Figure 18 Curve radius in the continuation of direction of a certain length

Direction as design element is not recommended between circular curves of the same direction. If, however, such a case cannot be avoided, the length of direction between the same circular curves should not be shorter than 600 m for class K1 and 400 m for class K2 and K3. In these cases, the ratios given in the chart on Figure 18 Curve radius in the continuation of direction of a certain length should be applied.

5.2.3 Transition curve

Transition curve is a design plan element between direction and a circular curve, as well as between two circular curves. In exceptional justified cases, it is possible to avoid transitional curve, for example when the difference in the sprung of two adjacent curves is minor or when the circular curve radius after the direction R> 1,000 m or in the case of an "S" curve with applied radius of R> 2,000 m
The transition curve is represented by a clothoid. The following relation applies to the clothoid:

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

A [m] = clothoid parameter

R [m] = Circular curve radius of the at the end of transition curve (clothoid)

L [m] = Length of transition curve (clothoid) from circular curve radius from 0 to R (R= ∞ - R)

While the clothoid parameter should be applied in the following range:

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

A/R ratio should tend to the upper allowed limit when applying small sizes of circular curve radius, and to the lower limit when applying large sizes of radius R. Clothoid parameter A<100 should be avoided.

The clothoid parameter AR / 3 ensures clothoid visual perception (change of the slope angle of clothoid direction by t> 3°)

Figure 19 shows the common manner of applying a transition curve.

The transition curve can be omitted for extremely "shallow" circular curves with a small turning angle.

The transition curve can be omitted in cases of particularly "shallow" circular curves with a small turning angle of t< 9°. The minimum length of such curves should be 200 m for local roads K1, 150 m for K2 and 100 m for K3. Rather than such "shallow" curve, it is possible to apply an apex clothoid.

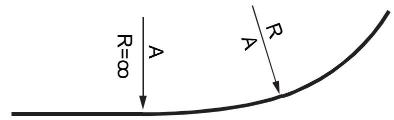
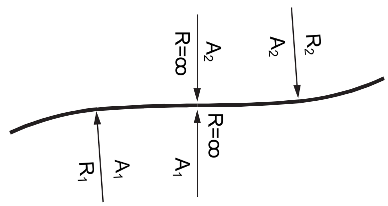
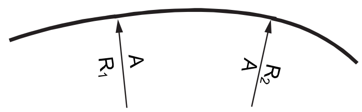
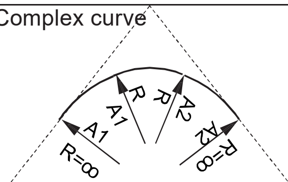
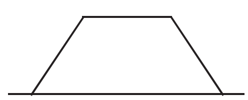
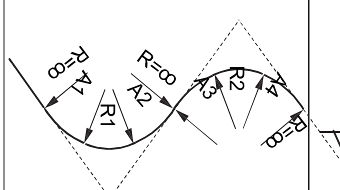
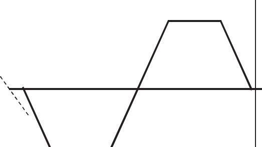
connection	appliance
Direction with circular curve	Simple clothoid 
Two circular curves	Reversible clothoid “S” curve 
	Oval curve “O” curve 

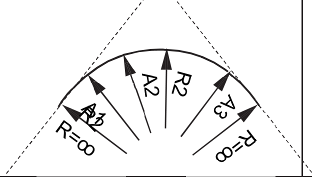
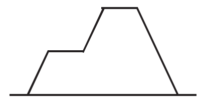
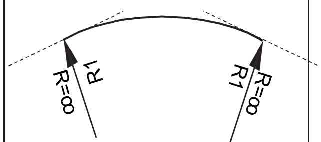
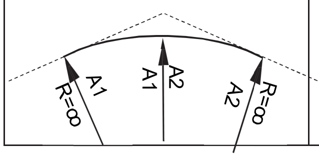
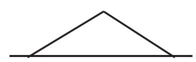
Figure 19 Examples of appliance of transition curves

5.2.4 Curve plan elements

The following examples show conceivable appliance and connections of curved plan elements of road axis. (Table 15 plan elements).

Table 15 Curve plan elements

Description	An array of curvature elements	Conditions for appliance	Grade
Complex curve 	R = ∞ - A1 - R1 - A2 - R = ∞ 	it is advisable that the curves are symmetrically designed so that A1 ≈ A2. In the case of different applied parameters, asymmetric curvature, the parameter ratio should be in the range A1: A2 ≤ 1.5	Very good
Alternate “S” curve 	R = ∞ - A1 - R1 - A2 - A3 - R2 - A4 - R = ∞ 	The adjacent curves ratio should be applied in accordance with chapter 5.2.2. It is advisable that both alternating “S” curves have the same applied clothoid parameter A2≈A3. In case of applying an asymmetric curve, the ratio A2:A3 should be max 1.5. In case there is an intermediate direction between two curves, its length shall not be greater than Lm ≤ 0.08•(A2+A3). Otherwise, both curves are designed separately as compound curves.	Very good

Oval curve 	R = ∞ - A_1 - R_1 - A_2 - R_2 - A_3 - R = ∞ 	When one curve lies inside the other, they do not touch and are not concentric to form an oval curve. The radius ratio should be adjusted according to chapter 5.2.2 The change in the curvature angle of the clothoid in the oval curve should be at least t ≥ 3°.	Good (provided that the terms of use are respected)
“Shallow” curve 	R = ∞ - R_1 - R = ∞ 	“Shallow” kerbs are allowed for small changes in direction γ<10°, or when applying large radius curves. The length of the curve should be aligned with the chapter 5.2.3. The cross slope of circular curve carriageway should be kept at the top for a length of 60m.	Good (provided that the terms of use are respected)
Curve with apex chothoid 	R = ∞ - A_1 - A_2 - R = ∞ 	Apex clothoids are allowed when applying minor changes in direction γ<10° Appliance of symmetrical curve is recommended where A1 ≈ A2. The length of the curve should be in accordance with chapter 5.2.3	Satisfactory (provided that the terms of use are respected)

5.3 Vertical profile

5.3.1 Longitudinal slope

The advantages of the finished level with minor longitudinal grades are:

- improvement of safety,
- capacity and level of service improvement,
- reduction of operational costs, traffic users’ costs and reduction of harmful gas emissions.

It is advisable to apply longitudinal grade i< 4.0%.

On the other hand, great values of longitudinal grade contribute to:

• better adjustment of alignment to the terrain,

• less impact on the environment in terms of construction intervention,

• lower construction costs

Table 16 provides the maximum values of longitudinal grades on local roads of class K, which should not be higher from the aspect of traffic safety.

Table 16 Max values of level longitudinal slopes

Design class	**max i** [%]
K 1	6 (7)
K 2	8 (9)
K 3	9 (10)
K 4	10 (12)

In exceptional, justified and explained cases, the maximum longitudinal grade should not exceed the value of 10.0%, on local roads of class K1-K3 (see chapter 5.7.1).

In tunnels longer than 400 m, the longitudinal grade should not exceed 4.0%.

Within the zones of surface intersections, a longitudinal grade i≤4.0% should be applied, while a grade i > 6.0% should be avoided.

In order to avoid delicate drainage areas of the carriageway surface, a minimum grade of i≥1.0% (preferably 1.5%) shall be ensured, particularly in inflection zones (see chapter 5.7.2). If in special cases the recommended minimum value of the level grade, with adequate proof cannot be provided, it is possible to apply grade i=0.7%

When it comes to cases when the carriageway edge is lined with elevated kerb, it is possible to apply a longitudinal grade of i = 0.5% towards all edge gullies. Otherwise, surface water from the carriageway is drained using special drainage systems.

On long bridge structures (clear length ≥ 100 m) and tunnels, a minimum longitudinal grade of i=0.7% shall be applied to ensure efficient drainage. In order to avoid pumping water outside the tunnel, depression locations on the leveling should be avoided.

5.3.2 Convex and concave vertical curves

The change in the grade of vertical alignment is warped by appliance of vertical curve. When radius of rounding of convex or concave curve is selected, a good embedding in the spatial plan shall be provided in addition to provision of good visual visibility, adaptation to the terrain topography and environmental protection.

Concave and convex level rounding are achieved with approximate appliance of circular arc using a square parabola.

Table 16 shows recommended minimal values of vertical curves and minimal tangent lengths at a point of change of the vertical grade

Table 17 Minimum and recommended values of convex (crest) and concave (sag) curves and minimal values of tangent lengths of rounding at a point of change of the vertical grade

Design Class	Convex (crest) curve Rvc [m]	Concave (sag) curve Rvs [m]	Minimum tangent length min T [m]
K1	3500, ≥ 6.000	2500, ≥ 3.500	85
K2	1250, ≥ 5.000	1250 ≥ 3.000	70
K3	900, ≥ 3.000	800, ≥ 2.000	55
K4	550, ≥ 2.000	400, ≥ 1.500	40

In some particular and justified cases, appliance of reduced values than recommended values of vertical rounding from Table 17 by 15% is possible, with particularly increased attention to the fact that the plan and profile elements overlap in position and complied size. Minor radius values of concave curves should not be combined with small radius values of horizontal circular curves. In any case, the spatial compliance of the plan and profile elements shall be checked in accordance with chapter 5.4. The required stopping visibility in accordance with 5.6 must be checked for each spatial section.

In other specific cases on hilly terrain, the applied radius of convex curve is greater than the concave one (see 5.4.2). Given the requirements for spatial alignment compliance, the radius of the vertical concave curve shall not be less than half of the adjacent convex curve. On the other hand, in case of slightly corrugated terrain and vertical change of grades, the applied concave curves radius should be significantly greater than the convex warping level radius in order to maintain the visual balance of road direction.

5.4 Spatial compliance of the plan and profile

5.4.1 General

The task of the road design and its equipment (elements for guidance along the alignment, terrain surface modeling, greening, etc.) in terms of the spatial conditions is to improve the road direction in terms of optimal visual guidance of the driver. At the outset, to enable the driver to acquire a visual perception of the road ahead in conditions of hilly terrain and curves with reduced visibility. Primarily, this task is effectively achieved by planting in a line at a safe distance from the edge of the road.

When horizontal and vertical design elements are overlapping (plan and profile elements), spatial road sequences appear. A linear series of such spatial road sequences can satisfy the spatial requirements of road direction, if the basic rules of linear arrangement and recommended sizes of design elements are applied (see chapters 5.2 and 5.3).

In general, spatial embedding of road direction is considered as satisfactory when the horizontal geometry contraflexures coincide with the vertical geometry contra flexures. It is explicitly unfavorable when the number of contra flexures in the vertical plan is greater than the number of contra flexures in the horizontal plan. If a different number of contra flexures of vertical and horizontal plans cannot be avoided, then the coincidence of contra flexure tangents cross of one level with the intersection of the contra flexures tangents in the second level should be avoided. In general, the vertical plan should be combined with the horizontal elements plan.

5.4.2 Standard spatial sequences - elements

Standard spatial elements are formed when the beginning and end of a horizontal curve coincides with the beginning and end of a convex or concave curve in vertical profile. The horizontal direction is considered as a horizontal design element with $R = \infty$ and is paired with a "rounded" continual longitudinal slope by vertical curve $Rv = \infty$, which is considered as a standard spatial element. Deviation from the precise overlapping of two elements is possible, by moving the start and end per direction for 20% of the horizontal plan element's length.

Figure 20 shows an example of road direction division on standard spatial elements.

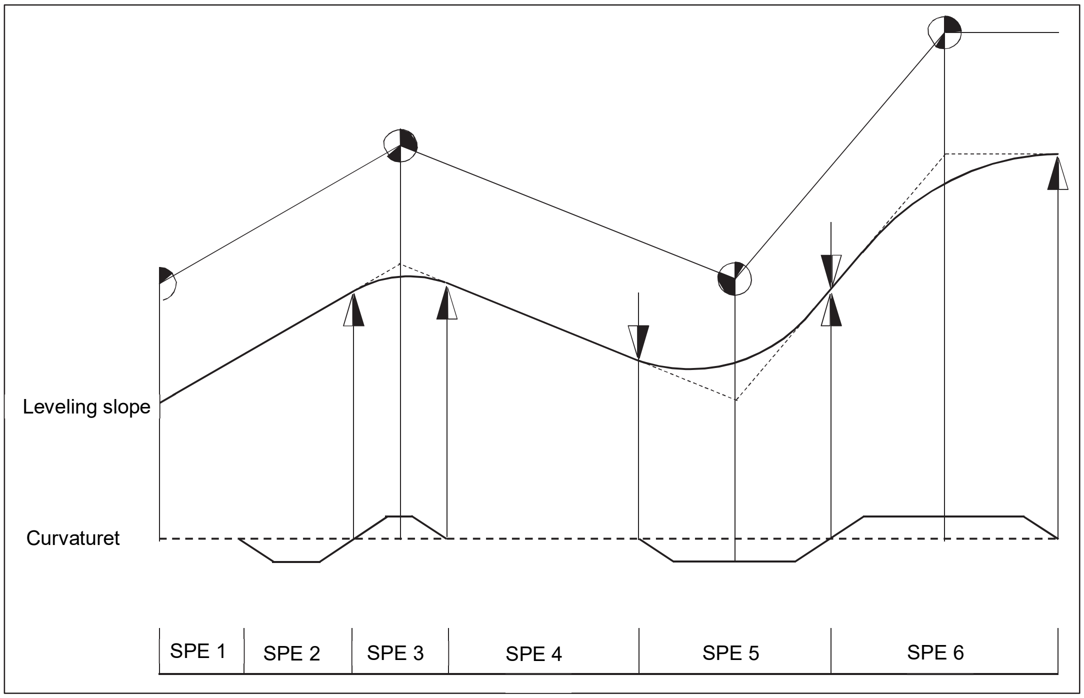


Figure 20 Example of road direction division into standard spatial elements (SPE)

Figure 21 and Figure 22 show the effects of different combinations of vertical and horizontal plan elements which form standard spatial elements.

A standard spatial element is established provided that the following conditions are met:

In case when vertices of a convex curve / horizontal curve are overlapping, it may be necessary to move the beginning of the curve before the start of the vertical convex curve to ensure visual requirement that the start of the horizontal curve is recognizable. The values given in Table 18 take into consideration the most unfavorable case of a number of plan and profile elements; directions (with constant longitudinal slope) - clothoid (with vertical convex rounding) - circular arc

Table 18 Required movement of the beginning of vertical rounding of convex curve behind the beginning of horizontal curve in the part of transition from the direction over the clothoid to the circular curve

Convex curve radius Rv [m]	**Clothoid parameter A** [m]			
	150	**200**	**250**	**≥ 300**
3.000	25	50	65	80
4.000	15	35	55	75
5.000		25	50	70
6.000		15	40	60
7.000	Movement is not required		30	55
8.000			20	45
9.000			10	40
10.000				30

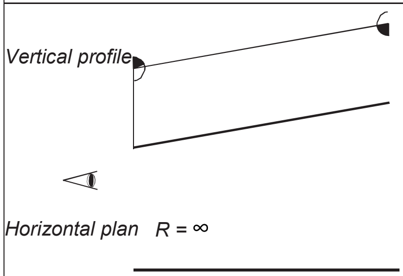
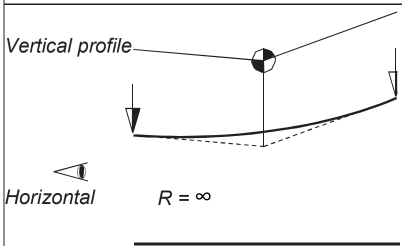
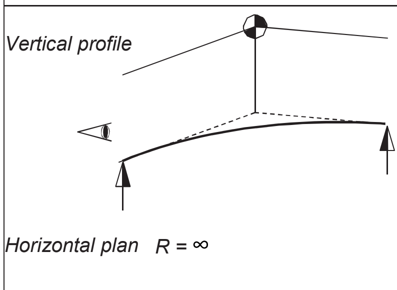
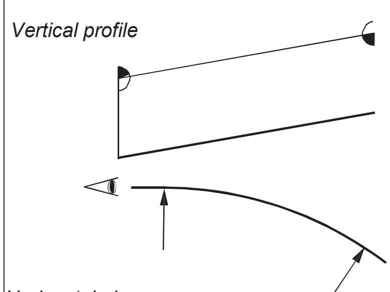
Horizontal plan/Vertical alignment	Perspective view	Grade / Recommendation
Direction on constant slope		
		- the road looks monotonous with long lengths, - it often does not visually suit well into the surrounding landscape, - enables a blinding effect during nighttime driving conditions, - the route fits well into flat terrain, - good conditions for formation of surface intersections.
Direction in concave curve		
		- allows good visibility and good visual traffic guidance, - good alternative of direction with a long slope with the use of a large value of vertical curve radius, - good conditions for forming one-level intersection, - good conditions for overtaking.
Direction in convex curve		
		- limited visibility - adversely affects the visual traffic flow - unfavorable conditions for forming a one-level intersection – - unfavorable conditions for overtaking

Figure 21 Standard spatial element with direction in horizontal plan

Horizontal plan/Vertical alignment	Perspective view	Grade / Recommendation
Curve on constant slope		
		- there are no problems in providing sufficient visual visibility - it fits well into the surrounding landscape - suitable for overtaking and forming surface intersections
Krajina u in concave curve		

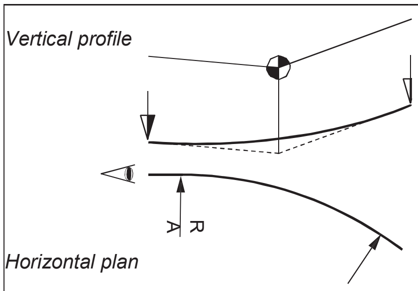
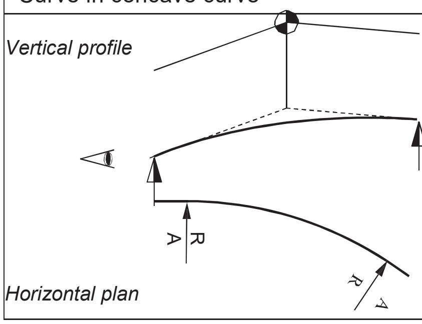
		- suitable for appliance of design elements with large curvature values - enables high speed in traffic movement - fits well into the surrounding landscape - provides good visual guidance - is not suitable for appliance of small values radius of circular curve in horizontal plan.
Curve in concave curve		
		- suitable for appliance of design elements with great values of curvature - enables good visual guidance - conditions lower traffic speeds - not suitable for forming surface intersections

Figure 22 Standard spatial element with curve in horizontal plan

Bridge structures are being adjusted to the road geometry. For example, instead of a bridge in slope between two concave curves, a longitudinal level with a great vertical radius should be formed.

5.4.3 Deficiencies due to route survey errors

Errors in creation of spatial elements and their sequences lead to negative consequences for the traffic flow on the road.

Table 18 lists individual cases of inadequately applied design measures and the consequences such measures on driving conditions and traffic safety.

Table 19 Impact of deficiencies on the spatial embedding and road function

Deficiency	Impact to the drivers behavior and traffic safety
Visual shadow (up/down route)	High
Unclear start of the curve	High
Stretching	Mid
Compression	low
Design disadvantages	Low

With respect to new road construction, the deficiencies listed in Table 19 should be entirely avoided, while, when it comes to rehabilitation and reconstruction, deficiencies having high negative impact on traffic safety and driver behavior, especially shaded visors, should be avoided.

Shaded sight

Shaded sight occurs when, at a certain height above the roadway (ho = 1.00m), part of the roadway level is invisible for the driver's eye, while the roadway in front of and behind that location is visible. Typically, this occurs when the level of the road is frequently up and down, i.e. when in front of the driver's sight is in gradient in a convex curve, followed by a down gradient, then a concave curve and a repeated gradient, so that the "dip" in the level is masked by a vertical curve in front, while the gradient behind is again visible. The described case could be very challenging if the shaded road surface extends over a length of more than 75m and if that area in front of the driver is located at a distance of less than 600m (Figure 23). In particular, the situation becomes critical if the depth of the shaded road surface is deeper than 0.75 m, and especially if in that zone the opposing traffic lane is used for overtaking. The assessment at that location implies possible ban on overtaking.

Areas of visible shadow can arise from up and down route levels (Figure 23)

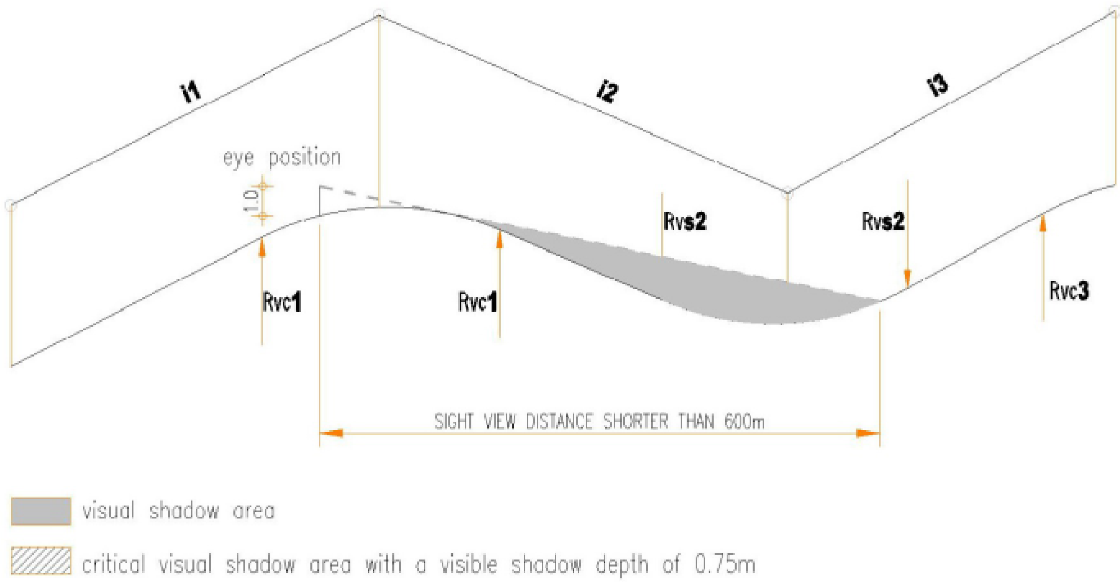
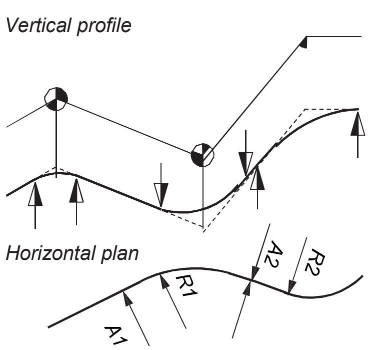


Figure 23 Critical sight with shaded surface

Horisontal plan/Vertical alignment	Perspective view	Grade / Recommendation
Skok		
		- Avoid multiple contra flexures in level within the zone of the horizontal plan element - Apply the largest possible radius of horizontal curve - Apply the level rounding radius greater than 5,000 m (without a constant slope between the vertical curves on vertical alignment) - The smaller the radius of the concave curve is, the
Uranjanje		

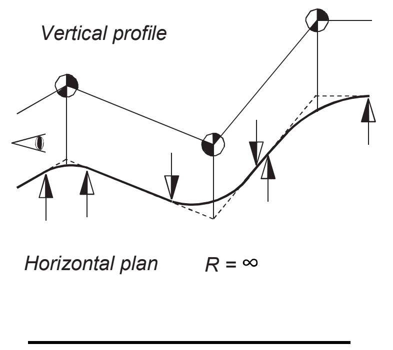
		deeper the zone of the shaded sight - Avoid leveling with a constant slope between two vertical curves when it come to a leveling contra flexure of less than 8%. - Inspection (e.g. using a perspective graphics) shall be performed within the zone of the first convex peak in short zones of constant vertical alignment slope

Figure 24 Shaded sight – corrugated vertical profile

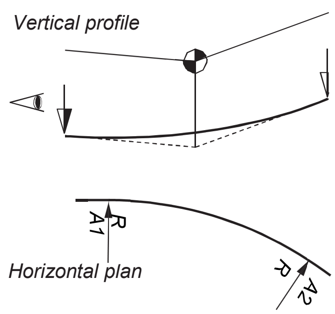
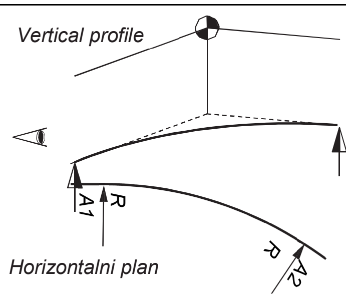
Horizontal plan/Vertical alignment	Perspective view	Grade / Recommendation
Extension – Extending the sight by applying a large concave vertical curve		
		- at the ratio R:Rv 1:10: there is a speed increase while the traffic safety is decreased
Compression – Shortening the view sight by applying a smaller convex vertical curve		
		- at the ratio R:Rv 1:10: there is a speed decrease while the traffic safety is increased - at the ratio R:Rv> 1:10: there is a effect decrease for speed reduction in this zone

Figure 25 Elongation and compression of sight at the same horizontal curve radius

Unclear beginning of horizontal curve

The beginning of the horizontal curve is hidden, if from a distance of 75 m, before the beginning of the horizontal curve it is not possible to see the road surface in front of the vehicle, at least up to the point where there is a change in the horizontal direction of 3°. It is necessary to enable the beginning of the convex vertical curve, which is visible for the driver, to be further away from the point of change of horizontal direction. With the use of a larger clothoid parameter (A ≥ 300 m), a satisfactory effect is attained, if the transition curve can be seen from a distance of at least 100 m (See Table 18).

Elongation and compression

The radius of the same horizontal curve visually appears to be additionally elongated in case of a concave vertical curve or additionally compressed in the case of a convex vertical curve

(Figure 25), compared to when it is on a constant level slope. The size ratio of horizontal and vertical radius (R:Rv) affects the effects of stretching/compression.

Deficiencies due to design inconsistency

Incoherence in road direction means that the driver has a disturbed balance in vision and driving (Figure 26 and Figure 27).

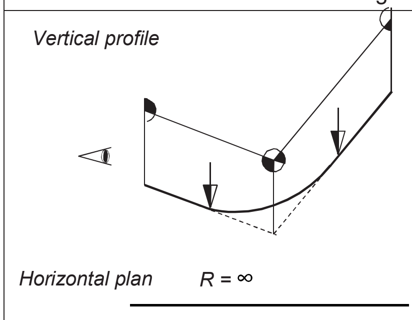
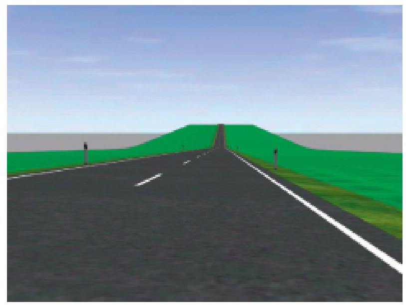
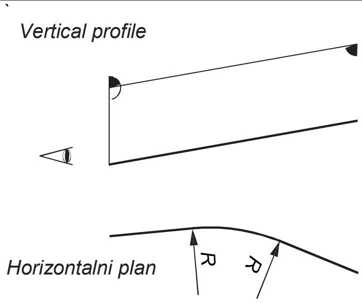
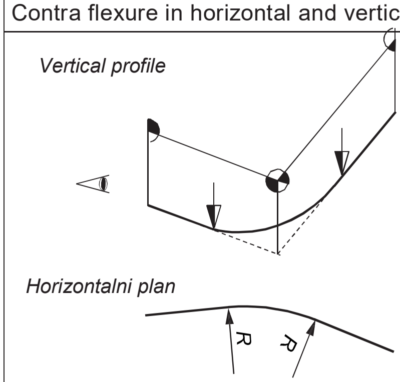
<table>
<tr><th>Horizontal plan/Vertical alignment</th><th>Perspective view</th><th>Grade / Recommendation</th></tr>
<tr><td colspan="3">Vertical contra flexure of vertical alignment</td></tr>
<tr><td>
</td><td></td><td rowspan="5">- Long horizontal lines with constant steps shall be avoided
- Concave vertical curves with short tangent lengths between long constant slopes shall be avoided.
- Appliance of min. values of vertical curves in case of leveling contra flexure of more than 10% shall be avoided.
- Direction contra flexures in direction in horizontal plan > 3° shall be applied.
- Use of contra flexure minor radius in horizontal plan shall be avoided.</td></tr>
<tr><td colspan="2">Contra flexure in horizontal plan</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td colspan="2">Contra flexure in horizontal and vertical plan</td></tr>
<tr><td>
</td><td></td></tr>
</table>

Figure 26 Designing disadvantages - contra flexures

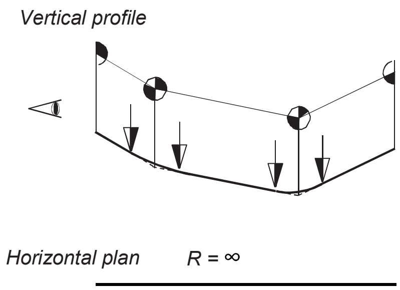
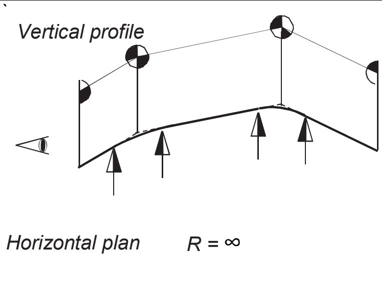
Horisontal plan/Vertical profile	Perspective view	Grade / Recommendation
Flatening		
		- Horizontal directions with constant longitudinal slopes between two consecutive concave or convex curves shall be avoided. - The engineering structures shall be adjusted to the route elements of vertical plan and, if possible, to the horizontal plan elements
Buckling		
		

Figure 27 Designing deficiencies - leveling and buckling of the road level, with or without engineering structures in the road base

5.4.4 Revision of spatial elements

The analysis of spatial elements is being carried out in three steps - working stages.

The first step includes verification whether the spatial elements are correctly established within the road direction sections and if there is sufficient coordination between the locations of the plan contra flexure points and the profile and the possibility of their correction through repositioning.

When the sections do not correspond with the standard spatial elements, the possibility of recomposing the location of the contra flexure points shall be checked.

Following the inspections and corrections in the first step, the second step of analysis includes those sections that did not meet the requirements from the first step. With regard to the spatial elements that are not sufficiently complied, further locations are checked where the starting points of the curve elements are not in time recognizable enough for the driver's eye, and whether there are shaded road surfaces.

These critical deficiencies must be eliminated using the procedure of changing the design elements of the plan and profile. One of the manners to effectively check the compliance of the designed alignment is by perspective sequences of road views, so that by look in the travel direction, the perception and recognizable reaction of the driver is simulated.

In the third stage, the presence of designing inconsistencies with regard to general principles and recommendations is checked. This procedure is consisted of qualitative analysis of the applied horizontal and vertical design elements, using the recommended visual perspective road view and its surroundings. The examples, explanations and recommendations given in point 5.4.3 can be used as support. After establishing that it is impossible or unjustified to apply the recommended design principles, these deficiencies could be tolerated and accepted, but prior appropriate clarification is required.

5.5 Relevant speed

The elementary parameters for roads design are the speed and request for traffic service, being uttered through the traffic load, i.e., the traffic flow through the road profile, on the basis of which the plan and profile elements, including the cross sections, are defined.

5.5.1 Basic speed V_0

The basic speed V_o is the initial program parameter related to the level of service of a certain road direction at the relevant traffic load Qmer (See Rulebook).

Table 20 V_0 Values in function of terrain characteristics

Type of road	Terrain characteristics		
	plain		plain
Remote	100	80	60
connecting	80	70	50
collector	60	50	40
Access	50	40	30

5.5.2 Computational speed V_r

The computational speed Vr is a theoretical speed which serves to determine the minimum limit values of the plan and profile. The calculated speed depends on the basic speed Vo and at the same time represents the highest safe speed in the free traffic flow when passing through the limit values of plan and profile elements. Vr values in a function of road category and terrain conditions are given in Table 21 Values of calculation speed Vr.

Table 21 Values of calculation speed Vr for two-lane roads

Type of road	Terrain characteristics		
	plain	hilly	mountainous
remote	100	100	80
connecting	100	80	70
collector	80	60	50
access	60	50	40

The maximum calculation speed is the highest speed that can be achieved on the road and it is determined as Vr + 20, i.e. it is a speed that ensures homogeneous uncertainty of the road.

5.5.3 Design speed V_p

Design speed Vp is being determined based on the applied geometric characteristics of the alignment plan and profile, whereby Vp is obtained as a function of the element geometry with the achieved driving comfort and safety. The design speed is in the range Vri ≤ Vp ≤ maxVr and is calculated as the resulting achievable speed derived from the applied plan and profile element, with the upper value not exceeding maxVr.

The profile graph of the design speed Vp is prepared by overlapping:

- Design speeds in a function of horizontal curve Vp-R radius
- Design speeds in a function of longitudinal slope Vp-i
- Driving simulations with a variation of Vp as a result of vehicle acceleration and deceleration due to plan and profile elements.

The design speed Vp analysis is performed during the design preparation stage when the resulting profile Vp is obtained, on the basis of which the design road elements are checked in function of the required visibility Pzp.

5.6 Visual visibility (sight distance)

5.6.1 Required stopping visibility - Pz

Road obstacles must be visible at any point, from the distance the driver needs to be able to see ahead and to have enough time to avoid an obstacle from a given speed assigned to the appropriate design class K, regardless of presence of water on the carriageway.

Figure 28 shows the values of stopping visibility depending on the design class K and the longitudinal slope of the road level.

In order to ensure adequate stopping visibility, the vehicle visibility must be at least 30% higher. This is primarily for the reason that the driver is provided with a full perception of the road ahead, and to enable driving without increased attention and to stop the vehicle safely when an obstacle is detected.

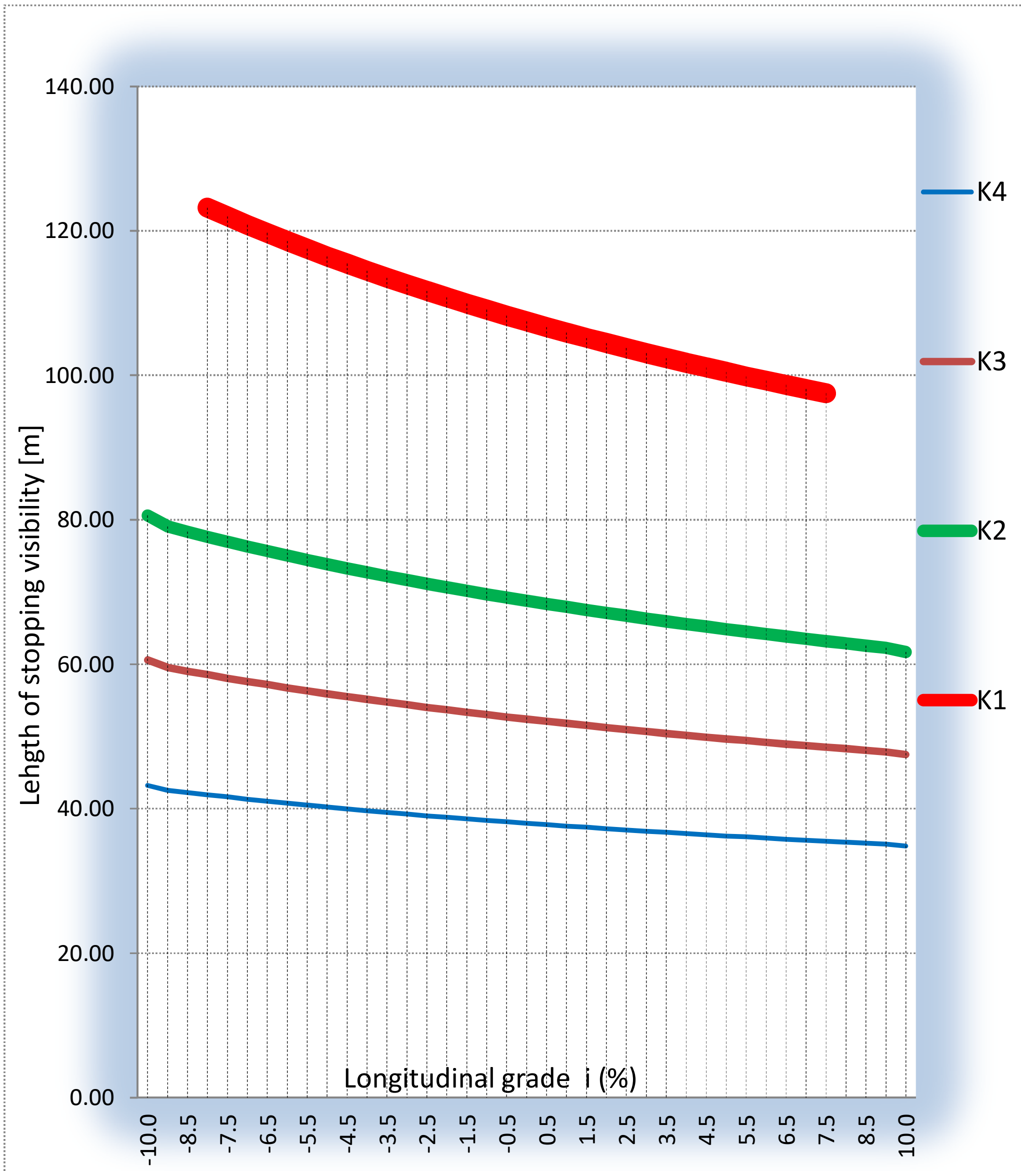


Figure 28 Required stopping visibility Pz in a function of level longitudinal slope and the design class K

In order to ensure traffic flow and safety, proper possibility of overtaking shall be ensured for vehicles driving at different speeds. In this regard, sufficient overtaking visibility shall be guaranteed. Overtaking on long sections of local road is done on sections with overtaking lanes and on roads of class K1.

5.6.2 Required visibility - Pzp

The required visibility implies safe driving conditions at a design speed Vp higher than Vr. Therefore, the existing visibility at each point of the road section is being checked, which should be within the limits of the required visibility, i.e. an appropriate correction is made in terms of ensuring the length of required visibility. Spatial elements that must meet the required visibility conditions are the vertical curves radius, visibility berms, visibility zones at intersections, etc.

Visibility is unhindered length of the sight line between the driver's eye and the target point, both at a height of 1.1m above the center of the carriageway. Visibility is being checked and ensured for both directions of traffic movement, in movement at the resulting design speed Vprez.

Based on the above inspection for both directions, a profile of the required visibility of the Pzp is done.

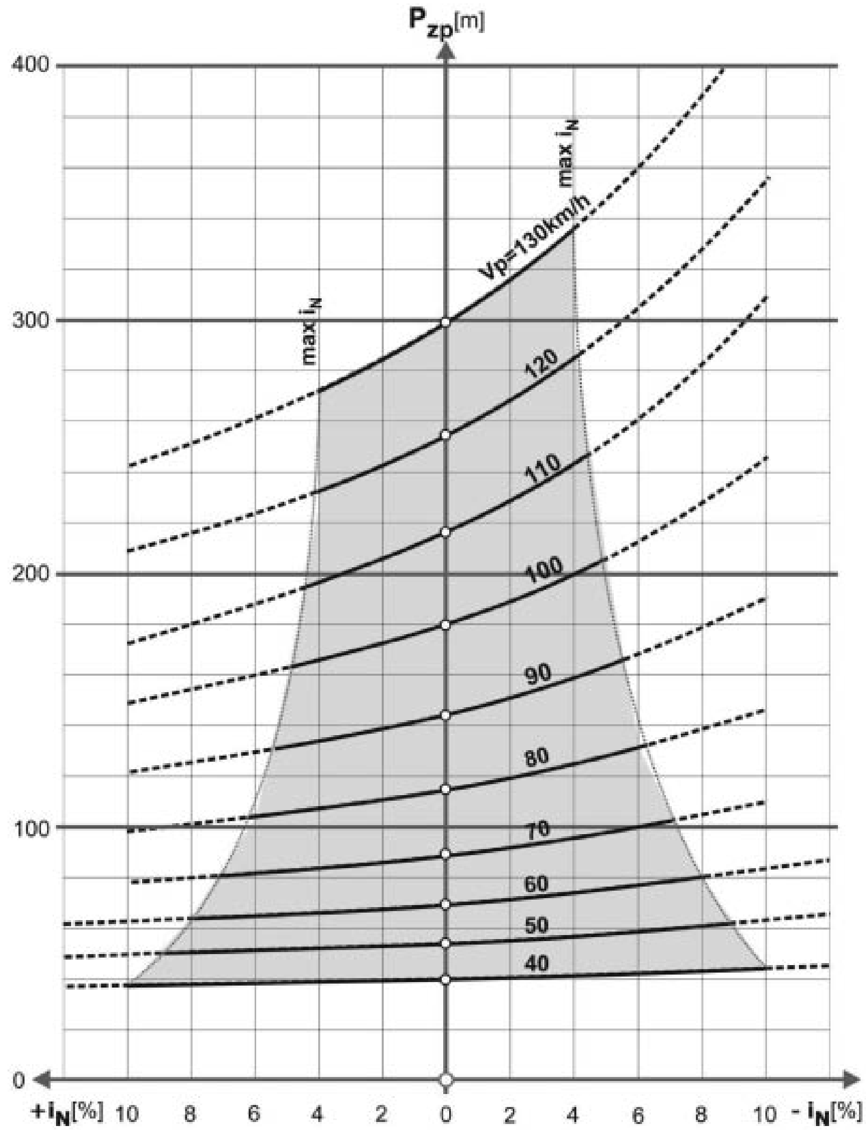


Figure 29 Diagram of required visibility (Pzp) in a function of (Vp) and longitudinal slope (±ip)

5.6.3 Inspection of stopping visibility

In the interest of traffic safety, at each point of the vehicle's movement, it shall be checked whether the existing visibility is better than the stopping visibility. This check is done in sections including vertical and horizontal road elements. When it is established that the existing visibility is less than the stopping visibility, and it is not possible nor justified to make corrections, while the correction is related to the environment protection, in that case the possibility of introducing a speed limit shall be considered.

5.6.4 Overtaking visibility - Pp

The required length of overtaking visibility shall be ensured on road sections where overtaking vehicles are driving at different speeds is possible.

The length of overtaking visibility depends on the calculation speed Vr. Within Table 22 Required lengths of overtaking visibility , values of overtaking visibility for a two-lane road are provided.

Table 22 Required lengths of overtaking visibility

Vri (km/h)	40	50	60	70	80	90	100
Pp (m)	260	320	370	430	480	540	600

5.6.5 Available visibility - Pr

The available road visibility is being examined graphically, by drawing visual strips (fields), taking all obstacles into account, such as natural terrain, guardrails, noise protection barriers, vegetation, structures on the side of the road and in the road bed, hanging parts of road equipment etc. With respect to the position of the driver's eye position located at a height of h=1.1m above the carriageway, a 3D analysis of the road route is done. In case of existing roads being under reconstruction or rehabilitation, the inspection is carried out on the spot. The results of the said analysis shall be presented graphically with a visibility diagram where all visibility values are entered (Figure 30). The analysis is performed for both driving directions, while the final result should clearly demonstrate the share in percentage of the provided overtaking visibility with regard to the total length of the road section. The obtained value [%] of overtaking visibility should be harmonized with the values given in Table 11.

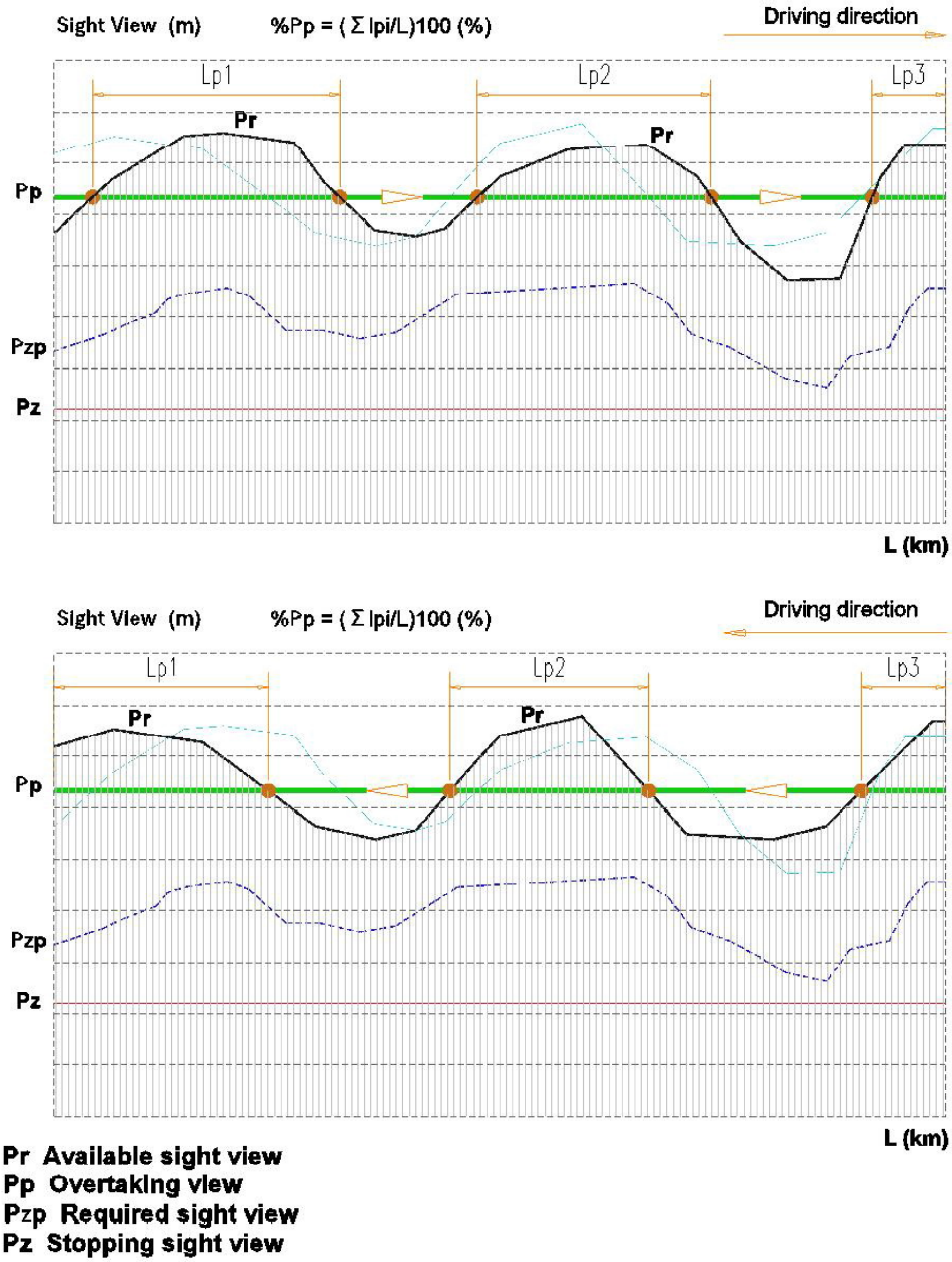


Figure 30 Visibility diagram

5.7 Carriageway leveling

5.7.1 Carriageway cross slope

Generally, one-sided carriageway cross slope is applied on road directions. The min. carriageway cross slope is ip = 2.5%.

Overtaking lanes, including the entry or exit lanes from the basic direction, maintain the carriageway cross slope of the basic direction.

In order to attain better visibility and driving dynamic conditions in horizontal curves, the carriageway cross slope is directed towards the center of circular curve gradually from the minimum value of ip = 2.5%, to the maximum value of ipmax = 7.0%, exceptionally 8.0%.

On Figure 31, the chart of carriageway cross slope in [%] is shown, in a function of circular curve R radius and is rounded-off at greater 0.5%.

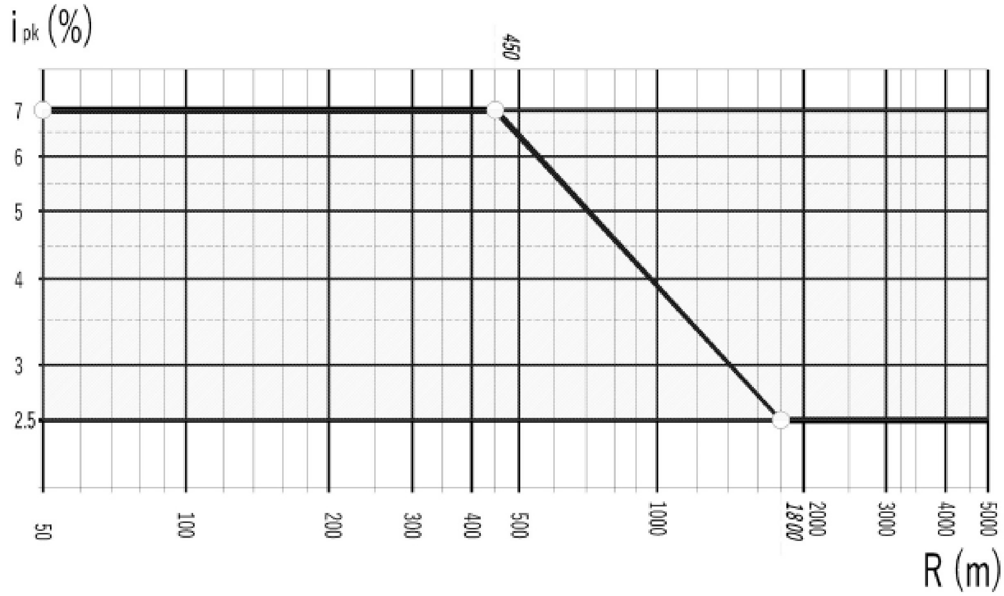


Figure 31 Cross slope in function of circular curve radius

$$ipki = 7\left(\frac{\min R(Vpki)}{Ri}\right)^{0.74}$$

Where:

Min $R(V_{pki})$ is the minimum radius of the horizontal curve in a function of resulting value of designed speed in the i-th curve (m),

i_{pki} cross carriageway slope in i-that curve,

R_i radius i-of that curve

On bridge structures, the radius of the horizontal curve should be selected in a way that the cross slope is limited to a maximum value of ip = 5.0%.

When it comes to appliance of the horizontal curve radius R> 2,500 m, it is possible to apply a negative value of cross slope ip = 2.5%, with a special explanation and provided that such a measure does not jeopardize the effective drainage of the carriageway.

In order to avoid possible run-off of the vehicle from the carriageway, in winter driving conditions, the resulting slope (cross + longitudinal) shall not exceed the value of max ir = 10%, where:

$i_{rez} = \sqrt{(i^2 + i_p^2)}$ (3)

i [%] = Vertical profile [%]

i_p [%] = Vertical profile

Shoulders or side strips shall be treated with a slope of 12% if the carriageway is drained over them, otherwise the slope is ip = 6.0% (4%).

5.7.2 Superelevation

A change of the cross slope (superelevation) is, as a rule, performed in the transition curve zone, regardless of the line around which the carriageway rotates. On carriageways with two opposite-direction traffic lanes, superelevation is performed, as a rule, around the road axis, or, in special cases, around one of the carriageway edges.

Superelevation around one of the carriageway edges is applied on one-way carriageways, and on junction slip roads, around the inner edge. On roads with separate carriageways, superelevation is performed around the carriageway edges along the median strip (the left edge).

If the transition curve is not applied (see chapter 5.2.3), superelevation is performed in two halves, before and after the contact point.

If in exceptional cases, superelevation is performed in a straight section zone as the plan element, then the change of the cross slope is done at the beginning or at the end of the straight section.

Superelevation should be avoided at all costs on road structures (bridges).

Figure 32 provides examples of the carriageway superelevation around the rotation point

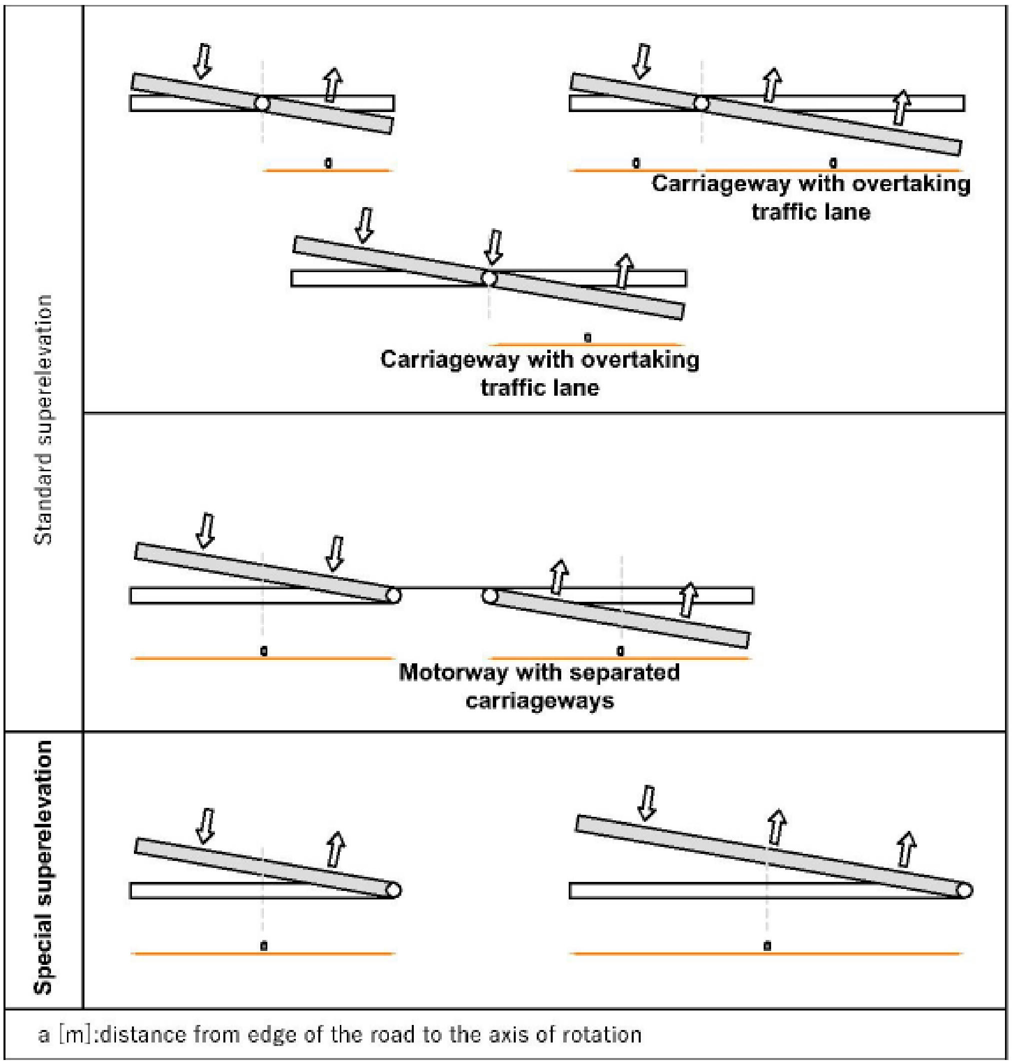


Figure 32 Rotation axes in carriageway superelevation zone

Specific cases

The superelevation ramp gradient i_{rv} [%] is the longitudinal gradient of the carriageway edge, rising/falling due to the change of the cross slope from the initial cross slope i_p to the final curve cross slope i_{pk} on the section where the superelevation is performed (most often in the transition curve). The change of the carriageway cross slope is performed by rotating the carriageway slab around the point located at the distance "a", from the carriageway edge (most often on the carriageway axis).

$$irv = \frac{i_{pk} - i_{pa}}{L_v} \; . a \qquad (4)$$

i_{pk} [%] = carriageway cross slope at the end of the superelevation ramp

i_p [%] = carriageway cross slope at the beginning of the superelevation ramp (with a negative sign if the initial slope is opposite to ipk)

L_v [m] = length of the superelevation ramp

a [m] = distance from the carriageway edge to the rotation point

In order to avoid an abrupt elevation of the carriageway edge, i.e., a change of the carriageway cross slope, through the superelevation zone, the maximum values of the superelevation ramp irv cannot be greater than the values shown in the Table 23 Borderline Values of Superelevation Ramp. When the recommended values for the circular curve radius and adequate values for the clothoid parameter are applied, satisfactory values for the superelevation ramp are obtained. Exceeding the superelevation ramp value i_{rv} can be avoided by applying greater values for the clothoid parameter.

If the calculated value min irv is in accordance with Table 23, when the rotation axis is placed eccentrically in the cross slope, greater than the max irv value, then the calculated value is considered relevant

Table 23 Borderline values of superelevation ramp

Design Category	**max irv** [%]	**min i_{rv}**[%] kod **$i_p \leq 2{,}5\,\%$**
K 1/K 2	0.8	0.10 · a
K 3	1.0	
K 4	1.5	
a [m]: Distance from carriageway edge to rotation point		

The minimum length of the superelevation ramp is obtained from the following formula:

$$min\ L_v. = \frac{i_{pk} - i_p}{max\ irv} \; . a \qquad (5)$$

min L_v [m] = minimum length of the superelevation ramp

i_{pk} [%] = carriageway cross slope at the end of the superelevation ramp

i_p [%] = carriageway cross slope at the beginning of the superelevation ramp (the cross slope has a negative sign if the initial slope is opposite to ipk)

max i_{rv} [%] = maximum superelevation gradient

a [m] = distance from the carriageway edge to the rotation point

The basic superelevation forms are shown in Figure 35.

Use of Superelevation for Carriageway Drainage

In order to obtain proper water drainage from the carriageway surface in the zone of transition from one superelevation zone to another (inflection point) with a counter cross slope, where this slope varies from i_p=2,5% to i_p=-2.5%, it is necessary to secure that the superelevation ramp gradient is not below the min irv value, in accordance with the values from Table 23. It is necessary to check the borderline values min irv for every transition curve in the zone between the inflection point with i_p = 0% and the point where a cross slope i_p = ±2.5% is obtained, i.e., a minimum superelevation ramp gradient min irv must be provided. The superelevation left until the final value for the cross slope i_{pk} is obtained is done by constantly increasing the value of the superelevation ramp i_{rv}.

In order to provide minimum conditions for water drainage from the carriageway surface, a resulting gradient of 0.2% for the carriageway surface in the superelevation zone must be provided, i.e.

$$i - i_{rv} \geq 0,2\ \% \qquad (6)$$

meaning:

i [%] = longitudinal gradient of the road alignment

i_{rv} [%] = superelevation ramp gradient

Fulfilling the conditions from this relation also eliminates the possibility of the development of a counter slope of the carriageway edge regarding the alignment in the superelevation zone.

Generally speaking, taking into account the conditions for providing efficient water drainage from the surface, the resulting carriageway surface gradient should be ir ≥ 0.5%.

If providing minimum values for the resulting longitudinal carriageway gradients is not possible for the limiting construction reasons, then the inflection point can be moved in relation to the beginning of the transition curve by L = 0.1A.

The change of the carriageway cross slope on the straight sections is allowed outside the zones of poor conditions for the carriageway surface drainage.

A deciding factor for the superelevation ramp in the carriageway widening zone or the zone of the introduction of an additional traffic lane, is the gradient of the basic driving lane.

The transition from the carriageway surface with a centerline crown to a cross slope should be performed in accordance with the example given in Figure 36.

5.7.3 Carriageway Widening in Small Radius Curves

Two-way roads where the horizontal curve has a radius R <200 m, should be widened by the value Pk. The widening of the carriageway by the total value Pk is applied on the entire length of the circular curve and on its inner side as a rule. The required widening is calculated using the following formula:

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

Pk [m] = Carriageway widening

R [m] = Horizontal curve radius 0

The widening distribution from 0 to Pk is performed linearly in the transition curve zone (Figure 34).

With roads where selective traffic involving vehicles of various dimensions in traffic lanes is expected, the widening is performed in traffic lanes by the value Δp depending on the vehicle dimension and combination of vehicles passing each other in the circular curve zone. The widening is performed by the “Rulebook” and using the nomogram in Figure 33

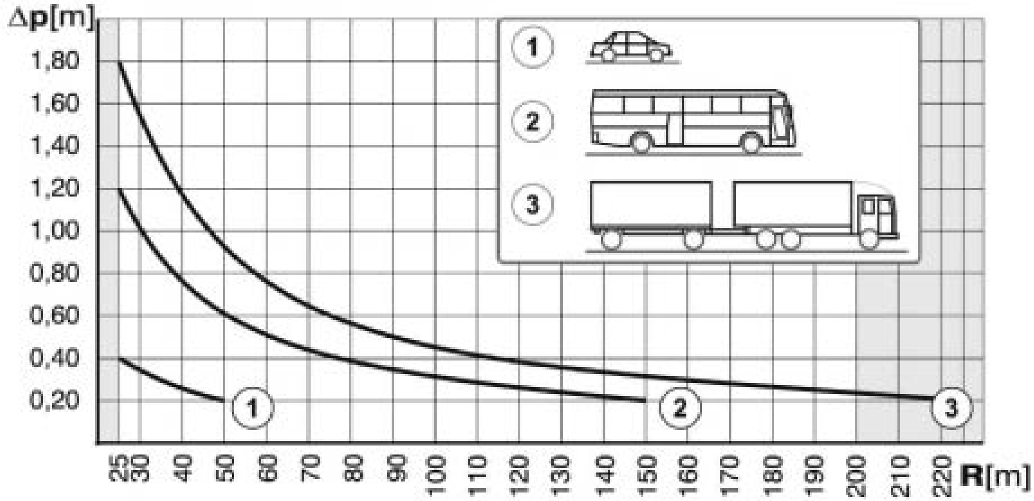


Figure 33 Required scale of traffic lane widening in curve

Total widening Pk = ΣΔpi

In order to keep the continuity of the road edge line in the carriageway widening zone, greater values than the minimal lengths of the plan elements are applied, where the minimum length for the transition curve is 15.0m, and for the circular curve as well. Formation of the carriageway edge lines is otherwise done using the relevant vehicle trail curve. The distribution of the carriageway widening in the curve is provided in Figure 34. The widening Pi at the distance Li from the widening beginning is calculated using the formula

$$Pi = \frac{1}{2}P(1 - \cos x\pi), \qquad x = \frac{Li}{L\Delta}, \qquad Pi = \Sigma\Delta pi$$

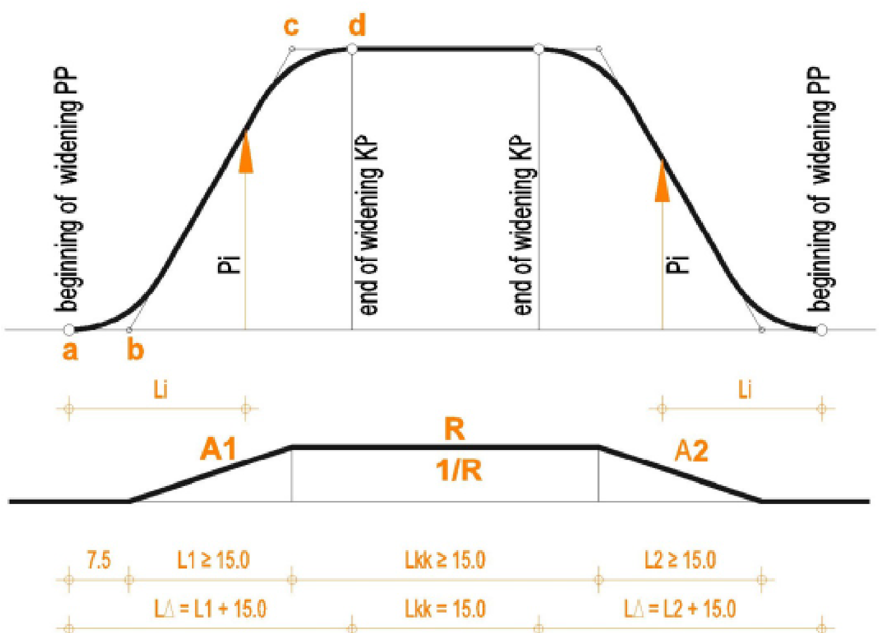
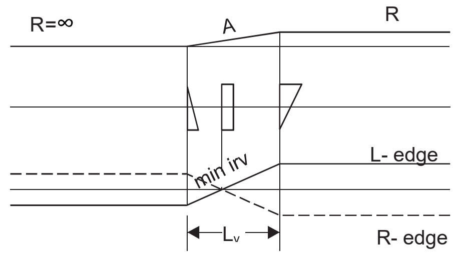
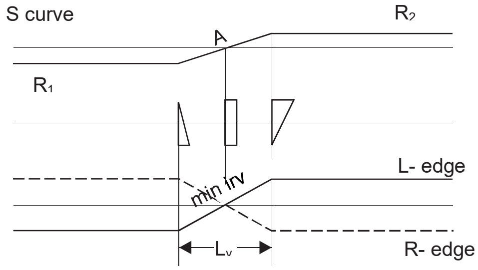


Figure 34 Graph showing widening distribution in a simple horizontal curve

<table>
<tr><th>Superelevation</th><th>irv</th><th>Straight section - transition - curve</th><th>Curve - transition - curve</th></tr>
<tr><td>Opposite cross slope of different or same cross slope value ipk</td><td>≥min irv</td><td>
</td><td>
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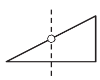
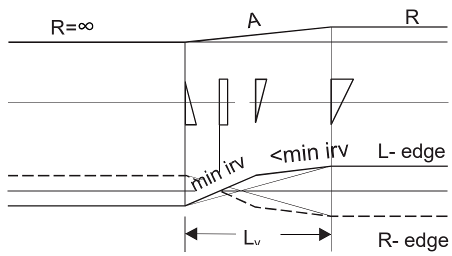
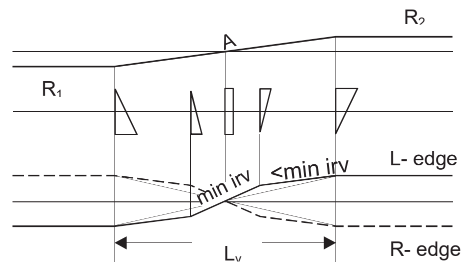
<tr><td></td><td><min irv</td><td>
</td><td>
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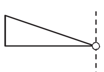
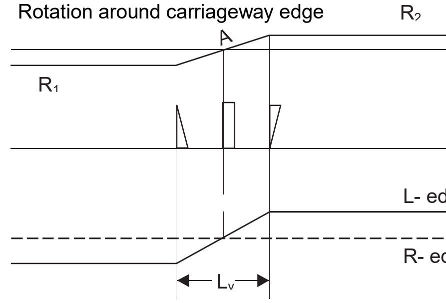
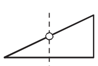
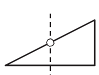
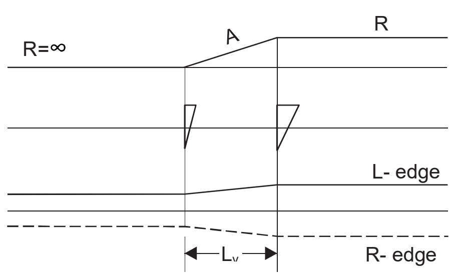
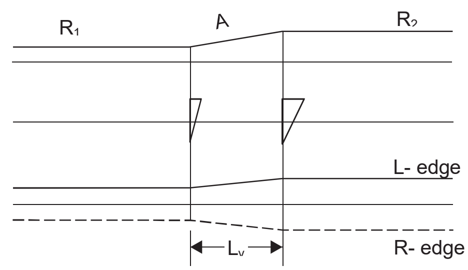
<tr><td></td><td>≥min irv</td><td></td><td>Rotation around carriageway edge
</td></tr>
<tr><td>Same direction cross slope
Different value of cross slope</td><td></td><td>
</td><td>Ovoid curve
</td></tr>
</table>

Figure 35 Carriageway superelevation with cross slopes

o Rotation point

L_V Superelevation length

min irv Minimal superelevation ramp gradient

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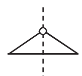
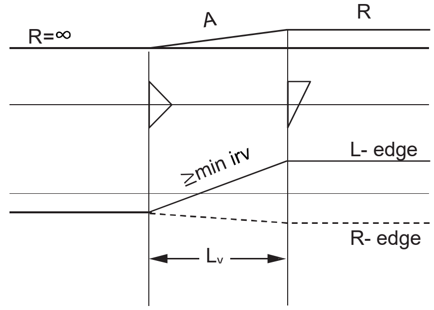
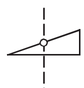
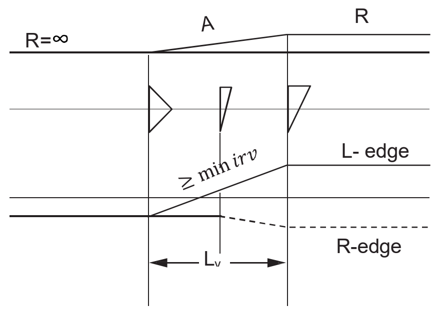
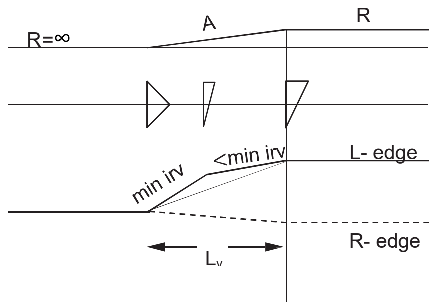
<table>
<tr><th>Superelevation</th><th>irv</th><th>Straight section - transition - curve</th></tr>
<tr><td>Centerline crown carriageway cross slope
</td><td>$\geq \min irv$</td><td>
</td></tr>
<tr><td>Single carriageway cross slope
</td><td>≥min irv</td><td>
</td></tr>
<tr><td></td><td><min irv</td><td>
</td></tr>
</table>

Figure 36 Two sided slope superelaevation (roof profile)

o Rotation point

L_V Superelevation length

min irv Minimal superelevation ramp gradient

In case that the applied clothoid is insufficiently long for the superelevation to be performed in its zone, with very sharp curves, then the beginning of the superelevation overlaps with the straight section on one side and the circular curve on the other. In that case, introduction of a separate inner carriageway edge axis is possible in order to incorporate the carriageway widening in the curve into the superelevation process.

5.7.4 Carriageway widening

The edge of the road in the carriageway widening zone can be marked using two square parables to form an S curve, or to be defined using a separately defined axis outside the main road axis with two circular opposite direction curves. Formation of an independent road edge axis is advisable, if the driving lane is oriented towards the road edge. In order to avoid the formation of counter curves in the zone of “sharp” radius curves, the carriageway widening line should be extended, i.e., the carriageway edge in the widening zone should be independently geometrically shaped.

The carriageway widening in case of an increase of the basic driving lane width should be performed independently in relation to the road axis, through an independently formed road edge axis.

Carriageway widening for the purpose of lateral relocation of the basic driving lane on the location of the formation of a left turn lane is performed analogically (see chapter 6.4.5).

Table 24 contains the recommended section lengths for the carriageway widening.

Table 24 Carriageway widening section lengths

Carriageway widening d [m]	**Length of widening line l_z** [m]		
	K 1 K 2	K 3	K 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	–

5.7.5 Special Recommendations for Construction of Carriageways in Bridge and Tunnel Zones

Bridge structures need to be adapted to the road carriageway.

The length of the bridge structure depends on the angle of the structure's axis intersection with an obstacle. This angle should range from 72°to 108° to achieve an optimal bridge length.

Applying the straight section as a design road element in the bridge structure zone is the most efficient measure, and if a circular curve cannot be avoided, a radius allowing the application of a cross slope of max ip=5% should be selected.

Transition curves in the bridge zones, as well as cross-slope modifications, should be avoided.

Application of a continuous longitudinal gradient is advisable on the bridge structure location. With very long bridge structures, application of the constant plan element, the straight section or the circular curve values is advisable, and also the value of the longitudinal profile with constant gradient or in the constant vertical curve, which is suitable for the selected bridge construction technology, the incremental launching method.

To provide efficient drainage of the carriageway surface, the longitudinal gradient should be min i = 7.0% on bridge structures with a sheer length: 100m.

In places where it is not possible to avoid the application of a concave or convex curve on the longitudinal profile, small longitudinal gradient at peak points require short distances between the gutters on the structure, which increases the costs of construction and maintenance. Depression points should be especially avoided due to difficult drainage and consequently, safety reasons.

Tunnel structures should be designed with as comfortable plan and profile elements as possible. The longitudinal tunnel gradient shouldn't generally be greater than i=3.0%, and with tunnels longer than 500m, the maximum longitudinal gradient should not be greater than i=2.5%.

6 Traffic nodes – Intersections

6.1 General

Intersections on a local road are designed in accordance with the category of the road with which the road is connected. They differ in accordance with the basic structural and operational form. The basic structural forms are: junctions, partial junctions, grade separated junctions and one-level intersections or intersections and roundabouts (see Table 25). Grade separated and partial junctions consist of several intersections in the form of on-ramps, off-ramps, access roads, intersections and roundabouts and respective ramps. The difference is mainly in the right-of-way through the intersection being regulated with traffic signage or traffic lights.

From the point of view of the safe flow of traffic on local roads, European practice recommends the application of the following principles when designing intersections:

- Avoid the use of four-leg intersections wherever possible, as they do not provide sufficient safety capacity. Apply the principle of two dislocated three-leg intersections or a roundabout.
- Use traffic lights only in the case when other solutions do not ensure sufficient traffic flow and safety.
- It is recommended to use roundabouts instead the use of three-leg intersections for the reason of ensuring greater traffic safety.
- In the case when the ratio of traffic intensity between the primary and secondary directions is 5-10 times higher in favor of the priimary direction, the priority over the roundabout is the implementation of a three-leg intersection.

6.2 Intersection planning

6.2.1 Basic requirements

Traffic nodes are designed so that traffic can flow safely through the intersection, turn and enter, turn and pass. To achieve an intersection function for all types of traffic and all roadways, it is necessary that:

- It can be timely spotted
- It is obvious
- The traffic function is comprehensible, especially the right-of-way
- An easy and safe passage for drivers and pedestrians is provided.

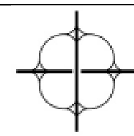
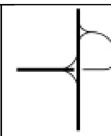
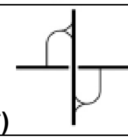
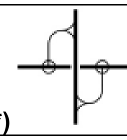
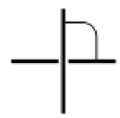
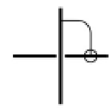
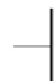
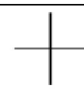
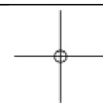
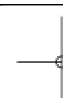
Also, the number and appearance of intersections on one roadway should allow for the planned driving speed at the planned traffic volume and service level to be attained.

To maintain a recognizable concept of roadway standardization, it is recommended that a uniform intersection design is applied on that roadway.

Intersections of local roads of designing categories K1 and K2 with the local road K4 are not recommended, which also stands for the access of country roads. Country roads accessing the category K3 local roads should be reduced to a minimum.

It is necessary to check if the intersections meet the prescribed level of service, as well as maintain the average value of the basic driving speed, adopted for a specific roadway.

Table 25 Basic structural traffic node forms

Basic structural forms	Traffic function in sub-node / node		Examples (Main roadway is vertical)	
	Main roadway	Secondary roadway		
Grade separated crosses	Entry / Exit	Entry / Exit		
Partial junctions	Entry / Exit	Left and right turn / Turn - roundabout	 *)	 *)
Aligned slip roads at partial junction	Left and right turn	Left and right turn / Turn - roundabout		
Intersections				
Access road	Left and right turn	Left and right turn		
Intersection	Left and right turn Intersection	Left and right turn Intersection		
Roundabout	Roundabout			
*)Intersection can be designed as a rhombus. Road with right-of-way is in bold				

6.2.2 Distance between Traffic Nodes

The distance between the traffic nodes (intersections) should be long enough to secure safe traffic flow at the designed speed. For design category K1 roads, the distance between the intersections should not be less than 3 km, and for design category K2, it should not be less than 2 km.

If the local road network requirements dictate shorter distances, the possibility of integrating two nodes or intersections into one should be considered.

6.2.3 Primary or Main Local Road

In the case of intersections, roads with a higher design category K have an advantage. When both roads have the same K category, the local road with a higher traffic volume (PGDS) has an advantage.

In cases when one road merges into another, the one with a continual traffic flow has an advantage.

6.2.4 Alignment

Axes of intersecting roads also intersect as a rule, as much as possible, at a right angle, i.e., at the angle ranging from 70° - 110°. Otherwise, the secondary road axis is laterally moved to the right, or, instead of an intersection, two “T” intersections are formed by moving the axis to the left, as shown in Figure 37. Lateral relocation of the roadway to the right for perpendicular intersection with the primary road is a financially more favorable solution. The relocation to the left has certain advantages:

- Capacity is increased
- Waiting time is reduced
- Mandatory waiting is clearer
- Traffic safety is increased

In any case, both solutions should be considered and explained.

Visibility in the intersection zone is of great importance for traffic safety. Early detection of the right of way is of particular importance, especially when approaching the intersection, without regulation with traffic lights, from a secondary road, when turning left, right or at the intersection. On the other hand, the traffic lights system must be easy to spot at the intersection from every direction.

Design category K1 intersections must be easy to spot from the distance ≥ 300m, K2 intersections from the distance ≥ 200 m.

The most favorable case for intersection visibility is when it is located in a concave curve. The intersection must be provided with adequate traffic signage.

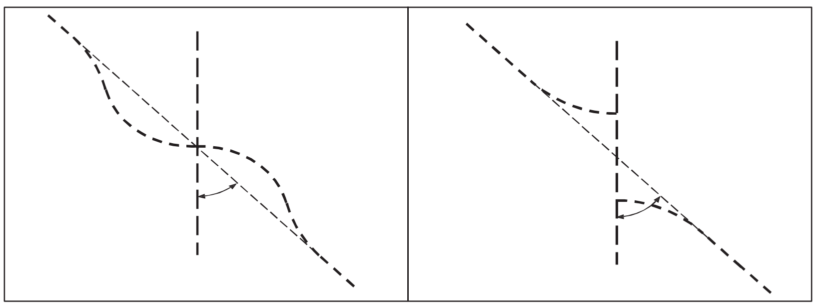


Figure 37 Secondary road access at intersection.

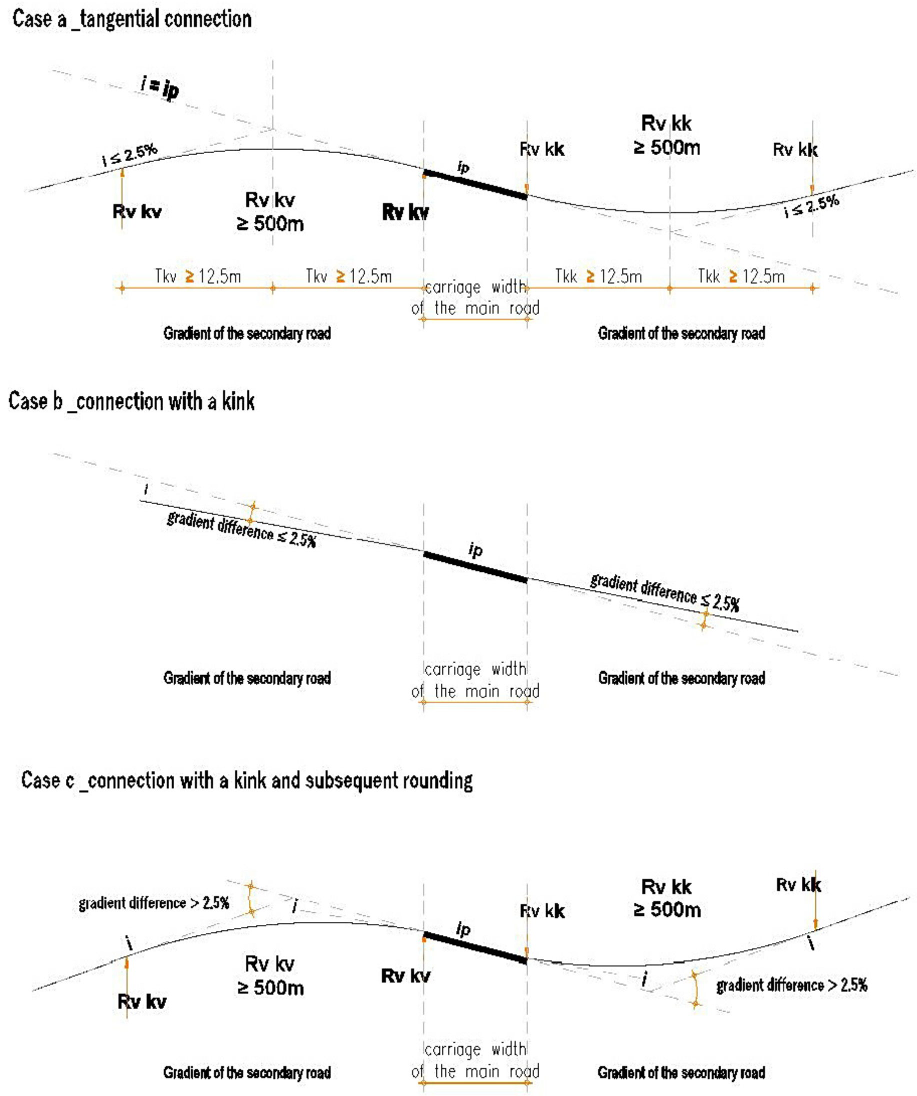


Figure 38 Vertical primary and secondary road intersection plan

For the primary road in the intersection area, the general specifications for the routing in the horizontal plan, and vertical plan according to Sections 5.2 and 5.3 apply unchanged. The cross slope is set according to Section 5.6.1.

Gradients and road surfaces of the secondary junction access points are to be adapted to the geometry of the primary road alignment.

The longitudinal slope of the primary road alignment at the intersection access should be as little as possible, not bigger than 4% (max 6%).

The longitudinal slope of the secondary road alignment at the intersection access should be smaller than the allowed values for the slope shown in Table 15. Limitations help provide visual clearance, the length of stopping distance and the necessary length for the acceleration of a vehicle. At immediate access points at intersections from a secondary road, it is necessary to provide a maximum longitudinal slope of 2.5%, at the distance L ≥ 25 from the primary road carriageway edge.

The longitudinal slope of a secondary road can have an access to the cross slope of the primary road carriageway in many ways. The tangent connection (Figure 38 example a) implies the connection of a longitudinal slope of the category K2 or K3 secondary road with the cross slope of the category K1 or K2 road carriageway. The transition from the longitudinal slope of the secondary road to the cross slope of the primary road carriageway is rounded using a vertical curve Rv ≥ 500 m, with the condition that the length of the curve tangent is T ≥ 12.50 m.

If the condition to provide access of the secondary roadway alignment to the cross slope of the primary roadway carriageway using the previously described method cannot be fulfilled, then it is possible to provide access of the secondary road longitudinal slope to the primary road cross slope using an alignment break (Figure 38, examples b and c). A breakpoint formed like this is not rounded if the difference in gradients at the breakpoint is less than 2.5% (Figure 38 example b), i.e., it is rounded using a vertical curve Rv as with the example c, in Figure 38, if the alignment break is more than 2.5%

6.3 Types of intersections

6.3.1 Traffic Management and Intersection Types

The basic structural form results from the requirement for directing the traffic flow on roadways being connected in the intersection zone (Table 25). The type of intersection is established based on the combination of the structural form and the operational form.

6.3.2 Areas of Intersection Type Application

Types of intersections with adequate limitations are applied on roads with an allocated design category K.

Table 26 and Table 26 show the standard selection of the intersection type application.

- In exceptional cases for which a special explanation should be provided, due to certain requirements or local conditions, while taking into account the conditions given in chapter 2.1 (traffic safety, level of service, compatibility with the environment protection and construction costs), the second intersection type can be applied, due to better applicability.

Table 26 Standard application of intersection types with four access roadways

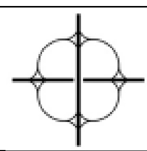
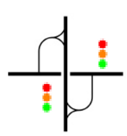
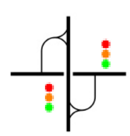
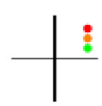
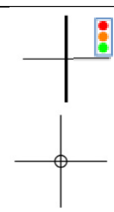
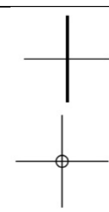
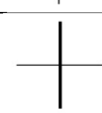
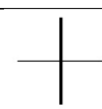
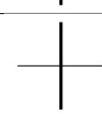
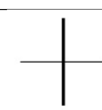
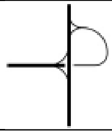
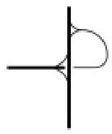
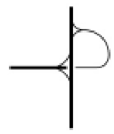
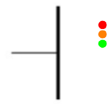
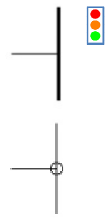
Primary road **Secondary road**	**AP**	**K1 (PP21)**	**K1**	**K2**	**K3**	**K4**
K1 (PP21)				**Traffic lights** **Consider the necessity of introducing traffic lights**		
K1				**The primary road is shown vertically** **Road with right of way is shown in bold**		
K2	**Not applicable**	**Not applicable**				
K3	**Not applicable**	**Not applicable**	**Not applicable**			
K4	**Not applicable**	**Not applicable**	**Not applicable**	**Not applicable**		

Table 27 Standard application of intersection types with three access roadways

Primary road / Secondary road	AP	K1 (PP21)	K1	K2	K3	K4
K1 (PP21)						
K1						
K2	**Not applicable**	**Not applicable**				
K3	**Not applicable**	**Not applicable**	**Not applicable**			
K4	**Not applicable**	**Not applicable**	**Not applicable**	**Not applicable**		

Traffic lights

Introduction of traffic lights should be considered

Primary road is shown vertically
Road with right of way is shown in bold

The selection of the intersection type as well as the design category must be adapted to the traffic requirements and local conditions for each intersection respectively. The following entry parameters must be considered:

- Intensity and direction of traffic flow
- Adjacent traffic nodes
- Spatial conditions
- Limiting conditions
- Natural conditions in the field

Frequently used access roads leading to the surrounding properties are treated as the design category K4 access roads. The use of traffic nodes depending on the design category K was analyzed in chapter 6.3.3

6.3.3 Formation of Traffic Node Types

6.3.3.1 Grade separated junctions

Grade separated connect roads intersecting on two levels. They consist of on-ramps, off-ramps and connection ramps. These intersection types are applied when the local road of K1 design category with separate carriageways for each direction and the cross-section PP21 (Figure 11) intersects with the motorway (MW). A standard solution for junctions designed like this, with four traffic directions, is the “clover leaf junction” (Figure 39).

Grade separated connection with three traffic directions is applied when the local road of K1 design category, with separate carriageways for each direction and the cross-section PP21 is connected to the motorway. A standard solution for junctions designed like this, with three traffic directions, is the “trumpet” (Figure 40).

Grade separated traffic nodes are designed in line with the Rulebook, Appendix 4,1. Junctions. Exit and entry traffic zones are designed with one traffic lane in accordance with chapter 6.4.2 and 6.4.3. Ramps are formed as “S” curves as a rule, in accordance with chapter 6.4.4.

6.3.3.2 Partial grade separated junctions

Partial grade separated junctions connect roads intersecting on two levels. They consist of on-ramps and off-ramps and the ramps connecting on the primary road and with three-leg intersections on the secondary road, with or without traffic light regulation or with roundabouts. Intersections like this are applied when the design category K1 local roads (Figure 11) intersect with the motorway (MW) or with the design category K1 local road with dual carriageways (Figure 11). In special cases, which should be proved through the significance of connecting in the sense of traffic, it is possible to apply this type of intersection when a category K2 secondary local road is in question, and intersections are done without the traffic lights.

A standard solution for grade separated junctions designed like this, with four traffic directions, is the “partial cloverleaf” junction type (Figure 41).

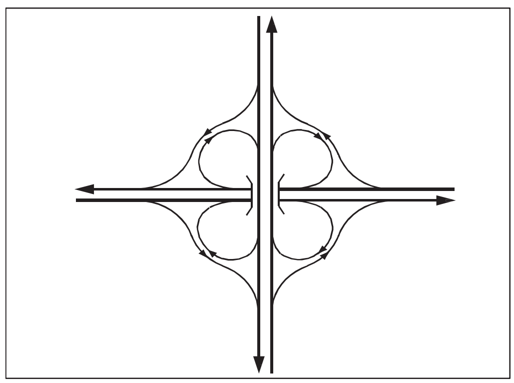


Figure 39 Schematic of “cloverleaf” junction”

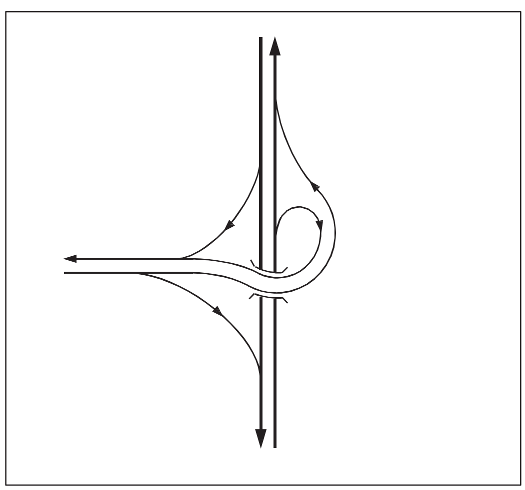


Figure 40 Schematic of “trumpet” type junction

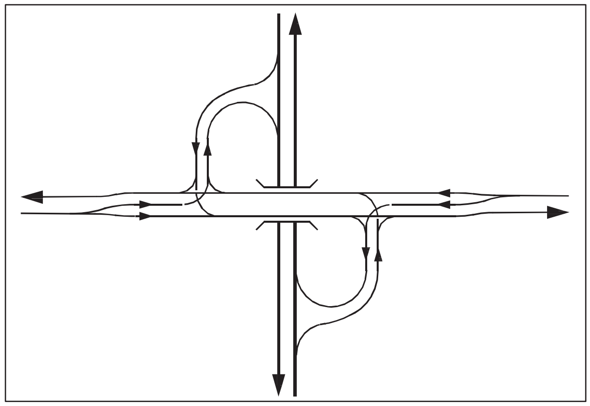
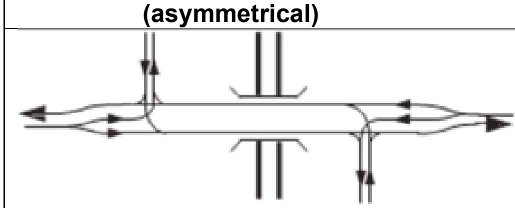
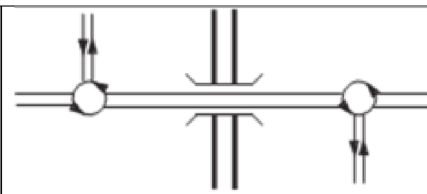
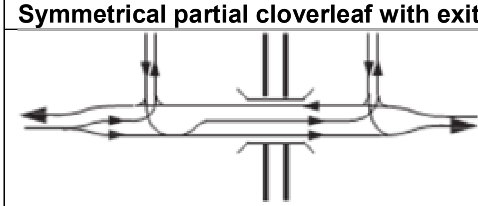
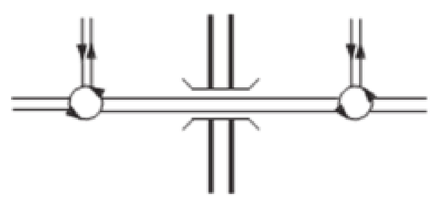
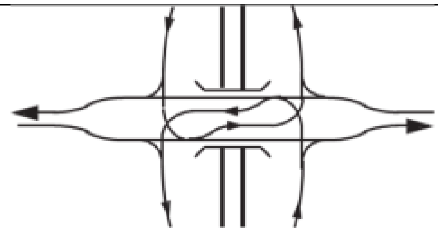
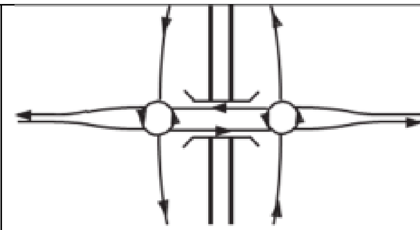


Figure 41 Schematic of “partial cloverleaf” type junction

Traffic flow management on three-leg secondary road intersections as part of “partial cloverleaf” junctions

<table>
<tr><td colspan="2">Diagonal partial cloverleaf with exit before bridge structure as part of junction (asymmetrical)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Advantages:
• Possibility of extending the left-turn lanes on the secondary roadway
• Suitable for heavy traffic flows when turning from the main roadway.
• Relatively narrow bridge structure
Deficiencies:
• Large spreading of the three-leg intersections on the secondary road.</td><td>Advantages:
• Avoidance of the left-turn lanes
• Slight spreading of nodes on the secondary road
• Minimal bridge width
Deficiencies:
• Difficult management of transitory traffic on the secondary road.</td></tr>
<tr><td colspan="2">Symmetrical partial cloverleaf with exit before bridge structure as part of junction</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Advantages:
• Suitable for zones where there is a spatial restriction on one side of the secondary road
Deficiencies:
• No convenient exit in any direction
• Off-ramp hinders the dynamic driving conditions
• Relatively wide bridge structure</td><td>Advantages:
• Avoidance of left-turn traffic lanes
• Minimal bridge width
Deficiencies:
• Off-ramp hinders the dynamic driving conditions
• Possible issue with the surface drainage at the off-ramps due to the return flow.
• Requires larger space
• Difficult management of transitory traffic on</td></tr>
</table>

	the secondary road.
Rhombus	
	
Advantages: • Suitable conditions for the driving dynamics (quick access from the off-ramp), when the secondary road is above the primary one • Takes less space than the partial cloverleaf • Slight spreading of intersections on the secondary road Deficiencies: • Relatively wide bridge structure • Great speed at ramps • Reduced visibility at intersections. • A wrong turn may be selected.	Advantages: • Suitable conditions for the driving dynamics (quick access from the off-ramp) when the secondary road is above the primary one • Avoidance of the left-turns • Minimal bridge width Deficiencies: • Large spreading of roundabouts on the secondary road. • Requires larger space • Difficult management of transitory traffic on the secondary road • A wrong turn may be selected.
Primary road was shown vertically.	

6.3.3.3 Same gradient intersections and access roads with traffic lights.

Same gradient four-leg and three-leg intersections with traffic lights are applied when two K1 design category roads intersect (are connected).

The same intersection type can be applied when a K1 category road intersects or is connected with a K2 category road, or both roads are of K2 category, which must be checked through a special analysis. The analysis must contain the fulfillment of an adequate level of service and traffic safety, as well as traffic regulation at the adjacent intersections.

If possible, the installed traffic light system should be controlled, in the sense of operational regime modifications, following the traffic flow conditions. To fulfill the safety requirements for the left turns, a separate phase should be provided in the signage plan. The traffic light signage should be in compliance with the Rulebook on Traffic Signage (“Official Gazette of RS”, nos. 85/2017 and 14/2021).

Intersections provided with traffic light signage should be designed with an intersecting angle between 70° - 110°. Vertical kink in longitudinal profile should be avoided at the locations for intersections with traffic lights. chapter 6.2.4. should be referred to for the longitudinal gradient profile in the intersection zone. The intersection of a secondary and a primary road should be avoided, as seen in the example from Figure 38, example b.

6.3.3.4 Same gradient intersections and access roads without traffic light regulation [2].

Same gradient four-leg and three-leg intersections without traffic light regulation are applied when two K2 design category roads intersect (are connected), i.e., as a standard solution for intersections (connection) of K3 or K4 category roads.

2 When the average higher costs are considered for the construction of an intersection with traffic lights, including operational costs, the difference is compensated with additional costs arising from traffic accidents during the service life of a road, when a daily traffic flow of approximately 5,000 vehicles/24h takes place on that intersection.

T-intersection type (three leg intersections) are, from the right of way aspect, more appropriate than four leg intersections, so, in certain cases, they should be considered for application.

Four leg and three leg intersections should be avoided in sharp curves. When a secondary road is connected from the inside of the curve, the visibility aspect for drivers waiting to access the intersection area is unfavorable. When a secondary road is connected from the outer side of the primary road curve, the intersection does not have good visibility for drivers using the opposite traffic lane (from the inside of the curve), and therefore the estimate of the higher category traffic flow speed is problematic. Guidelines provided in chapter 6.6 should be particularly considered.

Intersections at the top of convex vertical curves or on locations with shaded visibility zones (Figure 23) should be avoided. If these locations cannot be avoided for the connection of a secondary road, then special design measures for improvement of visibility for positions where traffic participants are required to wait for passage should be applied, with specific explanations. The measures on these positions imply the installation of median islands, restrictive planting of vegetation, and also the positioning of road structures such as retaining walls etc., which obstruct the view.

At intersections without traffic lights, the entry requiring waiting should be designed with one separate traffic lane.

The introduction of speed limits should also be considered for the primary traffic flow in the intersection zones with problematic visibility. This aspect should be particularly taken into consideration if directed bicycle and pedestrian traffic takes place in the intersection zone.

6.3.3.5 Roundabouts

Roundabouts are applied as an optimal traffic solution with K2, K2 and K3 and restrictively K3 category roads. Roundabouts can be applied when connecting a K2 road (K3) with a higher K1 category road while applying the junction type. (Figure 41).

The application of roundabouts is particularly suitable for intersections with steady traffic flow intensities on roads accessing the roundabout.

A leg with low traffic volume accessing the roundabout should have a minimum of 15% of the total traffic on the three leg roundabout, i.e., 20% for a four leg roundabout.

The traffic service level check is mandatory at roundabouts. If the check establishes an insufficient traffic service level, the construction of a separate lane for the right turn (bypass) should be considered. See chapter 6.4.15.

Introduction of roundabouts with two concentric traffic lanes, i.e., the introduction of another traffic solution should be considered for roundabouts with high traffic volumes in order to accomplish the required service level.

Road axes passing through the roundabout can be designed spirally towards the circle center

6.4 Intersection Elements

6.4.1 Continuous Traffic Lanes

Continuous (passing) traffic lanes in the intersection zones are the same width as outside them. In some cases, which should be specifically explained, the continuous lane width can be narrowed by 0.25 m, if it is not possible to form the adjacent turn lanes otherwise.

If the continuous traffic lane must be relocated due to the formation of a median island or a left turn lane, see chapter 5.7.4

The required widening of the traffic lane in the circular curve zone is performed in accordance with chapter 5.7.3.

As for grade separated and partial grade separated intersections, in the convergence zones in exit and entry traffic lanes, a cross slope break of an additional traffic lane can be applied against the basic one if the limitations resulting from the carriageway superelevation of the exit/entry lane in the transition curve zone require that. In any case, the difference between the ramp carriageway cross slope and the basic carriageway must not be greater than 5% at the point on the island elevation where the ramp begins or ends, otherwise the carriageway separation edge line must be extended compared to the dimensions provided in chapters 6.4.2 and 6.4.3.

The longitudinal slope of the traffic lane must be such that areas of poor surface water drainage in the superelevation inflection zones are avoided. If there is a sufficient longitudinal slope, the superelevation zone can be moved forward in the convergence zone of the exit / entry traffic lane.

6.4.2 Exit traffic lanes

An exit zone is formed using a parallel traffic lane where traffic leaving the main roadway is diverted. (FigureFigure 42).

An exit traffic lane (including the broken center line) is 3.25 m wide. The edge line in the convergence zone and the zone of exit from the main traffic lane is 0.25m wide.

The exit traffic lane length l_Z is 150m for single-carriageway roads or 200m for dual-carriageway roads (motorways). The beginning of the hatched marking zone is in the location where the exit lane carriageway reaches the width of 4.50m through the transition curve, the edge line width is 0.75m, i.e., 5.25 in total, which is the PPR1 ramp carriageway width at the same time. The length of the borderline before the hatched marking area is $0.1 \cdot l_Z$. The beginning of the island is in the location where the edge lines are spread 2.00m perpendicularly to the basic roadway edge. The hatched marking area is in accordance with the Rulebook SS.

The “S” line length for the formation of an exit traffic lane is usually Lp=30m

The exit traffic lane should not be formed in the location where the overtaking lane ends, i.e., instead of it! (see chapter 4.5.2.3).

6.4.3 Entry traffic lanes

An entry zone is formed using a parallel traffic lane from which traffic enters the main roadwayFigure 43).

The traffic lane for entry and convergence with the traffic in the main traffic lane is 3.25m, while the edge line in that zone is 0.25m.

The change of the traffic lane ramp and the responding shoulder width, from the ramp PPR1 width, takes place in the hatched marking area behind the end of the island. The end of the island is formed in the location where the carriageway edges are spread 2.0m perpendicularly to the main carriageway edge. The hatched marking area is in accordance with the Rulebook for Traffic Signalization.

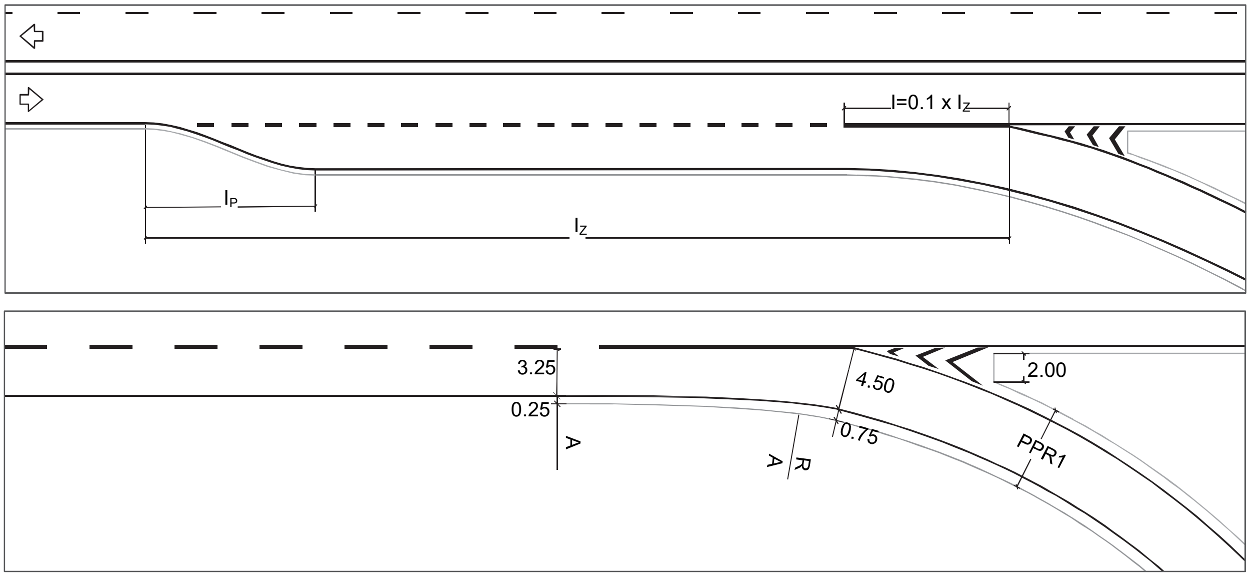


Figure 42 Exit traffic lane with island formation

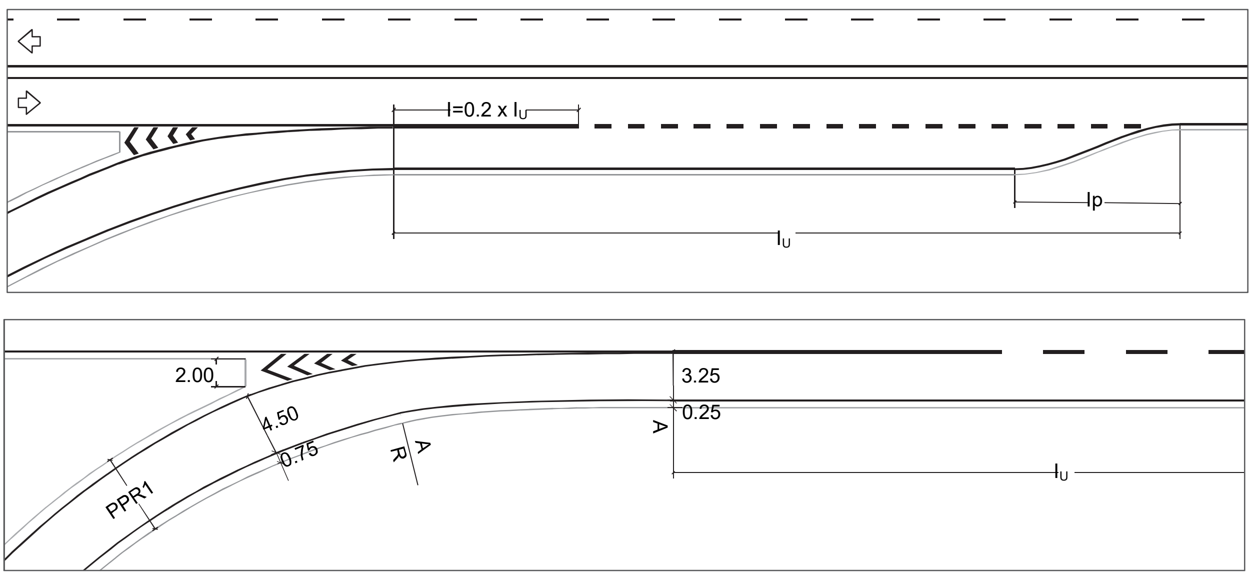


Figure 43 Entry traffic lanes with convergence zones and formation of islands

The length of the entry traffic lane for traffic convergence l_U is 150m for single-carriageway roads or 200m for dual-carriageway roads (motorways). The length of the edge line behind the beginning of the entry traffic lane for convergence is $0.2 \cdot l_U$.

The length of the "S" line for terminating the entry traffic lane is usually Lp=30m

The exit traffic lane can be formed in a combined manner at the location where the overtaking lane begins! (see chapter 4.5.2.3).

6.4.4 Ramps

Ramps are divided into direct, semi-direct and indirect ramps according to the type of connection on the layout.

Per rule, ramps are shaped with adjusted geometry. Table 28 presents the range of values of minimum radius which are applied in ramp design. The referral line for applying radius is the internal edge of the carriageway.

Ramps must be free of any connections or crossings. In the crossroad zone, the land cannot be used for other purposes. Exception can be made solely for maintenance points or for police functions. presents standard cross sections of ramp profiles and ranges of their application.

Table 28 Range of minimal values of applied radii of ramps related to the type of traffic nodes and types of ramps.

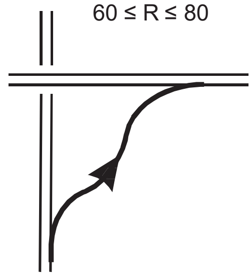
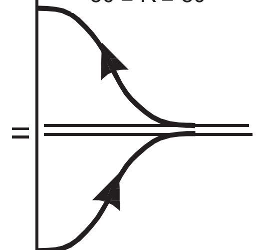
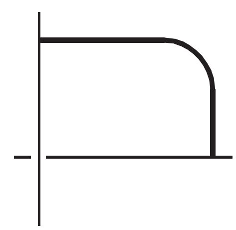
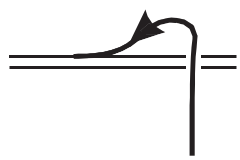
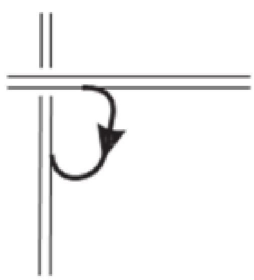
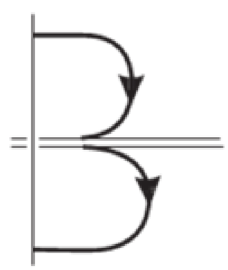
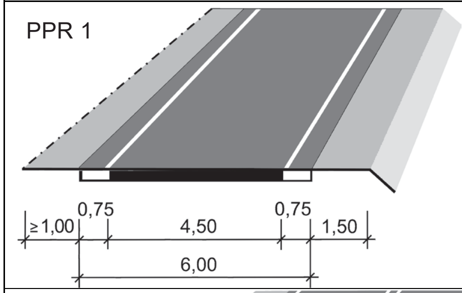
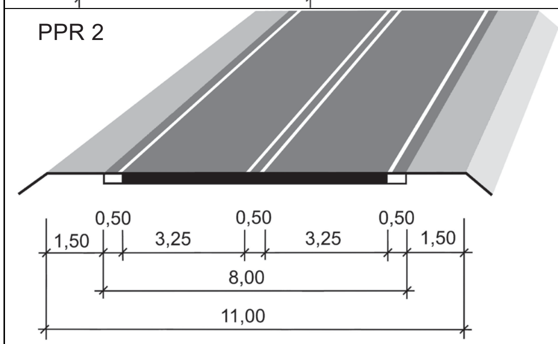
<table>
<tr><th>Type of traffic nodes
Type of ramp</th><th>Grade separated intersections</th><th>Partially grade separated intersection</th><th>Grade separated road directions with connections at level</th></tr>
<tr><td>Direct</td><td>60 ≤ R ≤ 80
</td><td>50 ≤ R ≤ 80
</td><td rowspan="3">40 ≤ R ≤ 50
</td></tr>
<tr><td>Semi direct</td><td colspan="2">50 ≤ R ≤ 80
</td></tr>
<tr><td>Indirect</td><td>40 ≤ R ≤ 50
</td><td>30 ≤ R ≤ 50

40 ≤ R ≤ 50</td></tr>
<tr><td colspan="4">(Systemic sketch, values in [m])</td></tr>
</table>

Table 29 Field of application of cross section profiles of ramps for connection

Cross-section profile of a ramp	Field of application
PPR 1 	**Grade separated intersections and partially grade separated intersections with short length of parallel entry and exit ramps**
PPR 2 	**Traffic nodes with combined entry exit ramps and connections at level.**
Dimensions in [m])	

The ramp design elements are restrictive and reduced related to the design elements applied on open routes. The following limiting conditions should be met:

- It is necessary to provide adequate road visibility (stopping visibility, visibility according to traffic signalization)
- Ramps need to have right geometry in front of connections (crossroads) per level, both horizontal and vertical, so that there would be clear visibility of the entire traffic situation from a distance of 50 m.
- Visibility of small radius has the priority over visual representation of a traffic lane
- The length of the ramp should allow for changing lanes and arrangement of any traffic line for waiting, connection at level with traffic light signalization.

Table 30 shows limit values of ramps design elements related to the dimensions of applied radius of curves.

Table 30 Limit values of design elements for ramps

Radius of horizontal curves	**R**	**[m]**	**30**	**40**	**50**	**60**	**80**
Radius of a convex curve	min R_{kv}	[m]	1,000	1,250	1,500	1,750	2,000
Radius of concave curve	min R_k	[m]	500	625	750	850	1,000
Limit values of a longitudinal slope	max i	[%] Slope	+6.0				
	min i	[%] Downhill	-7.0				
Range of stopping visibility	P_Z	[m]	30	35	40	45	55
Minimum cross slope	min ip	[%]	2.5				
Maximum cross slope	max ip	[%]	6.0				
Minimal value of a ramp Distortion	min irv	[%]	0.1· a a [m]: Distance from the rotation point to the edge of the road				
Maximum value of a ramp	max irv	[%]	2.0				

Distortion					
Maximum of the resulting slope max ipr [%]	10.0				
Expansion in a curve for PPR 2 [m]	2.00	1.00	0.50	-	-

The following details need to be specifically observed:

- In order to timely observe the radius of a curve at the beginning of an island, transitional curves with a small parameter must be used. The right edge of the carriageway is referential for applying radius of curves.
- The selection of parameters of the clothoid needs to be designed so that the ramp of distortion does not have a higher value of 2.0% and that the distortion of the carriageway needs to be done within a transition curve (see point 6.4)
- The curve radius which leans on crossing point is regarded as a part of relatively established axis, and the following radius, if possible, should not be significantly lower than the previous one. If between two radius there is a direction longer than 100m, then the following radius needs to be as longer as possible from the previous one (the target proportion is: R2 : R1 ≥ 1.5: 1).
- When the cross slopes of the intersecting roads are large, and therefore the slope of the ramp that connects them, the limit values given in Table 30 should be observed, i.e. up to the maximum permitted cross slope of the ramp of 10.0%. The minimum longitudinal slope of the ramp is 0.5%.

In the case of minor values of the circular curve ramp radius, it is necessary to apply a width of the cross profile on ramp greater than 6.0 m, to enable the rounding of heavy vehicle in the event of a breakdown, or a stopped service vehicle. In case of ramps with a cross profile PPR1, for a curve radius of R=50m, an extension outside the roadway of 1.0m should be provided, and when R=30 m, an extension of 2.0m. If a railguard is installed, it should be adapted to this extension.

6.4.5 Left turns

Depending on the design class K, type of intersection and traffic requirements, appliance of various type of left turns LT1-LT4 is recommended (Table 30).

Table 32 show areas of application of left turns depending on design class K roads from which the left turn takes place, operation mode of the intersections and the design class K to which the left turn is made.

Table 31 Types of left turns

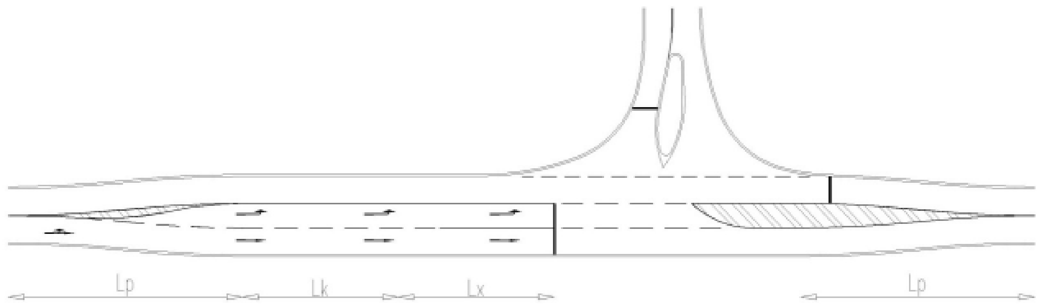
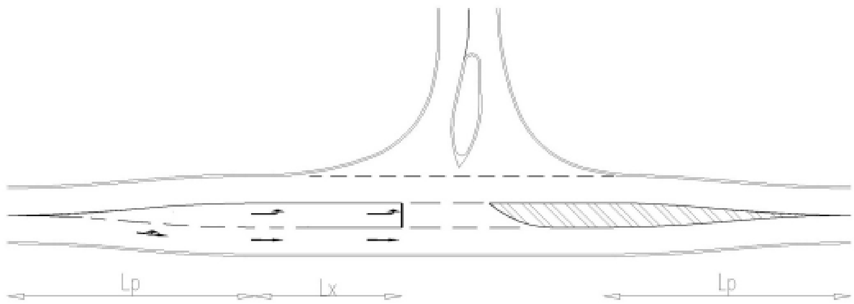
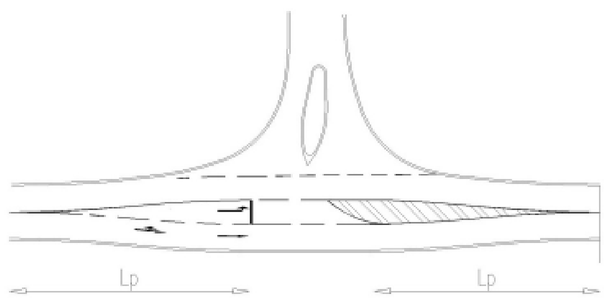
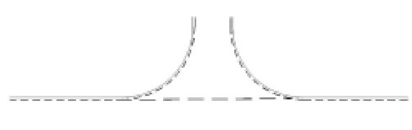
Types of left turns	**Sketches**
LT1	
LT2	
LT3	
LT4	
A systematic sketch	

Table 32 Area of application of types of left turns

Class of road K from which the left turn takes place	Operations mode of traffic node	Class of road K to which the left turn is made	Type of left turn
K1	with TS (with traffic light signalization)	K1	LT1
K1	with TLS	K2	LT2
	without TLS	K2	LT2
K2	without TLS	K2/K3	LT3
K3	without TLS	K3/K4	LT4

Type of left turn LT1 is used for intersections between roads of class K1 and between roads of K1 and K2 with traffic lights regulation.

Type LT1 requires forming of a separate lane for left turns consisting of a part for waiting Lx, a part for slowing down Lk and a part for changing lanes Lp.

The left turns lane is 3.25m wide. The location of the cross line for vehicles stopping is in line with pedestrian and bicycle traffic, which also conditions the location of the transmitter of signalization. The left turns lane is initialized by a striped restrictive area of the carriageway.

The length of the part for waiting Lx is determined by traffic analysis for the intersection in question, or the minimum length of 20m is adopted.

The length of deaccelerating part for is 20m, whereas the length of the part for changing lanes Lp when the lane for left turn is expanded on both sides is 30m, or 50m when the lane is expanded on one side.

Type of left turn LT2 is used for intersections between roads of classes K1 and K2, as well as between roads of K2 without traffic lights regulation.

Type LT2 requires forming of a separate lane for left turns consisting of a part for waiting and a part for changing lanes Lp. The lane for left turns is initialized by a striped restrictive area of the carriageway.

The left turns lane is 3.00/2.75 m wide. The location of the cross line for stopping of vehicles is in line with the position according to Figure 44. The geometry of the left turn must be checked with a curve of traces of a truck, the same as for four side intersections, so that the traces of truck do not overlap with the left turn.

The length of the part for waiting Lx is determined by traffic analysis for the intersection in question, or the minimum length of 10m is adopted.

The length of the part for changing lanes Lp when the lane for left turn is expanded on both sides is 30m, or 50m when the lane is expanded on one side.

Type of left turn LT3 is used for intersections between roads of class K2, as well as between roads of K2 and K3 without traffic lights regulation.

Type LT3 requires forming of a separate lane for left turns consisting of a part for changing lanes together with the part for waiting Lx (10 m) and when it is expanded on both sides the length of the lane for left turn is 30 m in total. The part of the lane for changing lanes starts without a striped area.

The left turn lane is 2.75 m wide.

The geometry of the left turn must be checked with a curve of traces of a truck, the same as for four side intersections, so that the traces of a truck do not overlap with the left turn. In low intensity traffic of trucks (<2 vehicles / h) during the left turn it is allowed to use the surface of the next traffic lane.

Type of left turn LT4 is used for intersections between roads of classes K3 and K4 without changes in the carriageway geometry in the intersection zone.

These intersections are present on roads with low traffic, especially with low heavy traffic flow. When heavy vehicles make the left turn, it is allowed to use the overall carriageway surface.

6.4.6 Right turns

Depending on the design class K, functional type of intersection and traffic requirements, application of various types of right turns RT1-RT6 is recommended (Table 33).

Table 34 show areas of application of right turns and corresponding type of access to an intersection, passing and turning depending on design class of K roads from which the right turn takes place and the class K of the road to which the right turn is made.

Type of right turn RT1 is used for intersections with traffic lights on roads of class K1 with a single carriageway and the access types A1 or A2.

Type of right turn RT1 consists of a right turns traffic lane formed parallel with the lead direction, a triangular traffic island and a division traffic island in the shape of a large "droplet".

The right-turn lane consists of the following sections: Lp realignment section, Lk deceleration section and Lx waiting section. The traffic analysis for the node in question calculates the return flow that defines the Lx length of the waiting section in front of the crossed stop line. If the value is not calculated, then Lx is determined not shorter than 20m. The length of Lp is 30m, and the length of Lk is 40m.

The width of the right turn lane along with the interrupted line is 3.25m, whereas the edge lane is 0.25. The width of the carriageway next to the triangular island is 5.50m. However, the passage next to the island must be checked by a curve of traces of an adequate truck in accordance with point 6.7. The angles are rounded with a circular line.

The triangular traffic island is formed in accordance with point 6.4.9.

The right turn is regulated by a special phase in the traffic signalization Signal plan.

If bicycle and pedestrian traffic is conducted in lanes on a separate carriageway parallel to the primary carriageway and passes over an intersection island with a recessed surface in the width of the lane over a triangular and dividing "droplet" of the island, then the lane is positioned parallel at a lateral distance of up to 4.0m from the edge of the main carriageway.

Type of right turn RT2 is applied on traffic light intersections of roads K1 with a single carriageway and roads K1 and K2 with types of access A1 or A2. It can be applied on intersections of roads K1 and K2 with lower traffic intensity, in which cases a triangular island is not necessary or cannot be formed (see chapter 6.4.7).

The edge of the right turn is formed as a three-part curve, whereas the division island of the access is in the shape of a small "droplet" (see chapter 6.4.8). The main radius of the line of right turn is determined according to point 0.

If bicycle and pedestrian traffic is conducted in lanes on a separate carriageway parallel to the primary carriageway, then the lane in the merging zone with access over the division island – the "droplets" – is set in parallel to the edge distance up to 4.00m in relation to the main carriageway edge.

The right turn traffic lane RT2 is formed in parallel with the main carriageway of the main direction, if required by traffic analysis.

The right turn traffic lane RT2 consists of the following parts: Lp part for changing lanes, Lk part for deaccelerating and Lx part for waiting. By performing traffic analysis of the traffic node in question, the return stream which defines the Lx part for waiting in front of the cross line for stopping is calculated. If there is no calculated value, then Lx is determined to not be shorter than 20m. The length of the Lp is 30 m, whereas the length of the Lk is 40 m.

The width of left turns lane, along with the interrupted line is 3.25m, whereas the edge line is 0.25.

Type of right turn RT3 Is applied for intersections without traffic lights between roads K2 and type of access A3. The right turn should be made fast due to the extensive traffic load on the primary road (see chapter 6.4.7).

The edge of the right turn is rounded by a circular curve along with forming of a triangular traffic island and a separation island on the access road in the shape of a big drop. The radius of the rounding of the right edge is 25.0m, whereas the triangular island is formed according to chapter 6.4.9. The width of the carriageway next to the triangular island is 5.50m. However, passing by the island must be checked by a curve of traces of adequate trucks, in line with point 6.7.

At the right turn lane exit, adequate signalization II-1 and an interrupted line should be placed.

This type of right turns is not adequate for bicycle and pedestrian traffic crossing.

Type of right turn RT4 Is applied for intersections without traffic lights between roads K2 and roads K3 with type of access A4. (see chapter 6.4.7).

The edge of the right turn is formed as a three-part curve, whereas the division island of access is formed in the shape of a small “droplet” (see chapter 6.4.8). The main radius of the right turn line is determined in line with point 0.

If bicycle and pedestrian traffic is guided by lanes on a special carriageway parallel to the primary carriageway, then the lane in the intersection zone with access over the "droplet" dividing island is placed parallel at a lateral distance of at least 6.0m to the edge of the main carriageway. Cyclists and pedestrians must stop on the island (see chapter 6.8.2).

Type of right turn RT5 is applied for intersections without traffic lights between roads K2 and roads K3 with type of access A5. (see chapter 6.4.7).

The right turn edge is formed as a three-part curve, whereas the division island of access is formed in the shape of a small “droplet” (see chapter 6.4.8). The main radius of the right turn line is determined in accordance with point 0.

If bicycle and pedestrian traffic is guided by lanes on a separate carriageway parallel to the primary carriageway, then the lane in the intersection zone with access over "droplet" division island is placed parallel at a lateral distance of 4.0m from the edge of the main carriageway (see chapter 6.8.2).

The type of right turn RT5 is adequate for low traffic intensity on the main direction, as well as intersections with good visibility where cyclists and pedestrians can be easily and timely seen when making a right turn.

The type of right turn RT6 is applied on intersections without traffic lights between roads K3 and roads K3 or C4 with access type A6 (see chapter 6.4.7).

The right turn edge the is formed by a simple circular curve.

For right turns of heavy vehicles, the use of traffic surface for vehicles in the opposite direction is possible.

Table 33 Type of right turns

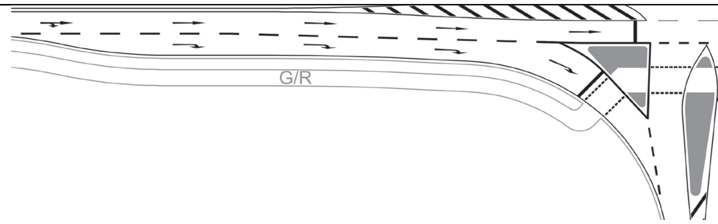
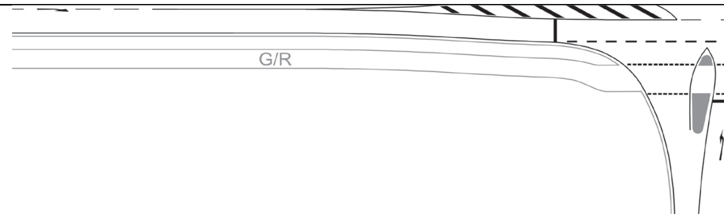
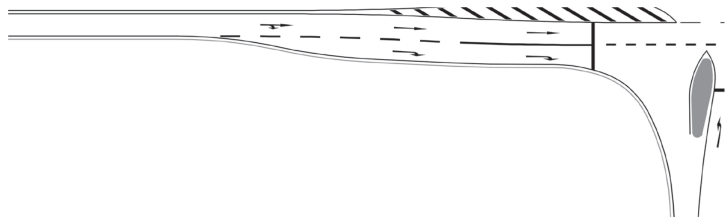
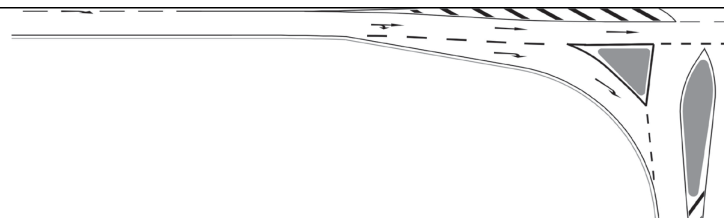
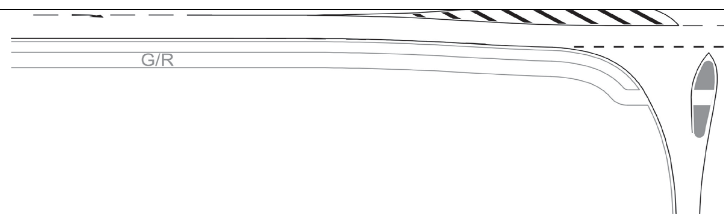
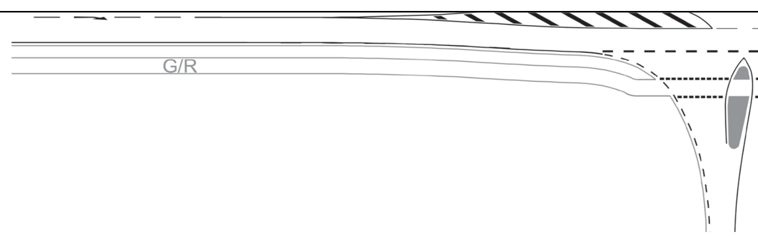
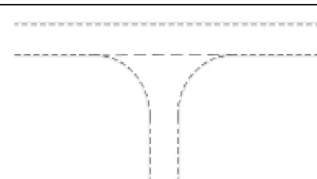
Type of right turn	Sketch	Access type
RT1		A1/A2
RT2	 	A1/A2
RT3		A3
RT4		A4
RT5		A5
RT6		A6

Table 34 Appliance of right turns types and corresponding types of access on secondary roads

Class K of a road from which the right turn is made	Operations mode of an intersection (Traffic light signalization)	Class K of a road where the turn takes place	Independent leading of cyclists / pedestrians		Type of right turn	Corresponding type of access
			Parallel to the primary road over a separate traffic surface	Over an access road		
K1	with traffic lights	K1/K1	Yes	Yes	RT1	A1/A2
K1	with traffic lights	K1/K2	Yes	Yes	RT2	A1/A2
K2	without traffic lights	K2	No	No	RT3	A3
	without traffic lights	K3	Yes	Yes*	RT4	A4
	without traffic lights	K3	Yes	Yes*	RT5	A5
K3	without traffic lights	K4	-	-	RT6	A6
*) applied only for connections (three-sided intersections)						

6.4.7 Crossing and turning

At interchanges at level to an access road, with formation of separate traffic lanes for passing through the intersection, as well as for turns, the capacity is increased and there is room for lining vehicles waiting to pass.

In order to make the function of lining up and the obligation to wait clearer, specific islands for separation and directing traffic flows (in the form of “droplets”) are formed. These islands are formed in accordance with chapter 6.4.8. To make the function of such islands clearer, as well as the visibility to the left wider, the tips of the island are rounded with small radius in accordance with the geometry of adequate vehicles. The angle of the right turn is shaped with a three-part radius. The main radius of the three-part curve is determined in line with the recommendations presented in point 0. The width of the carriageway between the division island and the external edge of the right turn is minimum 4.50m, together with the edge lane.

Tre traffic lanes for access and passing of traffic through the intersection need to be shaped so that the change of direction of movement is minimally changed.

There are six types of access to an intersection with the function of passing and turns (Table 33).

Type A1 of access to an intersection is used for intersections with traffic light signalization combined with types of right turn RT1 and RT2.

Type A1 access of an intersection belongs to intersections with separate left oriented traffic lanes and separate right oriented traffic lanes. On the intersection itself, next to the traffic lane for passing through the intersection there are separately formed lanes for left and right turns. If there is no need for separate lanes for both turns, then the traffic lane for passing through the intersection is used for right turns, as well.

The traffic lanes for left and right turns are 3.25m wide. The length of the part for waiting is determined by a traffic analysis for the intersection.

On the access of a secondary road to an intersection, the expansion of the carriageway for forming additional traffic lanes for left and right turns is done on the right side.

As a division island for separating and directing traffic directions in the intersection zone, a large “droplet”-shaped island is used in combination with the RT1 right turn type, and a small droplet-shaped island in combination with the RT2 right-turn type is used. The edge strip on the right side of the carriageway is 0.5m, and around the island it is provided with a width of 0.25m or it is extended to 0.5m, if it is used for drainage.

If bicycle and pedestrian traffic is conducted in lanes with a special carriageway parallel to the main carriageway and crosses over the division island with a recessed surface in the width of the lane, then the solution RT1 and RT2 is applied (Table 33).

Type A2 access to a traffic light intersection with road K1 is used in combination with types of right turn RT1 and RT2, if one traffic lane is sufficient for traffic emerging from the secondary direction, based on analysis of traffic overload for the intersection in question.

A big “droplet” is formed in combination with the right turn type RT1. For right turn RT2, a small “droplet” is formed.

If bicycle and pedestrian traffic is led on lanes on a separate carriageway parallel to the main carriageway and goes over the island of intersection with lowered surface as wide as the lane, than the solution RT1 and RT2 is applied (Table 33).

Type A3 access to an intersection with road K2 without traffic lights is used in combination with type of right turn RT3.

A division island in the form of a big “droplet” is formed. If the carriageway is in a great slope and the traffic to the right turn has a great number of heavy vehicles, it is recommended to form a separate changing lane 150 m long, as well as directing the right turn with a triangular island.

Type A4 access to an intersection with road K2 without traffic lights is used in combination with type of right turn RT4.

A division island in the form of a small “droplet” is formed.

If bicycle and pedestrian traffic is conducted on lanes on a separate carriageway parallel to the main carriageway and crosses over the island of the intersection with lowered surface as wide as the lane, than the solution RT4 is applied (Table 33).

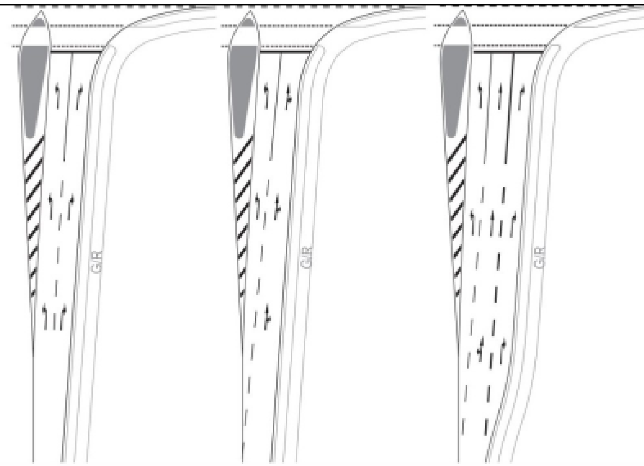
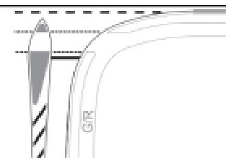
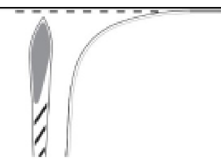
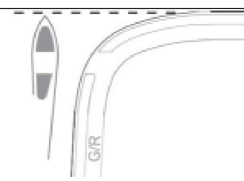
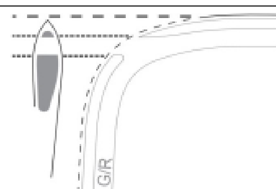
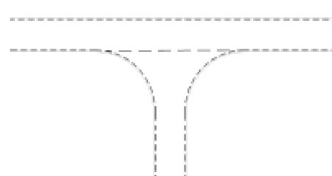
Type A5 access to an intersection with road K2 without traffic lights is used in combination with type of right turn RT5.

A division island in the form of a small “droplet” is formed.

If bicycle and pedestrian traffic is conducted on lanes on a separate carriageway parallel to the main carriageway and crosses over the island of the intersection with lowered surface as wide as the lane, than the solution RT5 is applied (Table 33).

Type A6 access to an intersection with road K3 without traffic lights is used in combination with type of right turn RT6.
There is no separate traffic surface for pedestrian and bicycle traffic.
For right turn of heavy vehicles, the traffic surface for moving of vehicles from the opposite direction is used.

Table 35 Types of access of passing through intersections and turns

Type of access	Sketch	Type of right turn
A1		RT1/RT2
A2		RT1/RT2
A3		RT3
A4		RT4
A5		RT5
A6		RT6

6.4.8 Central division traffic island

In general, a central division traffic island is formed in the connection zone on the access part of a secondary road, with the aim of channeling the movement of vehicles, as well as to inform drivers about their obligation to wait on that spot.

If the left turn is conducted in accordance with chapter 6.4.5 without structural changes to the geometry of the road, the division island can be omitted, if the right of way is clearly recognized based on traffic signals and/or lateral planting.

Division islands are usually shaped with rounded kerbs, and the surface for passing for pedestrians and cyclists are adjusted to the function of traffic without obstacles.

The central division islands are formed in the shape of a big or small “droplet” (Figure 44).

Simultaneous left turns from opposite directions at intersections should be possible. However, it should be checked that such turns do not overlap by using curves of traces of adequate vehicles. On the basis of the check of traces of adequate vehicles it is determined whether the division island should be moved in debt further away from the edge of the carriageway of the primary direction, in line with chapter 6.7.

At intersections with traffic light regulation it should be checked that the directions of adequate vehicles do not overlap with simultaneous left turns. This check is conducted by a curve of traces of adequate vehicles in line with chapter 6.7.

If the axis of the secondary road, when division the intersection, is oriented in a right curve or in a bend, it is necessary to check the visibility of the dividing island including the function of traffic directing. This is best achieved with perspective representation of the location which is checked, and if necessary the division island is expanded with the aim for it to be observed entirely.

6.4.9 Triangular island

As a rule, triangular islands are edged with sloped kerbs, and the edges are parallel to the corresponding traffic edge lines. For the short sides of the triangle, it is possible to draw right lines. The sides of the triangular island should be formed not shorter than 5m and no longer than 20m. The result of a well shapes triangular island is that the left and right turns are clearly directed, limited and dimensionally ensured.

If the lowered surface of the bicycle and pedestrian lanes crosses over the island, the lowered edge along the path should be at least 1.5m long.

Recognition of a triangular island is provided by:

- introducing it with horizontal signals
- vertical traffic marks
- signal light transmitters
- reflectors

6.4.10 Central islands for passing of pedestrians and cyclists

Central islands are formed so that bicycle and pedestrian traffic can safely cross over traffic lanes. The crossing points should be clear to drivers, with a sufficient distance to prepare the braking maneuver in time. The field of vision for cyclists, particularly for safe crossing should be clear and free of obstacles (traffic signalization or plants) (see chapter 6.4.8.)

The crossing for cyclists and pedestrians should be formed as intersections.

In specific cases it is possible to form crossing outside the surface of intersection, based on specific justified reasons (Figure 45). Crossings formed in this way should structurally and safely correspond to the conditions resulting from the traffic load on the road, the proportional participation of heavy vehicles, as well as the number and structure of pedestrian and bicycle traffic.

Attention should be paid to:

- marking the crossing
- traffic lanes should be moved aside before the island and returned to the basic direction behind the island
- In case of high traffic volume of motor vehicles, it is possible to prove the need for introducing traffic lights signalization to regulate the crossing of pedestrians and cyclists.

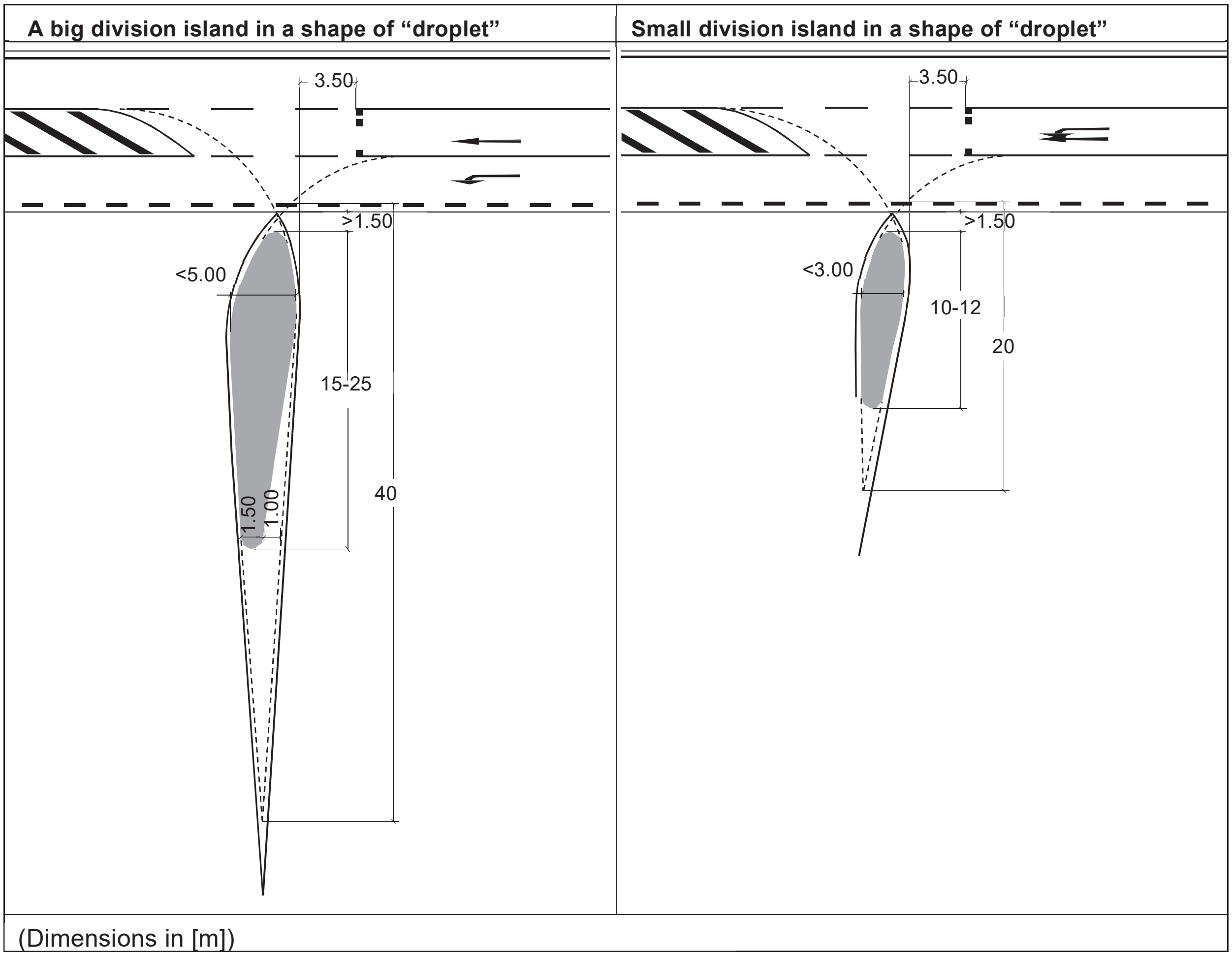


Figure 44 Central division island with access roads to intersections with three and four arms

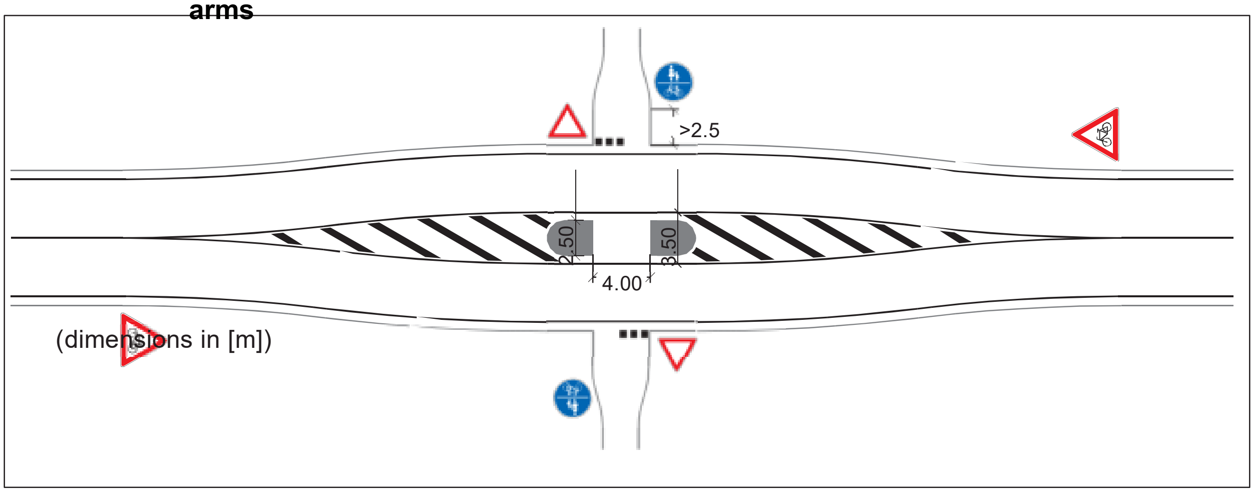


Figure 45 Central island in function of crossing for pedestrians and cyclists

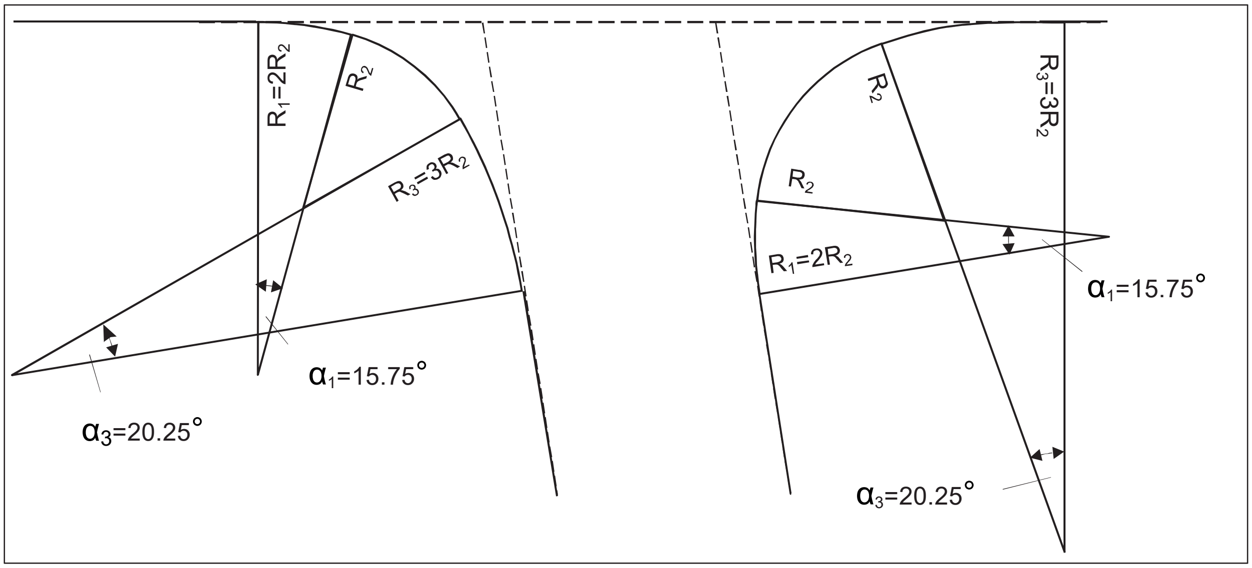


Figure 46 Rounded edges of a carriageway for a right turn with three-part radius

6.4.11 Rounded carriageway edges of the right turn

The basket shaped curve of the right turn edge is formed with three successive radius (Figure 46). Thus formed rounding curve is particularly suitable for matching the curve of the wheel tracks of a motor vehicle when turning, because it occupies a smaller area of space.

The size of the main arch R2 radius is selected so that the vehicle when turning should remain within the scope of the traffic lane which it uses, without taking up the space of the opposite traffic lane.

The three-part curve of rounding is formed with radius in the following proportion

$$R1: R2: R3 = 2: 1: 3 \qquad (8)$$

R1 [m] = lead radius

R2 [m] = lead radius

R3 [m] = lead radius

The lead radius R1 and R3 always have constant central angles (α1 = 15.75° and α3 = 20.25°) without regard to the central turning angle.

In order to prevent obstruction of the approach visibility of the right turn due to a large right rounding, long trucks are allowed to partially move in the left turns lane.

For intersections with 90° angles and a division island on the access roads, the main radius of rounding of the edge line of the right turn R2 should have the value of 15m for right turns type RT2, RT4 and RT5 and 12 m for access types A1, A2, A3, A4 and A5. For right turn type RT6, the radius of rounding the right turn is 10m, and for the access type A6 it is 8 m.

The width of the carriageway between the rounded edge of the right turn and the island is minimum 4.5 m. If the distance is significantly greater, the use of radius <15 m should be considered. See chapter 6.7.

6.4.12 Roundabout

Roundabout is constructed with a constant radius and constant carriageway width (see chapter 6.3.3.5).

Table 36 Width of the carriageway of a roundabout including the edge lane in function of external radius. The defined dimensions include the width of the edge lane of 0.50m from both sides.

Table 36 Width of the carriageway of a roundabout including the edge lane in function of external radius.

Type	A small roundabout	
External diameter D [m]	35 ≤ D < 40	40 ≤ D ≤ 50
Width of the carriageway of a roundabout KKT BK [m]	7.50	7.00

The bigger the external diameter of the roundabout, the passing of heavy trucks is easier.

The roundabout is formed with a separate carriageway. Due to efficient surface drainage, the cross slope of 2.5 % is used. The cross slope of the road towards the outer edge contributes to better visibility of the roundabout. If a second carriageway cross slope is applied, the maximum applied slope cannot be greater at any point than 6.0%.

6.4.13 Circular island

Circular island is formed so that vehicles, in normal traffic, do not go over its surface. It is not allowed to place any obstacles which could lead to serious consequences in case of a collision with motor vehicles in the roundabout on the island.

The circular island is separated from the carriageway with an angled edge. The levelling is processed as for a cone elevation with a slightly shaped slope.

Particular attention shall be devoted to the passing of long trucks through the roundabout when forming the circular island.

6.4.14 Entry and exit roundabout traffic lanes

The entrance to the roundabout is typically designed with one carriageway and one traffic lane, but if the need is proven due to traffic requirements, the entrance to the roundabout can be formed with two traffic lanes. The exit from the roundabout is always designed with a carriageway with a single traffic lane.

The entry in the roundabout should be radially oriented as much as possible.

The entry and exit carriageway should be separated by division islands. The division islands axis should be oriented towards the center of the roundabout.

The width of the carriageway along the division island should be minimum 4.50 m, but not more than 5.00 m at the narrowest point of entry, or 5.50 m from the exit. The edge lane along the carriageway is 0.50 m, whereas along the division island it is 0.25 m. The passing through the surface of the roundabout should be checked against serves of traces of adequate vehicles in compliance with chapter 6.7.

Division islands have edges with lowered surface. At the pedestrian and bicycle traffic passing point, the width of the island should be minimum 2.50 m.

If the access road to the roundabout is in a right oriented curve or slope, it is recommended that visibility in the access to the roundabout and division island is checked by a perspective view. If the check proves the need, the division island should be extended (see chapter 6.4.8 and Figure 44).

The rounding of the right turn edges is done by appliance of a simple round arch. The right edge rounding radius of the entry is 14-16m, while for the exit it is 16-18 m. If the exits do not intersect with the bicycle lane, these values can be increased by 30%.

6.4.15 Bypass

With the introduced carriageway cross connection, vehicles turning right are conducted directly outside the roundabout. Vehicles turning right from the main road are moved outside the main traffic lane to a separate right-turn lane and through the inflow lane they enter the direction of the other road. (Figure 47)

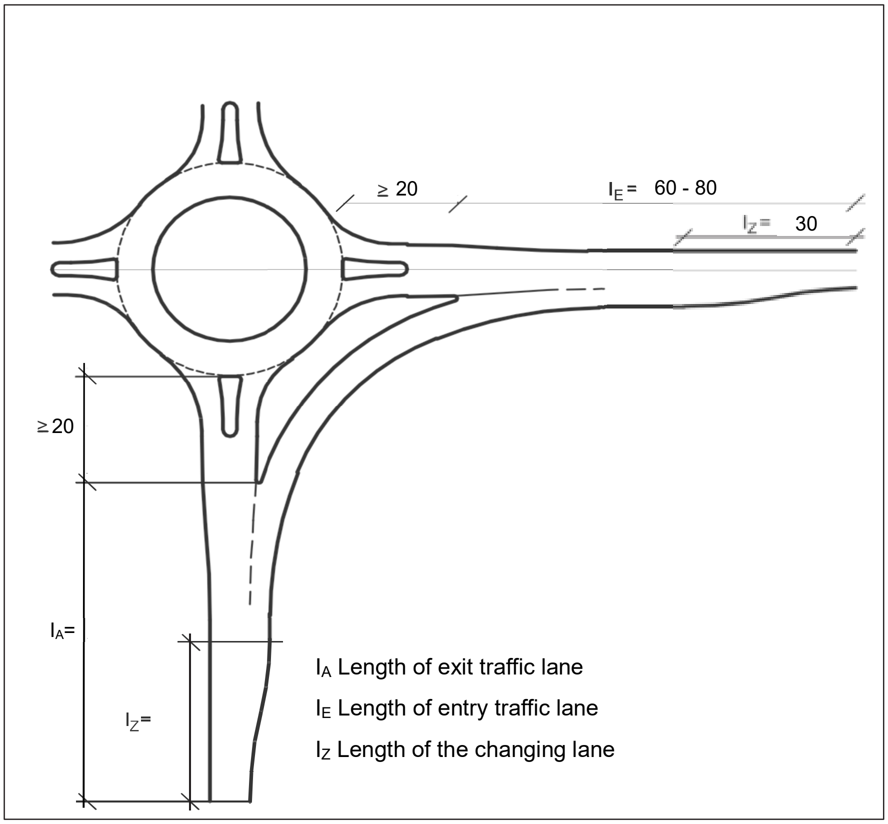


Figure 47 Bypass and roundabout

The exit lane towards the cross connection is 3.25m wide along with the dashed boundary line. It consists of a part for changing lanes 20m long and a part for deceleration and chnageing lane. The edge lane is 0.25 m wide. The length of the entry lane is determined based on the traffic analysis for the roundabout, the access to the roundabout, number of vehicles which are directed towards the cross connection with the aim to prevent blocking the exit from the return traffic flow.

The cross connection is formed as a separate carriageway 5.50 m wide. Passing through the cross connection should be checked against curves of traces of adequate vehicles.

The inflow traffic lane to the other road direction from the cross connection is 3.25m wide along with the dashed boundary line. The inflow lane is 60-70 m long including the part for changing lanes Lap which is 30m long. The edge strip is 0.25m wide.

If the traffic analysis shows the need to introduce more than one cross connection outside the roundabout, appliance of another type of intersection shall be considered.

6.5 Carriageway levelling

The adjustment of the longitudinal and cross slope, as well as the resulting slope due to carriageway rounding, efficient water evacuation shall be ensured by using the shortest way from the carriageway surface at intersection. The following principles need to be observed:

- the primary road direction slope in the intersection zone should remain unchanged, whereas the secondary access road directions are adjusted to the geometry of the primary road direction.

- the surface water accumulated on the carriageway surface which approaches the intersection are adjusted to the main road direction geometry.
- in case the range of the roads which access the intersection are the same, the aspects of levelling in drainage function have advantage over driving dynamic requests.
- the lowest points in the intersection zone in concave profiles and the top points for convex profiles can be allowed only when the cross slope of the carriageway has sufficiently high value (ip ≥ 2.5%).
- generally, the required cross slope of the carriageway of ip ≥ 2.0% can be reduced in the rounding zone of the carriageway, but cannot be lesser than 0.5%.

Division and triangular islands can increase the efficacy of the surface drainage since they:

- structurally separate the intersection surface
- enable forming of positive cross slopes and
- enable forming of lowest points and gullies on those locations along the edge of the island.

The change and adaption of the surface slopes is the basis for preparation of intersection levelling plan, and if necessary, for construction of isohypses. By the means of iso-lines and fault lines, crest and depression points are determined, and hence positions for placement of gullies are defined.

Changes of the carriageway cross slope and the occurrence of depression points are influenced by:

- the slope of the secondary approach to the intersection, with or without difference in the slope should be connected to the cross slope of the carriageway of the primary direction (see Figure 38).
- The division island and the triangular island are formed within the approach of the secondary road towards the intersection.

By forming separate longitudinal profiles along the curb lines, directing of the surface water flow, as well as precise positioning of the gullies can be checked.

6.6 Visibility

6.6.1 General

Access visibility towards intersection and connections shall be uninterrupted and clear so that drivers can timely stop if necessary, in front of a vehicle passing through the intersection or turning, as well as in front of a cyclist or a pedestrian.

Additionally, drivers, cyclists and pedestrians which need to wait at an intersection need to have adequate visibility towards constant obstacles (including traffic signs) and plants which can obstruct visibility. Only necessary traffic and road equipment, such as lamp posts, traffic and light signalization are allowed in the visual field.

Visibility should be clear and should be spatially determined (field of view). The following parameters are adequate for an analysis:

- the height of the driver eye 1.10m
- the height of the eye of a truck driver: 2.50m (this is related to vision towards underpasses, traffic signs and posts)
- the height of the objective of vision on a selected traffic lane > 1.10m

The height of the available field of view should be free of obstacles and depends of the design class K or maximum allowed speed for the intersection in question. Visibility is specifically checked for:

- visibility for stopping
- merging field of view
- immediate visibility

6.6.2 Visibility for stopping

Stopping visibility Pz is checked on all approaches to the intersection in accordance with the values given on the graph in Figure 28. The right right-of-way rule is perceived in time, as well (Figure 48).
If the visibility does not provide perception of the right priority of passing, in specific justified cases, the right of way rule should be timely announced. The need to limit the speed in the approach to the intersection, shall be additionally considered.

6.6.3 Entry field of view in intersections

The entry field of view in intersections is the field of view, necessary for a driver who has stopped at the entrance of the intersection from a secondary road direction, at a distance of 3m from the carriageway edge of the primary direction (Figure 49). Pedestrian and bicycle paths are not taken into consideration in this case.

The entry field of view should be sufficiently wide, so that a driver having an acceptable disability, can safely access the primary road from a still position to a moving position on the carriageway traffic lane of the primary road direction. This condition is valid both for intersections and connecting to an intersection with or without traffic lights.

The length of triangle base of the entrance field of view is L=100m if the permitted speed is limited to 60 km/h. For intersections where the speed limit in the main direction is 80 km/h, the length of the base of the triangle of the visual field is L=200 m.

If, due to local specific conditions, it is not possible to ensure the entrance field of vision, it is additionally considered if speed shall be limited in the approach to the intersection on the main direction.

6.6.4 Access field of view

Access field of view of intersection is the field of view of a driver when approaching an intersection from a secondary road direction from a distance of 15m. In case of increased proportional participation of heavy vehicles, the necessary distance from the intersection is 20m from the edge of the carriageway of the primary direction. Pedestrian and bicycle lanes are not taken into consideration in this case.

If the access field of view is adequately wide, the driver can access the primary road without stopping (Figure 50). For traffic safety reasons, this option is possible only if the speed on the primary direction is limited to 60km/h. The length of the basis of the triangle of the access field of view is L=100m.

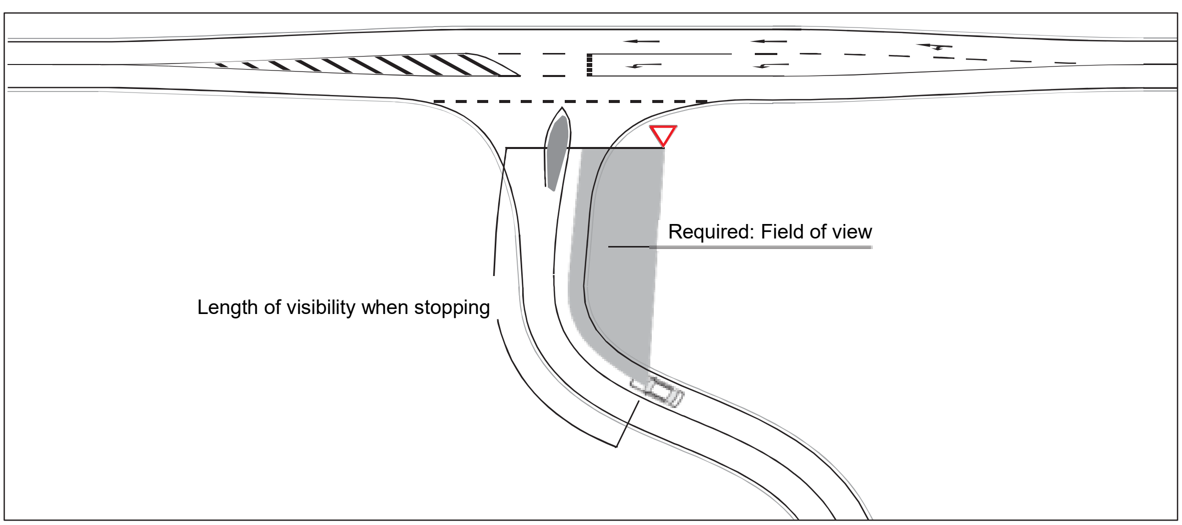


Figure 48 Field of view in function of the length of the visibility when stopping when accessing an intersection from a secondary road

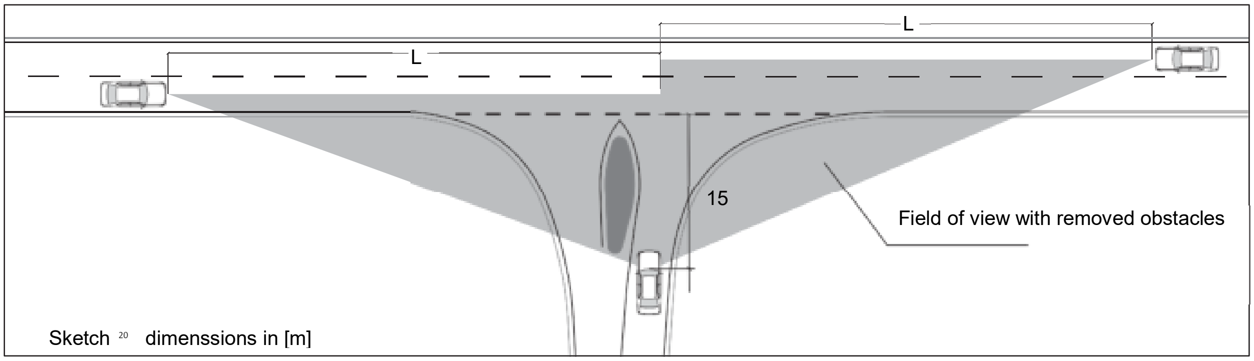


Figure 49 Entry field of view from a secondary road immediately in front of an intersection

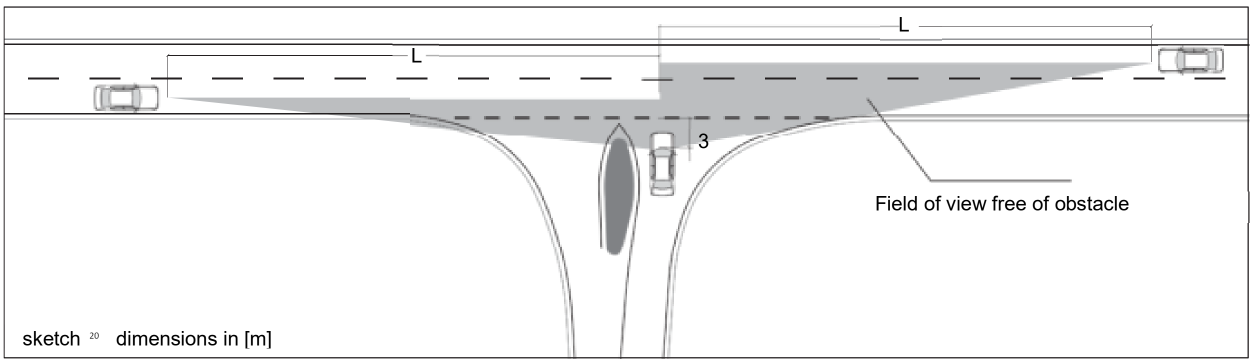


Figure 50 Access field of view from a secondary road close to an intersection

At intersections where it is not possible to provide the required access field of vision or where the speed limit is not 60 km/h, it is necessary to install a traffic sign II-2 for access from a side direction (STOP), and place appropriate markings on the carriageway

6.7 Checking the passage of intersection

With regard to intersections at level, it is necessary to check the passage for all turns (left and right) using the wheel track curve of the relevant vehicle by appliance of verified software system or by using standard curves of minimal values.

The type of relevant vehicle is determined according to road categories which form the intersection, i.e. according to the design class K of the primary road and the design class K of the secondary road, as well as the conditions related to the vehicle maneuvers at the intersection.

Conditions for maneuvers of relevant vehicles are related to a possible collision of the external contours of vehicles (curves of traces and size of vehicles) when turning (Figure 51). There are four cases of vehicle contour collision when turning (left and right):

Type 0 When relevant vehicle turns, its external conture does not enter the space of other vehicles contures

Type 1a The external contures of the vehicle enter the neighboring traffic or manipulative lane in the direction to which the turn is made (a single overlap).

Type 1b The external contures of the vehicle enter the neighboring traffic or manipulative lane in the direction from which the turn is made (a double overlap).

Type 2 The external contures of the vehicle enter the neighboring traffic or manipulative lane in the direction to which the turn is made and in the direction from which the turn is made (a double overlap)

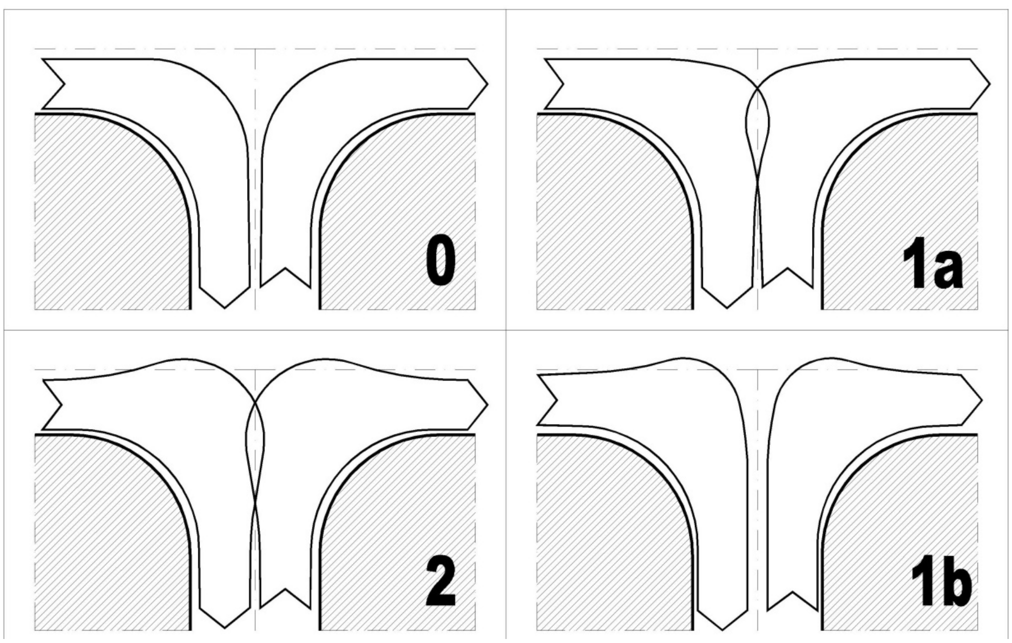


Figure 51 Conditions for maneuvers of relevant vehicles

The standard curve of minimum passing is designed as a basket curve consisting of three radius in certain ratio (see chapter 6.4.11). The usual ratio is R1:R2:R3=2:1:3. The turning angle γ° is distributed so that:

$\alpha = 15.75°$

$\beta = \gamma - 36°$

$\delta = 20.25°$

The main radius R2 is selected according to the category of relevant vehicle and in the function of the turning angle γ according to the graph presented on Figure 52.

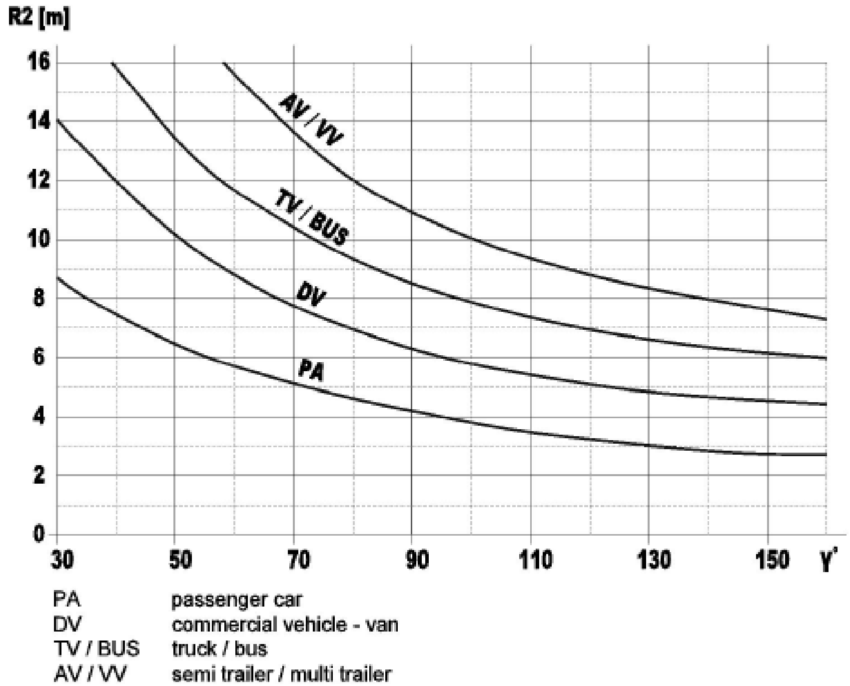


Figure 52 Selection of radius R2 in function of the turning angle γ and an relevant vehicle

The selection of value of radius R2 should not exceed the size of 25m, in which case the radius of the circular curve should be applied in value higher than 25.0m with a crossing point.

For right turns, the protective width of 0.25m related to both contures of the curve (Figure 53 . For left turns, except in cases of greater participation of heavy vehicles and buses in both directions, a simultaneous turn of heavy and passenger vehicles is enabled, with protective width of 0.25 for each curve (a total of 0.50m).

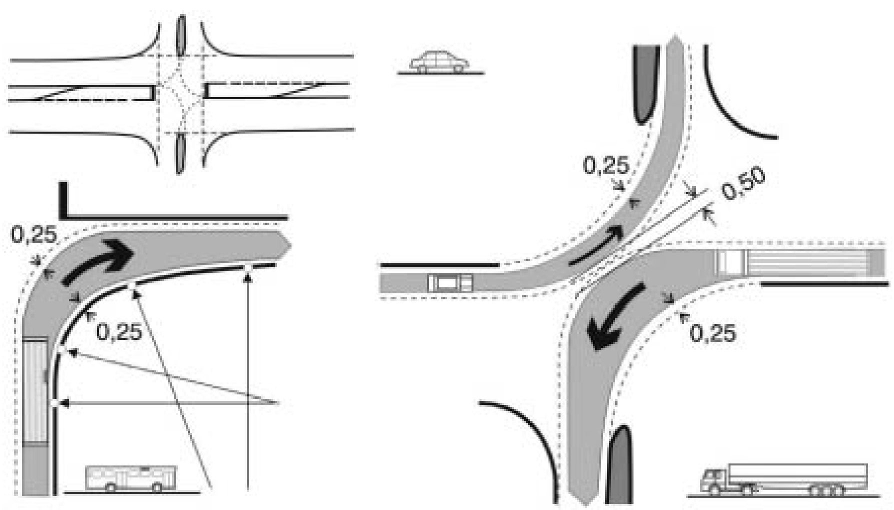
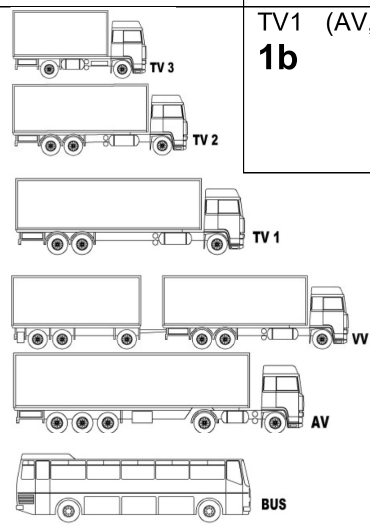


Figure 53 Limit conditions for passing for left and right turns

Relevant vehicles, type of maneuvers of relevant vehicles in the function of the road category are presented in Table 37.

Table 37 Selection of relevant vehicles and types of maneuvers in the function of class C (local road category)

	K1 (SP IV)	K2 (SP V)	K3 (PP V)	K4 (PP VI)
K1 (SP IV)	AV, VV - **0**	AV, VV (TV1) – **1b**		
K2 (SP V)		TV1 (AV, VV) - **1b**	TV1 (BUS, TV2) - **1b (1a)**	
K3 (PP V)			TV2 (BUS, TV3) - **1b (1a)**	TV3 (BUS, TV2) - **2**
K4 (PP VI)				TV3 - **2**

6.8 Bicycle and pedestrian traffic management

6.8.1 General

Bicycle and pedestrian traffic is per rule conducted on an independent carriageway with movement in two directions. In the intersection zone, due to high speed of movement of motor vehicles, it is necessary to provide good visibility, clear guidance and regulation of advantage of passing of non-motor traffic.

In order to guide cyclists and pedestrians through an intersection over a carriageway of primary and secondary roads, adequate adjustment of the intersection elements shall be ensured (see chapters 6.4.5, 6.4.6, and 6.4.7).

6.8.2 Intersections without traffic lights regulation (TL).

When bicycle and pedestrian traffic is conducted in both directions over an independent carriageway in parallel to the main road direction, crossing over a secondary road of class K2 in an intersection zone is conducted through a division island over a specific surface at a distance of minimum 6m from the edge of the carriageway of the main direction. Pedestrian and bicycle traffic, due to traffic safety conditions, generally do not have the right of way over the secondary road. The width of the division island at the crossing point for cyclists and pedestrians should have an approximate width of 2.5m to provide a waiting area for crossing the carriageway. The obligation of waiting for pedestrians and cyclists should be clearly marked in terms of traffic signalization.

When bicycle and pedestrian traffic is conducted in both directions on independent carriageway in parallel to the main road, the crossing over the secondary road of class K3/K4 in the intersection zone takes place with the right of way for cyclists and pedestrians. In this case, the crossing over the secondary road in the intersection zone takes place close to the edge of the primary road, typically at a lateral distance of 4.0m. The right of way for cyclists and pedestrians must be clearly marked. The bicycle lane is marked in red in order to highlight the right of way. This type of traffic solution implies a low traffic load with motor traffic on both road directions in the intersection zone, as well as good visibility of the intersection.

When cyclists and pedestrians need to cross over the main direction, for example:

- between a separate lane parallel to the secondary direction and the lane parallel to the main road which is from the opposite side of the primary direction
- in order to cross over the other side of the primary direction to cross over the secondary road from the other side
- to change the side of movement in relation to the primary road in the intersection zone

For safety reasons, it is recommended to use a central (median) island for crossing over the primary road of class K1/K2 with heavy traffic load (see chapter 6.4.10). Such crossing can be used in left turns of types LT2 and LT3 with the location of crossing from the other side of the left turn over a striped restrictive zone.

The structural width of the central island is 2.50m. The waiting area for pedestrians and cyclists to the central island is 4.0m wide.

In particular, it is necessary to consider the need to introduce speed limits for motor traffic in the zone of the central island and crossings for cyclists and pedestrians.

A completely safe crossing of non-motor traffic over a primary road can be provided only with an introduction of traffic light regulation of traffic).

6.8.3 Intersection (crossings and connections) with traffic light regulation

At intersections with traffic lights regulation, bicycle and pedestrian traffic should be regulated by a special signal plan. Pedestrian and bicycle traffic management at the crossing over the secondary road is carried out in the immediate vicinity of the carriageway edge of the main direction, typically at a distance of 4.00 m over the path marked in red. The lane is crossed over a division island with a lowered surface which is 4.00 m on that spot in order to provide room for waiting for pedestrians and cyclists to cross.

For right turns type RT3, motor vehicles which turn right need to have a specific phase in the signal plan in coordination with the signal plan for non-motor traffic.

6.8.4 Roundabouts

On roundabouts, a specific lane for non-motor traffic outside of the roundabout carriageway shall be ensured, provided that non-motorized traffic is also included on at least one access to the roundabout.

6.9 Public transport management

When designing surface intersections, special attention should be devoted to the participation of public transport in traffic, particularly regarding the location and methods of shaping BUS stops for public transport. Special traffic lanes for movement of public transport vehicles are not envisaged, in general.

BUS stops and the passenger waiting area must be visible to drivers, at distance required by the stopping visibility of Pz. The public transport bus stop must be connected to the surrounding footpaths.

For roads of class K1, the BUS stop needs to be located at a structurally separate traffic lane outside the main carriageway.

On roads of class K2, with a heavy traffic load, the BUS stop should be located on the extension of carriageway, BUS STOP, outside the main carriageway. The dimensions of the shaped BUS stops for public transport are shown on Figure 54.

At intersections without traffic lights, the BUS stop is formed behind the intersection. At intersections with traffic light regulation, the BUS stop is formed freely if it is designed with BUS stop location. In any case, the BUS stop is formed before the pedestrian and bicycle crossing, and if it is formed at the beginning of the roundabout, it is formed behind the pedestrian and bicycle crossing.

In general, the location of bus stops within intersections must be coordinated with the pedestrian and bicycle traffic management. A special location for BUS stop on right turns should be avoided, due to obstructed visibility when vehicles merge in the main traffic flow, otherwise the maneuver of changing lanes for vehicles for public transport needs to be proved by controlling visibility.

On public roads of class K2 having a slighter traffic volume and on roads of class K3, a BUS stop can be formed in the intersection zone on the main carriageway, provided that the frequency of public transport is low. BUS stops on the main carriageway, on these roads classes, should not be formed behind the intersection.

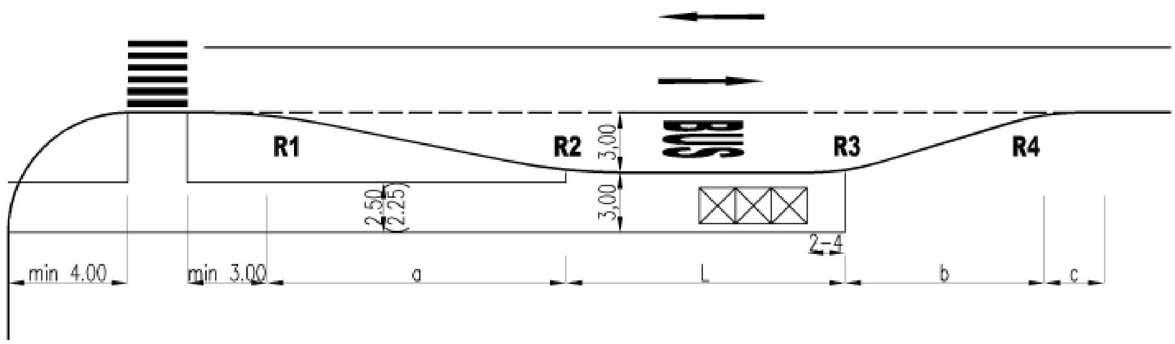


Figure 54 Dimensions for BUS stops for a standard bus

Type of a bus		A	b	C	R1	R2	R3	R4
L = 13.5 m	Min	15.00	10.00	3.00	30	20	12	20
L = 18.75 m	Norm	25.00	15.00	4.00	80	60	20	40

7 Road equipment

7.1 General

The equipment of local roads as well as the road belt is the subject of design in all phases of design development because it has a significant impact on safety and the behavior of road users in traffic movements.

Vertical traffic sigange, road markings, other equipment and greenery are inseparable elements of the entire road through the phases of design, construction, use and maintenance of the road.

"Traffic Signage Rulebook" ("Official Gazette of the RS", no. 85/2017 and 14/2021), "Regulations on conditions that must be met by road facilities and other elements of the public road from the aspect of passenger safety", "Law on Roads" " and the "Law on Planning and Construction" provide the legal basis for the overall process of designing, building, exploiting and maintaining roads, including signaling and road equipment.

7.2 Road markings

Road markings are basic element of visual traffic guidance. Road markings ensure safe direction of traffic movements in the directions on the open road and direct traffic movements at intersections. Road markings instructs the driver to distinguish the types of local roads that are designed according to different design classes, thus instructing the driver to adjust the speed according to the appropriate road class and to recognize its function at the network level.

The rulebooks and standards define the appearance, dimensions and way of marking elements of road markings.

Starting from one of the basic road safety requirements for roads to be self-explanatory, for each class of local road design, an appropriate way of marking of longitudinal markings in road cross sections is defined. A clear way of marking the basic elements of road markings gives the driver a clear picture of the class of the local road, and the basic dangers, restrictions, and situations he can expect on the same. In chapter 4.3 Standard normal transverse profiles, i.e. in pictures no. 7 - 10 of this chapter, the method of marking of longitudinal markings in cross section of the local road, for different design classes defined in these Guidelines, is shown.

On roads of class K1, with one carriageway, it is possible to mark a double center line, so that the impression of a dividing strip 0.5m wide, together with the lines, is created. This is especially recommended in places where it is necessary to visually narrow the width of the traffic lanes in order to reduce the speed of the vehicle. An example of the application of the above can be the section of the K1 class local road through the settlement, where the width of the traffic lanes is reduced to 3.00m by applying a double dividing line.

Slika 55 Example of double center line from Republic of Holland

On the K2 road, in places where overtaking and crossing into the opposite traffic lane is expressly forbidden, a double solid center line is marked.

Class K3 and K4 roads do not have a center line. On these roads, edge lines are marked at a distance of 0.25 m from the edge of the road. These lines are marked with a broken line in a 1:1 grid (1m line, 1m space).

Also, when safety reasons require it, the longitudinal markings that mark traffic lanes and separate them by direction can be made of textured materials so that they have a vibro - audible effect when vehicles pass over them.

In addition to the way of marking of longitudinal markings depending on the design class of local roads, the method of marking specific situations on the road such as the entrances to the settlement (Appendices No. UN-01 - UN-04), railway crossings (Appendices No. PP -01 - PP-04), school zones (Attachments No. ZS-01 - ZS-04) and dangerous curves (Attachments No. OK-01 - OK-04). The mentioned attachments show in detail the way of marking of road marking elements in the mentioned specific situations, which are frequent and characteristic for local roads, all depending on their design class.

Road markings must be visible to a sufficient extent during the day, and especially during the night and in conditions of reduced visibility on the road. The materials and characteristics of the materials used for road markings on local roads are defined by the Rulebook and standards. Bearing in mind the planned traffic and technical conditions for each design class of local roada, the following Table provides recommendations for usage of materials with appropriate characteristics for each class individually.

Tabel 38 Recommended materials and values of reflectivity and SRT units in function of design class K (category of local roads)

K	**Type of material**		**Reflectivity value R_L**	**Reflectivity value R_W**	**SRT units**
K1 - divided carriageways	Thick markings (exceptional, thin markings)	new markings	≥ 300	≥ 100	≥ 50
		during exploatations	≥ 150	≥ 50	≥ 45
K1	thin markings (ped. crossings, stop lines, symbols in school zones as a thick markings)	new markings	≥ 200	≥ 100	≥ 50
		during exploatations	≥ 100	≥ 50	≥ 45
K2	thin markings	new markings	≥ 200	≥ 100	≥ 50
		during exploatations	≥ 100	≥ 50	≥ 45
K3	thin markings	new markings	≥ 150	≥ 75	≥ 50
		during exploatations	≥ 100	≥ 35	≥ 45
K4	thin markings	new markings	≥ 150	≥ 50	≥ 50
		during exploatations	-	-	≥ 45

R_L - reflectivity coeficient (mcd x m-2 x lux-1)

R_W - reflectivity coeficient in wet conditions (mcd x m-2 x lux-1)

*All reflectivity values are given for the white color

7.3 Traffic signs

The term vertical traffic signage is most often identified with traffic signs. Vertical signage can be defined as a set of specially coded signs intended for road users, which are placed in the vertical plane in relation to traffic surfaces. The basic importance of vertical traffic signage is reflected in the fact that it provides basic information about permitted speeds, priority conditions and movement regimes on certain road segments.

The rulebooks and standards define the appearance, dimensions and way of placing elements of vertical signage.

Regarding the dimensions of traffic signs placed on local roads, the following table provides recommendations for the dimensions of basic traffic signs in relation to the design classes defined in these Guidelines.

Tabela 39 Recomeneded dimensions of basic traffic signs In relation to design class K (local road category)

K	△	○	□	▯	▭
K1 - divided carriageways	90x90x90cm	Ø60cm	60x60cm	60x90cm	60x30cm
K1	90x90x90cm	Ø60cm	60x60cm	60x90cm	60x30cm
K2	90x90x90cm	Ø60cm	60x60cm	60x90cm	60x30cm
K3	60x60x60cm	Ø40cm	40x40cm	40x60cm	40x20cm
K4	60x60x60cm	Ø40cm	40x40cm	40x60cm	40x20cm

Among the basic information that should be presented to the users of local roads by means of traffic signs is also information on permitted speeds. The speed limit that is defined during the design of the local road depends on the traffic-technical characteristics of the stretch where the speed limit is introduced. Speed limits must be defined in such a way that they are logical to drivers, first of all in relation to the geometry on which the limit is defined, then correctly set, as well as logical for following (without frequent changes in speed limits that can lead to driver frustration and mistrust in traffic signs). Sectoral speed limits on homogeneous stretches derive from the basic speed used for dimensioning the elements of the plan and profile of the local road (Table 11 Design classes and basic values of design elements).

Specific situations on stretches of local roads, where due to geometry (sharp curves, reduced stopping visibility) or other functional elements of the road (intersections, pedestrian crossings, narrowing of the road), it is necessary to adopt a different speed limit, are analyzed separately. Depending on the traffic and technical conditions at those specific locations, as well as on the basis of road safety requirements, the corresponding speed limit is defined.

It is recommended that the section of the local road to be divided into homogeneous stretches from the aspect of speed management and in relation to the geometry of the road, objects on the section, then major intersections, the beginning/end of the settlement, zones of public and private facilities along the road. Bearing in mind the aforementioned that speed management should be logically defined and clear for drivers, then easy to follow, it is necessary to define homogeneous stretches of appropriate length under one movement speed limit. The recommendations related to the minimum length of a stretch under one speed limit were taken from the research of the Australian road association, Austroads, and are about 2000 m, for design classes 1 and 2, and 500 m for design classes 3 and 4. The exception is the zone of isolated pedestrian crossings, or intersection zones where, on a relatively short stretch, it is necessary to define a different speed limit than the stretches in front and behind (usually a lower speed limit). It is recommended that the zones under the second speed limit in this case should not be shorter than 200m.

For the purposes of speed control on a stretch, it is not always necessary to place only standard traffic signs II-30, according to the Traffic Signage Rulebook. Here it is possible to introduce signs of the recommended speed, as well as LED panels on which the corresponding speed limit will be displayed, i.e. valid, only in moments when there is a real need for a speed limit (e.g. the zone of bus stops where public transport buses stop once or twice per day or a slippery road zone, which is why it is necessary to limit the speed of movement only in conditions when it is raining, i.e. at low temperatures when there is a possibility of ice forming on the road).

It is also important to note that changes when reducing the speed limit of more than 20 km/h are unpleasant for drivers, which may result in the driver's unpreparedness to adjust the speed of the vehicle to the new speed limit from the place where it is set. In this regard, it is always necessary to gradually reduce the speed limit, so that the driver gradually adjusts the speed of the vehicle. Research conducted in 1989. in SFRY (S. Milošević, "Perception of traffic signs") shows that placing several speed limit signs at the appropriate distance, one after the other, increases the percentage of drivers who notice these signs in time and respect the defined speed limit on the sign.

Also, there will often be situations where the right of way is regulated on stretches of local roads in relation to organized and unorganized connections of agricultural and other uncategorized roads and approaches to buildings. In this regard, it is recommended to place road marking signs with right-of-way at the beginning of the local road section, III-3, with the possible addition of an additional board with a local road marking according to the categorization of roads in the territory of the local self-government (if there is a defined Decision on categorization). This unambiguously informs the driver that he is on a road with the right of way in relation to the junctions of other roads of a lower category, as well as facilitates the definition of the right of way and the announcement of junctions (reduces the number of signs) at the intersections themselves. The designer reserves the right to, depending on the specific situations of the terrain, adopt a different principle of solving the right of way. In places where a section of a local road intersects with a road of a higher rank (e.g. a state road), a traffic sign for the end of the road with right-of-way, III-4, is placed.

The Appendices of these Guidelines show the placement of traffic signs in specific situations that can be found on local roads, such as: entrances to the settlement (Appendices No. UN-01 - UN-04), railway crossings (Appendices No. PP-01 - PP-04), school zones (Attachments No. ZS-01 - ZS-04) and dangerous curves (Attachments No. OK-01 - OK-04). Placement of traffic signs in the specified specific situations are elaborated for each design class of local roads separately.

Traffic signs must be visible to a sufficient extent during the day, and especially during the night and in conditions of reduced visibility on the road. The materials used for the production of traffic signs placed on local roads are defined by the Rulebook and standards. Bearing in mind the planned traffic and technical conditions for each design class of local roads, the following Table provides recommendations for the use of materials with appropriate characteristics for each class individually.

Tabela 40 Recommended reflectivity classes of front materials in function of design class (category of local roads)

K	Class 1 reflectivity	Class 2 reflectivity	Class 3 reflectivity
K1 - divided carriageway		√	
K1		√	
K2	√	I-32, I-33, I-34, I-35 II-1, II-2 III-5, III-6, III-7, III-11, III-28, III-85, III-86 umetnuti znakovi na žuto - zelenoj osnovi	
K3	√	I-32, I-33, I-34, I-35 II-1, II-2 III-5, III-6, III-7, III-11, III-28, III-85, III-86 umetnuti znakovi na žuto - zelenoj osnovi	
K4	√		

7.4 Directional signage

In order to inform road users about turnings to destinations and avoid dangerous driving maneuvers, directional signs must provide road users with early information about necessary driving decisions. Therefore, directional signs are required on all access roads to intersections. The number of destination details should be limited to what is necessary to avoid visual overload and confusion for road users.

The rulebooks and standards define the appearance, dimensions and way of placing elements of directional signage. The list of valid regulations and standards in this area is given at the end of the chapter.

In the case of design classes K1 and K2, it is recommended to install at least two levels of user notification in front of the turn point, namely the first and third level of notification ("Crossroads" sign and directional board / arrow sign). Considering the expected traffic load, as well as the functional elements of local roads of design classes 1 and 2, these classes should be treated in a similar way as state roads of IB or II rank. At the intersections of these classes of local roads with state roads, and if necessary, it is possible to include a second level of user notification - directional boards for defining of purpose of lanes by direction of movement.

In the case of design classes K3 and K4, due to the expected reduced speed of user movement resulting from the geometrical and environmental characteristics, as well as the spatial limitation within the road plot, it is recommended to install only the third level of user notification (directional board / arrow sign).

In places where local roads of design class 3 and 4 intersect with roads of a higher rank, and if it is necessary and spatial conditions allow it, several levels of road user notification can be installed.

When placing traffic signs on local roads of design class 3 and 4, one should be rational. On local roads, there will often be a need for guidance to tourist destinations, and the installation of tourist signage (tourist directional boards, tourist arrow signs). In the majority of cases, tourist signage clearly points to destinations whose names would be used on road signs, and in this case, it is sufficient to place only tourist signage.

The height of the text used on road signs is defined by Serbian standards and the Rulebook, depending on the speed of the vehicle along the road. In this regard, on local roads of design class K1 (with one carriageway or divided carriageways) the letter height (H) of 175mm is applied. Furthermore, the height of the letters on road signs that are placed on other classes of local roads, K2 - K4, the height of the letters (H) is 140mm. An exception can be represented by the classes of local roads K3 and K4, where due to the expected traffic and technical conditions and space limitations, it is possible to define letters with a height of less than 140 mm. In this regard, it is possible to define a lower height of the letters, but not less than 100 mm, in which case it is necessary to analyze the visibility of the inscriptions on the signs in relation to the expected operational speed and the characteristic places of placing traffic signs (on the embankment on the road, on the embankment in the curve of the minimum radius, etc.). Attention should be paid to the uniformity of the height of the letters on road signs placed on one section of a local road.

Directional signs must meet all the requirements as well as standard traffic signs. The recommendations of the materials used for the production of traffic signs are the same as for standard traffic signs and are given in Table 39.

7.5 Traffic signals

For the purpose of greater safety and protection of road users turning left, separate signal phases should be provided on approaches to the intersection from the primary road to ensure quick passage through the intersection for passing traffic lanes. This is an essential way to guarantee a high level of safety on the road with a traffic light system.

Traffic signal systems should have an adaptable mode of operation in accordance with the intensity of traffic, in order to reduce waiting times for passing and turning. Public transport vehicles and non-motorized traffic have priority in regulation.

When designing an intersection, the location of traffic signals, cables and shafts for laying and distributing installations must be taken into account at the same time.

7.6 Guidance systems - directional indicators

Directional indicators are used to optically guide road users and highlight the route of the road, with their effect complementing the markings on the road. On local roads of design classes K1 and K2, light markings are designed continuously along the road, while on roads of other design classes they are placed according to need, that is, possibilities, taking into account the width of the shoulder and edge content, the possibility of passing vehicles and other circumstances. As a subgroup of directional indicators, which will receive primary attention in these Guidelines, are delineator posts.

The rulebook and standards define the appearance, dimensions and way of placing elements of directional indicators.

As already mentioned, directional indicators - delineator posts are placed continuously along local roads of design class K1 and K2, with a basic distance of 50m. In sharp horizontal curves and on crests, the distance should be reduced in order to have a better guiding effect. On local roads of design class K3 and K4, delineator posts are placed according to the need and the possibilities on the site. Due to spatial limitations in the form of a narrow carriageway in the design class of local roads K3 and K4, it is expected to use the shoulder when passing vehicles (especially in the design class K4). In this regard, the continuous use of delineator posts is recommended in situations of a wider shoulder, when the delineator posts can be set to min. 1.0m distance from the edge of the carriageway. Also, the use of delineator posts on local roads of design class K3 and K4 is possible for the purpose of marking dangerous places, such as dangerous curves, etc. and only on a limited length so that the mentioned equipment does not hinder the passing of vehicles on longer stretches.

In connection with the previous ones, certain appendices of these Guidelines show how to install directional indicators - delineator posts in specific situations that can be found on local roads, e.g. dangerous curves. Placement of delineator posts in the specified specific situations were elaborated for the design class of local roads K3 and K4.

Like standard traffic signs, delineator posts must also be sufficiently visible during the day, and especially at night and in conditions of reduced visibility on the road. The materials used for the production of delineator posts placed on local roads are defined by the Rulebook and standards. The visual performance of the delineator posts (retroreflection and chromatic characteristics of the day and night markings on the body of the delineator posts) must correspond to the provisions of the standard SRPS EN 12899, chapter 6.3, while the physical performance of the delineator posts is defined by the same standard SRPS EN 12899, chapter 6.4.

7.7 Vehicle restraint systems (guardrail)

The space outside the roadway should be designed so that due to a road accident or a vehicle leaving the roadway, there are no serious consequences of such accidents, and to be possible to regain control over the vehicle (application of the principle of "self-forgiving" roads). If it is not possible to provide adequate "side protection zones", i.e. if it is not possible to apply road elements that mitigate the consequences in the event of a vehicle leaving the roadway (slight slopes, a zone beside the road without obstacles, etc.), it is necessary to install a vehicle restraint system.

The areas of application of the vehicle restraint system are listed in the Technical Instructions for the Application of the Vehicle Restraint System on State Roads of the Republic of Serbia JPPS BS-04/2021. The dimensions, appearance and materials from which the vehicle restraint systems are made depend on the type of system being installed, whereby all systems must meet the provisions of the SRPS EN 1317 standard. Steel and concrete protective fences are most often used in practice on roads in the Republic of Serbia where it should be emphasized the existence of wooden and wire protective fences, which can be used on local roads. In addition to protective fences (including transitional and final elements), crash absorbers are also used on roads in Serbia, which may also be necessary on local roads, especially with higher classes of local road design (K1 and K2).

Within roads cross section, outside the carriageway, there should be sufficient available width for the installation of the vehicle retention system at a distance of not less than 0.50m from the edge of the carriageway in accordance with the above-mentioned technical instructions.

The height of the curb, if any, in front of the vehicle restraint system should not be higher than 7 cm.

The areas of application of the restraint system, as well as the type of system (containment level, working width (dynamic deflection) of the guardrail, performance class of end elements and crash absorbers) installed on local roads of design classes K1 and K2 are fully adopted according to the provisions of the Technical Instruction JPPS BS-04/2021, as good practices for the use of road restraint systems.

Exceptions are possible in the case of local roads of design class K3 and K4. Spatial restrictions in road cross section of these classes also limit the installation of vehicle retention systems, especially on longer stretches. For these classes, the guardrail is placed where there are spatial possibilities, i.e. a distinct danger on the side of the road. It is also important to note here that it is expected that the elements of the road plan and profile of these design classes will be adopted in such a way that they will prevent movement at higher speeds, which is one of the main conditions that determine the installation of a vehicle retention system on the road. Also, these design classes are characterized by extremely low traffic loads, almost without the participation of commercial vehicles in the traffic flow, which is also one of the conditions for deciding on the installation of a guardrail.

In situations where the road embankment is higher than 3.0 m and slopes steeper than 1:2, a gurardail is installed in the case of all classes of local road design. With the fact that, in the case of installing a guardrail on longer sections (longer than 300m) of local roads of design class K3 and K4, passing bay must be provided. The arrangement of passing bays results from the conditions of visibility of vehicles from the opposite direction, arrangement of the elements of the guardrail along the stretch of the local road.

On local roads of the K3 and K4 design classes, passing bays can be provided in the event that the guardrail is installed on shorter stretches, all depending on the road safety requirements at that location. On the other hand, on shorter stretches with a guardaril installed on one or both sides of the road, the free road profile narrows. In those situations, it is necessary to define signs for alternately regulating the right of way of vehicles, in places where it is possible to safely pass vehicles, i.e. giving up the right of way. For this purpose, it is also possible to use passing bays.

7.8 Road drainage

Surface water from the carriageway of the local road should be drained by an open system for environmental and economic reasons, whereby the surface water is drained over the shoulder to natural depressions and absorbed into the surrounding soil.

Closed drainage system could be necessary if:

- the water drainage cannot be done by an open system
- the route crosses over water-retention area
- it is required by other water requirements
- if the cross slope of the carriageway is turned to the side where water needs to be accepted and evacuated through canals and pipes

Surface water collected on the edge of the carriageway are brought to the recipients through sewage systems which can be separate structures (retention pools, cleaning system for rain water, etc.)

Conditions for the type of local roads drainage and shaping of the local land are determined according to the protective ability of gully areas.

Road drainage details can be found in chapter 3 **Drainage.**

7.9 Public lighting

Local roads are generally not lightened on open route. If public lighting is introduced on a local road for special reasons, for example due to the requirement for better visibility in the intersection area, the design should be harmonized with the specifications of the standard SRPS EN 12665:2018 Light and lighting - Basic terms and criteria related to the determination of lighting requirements.

7.10 Measures prevent shading and measure to protect wild life

Measures against shading on single carriageway roads generally may be necessary if there is a parallel traffic direction in the immediate vicinity.

On dual carriageway sections of a local road, protection against reflection generally should be provided only for car traffic. Therefore, vehicle restraint systems with a height of h=0.80 m are sufficient for the purpose of anti-shadowing in the central reserve, even without an upgrade.

Guardrails may be installed on local K1 roads, on locations where frequent crossings of game animals are expected.

If wildlife protection structures (e.g. flyover aids) are located close to the road, it must be checked that sufficient stopping visibility is guaranteed (see chapter 5.6.2).

7.11 Noise protection

The law on protection against environmental noise ("Serbian Gazette, issue 96/2021), the Rulebook on allowed level of noise in environment ("Serbian Gazette, issue 72/2010 from 8.10.2010), formed the legal foundation for protective measures based on principles of noise prevention.

Noise protection measures (for example, noise protection walls) generally should be prioritized against passive measures for protection on buildings which need to be protected.

If there is sufficient space, a rampant made of soil material against noise is a more favorable solution than artificial barriers against noise from environmental and economic reasons. Per rule, rampant are designed with a slope of 1:1,5 and a crown 1,00 m wide.

7.12 Plants

Under the Law on nature protection ("Serbian Gazette RS", issues. 36/2009, 88/2010, 91/2010 - amended., 14/2016, 95/2018 – other law and 71/2021) protection and preservation of nature, biological, geological and regional diversity as part of the environment is required. Nature as an asset of general interest enjoys special protection in accordance with this law and special law.

This law requires that in case of intervention (construction) in nature, it should be carried out so that it restores or redesigns it in a way which does not disturb the existing environment, or possibly improve it.

In order to support the spatial compliance, it is necessary to plant trees from the sides of the road. When planting, stopping visibility shall be ensured (see chapter 5.6.1).

While planting next to the carriageway, attention should be paid to traffic safety. The edge surfaces thus need to be designed in a way to enable minimum consequences from possible vehicle run-off from the carriageway.

Planting bushes are not considered as dangerous obstacle if their trunk diameter does not exceed 8 cm, otherwise they are cut off in terms of thinning. Such plants should be placed at a distance of more than 3.00 m from the road edge and must not obstruct the field of vision, which should be free.

When planting new trees near the roadway, attention should be paid that over time they will grow and become a dangerous obstacle. Thus, trees should only be planted in areas that cannot be reached by vehicles that may run off the carriageway (e.g. behind vehicle restraints or on shoulders). Planting should be more than 3.00m behind the vehicle restraint system in relation to the carriageway edge.

7.13 Extensions for stopping and parking

On roads of class K1, it is preferable to form expansions on the carriageway or separate areas for stopping and parking.

Dimensions, types and inter-distance of the space for parking depend on traffic load and structure of vehicles which use the road. Consideration should be given to the need for possible extension of the parking space in accordance with the growing requirement (traffic). The connection of the separate parking lot with the main road should be provided as a road of class K3.

7.14 Rest area and gas stations

Rest stops are generally envisaged and constructed on the same location as gas stations. The location for designing and constructing a rest stop and-or gas station should be sufficiently distant from the closest intersection. Access to these contents, entrance and exit from them, from the road of class K1 should be done through a specially formed lane for exit and entrance from the main road direction.

7.15 Installations

Underground installations which are led along the road base should be sufficiently distant from the edge of the carriageway, i.e. road drainage, sufficiently deep so that they cannot collide with the guardrails posts of traffic signalization posts.

8 Graphic attachments

No.	Attachment	Attachment no.
1	The method of marking dangerous curves on the local road of the design class K1 (standard cross section PP10.0)	OK-01-K1 (Figure 56)
2	The method of marking dangerous curves on the local road of the design class K2 (standard cross section PP9.0)	OK-02-K2 (Figure 57)
3	The method of marking dangerous curves on the local road of the design class K3 (standard cross section PP7.5)	OK-03-K3 (Figure 58)
4	The method of marking dangerous curves on the local road of the design class K4 (standard cross section PP6.2)	OK-04-K4 (Figure 59)
5	The method of marking the road crossing over the railway on the local road of the design class K1 (standard cross section PP10.0)	PP-01-K1 (Slika 60)
6	The method of marking the road crossing over the railway on the local road of the design class K2 (standard cross section PP9.0)	PP-02-K2 (Figure 61)
7	The method of marking the road crossing over the railway on the local road of the design class K3 (standard cross section PP7.5)	PP-03-K3 (Figure 62)
8	The method of marking the road crossing over the railway on the local road of the design class K4 (standard cross section PP6.2)	PP-04-K4 (Figure 63)
9	The method of marking the entrance to the suburb on the local road of the design class K1 (standard cross section PP10.0)	UN-01-K1 (Figure 64)
10	The method of marking the entrance to the suburb on the local road of the design class K2 (standard cross section PP9.0)	UN-02-K2 (Figure 65)
11	The method of marking the entrance to the suburb on the local road of the design class K3 (standard cross section PP7.5)	UN-03-K3 (Figure 66)
12	The method of marking the entrance to the suburb on the local road of the design class K4 (standard cross section PP6.2)	UN-04-K4 (Figure 67)
13	The method of marking the School zone on the local road of the design class K1 (standard cross sectionl PP10.0)	ZS-01-K1 (Figure 68)
14	The method of marking the School zone on the local road of the design class K2 (standard cross section PP9.0)	ZS-02-K2 (Figure 69)
15	The method of marking the School zone on the local road of the design class K3 (standard cross section PP7.5)	ZS-03-K3 (Figure 70)
16	The method of marking the School zone on the local road of the design class K4 (standard cross section PP6.2)	ZS-04-K4 (Figure 71)

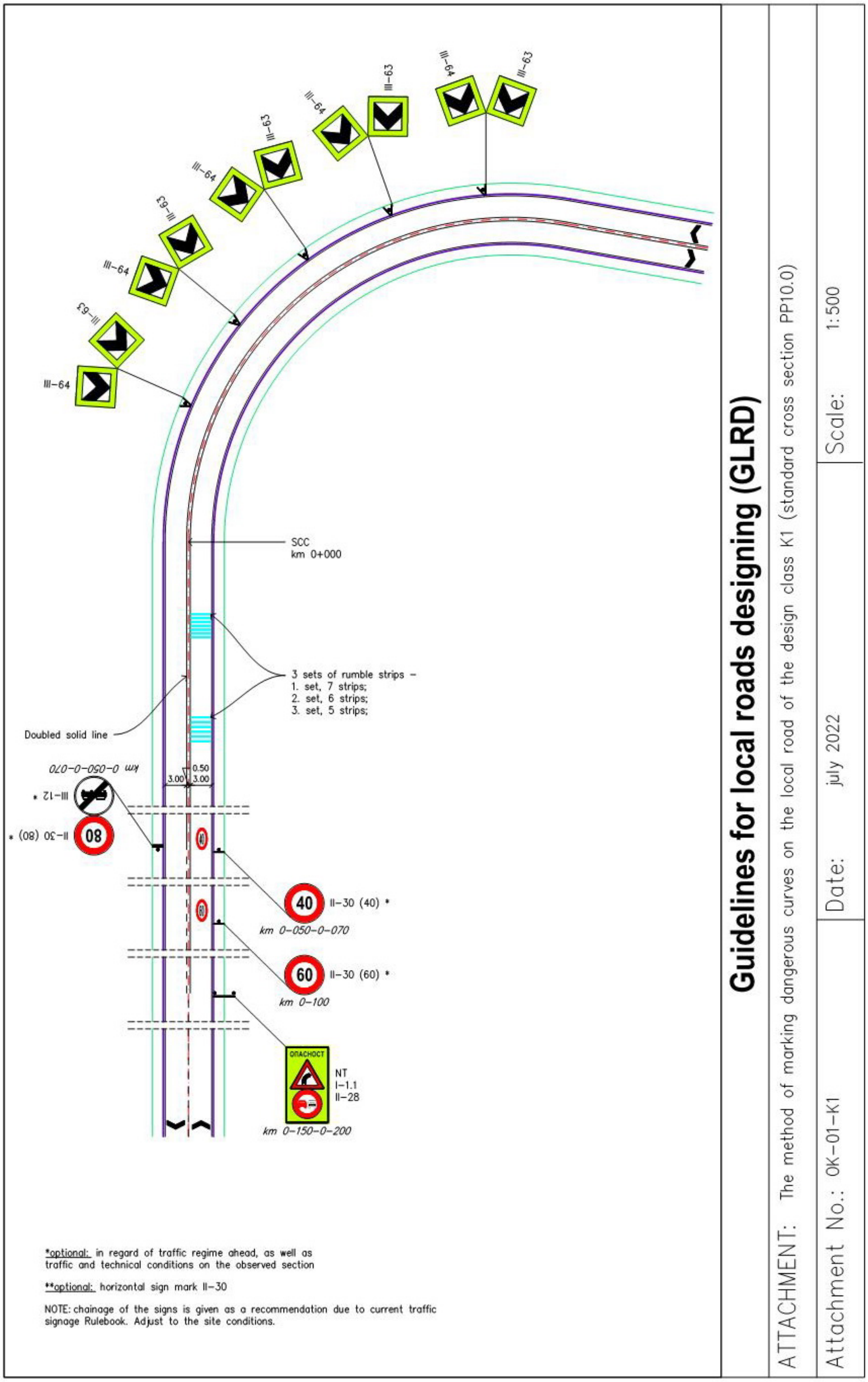


Figure 56 The method of marking the entrance to the suburb on the local road (K1)

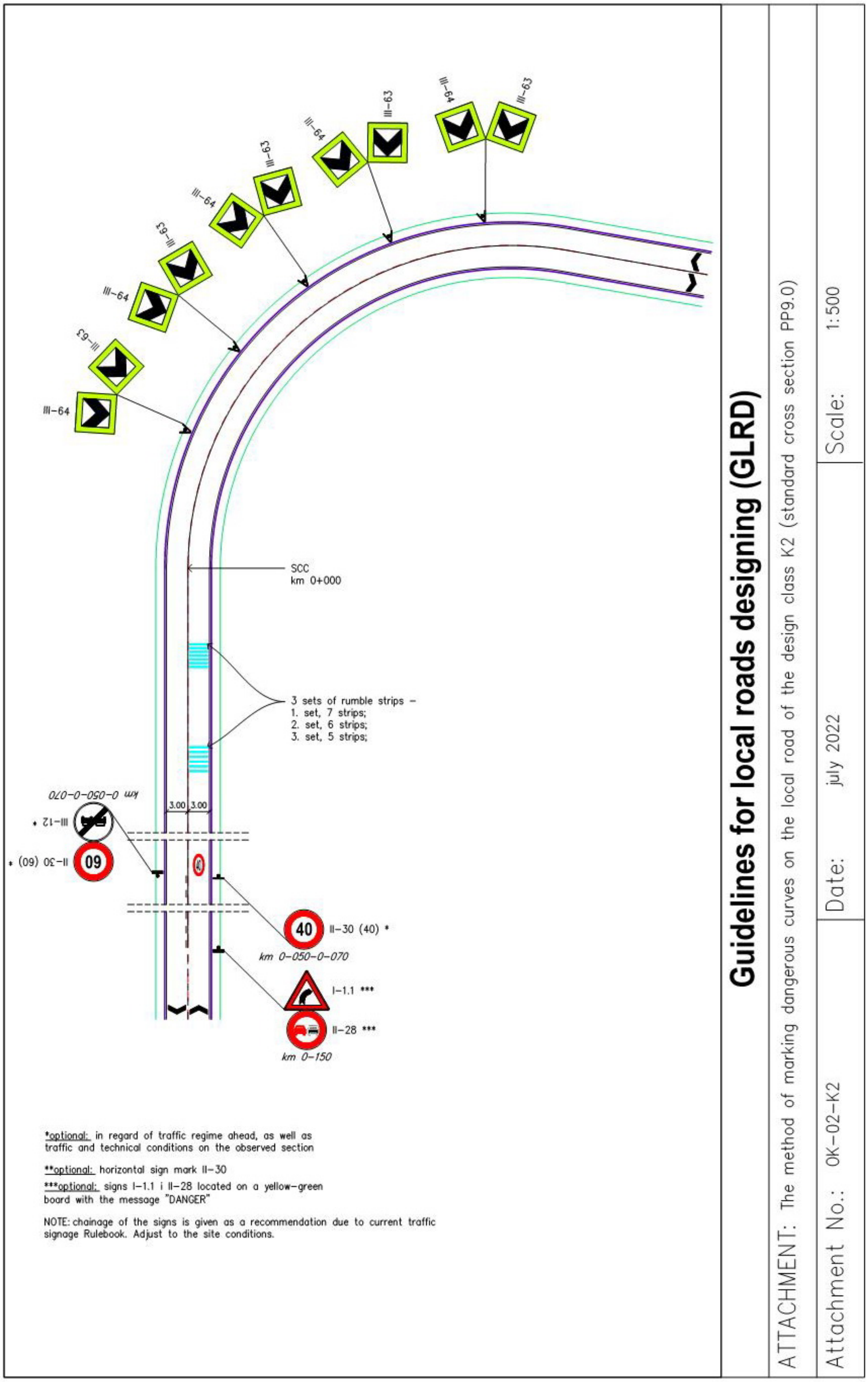


Figure 57 The method of marking the entrance to the suburb on the local road (K2)

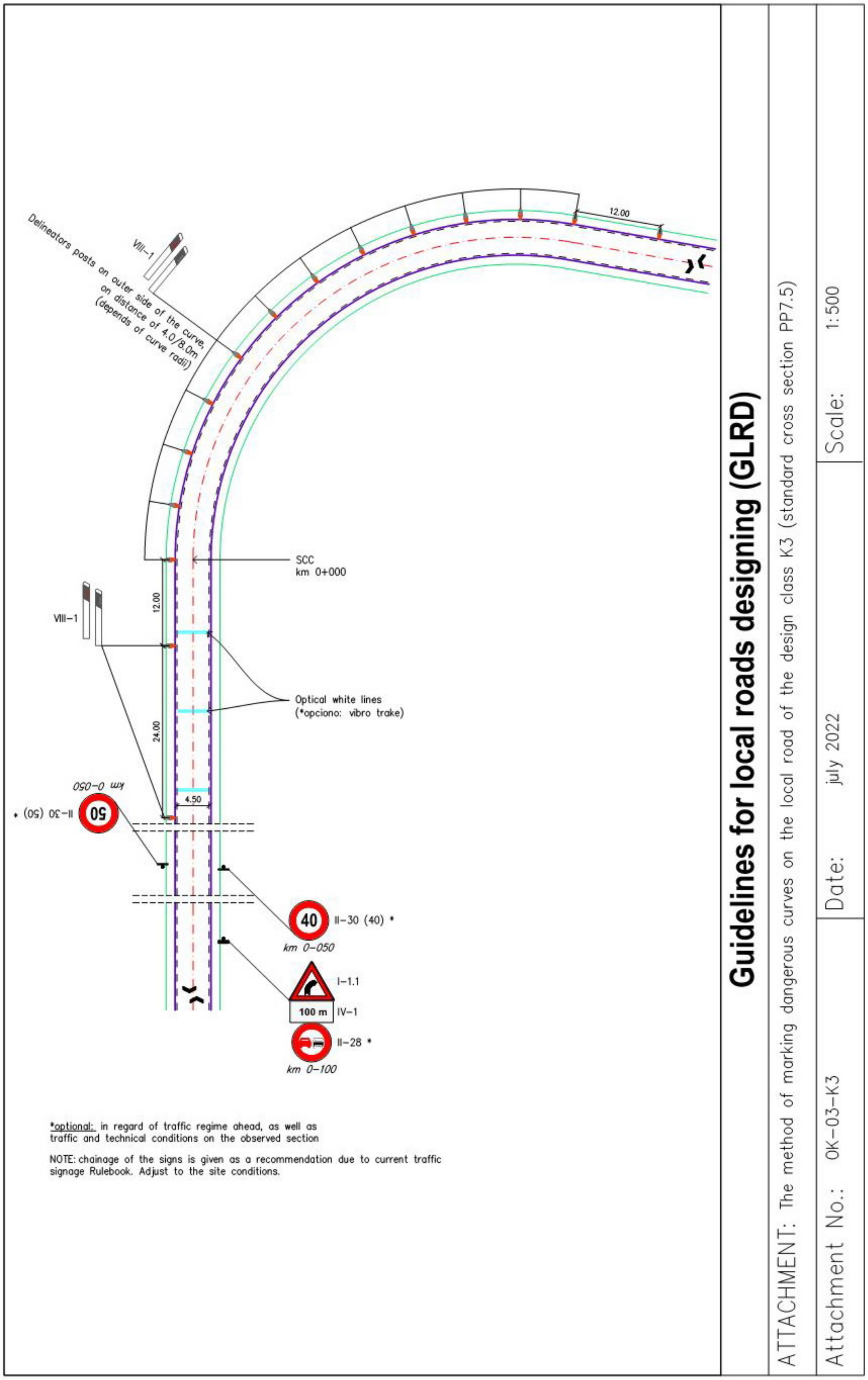


Figure 58 The method of marking the entrance to the suburb on the local road (K3)

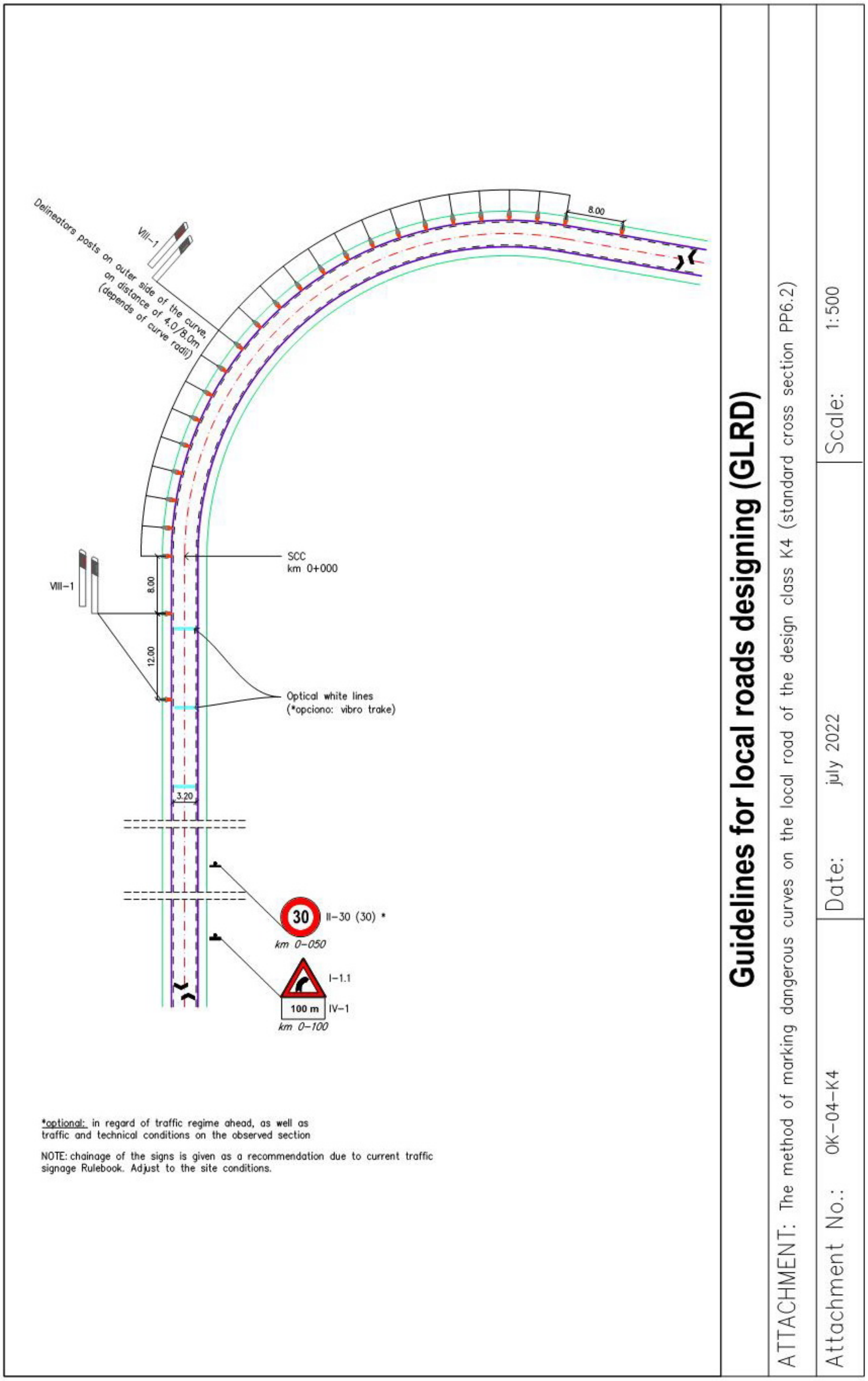
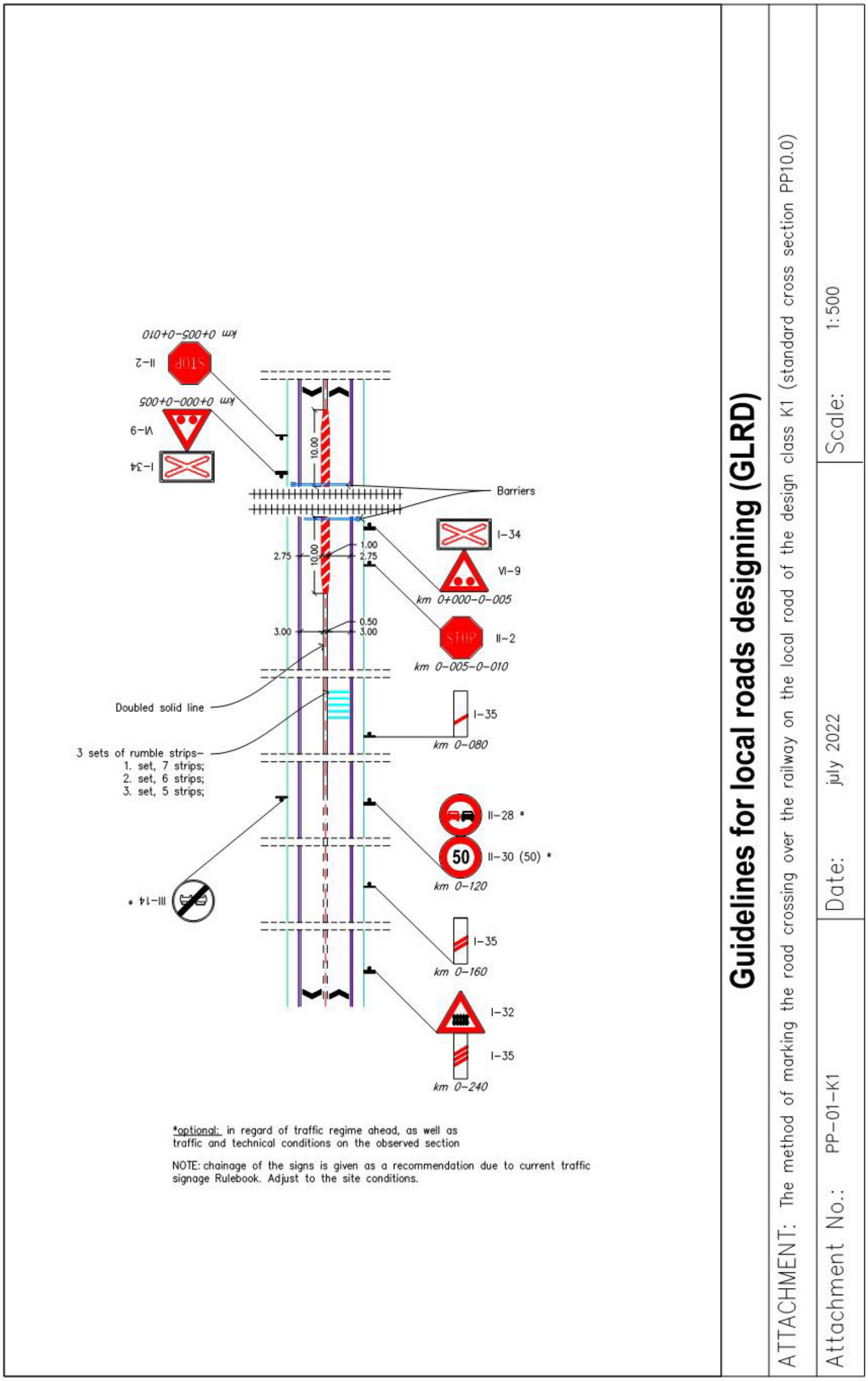


Figure 59 The method of marking the entrance to the suburb on the local road (K4)



Slika 60 The method of marking the road crossing over the railway on the local road (K1)

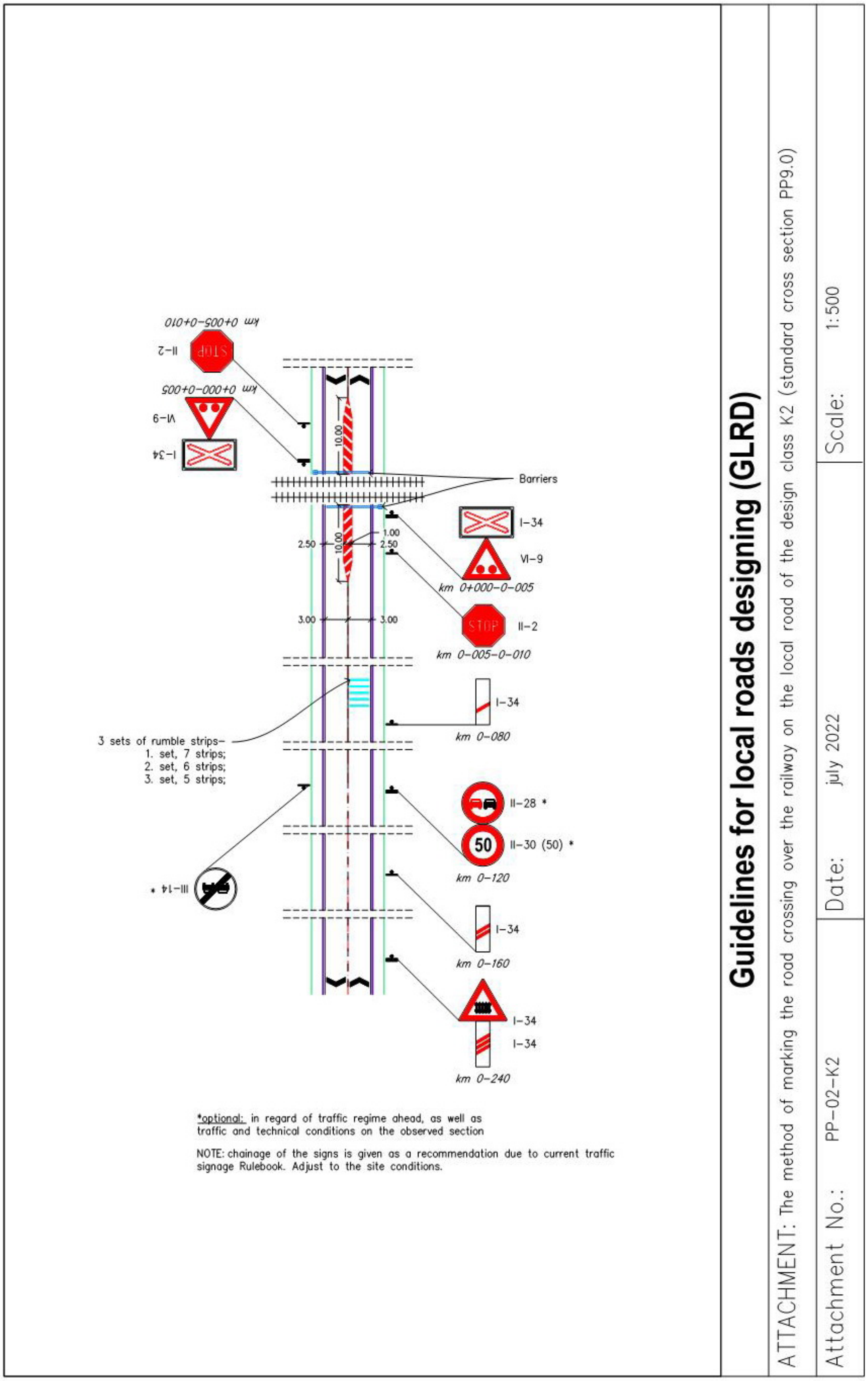


Figure 61 The method of marking the road crossing over the railway on the local road (K2)

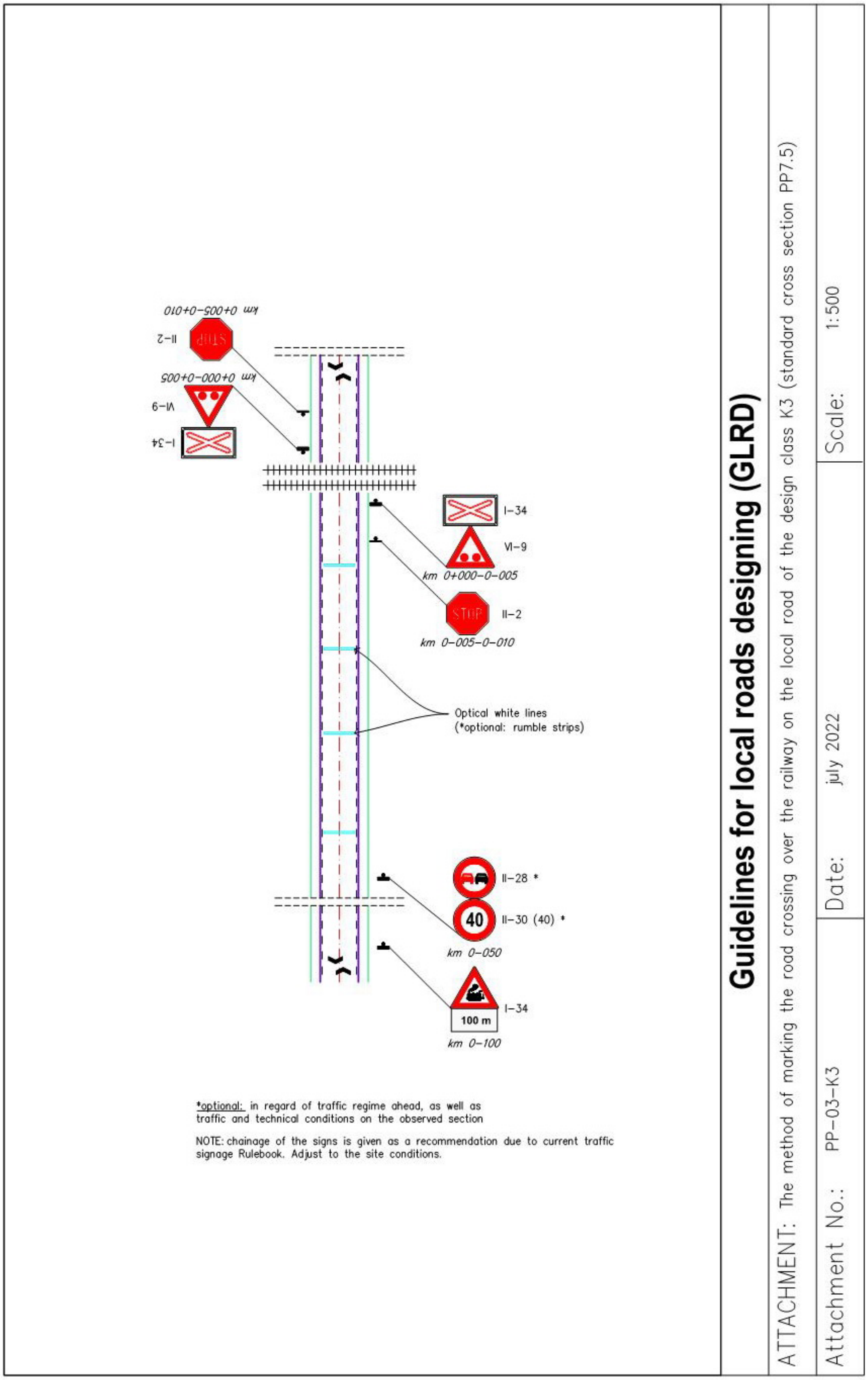


Figure 62 The method of marking the road crossing over the railway on the local road (K3)

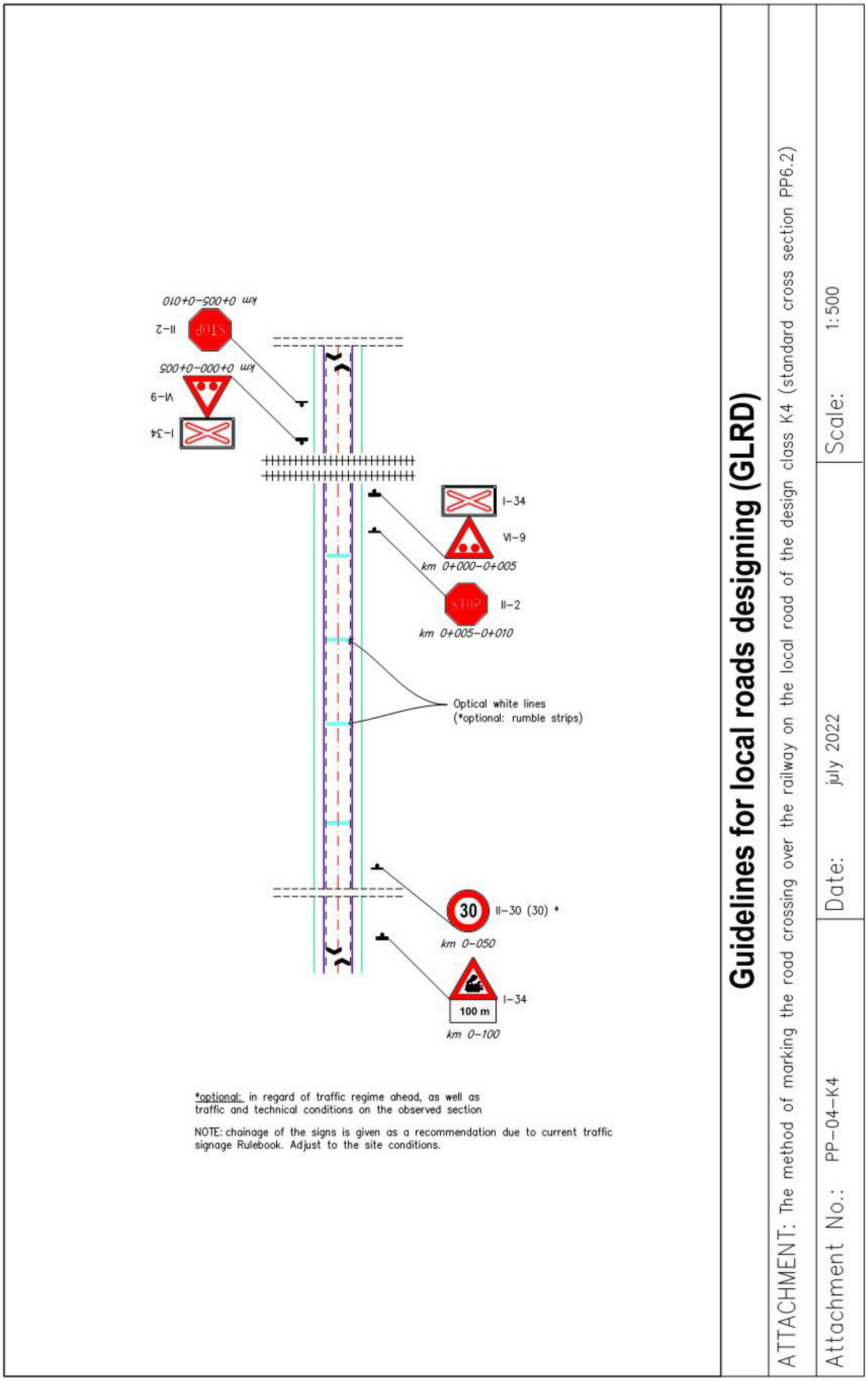


Figure 63 The method of marking the road crossing over the railway on the local road (K4)

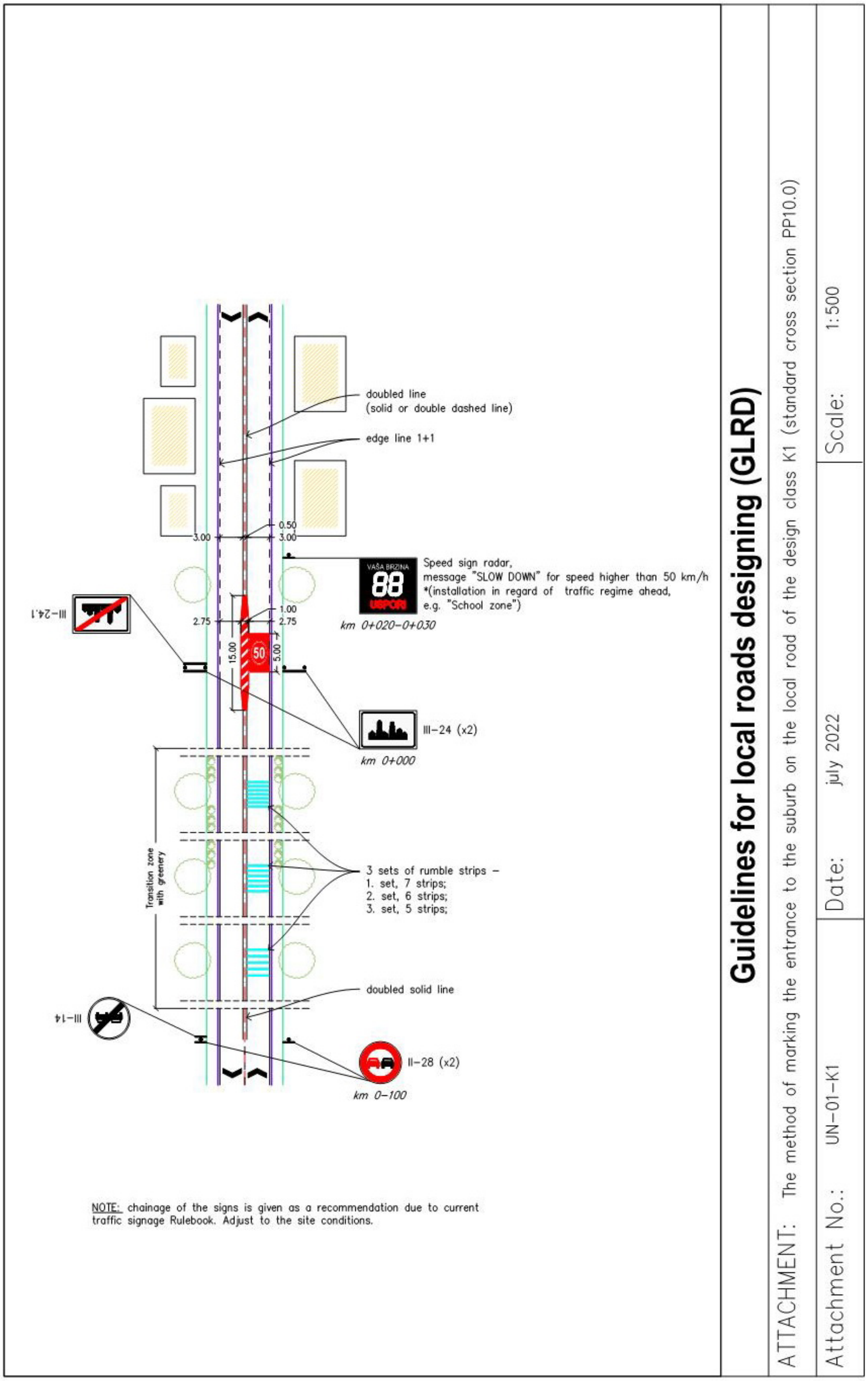


Figure 64 The method of marking the entrance to the suburb on the local road (K1)

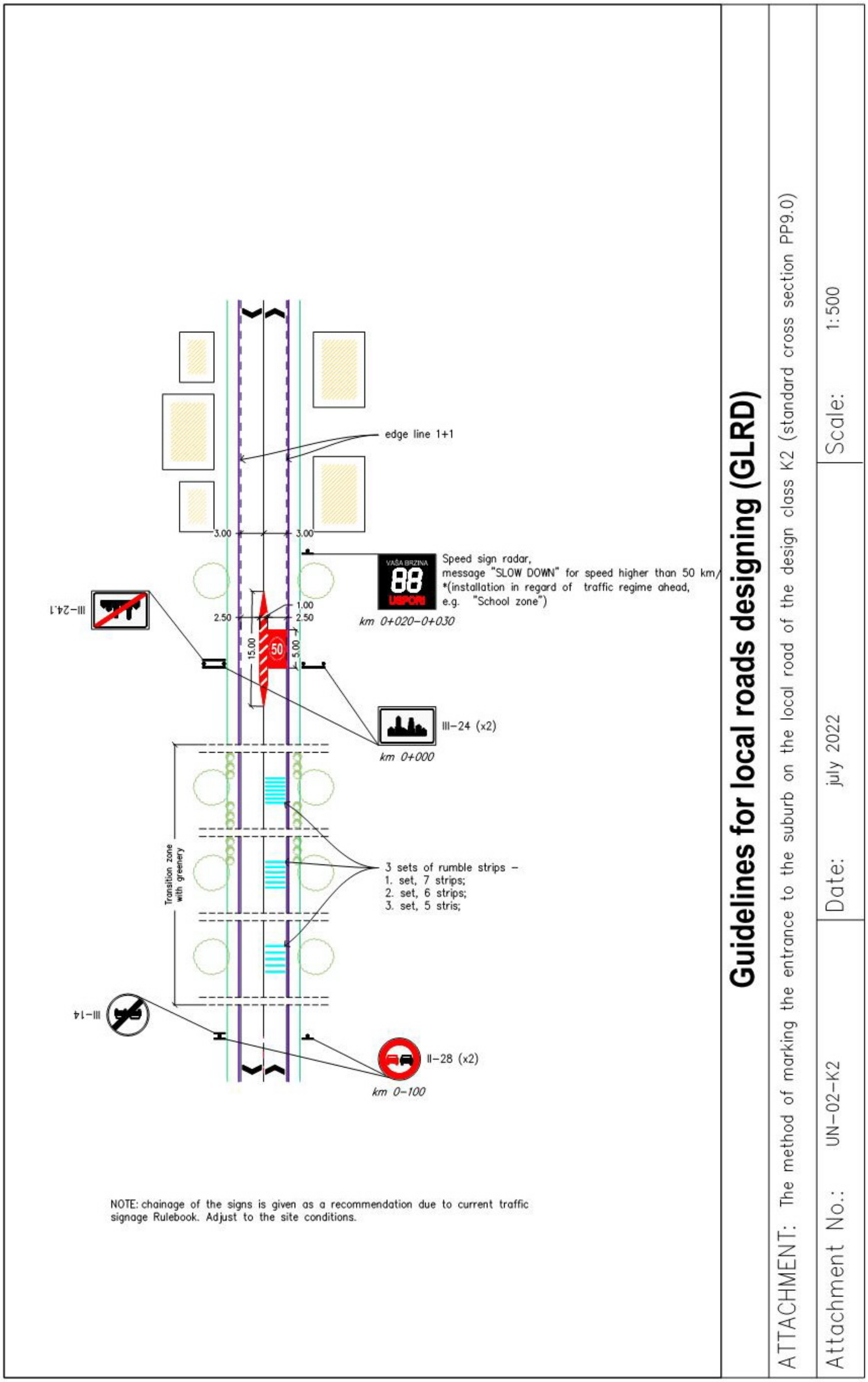


Figure 65 The method of marking the entrance to the suburb on the local road (K2)

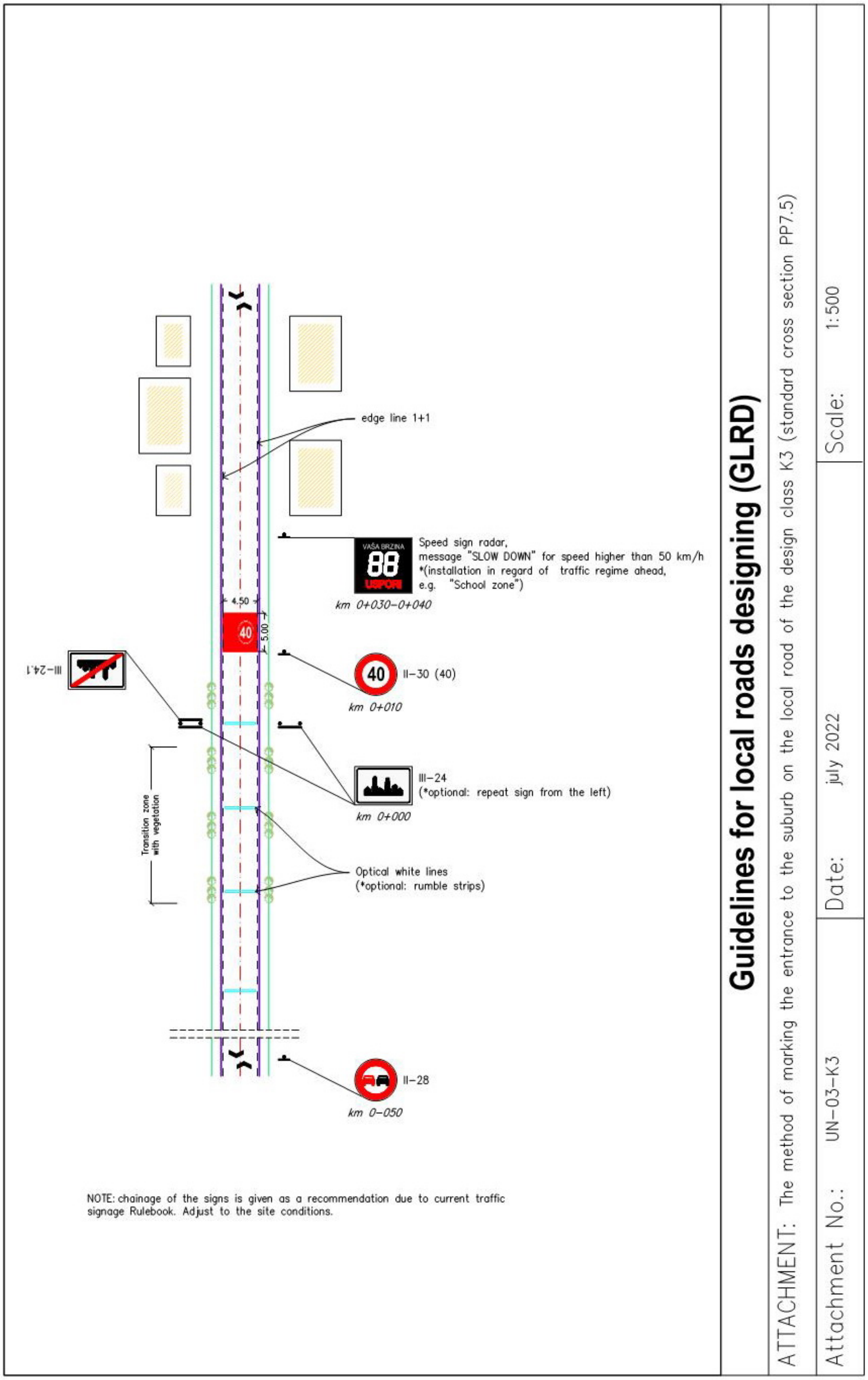


Figure 66 The method of marking the entrance to the suburb on the local road (K3)

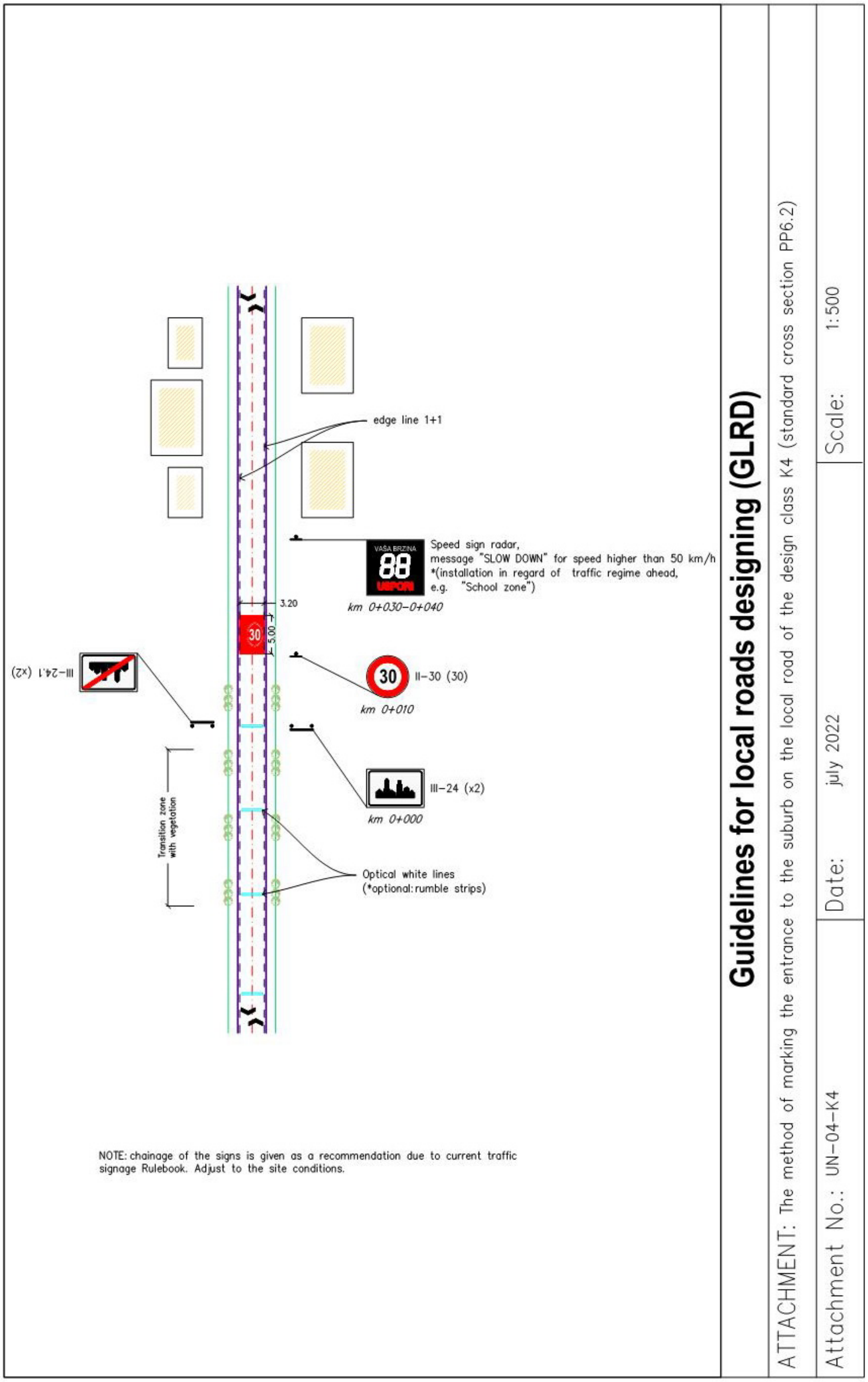


Figure 67 The method of marking the entrance to the suburb on the local road (K4)

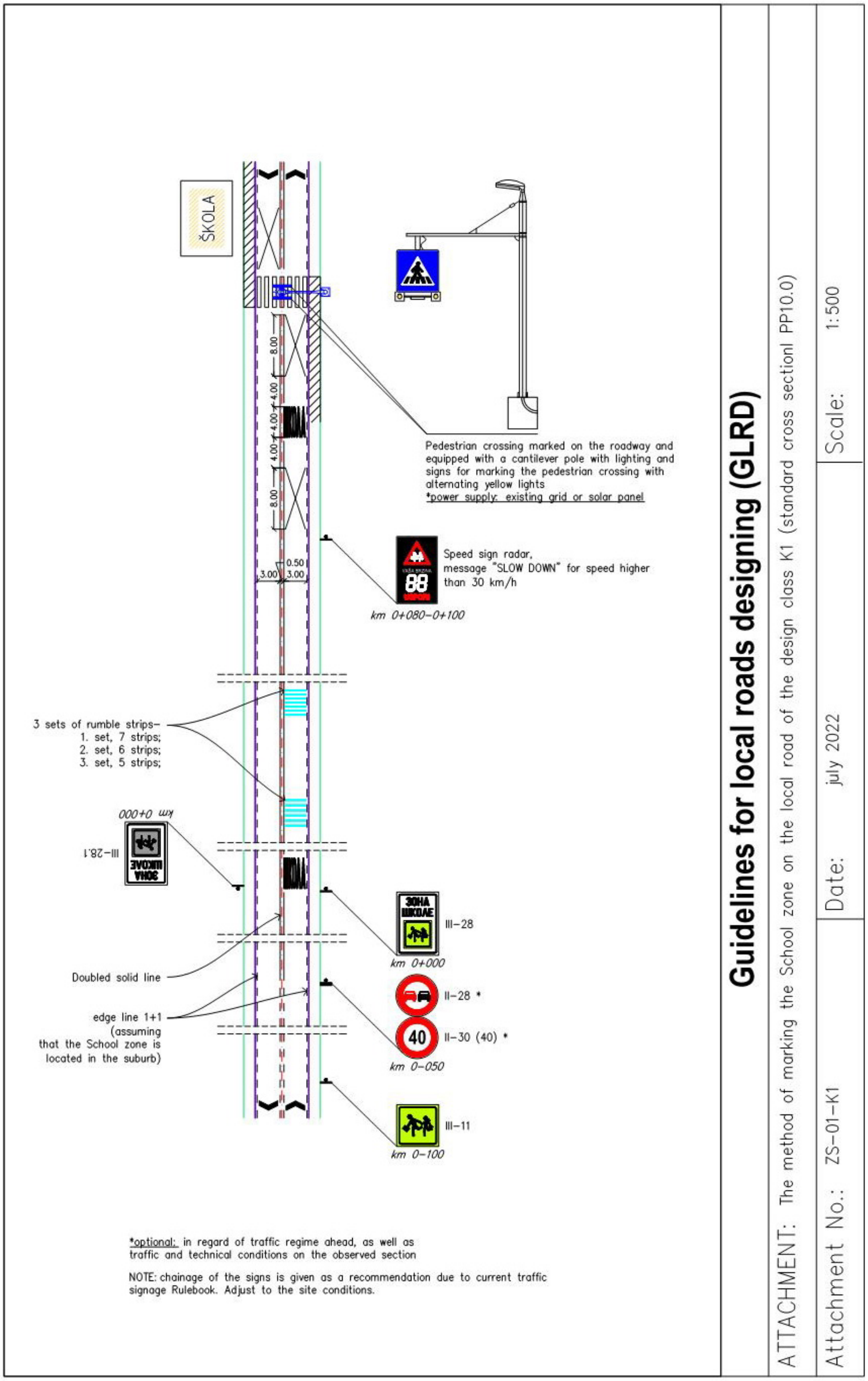


Figure 68 The method of marking the School zone on the local road (K1)

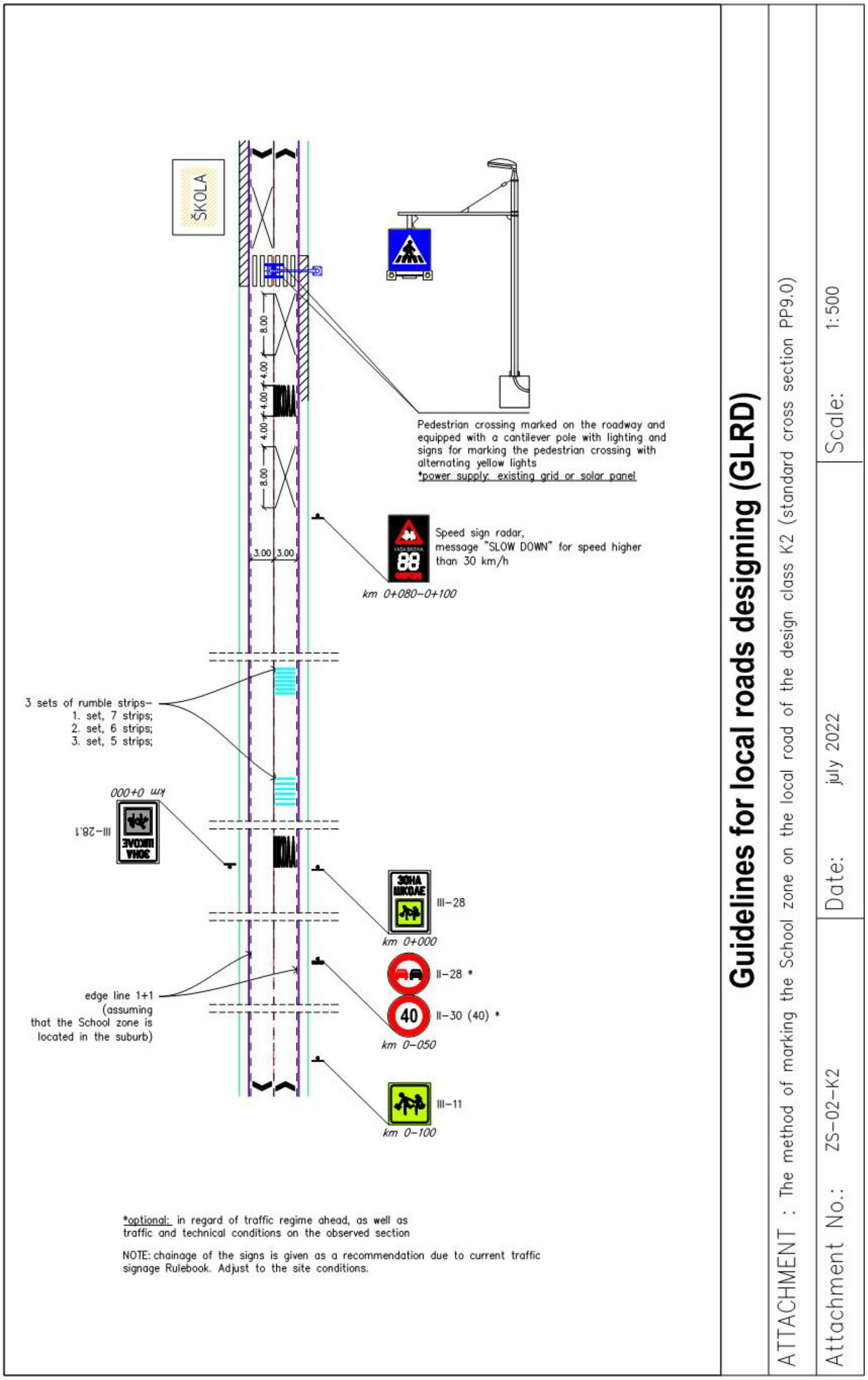


Figure 69 The method of marking the School zone on the local road (K2)

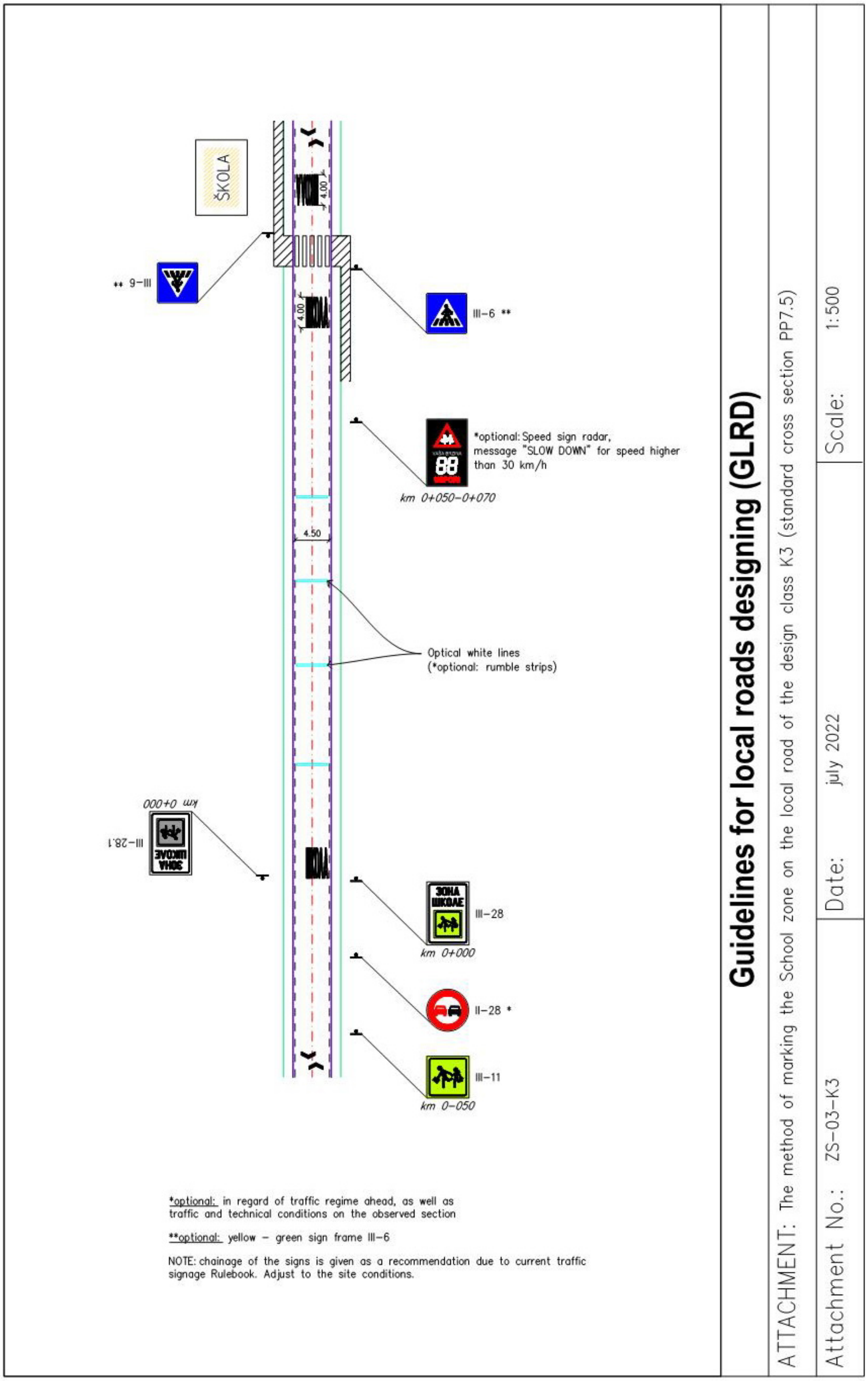


Figure 70 The method of marking the School zone on the local road (K3)

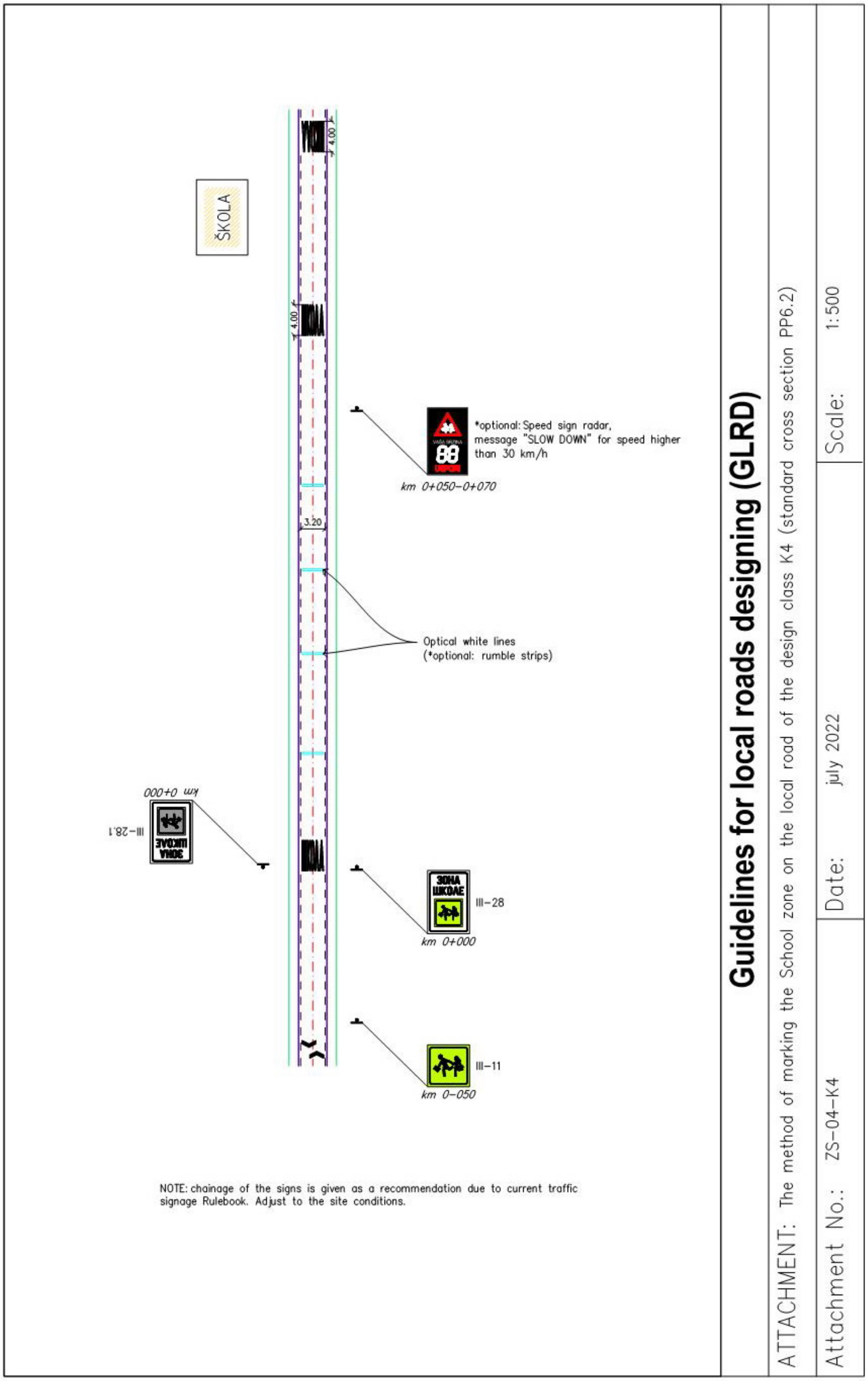


Figure 71 The method of marking the School zone on the local road (K4)