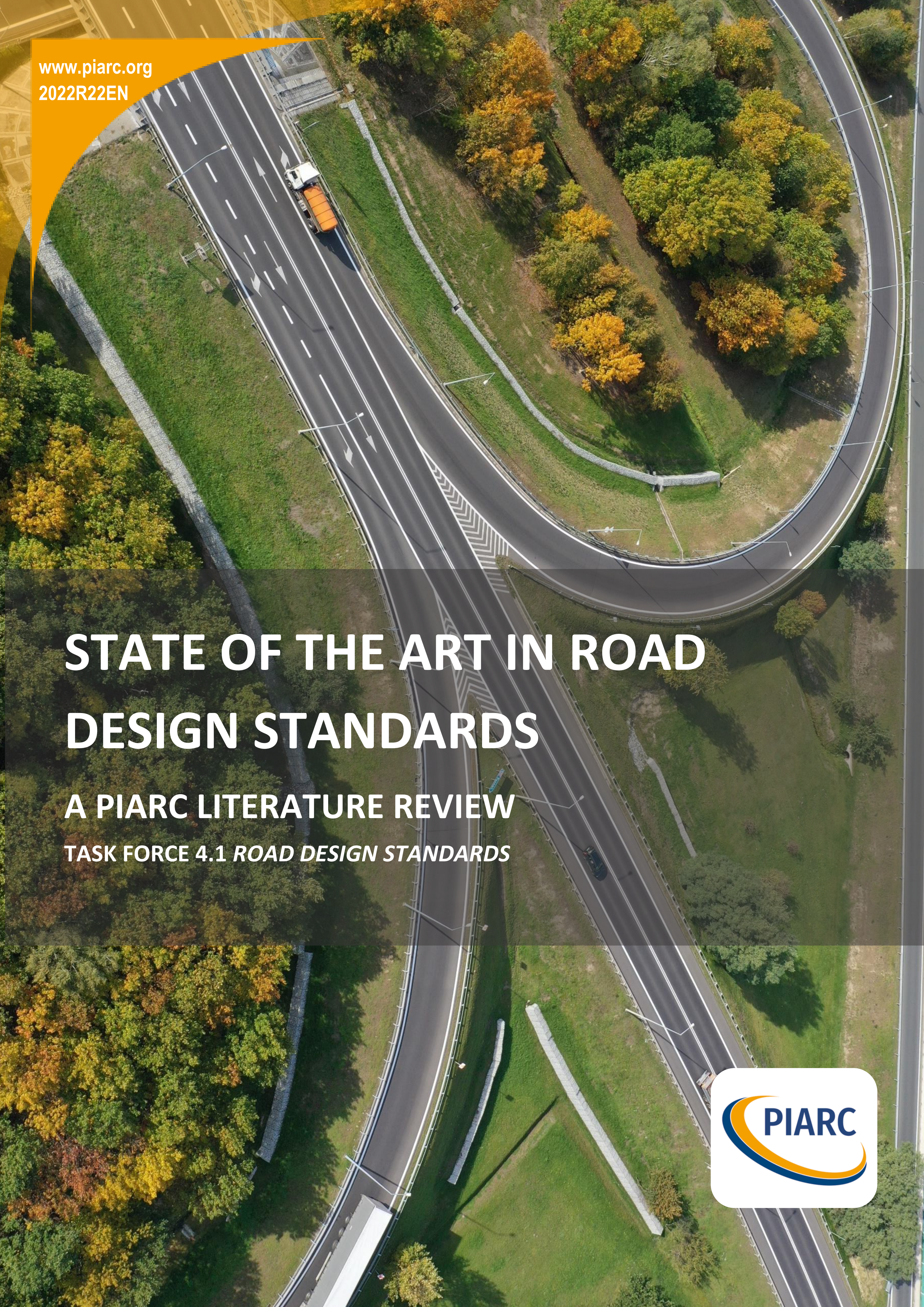

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STATE OF THE ART IN ROAD DESIGN STANDARDS

A PIARC LITERATURE REVIEW

TASK FORCE 4.1 *ROAD DESIGN STANDARDS*

PIARC

STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2020– 2023 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

This report is available from the internet site of the World Road Association (PIARC): http://www.piarc.org

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EXECUTIVE SUMMARY

2022R22EN

STATE OF THE ART IN ROAD DESIGN STANDARDS

This literature review is the first of two planned publications of PIARC Task Force 4.1 “Road Design Standards” in the period 2020 – 2022. PIARC considered importance of comparison international road design standards to check their updated status and the degree of their readiness to face the forthcoming innovations in the road mobility.

The report presents a literature review in the field of road design standards based on reviewing reports, guidelines, and research papers on the subject matter. It is the first document since many years comparing road design standards in several countries. The document aims to identify similarities and differences between the approaches adopted in different countries and evaluates the possible need of their adaptation to the requirements of a rapidly changing world in the field of road transport systems: new technologies, changes in mobility modes (new propulsion techniques, new personal transport mode, and connected and autonomous driving) and availability of multiple diffused data sources (Big Data).

The comparison and conclusions were drafted basing on the answers received to the Questionnaire launched among the members of Task Force 4.1. Ultimately, the comparison covered 15 countries from around the world: Austria, Australia, Belgium (Wallonia), Canada (Quebec), Chile, China, Czechia, France, Germany, Italy, Japan, Mexico, Poland, Portugal and Spain.

The literature review focuses on reviewing the following topics: road classification, speed in road design standards, traffic composition and multimodal consideration in road design standards, design criteria, driving performance and human factors, design parameters considered in road infrastructure design. This part is supported by summarized the answers received to the questionnaires reported in tables included in Annex B.

A comparison of analogies and differences in the road design standards in detail will be included in the full report, which is expected to be concluded in 2022.

CONTENTS

1. INTRODUCTION

Road Administrators have standards in place establishing the technical requirements which roads must meet. The technical requirements depend on the type of road planned, the flow rate and the composition of traffic. In this way, the design of the road elements is defined according to various factors such as the independence of the carriageways, access control, orographic conditions, urban environment, and its functionality as part of the overall transport system. The minimum parameters of the horizontal alignment, vertical alignment and cross-section are defined, as well as the general criteria for obtaining adequate coordination between them. These are based on functionality, road traffic comfort and road safety, together with economic and environmental considerations.

Development of road transport systems, new technologies, and changes in mobility (new propulsion techniques, new personal mode transport, and connected and autonomous driving) as well as new possibilities of collecting data (Big Data) are forcing a new approach to road design or at least changes to existing requirements. Work on updating design standards is underway in some countries however, the comparison of international road design standards (RDS) has not been reviewed for many years and their current reliability needs to be checked. Therefore, it is necessary to collect knowledge from all over the world and share it with countries who are unable to develop or update their road design standards.

1.1. THE PURPOSE OF THE LITERATURE REVIEW

The aim of the literature review is the comparison of road design standards from several countries based on guidelines, reports and papers. In order to compile a list of standards in geometric design the type of road (based on its functionality), the flow rate and composition of traffic, as well as other orographic, environmental and economic constraints were considered. Conclusions and next steps have been defined based on the literature review. In the literature review mainly general road design standards from selected countries are included. Comparison of analogies and differences in the road design standards will be included in the full report, which is expected to be concluded in 2022.

1.2. THE STRUCTURE OF THE LITERATURE REVIEW.

The literature review will mainly consist of a review of existing Road Designs Standards and will report on the current state of knowledge based on existing documents.

The document “State of the Art Road Design Standards” has five main chapters and appendix:

- Methodology – explaining which materials have been considered and the ideas presented in the document.
- Road Design Standard Research – a short description of the existing materials (guidelines, reports, papers)
- General Review of Road Design Standards – the main chapter of the literature review with notes on guidelines and standards presented on a country-by-country basis. A comparison of the principles of the road design standards are presented in this chapter.
- New Technology in Road Design Standards – a description of the development of road transport systems, new technologies, and changes in mobility as well as future possibilities and the necessity to apply them in road design standards.
- Conclusions and Next Steps.

- Appendix – a template of the survey questionnaire for the collection of road design guidelines data is included (Annex A) as well as a comparison of the detailed information from the review of road design guidelines (Annex B).

2. METHODOLOGY

In the period 2020-2022 PIARC TF 4.1 – "Road Design Standards" focuses on the review road design standards. Two deliverables are planned during the period, i.e. the literature review and full report. The literature review has been performed based on technical and research reports, guidelines, journal and conference papers. The literature review focuses on road design standards (guidelines and requirements) as well as the impact of new technology and mobility and big data collection on road design standards. The main source of material is from TF 4.1 members from their respective countries and areas of interest. Material has been analysed and developed for inclusion in the literature review report according to PIARC requirements. The literature review is the first stage of development of the full report.

2.1. ROAD DESIGN GUIDELINES

To obtain inputs for the state of art road design standard a questionnaire template was prepared and circulated to PIARC members for response. The most important questions were related to the following: general classification, design criteria, requirements, conditions, and hypotheses to satisfy what is included in guidelines, which factors are considered and which models are used. General answers were expected in order to compare the various standards. The questionnaire consisted of two parts. The first part included general information about guidelines, which were used to prepare a portion of chapter 3. In the second part of the questionnaire, the following problems were described: 1. Road classification, 2. Speed in road design standards, 3. Design criteria and factors considered, 4. Design of geometrical elements, 5. Road infrastructure (which are included in guidelines), 6. New technology and Smart roads, 7. Human Factors principles introduced in RDS. This part was used to prepare chapter 4 of the literature review. In the questionnaire, it was possible to add comments and a short relevant description of guidelines not included in the previous part. The format of the questionnaire is included in an Appendix (Annex A) of the literature review document. Due to limited time to prepare deliverables, the questionnaire was distributed only among Task Force 4.1 Members. The questionnaire, after incorporating minor improvements will be circulated amongst all PIARC members to collect additional data before preparation of the full report.

2.2. OTHER DOCUMENTS

A limited internet search (including PIARC, CEDR, BASt, Web of Science, Scopus, and Transport Research International Documentation (TRID) websites) was conducted to identify any journal or conference papers as well as technical and research reports. The keywords searched were: "road design standard" and "road design guideline". Reviewed documents were selected based on their relevance to the direct comparison of road design standards or principles in road design standards. A small number of documents directly addressed road design standards or a comparison of road design standards while many papers focused on selected topics within road design standards. These will be utilized as a basis for the problems analyzed in the full report.

PIARC technical reports were reviewed which were obtained from the PIARC website https://www.piarc.org/en/activities/PIARC-Directory-Technical-Reports. In addition TF4.1 communicated with other TCs and TFs, such as TC 1.4 - Climate change and resilience of road networks, TC 1.2 – Planning Road Infrastructure and Transport to Economic and Social Development, TC 2.4 Road Network Operation/ITS, TC 3.1 – Road Safety, TC 3.3 – Asset

Management TC 3.4 Environmental Sustainability in Road Infrastructure and Transport, TC 4.2 - Bridges, TC 4.3 - Earthworks and TC 4.4 – Tunnels, regarding reports in progress.

3. RESEARCH OF ROAD DESIGN STANDARDS

The literature review was carried out considering various documents. These can be classified into three defined groups as follows:

- Technical and research reports (mainly PIARC)
- National and regional road design standards from numerous countries, which formed the basis for further analyzes and evaluation of state of the art design standards and
- Journal and conference papers.

The literature review focuses mainly on comparisons of design standards and the main criteria in road infrastructure design. The analysis of the literature on all issues related to road design is not possible because of the limited thematic scope of the works carried out. This chapter contains a short description of each group. The scope, period, number of references and relevant topics in the material reviewed are presented for each document group.

3.1. Technical and Research Reports

The review of technical reports includes the database of published PIARC reports. These contain comparisons of many aspects in road planning, design, construction and maintenance. All available documents in the PIARC database (a total number of 357) were reviewed (https://www.piarc.org/en/activities/PIARC-Directory-Technical-Reports).

Only one PIARC report deals directly with the overall road design standards ("Human factors in road design. Review of design standards in nine countries", 2012R36EN). This report was published in 2012, which means that in the last 9 years a comparison of road design standards has not been undertaken. During this time major advancements in transport systems, mobility, vehicles and technology have been observed which likely have an impact on road design. The report reviews how human factors are explicitly or implicitly considered in the road design standards of the following countries: Australia, Canada, China, Czech Republic, France, Hungary, Japan, the Netherlands, and Portugal. The report identifies best practices and provides recommendations for the missing links such as: the optical density of the field of view; transition zones; fixation objects in the lateral roadside environment; depth of the field of view.

The comparison of road design standards is often described indirectly in reports which analyze the impact of the human factor, road safety, or specific topics which are related to the road design standards. Most references to road design standards are found in the traffic safety reports, which are presented below.

In the PIARC report, "Road Safety - Catalogue of Case Studies" (2019R47EN), one of the key factors i.e. the human factor in road design is considered. Some of the case studies are examples that have already proved to be effective in increasing road safety, some are interventions implemented to solve a specific safety problem but whose effectiveness will only be proven in future years, some are projects designed to face an identified problem and others are conceptual solutions. The presented case studies can be considered in future iterations of road design standards.

The human factor in road design is also described in the PIARC report "Road Safety Evaluations Based on Human Factors Method" (2019R27EN). This presents potential benefits that road safety evaluations based on the Human Factors' Method can offer. A pro-active approach methodology, which applies the Human Factors' principles in road design to identify infrastructure deficiencies and select countermeasures in road geometry, equipment, and road environment preventing accidents is presented in the report.

Partial road design standards are indirectly included in the PIARC Road Safety Manual (2019, https://roadsafety.piarc.org/en). In this manual the impact of various factors related to the principles in road design standards are presented, for example human factor, land use and the main technical characteristics of the road infrastructure and their relationship to human factors. Two chapters specifically address the impact of road design standards on road safety i.e. design for road user characteristics and compliance and Infrastructure safety management: policies, standards, guidelines and tools.

Another example of a PIARC report in which a comparison of the selected principle design features for roads is included is ”PIARC Catalogue of design safety problems and potential countermeasures” (2009R07EN). This catalogue considered a comparison of road design standards used in different countries in relation to safety considering the following topics: function, cross-section, alignment, as well as intersections, public and private services, vulnerable road users, traffic signing and marking, roadside features.

In the PIARC reports, selected road problems such as road classification and accessibility are described. The report entitled “Land use and safety: an introduction to understanding how land-use decisions impact the safety of the transportation system” (2016R32EN) provides an introduction to land use planning concepts and fundamental transportation decisions (functional classification of roads, transit availability, speed, access) which may impact road safety. Three main highway functional classifications - arterial, collector, and local roads - and the relationship between functional classification and land access are discussed in the report.

Another topic related to road design standards is speed. In the PIARC report entitled “Setting Credible Speed Limits - Case Studies Report” (2019R26EN) a short theoretical introduction related to the role of speed in road safety and the importance to set speed limits is given. One of the important issues is to provide safe speeds through design of the road system (road, environment, and operation) that reduce crash risks and/or severity. A concept of ‘Hierarchy of Control’ within treatments is strongly recommended. Roles and responsibilities in setting of speed limits varies across countries and areas. Different approaches are given for existing roads and newly constructed roads within the design phase.

The analysis of the case studies clearly shows that the effectiveness of a specific case study will vary according to the local conditions, driving habits, traffic rules, regulations, and/or signing and marking standards. Over and above the road and its environment the cultural aspect is also an important factor to consider.

“Big Data for Road Network Operations” PIARC report (2019R18EN) is one of the reports which focuses on using big data in road transport. The main topic of this report is the application of big data for road network operation, but possible future applications in the areas of road planning and design are also discussed.

Specific requirements in road design are also included in reports related to tunnels. The most recent PIARC Report in this topic entitled “Prevention and mitigation of Tunnel-related collisions” (2019R03EN), recommends possible organizational and technical measures one can implement to lower the probability or the mechanical consequences of tunnel-related collisions. Although the road layout (radius of curves and vertical alignment) within tunnels is generally designed in a similar manner to open roads, the following aspects should be considered in the design of tunnels:

- Providing sufficient sight distance, by avoiding small radius curves and steep gradients in combination with a low tunnel ceiling,
- Design of self-explaining roads
- Cross-section organisation (uni or bi-directional tunnel, a wider cross-section for the tunnel and organization of the median)
- Speed in the tunnel and its impact on geometric parameters (radii, lane width, sight distance, etc.)

Relevant technical and research projects are also conducted by CEDR (Conference of European Directors of Roads). Among many reports published in recent years, two are related to the topics in question. The report entitled “European Sight Distances in perspective - EUsight” (CEDR, 2016) presents a detailed examination of the subject of Stopping Sight Distance (SSD) and its role and impact on highway geometric design, taking into account differences (and similarities) between European countries. Comparison of stopping sight distance models from 7 countries is presented. The second CEDR report is entitled “Forgiving roadsides design guide” (CEDR, 20212) in which requirements for the following roadside features have been developed: barrier terminals, shoulder rumble strips, forgiving support structures for road equipment, and shoulder width.

Among many reports developed around the world, it is worth paying attention to those created in Germany and in the United States of America. This is because many countries apply those road design standards and knowledge as a benchmark when developing their own guidelines.

Numerous reports on planning, designing, and operating the road network are carried out in BASt (Die Bundesanstalt für Straßenwesen, The Federal Highway Research Institute, Germany). Based on the review of reports from the last 10 years, several reports on road design standards can be identified.

Report "Design parameters for high capacity roads within built up areas" (Entwurfsparameter von Hochleistungsstraßen innerhalb bebauter Gebiete, BASt-Bericht, V 325, 2020) presents the problematic of roads which are not a category in the existing guidelines of the German “Road and Transportation Research Association” and therefore there are no corresponding design recommendations. High capacity roads are used by long-distance traffic and local traffic. The cross-section of these roads which are designed urban or motorway-like consists of at least two lanes per the direction of travel, which enable them to handle high traffic volumes. In the report design parameters for high capacity roads in consideration of road safety, travel speed, noise protection measures as well as aspects of urban development and urban planning were developed. The developed design parameters and recommendations were intended to introduce the so far non-existent road type of the high capacity road into the existing guidelines of the German “Road and Transportation Research Association” taking into account not only transport issues but also urban planning and urban development aspects.

One of the reports analyzing the impact of human factors on road design is the report "Perceptual-psychological aspects (human factors) and their influence on rural road design" (Wahrnehmungspsychologische Aspekte (Human Factors) und deren Einfluss auf die Gestaltung von Landstraßen, BASt-Bericht, V 317, 2019). The report investigates the psychological aspects of drivers and suggestions for integrating results into the guidelines on road design in a generalized form. For this purpose, a close interdisciplinary collaboration between the subject areas of traffic and transportation psychology and road planning/road design was carried out. Firstly, a comprehensive analysis of the national and international literature was carried out on human factors relevant to rural road design. Based on this, all design elements relevant to the consideration of Human Factors in rural road design were researched. Finally, action proposals were formulated on how the human factors relevant to the road design can be used in the design and in the evaluation of existing roads of the network.

In BASt reports authors focus also on specific topics in road design. In the Report "Verification of the existing model for passing sight distance on rural highways" (Aktualisierung des Überholmodells auf Landstraßen, BASt-Bericht V 282, 2017) the challenge of designing passing sight distance is presented. In order to reduce accidents caused by passing among others, new "Guidelines for the Design of Rural Road" (RAL, 2012) have been introduced. The RAL (2012) defines four different types of roads (design classes) including different principles for passing. On roads of design class 2 and 3 passing by using the opposing traffic lane is still possible. For this reason, the RAL recommends a passing sight distance of 600 m on single carriageway two-lane rural roads. This value was determined by a theoretical model. The aim of the project was to verify and update the current passing sight model. The parameters of the passing maneuvers were evaluated. As a research result, recommendations for the required passing sight distance on single carriageways two lane rural roads has been given.

Also, the problem of road design in tunnels is included in German reports. The design and the operation of tunnels for Federal motorways are regulated in the guidelines for both the Design of Motorways (RAA, 2008) and for Equipment and Operation of Road Tunnels (RABT, 2006). In BASt a report "Technical design recommendations for motorway tunnels" (Entwurfstechnische Empfehlungen für Autobahntunnelstrecken, BASt-Bericht V 265, 2015) was developed. The references for the choice of the tunnel cross-sections and for the values of the road plan, as well as the requirements for safety and operational procedures, are included in this report. The aim of this research project was to investigate the tunnel with regard to road safety.

A large number of studies involved research into the design and functional requirements for longer trucks (Gigaliner) From January 1st, 2012 to December 31st, 2016, the Federal Government of Germany has conducted a nationwide field test with longer trucks. In 2020, the report "Route approval guideline for the use of longer trucks" (Leitfaden für die Streckenfreigabe für den Einsatz von Lang-Lkw, BASt-Bericht V 331, 2020) was published. The field test has shown that longer trucks perform well on the tested road network (positive network). Challenges are shorter emergency stop bays in tunnels and parking stands at rest areas. 15 federal states have approved routes for longer trucks. The testing and approval of routes for the positive network is the responsibility of the national transport authorities. Using two design vehicles, selected traffic facilities were checked by geometric measurements. The results show which minimum dimensions of traffic facilities can be used by long trucks and where a case-by-case examination is necessary. All findings are integrated into a separate action guide, which serves as a decision aid for the review of requested longer trucks routes.

The reports prepared as part of The National Cooperative Highway Research Program (NCHRP) in United States of America are very valuable in terms of road planning and design. Similarly to the BASt database, reports from the last 10 years (a total number of 355 reports) have been reviewed.

None of them dealt directly with the comparison of road design standards. Some of them concern the principles in road design and the human factor.

Reports dealt with principles in road design standards are "An Expanded Functional Classification System for Highways and Streets" (NCHRP Report 855, 2018) and "Developing an Expanded Functional Classification System for More Flexibility in Geometric Design" (NCHRP Web-Only Document 230, 2018), which documents the methodology of NCHRP Research Report 855. The objective of the reports was to develop a flexible framework that replaces the narrow Functional Classification System (which considers only mobility and access) and facilitates optimal geometric design solutions that take into account context, functions, and user needs. To develop this alternative classification system, a two-phased approach was employed. The first phase involved a literature review, a survey of transportation agencies/practitioners, identification of existing alternative systems, and an evaluation of those existing alternative systems and their components. Work during this phase identified promising elements to be considered for inclusion in the proposed system. In the second phase, the proposed approach is fully developed, its implications for design are documented, and the effects on other areas are highlighted. In the report a new alternative classification system to aid designers in developing contextual designs that balance a range of user’s needs is presented.

An interesting approach to the design process is presented in the report "A Performance-Based Highway Geometric Design Process", (NCHRP Report 839, 2017). The report provides suggestions for a new highway geometric design process and demonstrates the value of the process through six case studies. The new process focuses on the transportation performance of the design rather than the selection of values from tables of dimensions applied across the range of facility types. A potential outline to a new policy is developed and provides direction to use the categories of new construction, reconstruction of an existing route, or rehabilitation of an existing facility as the basis of geometric design. The geometric design criteria for any given project is recommended to be based on the context of the project location, and not limited to the facility type. This revised highway design process is intended for further development to become fully implementable. Additional knowledge gaps are identified as part of this research. A more robust range of definitions of land uses will address the requirements of the users and surrounding development that the roadway will serve.

In the report “Evaluation of the 13 Controlling Criteria for Geometric Design", (NCHRP Report 783, 2014) the impact of the controlling roadway design criteria on safety and operations for urban and rural roads is described. The 13 controlling criteria are (1) design speed, (2) lane width, (3) shoulder width, (4) bridge width, (5) structural capacity, (6) horizontal alignment, (7) vertical alignment, (8) grade, (9) stopping sight distance, (10) cross slope, (11) superelevation, (12) vertical clearance, and (13) horizontal clearance. These design elements are still key considerations in design. In the report knowledge about the relationships between geometric design elements and safety and operation has been gained. The use of the controlling criteria in design exception processes was also explored.

Similar to PIARC and BASt reports also in NCHRP report human factor in road design was analyzed. Report “Human Factors Guidelines for Road Systems: Second Edition” (NCHRP Report 600, 2012) provides data and insights of the extent to which road users’ needs, capabilities, and limitations are influenced by the effects of age, visual demands, cognition, and influence of expectancies. NCHRP Report 600 provides guidance for roadway location elements and traffic engineering elements. The report also provides tutorials on special design topics, an index, and a glossary of technical terms.

The second edition of NCHRP 600 completes and updates the first edition, which was published previously in three collections.

The number of reports directly related to road design standards is limited, however, as in the examples previously described, there are reports on specific topics that are important in road design. Some of the topics for such reports are:

- Designing of Low-Speed roads (speed lower than 45 mph): "Design Guide for Low-Speed Multimodal Roadways" (NCHRP Report 880, 2018). The report provides the best practice guidance by referencing a range of acceptable elements, criteria, and values for critical dimensions for design of low- to intermediate-speed roadways with a mix of users. The report assists designers in establishing a balance between operational efficiency, comfort, safety, and convenience for modes on the low- and intermediate-speed roadways.
- Selected sight distance problems: "Design Guidelines for Horizontal Sightline Offsets" (NCHRP Report 910, 2019). Horizontal sightline offset (HSO) is the distance between the driver's line of sight along the roadway ahead on a horizontal curve and a sight obstruction on the inside of the curve. Report is a guidance to address the types of sight distance restrictions that are most likely to be encountered on specific roadway types. This report presents research to evaluate these situations and determine what criteria or mitigation will provide acceptable solutions when impaired horizontal sightline offsets are encountered.
- Designing of transitions zones: "Design Guidance for High-Speed to Low-Speed Transitions Zones for Rural Highways" (NCHRP Report 737, 2016). Report presents guidance for designing the transition from a high-speed rural highway to a lower-speed section, typically approaching a small town. The report includes a methodology for assessing these highway sections and a catalog of potential treatments for addressing problems.

One of the more interesting topics in road design are new technologies and big data. Report "Guidebook for Managing Data from Emerging Technologies for Transportation" (NCHRP Report 952, 2020) provides guidance, tools, and a big data management framework, and it lays out a roadmap for transportation agencies on how they can begin to shift toward effectively managing data from emerging technologies. With increased connectivity between vehicles, sensors, systems, shared-use transportation, and mobile devices, unexpected and unparalleled amounts of data are being added to the transportation domain at a rapid rate, and these data are too large, too varied in nature, and will change too quickly to be handled by the traditional database management systems of most transportation agencies. Modern, flexible, and scalable "big data" methods to manage these data need to be adopted by transportation agencies if the data are to be used to facilitate better decision-making.

3.2. Guidelines

Most countries have their own guidelines on road design standards. Some of them have more than one guideline. The guidelines offer a good starting point in providing greenfield, brownfield or upgraded road infrastructure to a modern standard. Compiling a document on guidelines from different countries is one step towards identifying current best practices in design. Therefore, one of the main aims of this document is the comparison of road design standards from selected countries.

There are many road design guidelines around the world. Most countries or regions develop their own guidelines using other countries guidelines, expert knowledge, scientific articles and research reports. The most well-known guidelines worldwide, which often constitute a basis for guidelines in other countries are:

- United States, manual commonly referred to as the Green Book, which contains the current design research and practices for highway and street geometric design ("A Policy on Geometric Design of Highways and Streets", 7th Edition, AASHTO, 2018)
- Great Britain, manual which is part of Standards for Highways and is called The Design Manual for Roads and Bridges (updated 1st April 2020) (Available at: https://www.standardsforhighways.co.uk/dmrb/),
- Germany (see tables in Appendix),
- Australia (see tables in Appendix).

Design Manual for Roads and Bridges from Great Britain is not included in this report, while the Green Book from the US is only included in a limited way.

A few countries have collaborated together to develop road design standards. An example is "Asian Highway Design Standard for Road Safety, Design Guidelines" (October 2017, https://www.unescap.org/sites/default/d8files/3-Detailed%20Design%20Guidelines.pdf). This document consists of recommended guidelines related to the Intergovernmental Agreement on the Asian Highway Network. The countries participated in the project by providing up-to-date information on their current design standards and use of road safety infrastructure facilities. National Experts from member countries (viz. Bangladesh, China, India, Republic of Korea, Thailand) provided inputs, in the form of national reports. The document includes aspects such as Road Network, Road Infrastructure, Intersections, Roadside Safety, Pedestrians, Slow Vehicles and Traffic Calming, Delineation, Pavement Markings and Road Lighting, Road Signage, Tunnels.

Some of the road design standards consist of one large and extensive document (US) or a set of smaller ones (Germany, Austria, Great Britain, etc.), prepared for specific road infrastructure or for a specific issue. The second format has become more popular as it is easier to update.

The most complete set of road design standards is presented in report "Road Design Standards - by Country", (available at: https://roaddesignstandards.wordpress.com/3), ver. 6.1, prepared by Bartlett, R. in 2016. The Author have noticed that if the road transport system is similar in different countries, in terms of needs, road users and transport mode then perhaps the road design manuals should state similar principles regardless of the country. In order to commence with an analysis of the differences a list of road design standards, for as many countries as possible was prepared and included in abovementioned report. The list of 79 countries and 7 multi-country road design standards are included in this report. Information for each road design standard consists of a table with title of road design standard document, publisher, year of publication, language and reference number, as well as limited comments on sources and web links. In "Road Design Standards - by Country" some non-uniformities, which make direct comparisons challenging are highlighted. They include, among others:

- different terms and meanings for the concept of a "standard" (manual, guideline, handbook)
- the application of different design standards for different road types (road classes)

- often several design standards existing in one country defining different levels on infrastructure (national, regional)
- design manuals from different countries can give conflicting advice for the same design parameter
- continuous updating of road design standards (some as frequently as every few years) relating to lifecycle costing of road infrastructure
- publication of standards in different languages, even within one country

In order to alleviate some of the above-mentioned challenges a concise comparison of standards, based on knowledge collected by members of Task Force 4.1 was carried out. The current state of the art road design standards for 15 countries were reviewed. In the table B.1 (Appendix) general information about road design standards is presented. In this table the list of road design standards (principles in geometric road design standards) with the following information is included:

- level of road design standards (national, regional),
- application requirements (obligatory by law, recommended, practice book),
- exceptions from obligatory road design standards,
- the basis for the country's guidelines (experiences or other foreign guidelines),
- scope of road design standard, if not included in the title.

Only a few reviewed national road design standards consist of one document (e.g. Chile, China, Poland, Mexico) while others consist of several or more documents, each with a specific topic. The latter appears to be the preferred approach currently as greater detail can be included in each individual document and updates can be accommodated with greater ease.

The documents presented were from the 1990s (Spain, Portugal, Poland) as well as this year (Spain), which indicates the ongoing changes in road design and the definite need to update road design standards on an ongoing basis.

Most of the presented documents are used for national planning and design purposes. Only the road design standards from Belgium, Canada, Japan and Italy (Lombardia) are applied on regional level. However, it should be noted that the review was mainly focused at national level and often related to national law. Therefore, most of them are obligatory and only a few are recommended (Germany, Spain, Portugal, Mexico, Japan, Czechia). The recommended standards are most often less important.

In almost all design standards exceptions to the standards are possible. However, this requires special procedures or responsibility to be taken by the designer over and above mere justification. Most often, the use of exceptions to the standards is caused by the presence of site specific environmental, landscaping, archaeological and economic conditions.

The review of the road design standards confirmed that the basis for their creation is mostly from German standards, when considering Europe and US standards when considering the rest of the World. This basis has largely been adapted to meet local conditions by revising portions based on local experience. Only a few countries have developed standards based on their own knowledge (Germany, Spain), but not exclusively so.

Most guidelines are updated periodically. The presented road design standards contain current documents, although some countries are currently in the process of updating their standards (Poland, India, Spain, Belgium). In the section of the full report dealing with the comparison road design standards (programmed for completion in 2022) the newest revision of each countries standards will be considered.

A comparison of road design standards is presented in chapter 4. This is based on more detailed information from the documents listed below (also mentioned in the table B.1):

Austria

- RVS 03.01.11, Anforderungsprofile an Straßen (Requirement Profiles on Roads), July 2012
- RVS 03.01.13, Kategorisierung und Anforderungsprofile an Straßen (Categorization and Profile of Requirements of Roads), July 2012
- RVS 03.02.12 Fußgängerverkehr (Pedestrian Traffic), October 2015
- RVS 03.02.13 Radverkehr (Bicycle Traffic), February 2014 (currently under revision)
- RVS 03.03.21 Räumliche Linienführung (Spatial Road Alignment), June 2001 (currently under revision)
- RVS 03.03.23 Linienführung und Trassierung (Alignment and Geometric Road Design), August 2014
- RVS 03.03.31 Querschnittselemente sowie Verkehrs- und Lichtraum von Freilandstraßen (Cross-Section Elements and Envelopes of Clearance of Rural Roads), August 2018
- RVS 03.03.32 Straßenböschungen (Slopes), June 2019
- RVS 03.03.33 Dreistreifige Querschnitte (2+1-Querschnitte) (2+1 Roads), June 2008 (amendment 2018)
- RVS 03.04.12 Planung und Entwurf von Innerortsstraßen (Planning and Design of Urban Roads), March 2020
- RVS 03.05.11 Planungsgrundsätze, (Planning Principles), May 2005
- RVS 03.05.12 Plangleiche Knoten – Kreuzungen, T-Kreuzungen (Intersections at grade – Crossroads – T-junctions), March 2007
- RVS 03.05.13 Gemischte und Planfreie Knoten (Mixed Junctions and Grade Separated Junctions), March 2001 (currently under revision)
- RVS 03.05.14 Plangleiche Knoten – Kreisverkehr (Intersections at grade – Roundabouts), October 2010

In Austria the road design standards are regulated in the so-called RVS (Guidelines and Regulations for Planning, Construction and Maintenance of Roads). The FSV (Österreichische Forschungsgesellschaft Straße-Schiene-Verkehr, Austrian Research Association for Road-Rail-Transport) is responsible for this. These regularly updated set of rules and regulations deal with issues relating to traffic and transport on roads and are prepared and owned by the FSV.

Australia

- Austroads Guide to Road Design (AGRD),
- DM 05.11.2001, Road geometric and functional design standards for new roads sections,
- DM 22.04.2004, Road geometric and functional design standards for new intersections and junctions,
- DM 19.04.2006, Road design standard for the upgrading of existing road sections, intersections and junctions

Belgium (regional standard)

- CT.98.12(01), Caractéristiques routières et autoroutières

Canada (Quebec – regional standard)

- Standards for geometric design of roads (MINISTÈRE DES TRANSPORTS DU QUÉBEC. *Tome I – Conception routière*, Québec, Les Publications du Québec (collection Normes – Ouvrages routiers)

Chile

- 30.06.2020, Highways Manual - Volume N ° 3 Instructions and Design Criteria:
- Chapter 3,200 Geometric Layout Design
- Chapter 3,300 The Cross Section
- Chapter 3,400 Intersections
- Chapter 3,500 Interchange

China

- JTG D20-2017, Specifications for Geometric Design of Highways

Czechia

- ČSN 73 6101, Projektování silnic a dálnic (Design of Highways and Motorways)
- ČSN 73 6102 ED.2 Projektování křižovatek na pozemních komunikacích - 2. Vydání (Design of Intersections on Highways - 2nd edition)
- ČSN 73 6110 Projektování místních komunikací (Design of Urban Roads)
- ČSN 73 6056 Odstavné a parkovací plochy silničních vozidel (Parking Areas for Road Vehicles)
- ČSN 73 6058 Jednotlivé, řadové a hromadné garáže (Small, Multi-storey and Mass Garages)
- ČSN 73 6425-1 Autobusové, trolejbusové a tramvajové zastávky, přestupní uzly a stanoviště - Část 1: Navrhování zastávek (Bus, Trolleybus and Tramway Lines Halts, Part n. 1 - Design of Halts)
- TP 103 Navrhování obytných a pěších zón (Design of Residential and Pedestrian Zones)
- TP 179 Navrhování komunikací pro cyklisty (Design of Bicycle Pathways and Lines)
- TP 218 Navrhovaní zón 30 (Design of Zones 30)
- TP 135 Projektování okružních křižovatek na silnicích a místních komunikacích (Design of Roundabouts on Rural and Urban Roads)

France

- Catalogue des types de route pour l'aménagement du réseau routier national (Catalogue of road types for the development of the national road network)
- ICTAAL: instruction sur les conditions techniques d'aménagement des autoroutes de liaison (National instruction on technical design requirements for rural motorways)
- Les échangeurs sur route de type "autoroute"
- 2x1 voie – route à chaussées séparées (Handbook on design of dual carriageway roads with one lane per direction)
- ARP – Aménagement des routes principales (Handbook on design of major roads)
- ACI – aménagement des carrefours interubains (Handbook on the design of interurban intersections on major roads (grade junction)
- Voies structurantes d'agglomération – conception des artères urbaines à 70 km/h, (Urban structuring roads – design of 70 km/h urban arteries)

- Voies structurantes d'agglomération à 90 et 110 km/h (Urban structuring roads – design 90 and 110 km/h roads)
- Conception des routes et autoroutes – révision des régles de visibilité

Germany

- Richtlinien für integrierte Netzgestaltung – RIN (R1) (Road network planning), 2008, FGSV
- Richtlinien für die Anlagen von Landstraßen - RAL (R1) – (Designing of rural roads, excl. motorways), 2012, FGSV
- Richtlinien für die Anlagen von Stadtstraßen – RASt 06 (R1) (Designing of urban roads - street), 2006, FGSV
- Richtlinien für die Anlage von Autobahnen – RAA (R1) (Designing of Motorway), 2008, FGSV
- Richtlinien für Bemessungsfahrzeuge und Schleppkurven zur Überprüfung der Befahrbarkeit von Verkehrsflächen – RBSV (R1) (Corridor of vehicle movement), 2020, FGSV
- Richtlinien für den Ländlichen Wegebau – RLW (Low Volume Roads), 2016, FGSV

Italy

- DM 05.11.2001, Road geometric and functional design standards for new roads sections.
- DM 22.04.2004, Requirements for upgrading existing road sections.
- DM 19.04.2006, Road geometric and functional design standards for new intersections and junctions
- Guidelines of Lombardia Region RR 24.4.2006 n. 7 "Road design standards"

Japan

- Road Design Ordinance (Government Ordinance) , 2011(English translated)
- Road Design Ordinance (municipal governments) ,(Japanese only)
- Road Design Guidebook ,2017(Japanese Only)

Mexico

- Manual de Proyecto Geométrico (Manual for Road Geometric Design, 2018)

Poland

- Regulation of the Minister of Transport and Maritime Economy on technical conditions for public roads and their location. Regulation, No 43, pos. 430.1999, Upgrading: 1. Regulation pos.124.2016, 2. Regulation, pos.1643.2019 (It is presently under revision)
- Design guidelines for intersections, 2001, part 1 (Intersections), Part2 (Roundabouts), (It is presently under revision)

Portugal

- Design Standards (Norma de Traçado JAE P3/94)
- Intersections Standards (Norma de Interseções JAE P5/90)
- Junctions Standards (Norma de Nós de Ligação JAE P6/90)
- Provisory Design Standards (Norma de Traçado de Estradas)

Spain

- Instrucción de Carreteras. Norma 3.1-IC, (Road Instruction. Norm 3.1-IC)
- OC 21/2012 Guía de nudos viarios (Guide on road interchanges)

- OC 1/2021 Recomendaciones para el diseño de carreteras 2+1 y carriles adicionales de adelantamiento, (Recommendations for the design of 2+1 roads and overtaking additional lanes)
- Orden FOM 3317/2010 Instrucción sobre las medidas específicas para la mejora de la eficiencia en la ejecución de las obras públicas de infraestructuras ferroviarias, carreteras y aeropuertos del Ministerio de Fomento, (Effectiveness measures in Public Works)
- Ley 37/2015, de 29 de septiembre, de carreteras (Law of Roads)
- Real Decreto 1812/1994, de 2 de septiembre, por el que se aprueba el Reglamento General de Carreteras (Road regulation). It is presently under revision.

3.3. JOURNAL AND CONFERENCE PAPERS

Most of the description of the road design standards are contained in the technical reports or mainly in guidelines for road design.

A small number of papers on road design standards are available in journals. In journals, selected research road design problems are mainly described, therefore papers are focused on specific topics, for example, sight distance evaluation, designing of curves, impact of connected and automated vehicles (CAV) on road operation, using driving simulator in road geometry evaluation, road consistency, etc. Therefore, this literature review will be included in the full report, where selected models used in road design will be compared in detail.

Among conference papers, those prepared for the International Symposium on Highway Geometric Design (ISHGD) are significant in road design. Considering the period from 2010, two conferences were held in 2010 in Valencia and in 2015 in Vancouver. During these conferences, the so-called country reports, which contain the most interesting changes in regulations and approach to road design in different countries of the world were presented. In 2010, it was 10 out of 97 papers, from Denmark, Italy, Sweden, United Kingdom, Poland, Austria, Netherlands, Canada, New Zealand, Mexico. In 2015, 19 national reports were presented from Canada, Australia, Denmark, Poland, Argentina, Mexico, Germany, Netherlands, India, Ireland, Israel, Colombia, New Zealand, Hungary, China, South Africa, Sweden, US, Ghana. The remaining papers referred to specific topics in road design.

Apart from the above-mentioned conference, a small number of papers related to principles in road design are available in the last years, e.g.:

- The German Guidelines on Urban Road Design: Approach, Current Practice, and Perspectives, Gerike R., Schmotz M., Transportation Research Board 100th Annual Meeting, 2021
- New Design Principles for Planning, Building and Upgrading National and International Road Networks Cutting Through Rural Communities – With Consideration to the Local Transport and Living Demands, , Folkesson J., 26th World Road Congress, World Road Association (PIARC), 2019
- Functional Structuring of Road Networks, Friedricha M., World Conference on Transport Research - WCTR 2016, Transportation Research Procedia, Vol 25, 2017,
- Functionally Hierarchical Road Classification Considering the Area Characteristics for the Performance-oriented Road Planning, Goto A., Nakamura H., International Symposium on Enhancing Highway Performance (ISEHP), 7th International Symposium on Highway

Capacity and Quality of Service, 3rd International Symposium on Freeway and Tollway Operations, Transportation Research Procedia, Vol. 15, 2016,

4. GENERAL REVIEW OF ROAD DESIGN STANDARDS

In this chapter a general review of the principal issues in road design standards is presented. It is considered the most important part of this document. The review was conducted from surveys undertaken by PIARC Task Force Members as described in the Methodology chapter. The principles of road design standards have been divided into the following groups, which are described in the following subchapters:

- Functional classification of the road
- Speed in road design standards
- Traffic composition
- Design criteria
- Driving performance and human factors
- Design of road infrastructure

In each subchapter analogies and differences in road design standards are identified. A detailed analysis of differences between countries will be presented in the final report.

4.1. ROAD CLASSIFICATION FOR GEOMETRIC DESIGN

The most important factor when considering road design standards is the functional classification of the road. It defines the role of road in the overall transport network. The aim of this chapter is to review the approaches undertaken by the countries considered in defining a roads functional classification and its application in the design process. Functional classification should consider the expectation of the road in question with regard to design requirements, speed, traffic operations, road access, road users, mobility requirements, etc.

Functional classification should enable the design of a hierarchical road network and should consider land-use development planning. In the literature, various road classes can be distinguished, such as in the US (Green Book, 7th ed.]: freeways, arterials, collectors and local roads, which, in general differ in terms of access to the road, the proportion of through traffic volume to total traffic volume and the vehicles expected travelling speed.

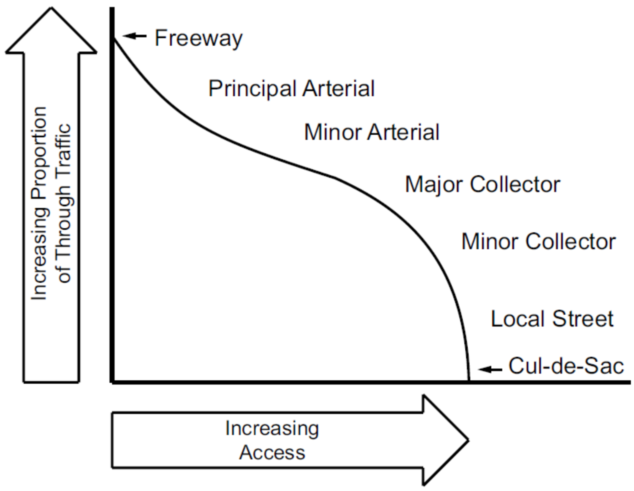

Fig. 1. Relationship of functional classification of road, traffic serving and access (Green Book, 7th ed.).

As a whole, road guidelines may cover:

- Geographical aspects – guidelines may be general or specifically refer to urban, suburban or rural roads. Other special features, such as mountain or seaside areas may also be taken into account.
- Hierarchical/functional aspects – guidelines may be specific for a given category, such as motorway, secondary road, arterial road or 2+1 roads. To date no coincident classification of categories has been determined across all countries.
- Technical aspects – horizontal and vertical layout guidelines. Other geometrical design criteria covered includes the combination and compatibility of horizontal and vertical elements and safety criteria. The scope of analysis of this document excludes other auxiliary road components such as barriers, signaling, distances between exits, construction materials or drainage elements.
- Constitutive aspects – guidelines may be specific for linear elements such as the trunk or collector/lateral roadways or specific for joint components: interchanges, intersections or roundabouts.

National guidelines very rarely completely cover all four aspects as a whole, they rather partially address the aspects by use of heterogeneous combinations.

A roads functional classification influences the drivers expectations. This means that drivers, when considering the cross-section organization and general road layout, identify the class of road they are driving along and unconsciously choose their driving behaviour (in terms of speed and alertness). The drivers make this choice by comparing the perceived road environment with pre-stored road categories. Only three or a maximum four categories can be unconsciously recognized by drivers. Therefore a maximum of four road functional classes for each road environment (rural or urban) should be considered.

As stated previously, the functional classification depends on the transportation function and its relationship with the adjacent road network. The road characteristics (in terms of cross section organization, design speed, geometric features, served road users, intersections types and access management) are defined from the road functional class to provide a safe transport service.

In table B.2 a review of functional classification of roadways for 14 countries is presented. The reported data and characteristics are derived from the synthetic overview of the road standard given by each Country TF member who responded to the survey questionnaire.

In almost all of the reviewed guidelines, rural and/or urban areas are distinguished. In some countries suburban (Spain) and arterial (Belgium) road environments can be selected. In China and Germany a motorway environment is distinguished.

Road classifications differ in the number of road classes and names. Class names are related to a road function or have symbols corresponding to a function in the road network. All road classifications maintain the hierarchical structure of the road network from a motorway (with restricted access control) to local roads (with non-limited access).

The basic factors that are taken into account in the classification of the road network are the location and function of the road within the road network as well as access to the road and the scope of its application. In a few cases, the road classification is influenced by the traffic volume or the heavy vehicle traffic volume (Belgium). It is also related to the roads cross-section (number of roadways and lanes). The traffic volume is therefore indirectly taken into account in the road classification through application of the cross-section.

The road class is closely related to the speed limit (as described in chapter 4.2) as well as the possibility of road users to use multiple modes of transport (chapter 4.3).

It should also be noted that the type of vehicle generally does not constitute a relevant condition in the road classification.

4.2. SPEED IN ROAD DESIGN STANDARDS

Speed is one of the most important parameters in road design standards. Design or operating speed should provide a sufficient balance between drivers' expectations and safety issues[1]. Speed affects the attractiveness of the means of transport as well as the choice of the travel route. The aim of design is to ensure the speed expected by road users (i.e. efficient traffic operations) is matched with a high level of road safety and a low severity of accidents.

Important differences in design criteria are observed for low and high-speed roads. Design and operating speeds are the main parameters used to define road geometric characteristics in road design standards. Design and operating speeds should be matched and the generalized maximum speed limit fixed by the Road Code for each class of road. The latter aspect features significant differences between the countries considered.

When it comes to the speeds in road design standards, there are some similarities between the countries, but in other cases the situation differs greatly. A direct comparison is often very difficult because the countries have different road functional classification systems.

It is noticeable that the V85 speed is taken into account as a parameter in road design standards in many countries. There are however differences with regard to its application. The V85 speed is often used for the operating speed, while in Austria and the Czech Republic it is important for determining the design speed. Another difference is that in some countries the road surface has an impact on the V85 speed selection. To determine the speed one can distinguish a wet but clean road, whereas in some countries, good weather conditions are used.

The comparison of the highest permissible speed (speed limit) for the highest road class (motorway, freeway, primary) is also interesting. Poland and Spain have the highest permitted speed of 140 km/h each. In Germany, the speed on motorways is generally not limited, but there are local restrictions where a maximum permissible speed of 130 km/h is assumed. In China a maximum speed of 100 km/h is allowed. This is the lowest value of all the countries reviewed. Japan's general roads have networks built under design conditions aiming for a travelling speed of 60 km/h from the viewpoint of economy and safety, so the upper limit of the standard speed set as a national uniform standard is 60 km/h.

In addition, it looks as if the countries interpret design speed and operating speed differently. In some countries, the road is designed for the "design speed" and the maximum permissible speed (speed limit) is set below the design speed. This is for safety reasons. In some countries, a higher speed is officially permitted than the road is designed according to the design speed. This probably

[1] For the definiton of Design Speed, Operating Speed, generalized or locally posted Speed Limits see also PIARC Report "Setting Credible Speed Limits", 2019R26EN

has local reasons. In these cases, design speed doesn't reflect the real behavior of drivers, but design speed is considered the technical parameter for designing selected geometrical parameters.

In some countries design and operating speed are used. The base parameter is design speed, but operating speed is used for selection of geometric parameters (related to safety) on high-speed roads (e.g. Poland).

In the table B.3 (Appendix) different speeds (definition) used in road design standards as well as factors affecting their values are presented.

4.3. TRAFFIC COMPOSITION AND MULTIMODAL CONSIDERATION IN ROAD DESIGN STANDARDS

The needs of transportation modes should be considered in both the design and operation stages. Roads should be designed to meet the expected road users and road function (road classification). A roads design has an impact on its ultimate traffic composition (see table B.2). For high-speed roads access is limited to some users whereas all road users are allowed access to low-speed roads. Based on the reviewed standards, road users can be categorized into the following transportation modes: cars, trucks, buses, motorcycles, moped, cyclists and pedestrians.

Multimodality is the combined use of several modes of transport during the same travel or between a point of origin and a point of destination.

Very few countries consider multimodality as a specific element during the design stage. Multimodality is generally considered when planning new road corridors or adapting existing corridors so that it is favored. These considerations appear in the form of reserved spaces on the roadway, such as specific areas reserved to certain users and carpooling lanes that allow mobility as well as provision of park-and-ride facilities adjacent to the roadway which facilitate the change from one mode of transport to another.

In Austria a multimodal alternative examination (strategic examination of traffic) must be carried out when making a fundamental decision to build a new transport infrastructure (for federal roads such as motorways or expressways).

France has design criteria for multimodal transport. The addition of reserved lanes on some of its urban and suburban roads promotes public transport (buses) and carpooling.

4.4. DESIGN CRITERIA

In this chapter, design criteria in relation to functional classification have been compared. This comparison is very general and should indicate which criteria are included in the reviewed standards as well as which factors have an impact on selected criteria and what is required (table B.4, Appendix). The following criteria has been distinguished:

- Access management (how is required, hierarchical structure)
- Traffic characteristics (design vehicle, type, the variability of traffic)
- Traffic performance (required Level of Service)
- Safety (general information)
- Environment (which factors are considered)
- Pedestrians (facilities for pedestrian – requirements)
- Cyclists (facilities for cyclists – requirements)

- People with disabilities (requirements)
- Cost (economic requirements)

In all standards requirements for access management are described. In some countries, partial access control is provided. For all roads with high-speed full access control is required. Access control can differ according to location (rural, urban) for similar road classes.

Traffic characteristics are partially required in the standards and it depends on the situation and law (for example accepted road users). Not all road design standards provide requirements for design vehicles, variability of traffic (Poland).

Traffic performance criteria can be defined by Level of Service (most often), level of (eventually heavy) traffic volume (Belgium, France), and travel speed (Germany). Mostly LOS is calculated based on US Highway Capacity Manual (HCM, different editions). Better LOS is required for rural roads while for urban roads capacity should be needed. Only in a few countries traffic performance requirements are not defined (Poland, Japan).

Safety in design criteria is provided by key performance requirements (visibility, balance on a curve, human factors, etc.). This topic will be described in the detail in the full report. In some countries, mainly EU Countries, additional requirements of road safety inspection, road safety audits, road safety impact assessment should be fulfilled in the Trans-European Road Network (TERN).

One of the most important factors considered in recent years in road design standards (apart from safety) are environmental factors. Road design standards mainly consider factors related to noise, emission, water pollution, vibration, flora, fauna, archeology, etc.

Requirements for pedestrians and cyclists are included in all road design standards. They depend on road location (rural, urban) and level of access control. Requirements are defined where pedestrians and cyclists are allowed and present possibilities to provide pedestrian and cyclist traffic on the shoulder, within the roadway and on walkways.

For people with disabilities, the requirements are mainly defined as designing without architectural barriers.

It is not common to consider the cost of construction in road design standards. This factor is only included in a few standards (Germany, Spain).

4.5. Driving performance and human factors

A well designed road which considers the driver's capabilities, allows for more comfortable driving resulting in improved traffic performance and a reduced number of crashes. To allow for improved interaction between the road and the drivers Human Factor principles should be taken into account in road design standards. Some road design standards take into account the requirements related to the human factor however with varying degrees of detail. In the review of road design standards, decision-making sight distance (DMSD) (considered in 9 out of 15 countries); control of the field of view quality (considered in 7 out of 15 countries); and user's expectation considerations (considered in 7 out of 15 countries), were considered (table B.5, Appendix).

Depending on road design standards, DMSD is obligatory or recommended. It can depend on road classes and cross-section. The factors impacting on DMSD are operating speed, location, and driving performance related to the available advance warning, anticipation and response times.

Fulfillment of the requirements for Control of the field of view quality is obligatory for intersections however, requirements for road sections are only introduced in a limited way. A recommendation is to consider the continuous field of view of the road and the limitation to the field view caused by obstructions. This includes limiting visible advertising.

Road user expectation is mainly included in road design standards through recommendations for maximum and minimum length of straights, circular curves and clothoid parameters, ratios of successive curves, spatial coordination of the road plan, and the road profile.

4.6. Design of road infrastructure

The aim of this subchapter is to collect basic information about the geometric parameters taken into account for design of the road layout. The information contained in this subchapter has been taken from sections 4 and partly section 7 of the questionnaires (refer to Annex A, Appendix).

The first section entails information about the required vehicle stopping and sight distances and the factors considered in the determination of these distances. These distances are defined as follows:

- *Stopping sight distance:* this is considered in all studied countries. In Australia and Belgium it is simply referred to as *sight distance*. It usually depends on speed and slope, but other factors like perception-reaction time, longitudinal friction, rolling resistance, aerodynamic drag, road class, height of the driver's eye or height of the obstacle may also affect its value. Perception and reaction time is 1 s in Belgium and 2 s in Spain, while in Japan, Mexico, Canada and the US a time of 2,5 s is considered to allow for the so-called braking stopping sight distance. In Italy it is a function of the design speed of each considered road element (values range from 1,4 s to 2,3 s).
- *Overtaking sight distance:* this usually depends on travelling speed and applies to most countries.
- *Lane changing distance:* this usually depends on travelling speed and the road category. It applies in Australia, Chile, Czechia, Italy and Spain.

Stopping sight distance is mostly applied on the approaches to intersections. Many countries consider stopping sight distance on approaches to intersections (with or without indication of the actual distance) and/or visibility triangles.

For roundabouts the visibility along ¼, or a certain length of the ring lane must usually be ensured. Other measures may imply the addition of a lane in ramps or simply the lack of obstructions in the visible area.

Design homogeneity is formally taken into account in only Canada, Germany, Italy, Poland and Spain. Of these countries, Canada and Spain express basic principles of homogeneity for intersections, although a more systematic development of this concept is lacking. Homogeneity is expressed by means of ratios between consecutive radii in Germany, Italy, Poland and Spain. Besides that, Canada, Poland, and Spain consider deviations of operating speed up to 20 km/h within a section or from adjacent sections.

Horizontal and vertical alignment coordination is targeted in the road design standards for all considered countries:

- Canada recommends that the horizontal curve must be longer than the vertical curve where these curves co-exist. In Spain, however, it is recommended that a much longer horizontal curve than vertical curve be avoided where these curves co-exist.
- Czechia establishes a minimum and a maximum total slope as well as a progression between radii, curvature, superelevation and slope.
- Poland establishes a minimum length for a smooth and continuous field of view of c.a. 2,5 times design speed. A maximum superelevation of 4% in urban roads and 5% in rural roads is recommended following a long straight element.
- Spain and Italy describe a series of undesired situations where the effect of layout loss, orientation loss, dynamic loss or disproportions impair coordination between horizontal and vertical layout.

As far as alignments are concerned, most countries use straights, circular curves and transition curves. Transition curves are usually clothoids. Besides clothoids, other types of spirals are used for example in Canada. Widening and, when necessary, a clear zone are frequently required for tighter radius curves.

Factors to be taken into account in horizontal layout parameters (radius, superelevation) vary from country to country, but they normally entail speed, lateral acceleration, transversal friction (affecting transversal equilibrium), tractrix curves, slope, rollover possibility, transversal acceleration change rate, cinematic vehicle encumbrance and visual perception. It is to note that Italy and Mexico have limited the acceleration rate, which is expressed in ms^{-2} whereas in Spain its variation expressed in ms^{-3} is used.

In vertical alignments slope and parabolic curves are the main elements used. Factors to be considered in the limitation of parameters are usually speed, widening, number of roadways or additional lanes, comfort of the users, visual perception, lighting conditions, traffic composition, drainage and superelevation of the road. Longitudinal slope value in rural roads can vary between 0,3% (in Poland) to 7%, with some exceptions on local roads with 12%. China, as an exception, does not prescribe the use of any particular kind of alignment but rather advocates for a flowing layout equilibrium, matching and harmonizable to the surrounding terrain environment.

The design of junctions, i.e. interchanges, intersections and roundabouts is also subject to geometrical and functional factors. Number of legs, visibility and tractrix curves, among other factors, determine the typology of interchanges and intersections. Roundabout diameters range from 12 to 50 m. Maximum ramp slopes for interchanges are typically limited to 5% - 10% (Canada, Italy). Austria and Czechia apply a stricter limitation of 4%. Poland, Spain and Portugal have intermediate limitations with a maximum value of 6%. The longitudinal slope in roundabouts is limited to 6% in Czechia, Portugal and Poland, whereas in Spain it is not recommended to place a roundabout where any legs slope is higher than 2%.

All relevant information is included in the table B.6 (Appendix).

5. IMPACT OF NEW TECHNOLOGY ON ROAD DESIGN STANDARDS

Development of road transport systems, new technologies, and changes in mobility (new propulsion techniques, new personal mode transport, and connected and autonomous driving) as well as new possibilities of collecting data (Big Data) force a new approach to road design, or improvement of existing requirements. Works on reviewing road design standards to cover the ongoing transformations of the road transport system are ongoing in some countries, but they are still at a preliminary study level. The dynamic evolution of the technologies and their current development status do not allow yet to introduce modifications to the current road design standards but make it essential to start discussing the assumptions for the operation of such transport modes.

5.1. IMPACT ON INFRASTRUCTURE PLANNING

The introduction of new technologies and transport modes will have a great economic impact on the future society and requires predictions of impending conditions and needs. The prediction of the implementation time-line of these new mobility systems is considerably uncertain but, as far as they impose external costs and rely on public infrastructures, whose modification is expensive and very slow, land and urban planning activities must take care of this today and regulation modifications must be considered to control and properly support the transformation. Roadway design, road equipment, parking spaces, fueling facilities, traffic safety measures, dedicated spaces, to cite just a few examples, rise various planning issues. The expected great benefits provided by the transformation are shown off by automotive industries and service providers, but the possible forthcoming problems must be analyzed and carefully considered.

First research results in this field seems to indicate that, during the long transition period, reduced efficiency and safety could result from the introduction of new transport systems and this should be prevented in all the possible manners. Mixed traffic including “conventional” and “technologically advanced” vehicles should be allowed only on modified and safety managed infrastructures where separation criteria are implemented and dedicated spaces are provided without impeding traffic capacity.

Planning of new road infrastructures or adapting the existing ones to prepare them for the future needs require cautious but knowledgeable political decisions to avoid suffering instead of addressing the expected transformation.

5.2. IMPACT ON GEOMETRIC DESIGN

Most of the road design standards improvements have historically been related to the improvement of driving comfort and the safety of users. The emergence of new technologies in road transport, the changes in mobility, the use of alternative power sources for vehicles and the forthcoming connected and autonomous vehicles (CAV) will require revising the existing standards to adapt them to support their safe and efficient introduction.

Many actors in the ongoing transformation assume that the infrastructures will play no role, as the on-board technologies will be able to manage infrastructures as they are now. But many others, as well, consider that the safe and efficient transition to the new mobility systems will not be possible without the right infrastructure

Adapting roads to connected and autonomous vehicles (CAV) will be a greater challenge than adapting them to alternative power sources for vehicles. However, the changes will not happen immediately. They will take place in stages and will require changes in the road infrastructure will likely have the due time for their implementation. The condition is to start considering them today, in order to be prepared or, better, to manage the transition.

To do this, careful attention has to be given to identify which road design standards changes should be required by the development of autonomous vehicles and should take into account the transitional stage that has already begun as well as the target stage, i.e. when the vehicles will become fully autonomous. Each stage should take into account both changes related to the road infrastructure, including road geometry (geometric features of the road) and additional equipment and maintenance. Full autonomy will cause a complete change in the current system of human-road-environment interaction. Therefore, changes in design standards should apply to all countries, regardless of the advancement of the development of the road network and its equipment. The introduction of autonomous or partially autonomous vehicles in one country, where the roads will be adapted to these vehicles, may make these vehicles unable to move in another country due to inadequate road infrastructure. This would cause very big challenges for road administrations in all countries, and at the same time would require uniform standards for roads and road infrastructure on an international scale (to levels never before envisaged). Due to the CAV requirements, these standards should apply to design, equipment and maintenance of road infrastructure. The main issues related to standards in the different stages of CAV implementation are summarized below.:

- *Design standards:* Regardless of the state of development of the road network in countries, the introduction of CAVs will require significant changes in road design standards for new roads as well as those that will be retrofitted. The huge costs related to the construction, or reconstruction and adaptation of roads to CAVs will be partially the same costs that are anyway required to improve road safety for the present road system and make it necessary to determine which types of roads should be adapted to CAV in the first place. This issue raises a number of questions such as:
    - Should CAV design standards apply to all roads or only to those with the highest parameters?
    - If ultimately CAVs will be able to move on all roads how is the adaptation of these roads, through stages of implementation, applied to appropriate design standards?
- *Equipment standards:* Regardless of the type of road (motorway, regional, local road, etc.), some of the equipment, mainly for road safety reasons, will have to be the same for different roads. However, for major roads, CAV systems will need better and more precise CAV facilities.
- *Maintenance standards:* This issue is very important in the case of maintaining a high level of CAV road safety. The current standards, which mainly concern the possibilities and perception of a human being as a driver, are not required for CAVs, where the role of a human observer will be overtaken by various devices and sensors. An example is the significant role of road markings, where in the case of the transition phase it is very significant for CAVs.

The introduction of fully autonomous vehicles will be a step-by-step process depending on their development and adaptation of infrastructure to their capabilities. This is evidenced by the assumed levels of autonomous driving of the vehicle, from level 1 (no automation) to level 5 (fully autonomous) [1], [2], [3].

The rate of achieving individual levels of autonomy will vary in different countries and will depend on many factors, including the condition of the road network, planned new roads or their reconstruction, but also the level of wealth of the society which will affect the replacement rate of the infrastructure. It can be assumed that there will be two periods that will have an impact on road design standards, i.e. the transition period (mixed traffic) and the period of full autonomy.

The period of introducing CAVs will depend on the infrastructure and the changes that will be necessary for its adaptation. Infrastructure changes, due to the behavior of CAV users, should be implemented proactively, not reactively. At the same time, the existing standards of road design, equipment and maintenance should be updated to stay ahead of implementation. The changes to the standards will take into account [1]:

- An advanced level of road maintenance and traffic control. This mainly concerns the quality of road markings and road signs. The quality and condition of the road surface is also an important factor. Existing traffic control systems will change. Knowledge about the location of the vehicle and its operational parameters will result in a more optimized use of the road network and the improvement of traffic operations and conditions.
- Introducing new infrastructure elements, which will likely include:
    - additional traffic lanes for specific speeds and targets during the initial CAV introduction periods,
    - separated lanes during the transition period of CAV introduction, when the solution will be used by traditional vehicles and CAV,
    - lanes to be used only by heavy goods vehicles (truck convoys),
    - dedicated lanes for the exclusive use of autonomous buses,
    - modern traffic management infrastructure at intersections,
    - devices and infrastructure for electric vehicles,
    - an integrated cyber-physical infrastructure network supporting various types of communication – Infrastructure to vehicle (I2V), vehicle to infrastructure (V2I), vehicle to pedestrian (V2P), and vehicle to everything (V2X).
- Changes in the design of some infrastructure elements, including changes in geometry. The introduction of fully CAV will result in changes in the design of some elements, which will become redundant or their parameters will change. Due to the fact that CAVs ensure safety, the need for some safety measures, e.g. shoulders, barriers, could be reduced. Also due to changes in the engine, it will be possible to reduce or remove some environmental protection devices, such as noise barriers. Due to the increased road safety, the geometric parameters of some elements may change – mainly the parameters requirements will be reduced. As the main laws of physics governing vehicle performance remain the same, CAVs will not have a significant impact on the standards of geometric design. Two key phenomena, i.e. CAV acceleration and deceleration, can influence the geometric design (e.g. length of dedicated lanes at intersections). However, in order to maintain driving comfort, it is assumed that they will not have a very significant impact on the geometry.
- Removal of some infrastructure elements. In most cases, after reaching CAV level 5, some devices and infrastructure elements, such as traffic signals, park and ride systems, etc., will no longer be required. Due to the specific possibility of not requiring these elements over time, it may be possible to remove them.
- Relocation of some infrastructure elements. The introduction of CAV will contribute to changes in the use of vehicles, especially passenger cars. The need to provide large parking spaces in cities will be reduced. In the event that CAV becomes a shared service, it will be possible to transfer some city functions that have so far been used for parking cars.

In order to adjust for CAVs changes in the approach to the existing road classification will have to be made as well as changes to the standards for road design, equipment and maintenance. The existing classification related to the function of the road will have to consider the changes in the equipment utilizing the road. One such example of a change to the road classification due to their adaptation to CAV traffic is the classification system proposed in [4]. It assumes classification of roads into 4 classes [4]:

- Class 1 – basic class, where these are the roads currently used by drivers (HDV - Human-Driven Vehicle) containing all the necessary equipment (barriers, road markings, markings, etc.).
- Class 2 – modified HDV roads with CAV support elements. Within this class, it is planned to introduce new solutions to facilitate CAV service and to redesign some of the infrastructure to facilitate CAV operations. Such solutions may include the introduction of dedicated CAV lanes, for example.
- Class 3 – roads dedicated to advanced CAV. Most of the solutions for these roads will concern mainly CAV and the equipment of these roads will be dedicated to these vehicles - e.g. sensors mounted in the pavement, road signs, installations related to communication (also between vehicles). Assuming that CAV will develop towards electric powered vehicles, charging stations and charging devices while driving are foreseen.
- Class 4 – roads dedicated to CAV from which solutions for HDV will be eliminated. In the case of this class reduced or increased dimensions and design features (e.g. lane width, shoulder widths), varied road surfaces (in and out of the wheel line), restriction of some road equipment (e.g. road signs), amongst others are envisaged. With time and with the full saturation of CAV some solutions, mainly road equipment, will be withdrawn due to the aging of the infrastructure.

5.3. Impact of Big Data

The availability and widespread use of sensors along roads and on-board vehicles allow to continuously collect data concerning the traffic conditions, the travel paths followed by vehicles, the speed environment of each road section, the acceleration environment inside the vehicle and many others. With this wide availability of data through different technologies, data sets can rapidly become so large and Big Data applications introduce new perspectives in road management and safety analysis.

Sources of data are sensors and video cameras along the roads, unmanned aerial vehicles, on-board units of vehicles, CAVs, traffic sensors and actuators, information collected by traffic management systems and ITS equipment. The data acquisition can be both automatic and on demand.

Big data are used to feed traditional traffic modeling procedures, to calibrate them, to develop new models providing low cost information, to monitor pavement performances and distress evolution.

Aspects to be evaluated are the free availability of these data, their proprietary status and their commercial use. In any type of application, the evaluation of the data reliability must be a concern.

Also, road design standards should profit from the availability of these data to calibrate driving models, to produce guidelines to design the road elements according to the effective driving performances and to reduce traffic bottlenecks. The knowledge of the vehicles’ operative speed, actual trajectories, traffic volumes and composition and the presence of heavy vehicles carrying dangerous goods in the traffic flow will allow performing tailored safety and risk analysis to identify the minimum performance requirements for the different road environments.

5.4. FUTURE DIRECTION IN ROAD DESIGN STANDARDS

During the review of road design standards the inclusion of new technologies was analyzed taking into account: changes in mobility (new transport mode, connected and autonomous vehicles (CAV), introducing long heavy vehicles – longer than standard – Gigaliner), BIM (Building Information Modeling), e-infrastructure, smart roads and new possibilities of collecting data (Big Data).

Some of the above-mentioned issues are of interest to various PIARC Technical Committees (TC). As a result, other TC's are, or will be reporting on these issues but not directly as an inclusion to the road design standards (including mandatory regulations). The review of the design standards shows that in most cases the new technology and smart roads factor is not included in the reviewed design standards. On the other hand, work on updating design standards is underway in some countries.

BIM integration in road design standards is considered to be at the most advanced stage of all new technologies. BIM design is being introduced but is not mandatory in Australia, Canada, Italy, China, Czechia, Spain while it is currently being researched for introduction in Chile and Poland.

Using Geographic Information System (GIS) seems to have its focus mainly in the maintenance of road systems. It has been used in studies on road maintenance management in some countries, but it is not included in road design standards.

In most countries, e-infrastructure, e-mobility and transport automation are at research and assumptions stages and have not been included in the road design standards.

As an example, regulations for e-infrastructure at rest stops and petrol stations on federal roads or for electric vehicle charging infrastructure in public areas are in place in Austria. An ITS Directive was implemented in Austria at a national level in 2013, by way of the ITS Act (BGBL 2013 I 38). Some of the regulations are related to big data collection:

- The provision of EU-wide multimodal travel information services (Delegated Regulation No 2017/1926, 31.05.2017)
- The provision of EU-wide real-time traffic information services (Delegated Regulation No 2015/962, 18.12.2014)
- Data and procedures for the provision, where possible, of road safety-related minimum universal traffic information free of charge to users (Delegated Regulation No 886/2013, 15.05.2013)
- The provision of information services for safe and secure parking places for trucks and commercial vehicles (Delegated Regulation No 885/2013, 15.05.2013)

It should be noted that all the above-mentioned documents are not included in the road design standards.

REFERENCES to chapter 5

[1] Saeed T. U. (2019) Road Infrastructure Readiness for Autonomous Vehicles. Purdue University. August, 2019.

[2] Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety. 2016, National Highway Traffic Safety Administration. US Department of Transportation.

[3] SAE (2014-2016) Taxonomy and definitions for terms related to on-road motor vehicle automated driving systems. SAE International. Issued in 2014-01 and revised in 2016-09. On-Road Automated Vehicle Standards Committee.

[4] Saeed T. U., Alabi B. N. T., Labi S. (2021) Preparing Road Infrastructure to Accommodate Connected and Automated Vehicles: System-Level Perspective. Journal of Infrastructure Systems, 27(1).

6. CONCLUSIONS AND NEXT STEPS

The scope of the literature review has been limited to only cover the road design standard principles, not their full details. This document focuses mainly on state of the art road design standards based on the review of selected member countries involved in the work of Task Force 4.1.

During the review of the existing road standards, the following problems were identified that should be addressed in more detail in the standards and will be analyzed in the full report:

- **only partial consideration is given to Human Factor principles in the existing standards. Therefore, the Human Factors should be taken into account to a greater extent in road design standards**. These relate to drivers' expectations, such as decision-making sight distance, control of the symmetric composition of the field of view, control of eye-catching objects, optical illusions due to wrong planimetric and altimetric coordination, road recognition, minimum vertical and horizontal curves of radii, transition zones between rural and urban areas and excessive cognitive workload.
- **the self-explaining and forgiving roads concept should be considered more in detail**, although in some countries it is assumed that a road designed to the stated standards is expected to feature self-explaining and forgiving characteristics.
- **no consideration on how to assess design solutions, the correctness of the results achieved in terms of traffic operation, road safety improvement, and environment protection** in given in the analysed road design standards.
- **Some of the standards are more than 30 years old. Updating of them is therefore highly advisable** to take cognizance of technological improvements and new knowledge acquired through the most recent research findings. In some countries, standards are continuously revised, updated and adapted to state of the art technologies. New developments are continuously considered in road design standards in countries such as Great Britain, Austria and Czechia. In some countries, such as Poland, Spain, India and Belgium updating of the standards is in progress. New findings will be presented in the full report.
- Road design standards may consist of one document or more documents. It is considered advisable to split road design standards into separate volumes, each with their own distinction (e.g. urban or rural location). **The structure of the road design standards should allow them to be adapted to be quickly updated due to changing requirements and transport developments worldwide** (e.g. in Austria, many volumes with specific topics).
- Existing road design standards do not give consideration to the advantages that could be offered by the knowledge provided by **big data analysis**. This is especially important and valuable to the design upgrades to existing roads based on a deep knowledge of the traffic, safety and environment, all of which could be improved.
- Existing road design standards do not give consideration to the **transition to automatic driving and its related modes of transport**. New transport modes are not planned to be included in any special way.
- **Road design standards should enable a more adaptive design** to the existing road, traffic conditions and requirements in some cases (e.g. in cities).
- **The functional hierarchical road classification in different countries should be reviewed in detail**. The classification should be simplified and harmonized because in most cases it has a direct or indirect (e.g. based on design or operating speed) influence on the required limit values for the design parameters of the different road elements.

Based on the reviewed road design standards as well as other documents the following steps are envisaged for compilation of the full report in September 2022.

- Comparison of analogies and differences and compilation of a list of standards for the geometric design of roads,
- Analyze the reliability of various models used in road design standards, including human factors. The models are used to define the lengths and geometric parameters of the various lay-out elements, as well as those used to calculate the sight distances required for various driving actions (stopping, overtaking, taking decisions based on signs and unforeseen events, crossing intersections, speed changes). These have been reviewed and their current reliability will be checked. As a minimum the following models will be analyzed in the full report:
    - stopping distance
    - stopping sight distance
    - overtaking distance
    - overtaking sight distance
    - decision-making distance
    - decision-making sight distance
    - crossing distance
    - crossing sight distance
    - minimum radius of curves
    - speed change distance for entries and exits
    - additional lane on ramps
- Investigate the use of Big Data with regard to the geometric design of road infrastructure.
- Analyze the implications of the new mobility and technology in geometric design of road infrastructure. Provide an opinion of the potential impact of connected and automated vehicles on the design of road infrastructure.

The full report will include the general requirements and recommendations for harmonization of road design standards also in LMIC.

7. RECOMMENDATIONS

Because of planned full report recommendations are not included and will be developed in detail in the full report which is expected for the last quarter 2022.

8. GLOSSARY

Term	Definition
AADT	Average Annual Daily Traffic
AV	Autonomous vehicle
BASt	(Die Bundesanstalt für Straßenwesen, The Federal Highway Research Institute, Germany)
BIM	Building Information Modeling
CAV	Connected and autonomous vehicles
CEDR	Conference of European Directors of Roads
DMSD	Decision-making sight distance
Green Book	A Policy on Geometric Design of Highways and Streets, 7th Edition, AASHTO, 2018, US
HCM	Highway Capacity Manual, US
HDV	Human-Driven Vehicle
LoS	Level of Service
NCHRP	The National Cooperative Highway Research Program, US
OSD	Overtaking sight distance
RDS	Road Design Standard
RSA	Road Safety Audits
RSI	Road Safety Inspections
SD	Stopping distance
SSD	Stopping sight distance
TF	Task Force PIARC

APPENDIX: REVIEW OF ROAD DESIGN STANDARDS

ANNEX A – PRELIMINARY FOR THE COLLECTION OF ROAD DESIGN STANDARDS DATA

Review of Road Design Standards – *…….(country)…..*:

The description should be overall to prepare a literature review. More important are the following: general classification, criteria, requirements, conditions, and hypothesis to satisfy, what is included in standards, which factors are considered, which models are used, but no formulas. Details in this step (literature review) are less important, but they will be necessary for the next step (Full report).

I. General information (to prepare chapter 3):
   a. „Level" of standards (national, regional, list of standards)
   b. Application requirements (obligatory, recommended, practice book), national or regional law
   c. Exceptions from obligatory standards (under what circumstances? based on ?? knowledge, list of standards, etc.)
   d. If you know what experiences (partially or fully) or standards were the basis for the country's standards (for example, German, US, Australia, etc…). It can be also mixed.
   e. Please add other information if needed

Standard	**Level of standard**	**application requirements**	**exceptions**	**Country, region**	**creating based on experiences from**	**Road infrastructure**
title	*national, regional,*	*Obligatory, recommended, practice book*	*YES/NO* *If YES (under what circumstances based on ….)*	*Country standard, regional standard*	*US, Germany, France, etc.*	*Road sections (function, technical classification),* *Intersection* *Interchange,* *…..*

II. Detailed information (to prepare chapter 4)
   1. **Road classification** (classification for geometric design) – *general information, based on this classification the next tables should be filled.*
   a. Road environment (rural, urban, suburban, arterials, etc.)
   b. Number of road classes for each road environment (primary, secondary, regional, local, collector, etc.),
   c. Number of lanes and roadways
   d. Speedgeneral speed limit, design speed, operating speed, other speed for each road

e. Road users accepted or excluded in each road class (light vehicles, bus, trucks, motorcyclists, animals, pedestrians, cyclists, etc
f. Multimodal consideration in road design standards (bikers, pedestrians, type of vehicles, public transport, long vehicles – gigaliner, etc.)
g. …..other…

Road environment	Number of road classes and classification	Basis of classification	Speed km/h				Number of roadways	Number of lanes Per direction	Road users accepted or road users excluded	Multimodal consideration in road design standards	Other …….
			General limit	design	operating	Other					
urban											
suburban											
arterials											
Etc.…											

2. **Speed in road design standards** (how is selected, which factors have an impact on speed)
   a. Design speed (how is selected, based on….., which factors are considered)
   b. Operating speed (how is selected or calculated, which factors are considered)
   c. Other speed (how is selected or calculated, which factors are considered)
   d. …….

Road (based on road classification)	Design speed	Operating speed	Other (if exists) speed
xxxx	definition	definition	definition
	Selected (assumed), calculated	Selected (assumed), calculated	
	factors affecting selection/calculation	factors affecting on selection/calculation	

3. **Design criteria and factors considered** (which criteria and factors are included in standards and how)
   a. Access management (how is required, hierarchical structure)
   b. Traffic characteristics (design vehicle, type, the variability of traffic)
   c. Traffic performance (required level of service, manuals to traffic performance calculation (national), international manuals application)
   d. Safety (general information)
   e. Environment (noise, emission, protection, which factors are considered)
   f. Pedestrians (facilities for pedestrian – requirements)
   g. Cyclists (facilities for cyclists – requirements)
   h. People with disabilities (requirements)
   i. Cost (economic requirements)
   j. ….other…

Road (based on road classification)	Access management	Traffic characteristics	Traffic performance	Environment	Pedestrians	Cyclists	People with disabilities	Cost	Safety

4. **Design of geometrical elements (sight distance, horizontal and vertical alignments)**
   a. sight distances (needed from terms of references: *stopping distance (SD), stopping sight distance (SSD), overtaking distance (OD), overtaking sight distance (OSD), decision-making distance (DMD), decision-making sight distance (DMSD), crossing distance (CD), crossing sight distance (CSD), minimum radius in curves (Rmin), speed change distance for entries and exits (DeltaV), additional lane on ramps (AL), etc.*)
   b. design homogeneity requirements (for instance: speed difference between the max allowed speed by the road code for that road class and the maximum design speed)
   c. horizontal alignment (curve and tangent requirements, conditions and hypothesis to satisfy, superelevation, widening, etc.)
   d. vertical alignment (grade and curves requirements, climbing lanes, longitudinal slope min., max, etc.)
   e. coordination horizontal and vertical alignment
   f. …any ideas….

Design of geometrical elements – requirements (fill by factors, not numbers)

Road infrastructure (road sections based on road classification)	Stopping and sight distances (which are included in standards, factors affecting)	design homogeneity (yes /no, how is considered, which factors affecting)	horizontal alignment	vertical alignment	coordination horizontal and vertical alignment
…..					
…..					
intersection		-----	-----	-----	-----
interchange		-----	-----	-----	-----
Other…..					
Other…..					

5. **Road infrastructure** (what types, elements, etc. are included in standards)
   a. Elements of cross-sections (lanes, width, 2+1, clearance zone, pedestrian facilities, bike path, shoulders, medians, frontage roads, public transport facilities, parking, Driveways
   b. Intersections (design requirements or considerations, types, number of legs, etc.)
   c. Interchanges (design requirements or considerations types, number of legs, etc.)

General information included in all standards (in the bracket information about level - national, regional, application requirements)

Road infrastructure	design requirements
Intersection	
Interchange	
Cross-section: width of lane, roadway, additional lanes clearance zone, pedestrian facilities, bike path, shoulders, medians, frontage roads, public transport facilities, parking, driveways	

6. **New technology and Smart roads** (included, not included in guidelines. If included, we should reply for example: how it is included and what kind of issues: new transport mode (personal transport mode, e-mobility), e-infrastructure, AV and CV, BIM in designing (obligatory or not), Gigaliner (long heavy vehicles longer than standard), etc.)
   The list is not limited, fell free to add others.

<u>*No table, just a short description.*</u>

7. **Human Factors principles inserted in RDS**
   a. Decision-making sight distance (DMSD): time distance required prior of critical locations (curve initial point, bus stops, pedestrian crossings, intersections etc) (seconds). The DMSD includes the response, the anticipation and the advance warning distances and excludes the maneuver distance
   b. Control of the field of view quality (YES/NO. If YES: min – max optical density, control of the symmetric composition of the field of view, framing of the curve external and internal margins, control of eye catching objects, optical illusions due to wrong planimetric and altimetric coordination)
   c. Users' expectations considerations (max, min length of straights and circular bends, min radius after a long straight, transition zones between rural and urban areas, excessive cognitive workload)

Road infrastructure (road sections based on road classification)	Decision-making sight distance (DMSD)	Control of the field of view quality	Users' expectation consideration

Additionally, based on the above information each member of the TF should prepare approx. 1 page containing a short description of the contents of the RDSs of his/her country that has been included in Chapter 3.

Some comments of the TF member concerning the possible or expected improvements to the documents at present in force in his/her Country should be appreciated.

ANNEX B – COMPARISON OF ROAD DESIGN STANDARDS

Table B.1 (chapter 3.2 – Road Design Standard - Guidelines)

Austria*					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
RVS 03.01.11, Anforderungsprofile an Straßen (Requirement Profiles on Roads), July 2012	National	Obligatory for federal roads, recommended for other roads	Yes, in justified exceptional cases, if there are no important reasons to the contrary. *) NOTE: this list of guidelines includes just the most important guidelines in Austria RDS. A list of road design standards in Austria is available at: http://www.fsv.at/cms/start.aspx	-	General Requirements of Roads
RVS 03.01.13, Kategorisierung und Anforderungsprofile an Straßen (Categorization and Profile of Requirements of Roads), July 2012	National	Leaflet but linked to RVS 03.01.11		-	General Categorization of Roads
RVS 03.02.12 Fußgängerverkehr (Pedestrian Traffic), October 2015	National	Leaflet (recommended)		-	Pedestrian Traffic
RVS 03.02.13 Radverkehr (Bicycle Traffic), February 2014 (currently under revision)	National	Leaflet (recommended)		Based on German and Dutch standards	Bicycle Traffic

Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**		**Creating based on experiences from**	**Scope of RDS**
RVS 03.03.21 Räumliche Linienführung (Spatial Road Alignment), June 2001 (currently under revision)	National	Leaflet (recommended)		-	Road sections (function, technical classification, functional and geometric layout)
RVS 03.03.23 Linienführung und Trassierung (Alignment and Geometric Road Design), August 2014	National	Obligatory for federal roads, recommended for other roads		-	Road sections (function, technical classification, functional and geometric layout)
RVS 03.03.31 Querschnittselemente sowie Verkehrs- und Lichtraum von Freilandstraßen (Cross-Section Elements and Envelopes of Clearance of Rural Roads), August 2018	National	Obligatory for federal roads, recommended for other roads		-	
RVS 03.03.32 Straßenböschungen (Slopes), November 2019	National	Obligatory for federal roads, recommended for other roads		-	Road sections, Slopes (function, technical classification, functional and geometric layout)
RVS 03.03.33 Dreistreifige Querschnitte (2+1-Querschnitte)	National	Recommended		-	Road sections, 2+1 Roads (function, technical classification, functional and geometric layout)

(2+1 Roads), June 2008 (amendment 2018)					
RVS 03.04.12 Planung und Entwurf von Innerortsstraßen (Planning and Design of Urban Roads), March 2020	National	Recommended		-	Road sections, Urban Roads (function, technical classification, functional and geometric layout)
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**		**Creating based on experiences from**	**Scope of RDS**
RVS 03.05.11 Planungsgrundsätze, (Planning Principles), May 2005	National	Obligatory for federal roads, recommended for other roads		-	Intersection, Planning Principles (function, technical classification, functional and geometric layout)
RVS 03.05.12 Plangleiche Knoten – Kreuzungen, T-Kreuzungen (Intersections at grade – Crossroads – T-junctions), March 2007	National	Obligatory for federal roads, recommended for other roads		-	Intersection (function, technical classification, functional and geometric layout)
RVS 03.05.13 Gemischte und Planfreie Knoten (Mixed Junctions and Grade Separated Junctions), March 2001 (currently under revision)	National	Obligatory for federal roads, recommended for other roads		-	

RVS 03.05.14 Plangleiche Knoten – Kreisverkehr (Intersections at grade – Roundabouts), October 2010	National	Obligatory for federal roads, recommended for other roads		Based on German and Swiss standards	
Australia					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
Austroads Guide to Road Design (AGRD)	National	Recommended – best practice	Guidelines refer to two types of design criteria: 1. Normal Design Domain (NDD) which is applicable for the design of new roads 2. Extended Design Domain (EDD) which is applicable in Brownfield sites (if required) In addition to the above 'Design Exceptions' may be used if justified on an individual basis. Design exception values are below	Original design criteria predominantly USA but significant tailoring and modification to Australian conditions over time. European practice is also considered as in the results of Australian research.	Predominantly for main roads owned by the state road authorities (motorways, rural highways and urban arterials). Not a lot on local streets but Local Authorities still refer to the AGRD and have their own documents.

			NDD and EDD and designers must justify their choice of such values. Each state of Australia also has its own supplement to the AGRD which details local exceptions.		
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
DM 05.11.2001, Road geometric and functional design standards for new roads sections.	National	Obligatory	YES, if special local, environmental, landscaping, archaeological and economic conditions occur. Exception must be accepted by the Authority	USA and European road design standards review	Road sections (function, technical classification, functional and geometric layout)
DM 22.04.2004, Road geometric and functional design standards for new intersections and junctions.	National	Obligatory	YES, if special local, environmental, landscaping, archaeological and economic conditions occur. Exceptions must be accepted by the Authority	USA and European road design standards review	Intersection, Interchange, (function, technical classification, geometric layout)
DM 19.04.2006, Road design standard for the upgrading of	National	Obligatory	YES, based on designer evaluation of their impact	Review of international literature on	Road sections and Intersection, Interchange

existing road sections, intersections and junctions			on road functionality and safety	context related constraints	
Belgium					
CT.98.12(01), Caractéristiques routières et autoroutières	Regional (Wallonia)	Obligatory	YES, if: - Traffic at peak hours > 15% average daily traffic - Heavy traffic > 30% average - Justified particular situation	Accord Européen sur les grandes routes de traffic international (UN - AGR)	Geometric layout of new roads
Canada (Quebec)					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
Standards for geometric design of roads	Quebec , ministry of transporta tions (Regional)	Obligatory	Yes, but agreement from the regional office of the provincial DOT is required.	*Geometric Design Guide for Canadian Roads* (TAC) and *A Policy on Geometric Design of Highways and Streets* (AASHTO, USA)	Classification of roads, environmental considerations, traffic, definition, Typical cross sections, horizontal and vertical alignment, sight distances (stopping, decision, overtaking, intersection), intersection design, interchange design, access design, access control, low volume roads, cycling path

					design, parking, intervention on existing roads
Chile					
30.06.2020, Highways Manual - Volume N ° 3 Instructions and Design Criteria: - Chapter 3,200 Geometric Layout Design - Chapter 3,300 Cross Section - Chapter 3,400 Intersections - Chapter 3,500 Interchange	National	Obligatory if the contract and technical bases establishes it	Yes, exceptions are accepted by the authority if they are technically justified and officially approved. The design must also be developed considering the environmental and road safety aspects indicated in volumes no. 6 and no. 9 of the Highways Manual.	US, Spain, Chile,	Road sections (function, technical classification, functional and geometric layout)
China					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
JTG D20-2017 Specifications for Geometric Design of Highways	National	Obligatory	YES, Implement the basic national policy of strengthening environmental protection and rational use of land resources	USA and European road design standards review	Road sections (Classification, capacity, route location, cross-sections, horizontal alignment, profile, geometric design, at-grade junctions, grade-separated junctions)
Czechia					

ČSN 73 6101, Projektování silnic a dálnic (Design of Highways and Motorways)	National	Generally recommended but many particular legal constraints require to respect many particular Czech State Norms	YES (but under very rare circumstances), It must exist very significant and serious reason for non-using of a particular regulation given in the Czech state norm. The necessary condition is that any law regulation mustn't require using this particular non-used state norm regulation. In the case of a court litigation there must be given very good reasons for non-using of the particular norm regulation.	-	Road sections (function, technical classification, functional and geometric layout)
ČSN 73 6102 ED.2 Projektování křižovatek na pozemních komunikacích - 2. Vydání (Design of Intersections on Highways - 2nd edition)	National			-	Intersection, interchange (function, technical classification, functional and geometric layout)
ČSN 73 6110 Projektování místních komunikací (Design of Urban Roads)	National			-	Road sections (function, technical classification, functional and geometric layout), level intersections
TP 179 Navrhování komunikací pro cyklisty (Design of Bicycle Pathways and Lines)	National	Recommended		-	Bicycle traffic
TP 218 Navrhovaní zón 30 (Design of Zones 30)	National	Recommended		-	Road sections, level intersections
TP 135 Projektování okružních křižovatek na silnicích a místních komunikacích (Design of Roundabouts on Rural and Urban Roads)	National	Recommended		-	Level intersections
France					

Road Design Standard (RDS)	Level of RDS	Application requirements/ prescriptive level	Exceptions	Creating based on experiences from	Scope of RDS
Catalogue des types de route pour l'aménagement du réseau routier national (Catalogue of road types for the development of the national road network)	National	Obligatory on national network can also be used by local authorities for the classification of their network	No	-	General Categorisation of Roads, mainly based on their cross section, types of interchange, their functions (including level/type of traffic) and their environment
ICTAAL: instruction sur les conditions techniques d'aménagement des autoroutes de liaison (National instruction on technical design requirements for rural motorways)	National	Obligatory for rural motorways	YES, derogations are possible if the consequences in term of cost or impact are disproportionate. The use of a derogation must be motivated and the resulting deviation from the normal rule must be optimized (i.e. as little as possible under reasonable conditions) Before using a derogation, the guidelines also offer some flexibilities which can used if necessary in order to reduce the impact of the		
Les échangeurs sur route de type "autoroute" (Motorway interchanges)	National	Obligatory for rural motorways			
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**		**Creating based on experiences from**	**Scope of RDS**
2x1 voie – route à chaussées séparées (Handbook on design of dual carriageway roads with one lane per direction).	National	Obligatory on national network can also be used by local authorities for			Design of dual carriageway roads (2x1 lane). Junctions can be at-grade or grade separated

ARP – Aménagement des routes principals (Handbook on design of major roads)	National	the design of this type of road on their main network	project and optimize its definition		Design of single carriageway roads with 2 or 3 lanes or dual carriageway roads (2x2 lanes), both with grade junctions
ACI – aménagement des carrefours interubains (Handbook on the design of interurban intersections on major roads (grade junction)	National				Design of grade junction on major roads
Voies structurantes d'agglomération – conception des artères urbaines à 70 km/h, (Urban structuring roads – design of 70 km/h urban arteries)	National				Design of urban structuring roads at 70 km/h in urban or suburban area. They don't have motorways characteristics.
Voies structurantes d'agglomération à 90 et 110 km/h (Urban structuring roads – design 90 and 110 km/h roads)	National				Design of urban structuring roads, which have motorways characteristics but in urban or suburban area
Road Design Standard (RDS)	**Level of RDS**		**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
Conception des routes et autoroutes – révision des régles de visibilité (Road and motorway design - revision of visibility rules)	National		YES, derogations are still possible if the consequences in terms of cost or impact are disproportionate.		Revision of all visibility rules on main rural/suburban/urban) roads (whose design is determined by the afford-mentioned handbooks)

			A motivation is necessary and the resulting deviation from the normal rule must be optimized to a minimum. Before using a derogation, guidelines modulate the requirements depending on the safety stakes of the configuration and also offer some flexibilities which can be used if necessary in order to reduce the impact of the project and optimize its definition. For some visibility distances (e.g. stopping sight distance), several values can be considered. Safety levels can be acceptable or not depending on their configuration and stakes.		
Germany					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**

Richtlinien für integrierte Netzgestaltung – RIN (R1) (Road network planning)	National	Recommended by the Ministry, can be obligatory, in particular, if agreed on as an integral part of the contract. In practical approach, it is usually applied in road design	possible exceptions are the responsibility of the designer	Documents prepared by FGSV working groups mainly using the knowledge of experts and researchers in Germany, cooperation within the so-called DACH (Germany - Austria - Switzerland)	-
Richtlinien für die Anlagen von Landstraßen - RAL (R1) – (Design of rural roads, excl. motorways)	National				
Richtlinien für die Anlagen von Stadtstrassen – RASt 06 (R1) (Design of urban roads - street)	National				-
Richtlinien für die Anlage von Autobahnen – RAA (R1) (Designing of Motorway)	National				-
Richtlinien für Bemessungsfahrzeuge und Schleppkurven zur Überprüfung der Befahrbarkeit von Verkehrsflächen – RBSV (R1) (corridor of vehicle movement)	National				-
Richtlinien für den Ländlichen Wegebau – RLW (Low Volume Roads)	National				-
Italy					

Road Design Standard (RDS)	Level of RDS	Application requirements/ prescriptive level	Exceptions	Creating based on experiences from	Scope of RDS
DM 05.11.2001, Road geometric and functional design standards for new roads sections.	National	Obligatory	YES, if special local, environmental, landscaping, archaeological and economic conditions occur. Exceptions must be accepted by the Authority	USA and European road design standards review	Design of new road sections (functional classification and geometric layout)
DM 22.04.2004, Requirements for upgrading existing road sections.	National	Obligatory	YES, based on the designer evaluation of their impact on road safety and functionality. If the standards for new roads (that are not obligatory for upgrading existing roads) cannot be met, the designer has to demonstrate that the upgraded road will be anyway safer than the existing road.	USA and European road design standards review	Upgrading design of existing road sections
DM 19.04.2006, Road geometric and functional design standards for new intersections and junctions	National	Obligatory	YES, if special local, environmental, landscaping, archaeological and economic conditions occur. Exceptions are allowed providing that road safety is	Review of international literature on context related constraints.	Design of new interchanges and intersections (technical classification, geometric layout, traffic flow requirements).

			guaranteed and pollution avoided. Exceptions must be accepted by the Authority		
Guidelines of Lombardia Region RR 24.4.2006 n. 7 "Road design standards"	Regional	Obligatory for regional road network, provided national standards are anyway respected.	YES, if special local, environmental, landscaping, archaeological and economic conditions occur. The designer has to demonstrate that road safety is guaranteed.	National standards and local practices.	Design of new road sections and intersections and design of existing roads upgrading (geometric and functional characteristics).
Japan					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
Road Design Ordinance	National	Obligatory	YES (in unavoidable cases such as for a topographical reason and due to conditions of urbanization.)	US (Partly), Germany (Partly)	Road sections (function, technical classification, functional and geometric layout),
Road Design Ordinance	Regional (x47 prefects)	Obligatory	YES (in unavoidable cases such as for a topographical reason and due to conditions of urbanization.)	Road Design Ordinance (National)	
Road Design Guidebook	National	Recommended	YES (in unavoidable cases such as for a topographical	US(Partly), Germany(Partly)	

			reason and due to conditions of urbanization.)		
Mexico					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
Manual de Proyecto Geométrico (Manual for Road Geometric Design, 2018)	National	Recommended	YES, if special local, environmental, landscaping, archaeological and economic conditions occur. Exceptions must be accepted by the Authority	USA	Road sections (function, technical classification, functional and geometric layout)
Poland					
Regulation of the Minister of Transport and Maritime Economy on technical conditions for public roads and their location. Regulation, No 43, pos. 430.1999 Upgrading: 1. Regulation pos.124.2016 2. Regulation, pos.1643.2019* It is presently under revision.	National	Obligatory	YES, if special conditions occur. Exceptions must be accepted by the Ministry	European road design standards review, mainly German	Design of new road sections and retrofitted (functional classification and geometric layout,), all elements of road infrastructure are included

Design guidelines for intersections, 2001, part 1 (Intersections) Part2 (Roundabouts) It is presently under revision.	National (only public roads)	Recommended	-	European road design standards review	Design of new or retrofitted intersections (technical classification, geometric layout, traffic flow requirements).
Portugal					
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
Design Standards (Norma de Traçado JAE P3/94)	National	Obligatory	YES, if special local, environmental, landscaping, archaeological and economic conditions occur. Exception must be accepted by the Authority	USA and European road design standards review	Road sections
Intersection Standards (Norma de Interseções JAE P5/90)	National	Obligatory		USA and European road design standards review	Intersections
Interchange Standards (Norma de Nós de Ligação JAE P6/90)	National	Obligatory		USA and European road design standards review	R Interchanges
Provisory Design Standards (Norma de Traçado de Estradas)	National	Recommended		USA and European road design standards review	Road sections
Spain					

Instrucción de Carreteras. Norma 3.1-IC, (Road Instruction. Norm 3.1-IC)	National	Obligatory	Admitted with a founded justification. Urban roads, mountain roads, roads in natural spaces with high environmental interest or fragility as well as existing roads.	USA AASHTO	Linear elements, lanes, roadways, accesses
OC 21/2012 Guía de nudos viarios (Guide on road interchanges)	National	Recommended		-	Intersections, interchanges, roundabouts
Road Design Standard (RDS)	**Level of RDS**	**Application requirements/ prescriptive level**	**Exceptions**	**Creating based on experiences from**	**Scope of RDS**
OC 1/2021 Recomendaciones para el diseño de carreteras 2+1 y carriles adicionales de adelantamiento, (Recommendations for the design of 2+1 roads and overtaking additional lanes)	National	Recommended	Under justification.	-	Linear elements, lanes, roadways, accesses
Orden FOM 3317/2010 Instrucción sobre las medidas específicas para la mejora de la eficiencia en la ejecución de las obras públicas de infraestructuras ferroviarias, carreteras y aeropuertos del Ministerio de Fomento, (Effectiveness measures in Public Works)	National	Obligatory	YES, under justification and approved either by General Director or by Secretary of State	Spanish experiences	Whole infrastructure. Establishes limitations to the total road cost per km, structure cost per m^2, total cost for interchanges, measures exceeding the reasonable minimum for maintenance, environmental protection as well as the addition of elements not foreseen in previous studies.

Ley 37/2015, de 29 de septiembre, de carreteras (Law of Roads)	National	Obligatory	Exceptions are very punctual and need justification.	Spanish experiences	Whole infrastructure
Real Decreto 1812/1994, de 2 de septiembre, por el que se aprueba el Reglamento General de Carreteras (Road regulation). It is presently under revision.	National	Obligatory		Spanish experiences	Whole infrastructure. It defines road protection zones.

Table B.2 (chapter 4.1 – Road Classification for Geometric Design)

Austria							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**
Rural	Motorway (primary road network, transnational or transregional road network) expressway (transnational or transregional road network, primary road network, if prescribed as motorway, cf. road traffic act) road for motor vehicles (secondary road network, transregional road network)	Territorial and mobility functions; responsibility	60-130	1R or 2R (motorway, expressway, road for motor vehicles) / 1L or min. 2L (motorway, expressway, road for motor vehicles),	Motorway, expressway, road for motor vehicles - no pedestrians, no animals, no cyclists; motor vehicles with a design speed ≥ 60km/h, others - Generally everything allowed or not forbidden	Motorway, expressway - In the fundamental decision regarding the construction of a motorway, multimodal alternative examination (strategic	Not applicable

	major roads (secondary road network, central-locational / regional road network regional roads (regional road network) local road (connections between communities)			For motorways and expressways additional emergency lane		examination of traffic) Others (excl. road for motor vehicles) - Modal mixture or separation of cycling and walking is implemented on the base of the national guidelines for cycling and walking	
Urban	motorway (primary road network, transnational or transregional road network) expressway (transnational or transregional road network, primary road network, if prescribed as motorway, cf. road traffic act) major roads (secondary road network, central-locational / regional road network regional roads (regional road network) local road (urban road network)		30-100				not applicable
Australia							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L)**	**Road users**	**Multimodal consideration in RDS**	**Other**

				(L/direction)			
Rural	primary, principal, secondary, local roads	Territorial and mobility functions	90-130	Primary, principal 1R or 2R 1L or min. 2L	C, HGV, B, MTW (min 120 cc) (primary, principal) C, HGV, B, MTW, P, Cy, A, O,CC (others)	No	not applicable
Urban	primary, high speed, collector, local roads		50-130	1R or 2R (primary, high speed) / 1L or min. 2L (primary, high speed)	C, HGV, B, MTW (min 120 cc) (primary, high speed) C, HGV, B, MTW, P, Cy, A, O,CC (others)	No	not applicable
Belgium							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**
Rural / urban / Arterial		AADT<9000	50-90	1R / min. 1L	All	No	
Arterial		9000<AADT<18000	120	1R or 2R / min. 2L	All	No	
	2x2 Motorway, Highway	18000<AADT<40000	120	2R / 2L	No light traffic, no slow traffic	No	

	2x3 Highway	AADT>40000	120	2R / 3L	No light traffic, no slow traffic	No	
Canada							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**
Rural	Freeway, national, regional, collector, local	Priority to mobility function (freeway, national) Access but priority to	50-100 (110 in some parts of the country)	1R or 2R (freeway) / 1L or min. 2L (freeway)	Freeway: C, HGV (20%), B, MTW National: C, HGV (20%), B, MTW, P, Cy, A, O,CC, Regional: C, HGV (20%), B, MTW P, Cy, A, O,CC,	No	AADT (regarding road class and location)

Urban	freeway, national, regional, collector, local	mobility functions (regional) Equality between access and mobility functions (collector), Priority to access function (local)	40-90		Collector and local: C, HGV (exc. local), B, MTW, P, Cy, A, O, CC	No	AADT
Chile							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**
Rural	Highway, autoroute, collector, primary, collector, local, development	Territorial mobility and geometric functions	30-120	1R or 2R / min. 1L	LV,B,T, M	No	Not applicable
No urban						Yes	Not applicable

China							
Rural/highway	Motorway	Traffic characteristics and capacity of interference control	100	2R / min. 2L	C, HGV, B	No	Not applicable
Rural/urban	Rural: Class 1, Class 2, Class 3, Urban: Class 4		30-100	2R / min. 2L, (Classes 1-3) 1R or 2R / 1L (Class 4)	Class 1: C, HGV, B, MTW, P Classes 2-4: C, HGV, B, MTW,P, Cy, A, O, CC	No	not applicable
Czechia							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**
Rural	Motorway, Class 1, Class 2, Class 3,	Territorial and mobility functions	90-130	2R motorway, 1R or 2R class, 1R other: min. 2L+ emergency lane for	Motorway: P, A, Cy, MTW with a maximal allowed speed < 80km/h are excluded.	No	not applicable

				motorway, 1L or 2L class 1, 1L other	Class 1: Generally everything allowed or not forbidden with the exception of roads marked as 'road for motor vehicles' Other: Generally everything allowed or not forbidden		
Urban	Class 1 (expressway), Class 2 (collector), Class 3 (local), Class 4 (non-motorized),		50-80 20 (Class 4)	2R class 1, 1R or 2R class 2, 1R other / min. 2L classes 1 and 2, 1L classes 3 and 4	Class 1: Excluded are P, A, Cy, MTW with a maximal allowed speed < 80km/h Classes 2 and 3: Generally everything allowed or not forbidden Class 4: Motor vehicles excluded (ways for pedestrians, bicycles) or allowed under specific conditions (pedestrian or residential zones)	No	not applicable
France							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**

Rural	Type 1: (motorway) Type 2: 2+1 road at grade-separated intersections Type 3: Dual carriageway road at grade intersections Type 4: Single carriageway roads at grade intersections	- cross section and type of intersection, - environment of the road (rural/suburban/urban) - functions of the road (including type of traffic supported) - level of service - capacity	80-130	1R or 2R (Type 1, Type 3) / 1L or 2L (min. 2L for Type 1,) 2+1 (type 2)	Type 1: C, HGV, B, PTW (over 90 cm3) Type 2: C, HGV, B, PTW (considering a “road express” status) Types 3 and 4: C, HGV, B, PTW, P, Cy, O (except if specific status)	No (excl. Type 4)	not applicable
Suburban	Type 5: Urban structuring roads with motorway characteristics		90 or 110	2R / min. 2L	C, HGV, B, PTW (over 90 cm3)	Yes (reserved lanes for public transport services; carpool lanes)	not applicable
Suburban/urban	Type 6: Urban artery at grade separated intersections Type 7: urban artery with separated carriageways and at grade intersections Type 8: Urban artery with single carriageway		70	1R or 2R / 1L or 2L	C, HGV, B, PTW P and Cy	Yes	not applicable

Germany

Road environment (location)	Road classes and classification	Basis of classification	Speed limit [km/h]	No. of roadway (R) / lanes (L) (L/direction)	Road users	Multimodal consideration in RDS	Other

Rural/urban motorway	EKA 1 A, long-distance EKA 1 B, inter-regional motorway EKA 2, similar motorway EKA 3, urban motorway	Territorial (location); connection-function (continental, long distance, overregional, short distance, local)	80-130	2R / 2-4L	Motor vehicle	No	At grade separated intersectio n
Rural	Rural roads: EKL 1 (long distance) EKL 2 (overregional) EKL 3 (regional) EKL 4 (short distance)		70-110	1R or 2R / 1L or 2L, 2+1, 2-1	EKL 1: road for motor vehicles only EKL 2:, no pedestrians, no animals, no cyclists; EKL 3 and EKL 4: all road users	No	EKL 1: At grade separated intersectio n EKL 3:Traffic signals
Rural / urban	VS (rural main road) HS (urban main road) ES (access road)		30-70	1R or 2R / 1L or 2L, 2-1	All road users	No	Non-limited access
Italy							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**

Rural	primary principal secondary local	Territorial and mobility functions	130 110 90 90	primary, principal: 2R / min. 2L Others: 1R / 1L	primary, principal: C, HGV, B, MTW (min 120 cc) Others: C, HGV, B, MTW, P, Cy, A, O, CC	No	not applicable
Urban	primary high speed collector local		130 70 50 50	primary, high speed: 2R / min. 2L Others: 1R / 1L	primary, high speed: C, HGV, B, MTW (min 120 cc) Others: C, HGV, B, MTW, P, Cy, A, O, CC	No	not applicable
Japan							
Rural	primary (1-1) secondary (1-2) third (1-3,4) regional (3-1,2) local (3-3,4,5)	Territorial and mobility functions (only primary and secondary roads)	20-120	1R / 1L (local roads) or 2R / min. 2L (others)	Limited to motorway road users (excl. regional and local roads)	No	not applicable
Urban	primary (2-1,2), collector (4-1), collector (4-2,3)		30-80	2R / min. 2L (primary) or 1R / 1L (others)	All (excl. primary – limited to motorway road users)		not applicable
Mexico							

Road environment (location)	Road classes and classification	Basis of classification	Speed limit [km/h]	No. of roadway (R) / lanes (L) (L/direction)	Road users	Multimodal consideration in RDS	Other
Rural	ET4-A4, National ET2-A2, National B, Regional C, Regional D, local E, local	Territorial and mobility functions	50-110	1R / 1L (roads B-E) 2R / min. 2L	Roads ET: C, B, MTW and HGV (included gigaliner) Others: C, B, MTW and HGV	No	not applicable
Not for urban purpose							not applicable
Poland							
Rural	A, motorway S, Expressway GP, main road with fast traffic G, main road Z, collector L, local D, residential	safety and mobility functions, road access	90-140	A: 2R / 2L or 3L S, GP, G: 2+1, 1R or 2R / 2L or 3L (excl. G, max. 2L) Z: 1R or 2R / 1L or 2L L, D: 1R / 1L	A, S: C, HGV, B, MTW (excl. P, CC, MO, A, O) Others: All	No	A, S, GP, G, Z: limited access, L, D: non-limited access

Urban	S, Expressway GP, main road with fast traffic G, main road Z, collector L, local D, residential		30-80	S: 2R / 2L or 3L GP: 1R or 2R / 2L or 3L G, Z: 1R or 2R / 1L or 2L L, D: 1R / 1L	S: C, HGV, B, MTW (excl. P, CC, MO, A, O) Others: All	No	
Portugal							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**

Rural/urban	primary principal secondary	Territorial and mobility functions	90-120	Primary: 2R / min. 2L principal 2R / 1L secondary: 1R / 1L	primary and principal: C, HGV, B, MTW (min 120 cc) Secondary: C, HGV, B, MTW, P, Cy, A	No	needs justification for unidirectional roads
Spain							
Road environment (location)	**Road classes and classification**	**Basis of classification**	**Speed limit [km/h]**	**No. of roadway (R) / lanes (L) (L/direction)**	**Road users**	**Multimodal consideration in RDS**	**Other**
Rural	Major motorway	Dual carriageway roads with median, in exceptional cases, by other elements.	140	2R / min. 2L	Automobiles	No	Limited access, at grade-separated intersections

Rural/ suburban	Ordinary motorway	Do not meet all major motorway requirements, Dual carriageway roads	140	2R / min. 2L	Motor vehicles	No	Limited access, at grade-separated intersect.
Rural/ suburban	Multilane road	Not being major or ordinary motorways, have intersections.	100	1R / min. 2L	Motor vehicles	No	access partially limited
Rural/ suburban/ urban	Conventional road	Do not meet the characteristics of major and ordinary motorways, or multi-lane roads.	100	1R / 1L	Any vehicle	No	non-limited access

Acronyms:cars:C; Trucks:HGV; Bus:B; motorized-two-wheelers:MTW; pedestrians:P; cyclists:Cy; Animals:A; other:O; Citycars max 50 HP:CC; Moped:MO

Table B.3 (chapter 4.2 – Speed in Road Design Standards)

Austria		
Design speed	**Operating speed**	**Other (if exists) speed**
The **design input speed** („Entwurfseingangsgeschwindigkeit") is the speed for which the alignment of a longer road section is at least to be designed. The **project planning speed** („Projektierungsgeschwindigkeit") results from the design input speed and depending on the arc radius and straight line length as well as the permissible or permitted maximum speed (according to RVS 03.03.23). The project planning speed corresponds to the 85% speed (V85) of passenger cars (free-moving individual vehicles) which can be expected on wet and clean lanes due to the system conditions of the road (according to RVS 03.03.23). Design speed range: • Motorway: 100 – 130 km/h • Expressway: 100 – 130 km/h • auto road ("road for motor vehicles"): 80 – 130 km/h • major roads: rural: 80 – 100 km/h; urban: 60-80/100 km/h • regional roads: rural: 80 – 100 km/h; urban: 40 – 60/80 km/h • local: rural: 80 – 100 km/h; urban: 40 – 60/80 km/h	The targeted traffic speed is determined by the responsible road administration taking traffic and economic aspects into account. The dimensioning hour is to be defined as a further input variable (according to RVS 03.01.13)	None Speed limit range: • Motorway: rural: 130 km/h; urban: 80 – 100 km/h • Expressway: rural: 100 – 130 km/h; urban: 80 – 100 km/h • auto road ("road for motor vehicles"): 80 – 100 km/h • major roads: rural: 70 – 100 km/h; urban: 50-80/100 km/h • regional roads: rural: 60 – 100 km/h; urban: 50 – 70 km/h • local: rural: 60 – 100 km/h; urban: 30 – 70 km/h
Australia		
For all road classes: Design speed range: • Max value: max speed along straights, without traffic constraints and in good weather conditions. • Min value: reference speed for most limiting road elements	**For all road classes:** Definition: V85 (speed value not exceeded by the 85% of isolated vehicles travelling along each road element) Calculated	**For all road classes:** None **For all road types:** **"Desired Speed"** – the speed at which drivers desire to travel at, given the

• Max speed: calculated, equal to the max allowed speed for road category + 10 km/h • Min speed: assumed <u>factors affecting selection/calculation:</u> • max speed value: road functional category • min speed value: environmental and economic considerations **For all road types:** At any location, is a minimum of the 85th operating percentile speed	In rural environment: CCR (curvature change rate), environmental speed **For all road types:** The speed at which 15% of the drivers are exceeding and 85% are slower than. AGRD currently has an operating speed model for rural roads. Motorways generally don't require an operating speed model because of their consistent speed. AGRD doesn't have an operating speed model for urban roads, although geometric elements are driven at consistent speed. AGRD does have an operating speed model for heavy vehicles but only takes in account grade, not horizontal curvature. There is no operating speed model for motorbikes.	road type and geometry. Equal to the 85th percentile speed on the longer straights and horizontal curves. <u>Speed limit range:</u> • rural, primary: 130 km/h • rural, principal: 110 km/h • rural, secondary: 90 km/h • rural, local: 90 km/h • urban, primary: 130 km/h • urban, high speed: 70 km/h • urban, collector: 50 km/h • urban, local: 50 km/h
Belgium		
Design speed	**Operating speed**	**Other (if exists) speed**
All road classes: Design speed is the safety speed at which vehicles can travel in curvilinear and variable slope sections. <u>Design speed range:</u> • Highway: 90 – 120 km/h • Motorway: 90 – 120 km/h • Arterial: 90 km/h • Rural / Urban / Arterial: 90 km/h • Rural / Urban: 50 km/h	**All road classes:** The same **Highways:** Can't be less than 70 **Rural & Urban:** Limited to 50 in urban & village agglomerations. Can be 70 on major roads. Limited to 30 in "School zones"	**All road classes:** Speed limits are posted on local sections where the safety speed is less than the general design speed <u>Speed limit range:</u> • Highway: 120 km/h • Motorway: 120 km/h • Arterial: 90 km/h • Rural / Urban / Arterial: 90 km/h • Rural / Urban: 50 km/h

Canada		
Design speed	**Operating speed**	**Other (if exists) speed**
Freeways: Posted speed + 20 to 30 km/h, On freeway it means 130 km/h for design speed At exits and entries the design speed is based on the reference curve (can vary from 50 to 80 km/h) **National, regional, collector and local:** Posted speed + 10 km/h Speed varies with regard to the environment: • rural high range (90 to 70 km/h) or • urban lower range (40 to 70 km/h) • topography (in mountainous environment) and low volume road design speed can equal posted speed	**Freeways:** V85 speed **National, regional, collector and local:** V85 speed, For low radius curves and based on vehicle stability or limited sight visibility operating speed is -recommended to users.	None Speed limit range: • rural, freeway: 60 - 100 km/h (higher value of 110 km/h in some parts of the country) • urban, freeway: 60 – 90 km/h • rural, national: 90 km/h • urban, national: 90 km/h • rural, regional: 90 km/h • urban, regional: 90 km/h • rural, collector: 80 – 90 km/h • urban, collector: 80 – 90 km/h • rural, local: 50 km/h • urban, local: 40-50 km/h
Chile		
All road classes: **“Project speed”** Definition: Is the speed that allows defining the minimum geometric characteristics of the elements of the layout under conditions of safety and comfort	**All road classes:** **“Specific speed”** Definition: It is the maximum speed at which an element of the route can be circulated, considered individually, in conditions of safety and comfort.	**All road classes:** **“Operation speed”** Definition: It is the average travel speed that users can achieve on a road section of a given project speed under the traffic conditions, state of the pavement, meteorological conditions and the degree of its relationship with other roads and with the adjacent property. **“V85% speed”** Definition:

		It is the speed not exceeded by 85% of the users in a section of homogeneous characteristics, under the prevailing traffic conditions, state of the pavement, meteorological conditions and degree of relation of this with other roads and with the adjacent property. <u>Speed limit range:</u> • rural, highway: 80 - 120 km/h • rural, autoroute: 80 – 100 km/h • rural, collector: 60 – 80 km/h • rural, primary: 90 – 100 km/h • rural, local: 60 - 70 km/h • rural, development: 30 – 50 km/h
China		
All road classes: Factor: highway functions, technical classification, and other elements including terrain, engineering economy, excepted operating speeds and land use along the highway route.	**All road classes:** The differential of the operating speeds used in two adjacent segments shall be less then 20km/h, and the differential of design speed and operating speed used in the same segment should be less than 20km/h.	None <u>Speed limit range:</u> • highway, motorway: 100 km/h • urban, Class-1: 100 km/h • urban, Class-2: 80 km/h • urban, Class-3: 40 km/h • urban, Class-4: 30 km/h

Czechia		
Design speed	**Operating speed**	**Other (if exists) speed**
All road classes: Definition: this is the speed for which the alignment of a longer road section is at least to be designed. It corresponds to the 85% speed of passenger cars (free-moving individual vehicles) which can be expected on clean lanes with wet surface during ideal light and weather conditions (full daylight, temperatures above zero, no rain, no snowing etc.)	-	**All road classes:** **"Available speed"** ("mezní (dosažitelná) rychlost") Vm = [127 * R0 *(f+0,01*p)]^0,5 R0 … horizontal arc radius [m] p … cross-slope [%] f … coefficient of transverse friction [-] Speed limit range: • rural, motorway: 130 km/h • rural, Road of the 1-st class: 90 / 110 km/h • rural, Road of the 2-nd class: 90 km/h • rural, Road of the 3-rd class: 90 km/h • urban roads of the of the 1-st class – expressways: 80 km/h • urban roads of the of the 2-nd class – collectors: 50 km/h • urban roads of the of the 3-rd class – local roads: 50 km/h • urban roads of the of the 4-th class – non motorist: 20 km/h

France		
Design speed	**Operating speed**	**Other (if exists) speed**
For each type of road, one or several design speeds are possible, depending on the posted speed limit and the constraint level of the road site (both can be related): Design speed range: • Type 1: 130 or 110 km/h • Type 2: 90 km/h; 110 km/h on overtaking slots • Type 3: 90 or 110 km/h (110 km/h only on overtaking slots for 2x1 lane) • Type 4: 90 km/h or 80 km/h or 60/70 km/h • Type 5 : 110 or 70 km/h • Type 6, 7 or 8 : 70 km/h The design speed is used for determining: • minimal radius of horizontal curve at maximal cross slope (7 % in general) • minimal radius of horizontal curve at regular cross slope (2,5%) • minimal radius of vertical sag curve Is this part necessary here? If so, the same part should be prepared for the other countries. For application of visibility rules, the considered speed is mostly the V85 limited to posted speed limit. For some visibility rules with high safety stakes, this is the V85.	Usually V85	None Speed limit range: The same as the design speed range

Germany		
Design speed	**Operating speed**	**Other (if exists) speed**
‘**Planning speed**´ – assigned to design classes and related to the road function, streets - speed limit related to the street function and its location **Motorways:** The calculation of the limiting values for the design elements is based on the following speeds in the wet surface: • 130 km/h for long-distance motorways (EKA 1 A), • 120 km/h for inter-regional motorways (EKA 1 B), • 100 km/h for motorway-like roads (EKA 2), and • 80 km/h for urban motorways (EKA 3). **Rural roads (excl. motorways):** • 110 km/h for EKL 1 • 100 km/h for EKL 2 • 90 km/h for EKL 3 • 70 km/h for EKL 4 **Urban (streets):** • Category group VS comprises open roads leading into and within built-up areas. - the permissible maximum speed leading into built-up areas is preferentially 70 km/h, and within such areas mainly 50 km/h. • Category group HS comprises roads within built-up areas - the maximum speed limit is usually 50 km/h. • Category group ES comprises roads within built-up areas providing direct access to buildings - the permissible maximum speed on them is in many cases 30 km/h.	-	None Speed limit range: For motorways: • EKA 1 A: 130 km/h • EKA 1 B: 120 / 130 km/h • EKA 2: 100 / 130 km/h • EKA 3: 80 km/h

Italy		
Design speed	**Operating speed**	**Other (if exists) speed**
All road classes: Definition: Design speed range: • Max value: max speed along straights, without traffic constraints and in good weather conditions. • Min value: reference speed for most limiting road elements Definition of the upper and lower values of design speed range • Upper value: equal to the general speed limit for road category + 10 km/h • Lower value: selected by the RDS on the basis of environmental and economic considerations. • Design speed profile: Calculated value of the design speed of any road element, within the design speed range Design speed range: • Motorway, rural: 90 – 140 km/h, urban: 80 - 140 km/h • Principal roads, rural : 70 – 120 km/h, urban 50 – 80 Km/h • Secondary roads, rural: 60 – 100 km/h; urban: 40 - 60 km/h • Local roads: rural: 40 – 100 km/h; urban: 25 – 60 km/h	**All road classes:** Definition: V85 (speed value not exceeded by the 85% of isolated vehicles travelling along each road element) Calculated: Calculated according to operative speed prediction models factors affecting selection/calculation: Calculated according to operative speed prediction models	**All road classes:** Speed limit Definition: Speed limits are posted if the safety speed is less than the design speed Calculated: Calculated: equal to the safe speed – 10 km/h factors affecting selection/calculation: factors affecting selection/calculation: Road geometric features and visibility constraints Speed limits: • rural, primary: 130 km/h • rural, principal: 110 km/h • rural, secondary: 90 km/h • rural, local: 90 km/h • urban, primary: 130 km/h • urban, high speed: 70 km/h • urban, collector: 50 km/h • urban, local: 50 km/h
Japan		
All road classes: Definition: It is the speed enabling a driver with an average skill to drive safely and comfortably when the weather is good, the traffic density is	**All road classes:** Definition: For the 85th percentile speed, the reference speed considers	None Speed limit range: • rural, primary: 100 - 120 km/h • rural, secondary: 100 km/h

low, and the driving conditions of the vehicle are controlled only by the structural conditions of the road. <u>Selected</u> <u>factors affecting selection/calculation:</u> road functional category	• the risk of accidents in urban areas, • the risk of accidents due to the presence or absence of median strips, and • the viewpoint of pedestrian protection, and also considers general comprehensibility. Set at 10 km/h delimiters. In addition, many of Japan's general roads have networks built under design conditions aiming for a traveling speed of 60 km/h from the viewpoint of economy and safety, so the upper limit of the standard speed set as a national uniform standard is set. Set to 60 km/h. <u>Calculated</u>	• rural, third: 60 – 80 km/h • rural, regional: 60 – 80 km/h • rural, local: 20 – 60 km/h • urban, primary: 60 – 80 km/h • urban, collector: 30 - 60 km/h
Mexico		
Design speed	**Operating speed**	**Other (if exists) speed**
<u>Definition:</u> Maximum speed at which vehicles can safely travel on a road, and is used to determine the geometric elements of the road, such as degrees of curvature; critical lengths of longitudinal slopes; visibility distances, whether stopping, passing or meeting distances; over-elevations on curves, etc.	<u>Definition:</u> It is the speed adopted by drivers under prevailing traffic and road conditions. It is characterized by a random variable, the parameters of which are estimated from the measurement of the speeds of vehicles passing over a representative section of the road under the prevailing conditions (point speeds). For deterministic purposes, the operating speed is usually designated by the 85th percentile of the point speeds.	**Point speed:** <u>Definition:</u> The speed of a vehicle as it passes a point on a road. The usual values for estimating it are the average of the speeds at a point of all vehicles, or of a set class of vehicles. <u>Speed limit range:</u> • rural, ET4-A4, National: 110 km/h • rural, ET2-A2, National: 110 km/h • rural, B, regional: 100 km/h • rural, C, regional: 90 km/h • rural, D, local: 70 km/h • rural, E, local: 50 km/h

Poland		
Design speed	**Operating speed**	**Other (if exists) speed**
All road classes: <u>Definition:</u> It is a technical and economic parameter to which the limit values of the road elements, the proportions between them and the range of road equipment are assigned; the design speed is not related to the speed limit <u>Assumed</u> <u>factors affecting selection:</u> road classification, topographic, environmental and economic considerations traffic conditions, type of area (rural, urban), cross-section Range of design speed, Vd = 30-120 km/h.	**All road classes:** <u>Definition:</u> It is a parameter reflecting the speed of passenger cars in free flow traffic on the road, used to determine the value of road elements which are assumed because of road safety. Road parameters should be adapted to this speed; <u>Calculated or assumed:</u> • Calculated for rural road single roadway • Assumed for dual roadways and urban roads <u>Factors affecting calculation:</u> location (rural, urban), cross-section (occurrence of curb, 2+1), design speed **Rural roads (G, GP, S, A) 1 roadway:** CCR (curvature change rate), type of shoulder (paved, unpaved) **Rural roads (G, GP, S, A) 2 roadways:** design speed • Vop = Vd + 10 km/h for Vd ≥ 100 km/h, • Vop = Vd + 20 km/h for Vd ≤ 80 km/h (2+1 is included) **Urban roads (G, GP, S, A):** design speed, curb occurrence: • Vop = Vd + 20 km/h for no curb,	**All road classes:** Speed limit: <u>Definition:</u> Speed limits are posted if the safety speed is less than the design speed or operating speed, based on the regulation of traffic law <u>Calculated:</u> Calculated according to parameters of the road (to drive safely on wet pavement) <u>factors affecting selection/calculation:</u> Road geometric features and visibility constraints <u>Speed limit range:</u> • rural, motorway, A: 140 km/h • rural, express road, S: 100 – 120 km/h • rural, main road with fast traffic, GP: 90 – 100 km/h • rural, main road, G: 90 – 100 km/h • rural, collector, Z: 90 km/h • rural, local, L: 90 km/h • rural, residential, D: 90 km/h • urban, express road, S: 100 km/h • urban, main road with fast traffic, GP: 70 km/h

<table>
<tr><td></td><td>Vop = Vd + 10 km/h for road with curb</td><td>urban, main road, G: 50 km/h
urban, collector, Z: 50 km/h
urban, local, L: 50 km/h
urban, residential, D: 50 km/h</td></tr>
<tr><td colspan="3">Portugal</td></tr>
<tr><td>All road classes:

<u>Definition:</u>
Speed defined in the project planning that conditions the geometrical characteristics of the road. It´s used to calculate:
coordination plant profile
economic studies
The minimum horizontal curve radius;
The maximum road grade;
The cross-section type
Traffic
<u>Factors affecting selection:</u>

road classes / road environment</td><td>All road classes:

<u>Definition:</u>
V85 – traffic speed (speed value not exceeded by the 85% of the vehicles).
It´s used to calculate:
The sight distance;
The minimum vertical curve radius (parabolic transition)
<u>Factors:</u>

Calculated according to a cumulative speed distribution graph for one road section</td><td>-

<u>Speed limit range:</u>
Rural/urban, primary: 120 km/h
Rural/urban, principal: 100 km/h
Rural/urban, secondary: 90 km/h</td></tr>
<tr><td colspan="3">Spain</td></tr>
<tr><td>Design speed</td><td>Operating speed</td><td>Other (if exists) speed</td></tr>
<tr><td>All road classes:

Is called “Project speed”:
<u>Definition:</u>
Speed for which the geometric characteristics of the layout of a section of a road ensuring conditions of comfort and safety are defined.

<u>Design speed range:</u>
Max value: 140 km/h (motorways); 100 km/h (other roads)</td><td>All road classes:

V85: speed value not exceeded by the 85% of isolated vehicles travelling along each road element.</td><td>All road classes:

“Specific speed of a curve”:
<u>Definition:</u> Speed that a vehicle may develop along a circular curve considered in isolation, under conditions of comfort and safety, with wet pavement and tires in good condition. Weather, traffic and legal</td></tr>
</table>

• Min value: 80 km/h (motorways); 40 km/h (other roads).		conditions impose no limitations on that speed. Maximum value: Vp **"Routing speed":** Definition: Weighted harmonic mean of the velocities of route of homogeneous sub-sections. Speed limit range: • Rural, major motorway: 140 km/h • Rural/suburban, ordinary motorway: 140 km/h • Urban/suburban, multilane road: 100 km/h • Rural/suburban/urban, conventional road: 100 km/h
USA		
Speed used to determine the various geometric design features of the roadway. In selection of design speed safety, mobility and efficiency within the constraints of environmental quality, economics, aesthetics, social or political impacts should be considered. Factors: topography, the adjacent land use, modal mix, roadway functional classification. Range of design speed: 20-140 km/h.	The speed at which drivers are observed operating their vehicles during free-flow conditions. The 85^{th} percentile of the distribution of observed speeds is the most frequently used measure. Factors which have direct impact on operating speed: horizontal curve radius, grade, access, median, parking, VRU activity, traffic volume	Running speed – the speed at which an individual vehicle travels over a highway section. The running speed is calculated based on length of the road section divided by the time for a typical vehicle to travel through the section.

Table B.4 (chapter 4.4 – Design Criteria)

Road classes and classification	Access	Traffic characteristics	Traffic performance	Environment	Pedestrian, Cyclists	People with disabilities	Cost	Safety
Austria								
motorway expressway road for motor vehicles	Yes, controlled	According to situations and Road Traffic Act and Federal Road Act	No LOS explicit required	Noise, emissions, vibrations, light and shade, land consumption, water, Pollution, Landscaping, Flora, Fauna, Ecosystem, protected human, material and cultural goods	Not allowed	not applicable	not applicable	Key Performance Requirements Additional RSA and RSI are required
major roads regional roads local road	Yes, uncontrolled				Pedestrian: allowed only on local roads. Cyclists: allowed	Requirements exists		Key Performance Requirements
Australia								
primary, principal, high speed	Yes, controlled	According to situations	For rural roads LOS B (HCM) (primary and principal roads) LOS C (HCM) (others rural roads) For urban roads - capacity	noise, emissions, water pollution, landscaping, flora, fauna, ecosystem, archaeological factors	Primary, principal: Not allowed Others rural roads: in roadway	No architectural barrier	not applicable	Key Performance Requirements
Secondary Collector	Yes, uncontrolled							

local					Others urban roads on walkways			

Belgium								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
Rural / Urban	No access control. Access defined in traffic laws.	not applicable	AADT<9000	not applicable	Yes	Yes, no architectural barrier	not applicable	Key Performance Requirements
Rural / Urban / Arterial			AADT<9000		Yes	Yes, no architectural barrier		
Arterial			9000<AADT<18000		Yes	Yes, no architectural barrier		
2x2 Motorway, Highway	No traffic signals, slow traffic allowed if stated, (for highway , no slow traffic)		18000<AADT<40000		No	No		

2x3 Highway	No traffic signals, no slow traffic		AADT>40000		No	No		
Canada								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
Freeway, national,	Yes, controlled, Uninterrupted flow	not applicable	There is no specific traffic criterion depending on the type of road. Traffic performance interventions are primarily determined to reduce road safety risks	Noise in some cases along freeways, green gas emissions in general, water pollution, flora and fauna protection, ecosystem protection, archeological protection	Not allowed	not applicable		Key Performance Requirements no specific criterion for road safety other than: the road safety is considered throughout the road network,
National, regional	Yes, partially controlled, Uninterrupted flow except at traffic signals				Allowed on shoulder or sidewalks			

collector, local	Yes, uncontrolled, Flow interrupted			(all of these criteria are considered in general environmental laws)	Allowed on shoulder or sidewalks (collector) Share roadway (local)			problematic sites are analysed and corrected based the risks of fatal accidents and serious injuries
Chile								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
Highway, autoroute,	Yes, controlled,	According to situations	not applicable	noise, emissions, water pollution, landscaping, flora, fauna, ecosystem, archeological factors	Not Allowed	No architectural barrier. Accessibility Law.	not applicable	not applicable
collector, local, development	Yes, uncontrolled				Allowed			
Rural: Motorway Class 1	Yes, controlled,	According to situations	Traffic characteristics and capacity of interference control	Terrain, geologic, hydrologic, meteorological conditions,	Not Allowed	No architectural barrier	not applicable	Key Performance Requirements

Class 2 Class 3 Class 4 (urban)	Yes, uncontrolled			environmental sensitive areas. Immovable culture relics, water sources and natural reserves	Allowed in roadways			no specific criterion for road safety
Czechia								
Motorway, Class 1,	Yes, controlled,	according to situations and Road Traffic Act	Required LOS C (rural roads) LOS D (Class 1, urban roads)	According to situations: Noise, emissions, vibrations, light and shade, land consumption, water, pollution, landscape, flora, fauna, Ecosystem, protected human, material and cultural goods,...	Not allowed	not applicable	not applicable	Key Performance Requirements, additionally Road Safety Inspections (RSI) for existing roads and Road Safety Audits (RSA) for road planning
Class 2 Class 3 Class 4	Yes, uncontrolled	according to situations	Required LOS D (Class 2 – rural roads) LOS E (Class 3 – rural roads) Required Capacity (Class 2 and Class 3 – urban roads)		Allowed in roadway (rural roads and Class 4) or walkway (urban road, excl. Class 4)	Requirements exists for urban roads		Key Performance Requirements,
France								

Road classes and classification	Access	Traffic characteristics	Traffic performance	Environment	Pedestrian, Cyclists	People with disabilities	Cost	Safety
Type 1	Yes, controlled	Depending on situations	The traffic on the busiest lane must not exceed 1800 pcu/h (at the 30th busiest hour In a year)	According to situations: Noise, emissions, vibrations, land consumption, water, pollution, landscaping, flora, fauna, ecosystem, protected human, material and cultural goods,…	Not allowed	not applicable	not applicable	Key Performance Requirements, Safety audits at design, pre-opening, operation stage. Road Safety Inspections (RSI) every 3 years. SURE method: stake analysis on the whole network every 3 years. Then, diagnostic study (based on detailed analysis of accident circumstances and accident factors related to the infrastructure)
Type 2: 2+1 road	Yes, controlled		Adequate for moderate traffic, no higher than 15000 veh/d. Can be used with a traffic level between 15000 and 20000 veh/day, but with a lower level of service		usually not allowed			
Type 3	Yes, uncontrolled		2x2: Adequate for traffic level around 15000 veh/d. Can be used with traffic level non higher than 20000 veh/d, with a lower level of service 2x1: Well suited to traffic level around 10000 veh/d. Can be used with traffic level non higher than		Allowed or not allowed, depending on the status of the road	not applicable		

			15000 veh/d, with a lower level of service					and action plan on the routes on the network with the best safety potential/km/thematic approaches such as obstacles, rumble strips,…
Type 4			2 lanes: Adequate for traffic level non higher than 10000 veh/d. Can also be used with a higher traffic level 3 lanes: Adequate for traffic level around 15000 veh/d		Usually allowed Pedestrian: on shoulders Cyclist: paved shoulders are recommended in order to encourage the circulation of cyclists out of the lanes. (When the traffic of vehicles is higher than 45000/d, separate facilities for cyclists are recommended)	pedestrian accessibility regulations must be complied with at public transport stops and pedestrian crossings		
Type 5			The volume of traffic can reach high levels (over 80,000 veh/d for 2 x 2 lanes), which can generate recurrent congestion		Not allowed	not applicable		
Type 6			They generally receive a very high volume of traffic as soon as they are put		Pedestrians and cyclists are allowed and must be separated from motorized	pedestrian accessibility regulations must be		

			into service (over 20.000 veh/day). This traffic volume can reach much higher levels (over 30.000 veh/day), which can generate recurrent congestion.		modes (e.g. bicycle path + pavement) Crossings for active modes are grade separated	complied with at public transport stops and pedestrian crossings		
Type 7					Pedestrians and cyclists are allowed and must be separated from motorized modes (e.g. bicycle path + pavement) Crossings for active modes are placed at intersection			not applicable
Type 8			They generally receive a very high volume of traffic as soon as they are put into service (more than 15000 veh/day). This volume of traffic can reach higher levels (but not levels (but not exceeding 30000 veh/d), which can generate recurrent congestion					
Germany								

Road classes and classification	Access	Traffic characteristics	Traffic performance	Environment	Pedestrian, Cyclists	People with disabilities	Cost	Safety
Motorway	Yes, controlled	Yes	Yes, travel speed	Yes, qualitative description of key requirements	Not allowed	not applicable	Yes	Yes, qualitative description of key requirements
Rural roads	Yes, requirements	Yes, for all road legal vehicles	Yes, travel speed	Yes, qualitative description of key requirements	Yes	Yes	Yes	Yes, qualitative description of key requirements
Urban roads	Yes, requirements	Yes	Yes, partially, for some of streets	YES, qualitative description of key requirements	Yes	Yes	Yes	Yes, qualitative description of key requirements
Italy								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
primary principal	Yes, controlled			noise, emissions, water pollution,		No architectural barrier	not applicable	

high speed		according to situations	Primary and principal rural roads: LOS B (acc. HCM) Others rural roads: LOS C (acc. HCM) Urban roads: capacity	landscaping, flora, fauna, ecosystem, archeological factors	Primary and principal roads: not allowed Others rural roads: allowed on roadway Others urban roads: allowed on walkway			Key Performance Requirement
Secondary collector local	Yes, uncontrolled							
Japan								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
primary (1-1) secondary (1-2) third (1-3,4) regiona	Yes, controlled	according to situations	not applicable	Planting Strip (if necessary)	Not allowed (pedestrian bridge, if necessary)	No architectural barrier	not applicable	Key Performance Requirement not applicable

l (3-1,2) local (3-3,4,5)	Yes, uncontrolled				Allowed in roadway			
primary (2-1,2), collecto	Yes, controlled				Not allowed (pedestrian bridge, if necessary)	No architectural barrier		
r (4-1), collector (4-2,3)	Yes, uncontrolled				Pedestrian: On walkways Cyclist: on roadway			
Mexico								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
Rural – National (motorways)	controlled	According to situations	LOS B – acc. HCM	Noise, emissions, water pollution, landscape, flora, fauna, ecosystem,	Not allowed	not applicable	not applicable	Key Performance Requirement
Rural - Regional	Partial controlled		LOS B – acc. HCM					

Rural - Local	Uncontrolled		LOS C – acc. HCM	archaeological factors				
Poland								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
A, motorway	controlled	Undefined	undefined	Very general statement. Protection of: Noise;	Not allowed	No architectural barrier	No	

S, Expressway		Design vehicle is not defined		vibration; Emissions; waters and surface geological formations; nature, landscape, agricultural and forest lands; cultural environment	Specified – separated 10m from edge				Key Performance Requirement Road Safety Inspections (RSI) for national roads and Road Safety Audits (RSA) for selected road planning
GP, main road with fast traffic	Partially controlled				Specified – separated 5m from edge				
G, main road					Specified – separated 3,5m from edge (excl. cyclists on roadway in urban environment)				
Z, collector					Specified: Pedestrian: – walkway cyclist at the curb or on roadway (urban roads)				
L, local	uncontrolled				Specified				

D, residential					pedestrian: on roadway, shoulder (rural roads) walkway Cyclist: on roadway			
Portugal								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**
primary principal	Yes, controlled	According to situations	LOS B – acc. HCM	noise, emissions, water pollution, landscaping, flora, fauna, ecosystem, archeological factors	Not allowed	Existing requirements, only for collector and local urban roads	not applicable	Key Performance Requirements Additional Road Safety Inspections (RSI) for existing roads and Road Safety Audits (RSA) for road planning
secondary collector local	Yes, uncontrolled		Secondary LOS C – acc. HCM Other roads No LOS explicit required		Allowed in roadway (rural roads), on walkway (urban roads)			
Spain								
Road classes and classification	**Access**	**Traffic characteristics**	**Traffic performance**	**Environment**	**Pedestrian, Cyclists**	**People with disabilities**	**Cost**	**Safety**

Major motorway	Limited access, at grade-separated intersections	According to situations	LOS C or D required, It depends on speed: LOS C - ≥120 km/h - LOS D - 80-110 km/h	Natural factors: flora, fauna, air, noise, water, soil. Socioeconomic factors: human productive environment, human health, heritage, cattle trails.	Not allowed	not applicable	No	Key Performance Requirements Independent safety audit required
Ordinary motorway	Limited access, at grade-separated intersections				Not allowed		Yes Terrain/ max M€/km Flat: 3,5 Wavy: 5,5 Bumpy: 8,5	
Multilane road	Partially limited		LOS D or E required, It depends on speed: LOS D – 80-100 km/h - LOS E – 40-70 km/h		Allowed in roadway		No	Key Performance Requirements Safety audit required
Conventional road	non-limited access				Allowed in roadway		Yes Terrain/ max M€/km Flat: 2,4 Wavy: 4,4 Bumpy: 6,4	

Table B.5 (chapter 4.5 – Driving Performance and Human Factors)

Austria, Belgium, Chile, Mexico, Portugal

Decision-making sight distance (DMSD)	Control of the field of view quality	User's expectation consideration
(Not considered)		
Australia		
[motorway/expressway] Obligatory , [major/regional/local]Recommended		
[All classes of roads] Based on design speed and location (*rural 10,5 sec; urban 14,0 sec;, suburban12,5 sec*) *Anticipated stopping sight distance where the perception reaction time is increase (rural 3,0 sec; urban 9,0 sec)*	[All classes of roads]	[All classes of roads] general consideration for design without specifying particular values
China		
[All classes of roads] An overtaking segment, on which overtaking sight distance is provided, should allow a 3-minute traveling distance on a class-2 arterial highway		
Czechia		
[Motorway, 1st class] Obligatory [Other classes] Considered Braking stop sight distance	[Motorway, 1st class] Obligatory [Other classes] Recommended	[Motorway,1st class of roads] Obligatory [Other road classes] Included: max. and min length of straights and circular curves, min. horizontal radius after a long straight, coordination of the radius values of successive curves, transition zones between rural and urban areas not included: excessive cognitive workload
France		

Decision-making sight distance (DMSD)	Control of the field of view quality	User's expectation consideration
1,8 s +/- 10%, depending on the required level of performance	Road legibility is one of the seven fundamental criteria for assessing infrastructure safety Optical illusions and more globally, ambiguous configuration that can lead to a late reaction of the driver, a misunderstanding of the configuration and finally an operational error must be avoided. These aspects are assessed through road safety controls, road safety audits and also road safety inspections and road safety management	Rules for linking the components of the horizontal alignment are defined. This includes: -minimum curve radius after a more or less long straight section - progressivity rules between curves with moderate radius Transition zones between rural and urban areas to encourage drivers to adapt their behaviour. More generally, strong transitions must be ensured when a change in road type or road environment requires an adaptation of the driver's behaviour
Germany		
indirectly included in the R1 level of RDS, the recommendations of lower levels include studies clearly focused on design in terms of the human factor, e.g. designing infrastructure as an element of human-friendly public space		
Italy		
[All classes] Mainly not considered. The requirement for *changing lane in correspondence of an off-ramp considers* an anticipation + advance warning time of *4,5 sec in addition to the decision and maneuver time of 4,0 sec.*	(Not considered)	[All classes] Included: max, min length of straights, circular curves and clothoids, min radius after a long straight, coordination of the radius values of successive curves, planimetric-altimetric coordination. not included: transition zones between rural and urban areas, excessive cognitive workload

Japan		
Decision-making sight distance (DMSD)	**Control of the field of view quality**	**User's expectation consideration**
[All road classes] Considered Braking stop sight distance *Decision Making time 2.5s*	[All road classes] Change the shape of the guard fence and the type of tree planting(if necessary)	(Not considered)
Poland		
[Rural roads] Considered for *2+1 roads* (DMSD requirements for additional overtaking lane, in the beginning and in the end of changeover) Factors: operating speed: DMSD *300m (110 km/h), 250m (100 km/h), 200m (≤90 km/h)* Requirements for point of observation (1m) and aim of observation (0,6m-beginning or 0,3m-end of changeover)	[Rural roads] Requirements: 1. the field of view of the road is continuous, as well as smoothness and no visual illusions of the deformation of its edges on the *road* *Length min.:* *- 300m for Vd (design speed)=120 km/h,* *- 250 m for Vd(design speed)=100 km/h* *- 200 m for Vd(design speed)=80 km/h;*	[Rural roads] max, min length of straights, circular curves and clothoid parameters, spatial coordination.
Spain		
[All categories] *10 s*	[All categories] No conditions for elements external to the road. For rural roads, advertising visible from road public domain is	[All categories] *Limitations to straight (between curves) length:* *Lmin,s = 5 s , Lmin,o = 10 s , Lmax= 60 s* Minimum radius after a straight and clothoids:

	forbidden (§88, RD. 1812/1994, General Regulation of Roads).	Vp in group 1: Motorways A-140, A-130 700 in group 2: Motorways A-120, A-110, A-100, A-90, A-80, C-100 Vp in group 3: Conventional roads C-90, C-80, C-70, C-60, C-50 y C-40 *Perception and reaction time: 2 s*

Table B.6-1 (chapter 4.6 – Design of Road Infrastructure)

Austria			
Stopping and sight distances in linear elements	**Stopping and sight distances in junctions, intersections and roundabouts**	**Design homogeneity in linear elements**	**Design homogeneity in junctions, intersections and roundabouts**
SIGHT DISTANCE Factors: 1) planning speed 2) longitudinal inclination 3) pre-braking time & braking delay (Table 10, RVS 03.03.23) OVERTAKING SIGHT DISTANCE/VISIBILITY RANGE. Factor: planning speed (Table 11, RVS 03-03-23)	SIGHT DISTANCE IN JUNCTIONS: Factors:: 1) planning speed 2) longitudinal inclination 3) pre-braking time & braking delay (Table 10, RVS 03.03.23). Specifications for approach view (visibility triangles). ROUNDABOUTS: viewing area must be kept free of obstructions.	-----	-----
Australia			
STOPPPING SIGHT DISTANCE Factors: 1) initial speed, 2) perception-reaction time, 3) long friction,4) rolling resistance 5) aerodynamic drag, 6) longitudinal **slope** OVERTAKING SIGHT DISTANCE & CL DISTANCE:: function of travelling speed	JUNCTIONS: SSD AT GRADE INTERSECTIONS: Visibility triangles per priority, stop or signal controlled T or X intersections ROUNDABOUTS: Visibility of ¼ of the ring lane	-----	-----
Belgium			
SIGHT DISTANCE Minimum value stopping distance or passing distance. STOPPING DISTANCE Factors: 1) speed 2) slope 3)	-----	-----	-----

camber 4) turning radius 5) perception and reaction time (1s) OVERTAKING DISTANCE: D(m)=4*v (km/h)			
Canada			
Stopping and sight distances in linear elements	**Stopping and sight distances in junctions, intersections and roundabouts**	**Design homogeneity in linear elements**	**Design homogeneity in junctions, intersections and roundabouts**
STOPPING SIGHT DISTANCE Factors: 1) initial speed 2) perception-reaction time (2,5s) 3) longitudinal friction or deceleration rate 4) longitudinal gradient OVERTAKING SIGHT DISTANCE Factor: travelling speed DECISION-MAKING SIGHT DISTANCE Factors: initial speed (freeways)	STOPPING SIGHT DISTANCE AND DECISION-MAKING SIGHT DISTANCE IN INTERSECTIONS: on approaches VISIBILITY TRIANGLES. Factors: 1) gap acceptance 2) type of vehicle STOPPING SIGHT DISTANCE IN ROUNDABOUTS: 1) pedestrian passage considered 2) gap of 4,5s at the yield line on the circulatory roadway 3) central island visibility on approach	Analysis of a problematic section entails homogeneity of the operating speed (difference betw. consecutive geometric elements > 15 km/h).	INTERSECTIONS: Manoeuvring sight distance from approaches and sight visibility triangle based on gap acceptance and the type of vehicle. Justification criteria for right and left turn lane. ROUNDABOUTS: Central island visibility on approach.
Chile			
STOPPING SIGHT DISTANCE Factors: 1) initial speed 2) perception-reaction time 3) long friction 4) rolling resistance 5) aerodynamic drag 6) longitudinal gradient OVERTAKING SIGHT DISTANCE & CL DISTANCE Factor: travelling speed	-----	-----	-----
China			

STOPPING SIGHT DISTANCE Factor: design speed	APPROACH SIGHT DISTANCE = STOPPING SIGHT DISTANCE IN AT GRADE INTERSECTIONS DECISION SIGHT DISTANCE =1,25·STOPPING SIGHT DISTANCE IN GRADE-SEPARATED JUNCTIONS	No	-----
Czechia			
Stopping and sight distances in linear elements	**Stopping and sight distances in junctions, intersections and roundabouts**	**Design homogeneity in linear elements**	**Design homogeneity in junctions, intersections and roundabouts**
STOPPING SIGHT DISTANCE Factors: 1) design speed 2) slope OVERTAKING SIGHT DISTANCE Factor: design speed CROSSING DISTANCE (distance between neighbouring intersections) Factor: road category	INTERCHANGES: Additional lane on ramps JUNCTIONS & ROUNDABOUTS: Clearance zone (visibility triangles) according to SSD Factor: design speed	-----	-----
Germany			
STOPPING SIGHT DISTANCE Factors: 1) RAA RASt Speed (by defect 130 km/h) 2) RAA RASt Longitudinal gradient 3) RAL Design class 4) RAL Longitudinal slope 5) RASt reaction time 6) height of the eye (Height of the point of view: 1,0 m, 2,0 m (here it is different from RAL); height of target over the pavement: 1,0 m) OVERTAKING SIGHT DISTANCE Factors 1) RAL Design class 2) RAL longitudinal slope. Minimum 600 m (heavy vehicles), 300 m (slower vehicles)	STOPPING SIGHT DISTANCE AT INTERSECTION Factors 1) RAL Road class 2) speed limit providing field of view (triangular): 1. approaching to the intersection on curve entry 2) approaching to the intersection 3. at least from stopping RASt at intersection visibility requirements must be verified for stopping: for approaching; at crossings. FIELD OF VIEW AT INTERSECTION RAL	Yes - the ratio between the radii of the curves and the relationship between the radius and the straight section on the approach, determine the	-----

ORIENTED VISIBILITY ≈1,3 SSD in a significant part of the section		recommended ranges of the curves radii depending on the design class.	
Italy			
Stopping and sight distances in linear elements	**Stopping and sight distances in junctions, intersections and roundabouts**	**Design homogeneity in linear elements**	**Design homogeneity in junctions, intersections and roundabouts**
STOPPING SIGHT DISTANCE Factors: 1) initial speed 2) perception and reaction time 3) friction coefficient 4) rolling resistance 5) aerodynamic drag 6) longitudinal gradient. OVERTAKING SIGHT DISTANCE & CL DISTANCE Factor: 1) travelling speed	STOPPING SIGHT DISTANCE IN JUNCTIONS; VISIBILITY TRIANGLES IN AT GRADE INTERSECTIONS Factors: 1) priority 2) type of intersection (T or X) VISIBILITY IN ROUNDABOUTS ¼ of the ring lane	1) Minimum curvature radius following a long straight. 2) Maximum speed difference between consecutive road elements.	No
Japan			
Factor: design speed. 120 km/h - 210 m; 100 km/h - 160 m; 80 km/h -110 m; 20 km/h - 20 m. OVERTAKING DISTANCE §19. Two-lane roads will feature sufficient sections of oncoming highway visible to the driver for overtaking.	-----	-----	-----

Mexico			
STOPPING SIGHT DISTANCE Factors 1) design speed 2) perception-reaction time (2,5 s) 3) longitudinal friction 4) longitudinal grade OVERTAKING SIGHT DISTANCE Factors 1) design speed DECISION SIGHT DISTANCE Factors 1) design speed 2) perception-reaction time (bigger in secondary roads) 3) longitudinal friction 4) longitudinal grade. CROSSING DISTANCE (US) Distance for vehicles and pedestrians that should be kept as short as practical to reduce exposure to conflicting movements in an intersection (AASHTO GDHS 4ed.)	STOPPING SIGHT DISTANCE IN JUNCTIONS; VISIBILITY TRIANGLES IN AT GRADE INTERSECTIONS Factors: 1) priority 2) type of intersection (T or X)	No	No
Poland			
Stopping and sight distances in linear elements	**Stopping and sight distances in junctions, intersections and roundabouts**	**Design homogeneity in linear elements**	**Design homogeneity in junctions, intersections and roundabouts**
STOPPING SIGHT DISTANCE Factors: 1) operating or design speed 2) longitudinal slope 3) height of point of view:1,0m 4) height of target over the pavement depends on speed>100 km/h-0,45 m; 100-81 km/h - 0,30m; 80-61 km/h - 0,15 m; ≤60 km/h - 0,0 m.	Providing field of view (triangular), at the intersection: 1. approaching to the intersection on curve entry, factors: - Speed for minor road (operating or design speed (Z, L, D roads)) 2. approaching to the intersection from 10m (urban and rural collector and local roads) or 20m (GP and G	Maximum speed difference between design speed and operating speed (road classes G, GP,S, A).	-----

DECISION-MAKING SIGHT DISTANCE & OVERTAKING SIGHT DISTANCE Factor: operating speed	rural roads), factors - Speed for major road (operating or design speed (Z, L, D roads)) 3. at least from stopping (3m)), - Speed for major road (operating or design speed (Z, L, D roads))		
Portugal			
Stopping and sight distances in linear elements	**Stopping and sight distances in junctions, intersections and roundabouts**	**Design homogeneity in linear elements**	**Design homogeneity in junctions, intersections and roundabouts**
STOPPING SIGHT DISTANCE Factors: 1) perception-reaction time 2) travelling speed 3) coefficient of friction 4) road grade OVERTAKING SIGHT DISTANCE & DECISION-MAKING SIGHT DISTANCE Factor: travelling speed.	STOPPING SIGHT DISTANCE IN JUNCTIONS VISIBILITY TRIANGLES IN INTERSECTIONS Factors: 1) priority 2) type of intersection (T or X) VISIBILITY IN ROUNDABOUTS ¼ of the ring lane	-----	-----
Spain			
STOPPING SIGHT DISTANCE §3.2.1 Factors: 1) Initial speed 2) perception and reaction time (2s) 3) friction coefficient 4) rolling resistance 5) longitudinal gradient OVERTAKING SIGHT DISTANCE §3.2.3 & DECISION-MAKING DISTANCE §3.2.5 Factor: travelling speed CROSSING DISTANCE §3.2.7 Factor: time required to	VISIBILITY IN INTERCHANGES §4.7.4 (Knots guide) 10s in exits VISIBILITY IN INTERSECTIONS §4.7.2: VISIBILITY TRIANGLES DEPENDING ON: vehicle type, turning sense R/L , destination road specific speed. VISIBILITY IN ROUNDABOUTS §4.7.3. Factors: position	§4.6 3.1-IC norm: 10 km/h <$\|V_{85}-Vp\|$ ≤20 km/h 10 km/h <$\|(V_{85})-(V_{85})_{+1}\|$≤20 km/h.	Homogeneity. consistency and uniformity appear as basic principles, but are hardly developed §10.2 Norma 3.1-IC; §3.1.2 & §9.2.6 OC 32/2012

perform the crossing manoeuvre. This time is function of the driver's perception and reaction time, vehicle length, total width of crossed lanes and vehicle acceleration. This acceleration depends on the vehicle type.	(approach, insertion, pedestrian crossing), view orientation (R/L). §4.7.3.1 A ring sector 40 m long must be visible.	Table 4.7. sets radii proportions of consecutive curves without intermediate straight or curves separated by a straight of limited length.	

Table B.6-2 (chapter 4.6 – Design of Road Infrastructure)

Austria				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**
Elements: straight, curve, clothoid Factors: 1) Harmonious lines 2) change in the project planning speed of two successive elements 3) radius 4) radius sequence 5) transition curve 6) radius ratio 7) change in curvature 8) twisting of the road 9) lateral acceleration, 10) visibility 11)	JUNCTIONS: Preferably stretched alignment in the node area Factors to be considered: project planning speed, visibility, widening of the runway, tractrix curves, alignment	Elements: reference line, gradient, vertical curvature Factors to be considered: 1) road type 2) heavy traffic share 3) maximum longitudinal inclination 4) cross fall 5) widening of the runway 6) visibility 7) project	JUNCTIONS: Factors to be considered: maximum longitudinal inclination, visibility, twisting of the road, If the inclination changes, rounding is to be provided. longitudinal inclination of the higher-level road in the junction area max. 4%	Yes

widening of the runway 12) drainage 13) tractrices curves	ROUNDABOUTS: Diameter from 35 m to 60 m for 3 or 4 armed roundabouts At least 26m, if it is a single-lane roundabout Smaller than 26m, if in urban areas (the center must be trafficable) (RVS 03.05.14)	planning speed 8) drainage 9) twisting of the road	longitudinal inclination of the lower-level road in the junction area max. 6% (in accordance with RVS 03.05.12) ROUNDABOUTS: Cross fall of the circular lane between 1.5 - 4% (usually 2.5% to the outside) Max. Longitudinal inclination of the entrances and exits: 4%	
Australia				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**
Elements: straight, curves, clothoids. Factors: 1) vehicle transversal equilibrium accounting for superelevation and available friction 2) users’ comfort 3) rollover possibility 4) transversal acceleration change rate 5) cinematic vehicle encumbrance MIDBLOCK ROADWAY SECTIONS: Elements: horizontal straights, and	JUNCTIONS: minimum curvature radius according to speed. INTERSECTIONS: ------ ROUNDABOUTS: diameter from 14 to 50 m.	Elements: slope, parabolic curve. Factors to be considered: 1) SSD or OSD 2) users’ comfort 3) vehicle frame distance from pavement. max slope: motorways: 6%, local roads: 10%. MIDBLOCK ROADWAY SECTIONS: Vertical grades and vertical curves (latter designed as parabolas).	JUNCTIONS: longitudinal slope from 5% to 10%. INTERSECTIONS & ROUNDABOUTS: -----	Yes

circular horizontal curves joined by spirals or transition curves with sufficient tightness in horizontal curves. Horizontal curves may feature superelevation or adverse crossfall, depending on speed and radius. The basic principle of horizontal curve design is derived from application of the kinematics equation. Criteria exist for compound curves, broken back and reverse curves.		Crest vertical curves based on appearance criteria, riding comfort and sight distance (latter usually prevails). Sag vertical curves based on appearance, comfort criteria and headlight sight distance (latter where practical). Maximum grades dependent on terrain type. Maximum length of steep grades applies.		
Belgium				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**
Elements: straights, arcs, clothoids , widening (R) Straight sections: to be reduced: + environmental integration, - driving monotony ARCS Factors: 1) speed 2) slope 3) camber 4) friction coefficient	-----	Relation slope- camber- radius - speed. Slow vehicles lane added for high slopes	-----	Yes

Canada				
Elements: tangents, curves, spirals (clothoids). Factors in curves: 1) length 2) SSD/OSD 3) speed 4) radii 5) side friction 6) superelevation. 5) & 6) = f(rural/urban). Rollover for truck on exit ramps.	INTERSECTIONS: Straight alignment on approaches for the through movement. Minimum curvature radius according to speed. AT GRADE INTERSECTION Approach on the secondary road must be 20 m long and straight at the intersection.	Elements: slope, parabolic curve. Factors: 1) SSD/OSD 2) eyes height of users 3) height of object on road. Max slope: motorways 5-7%; primary and secondary 7%; collector and local roads 10%. Speed differential no greater than 15 km/h of heavy truck in ascending slope.	INTERSECTIONS on approaches as flat as possible to see the pavement at the crossing of the roads. Longitudinal slope from 5% to 10% ROUNDABOUT Central island visibility on approach.	Yes, in the case of the combination of a horizontal curve and a vertical curve, the horizontal curve must be longer than the vertical curve.
Chile				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**
Elements: straight, curves, clothoids. Factors to be considered: 1) vehicle transversal equilibrium account for superelevation and available friction 2) users' comfort 3) possible rollover 4) transversal acceleration change rate 5) cinematic encumbrance.	-----	Composing elements: slope, parabolic curve. Factors to be considered: 1) SSD or OSD 2) users' comfort 3) vehicle frame distance from road pavement.	-----	Yes

It shall be direct, continuous, in equilibrium, adaptable and harmonizable to terrain & environment.	-----	It shall be smooth and flowing, with continuous visibility and matching the surrounding environment	-----	Yes
Czechia				
Elements: straight, curves, clothoids. Factors: 1) clearance zone for SSD /OSD 2) min. radius 3) allowed range of cross angle between road and railway (min. 75°, max. 105°) 4) ratio R2/R1 between radii of successive curves <=2 5) ratio between clothoid parameters of successive curves <=1,5 6) widening of road lane (depends on horizontal radius and road lane width) 7) radius sequence, 8) minimal cross slope in the straight part 9) maximal cross slope (its range 6%-8% depends on design speed) 10) min. length of straight part, max. length of strait part (depends on the horizontal radius of a successive curve) Minimal horizontal radius is function of 1) design speed and cross-slope (for safe movement) 2) road	INTERCHANGE: Factors to be considered: 1) traffic volumes on all road legs (arms) 2) design speed 3) visibility 4) shape of terrain. JUNCTION: At least the middle part of intersection preferably situated in plain instead of hillside Allowed range of angle between intersection legs (depends on the intersection type: 75°-105° for 4 leg intersection), ideal angle between intersection legs 90° Factors to be considered: 1) traffic volumes on all road legs (arms) 2) design speed, visibility triangles 3) widening of road lanes 4)	Composing elements: longitudinal slope, cross-slope, parabolic curve. Factors to be considered: 1) road type 2) heavy traffic share 3) minimal vertical convex/concave radii (function of design speed and SSD/OSD) 4) additional climbing lanes 5) min length of parabolic curve, 6) emergency escape ramp . maximal longitudinal slope (its range 3% - 12% depends on road category and kind of terrain) . minimal longitudinal slope 0,5%, . min. length drainage	INTERCHANGES: ------ JUNCTIONS: Factors to be considered: 1) maximum longitudinal slope (recommended max. 3% for intersection space) 2) max. longitudinal slope of arms 4% 3) visibility. ROUNDABOUTS: Max. recommended longitudinal slope of the roundabout space: 6%, Max. cross slope of ring road belt 3,5%, recommended max. total slope of ring road belt 5% max. longitudinal slope of arms 4%, visibility	Yes Minimal and maximal total slope (vector sum of longitudinal and cross slope) 0,5%-14% (recommended 1%-13%), maximal total slope recommended: with increasing longitudinal slope increases horizontal radius, change in curvature,

category 3) longitudinal slope (for sufficient SSD).	min. entry/exit radii. ROUNDABOUT: Diameter from 23 m to 50 m for 3 or 4 armed single-roundabouts (roundabouts with one road lane on the ring road belt). Diameter larger than 50 m can be used only for single-rounds with 5 and more arms or roundabout with 2 or more road lanes on the ring road belt) Diameter less 23m only for mini-roundabout Factors to be considered: 1) traffic volumes on all road legs (arms) 2) visibility angles between neighbouring legs 3) minimal entrance/exit radii 4) minim. width of traversable apron 5) selected kind of roundabout and designed diameter, 6) share of heavy traffic 7) kind of vehicles			twisting of the road, and many other recommendations; Harmonious coordination horizontal and vertical alignment with other important objects (bridges, tunnels, intersections, petrol stations beside the road etc.)

Germany				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**
-----	-----	-----	-----	Yes
Italy				
Elements: Straight, curves, clothoids. Factors: 1) vehicle transversal equilibrium accounting for superelevation and available transversal friction 2) users' comfort 3) rollover possibility 4) transversal acceleration change rate, cinematic vehicle encumbrance	JUNCTIONS: Min curvature radius according to speed . AT GRADE INTERSECTIONS: --------- . ROUNDABOUTS: Diameter from 14 m to 50 m	Elements: slope, parabolic curve. Factors: 1) SSD or OSD, users' comfort 2) vehicle frame distance from road pavement. max slope for motorways: 6%, max for local roads 10%	JUNCTIONS: Long. Slope from 5% to 10% according to road classes AT GRADE INTERSECTIONS: Max slope of the incoming roads. ROUNDABOUTS: ------	Yes
Japan				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**
-----	-----	-----	----	Yes
Mexico				

Elements: Straight, curves, clothoids. Factors to be considered: 1) vehicle transversal equilibrium accounting for superelevation and available friction 2) users' comfort, rollover possibility 3) transversal acceleration change rate 4) cinematic vehicle encumbrance		Composing elements: slope, parabolic curve. Factors to be considered: 1) SSD or OSD 2) drainage 3) users' comfort and landscape. Max slope for motorways: 6%, max for regional roads: 7% and local roads: 12%.	-----	Yes
Poland				
Elements: Straight, curves, transition curves (clothoids). Factors: 1) vehicle transversal equilibrium accounting for superelevation and available transversal friction 2) users' comfort, rollover possibility 3) transversal acceleration change rate, water runoff conditions (oblique slope) 4) deflection angle for clothoids.	INTERCHANGES: Assumed based on design speed --> min value of radius, clothoid parameter, and superelevation. INTERSECTIONS AND ROUNDABOUTS: Angle of legs (right angle ±30 deg.) External diameter not limited FOR ALL: factors the same as for linear elements	Composing elements: longitudinal slope, curves (sag and crest). Factors to be considered: SSD or OSD, users' comfort, lighting conditions, longitudinal slope: min. 0% (urban) and 0,3% (rural): max 4% (motorway Vd*(design speed)*=120 km/h), max 12% (Vd*(design speed)*=120 km/h)	INTERCHANGES: Assumed based on design speed --> min value of radius (sag, crest), min. clothoid parameter; max.: superelevation, slope; entry or exit ramps; curve or straight section on road plan INTERSECTIONS AND ROUNDABOUTS: Max. longitudinal slope Major road 6% (rural) and 4% (urban) Minor road 3% for 20m from the edge of	Yes. Requirements: 1) minimum length of smooth and continuous field of view: 300m v=120km/h; 250m v=100 km/h; 200m v=80 km/h. 2) after a long straight element at road plan,

			intersection FOR ALL: factors the same as for linear elements	max. superelevation 4%v (urban) and 5% (rural)
Portugal				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**
Elements: Straight sections, clothoids (transition), circular curves. Factors: 1) minimum and maximum extension of straight sections 2) minimum normal radius of circular curves 3) minimum extension of circular curves 4) minimum clothoids parameter 5) minimum radius without superelevation	JUNCTIONS: Min curvature radius according to speed. INTERSECTIONS: -------- . ROUNDABOUTS: Recommended Diameter from 12 m to 40 m	Elements: slopes, parabolic curves. Factors: 1) maximum grade 2) critical extension 3) minimum radius of sag vertical curves 4) minimum normal radius of crest vertical curves 6) minimum normal extension of parabolic curves	JUNCTIONS: Long. Slope from max. 6%. INTERSECTIONS & ROUNDABOUTS: Long. Slope from max. 6%	Yes
Spain				
Horizontal alignment in linear elements	**Horizontal alignment in junctions, intersections and roundabouts**	**Vertical alignment in linear elements**	**Vertical alignment in junctions, intersections and roundabouts**	**Horizontal and vertical alignment coordination**

Elements: straight, circular curves, clothoids. Factors in circular curves radius §4.3.2: specific speed, friction coefficient, superelevation Conditions and factors in clothoids parameter §4.3: A) Limitation of centrifuge acceleration in horizontal plane. Factors: radius, specific speed, centrifuge acceleration variation, entrance and exit radius, entrance and exit superelevation. B) Limitation due to superelevation transition. Factors: transversal slope gradient, entrance and exit superelevation, distance from roadway margin to superelevation turning axis, number of lanes. C) Limitation due to visual perception. Factors: turning angle between straights, circular curve (sic) radius, length.	FACTORS: A FUNCTIONAL AND PHYSICAL: A1) number of legs A2) priorities A3) travel continuity A4) available space A5) terrain relief A6) leg basic lanes A7) leg setting and curvature A8) leg slope A9) available sight distance A10) margin drainage A11) uses of adjacent terrains A12) existence of services A13) landscape requirements A14) existence of adjacent nodes A15) other local roads A16) access policy. B HUMAN B.1) habitual or occasional character of users B2) driving habits B3) design consistency B4) driving expectations B5) perception and reaction time B6) natural tractrices B7) node aspect B8) lighting. C) TRAFFIC C1) vehicle dimensions and features C2) existence of cyclist or pedestrians C3) traffic	Composing elements: slope, parabolic curve. Factors to be considered in slopes §5.2.1: 1) project speed 3) number or roadways 3) type of situation (ordinary/exceptional). Max slope for motorways: 7%, max for local roads 10%. Conditions & factors for parabolic curves §5.3.2:. A) Visibility considerations. Factors: parable parameter and length, obstacle, driver & headlight height, required visibility, slope difference, light angle. . B) Visual perception considerations. Factors: length, project speed, slope differences.	INTERCHANGES & INTERSECTIONS: recommended slope for legs 3%, max. 6%. Not to be placed on convex agreements, much less behind them. ROUNDABOUTS: Legs slope inferior to 2% recommended §4.6.2.4. They should be avoided on convex agreements.	Yes §6 Norma 3.1-IC establishes the following situations to be avoided: -Layout loss -Orientation loss -Dynamic loss -Disproportions IF $V \leq 60$ km/h, then $Kv= 100 \cdot R/p$ or $Kv/R \geq 6$

	composition (special, collective vehicles) C4) intensities, densities, speed and travel times			

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