MODERN STANDARDS FOR HIGHWAY DESIGN

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Аннотация

В статье анализируется система современных норм проектирования автомобильных дорог на основе национальных нормативных документов Республики Узбекистан и международного опыта (AASHTO, Eurocode, немецкие нормы FGSV). Геометрические параметры автомагистрали категории I-а, элементы поперечного профиля и многослойная конструкция дорожной одежды сопоставлены с национальными и зарубежными нормами. Рассмотрены цифровые технологии (BIM, ГИС) и экологические нормы. На примере скоростной автодороги Ташкент–Самарканд показано практическое применение современных норм и даны предложения по гармонизации нормативной базы.

Ключевые слова: автомобильные дороги, нормы проектирования, геометрические параметры, поперечный профиль, дорожная одежда, международные стандарты, BIM-технологии, экологические нормы.

Abstract

The article analyzes the system of modern highway design standards based on the national regulations of the Republic of Uzbekistan and international practice (AASHTO, Eurocode, German FGSV guidelines). The geometric parameters of a category I-a motorway, cross-section elements and multilayer pavement structure are compared across national and foreign standards. Digital technologies (BIM, GIS) and environmental standards are reviewed. The Tashkent–Samarkand expressway illustrates the practical application of modern standards, and proposals for harmonizing the regulatory framework are given.

Keywords: highways, design standards, geometric parameters, cross section, pavement, international standards, BIM technologies, environmental standards.

Introduction

Highways are among the main arteries of a national economy, and the stable operation of the transport system directly affects the development of regional and international trade. Today, design standards are evolving from a simple set of numerical values into an integrated system based on safety, environmental protection, economic efficiency and digital technologies.

Uzbekistan is making large investments in transport infrastructure: the Tashkent–Samarkand and Tashkent–Andijan toll expressways, as well as the Tashkent–Charvak and

Urgench–Khiva routes, are planned on a public-private partnership basis [19]. For such projects to meet the requirements of international financial institutions, they must be designed according to modern standards.

In practice, the national documents — ShNQ 2.05.02-23 “Highways. Design Requirements” and ShNQ 2.05.03-22 “Bridges and Culverts” — are applied in parallel with the foreign AASHTO (USA), Eurocode (Europe) and FGSV (Germany) standards. In this multi-standard environment, ensuring the mutual compatibility of standards has become an important scientific and practical task.

The aim of the article is to analyze the system of modern highway design standards, assess the differences between national and international standards, review digital technologies and environmental requirements, and develop proposals for improving the regulatory framework.

System of Regulatory Documents Used in Design

The documents used in highway design can be divided into four groups (Table 1). The first three groups set the technical parameters, while the fourth regulates who performs the design process, at which stage and in what order.

Table 1. Classification of regulatory documents

Group	Main documents	Status
National standards	ShNQ 2.05.02-23, ShNQ 2.05.03-22, O‘z DSt, MQN, IQN	Mandatory or recommended within the Republic
CIS standards	SNiP 2.05.02-85*, GOST 33240-2015, GOST R 58406-2020	Used as a basis where no national document exists
International and foreign standards	AASHTO “Green Book”, Eurocode 1, 2, FGSV (RAL, RAA), RVS (Austria), ISO	For projects financed by international financial institutions (World Bank, ADB, EBRD)
Organizational and methodological documents	Expert review regulations, ISO 9001, GOST 21.101-2020 (SPDS), survey guidelines	Procedure for design, approval and authorization

Modern standards are being improved in three directions:

5. **Harmonization with international standards.** National documents are being aligned with AASHTO, Eurocode and ISO. This task is set out in Decree No. PF-25 of the President of the Republic of Uzbekistan dated 16 February 2026 as accelerating technical regulation reforms based on advanced international practice.

6. **Transition from prescriptive to performance-based standards.** A traditional standard strictly prescribes thickness, width and radius. The modern approach instead

specifies the result to be achieved — reliability, safety, durability — and leaves the choice of method to the engineer. This opens the way for introducing innovative materials.

7. **Digitalization.** Unified databases such as the "National Classifier of Construction Resources" are being created, and BIM design and electronic expert review are being introduced.

The first direction raises the content of the standards to the international level, the second increases flexibility, and the third speeds up practical application.

Geometric Parameters and Cross-Section

Category I-a covers motorways of international and national importance with a projected traffic volume of more than 14,000 vehicles per day. According to ShNQ 2.05.02-23, the technical category of a road is determined by the design annual average daily traffic and the importance of the road.

For motorways, the design speed is taken as 120–150 km/h. The stopping sight distance must be at least 250–300 m, and the passing sight distance at least 450 m. The minimum horizontal curve radius is 800 m at 120 km/h and 1200 m at 150 km/h; the longitudinal gradient is limited to 30–40 ‰. A comparison of these values with foreign standards is given in Table 2.

Table 2. Comparison of motorway geometric parameters

Parameter	ShNQ 2.05.02-23 (I-a)	AASHTO 2018 (120 km/h, e = 8 %)	RAA 2008 (EKA 1A, Germany)
Design speed, km/h	150	120	130
Minimum horizontal radius, m	1200	594	900
Maximum longitudinal gradient, ‰	30	30–40 (depending on terrain)	40
Traffic lane width, m	3.75	3.60	3.50–3.75

AASHTO allows a smaller radius because it takes into account a high cross slope (up to 8 % in superelevation) and the friction coefficient. The national standard, by contrast, requires a solution with a larger margin, which increases construction volumes but provides a safety reserve.

The cross-section consists of the following elements: the roadbed, the carriageway, the shoulder and its paved part, the median strip, side ditches and embankment slopes (Fig. 1). On a motorway, each traffic lane is 3.75 m wide, the paved part of the shoulder is 0.75–1.0 m, and the median strip is 5.0–6.0 m. The cross slope of the carriageway must be at least 15–20 ‰.

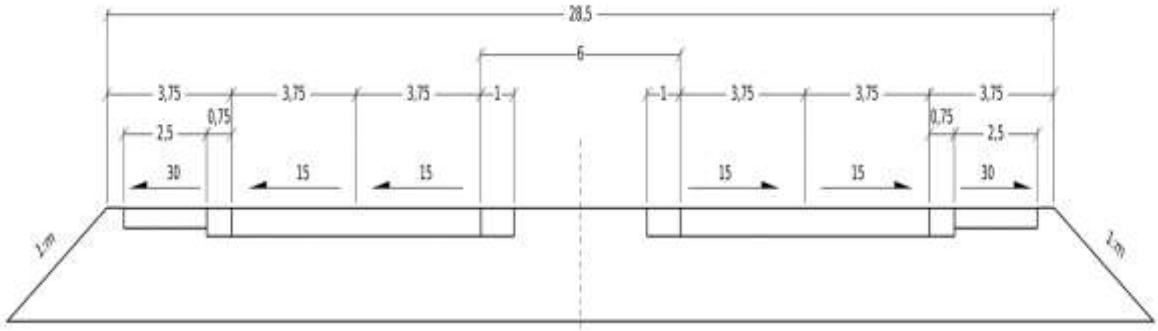


Fig. 1. Cross-section elements of highways

In the German RAL (2012) guidelines, rural roads are classified by **design classes (EKL — Entwurfsklasse)** (Table 3). Each class is assigned a standard cross-section (RQ), which allows drivers to recognize the road type by its appearance (Fig. 2).

Table 3. Design classes according to RAL 2012

Class	Road type	Characteristics
EKL 1	Trunk road	Long-distance heavy traffic; RQ 15.5 cross-section — a third lane is provided alternately for overtaking in each direction
EKL 2	Interregional road	High travel speed; RQ 11.5+ cross-section with overtaking sections
EKL 3	Regional road	Medium to high traffic; RQ 11 cross-section
EKL 4	Local road	Low traffic; RQ 9 cross-section

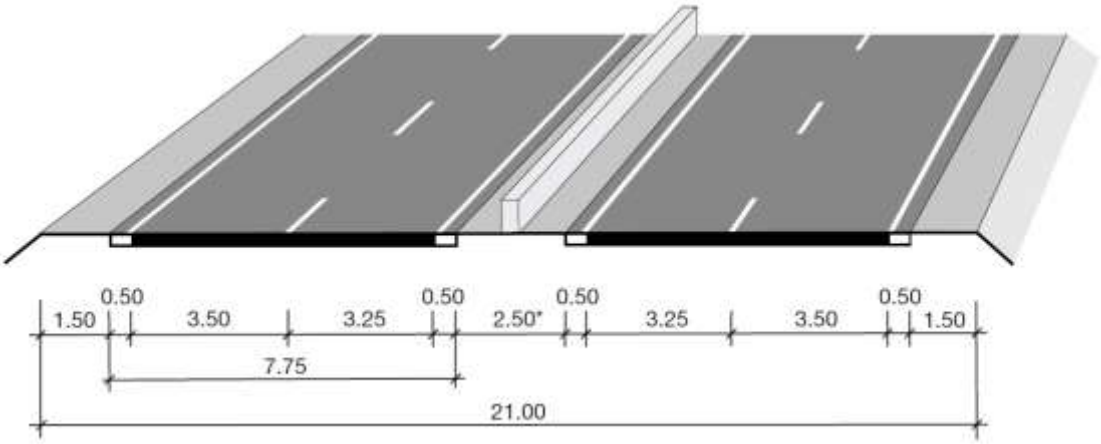


Fig. 2. Cross-section of a road with the RQ 21 standard section

4. Pavement Structure

The pavement receives repeated traffic loads and transmits them to the subgrade, reducing them to a level the subgrade can bear. Growing axle loads and the sharply continental climate have increased the demands on pavements. Therefore, the pavement is designed as a multilayer system in which each layer has its own function.

Basic principles of the standards:

- the structure is checked for strength under the design load and for the design service life;
- layers are arranged so that strength and cost decrease from top to bottom;
- the water-thermal regime, i.e. the effects of moisture and freezing, is considered separately.

Table 4. Typical structure of a five-layer flexible pavement

Layer	Material	Thickness, cm	Function
Surface course	Dense fine-graded asphalt concrete or SMA with PMB binder	4–6	Skid resistance, impermeability, rutting resistance
Binder course	Porous coarse-graded asphalt concrete	6–10	Resisting tensile stresses in bending
Upper base	Crushed stone treated with bitumen or cement	8–15	Load distribution
Lower base	Graded crushed stone	15–25	Load bearing, drainage
Additional (capping) layer	Sand or sand-gravel	20–40	Stopping capillary moisture, frost protection

The total thickness of the structure is 53–96 cm. The asphalt concrete layers act together as a monolithic slab, while the lower layers dissipate stresses to a level the subgrade can bear.

Thickness design is carried out according to the following criteria:

8. Elastic deflection — the overall modulus of the structure must not be lower than the required modulus.

9. Shear resistance — the shear stress in the subgrade and unbound layers must not exceed the allowable value.

10. Tension in bending — no fatigue cracks should form at the bottom of the asphalt concrete layers.

11. Frost resistance and drainage — checking the thickness of the additional layer for frost depth and drainage conditions.

If the thickness is insufficient, the layers are thickened or a stronger material is selected. The optimal solution is the option that meets the requirements at the lowest cost.

Table 5. Innovative solutions that extend pavement service life

Solution	Description	Advantage
Polymer-modified bitumen (PMB), PG grading	SBS polymer is added to bitumen; the PG system (AASHTO	Higher resistance to rutting in heat and cracking in cold

Solution	Description	Advantage
	M 320) selects the binder by its service temperature range	
Porous (drainage) asphalt	Surface course with 15–25 % open porosity	Water drains quickly; noise and aquaplaning risk are reduced
Reclaimed asphalt pavement (RAP)	Milled old pavement is added to the new mix at up to 30 %	Saves bitumen and crushed stone, reduces waste
Basalt composite reinforcement	Basalt fiber bars instead of steel	Corrosion-free, light and strong
Geogrid	Polymer or glass fiber mesh between base or asphalt layers	Reflective cracking is reduced and base thickness decreases

When these solutions are used together, the interval between repairs is extended considerably. However, each technology must be justified technically and economically, taking into account the local climate, traffic flow and materials baseDigital Technologies and Environmental Standards

BIM (Building Information Modeling) creates a single digital model of the road covering the plan, profile, cross-section, structures and quantities. The model serves as a single source of information at the design, construction and operation stages. Clashes between disciplines are detected already at the design stage, and quantities and cost estimates are calculated automatically.

BIM works even more effectively together with GIS and LiDAR. LiDAR scanners on unmanned aerial vehicles provide an accurate digital terrain model in a short time, while GIS makes it possible to analyze the route together with geology, hydrology and protected areas. Intelligent transport systems (ITS) — weigh-in-motion (WIM), variable message signs, video surveillance — have now become an element considered from the very start of a project.

Environmental standards include the following requirements:

- noise barriers and landscaping near settlements;
- collection and treatment of runoff from the road surface;
- wildlife crossings (ecological corridors);
- recycling of construction waste (RAP) and use of local materials;
- environmental and social impact assessment (ESIA) of the project — a mandatory requirement of international financial institutions.

Analysis and Discussion: the Tashkent–Samarkand Expressway

The Tashkent–Samarkand toll motorway is the largest project showing how modern standards are applied in practice. The project was developed by the Austrian company ILF

Consulting Engineers, and the EBRD participated in financing the feasibility study [17]. The main parameters of the approved feasibility study are given in Table 6 [18].

Table 6. Main parameters of the Tashkent–Samarkand expressway

Parameter	Value
Length	282 km, entirely new construction
Category and traffic lanes	Category I-a motorway, 6 lanes, each 3.75 m
Design speed	150 km/h
Pavement type	Cement concrete
Design axle load	13 t
Expected traffic volume	50,000 vehicles/day
Engineering structures	12 interchanges, 91 bridges, 16 overpasses, 60 underpasses, 258 culverts
Ground improvement	140 km of stabilization, 7.2 km of stone columns, 132.8 km of weak soil replacement
Digital systems	24/7 ITS, weigh-in-motion (WIM)
Construction cost	USD 2.25 billion
Construction period	5 years, phased commissioning



Fig. 3. Layout of the Tashkent–Samarkand toll road project

The data in the table confirm the regulatory trends discussed in the article:

• **Geometry.** The design speed of 150 km/h and lane width of 3.75 m fully comply with the category I-a requirements of ShNQ 2.05.02-23.

- **Pavement.** The cement concrete pavement and 13 t axle load are intended to ensure resistance to heavy freight traffic and rutting in a hot climate.
- **Digitalization.** ITS and WIM systems are included as an integral part of the project; WIM detects overloaded vehicles and thus preserves the service life of the pavement.



Fig. 4. A multi-lane highway being built to modern standards

At the same time, the project also reveals gaps in the regulatory framework. National standards on cement concrete pavements, submission of BIM models for expert review and operational quality (for example, the IRI index) are less detailed than foreign documents. As a result, designers are forced to apply national and foreign standards simultaneously, which lengthens the expert review period.

Conclusions and Recommendations

The analysis shows that highway design standards are moving from a system of static numerical values to a comprehensive, performance-based approach grounded in environmental protection and digitalization. The main conclusions are:

1. Harmonizing the national standards (ShNQ 2.05.02-23, ShNQ 2.05.03-22) with international standards (AASHTO, Eurocode) will increase design reliability and make it easier to attract foreign investment.

2. For geometric parameters, the national standard requires a larger margin than foreign standards (for example, a minimum radius of 1200 m versus 594 m under AASHTO). This increases safety but raises construction costs in difficult terrain.

3. Pavements should be designed as multilayer systems for a 20–25 year service life, and materials such as PMB, RAP, geogrids and basalt reinforcement should be used where technically and economically justified.

4. The Tashkent–Samarkand expressway (282 km, 150 km/h, 6 lanes, ITS and WIM) shows that a modern design school is emerging in the country and will serve as a model for future projects.

Recommendations:

- adopt a program to harmonize national standards with Eurocode and AASHTO and develop separate standards for cement concrete pavements;
- make BIM models and GIS data mandatory in category I and II road projects and adapt electronic expert review to BIM models;
- include operational quality indicators (IRI, friction coefficient) in the standards;
- introduce a professional development system on international standards for young specialists.

The analysis and recommendations of the article are of practical value for making sound engineering decisions in the design, construction and operation of highways.

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