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INLAND TRANSPORT COMMITTEE

Ad hoc Multidisciplinary Group of Experts on
Safety in Tunnels
(Fourth session, 9-11 July 2001)

QUESTIONNAIRE

Transmitted by the Russian Federation

Questions and answers on safety in road tunnels

Part A. General Questions

1. Do any normative instruments regulating safety in tunnels apply in your country?

Safety in tunnels is regulated by SNiP 32-04-97 "Tunnels, rail and road" from the series Construction Standards and Rules (SNiP) of the Russian Federation and by the rules for road traffic in tunnels laid down in the Highway Code of the Russian Federation as approved in Decision No. 1090 of the Council of Ministers (Government) of the Russian Federation dated 23 October 1993.

2. Do you consider your national rules on safety in road tunnels sufficient?

It would be helpful to have a single document setting out the rules on safety in road tunnels.

3. Are your national authorities responsible for the operation of roads/tunnels considering making any safety-related changes to the sections of the Highway Code applicable to road tunnels?

The need for such changes is under study.

4. Is there any specific methodology for risk assessment and risk management for tunnels in your country?

No.

5. Does your country classify road tunnels by the risks associated with their use or does it envisage doing so in future?

The matter is not under consideration at present.

PART B Tunnel data

Name/location of tunnel	**Length**, m	**Type** (I: single two-way tunnel II: two tunnels in each direction)	**Number/width of traffic lanes**, m	**Year opened**
Roksky (93 km)	3 600	I	2/4	1985
Km 48 on Dzhama – Zamarag road, Republic of North Ossetia – Alania	827	I	2/4	1986
Kanonersky, St. Petersburg	1 000	I	2/4	1983
Km 45 on Urvan – Ushtulu road, Kabardino-Balkar Republic	660	I	2/3.5	1998
Cape Vidny, Sochi – Adler road	580	II	2/4+ 2/4	1978
Gimrinsky, Republic of Dagestan	4 300	I	2/4	Being prepared for opening
Krasnopolyansky, Adler – Krasnaya Polyana road	2 400	I	2/4	Being prepared for opening
Matsestinsky, Sochi – Adler road	1 350	I	2/4	Being prepared for opening

Note: The tunnels are under State ownership

System of normative instruments in the construction industry

CONSTRUCTION STANDARDS AND RULES OF THE RUSSIAN FEDERATION

TUNNELS, RAIL AND ROAD

SNiP 32-04-97

Official Issue

STATE COMMITTEE OF THE RUSSIAN FEDERATION FOR HOUSING AND CONSTRUCTION POLICY
(GOSSTROI ROSSII)
Moscow
1997

SNiP 32-04-97

CONSTRUCTION STANDARDS AND RULES OF THE RUSSIAN FEDERATION

TUNNELS, RAIL AND ROAD

Put into effect: 1 January 1998

1. Sphere of application

The present rules and standards apply to design and construction of new tunnels and reconstruction of existing tunnels on the 1,520 mm-gauge railway network and on public roads of whatever category.

The present standards do not apply to tunnels built on high-speed (over 200 km/h) passenger rail lines or on high-speed motorways (having a design speed in excess of 150 km/h) or to transport tunnels in urban areas.

2. Standards referred to

The list of construction standards and rules and inter-State and State standards referred to in the following text appears in annex A.

3. General provisions

3.1 Tunnels must, throughout their service life (as defined in GOST 27.002), meet the following requirements: uninterrupted and safe passage of vehicles; economical, non-labour-intensive maintenance of structure and permanent installations; healthy and safe working conditions for maintenance and operating staff; environmental friendliness.

3.2 Rail and road tunnels are to be considered as structures of importance class 1 under GOST 27751, Amendment No. 1, i.e. structures whose failure may have serious

economic, social or environmental consequences.

3.3 The main design decisions pertaining to tunnels -- choice of route and longitudinal profile, determination of the advisability of building one twin-track or two single-track rail tunnels or of the number of road tunnels required to accommodate the desired number of traffic lanes, type and shape of lining cross-section, method of protection against groundwater, etc. -- must be based on comparison of the feasibility of the various options, bearing in mind the discounted construction and operating costs.

3.4 Tunnels should not be built in fault or landslide zones, in areas with a high flood risk (in gullies, under watershed saddles, etc.) or in possible karst zones, and tunnel portals and the near-portal sections of tunnels should not be sited in areas at risk from snow avalanches, mudslides or rock falls.

3.5 The design choices and the materials used should be such as to ensure that tunnel linings have a service life of at least 100 years. The time between repairs for structural elements of permanent installations should be at least 50 years.

3.6 Tunnels, galleries and other tunnel-related underground structures, with the exception of tunnel-related structures in strong, non-weathering rock, should be permanently supported by a lining.

3.7 Tunnel entrances and galleries opening to the surface must be reinforced and built with portals, head-sections and ramps.

3.8. In geologically hazardous zones (areas with a risk of landslides, caving, mudslides, snow avalanches, etc.), protective structures must be built or measures be taken in accordance with SNiP 2.01.15 to ensure that portals and the near-portal sections of tunnels are properly protected from the phenomena in question.

3.9 Tunnels must have refuge rooms and niches.

Rooms should be built on alternate sides of the tunnel at intervals of not more than 300 m. In tunnels between 200 and 400 m long there should be one room in the middle of the tunnel; in tunnels between 400 and 600 m long there should be two rooms, one on each side and equidistant from the portals.

There should be niches at 60 m intervals between the rooms and on each side of the tunnel.

[**Translator's note**: Sections of SNiP 32-04-97 between this point and section 6.11 not supplied by Russian Federation]

6.11 The total deviation of the internal dimensions of the lining from their design values must not exceed the clearance to tolerances.

6.12 During the building of tunnels, the work must be monitored to SNiP 3.01.01 and the requirements concerning regular quality control contained in annex C thereof must be adhered to.

6.13 A work log to SNiP 3.01.01, or an excavations log shall be kept at every building site, as shall logs for the following: procurement orders, project supervision or reports of the project-accompaniment group, surveying, survey measurements of completed work, safety matters, other types of work and the functioning of machinery.

The guidance and instructions given by the management of the building organization to section chiefs and shift workers concerning the: halting or resumption of excavation and other types of work; the correction of sub-standard work and the results of surveyors' inspections, as well as the

guidance and instructions from the Federal Mining and Industry Supervision Board, the State Health Supervision Committee or the customer shall be recorded in the general work log.

6.14 During construction or major overhaul, all tunnels shall have available the services of professional safety and rescue teams organized along military lines.

6.15 Work on building tunnels shall be carried out in accordance with: the safety rules set out in SNiP III-4; the fire-safety standards set out in SNiP 21-01-97; the fire-safety requirements of GOST 12.1.004; the electrical safety requirements of GOST 12.1.013; the regulations of supervisory bodies as per annex B hereunder; and other duly approved standards.

7. Permanent installations

Permanent way, carriageway

7.1 In rail tunnels, the permanent way must be to specifications consistent with the rail transport executive authority's standards for open-air sections of railway line.

7.2 The design of the permanent way must be suitable for mechanized track repair and maintenance.

7.3 The ballast must be of crushed stone and the thickness of the ballast under sleepers in the areas beneath rails must be at least 0.35 m.

7.4 In the interface areas between ballastless track within tunnels and ballasted track on tunnel approaches, sections of variable-elasticity transitional track not less than 25 m in length must be laid on each side of the tunnel.

7.5 The track in tunnels should be made of continuous welded rail. No joints between rail strings are permitted in tunnels 300 m or less in length.

7.6 In the case of tunnels more than 300 m long, the ends of the outermost strings of continuous welded rail should lie at least 200 m outside the tunnel.

7.7 The permanent way and other permanent installations on direct-current electrified sections of line must be protected against stray currents.

7.8 Rail tunnels must be equipped with bench marks set into the wall lining every 20 m on straight sections of track and every 10 m on curved sections, as well as with wayside signal signs, section numbers (for modular linings), direction indicators showing the way to refuge niches and rooms, protection-signal control panels and telecommunication devices.

7.9 On straight sections of track in single-track tunnels, the bench marks should be situated on the right-hand side (relative to the kilometre count) of the tunnel; on curved sections, they should be on the same side as the inside rail. In twin-track tunnels, there should be bench marks on both sides of the track.

7.10 At each bench mark, a sign showing the number of the bench mark, the distance from the mark to the inner edge of the nearer rail and the height of the mark above the head of that rail must be fixed to the tunnel wall.

7.11 Rail and road tunnels must have at each portal a bench mark for class III levelling.

7.12 In road tunnels, the materials and structure of the road surface must meet the requirements set in SNiP 2.05.02 for

hazardous traffic conditions on open-air sections of road. The road surface must have movement joints at the places where there are movement joints in the tunnel lining and at the portal exits.

Drainage and drainage devices

7.13 In tunnels, service galleries and safety galleries, water from the drainage system, from random flow through the lining or from tunnel-washing and fire-fighting must be evacuated fire covered gutters or sewers.

7.14 Groundwater drainage is not permitted when a tunnel is situated in ground that is subject to suffusion.

7.15 The drainage gutters in tunnels must not run under the railway track or the carriageway.

7.16 The bottoms of gutters or sewers must have a gradient of not less than 3 $^{o}/_{o}$.

7.17 Gutters or sewers must have at intervals of no more than 40 m inspection pits with sumps measuring not less than 0.04 m^3. The sumps must be accessible for periodic inspection.

7.18 To prevent the spread of burning petroleum products, the inspection pits must have at no more than 280 m intervals water seals (siphon-type) with sumps measuring not less than 0.2 m^3. Similar water seals must also be installed at the points where water is discharged into a service or safety gallery.

7.19 Provision must be made for water to be diverted away from the tunnel from the portal approach cutting at the higher end of the tunnel. Where this cannot be done, the water should be evacuated via a service gallery or, if there is none, via one of the tunnel's drainage gutters. In these cases, the gutter should be sized to allow for the water-collection capacity of the cutting plus an exceedance probability of 1:300 (0.33%).

7.20 No water from the ramps should be able to enter the drainage systems of subaqueous tunnels.

7.21 The design water level in tunnel drainage gutters should be below the base of the permanent way or road surface. The design water level in service-gallery gutters should not be above the bottom of the tunnel gutters.

7.22 To facilitate water runoff, holes, bores, shafts and other excavations in the floor within the near-portal areas of upland tunnels should be filled with non-draining soil. If necessary, a surface drainage system comprising a network of intercepting drains should be built.

7.23 There should be a gutter to remove surface water from the front slope beyond the parapet.

7.24 Tunnels in low-lying areas must have drainage sumps and dewatering plant located in independent premises. Dewatering plant should also be installed in the lower areas of tunnel ramps.

7.25 It should not be possible for water in drainage plant, conduits, drains or sumps to freeze. If necessary, the said plant, etc, should be insulated and heated.

Ventilation

7.26 Ventilation should be adequate for operation of the road or rail tunnel in the following conditions:

A. Normal: non-stop movement of vehicles at the maximum permitted speed and peak-period traffic density;

B. Slow: non-stop movement of vehicles at a speed of less than 20 km/h;

C. Jam: vehicles stationary for up to 15 minutes with motors running.

7.27 For the "Normal" condition (condition A), the maximum permissible concentration (MPC) of carbon monoxide as an indicator of the total exhaust gas content of the air in the tunnel's traffic zone should not exceed the values shown in table 4 below; for conditions B & C, it should not exceed the following MPCs (in mg/m^3) set by GOST 12.1.005:

Carbon monoxide: 200
Nitrogen oxide (as NO_2): 5
Soot: 4

Table 4. **Maximum permissible concentrations (MPCs) of carbon monoxide in the air in tunnels' transport zones**
(mg/m^3)

Duration *t* in minutes of vehicles' presence in tunnel	Tunnel	
	Rail	Road
5	28	60
6	24	51
7	21	45
8	19	41
9	17	38
10	16	35
15	12	26
20	9	21
Note: The duration *t* and the MPCs may, if necessary, be altered in either direction through extrapolation of the relationships between *t* and MPC, which are linear when both are expressed logarithmically.		

7.28 The design temperature of the air in the tunnel should not exceed the maximum temperature of the outside air determined according to SNiP 2.04.05 for condition C. No regulation applies regarding the minimum temperature of tunnel air.

Note

1. For rail tunnels less than 1, 000 m long and road tunnels less than 300 m long , the values for the above-mentioned temperatures and the relative humidity of the outside air shall be taken from the readings of the nearest weather station. For longer tunnels and in the case of tunnels on electrified rail lines, where special thermal conditions are created, the values shall be derived from readings taken over a period of not less than three years at the places of construction of the tunnel portals .

2. In the case of rail tunnels located in harsh climate zones, ventilation doors or other devices may be employed to limit the inflow of outside air.

7.29 In premises intended for tunnel staff to warm themselves, the wintertime air temperature should not be less than + 18 ^oC.

7.30 The mean cross-sectional velocity of the air in a tunnel's transport zone during operation of the ventilation system and disregarding the effect of vehicles should not exceed 6 m/s. No regulation applies regarding the local acceleration of the airflow in the vicinity of air outlets.

7.31 In longitudinally ventilated single-track rail tunnels and one-way road tunnels, the direction of movement of the ventilation

air should match the direction of the principal traffic flow.

7.32 In road tunnels, the ventilation system should ensure that the air remains clear enough for good visibility. For this, light attenuation should not exceed 0.0075 1/m [sic].

7.33 In road tunnels, refuge rooms more than 10 m deep and parking places for emergency vehicles should be ventilated by means of local ventilation plant.

7.34 In road tunnels, the ventilation system must not cause the formation of mist in any operating conditions or in the event of fire.

7.35 In the event of fire, a powered ventilation system must be reversible and capable of the following:

(a) maintaining the desired direction of flow of the ventilation air;

(b) keeping the evacuation routes smoke-free until evacuation is complete by producing an air pressure of not less than 20 Pa;

(c) switching in not more than five minutes when the ventilation flow is reversed.

7.36 The fan motors for exhausting the products of combustion in the event of fire must be situated out of the gas stream or have a forced cooling system.

7.37 The control gear for a tunnel ventilation system should include a package of devices for permanent monitoring of the physical and chemical parameters of the atmosphere in the tunnel, including the near-portal sections.

7.38 In tunnels, the level of the noise created by operation of ventilation equipment should not exceed the values shown in table 5 below; in plant spaces, staff rooms and other ancillary premises, it should not exceed the levels set by GOST 12.1.003. In residential areas, the noise at the ground surface should not exceed the values set in SNiP II-12.

7.39 When repair and other work is being undertaken in the tunnel, the concentrations of harmful substances in the air in the tunnel and in the work zones should not exceed the maximum permissible concentrations (MPCs) set in GOST 12.1.005.

Electric lighting

7.40 Tunnels and service galleries should have a fixed artificial lighting system. This applies to:

Rail tunnels more than 200 m long on straight sections of track or more than 100 m long on curved sections; and to

Road tunnels, which shall be lit to the requirements of tables 6 and 7 below.

In addition to their general lighting, tunnels and service galleries shall have emergency lighting.

7.41 Horizontal illumination in rail tunnels at the level of the rail heads and in service tunnels at the level of the finished floor shall not be less than 1lux.

Table 5. **Sound levels created in tunnels by operation of ventilation equipment**

Geometric mean frequencies of octave bands, Hz	63	125	250	500	1 000	2 000	4 000	8 000
Sound pressure levels, dB	97	88	83	76	72	62	54	47

Table 6. **Road tunnels: artificial lighting**

Nature of section	Length of tunnel, m	Mean horizontal illuminance E_{avg}, lux	
		Daytime	Evening and night
Straight, or curved with radius in plan greater than 350 m	From 61 to 100 Over 100	Not required As per table 7	30 30
Curved with radius in plan 350 m or less	Over 60	As per table 7*	30
Any	60 or less	Not required	15

* In tunnels with a radius of curvature in plan of 350 m or less in the entry zone, the value of the vertical illuminance E_v on the outside of the curve (within the tunnel) at a height of 1 m above the road surface must be at least 0.4 E_t if the cladding is of white tile or painted white over a distance of not less than 100 m from the portal, and at least 0.8 E_t if the lining is of concrete at a distance of not more than 175 m from the portal.

Note: In the centre section of road tunnels however aligned that are more than 1,300 m long, the horizontal illuminance during daytime, evening and night at a distance of 500 m from the entry portal may be reduced from 30 to 15 lux if no television system is used in the tunnel and increased to 50 lux if the television cameras used are insufficiently sensitive.

7.42 In road tunnels, the illumination and the mean horizontal illuminance afforded by the lighting system shall meet the requirements shown in tables 6 and 7. The illumination need not be intensified at the exit from one-way tunnels.

7.43 In road tunnels, the ratio of the maximum illuminance to the mean illuminance shall not exceed 3:1 in any section for which there is a prescribed value for the mean horizontal illuminance.

7.44 The overall lighting of road tunnels should be controllable both automatically as a function of the natural illuminance outside the tunnel and remotely, i.e. from the duty supervisor's station.

The switch to the evening and night-time illumination values should occur when the natural illuminance falls to 100 lux.

7.45 To permit the local connection of light fittings for the performance of repair or other work, there should be sockets: at 60 m intervals in service galleries; in refuge niches and rooms on one side of the tunnel in single-track and two-lane one-way tunnels and on both sides of the tunnel in twin-track and four-lane or wider tunnels.

7.46 The power for movable light fittings for local lighting should come from 220/12 V transformers.

Electricity supply, electrical equipment, automatic control equipment, signs and signals, telecommunications

7.47 To meet the needs of plant, lighting and other equipment, tunnels should have their own transformer substations supplying industrial-frequency 380/220 V alternating current, with common transformers for the power and lighting loads.

Note: Transformer substations' capacity will depend on the length of the tunnel. When there are supply centres near a tunnel, the power needs of plant, lighting and other equipment may be met from them.

7.48 Tunnels' transformer substations must be supplied with electricity via 6, 10 or 27.5

kV underground or overhead lines from power systems or power stations.

7.49 All transformer substations and electricity distribution points must be supplied from two independent, mutually redundant sources and be adequate for full-power operation of all simultaneously operating consumers.

7.50 Transformer substations and distribution points must, within the permissible overload envelope, withstand full-power operation of all simultaneously operating consumers. The following are classified as category I consumers: ventilation plant; annunciatory and protection signs and signals; dewatering plant; the lighting systems for tunnels, refuge niches and rooms, passageways and service galleries; heating systems for tunnel gutters; automatic fire-safety devices.

7.51 The electrical equipment in underground substations must not be oil-filled.

7.52 High-current and lighting cables should be laid on one side of the tunnel and low-current cables on the other. Cables may be laid on one side only in tunnels up to 300 m long, provided the requirements set in the Rules on Electrical Installations regarding distances between high-current and low-current cables are met.

7.53 In tunnels, high-current cables should be installed 760 mm above the top of the refuge niches; lighting cables should be installed not less than 2,800 mm from the level of the rail heads or of access passages.

7.54 When 12 or more cables are installed within a tunnel in the vicinity of access passages (cross-passages), protective partitions made of non-combustible materials must be built to cover the entire height of the cable bundle. They must abut the tunnel walls and project laterally at least 10 cm from the side of the cables; the openings in them must be sealed and the cables must be protected by non-combustible material over a distance of 0.5 m to each side.

7.55 Earthing and leak-current relays must be used to provide protection against electrical fires in the event of damage to the insulation of cables or plant.

7.56 To permit the connection of repair tools and other machinery to the 380/220 V electrical supply network, cabinets should be installed every 120 m throughout the length of the tunnel and at a height of 500-700 mm above the rail heads or the road surface. They should be installed on one side of the tunnel in single-track and two-lane one-way tunnels and on both sides in multiple-direction tunnels.

7.57 The work referred to in paragraphs 7.47-7.53 and 7.55-7.56 above must be carried out in conformity with the Rules on Electrical Installations.

7.58 When permanent service staff are present in a tunnel, the signs and signals warning of the operation of equipment in the tunnel and adjacent structures must function automatically and be controllable both locally and remotely.

7.59 On straight sections of track, rail tunnels 100 m or more in length, and on curved sections of track rail tunnels of whatever length, as well as all tunnels with deep cuttings on their approaches, must have the following in-tunnel signalling:

annunciatory: automatic (audio and illuminated);

protection: illuminated.

7.60 The lamps of protection and annunciatory signs in rail tunnels should have

an additional standby power supply (from batteries adequate for two hours' operation).

7.61 For traffic-control purposes, remotely controlled light signals (traffic lights) should be installed at the portals of road tunnels.

Road tunnels 300 m or more in length must have protection signals for the switching on of light signals prohibiting vehicles from entering the tunnel in the event of an emergency in it.

7.62 Provision should be made for parallel automatic switching on of prohibitory signals from the fire-alarm system sensors.

7.63 Road tunnels more than 400 m long must have telephone systems. Telephone sets must be installed in refuge niches and rooms every 180 m on both sides of tunnels having more than two lanes and of two-lane two-way tunnels.

7.64 Guarded rail tunnels must have a direct two-wire telephone link to the nearest block posts at each end of the tunnel and to the dispatcher stations and guard rooms and, on sections with centralized despatching, to the train dispatcher.

7.65 To permit radio communication with trains, tunnels must have a two-wire line or a radiating cable and the guard rooms of large tunnels (i.e., tunnels more than 5 km long) must have non-mobile VHF equipment.

7.66 Rail and road tunnels more than 1,000 m long must have a loudspeaker system, with speakers installed every 120 m.

7.67 In road tunnels, the remote surveillance devices (closed-circuit television monitors) should be installed within the limits of visibility, but not more than 300 m apart.

7.68 In guarded road tunnels, the portal and ramp sections should be equipped with television cameras for the transmission to the dispatcher stations of video information from the entry and exit zones.

7.69 The detailed design and the assembly of the permanent electricity-supply, equipment-control, signalling and telecommunications devices needed for the operation of tunnels should be carried out in accordance with special standards.

8. **Fire protection**

8.1 Rail tunnels more than 2,000 m long and road tunnels more than 600 m long should have firefighting points equipped for the extinction of fires, as well as a dry main that can be connected to, as appropriate, a fire train coming from the nearest station or a fire engine.

The absence of firefighting points in tunnels shorter than those referred to above must be approved by Gosgortekhnadzor, the State body responsible for safety in mines and other underground structures.

8.2 In tunnels, firefighting points must be located every 60 m in refuge niches or rooms and at the ends of emergency stopping areas (in road tunnels); in service galleries containing high-current or lighting cables, they must be located every 40 m.

There must also be firefighting points at each portal of guarded tunnels.

8.3 The minimum stocks and the consumption of extinguishants shall be determined from the time theoretically required to extinguish one fire in the tunnel every three hours.

8.4 Depending on the length of the tunnel, the dry main should be divided into sections (zones) such that the pressure at fire cocks is as stipulated in SNiP 2.04.01 and the time required for water to flow along the main to

the furthest fire cock does not exceed 5 minutes.

Where there is a safety gallery or safety tunnel, the dry main should be connected up through it.

8.5 Tunnels more than 5,000 m long should have additional firefighting facilities. The types of equipment and extinguishants should be justified in the design documentation.

8.6 Cross-passages between tunnels and service galleries or between parallel tunnels should have air locks with fireproof doors.

8.7 The locations of fire cocks, signalling buttons, fire-extinction system "start" buttons and the evacuation routes should be identified by illuminated signs having a duplicate electricity supply from the emergency lighting system.

8.8 The conditions for the emergency evacuation of people in the event of fire shall correspond to those laid down in GOST 12.1.004.

8.9 In the event of fire, the first thing to be done will be to remove the burning train or vehicle or the fire source on it from the tunnel and then to extinguish the fire source outside the tunnel. If removal is impossible, the fire should be contained and extinguished at its place of origin by taking the requisite fire-extinction measures.

9. Environmental protection

9.1 The construction and subsequent operation of a tunnel should not cause more than the permissible degree of pollution of the air, waterbodies, watercourses or groundwater, the exhaustion of water sources, erosion or the development of erosion, karst formation or other negative phenomena.

9.2 Measures to set aside land for tunnel construction and to protect the subsoil shall be in accordance with the legislation in force at the time.

9.3 During construction, care shall be taken to prevent outbreaks of fire in nearby woods and peat deposits and to limit and control harmful cryogenic processes.

9.4 When construction of a tunnel has been completed, the soil and plant cover should be restored and any slopes that have been formed, quarries, etc. that have been worked or spoil heaps that have been created should be consolidated and grassed over.

9.5 Measures and design choices aimed at protecting the environment that are applied in the course of construction should be agreed according to the established procedure with the local organs of the Ministry of Environmental Protection and Natural Resources and the local centres of the State Sanitary and Epidemiological Supervisory Committee.

9.6 Effluent, domestic waste water and surface run-off arising on the construction site and in the tunnel should be treated to a degree defined in accordance with health and surface-water-protection regulations.

Systems for the evacuation and treatment of effluent, surface run-off and domestic waste water during the construction and operation of tunnels shall meet the requirements of SNiP 2.04.03 and SN (Health Standard) 496-77.

9.7 Treatment plant shall be designed taking into account the use to be made of the water from the waterbodies into which discharge from tunnels and near-portal installations is intended.

9.8 When building rail tunnels in residential or industrial areas, provision must

be made for the damping of the vibrations caused by the passage of trains such that the vibration in residential and public buildings does not exceed the values permissible under health regulations and the vibration in industrial buildings does not exceed a level compatible with the type of industrial activity in question.

9.9 Tunnels shall be protected against the entry into them from nearby production facilities of substances injurious to human health.

Table 7. **Standards for daytime mean horizontal artificial illumination in road tunnels**

Entrance configuration	**Orientation of entry portal**	**Duration of snow coverage**	**Mean horizontal illuminance E_{avg} in lux of the carriageway by distance in m from the entry portal**						
			10	30	50	75	100	125	150 or more
Flat ground or with rise towards portal	North	<6 months	750	750	400	150	75	30	30
		> 6 months	1,000	1,000	550	250	100	50	30
	South	< 6 months							
		> 6 months	1,500	1,500	850	400	150	75	30
Descent towards portal	Any	Any	1,250	1,000	650	350	125	60	30

Note

1. "North" includes north-east and north-west; "South" includes south-east and south-west.
2. If the portal extends outwards from the tunnel proper, the distances should be measured from the beginning of the tunnel bore.