

Employer's Requirement (ERQ)

Minimum Safety Requirements for Road Tunnels

Employer's Requirements : Minimum Safety Requirements for Road Tunnels

This Section aims at ensuring a minimum level of safety for road users in tunnels in the Strategic Road Network by the prevention of critical events that may endanger human life, the environment and tunnel installations, as well as by the provision of protection in case of accidents.

It shall apply to all tunnels in the Strategic Road Network , whether they are in operation, under construction or at the design stage.

Definition: "Emergency services" means all local services, whether public or private or part of the tunnel staff, which intervene in the event of an accident, including police services, fire brigades and rescue teams.

Definition: "Tunnel length" means the length of the longest traffic lane, measured on the fully enclosed part of the tunnel.

Safety measures :-

The Contractor shall ensure that tunnel meets the minimum safety requirements laid down as below :

1. Basis for deciding on safety measures

1.1.Safety parameters

- 1.1.1. Safety measures to be implemented in a tunnel shall be based on a systematic consideration of all aspects of the system composed of the infrastructure, operation, users and vehicles.
- 1.1.2. The following parameters shall be taken into account:
 - tunnel length,
 - number of tubes,
 - number of lanes,
 - cross-sectional geometry,
 - vertical and horizontal alignment,
 - type of construction,
 - uni-directional or bi-directional traffic,
 - traffic volume per tube (including its time distribution),
 - risk of congestion (daily or seasonal),
 - access time for the emergency services,
 - presence and percentage of heavy goods vehicles,
 - presence, percentage and type of dangerous goods traffic,
 - characteristics of the access roads,
 - lane width,
 - speed considerations,
- 1.1.3. Where a tunnel has a special characteristic as regards the aforementioned parameters, a risk analysis shall be carried out to establish whether additional safety measures and/or supplementary equipment is necessary to ensure a high level of tunnel safety. This risk analysis shall take into consideration possible accidents,

which clearly affect the safety of road users in tunnels and which might occur during the operating stage and the nature and magnitude of their possible consequences.

Risk analyses, where necessary, shall be carried out by a body which is functionally independent from the Contractor and Employer at Contractor Cost. The content and the results of the risk analysis shall be included in the safety documentation submitted to the Employer. A risk analysis is an analysis of risks for a given tunnel, taking into account all design factors and traffic conditions that affect safety, notably traffic characteristics and type, tunnel length and tunnel geometry, as well as the forecast number of heavy goods vehicles per day.

1.2. Minimum requirements

1.2.1. The safety measures required by the following paragraphs shall be implemented at a minimum in order to ensure a minimum level of safety in all the tunnels covered by the **Specification**.

1.2.2. In order to provide a unified interface in all tunnels to which this **Specification** applies, no derogation from the requirements of the following paragraphs shall be allowed regarding the design of the safety facilities at the disposal of the tunnel users (emergency stations, signs, lay-bys, emergency exits, radio re-broadcasting when required).

1.3. Traffic volume

1.3.1. Where "traffic volume" is mentioned in this section of Specification, it refers to the annual average daily traffic through a tunnel per lane. For the purpose of determining the traffic volume, each motor vehicle shall be counted as one unit.

1.3.2. Where the number of heavy goods vehicles over 3.5 t exceeds 15% of the annual average daily traffic, or seasonal daily traffic significantly exceeds the annual average daily traffic, the additional risk will be assessed and taken into account by increasing the traffic volume of the tunnel for the application of the following paragraphs.

2. Infrastructure measures

2.1. Number of tubes and lanes

2.1.1. The main criteria for deciding whether to build a single or a twin-tube tunnel shall be projected traffic volume and safety, taking into account aspects such as the percentage of heavy goods vehicles, gradient and length.

2.1.2. In any case, where, for tunnels at the design stage, a 15-year forecast shows that the traffic volume will exceed 10000 vehicles per day per lane, a twin-tube tunnel with unidirectional traffic shall be in place at the time when this value will be exceeded.

2.1.3. With the exception of the emergency lane, the same number of lanes shall be maintained inside and outside the tunnel. Any change in the number of lanes shall occur at a sufficient distance in front of the tunnel portal; this distance shall be at least the distance covered in 10 seconds by a vehicle travelling at the speed limit. When geographic circumstances prevent this, additional and/or reinforced measures shall be taken to enhance safety.

2.2. Tunnel geometry

2.2.1. Special consideration shall be given to safety when designing the cross-sectional geometry and the horizontal and vertical alignment of a tunnel and its access roads, as these parameters have a significant influence on the probability and severity of accidents. The geometrical requirement along with the cross sectional details shall

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comply the **Nepal Road Standard – 2070, 2013** and/or requirements in below paragraphs

- 2.2.2. Longitudinal gradients above **4%** shall not be permitted in new tunnels, unless no other solution is geographically possible.
- 2.2.3. In tunnels with gradients higher than **3%**, additional and/or reinforced measures shall be taken to enhance safety on the basis of a risk analysis.
- 2.2.4. Where the width of the slow lane is less than **3,5 m** and heavy goods vehicles are allowed, additional and/or reinforced measures shall be taken to enhance safety on the basis of a risk analysis.

2.2.5 Inner section requirements: The space above the carriageway is determined by the required usable space, as well as the constructional and technical execution requirements. The usable space consists of the following elements:

- Usable space for traffic, consisting of:
 - clearance profile for passage through the tunnel;
 - space for walkways (service and emergency escape route);
 - space for equipment including any free space (safety margin).
- Usable space for constructional purposes, consisting of:
 - space for tolerances (a), which takes into account the deviations due to execution errors;
 - space for later constructional measures (b), which may be necessary during the service phase.
- Usable space for ventilation.

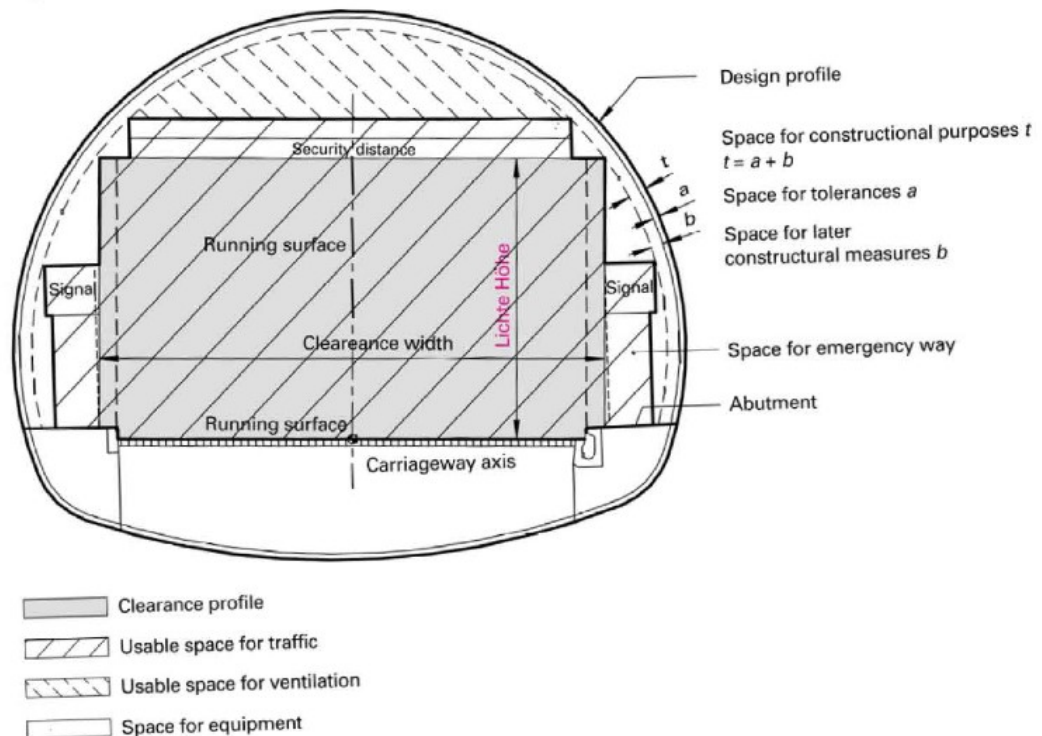


Figure 1: Definition of the usable space (road tunnels) according to SIA 197/2 Design of Tunnels – Road Tunnels

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As for the inner tunnel section, minimum space requirements are defined accordingly on the base of SIA197/02 and **ASTRA 11001**; main dimensions are:

- Sidewalk (to be used only in case of emergency) width ≥ 1 m;
- Available height on carriageway for traffic ≥ 4.5 m + 0.3 m (safety margin);
- Additional available height for signalling and equipment ≥ 0.4 m

The space for ventilation equipment is considered into the ventilation design.

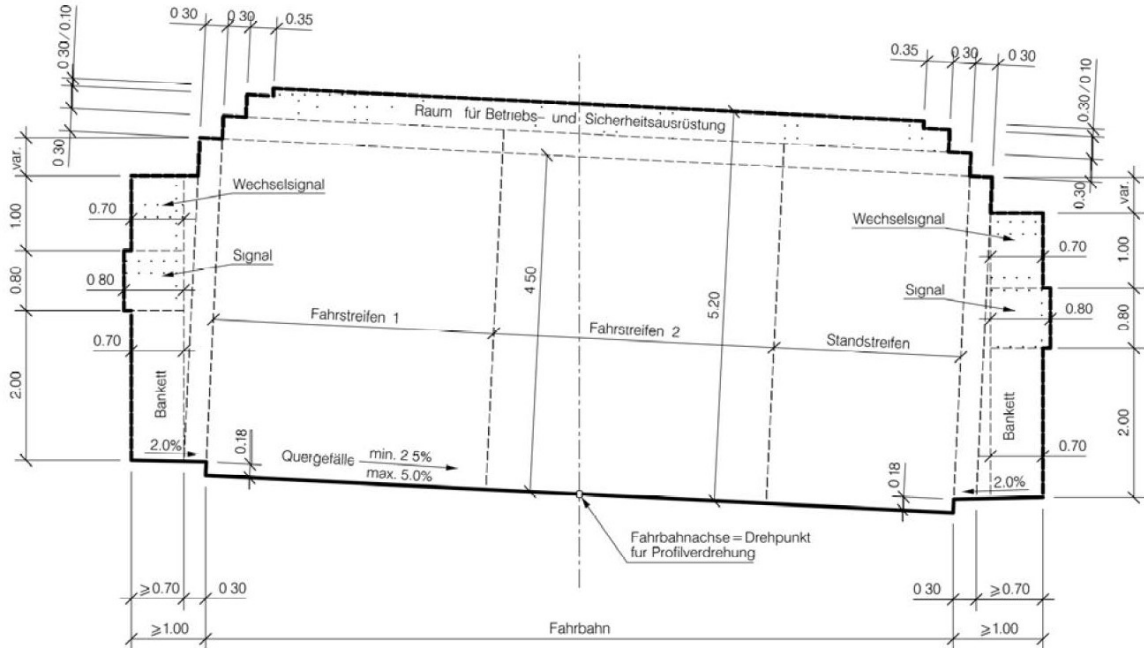


Figure 2: Operational envelope for traffic according to SIA 197/2 Design of Tunnels – Road Tunnels

2.3. Escape routes and emergency exits

- 2.3.1. Without an emergency lane, emergency walkways, elevated or not, shall be provided for use by tunnel users in the event of a breakdown or an accident. This provision does not apply if the construction characteristics of the tunnel do not allow it or allow it only at disproportional cost and the tunnel is unidirectional and is equipped with a permanent surveillance and lane closure system.
- 2.3.2. Emergency exits allow tunnel users to leave the tunnel without their vehicles and reach a safe place in the event of an accident or a fire and also provide access on foot to the tunnel for emergency services. Examples of such emergency exits are:
 - direct exits from the tunnel to the outside,
 - cross-connections between tunnel tubes,
 - exits to an emergency gallery,
 - shelters with an escape route separate from the tunnel tube.
- 2.3.3. Shelters without an exit leading to escape routes to the open shall not be built.
- 2.3.4. Emergency exits shall be provided if an analysis of relevant risks, including how far and how quickly smoke travels under local conditions, shows that the ventilation and other safety provisions are insufficient to ensure the safety of road users.
- 2.3.5. In any event, emergency exits shall be provided where the traffic volume is higher than 2000 vehicles per lane.

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2.3.6. Where emergency exits are provided, the distance between two emergency exits shall not exceed 300 m and SOS niches every 150 m or less.

2.3.7. Appropriate means, such as doors, shall be used to prevent smoke and heat from reaching the escape routes behind the emergency exit, so that the tunnel users can safely reach the outside and the emergency services can have access to the tunnel.

2.4. Access for emergency services

2.4.1. In twin-tube tunnels where the tubes are at the same level or nearly, cross-connections suitable for the use of emergency services shall be provided at least every 1500 m.

2.4.2. Wherever geographically possible, crossing of the central reserve (median strip) shall be made possible outside each portal of a twin- or multi-tube tunnel. This measure will allow emergency services to gain immediate access to either tube.

2.5. Lay-bys

2.5.1. For bi-directional tunnels longer than 1000 m where traffic volume is higher than 2000 vehicles per lane, lay-bys shall be provided at distances which do not exceed 750m, if emergency lanes are not provided.

2.5.2. Lay-bys shall include an emergency station.

2.6. Drainage

2.6.1. Where the transport of dangerous goods is permitted, the drainage of flammable and toxic liquids shall be provided for through well-designed slot gutters or other measures within the tunnel cross sections. Additionally, the drainage system shall be designed and maintained to prevent fire and flammable and toxic liquids from spreading inside tubes and between tubes.

2.6.2. Groundwater management: Water collection along the tunnel shall be based on the so called "separate" water management system. It pursues the separation between clean groundwater, collected outside the tunnel lining perimeter, and polluted waters, collected inside the tunnel lining perimeter. In addition to the dirty and water polluted water management, related to road water drainage system, possible groundwater has to be managed by a proper system, based on the following elements.

2.6.3. Groundwater, coming from the surrounding rock mass, shall be collected at the foot of the tunnel vault, thanks to the drainage and waterproofing layers around the tunnel. Flushing niches collect groundwaters and allow maintenance (regular flushing) of both drainage and seepage pipes.

2.7. Fire resistance of structures

2.7.1. The main structure of all tunnels where a local collapse of the structure could have catastrophic consequences, e.g. immersed tunnels or tunnels which can cause the collapse of important neighbouring structures, shall ensure a sufficient level of fire resistance.

2.8. Lighting

2.8.1. Normal lighting shall be provided so as to ensure appropriate visibility day and night for drivers in the entrance zone as well as in the interior of the tunnel.

2.8.2. Safety lighting shall be provided to allow a minimum visibility for tunnel users to evacuate the tunnel in their vehicles in the event of a breakdown of the power supply.

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2.8.3. Evacuation lighting, such as evacuation marker lights, at a height of no more than 15 m, shall be provided to guide tunnel users to evacuate the tunnel on foot, in the event of emergency.

2.9. Ventilation

2.9.1. The design, construction and operation of the ventilation system shall take into account:

- the control of pollutants emitted by road vehicles, under normal and peak traffic flow,
- the control of pollutants emitted by road vehicles where traffic is stopped due to an incident or an accident,
- the control of heat and smoke in the event of a fire.

2.9.2. A mechanical ventilation system shall be installed in all tunnels longer than 150 m.

2.9.3. In tunnels with bi-directional and/or congested unidirectional traffic, longitudinal ventilation shall be allowed only if a risk analysis shows it is acceptable and/or specific measures are taken, such as appropriate traffic management, shorter emergency exit distances, smoke exhausts at intervals.

2.9.4. Transverse or semi-transverse ventilation systems shall be used in tunnels where a mechanical ventilation system is necessary and longitudinal ventilation is not allowed under **point 2.9.3**. These systems must be capable of evacuating smoke in the event of a fire.

2.9.5. For tunnels with bi-directional traffic, with a traffic volume higher than 2000 vehicles per lane, longer than 3000m and with a control centre and transverse and/or semi-transverse ventilation, the following minimum measures shall be taken as regards ventilation:

- air and smoke extraction dampers shall be installed which can be operated separately or in groups,
- the longitudinal air velocity shall be monitored constantly and the steering process of the ventilation system (dampers, fans, etc.) adjusted accordingly.

2.10. Emergency stations

2.10.1. Emergency stations are intended to provide various items of safety equipment, in particular emergency telephones and extinguishers, but are not intended to protect road users from the effects of fire.

2.10.2. Emergency stations can consist of a box on the sidewall or preferably a recess in the sidewall. They shall be equipped with at least an emergency telephone and two fire extinguishers.

2.10.3. Emergency stations shall be provided near the portals and inside at intervals which for new tunnels shall not exceed 150 m.

2.11. Water supply

2.11. A water supply shall be provided for all tunnels. Hydrants shall be provided near the portals and inside at intervals which **shall not exceed 250 m**. If a water supply is not available, it is mandatory to verify that sufficient water is provided otherwise.

2.12. Road signs

2.12.1 Specific signs shall be used for all safety facilities provided for tunnel users. Signs and panels for use in tunnels are given in Annex III.

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2.13. Control centre

2.13.1. A control centre shall be provided for all tunnels longer than 3000 m with a traffic volume higher than 2000 vehicles per lane.

2.14. Monitoring systems

2.14.1. Video monitoring systems and a system able to automatically detect traffic incidents (such as stopping vehicles) and/or fires shall be installed in all tunnels with a control centre.

2.14.2. Automatic fire detection systems shall be installed in all tunnels which do not have a control centre where the operation of mechanical ventilation for smoke control is different from the automatic operation of ventilation for the control of pollutants.

2.15. Tunnel closing equipment

2.15.1. In all tunnels longer than 1000 m, traffic signals shall be installed before the entrances so that the tunnel can be closed in case of an emergency. Additional means, such as variable message signs and barriers, can be provided to ensure that instructions are obeyed.

2.15.2. Inside all tunnels longer than 3000 m, with a control centre and a traffic volume higher than 2000 vehicles per lane, equipment to stop vehicles in the event of an emergency is recommended at intervals not exceeding 1000 m. This equipment shall consist of traffic signals and possibly additional means, such as loudspeakers, variable message signs and barriers.

2.16. Communication systems

2.16.1. Radio re-broadcasting equipment for emergency service use shall be installed in all tunnels longer than 1000 m with a traffic volume higher than 2000 vehicles per lane.

2.16.2. Where there is a control centre, it must be possible to interrupt radio re-broadcasting of channels intended for tunnel users, if available, in order to give emergency messages.

2.16.3. Shelters and other facilities where evacuating tunnel users must wait before they can reach the outside shall be equipped with loudspeakers for the provision of information to users.

2.17. Power supply and electrical circuits

2.17.1. All tunnels shall have an emergency power supply capable of ensuring the operation of safety equipment indispensable for evacuation until all users have evacuated the tunnel.

2.17.2. Electrical, measurement and control circuits shall be designed in such a way that a local failure, such as one due to a fire, does not affect unimpaired circuits.

2.18. Fire resistance of equipment

2.18.1 The level of fire resistance of all tunnel equipment shall take into account the technological possibilities and aim at maintaining the necessary safety functions in the event of a fire.

2.19. Table displaying informative summary of minimum requirements

The table set out hereafter gives a summary of the minimum requirements laid down in the previous paragraphs. The minimum requirements are those set out in the operative text of this table A,B,C.

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Table A

Summary of Minimum Requirements		Clause	Traffic ≤ 2000 veh. per lane			Traffic > 2000 vehicles per lane				Additional conditions for implementation to be mandatory, or comments
			<150m	150-1000m	>1000m	<150m	150-1000m	1000-3000m	>3000m	
Structural Measures	2 tubes or more	2.1	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory where a 15-year forecast shows that traffic > 10000 veh./lane.
	Gradient ≤ 4%	2.2	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory unless not geographically possible
	Emergency Walkways	2.3	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory where there is no emergency lane, unless the condition in §2.3.1 is respected. In existing tunnels where there is neither an emergency lane, nor an emergency walkway additional / reinforced measures shall be taken.
	Emergency exists at least every 500m	2.3	⊖	⊖	Δ	Δ	Δ	Δ	Δ	Implementation of emergency exits in existing tunnels to be evaluated case-by-case.
	Cross connections for emergency services at least every 1500m	2.4.1	⊖	⊖ / ◇	⊖ / ◇	⊖	⊖	⊖ / ◇	◇	Mandatory in twin-tube tunnels longer than 1500 m.
	Crossing of the central reserve outside each portal	2.4.2	◇	◇	◇	◇	◇	◇	◇	Mandatory outside twin- or multi-tube tunnels wherever geographically possible.
	Lay-bys at least every 750m	2.5	⊖	⊖	⊖	⊖	⊖	⊖ / ◇	⊖ / ◇	Mandatory in new bi-directional tunnels >1500 m without emergency lanes. In existing bi-directional tunnels >1500 m: depending on analysis. Tunnels, depending on extra usable tunnel width.
	Drainage fro flammable and toxic liquids	2.6	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Mandatory where transport of dangerous goods is allowed.
	Fire resistance of structures	2.7	◇	◇	◇	◇	◇	◇	◇	Mandatory where a local collapse can have catastrophic consequences.

Δ Mandatory with exceptions

◇ Mandatory for all tunnels

⊖ Not Mandatory

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Table B

Summary of Minimum Requirements		Clause	Traffic ≤ 2000 veh. per lane			Traffic > 2000 vehicles per lane				Additional conditions for implementation to be mandatory, or comments
			<150m	150-1000m	>1000m	<150m	150-1000m	1000-3000m	>3000m	
Lighting	Normal Lighting	2.8.1	⊖	◇	◇	⊖	◇	◇	◇	
	Safety Lighting	2.8.2	⊖	◇	◇	⊖	◇	◇	◇	
	Evacuation Lighting	2.8.3	⊖	◇	◇	⊖	◇	◇	◇	
Ventilation	Mechanical Ventilation	2.9	⊖	⊖	⊖	⊖	⊖	◇	◇	
	Special Provisions for (Semi-) transverse ventilation	2.9.5	⊖	⊖	⊖	⊖	⊖	⊖	◇	Mandatory in bi-directional tunnels where there is a control centre.
Emergency	At least every 150m	2.10	⊖	Δ	Δ	⊖	Δ	Δ	Δ	Equipped with telephone and 2 extinguishers. A maximum interval of 250 m is allowed in existing tunnels.
Water Supply	At least every 250m	2.11	⊖	◇	◇	⊖	◇	◇	◇	If not available, mandatory to provide sufficient water otherwise.
Road Signs		2.12	⊖	◇	◇	⊖	◇	◇	◇	For all safety facilities provided for tunnel users
Control Center		2.13	⊖	⊖	⊖	⊖	⊖	⊖	◇	Surveillance of several tunnels may be centralised into a single control centre
Monitoring Systems	Video	2.14	⊖	⊖	⊖	⊖	⊖	⊖	◇	Mandatory where there is a control centre.
	Automatic incident detection and / or fire detection	2.14	⊖	◇	◇	⊖	◇	◇	◇	At least one of the two systems is mandatory in tunnels with a control centre.
Equipments to close the tunnel	Traffic signals before the entrances	2.15.1	◇	◇	◇	◇	◇	◇	◇	
	Traffic signals inside the tunnel at least every 1000m	2.15.2	⊖	⊖	◇	⊖	⊖	◇	◇	Recommended if there is a control centre and the length exceeds 3 000 m.

Δ Mandatory with exceptions

◇ Mandatory for all tunnels

⊖ Not Mandatory

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Table C

Summary of Minimum Requirements		Clause	Traffic ≤ 2000 veh. per lane			Traffic > 2000 vehicles per lane				Additional conditions for implementation to be mandatory, or comments
			<150m	150-1000m	>1000m	<150m	150-1000m	1000-3000m	>3000m	
Communication Systems	Radio Re-broadcasting for emergency services	2.16.1	⊖	⊖	⊖	⊖	⊖	◇	◇	
	Emergency radio messages for tunnel users	2.16.2	⊖	◇	◇	⊖	◇	◇	◇	Mandatory where radio is re-broadcasted for tunnel users and where there is a control centre
	Loudspeakers in shelters	2.16.3	⊖	◇	◇	⊖	◇	◇	◇	Mandatory where evacuating users must wait before they can reach the outside.
Emergency Poser Supply		2.17	⊖	◇	◇	⊖	◇	◇	◇	To ensure the functioning of indispensable safety equipment at least at during evacuation of tunnel users.
Fire Resistance of Equipments		2.18	⊖	◇	◇	⊖	◇	◇	◇	Shall aim to maintain the necessary safety functions

Δ Mandatory with exceptions

◇ Mandatory for all tunnels

⊖ Not Mandatory

3. Measures concerning operations

3.1. Operating means

Tunnel operation shall be organised and dispose of such means as will ensure the continuity and safety of the traffic through the tunnel. The personnel involved in the operation as well as the emergency services shall receive appropriate initial and continuing training.

3.2. Works in tunnels

Complete or partial closure of lanes due to construction or maintenance works planned in advance shall always begin outside the tunnel. Variable message signs, traffic signals and mechanical barriers may be used for this purpose.

3.3. Management of accidents and incidents

In the event of a serious accident or incident, all appropriate tunnel tubes shall be closed immediately to traffic.

This shall be done by simultaneous activation not only of the abovementioned equipment before the portals, but also of variable message signs, traffic signals and mechanical barriers inside the tunnel, if available, so that all the traffic can be stopped as soon as possible outside and inside the tunnel. Tunnels of less than 1000 m may be closed by other means. Traffic shall be managed in such a way that unaffected vehicles can quickly leave the tunnel.

The access time for emergency services in the event of an incident in a tunnel shall be as short as possible and shall be measured during periodic exercises. In addition, it may be measured during incidents. In major bi-directional tunnels with high traffic volumes, a risk analysis shall establish whether emergency services shall be stationed at the two extremities of the tunnel.

3.4. Activity of the control centre

For all tunnels requiring a control centre, including those starting and finishing, a single control centre shall have full control at any given time.

3.5. Tunnel closure

In the event of tunnel closure (long or short-term), users shall be informed of the best alternative itineraries, by means of easily accessible information systems.

Such alternative itineraries shall form part of systematic contingency plans. They should aim to maintain traffic flow as much as possible and minimise secondary safety effects on the surrounding areas.

The Contractor should make all reasonable efforts to avoid a situation.

3.7. Transport of dangerous goods

The following measures shall be applied concerning access to tunnels for vehicles transporting dangerous goods, as defined in the relevant Nepal legislation regarding the transport of dangerous goods by road:

- perform a risk analysis before the regulations and requirements regarding the transportation of dangerous goods through a tunnel are defined or modified,
- place appropriate signs to enforce the regulation before the last possible exit before the tunnel and at tunnel entrances, as well as in advance so as to allow drivers to choose alternative routes,

- consider specific operating measures designed to reduce the risks related to some or all of the vehicles transporting dangerous goods in tunnels, such as declaration before entering or passage in convoys escorted by accompanying vehicles, on a case by case basis further to the aforementioned risk analysis.

3.8. Overtaking in tunnels

A risk analysis shall be carried out in order to decide whether heavy goods vehicles should be allowed to overtake in tunnels with more than one lane in each direction.

3.9. Distances between vehicles and speed

The appropriate speed of vehicles and the safe distance between them are especially important in tunnels and shall be given close attention. This shall include advising tunnel users of appropriate speeds and distances. Enforcement measures shall be initiated as appropriate.

Road users driving passenger cars should under normal conditions maintain a minimum distance from the vehicle in front of them equivalent to the distance travelled by a vehicle in **2 seconds**. For heavy goods vehicles, this distance should be doubled.

When traffic stops in a tunnel, road users should maintain a minimum distance of 5 metres from the vehicle in front, except if this is not possible due to an emergency stop.

3.10. Key Personnel

3.10.1 Tunnel Manager

For each tunnel, whether it is in the design, construction or operating stage, the Contractor shall appoint a Tunnel Manager responsible for the management of the tunnel at the stage in question.

Any significant incident or accident occurring in a tunnel shall be the subject of an incident report prepared by the Tunnel Manager. This report shall be forwarded to the Safety Officer, to the Employer and to the emergency services within a maximum period of one month.

Where an investigation report is drawn up analysing the circumstances of the incident or accident or the conclusions that can be drawn from it, the Tunnel Manager shall forward this report to the Safety Officer, the Employer and the emergency services no later than one month after he receives it himself.

3.10.2 Safety Officer

For each tunnel, the Tunnel Manager shall, with the prior approval of the Employer, nominate one Safety Officer who shall coordinate all preventive and safeguards measures to ensure the safety of users and operational staff. The Safety Officer may be a member of the tunnel staff or the emergency services, shall be independent in all road tunnel safety issues and shall not be under instructions from an employer in respect of those issues.

The Safety Officer shall perform the following tasks/functions:

- ensure coordination with emergency services and take part in the preparation of operational schemes;
- take part in the planning, implementation and evaluation of emergency operations;

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- (c) take part in the definition of safety schemes and the specification of the structure, equipment and operation in respect of tunnels;
- (d) verify that operational staff and emergency services are trained, and he shall take part in the organisation of exercises held at regular intervals;
- (e) give advice on the commissioning of the structure, equipment and operation of tunnels;
- (f) verify that the tunnel structure and equipment are maintained and repaired;
- (g) take part in the evaluation of any significant incident or accident

3.11. Inspection Entity

The Employer shall perform the inspections, evaluations and tests. Any team/person performing the inspections, evaluations and tests must have a high level of competence and high quality procedures and must be functionally independent from the Tunnel Manager.

3.12 Commissioning

3.12.1. The initial opening of a tunnel to public traffic shall be subject to authorization by the Employer in accordance with the following procedure.

3.12.2. The Tunnel Manager shall transmit the safety documentation to the Safety Officer, who shall give his opinion on the opening of the tunnel to public traffic.

The safety documentation shall describe the preventive and safeguard measures needed to ensure the safety of users, taking into account people with reduced mobility and disabled people, the nature of the route, the configuration of the structure, its surroundings, the nature of the traffic and the scope for action by the emergency services of the **Specification**.

3.12.3. The Tunnel Manager shall forward this safety documentation to the Employer, and shall attach the opinion of the Safety Officer. The Employer shall decide whether or not to authorize the opening of the tunnel to public traffic, or whether to do so with restrictive conditions, and shall notify this to the Tunnel Manager. A copy of this decision shall be forwarded to the emergency services.

3.12.4 Modifications

For any substantial modification in the structure, equipment or operation, which might significantly alter any of the constituent components of the safety documentation, the Tunnel Manager shall ask for a new authorisation of operation following the procedure described under **point 3.12.2 & 3.12.3**.

The Tunnel Manager shall inform the Safety Officer of any other change in construction and operation. Furthermore, prior to any modification work on the tunnel, the Tunnel Manager shall provide the Safety Officer with documentation detailing the proposals.

The Safety Officer shall examine the consequences of the modification and in any event give his opinion to the Tunnel Manager, who shall send a copy to the Administrative Authority and to the emergency services.

3.13. Signing for tunnels

3.13.1 General requirements

The following are road signs and symbols to be used for tunnels. Road signs mentioned in this section are described in the **Vienna Convention on Road Signs and Signals of 1968**, unless otherwise specified.

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In order to facilitate international understanding of signs, the system of signs and signals is based on the use of shapes and colours characteristic of each class of sign and, wherever possible, on the use of graphic symbols rather than words.

Road signs shall be used to designate the following safety facilities in tunnels:

Lay-bys;

Emergency exits: the same sign shall be used for all kinds of emergency exits;

Escape routes: the two nearest emergency exits shall be signed on the sidewalls at distances of no more than 25 m, at a height of 1,0 to 1,5 m above escape route level, with an indication of the distances to the exits;

Emergency stations: signs to indicate the presence of emergency phones and fire extinguishers.

Radio: In tunnels where users can receive information via their radio, appropriate signs placed before the entrance shall inform users on how to receive this information.

Signs and markings shall be designed and positioned so that they are clearly visible.

3.13.2 Description of signs and panels

The contractor shall use appropriate signs, if necessary, in the advance warning area of the tunnel, inside the tunnel and after the end of the tunnel. When designing the signs for a tunnel, local traffic and construction conditions as well as other local conditions shall be considered. **Signs according to the Vienna Convention on Road Signs and Signals.**

3.13.2.1 Tunnel sign



The following sign shall be put at each entrance of the tunnel:

Sign E11A for Road Tunnels of the Vienna Convention; The length shall be included either in the lower part of the panel or on a additional panel H2.

For tunnels over 3 000 m, the remaining length of the tunnel shall be indicated every 1000 m.

The name of the tunnel may also be indicated.

3.13.2.2. Horizontal signing

Horizontal delineation should be used at the roadside edge.

In the case of bi-directional tunnels, clearly visible means should be used along the median line (single or twin) separating the two directions.

3.13.2.3. Signs and panels for signing of facilities

Emergency stations

Emergency stations shall bear informative signs, which shall be F signs according to the Vienna Convention and indicate the equipment available to road users, such as:

Emergency telephone



Extinguisher



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In emergency stations which are separated from the tunnel by a door, a clearly legible text, written in appropriate languages, shall indicate that the emergency station does not ensure protection in case of fire. An example is given below:

"THIS AREA DOES NOT PROVIDE PROTECTION FROM FIRE

Follow signs to emergency exits"

Lay-bys

The signs to indicate lay-bys should be E signs according to the Vienna Convention. Telephones and fire extinguishers shall be indicated by an additional panel or incorporated in the sign itself.



Emergency exits

The signs to indicate "Emergency exits" should be G signs according to the Vienna Convention. Examples are shown below:



It is also necessary to sign the two nearest exits on the sidewalls. Examples are shown below.



Lane signals

These signs can be circular or rectangular



Variable message signing

Any variable message signs shall have clear indications to inform tunnel users of congestion, breakdown, accident, fire or any other hazards.

4.0 Requirements during Construction

4.1 General Requirements

4.1.1 Safety of Personnel

Safety of personnel on the Site is the first priority above all in all construction activities. The Contractor shall vigilantly observe the requirements described hereunder. Rules and regulations currently effective under the laws of Nepal or bylaws imposed by the local authorities shall prevail in the event of disagreement.

Suitable Personal Protective Equipment (PPE) shall be provided to all persons permitted to be on site. PPE including head protection, respiratory protection, eye protection, reflective vest, etc. shall be of the type approved by the local authorities.

The Contractor shall prepare a written statement (a booklet) of safe systems of working which shall be issued to all persons at site.

4.1.1.1 Safety Training

Persons when first employed on the Site shall be instructed in the hazards inherent in the Site, precautions to be taken, the form of construction, and emergency procedures and firefighting. The Contractor shall maintain a record of all persons on assignments and each person shall be required to sign such record confirming that instruction has been received.

In addition, the Contractor is required to hold a daily toolbox talk before entering into tunnels with the aim of promulgating the inherent risks related to the activities scheduled on the day. The toolbox talk shall be conducted by each ganger in charge of particular activities. The record of assignment mentioned above can be logged at the end of such toolbox meeting before starting the given assignments.

4.1.1.2 Fire Prevention and firefighting Arrangements

Fire protection and proper firefighting arrangements such as fire extinguishers shall be provided on the tunnelling machines, other than machines which are too small to allow personal entry. Similar arrangement shall be provided when operations may emit potentially noxious gases or fumes in addition to ventilation arrangements stated hereinafter.

4.1.2 Temporary Electrical Installations

Unless specified in the Contract, the Contractor shall be responsible for obtaining an adequate electrical supply for all his Site operations.

Installations shall comply with the current edition of the rules and regulations of the local authorities. If required by the Engineer, the Contractor shall make available a copy of all certificates prepared upon completion of electrical installations.

The Contractor shall appoint a competent person to be solely responsible for ensuring the safety of all temporary electrical installations,

4.1.2.1 Ventilation during Construction

Constant supply of high quality breathable air is one of the more challenging safety aspects for tunnel workers. The Contractor shall provide a suitable ventilation system to remove dust caused by drill/blast and shotcrete as well as exhaust gases emitted from diesel engines during construction to comply with the requirements specified in clause 4.2 and Articles 86 [Ventilation] and 89 [Safety and Health] of Standard Specification for Tunnelling – 2006: Mountain Tunnels or as specified in referred codes/standards. The ventilation rate that is required to dilute the gas emissions from diesel engines of construction machines

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and dust produced during drill/blast and shotcrete application should be calculated taking account of type and numbers of equipment used inside tunnels.

For safe working of persons in the tunnels, the Contractor shall use the following limit values in calculating the total fresh air requirement at the face area;

- (a) The minimum fresh air supply shall not be less than 3 m³/minute/person measured at the face,
- (b) The target dust (respiratory dust) concentration should be not more than 3 mg/m³ measured at 50 m from the face,
- (c) The minimum air velocity throughout the tunnels shall not be less than 0.3 m/second, and
- (d) The maximum ambient temperature inside the tunnels shall be maintained below 30 degrees centigrade.

The Contractor shall, as a means of achieving the above values, determine the diameter of air piping and the capacity of fans, considering ventilation efficiency, machine efficiency and dimensions of profiles.

As drill/blast and shotcrete application take place at the face area, the Contractor will be required to provide a mobile dust collector attached extensible air duct at each tunnel face in order to achieve the limit value of the dust concentration.

For monitoring of the ventilation requirements, the Contractor shall provide necessary measuring devices to the satisfaction of the Engineer.

The Contractor shall submit a layout plan of his ventilation systems including dust collection systems along with a calculation of required fresh air supply for agreement with the Engineer before commencing tunnel excavation.

4.1.2.1 Lighting during Construction

Suitable and sufficient lighting shall be provided in working places and pathways, so as to secure safe working environments. Working places such as the face need sufficient light that should exceed seventy (70) lux (1 lux = 1 lumen per square meter) in order that the work can be performed safely and efficiently.

It is also necessary to light walkway areas for the safe passage of workers and the safe operation of vehicles. It may be difficult to secure uniform light in the whole walkway areas, but the light of a minimum of ten (10) lux is necessary at the darkest site and twenty (20) lux in average is desired as recommended in Article 85 [Lighting] of Standard Specifications for Tunnelling – 2006: Mountain Tunnels.

4.1.3 Security and Access Restriction

The Contractor shall be responsible for the security and tunnel entry in and around all tunnels work areas. Tunnel security and exit/entry procedures and controls shall be detailed in the Contractor's safety plan (or health and safety plan) for the Works. The Contractor shall co-ordinate and plan tunnel security and entry with others having access to the tunnels, including all interfacing contractors, so as not to disrupt or interfere with their operations.

The Contractor shall provide and maintain fences and barricades in good conditions. Notice signs shall be displayed at intervals (as consented by the Engineer) around the Site and portal areas to warn the public of the dangers of entrance.

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During the progress of the Works the Contractor shall maintain security patrols over the portal areas of the Works as may be necessary to protect the work and prevent trespassing.

4.1.4 Entry/Exit Procedures

The Contractor shall establish a procedure for recording all tunnel entry and exits, preventing unauthorized tunnel entry. This procedure, as a minimum, shall incorporate name cards and entry/exit records at all tunnel portals to record the entrance and exit of all personnel.

The Contractor shall set up and operate a system whereby only those persons entitled to be on the Site and/or in the tunnels can enter the Site and/or tunnel. The Contractor shall provide specific points of entry through a security fence or barricade. The Contractor shall provide gates and barriers at such points of entry and maintain a twenty-four-hour security guard or other security personnel as necessary to maintain security and prevent unauthorized entry

4.1.5 Temporary Communication Systems

The Contractor shall provide both a complete wired and a wireless telephone communication system capable of providing clear and concise communication between all tunnel works and the tunnel portals. The communication systems shall also provide for communication between the tunnel works, Contractor's site office, and Employer's and Engineer's site offices.

The Contractor shall maintain at all times both wired and wireless communication systems in full working order during construction. The communication systems and equipment shall be suitable for use in all area, providing clear and dependable communication. This shall be subject to approval by relevant authority prior to use as the case may be.

The communication systems shall incorporate underground communication stations (telephone receptacle with bell and Indication lamp) within 50-metre of any work and at 100-meter intervals along the driven tunnel. The Contractor shall provide and maintain communication systems until the completion and acceptance of all tunnel works or as otherwise required by the Engineer.

4.1.6 Daily Records/Reports

- (a) Notwithstanding reports on other work activities, the Contractor shall prepare daily records and reports of all tunnel works that shall include the following information and data, or as directed by the Engineer.
- ◆ duration of sequential excavation,
 - ◆ all personnel working in tunnel areas,
 - ◆ work stoppage, with reason for stopping work,
 - ◆ all instrument recordings with appropriate graphs,
 - ◆ weather conditions,
 - ◆ tunnel work equipment,
 - ◆ tunnel water inflows,
 - ◆ size of excavated sections,
 - ◆ length of advance,
 - ◆ station numbers,
 - ◆ photographs (not less than 12 Megapixels) of all tunnel faces after excavation, before support system installation,
 - ◆ the location and number of supports system members etc. for each round, and
 - ◆ reports and records required under specific specification requirements.

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- (b) Unless agreed with the Engineer, the Contractors daily records/report shall be submitted to the Engineer before 10 AM on the following working day, and
- (c) The Contractor shall, as witnessed in the presence of the Engineer, record in detail geological conditions and prepare geological maps with necessary photographs attached to evaluate the suitability of excavation methods and supports. These details and maps shall serve as the basis for anticipating geological conditions ahead of the excavated tunnel face.
- (d) The Contractor shall immediately notify the Engineer in case of substantial difference between actual geological conditions and anticipated ones, or when severe changes in geological conditions are observed.
- (e) For the recording of geological data by the Engineer, the Contractor shall give all necessary assistance, and provide all workforce, facilities and equipment as may be required by the Engineer.

4.2 Safety, Hygiene and Environment Protection

- (a) The Contractor shall comply with the relevant laws and regulations including laws in relation to health and safety of all persons entitled to be on the Site, particularly in confined working areas such as the tunnels. *Safety and health in underground coalmines, ILO code of practice Geneva, International Labour Office, 2009 and Underground Construction (Tunneling), OSHA 3115-06R 2003, Occupational Safety and Health Administration; may be considered as reference Occupational Safety and Health guidance.*
- (b) The Contractor shall provide temporary facilities to reduce blasting noise to the threshold value imposed by the Government of Nepal (GoN).
- (c) The Contractor shall minimise physical harm caused by construction vibration that impairs the value, usefulness, or normal function of properties of the nearby residents
- (d) It is strongly recommended that the Contractor performs inventory surveys of the properties and maintain photo records before any blasting takes place.
- (e) The Contractor shall establish a regular air monitoring scheme through which content of oxygen and noxious gases, in particular carbon dioxide, in tunnels.
- (f) The Contractor shall assign a competent person to perform air monitoring required to determine proper ventilation and quantitative measurement of potentially hazardous gasses.
- (g) The objective of monitoring the atmosphere in a tunnel is to ensure that it is free from levels of toxicants and that it contains sufficient oxygen for persons to breath.
- (h) Routine checking/monitoring of oxygen and other noxious gases at every place where persons normally work or travel is a primary requirement in underground operations.

Entering into tunnels shall be prohibited if the oxygen level in the air is below 18%(*a) and the carbon dioxide level exceeds 0.5% (5000ppm) (*b).

The oxygen level in the tunnel air body should be monitored at each shift before other gas samples are taken

(*a), (*b): TLV-TWA (Threshold Limit Value - Time weighted Average) recommended by American Conference of Governmental Industrial Hygienists (ACGIH)

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- (i) Unless the local authorities/GoN provide regulations related to entry to the tunnel, the following threshold points should be strictly observed until safe working condition is confirmed by the person in charge of monitoring. Checking of these gas concentrations shall be performed at every working shifts. If required under the local regulations, the Contractor shall obtain proper approvals in writing from the local authorities/GoN for the gas detectors that the Contractor intends to use. Otherwise, the Contractor shall obtain the Engineer's agreement for the use of such gas detectors before commencing tunnel excavation.\
- (j) The Contractor is responsible to disseminate the tunnel safety procedures among all persons entitled to be on the Site, including the Employer's Personnel.
- (k) The Contractor shall construct, operate and maintain sedimentation systems complying to the environmental codes and regulations of the local authorities/GoN/GoN. The Contractor shall also observe the following requirements.
- i) The sedimentation system shall be provided as close to the portal area as possible with at least two settlement ponds divided by the biological filters or as recommended/instructed by the local authorities/GoN.

Gas (Symbol)	Density (kg/m ³)	Physical Properties	Harmful Effects	Primary Source	TLV-TWA* ¹ (ppm)
Carbon Dioxide (CO ₂)	1.53	colourless, odourless, slight acid taste	asphyxiant, increased respiration	strata, breathing, oxidation processes	5,000
Carbon Monoxide (CO)	0.97	colourless, odourless, tasteless	toxic, explosive	fire, explosion, IC engines	25
Hydrogene Sulfide (H ₂ S)	1.54	colourless, rotten egg odour, acid taste	toxic, explosive	strata, stagnant water	10
Sulphur Dioxide (SO ₂)	2.26	colourless, irritating, acid taste	toxic	oxidation of sulphide ore IC engines	2
Nitrogen Dioxide (NO ₂)	1.59	irritating odour, red-brown colour bitter	toxic	blasting, IC engines	3
Nitrogen Monoxide (NO)	1.04	irritating odour, red-brown colour bitter	toxic	blasting, IC engines	25

*¹ : TLV-TWA (Threshold Limit Value - Time Weighted Average); it is the time weighted average concentration for a normal 8-hour workday without adverse effect **Source - American Conference of Governmental Industrial Hygienists (ACGIH) J**

- ii) All ground water emanating from tunnel excavation shall be discharged into these settlement ponds, to remove oil, sand, silt and other suspended matter.
- iii) A neutralizing agent and a sedimentation accelerating agent, either in liquid form or in powder form, shall be added to the contaminated water before discharging into the settlement ponds. The chemicals to be used shall conform to the laws and regulation of the relevant local authorities/GoN.
- iv) The inlet to the ponds shall be designed so that water discharged into the pond will not stir up sediment previously deposited in that pond. Provision shall be made for the ability to repair or clean the pond during the progress of the Works.
- v) The outflow from each settlement pond shall be so arranged as to prevent any floating oil from leaving the pond, irrespective of the volume of water entering the pond. The settlement pond shall be constructed using suitable watertight materials, and lined with PVC membrane or similar material to prevent leakage. Wire mesh fencing of 2 meters minimum height shall be installed around the perimeter of the ponds to prevent unauthorized access.
- vi) The outflow channel from the pond shall be designed and constructed to the satisfaction of the Engineer and in such a manner that soil erosion is prevented.

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- vii) To ensure the continuing satisfactory operation of the system, the Contractor shall remove accumulations of sand, silt, oil and sludge must be removed and disposed of at the locations approved by the Engineer.
- viii) Natural ground water and storm water from areas outside the immediate area of the Contractor' activities must be prevented from flowing into the pond. The Contractor shall ensure that any diversion berms or drain protecting ponds constructed below ground are adequately maintained.
- ix) Temporary drains or pipelines leading from the tunnel portal to the sedimentation ponds shall be designed to adequately handle the expected maximum initial flow of tunnel. In no case shall be less than 2.5 cubic meter per minute.
- x) The Contractor may, upon approval by the Engineer, employ mechanical facilities to treat water, in lieu of settlement ponds at no additional cost to the Employer.