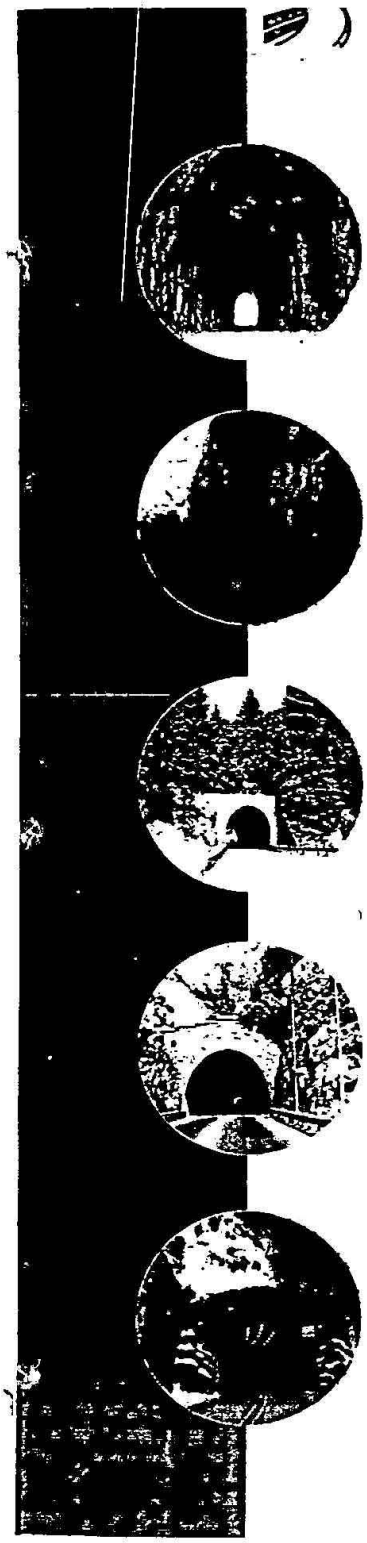

NATIONAL HIGHWAYS AUTHORITY OF INDIA

Consultancy Services for Preparation of Feasibility Study and Detail Project Report for Four Laning of the Section from Udhampur to Banihal, km 66 to km 188 of NH-1A (C-III/25,23)

Detailed Project Report

Volume - III : Electro - Mechanical Report
Package No. - NS-99A/J&K (Km 89 - 130)

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Gyanani Nashri Tunnelway Limited

PATNITOP TUNNEL

Tunnel Operation, Control, Safety and E/M Concept Report

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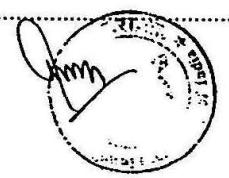

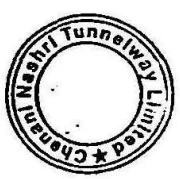

T. Tunnel Operation Safety and Traffic Control Section

Patnitop tunnel is designed as a bidirectional road tunnel on NH-1A national highway between Udhampur and Banihal of approx. 9,2 km length. With this length the tunnel, when constructed, would become the longest road tunnel in SE Asia. Therefore state-of-the-art solutions for tunnel operation and control are proposed in this stage of project preparation in order to guarantee adequate safety of the tunnel operation.

General system solutions are proposed and function descriptions provided at this stage, however, it is assumed that development in this field is very fast. Therefore detail specification for individual technical equipments as well as detail design should be provided as close to realization as practical. Considering construction time for the tunnel to be approx. 5 years, it seems reasonable to start with tender design earliest 2 years after tunnel construction would commence.

General tunnel data

The tunnel is 9,2 km long, cross sectional area provides 9,35m x 5m traffic area clearance. Carriageway width is enabling uninterrupted (reduced speed) traffic flow in case of a car break and is uniform with the other long tunnel on NH-1A under Pir Panjal mountain range. Parallel to the main traffic tunnel there is smaller escape tunnel of 2,5 x 2,5m clearance serving as emergency escape way as well as for tunnel maintenance and rescue operation purposes.

Cross adits between the main tunnel and escape tunnel are located at 300 m distances, emergency lay-bays in 600 m distance staggered on both sides of the carriageway, emergency call niches at 150m distance at both tunnel sides and fire fighting niches at 150 m distance on right tunnel side (station direction form South to North). There are 1m wide sidewalks on both sides of the carriageway.

Tunnel ventilation system is foreseen as a fully transversal one, supplied with fresh air from portal locations only.

T.1.0 Integrated Tunnel Control System

Functional Description

The Integrated tunnel control system (SCADA - Supervisory Control and Data Acquisition) serves to status monitoring of all tunnel technical systems, to automatic eventually manual telecontrol of them. It is realised by one integrated control programme which is implemented in main control PLC (Programmable Logical Control) stations. The system records all the states of monitored elements and all the activities and faults. The

system provides all appropriate data for MMI – Machine Man Interface, which will be realised by servers and monitors.

There shall be built-up **two control centres** by both portals of the tunnel. The operator's workplaces will make possible the operation of the tunnel technical accessories in the same range. Their function shall be identical. One of them shall be appointed for permanent attendance, the second one shall be stand-by operator's workplace, without permanent attendance.

The system shall operate and supervise following subsystems of Patnitop Tunnel:

- the proper tunnel control system – auto-diagnostic of all the control equipment, data acquisition and telecommunication elements;
- traffic control system;
- power supply system;
- ventilation system;
- lighting system;
- communication system;
- tunnel safety equipment;
- electrical fire signalling system;
- emergency call system;
- video surveillance system.

Other civil works control systems shall be parts of integrated tunnel control system as e.g. fire water reservoirs, air conditioning systems, etc.

Basic Specifications

Design

The control system is composed from two main PLC stations with implementation of identical integrated control programmes and several PLC field substations in which are not implemented control programmes. **The main PLC stations** shall operate in a hot stand-by (automatic back-jump) mode of operation. One main PLC station shall operate above all the systems and shall constantly communicate with the second main PLC station, which is situated in a building by the second tunnel portal. By a failure of the first main PLC station will the second one undertake its activity without any disturbance to control process.

The PLC substations with Input/Output modules shall be distributed near controlled elements above mentioned systems. There shall be implemented serial communication interface in execution of metallic field bus.

The main stations shall be connected in return and with the substations by double ring industrial bus in execution of optical cables. Tracing of two lines of one ring industrial bus shall not be the same from the safety reason. The control system shall alone analyse any communication fault and then shall opt for the new optimal transmission path without interruption of control and data acquisition process.

Operator's workplaces shall be equipped with two servers for providing of visualisation data to MMI. The two servers shall operate in a hot stand-by mode of operation.

Power supply to all the components of the integrated tunnel control system shall be executed by on-line UPS (Uninterruptible Power Supply) systems.

Civil Works

Design documentation for the construction has to regard cable traces and spaces for all the components of the tunnel control system.

Technical Accessories

Control system components; they should be of industrial execution produced by prestigious producers, e.g. GE-Fanuc, Siemens, Belden, etc.

Basic Graphical Description

See drawing No. ELT/ 01/ T.1.0 in the graphical enclosure hereinafter.

T.1.1 Local Control Centres

Functional Description

There shall be erected two control centres in technology buildings by southern and northern tunnel portals. One of them, the main local control centre shall be appointed for a non-stop attendance. The second one shall serve as a reserve one.

The reserve local control centre shall be equipped with only one terminal interactive monitor of the tunnel control system and only one monitor of the video surveillance system. From the reserve operator's workplace shall be possible full -value control and monitoring of tunnel traffic and operation of technical accessories.

The main local control centre shall be equipped with two terminal interactive monitors of the tunnel control system. It consists of two operator's workplaces for two persons of permanent service. The predestination of one of them shall be supervision of traffic, traffic control and operation of emergency services. The second one shall be

assigned for technology control and supervision of all the technical equipment. It further includes 6 monitors and two large-screen displays of the video surveillance system.

The local control centres further includes Electrical Fire Signalling Centrals, sound/visual alarm facilities (audible signalling device and warning light) and switchboards for emergency call system and for wireless communication / evacuative broadcasting systems with phonal input terminals. The switchboards of video surveillance system are also located in the local control centres.

The tunnel control system makes possible following **operator's activities**:

- watching of traffic status in overview diagram and detailed schematics;
- follow current traffic load and statistics;
- setting of variable message signs and traffic signals;
- watching of current status of technical systems and subsystems in overview diagrams and detailed schematics;
- watching of current status of select individual technical equipment in detailed schematics;
- observe of values of measured quantities, incl. history of them;
- command of functional aggregates and select individual equipment;
- generation of alarm signals which have arisen from a fire, traffic and technical equipment failures;
- follow of alarm statistics;
- entry to diaries of failures and emergency situations;
- generation of regular reports;
- overview of long-term traffic analysis;
- possibility to execute select systemic functions;
- monitoring of actual failures of technical equipment;
- monitoring and recording of historical development of failures withdrawing.

Basic Specifications

Design

The local control centres have to be designed by keeping all the ergonomical conditions, esp. as far as furniture, lighting and air conditioning are concerned. A comfortable rear area for the persons of the non-stop attendance is assumed.

The minimum size of the main control centre ground-plan shall be 60 sqm and for the reserve local control room the minimum value is 30 sqm. The sizes constitute also a reserve for other control terminals which could be installed for additional enlargement of the control system, e.g. for near traffic intersections or tunnels. The rear area could include small cooking place, a rest room and a cloak-room.

There is supposed an access control to the spaces of the local control centres.

Technical Accessories

Interactive terminal monitors: Size of 21"

Mode of operation: for all the system and subsystems from the interactive terminal monitors by using of electronic laser mouse and keyboard with exception of the terminals of the communication systems.

Basic Graphical Description

Examples of possible spatial solution of the Control centres are shown on drawings No. ELT/ 01/ T.1.1 No. ELT/ 01/ T.1.3 No. ELT/ 01/ T.1.4 in the graphical enclosure hereinafter.

T.1.2 Traffic Control System

Functional Description

Traffic control is operated by the integrated tunnel control system on basis of tunnel operator's interventions through interactive control system terminals. There shall be used following equipment for traffic control and influencing:

Traffic Signals

In case of emergency situations like a fire, a failure of power supply system, an accident, etc. the tunnel traffic shall be immediately closed. The **traffic lights three coloured** (TLTC) shall be used for closing the tunnel traffic and for a diversion of a tunnel traffic to the old route on crossroads before tunnel entrances. The amber light of the TLTC shall serve also as flashing warning signal (AFWL - see below) in exceptional traffic situations. Warning flashing of all the amber lights should be synchronized.

Variable Message Signs

Dynamic Road Information Panels (DRIP) providing textual messages in front of the tunnel are intended to inform drivers about traffic situation ahead traffic participants. The textual information shall be always executed in local language and in English. Certain information in the two languages will be displayed in rotation with a display time of one-lingual information of about 5 second. The textual information shall be complemented on the DRIP display by various traffic control symbols (VMS's) of directive, warning or information content.

See enclosed leaflet No. ELT/02/T.1.2.

The information about necessity of stopping of vehicle engines by an interrupt of traffic in the tunnel shall be given by the evacuative broadcasting as well.

In case of exceptional traffic situation like a vehicle breakdown, etc. vehicle speed should be limited by using of **Speed Limit Variable Message Signs** (SL), which shall be complemented by two **Amber Flashing Warning Lights** (AFWL).

See leaflet No. ELT/01/T.1.2.

SL Traffic signs combined with symbol of entryway prohibited are situated at the level of circular intersection exit for the tunnel entrance.

Entrance Variable Message Signs (EVS) with "Green Arrow", "Red Cross", "Crossover Yellow Arrow" and "One-way traffic - entryway prohibited" symbols support a tunnel closing, regular traffic operation and make possible automatic redirecting of the tunnel traffic.

Tunnel Variable Lane Signals (TLS) with "Red cross" and "Green Arrow" symbols shall be situated in traffic light signal sections above the middle of opposite direction traffic lane. The TLS will permanently signalling traffic prohibition by "Red Cross" symbol by standard tunnel operation.

Circular intersection **information signs with VMS** are assigned to inform drivers about tunnel through way prohibition. The embedded VMS represent the symbol of prohibited entryway in case of the tunnel shutdown. By standard traffic conditions there is not represented any symbol on VMS.

Luminous Traffic Signs

Luminous Traffic Signs (LTS) shall be used for marking of SOS boxes, escape exits to rescue cross adits and escape directions between escape exits inside the tunnel

tube. The LTSs for marking of SOS boxes shall be complemented by two AFWL for both traffic directions which will individually operate by opening the door of certain SOS box.

All the LTSs shall be permanently illuminated.

See drawing No. ELT/01/C.1.

Reflective Traffic Signs

Standing reflective traffic signs ("Overtaking Prohibition", "Switch Vehicle Lights On", "Switch Vehicle Lights Off", "Limits Cancelled", Transmitted Broadcasting Station Frequency and Name and Tunnel Name Plate) shall be located by standard regulations on outside public lighting poles.

Standing reflective traffic signs marking lay-bays ahead shall be installed in the tunnel tube in distance of 100 m in front of appropriate lay-bay. The distance shall be marked on the signs with descriptive number of individual lay-bay.

Other Traffic Control Equipment

Curbstone Lights (CL) with LED light sources shall be installed in sidewalk curbstone in distance of cca 25 m to accent carriageway limits to the drivers as traffic leading lighting.

See leaflet No. ELT/03/T.1.2.

Four **Traffic Counting Systems** (TCS) shall differentiate personal vehicles, wagon vehicles and trucks and will provide real time and historical statistics.

There shall be built two **Entrance Detection Control Systems** (EDCS) comprising Entrance Overheating Vehicle Control System (EOD) based on a thermovision detection principle, Entrance Smoking Vehicle Control System (ESD) based on a video-detection principle and Entrance Height Excessive Vehicle Control System (EHD) based on a light barrier detection principle. The EDCS's shall automatically stop unacceptable vehicles for tunnel traffic and decline them to the old road by using of Traffic Lights Three Coloured, with additional information to drivers which shall provide VMS's.

Besides, there will be installed rigid height barriers to physically prevent entering of oversized vehicles from entering the tunnel.

Mechanical barriers are assigned to support closing of the tunnel for traffic. Cross-bar of the mechanical barrier can be executed with horizontal or vertical working. It shall make possible a passage of rescue team vehicles by closing the tunnel.

Traffic safety inside the 9 km long Patnitop tunnel shall be significantly supported by recommendation of keeping minimum vehicle spacing by means of textual information provided by Dynamic Road Information Panels and by marking of **minimum vehicle spacing strokes** on road pavement inside the tunnel tube.

Basic Specifications

Design

The TLTC's shall be placed in front of the tunnel portals and at signal sections inside the tunnel tube with spacing of about 300 m at height of 2.5 m above emergency sidewalks. The diameter of one head lens of TLTC shall be 300 mm.

The DRIP's shall be placed in front of the tunnel portals (2 pieces) and in front of the places where drives could be declined to the old road aside the Patnitop Tunnel (next 2 pieces of DRIP's) in vicinity of the frame of Entrance Detection Control System (EDCS).

The SL's shall be placed in front of the tunnel portals and 50 m in front of signal sections for the TLTC inside the tunnel tube with spacing of about 600 m at height of 2.5 m above emergency sidewalks. The SL's shall be equipped with two AFWL whose flashing shall be synchronized with others AFWL in the tunnel tube and in front of the tunnel portals.

The EVS's are proposed to locate on outside entrance road gantries of a bridge type near the tunnel portals above centres of traffic lanes. There shall be located Traffic Counting Systems, Traffic Lights Three Coloured signal devices and rigid height barriers on the gantries.

The LTS's for marking of SOS boxes shall be positioned above or in font of SOS niches.

The LTS's for marking of escape exits shall be placed above fireproof doors of the exits.

The last mentioned LTS's for SOS boxes and emergency exits marking shall be executed as two-sided lighting (to both traffic directions).

The LTS's for marking of escape direction shall be placed on tunnel sides at height of 2.5 m above emergency sidewalks with spacing of about 50 m between emergency exits. The arrow of the signs will be pointed at the nearest escape exit. On every sign shall be marked a distance to the nearest exit (stated in meters).

The TCS's will be executed on a video-detection principle and they shall be placed near entries to the tunnel tube.

The frame of **Entrance Detection Control Systems** (EDCS) shall be executed in the way of the bridge road gantry. By findings of an unacceptable vehicle the system shall **initialize stopping** of the traffic by the red signal light on TLTC located in front of the crossroad with the old road.

Rigid Height Barriers shall be installed on outside entrance road gantries located in front of tunnel portals, together with TLTC, EVS's and TCS's.

The location of the mechanical barrier is illustrated at drawing **No. ELT/04/T.1.2.**

Civil Works

Civil works are assumed for the execution of the outside entrance road gantries (2 pcs.), the frames of the Entrance Detection Control Systems (2 sets), the foundations of intersection control, the foundations of the support structures of DRIP's and for appropriate cable traces.

The minimum vehicle spacing strokes shall be implemented transversally across tunnel traffic lanes on pavement with spacing of about 80 m in both directions along entire length of the tunnel tube.

Technical Accessories

Lighting sources for all the traffic signals, signs and lights shall be executed by LED's.

Basic Graphical Description

An example of possible spatial solution of the dynamic entrance traffic control system is shown on drawing No. ELT/ 04/ T.1.2 in the graphical enclosure hereinafter.

T.1.3 Access Control

Functional Description

The tunnel access control is operated by the integrated tunnel control system. The access control consists in announcement and visualisation of opening of access doors of all the buildings, rooms in operation, technology buildings and underground spaces, opening of selected panel boards, SOS boxes and escape exit doors.

It further consists in selected individual entry possibility (e.g. for service attendance personnel) to chosen rooms and to the tunnel tube from the escape adits and to the rescue tunnel from outside.

A removal of fire fighting equipment shall be signalised as well.

Basic Specifications

Design

Sensors are executed in the form of contact switches. An entry permit should be realised by individual chip cards.

Sensors shall always be integral parts of appropriate doors and equipment. They are not separately stated in BoQ's.

T.1.4 Electrical Fire Signalling System

Functional Description

The system consists from four **Electrical Fire Signalling (EFS) centrals** (Master EFS central in the control centre by the southern tunnel portal and Slave EFS centrals in the control centre by the northern tunnel portal and inside the tunnel tube) and fire detectors. Alarm messages of the Master EFS central are brought into the integrated tunnel control system by means of two connections – serial and discrete (contacts) for appropriate processing.

The centrals are connected with addressable line fire detector with fibre laser sensor, discrete automatic smoke and heat detectors and manual button detectors.

The EFS line detector serves for fire signalling inside the tunnel tube.

The EFS discrete detectors are located in all the operation and technology rooms, e.g. control centres, control rooms, machine-rooms.

The EFS manual button detectors are placed in SOS boxes, in operation and technology rooms and by the entries to escape exits in escape adits.

Basic Specifications

Design

The EFS line detector is divided to four sections. Evaluation units of the EFS line detector are placed in technology and control buildings (southern and northern ones) and two of them in the middle control rooms inside the tunnel (at sections No. 14 and No. 46. A cable of fibre laser sensor shall be installed under the tunnel tube roof in accordance with specifications of the sensor producer.

The execution of the system shall match to appropriate regulations.

Any fire alarm shall be announced in the local control centres by using of special alarm facilities – besides of advice of tunnel control system as well as by warning light and warning horn.

Basic Graphical Description

See drawing No. ELT/ 01/ T.1.4 in the graphical enclosure hereinafter.

T.1.5 Emergency Call System

Functional Description

The emergency call system consists of an **emergency switch board** on the workplace of operators and **SOS boxes** situated in front of the tunnel tube at both portals (2 pcs.) and inside the tunnel tube. The main purpose of the system is to assure verbal communication in between operator and a traffic participant for announcement and explanation/clarification of the opportune emergency situation, e.g. stopping vehicle (failure, without fuel), traffic restriction (loss of goods), health troubles, accident, fire e.t.c. The entry of any person to some SOS box shall activate telephonic communication with using speaker-phone and an amber warning flashing light above the SOS box, which is signalling some traffic problem. Further initialised telephonic communication in the same time has to be mute but signalised to operators.

All the **emergency calls** have to be recorded and archive for the time of one month (30 days).

It could be also further exploitation for the system – redundant communication possibility by execution of **service works** between service men and operators.

Basic Specifications

Design

The SOS boxes are executed as sound-tight cabinets, made from stainless steel with degree of protection IP 65. There are placed in the SOS box cabinet a speaker-phone, a manual button of fire alarm detector of EFS system, emergency push-buttons (with pictograms for claim of help for drivers with immobile car, health trouble and by an accident), two manual fire extinguisher and tools for fast extrication of persons from a cracked car. Emergency call niches contain also beside SOS box energy socket outlets for service purposes and other technology equipment could be installed there as panel board of low voltage electro-distribution network, components of the tunnel control system, etc.

The SOS box interior is permanently alight with an orientation light. Entry to SOS box is indicated optically and acoustically on operator's workplace. Then also a main interior lighting of a SOS box is automatically activated, above box are activated amber warning flashing lights (for both traffic directions) and at the same time TV picture of appropriate tunnel safety camera bears the shot of the activated SOS box surroundings area on the relevant alarm TV monitor to the tunnel operator.

Emergency functions of SOS boxes, traffic signs with SOS symbols and amber warning flashing lights shall be supplied from uninterruptible power source – UPS.

The SOS boxes will be marked by expressive numeral labelling (readable from a tunnel safety camera shot) and by outstanding inscription with the following text in local and English languages: **"This area does not provide protection from fire!!!"**

Basic Graphical Description

The lay-out solution of the emergency call niches is shown on drawing No. ELT/ 02/ C.1 in the graphical enclosure hereinafter. Basic information on SOS boxes could be found at the leaflet No. ELT/01/T.1.5.

T.1.6 Video Surveillance System (Close Circuit TV)

T.1.6.1 Video surveillance in front of tunnel portals

Functional Description

A part of the video surveillance system in front of the tunnel portal enables continuous monitoring of the road and its surroundings (e.g. outdoor emergency call box, technology and control building) by two revolving cameras - CR1 (in front of southern portal) and CR2 (in front of northern portal). Revolving cameras will enable retrieval of visual information about traffic in front of the tunnel and also information of immediate vicinity of the tunnel from range of two hundreds meters in front of tunnel entrance.

Basic Specifications

Design

System consists of two revolving cameras which are installed on specific rigid poles, resp. on public lighting poles. The camera revolving range is 360° horizontally and 90° vertically. Variable ZOOM objective of camera shall enable wide overview of the road traffic as well as detailed vehicle and person identification in relative wide scale of distances. Camera placing shall be in the height of cca 6 m and 60 m ahead of the portal.

Design documentation for the construction has to regard special rigid poles and cable channels.

Technical Accessories

Camera housing: Housing degree of protection is IP 66, heated, remote moving with rotation ability 360° horizontally and 90° vertically, variable ZOOM objective. Housing shall enable camera application in environment with temperature range from -35°C to +55°C.

Basic Graphical Description

An example of possible spatial solution of an area in front of the tunnel portal is shown on drawing No. ELT/ 03/ C.1 in the graphical enclosure hereinafter.

T.1.6.2 Traffic video surveillance system

Functional Description

Monitoring system of the operation in the tunnel tube is based on traffic monitoring with fixed cameras CT1 ÷ CT60 which will be disposed in the tunnel so as they will guarantee traffic monitoring along the whole length of the tunnel tube.

It is recommended to use a **video detection system** as above standard solution, which task is relatively accurate evaluation of operation parameters in right and left road traffic lanes. Cameras for the video detection system are constructional coincident with others cameras for the traffic monitoring, but the difference is that camera shot has limited view distance to 75m. Video detection systems make possible to provide alarm signal in the course of e.g. standing vehicle and a rise of a smoke.

Basic Specifications

Design

Traffic cameras are fixed on tunnel walls at a height of about 4.8 m over the road level by reason of effortless maintenance (regular cleaning). The distance between individual cameras shall be about 150 metres in the line of way. The number of cameras is determined on about 60 pieces. Individual camera visual angle shall be right adjusted and shots shall not be disturbed by obstacles and by curvature of the tunnel tube. A visual routing of the traffic cameras has to be unified to only one direction.

Civil Works

Power supply cables and cables for camera control and video-signal are leaded from distribution point to tunnel tube cross-sections where cameras are placed. Wire

bundle cross cable pit, then shelters in reveal to the box next the camera. They are leaded by sealed apertures to the camera. Transverse and lengthwise shelters, boxes and cable pits must be prepared before camera installation.

Technical Accessories

Stationary traffic camera: camera with long focal distance and coloured picture presentation is fixed on a console placed on the tunnel wall.

Camera housing: Housing degree of protection is IP 66, heated. Housing shall enable camera application in environment with temperature range from -35°C to +55°C. Housing is surface adapted by anodizing to outside aggressive environment.

Camera adjusting: Moving metal camera fixation joint enables adjustment of a stationary traffic camera. Camera adjusting has to be 30° in horizontal direction and 45° in vertical direction. The joint is also realised with alteration for aggressive environment.

Basic Graphical Description

An example of possible spatial solution inside the tunnel tube is shown on drawing No. ELT/ 02/ C.1 in the graphical enclosure hereinafter.

T.1.6.3 Tunnel safety video surveillance

Functional Description

The system secures monitoring of SOS boxes and their surroundings (fire fighting niches, lay-bays). This system is based on monitoring by stationary (emergency) cameras with short focal length (with continuous scan shot).

Further two cameras are basic parts of Entrance Smoking Vehicle Control Systems by the frames of the Entrance Detection Control Systems. The cameras shall be firmly positioned and they use a smoke video-detection system which could differentiate trucks too much emitting exhaust smoky gas and initialize diversion of the truck to the direction to the old road beside the tunnel route.

Basic Specifications

Design

Monitoring system of SOS boxes consists of stationary cameras with short focal length (with continuous scan shot) CE1 – CE59. These emergency cameras are fixed so that it would be possible monitoring of the whole surroundings alongside and in front of individual SOS box. Camera positioning for the monitoring of SOS boxes is fixed. The number of cameras for monitoring SOS is determined on about 59 pieces.

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The smoke video-detection system (cameras CE60 and CE61) shall be connected to the Entrance Detection Control System (see par. T.1.2) of the integrated tunnel control system for automatic truck diversion. A vehicle diversion could be operated also manually after a visual information evaluation by a tunnel operator.

Civil Works

Power supply cables and cables for camera control and video-signal are leaded from distribution point to tunnel tube cross-sections where cameras are placed. Wire bundle cross cable pit, then shelters in reveal to the box next the camera. They are leaded by sealed apertures to the camera. Transverse and lengthwise shelters, boxes and cable pits must be prepared before camera installation.

Technical Accessories

Emergency camera: camera with short (wide-angle) focal distance and coloured picture presentation is fixed on a console placed on the tunnel wall.

Camera housing: Housing degree of protection is IP 66, heated. Housing shall enable camera application in environment with temperature range from -35°C to +55°C. Housing is surface adapted by anodizing to outside aggressive environment.

Camera adjusting: Moving metal camera fixation joint enables adjustment of the stationary camera. Camera adjusting has to be 30° in horizontal direction and 45° in vertical direction. The joint is also realised with alteration for aggressive environment.

Basic Graphical Description

An example of possible spatial solution inside the tunnel tube is shown on drawing No. ELT/ 02/ C.1 in the graphical enclosure hereinafter.

T.1.6.4 Picture transmission and processing system

Functional Description

System of picture transmission and processing supplies signal transmission from individual cameras to control centres in two technical and technological levels:

- signal transmission from cameras to technological nodes via metallic lines,
- signal transmission from technological nodes to the control centres via fibre-optic lines.

Basic Specifications

Design

System of picture transmission and processing consists of several functional units which are connected this way: cameras are connected by metallic cables (control/video-signal/feed). Considering smoothness in the first and the last control rooms - distributing substations (Distributing substation DS1 and DS5) there are two and two multiplexers – 8 and 16-channel, in other distributing substations (Distributing substations DS2 and DS4) are only per one 16-channel multiplexer. Together there are 5x16 + 2x8 multiplexers for processing 96 video-signals. The same number of video-amplifier is required for it (at least 92 pieces). Video-signal is transmitted next by fibre-optic cable to video-central in technology and control buildings.

Civil Works

Project documentation for the construction must take into consideration supply cable, control and video-signal cables traces, location of video-amplifiers, multiplexers, video-signal cables and video centrals.

Technical Accessories

Metallic conductors: they are supply conductors to the camera, conductor between camera and video-amplifier and between video-amplifier and multiplexer.

Fibre-optic conductors: they are connecting conductors between individual multiplexers in tunnel and demultiplexer which is located next to video central.

Video-amplifier: they offset cable line slump and concurrently they adjust frequency characteristic of transmitted signal.

Multiplexer: it is used for unit of individual outputs from individual camera video-amplifiers to one fibre-optic cable line.

Basic Graphical Description

See drawing No. ELT/ 01/ T.1.6 in the graphical enclosure hereinafter.

T.1.6.5 Video-central and video recording

Functional Description

Video-central enables video-signal processing (video-matrix) from all cameras so that operator could monitor the picture from randomly selected camera on video monitors. It mainly enables preset allocation of alarm pictures to alarm monitors automatically.

Picture recording system enables permanent picture recording by using of picture digitalisation and by creation of digital records on some of modern data carrier – e.g. memory fields. There shall be recorded pictures from all the cameras for the duration of 14 days.

Basic Specifications

Design

Video-central system consists of several functional units which are connected in this way: fibre-optic cables of transmission system are connected to demultiplexer (input). Output is leaded to multiplexers, which enable next multiplexing of video-signal from 16 cameras on one output which is leaded to video-central input. It preserve picture replay on the monitors which are located on operator's workplace, processes video-signal for recording system. Control of revolving cameras (positioning and zoom) and overswitching of pictures of selected cameras to video monitors is executed by MMI (Machine-Man Interface) – controlling interactive display of integrated tunnel control system.

Civil Works

Project documentation for the construction must take into consideration leading of supply cables lines, signal cables and cables for video-signal, space for video central and video accessories.

Technical Accessories

Demultiplexer: it demultiplexes video-signal from individual fibre-optic feeds to the next processing.

Video-central: it preserves picture processing on monitors which are located on operator's workplace, it processes video-signal for the recording system and it is used as connected place for control of revolving cameras.

Memory field: it enables recording of video sequences from all the video cameras and their spooling out for retroactive analysis of emergency situations.

T.1.6.6 Video monitoring

Functional Description

The means of the video monitoring system on operator's workplace preserve 3 main tasks:

- automatic monitoring of emergency situations;

- traffic monitoring by standard conditions, automatic and individual overswitching of individual camera pictures on individual video monitors;

- control of outdoor revolving cameras (individual cameras control – slight turning/ZOOM).

Basic Specifications

Design

Monitors on operator's workplace are segmented into two groups. 6 operational monitors for video-picture monitoring from individual traffic and emergency cameras (pictures from individual cameras will be successively changing on appropriate monitor – e.g. northwards). By standard tunnel operation the monitors are assigned for automatic monitoring as follows : the first – southern portal (revolving camera), the second – the sector of the length of about 2.3 km, the third – 2.3 – 4.5 km, the fourth – 4.5- 6.7 km, the fifth – 6.7-9 km and the sixth monitor – northern portal (revolving camera). There shall be possible to overswitch any camera picture to any monitor from the video surveillance control part of arbitrary interactive control display.

The next group are two large-screen monitors. One of them is assigned for monitoring of alarm pictures and the second for projection of chosen interactive control display (traffic control, ventilation control, access control, lighting control, power supply control, water treatment control) by standard tunnel operation. There shall be possible to overswitch any camera picture to any large-screen monitor from the video surveillance control part of arbitrary interactive control display.

Civil Works

Project documentation for the construction must take into consideration traces of supply cables, signal cables and cables for video-signal and also the way of installation of individual monitors.

Technical Accessories

Monitors: LCD (lower power input) or plasmatic monitors (higher power input) are intended for 6 operational monitors (size of 21"), backward projection or direct projection systems for large-screen monitors (40").

E. Electro - Mechanical Equipment Section

E.1.0 Power Supply System

Functional Description

The system includes **high voltage** and **low voltage** distribution networks in the range of control rooms, transformers, technology LV network for power supply of all the technical systems, earthing and provision against erratic current. HV power transmission lines to both portals are not in the content of the tunnel power supply system.

Basic Specifications

Design

Voltage systems:

- HV - 3 AC 50 Hz 22 kV/ IT (arc suppression coil/resistance node earthing)
- LV - 3 PEN AC 50 Hz 400 V/ TN-C-S.

Short circuit relations have to be complemented on basis of electro distributor's data.

Protection against casualty:

HV - 3 AC 50 Hz 22 kV/ IT:

- Living parts - by insulation, constraints, locality;
- Non Living parts - by earthing in network where the source node is not grounded, potential consolidation.

Complementary protection in HV control rooms: dielectric carpet.

LV - 3 PEN AC 50 Hz 400 V/ TN-C-S:

- Living parts - by insulation, covers;
- Non Living parts - self-acting disconnection from a source, complementary potential consolidation.

The power supply shall be provided from two independent power sources - two independent HV transmission lines brought to both tunnel portals from two VHV networks.

HV/LV transformer stations shall be executed by both tunnel portals in technology buildings and further 3 transformer stations inside the tunnel cross adits No. 14, 30 and 46. The distance between transformer stations inside the tunnel shall not overlap 2.4 km. All the HV/LV transformers shall be loop connected from the transmission lines for the possibility of self-acting overswitching by a failure of one of them.

In the HV/LV transformer stations in the technology buildings by the tunnel portals shall be installed always 6 transformers (in total 12 x 1000 kVA). In the transformer stations inside the tunnel tube shall be installed always 2 transformers (in total 6 x 250 kVA).

The control rooms inside the tunnel shall be located along cross adits in detached fire segregate spaces.

If two independent transmission lines will be beyond possibility, it shall be necessary to use emergency power sources to ensure required level of power supply.

LV system shall be designed in the way that LV control rooms shall be located in all tunnel cross adits in detached fire segregate spaces. They shall be connected with HV/LV transformers with two detached cable power lines. One of them shall be located in the tunnel tube under tunnel sidewalks and the second shall be located in the parallel escape tunnel. Individual equipment in the tunnel shall be connected with LV control rooms with only one power supply cable.

To ensure uninterruptible power supply of individual equipment (elements of control system, traffic control system, emergency call system, emergency lighting there shall be installed on-line UPS in LV control rooms.

Energy balance:

Powered systems	Max. simultaneous power (kW)
Ventilation system	5 436
Lighting system	225
Other technical accessories	83
Total	5 744

Civil works

The control rooms of power supply networks shall be executed as separate fire segregated spaces. Cable passages through walls (borders) of fire segregated spaces shall be tightened by appropriate fireproof packing.

A corrosion investigation has to be executed before elaboration of a civil works design. Required level of protection provision shall be then elaborate on its results.

An earthing is preferentially designed as underlaying ground electrodes imbedded in concrete layers of tunnel foundation. The value of tunnel earthing resistance shall be less then 1 Ohm. All the electrical equipment of the tunnel is connected to the tunnel earthing system.

Technical Accessories

All components: they have to respond to using intention, transferred power or load and to conditions of objective environs of places of installation. Into the bargain there have to be determined fire resistance and resistance against corrosive effects of environs. The components which are installed in the tunnel tube have to agree with special operation conditions as humidity, salt, exhaust emissions, pollution, power water, e.t.c. Degree of protection of electrical equipment in the tunnel tube is required IP 65 and support structures, e.g. cable trays, have to be made from stainless steel of the type AISI316TI.

All cables which are placed in the tunnel tube environment have to be characterized by enhanced fire resistance, by low invasiveness of fire products and by low flame propagation.

For the civil works design should be calculated ground areas for the equipment of the power supply network as follows:

- HV transformer room in technology buildings by the tunnel portals – 4 m x 3 m for one HV/LV oil transformer with height of about 3.5 m;
- HV transformer room in technology spaces inside the tunnel adits (rescue stole connecting the tunnel tube with the escape tunnel) – 3 m x 2,5 m for one HV/LV oil transformer with height of about 3 m;
- HV control room in technology buildings by the tunnel portals – 10 m x 3 m for 6 HV/LV transformers situated next to it;
- HV control room in technology spaces inside the tunnel drifts – 4 m x 3 m for two HV/LV transformers situated next to it;
- LV control room intended also for panel boards of other technical systems of the tunnel complex situated in technology buildings by the tunnel portals - 2 x 5 m x 7 m for the one building;
- LV control room intended also for panel boards of other technical systems of the tunnel complex situated in technology spaces inside the cross adits - 4 m x 6 m for the one adit.

Basic Graphical Description

See drawing No. ELT/ 01/ E 1.0 in the graphical enclosure hereinafter.

E.1.1 Ventilation System

E.1.1.1 Main Tunnel and Escape Tunnel ventilation

Functional Description

A fully transversal ventilation system for the main tunnel tube is proposed. There are two air channels above the roof of the main tunnel tube. Traffic profile cross section of the main tunnel tube is 70 sqm. Ventilation channel cross-section for inlet of fresh air is the same as for exhausted air – 17.3 sqm. The inlet and the outlet of the air are executed from ventilation machine-rooms which are located at the tunnel portals (southern and northern portals).

The air flow in the tunnel tube shall be adapted, esp. in the case of the fire near the tunnel portals, by means of jet fans which shall be located at upper area of the tunnel tube by tunnel walls.

The spaces of the escape tunnel and tunnel cross adits shall be overpressured by means of two jet fans situated at roof niches by the escape tunnel portals. All cross adits are connected with escape tunnel having an overpressure of about 30 Pa – 50 Pa to prevent any infiltration of smoke to protected rescue ways by openings of emergency exit doors in case of fire in main tunnel. The fans shall serve to periodic operational ventilation of the spaces as well.

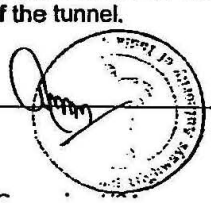
Basic Specifications

Design

Southern portal ventilation machine-room – ensures the ventilation of the southern half of the tunnel tube – length of 4600 m, amount of ventilation air – 400 c.m per second. There are proposed two ventilators for fresh air with capacity of – 2 x 200 c.m per second, pressure 2000 Pa, electric ventilator engines 2 x 650 kW. Outlet of the fresh air from fresh air ventilation channel is made by slots distanced 8 m along whole length of the tunnel tube.

For exhaust air outlet are foreseen similar ventilators of capacity – 2 x 200 c.m per second, pressure 2000 Pa, electric engines 2 x 650 kW. Inlets of the exhaust polluted air is made through ventilation flaps of the size of 2.5 m x 2.5 m with spacing of 80 m – 100 m. Ventilation flaps are installed in exhaust channel ceiling and are remote adjustable by means of servo-motors controlled through tunnel control system

Northern portal ventilation machine-room and ventilation system is identical with the southern ventilation part of the tunnel.



where:

- Δ hydraulic roughness (0.001 m – cast iron pipe)

The fire fighting system has to be designed to supply water with minimum pressure of 0.6 MPa (60 meters of water). The friction loss is app. 13 m/km of pipe (eq. 1) and it is more then the tunnel slope loss so the most critical point to assure minimal pressure is at the top of the tunnel (chainage 3625 m).

There was chosen two points to find the most critical one. The first one is the highest one in the tunnel and the second one is the farthest one from the reservoir (in the middle).

The highest one is app. 3.5 km far from reservoir what means friction loss 3.5·12.69 = 44.4 m = 0.44 MPa. The farthest one is app. 5.5 km far from reservoir what means friction loss 5.5·12.69 = 69.8 m = 0.70 MPa, but it is 10 meters lower. So the most critical point is the farthest one and to that point is necessary to cover 70 m of losses by the location of water level in the reservoir 70 m above this point.

The point with the highest water pressure is at the north portal. This point is app. 0.5 km far from the reservoir, it means about 6.5 m of friction loss so the water level in reservoir has to be maximally 100-6.5 = 93.5 m above this point to assure the pressure recommended range.

If at the south portal is a zero reference level so the water level in reservoir has to be between 71.6 – 72.4 m above reference level.

1.4. Air release valves

Automatic air release valves shall be installed at both reservoirs and at the highest point of the fair main.

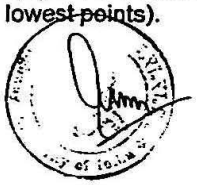
1.5. Hydrants

The hydrants shall be operated by the fire brigade or authorized staff only.

Hydrants of the pillar type (DN 100, PN 16) will be installed in niches.

1.6. Discharge devices

To empty the fire main discharge pipes with valves have to be provided at both portals (the lowest points).



Silencers are installed to inputs and outputs of the vent air from and to outer environment.

For fire ventilation, exhaust air inlets shall be used and should provide capacity of 210 m^3 per second, through 3 flaps in exhaust air channel closest to a fire location.

The informative evaluation of the transversal ventilation system

The basic input data for the ventilation calculation are:

- Tunnel dimensions;
- Maximum longitudinal pavement inclination – 0.5 %;
- Projection of traffic data trends to the year 2024 (15 years after the supposed tunnel opening) : - hour peak value M = 900 (number of vehicles in the tunnel in both directions), from that

  Mp = 360 (number of passenger cars)

  Mt = 540 (number of trucks)
- Required operational fresh air amount $Q_{FA} = \max(Q_{CO};Q_{OP})[m^3.s^{-1}]$, where

Q_{CO} - required fresh air amount for carbon-monoxide exhaust gas dilution;

Q_{OP} – required fresh air amount for elimination of inadmissible opacity.

$E_{CO} = \left(\frac{M_p e_p}{v_p} + \frac{M_t e_t}{v_t}\right).\frac{L}{3600}$; $[m^3.s^{-1}]$ – amount of CO emission, where

e_p – average passenger car CO emission in determined date, 0.06 $m^3.s^{-1}$;

e_t – average truck CO emission in determined date, 0.1 $m^3.s^{-1}$;

v_p – average passenger car speed in the tunnel in determined date, 70 $km.h^{-1}$;

v_t – average truck speed in the tunnel in determined date, 70 $km.h^{-1}$;

L - tunnel length, 9,2 km.

$E_{CO} = 0.00276$

$Q_{CO} = E_{CO}.\ 10^6\ .\ 1/c = 0.00276.10^6\ .1/200 = 13.8\ [m^3.s^{-1}]$, where

c – limit concentration of carbon monoxide (ppm) in the tunnel.

$E_{OP} = \left(\frac{M_p . o_p}{v_p} + \frac{M_t . o_t}{v_t} \right) . \frac{L}{3600}$; [$m^2.s^{-1}$] – amount of smoke emission, where

o_p – average passenger car smoke emission in determined date, 24 $m^2.h^{-1}$;

o_t – average truck smoke emission in determined date, 90 $m^2.h^{-1}$;

v_p – average passenger car speed in the tunnel in determined date, 70 $km.h^{-1}$;

v_t – average truck speed in the tunnel in determined date, 70 $km.h^{-1}$;

L - tunnel legth, 9,2 km.

E_{OP} = 2.09

$Q_{OP} = E_{OP}. 1/K = 2.09. 1/12 = 0.174$ [$m^3.s^{-1}$], where

K – limit value of opacity (m^{-1}) in the tunnel.

Additional axial jet fans shall be installed in the main tunnel tube to control longitudinal direction of the air flow in distances according to the drawing No. ELT/02/C.1 on the both sides of the main tunnel above sidewalks. There shall be installed 4 axial jet fans by the southern tunnel portal and 4 axial jet fans by the northern tunnel portal. Each of them shall have air pressure power of about 612 Pa. Fan drives – electric motors of the power 8 x 22 kW.

Cross adits and escape tunnel ventilation: In cross adits and in escape tunnel, there has to be provided superatmospheric air pressure by axial fans located by both escape tunnel portals. Two fans with capacity of 2 x 35 $m^3.s^{-1}$ assure velocity of air in the escape tunnel of 3 m per second. Outlet of the vent air from the cross adits into the tunnel tube is executed through overpressure fire flaps. Fan drives – electric motors of the power 2 x 30 kW.

Civil works

The ventilation machine-rooms of the tunnel tube ventilators shall be executed as separate fire segregated spaces. Cable passages through walls (borders) of fire segregated spaces shall be tightened by appropriate fireproof packing.

Smooth surfaces of vent air channels are presupposed.

For the design of civil works following space requirements for the equipment of main ventilation system are considered:

- machine-rooms in technology buildings by the tunnel portals – 25 m x 40 m for one building and four ventilators, with height of 6 m; the machine-room shall be equipped by an appropriate electric gantry crane.

Technical Accessories

Exhaust ventilators: heat resistivity of the vents has to be 250 degree of Celsius for the time of min. 90 minutes.

Control of ventilators: by the tunnel control system in accordance with the acquired data from the measuring facilities for CO and opacity values. For operation of fire ventilation are critical fire case scenarios and measurement of air convention, direction and velocity in the tunnel tube.

Emission limits in the tunnel tube	CO limit (ppm)	K limit (1/m)
Vehicle speed (km/h)		
10 - 100	100	0.007
0-10	150	0.009
The tunnel has to be closed	200	0.012

Basic Graphical Description

An example of the schematic main ventilation system and possible spatial solution of a ventilation building and air flow principles is shown on drawings No. ELT/ 01/ E.1.1 No. ELT/ 01/ E.1.3 No. ELT/ 01/ E.1.4 in the graphical enclosure hereinafter.

E.1.1.2 Physical Values Measurement

Functional Description

The operational ventilation of the tunnel tube shall be managed particularly in accordance with data acquired by continuous measurement of tunnel air quality conditions.

Measurements of amount of carbon-monoxide (CO) in tunnel air and opacity (transparency of tunnel air) are assured by integrated detectors for permanent acquisition of CO and opacity data. On the basis of the data, the operation of ventilation system by standard traffic conditions is automatically controlled by the integrated tunnel control system. The programme also advantageously makes use of special prediction routines based on acquired data by traffic counters (Traffic Counting Systems).

The control ventilation programme uses data of an air circulation measurement as well. These data are especially important for main tunnel tube ventilation in case of a fire. They include measurement of the air flow direction and velocity inside the tunnel tube and the barometric pressure by the tunnel portals.

The measurements of appropriate physical and electrical values of various tunnel devices, equipment and networks (e.g. bearing temperature, electrical power supply, current, etc.) are the parts of individual tunnel systems.

Basic Specifications

Design

Carbon-monoxide and opacity detector system consists from optical sender and receiver which are positioned in the distance of 10 m along a tunnel side. The systems shall be located in 14 locations equally situated along the tunnel tube in lay-bays to make easy their regular cleaning. They shall be installed in the height of 3.5 m above road pavement level. Evaluation units of the systems will be situated in close LV control rooms.

Air circulation detector systems (5 sets) shall be situated on the tunnel sides near the tunnel portals and inside the tunnel tube in the height of 4 m. They will operate on the ultra-sonic detection principle using evaluation of transversal ultra-sonic beam.

Two meteorological detectors by tunnel exit roads shall acquire data of air humidity, air temperature, wind velocity and direction, barometric pressure, intensity and type of precipitation..

Basic Graphical Description

An example of possible spatial solution of physical measurement devices inside the tunnel tube is shown on drawings No. ELT/01/C.1 and ELT/02/ C.1 in the graphical enclosure hereinafter.

E.1.2 Tunnel Lighting

E.1.2.1 Main Tunnel Lighting

Functional Description

Main tunnel lighting represents significant constituent of tunnel traffic safety. It consists of the night road lighting of tunnel access roads in front of the tunnel portals, the controlled lighting of accommodation sections at both ends of the bidirectional tunnel tube and of the trough (transit) lighting of the whole tunnel tube.

The accommodation section lighting regulation is implemented by a program of the integrated control system of the tunnel on basis of data from two luminance meters which are located in front of tunnel portals. Photometric sensors (CCD cameras) shall continuously evaluate outdoor luminance. The regulation is operational by day light in steps. It is assumed night degree of lightening (by CIE 88/90) with the through lighting.

Design

Access Road Sections: it is considered standard public road lighting with lighting posts along one side of the road (an access side). Lighting fixtures will be set for high pressure natrium discharge lamps (HPNL) with nominal power of 150 W, posts shall be of height of 12 m and with span of 20 m. Installation of the road lighting shall be executed up to 200 m from portals.

Accommodation Sections: threshold and transition zone lighting fixtures of the tunnel accommodation sections are situated on the roof of the tunnel tube in a line passing over the middle of an access traffic lane. They are in execution of Counter Beam Lighting (CBL) with nominal power of 400 W, resp. 250 W and 150 W. Lighting sources are HPNL.

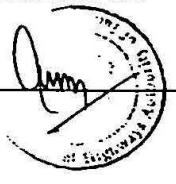
Required luminance of road pavement is given by tunnel light calculation. Accomplishment of luminance values is given by:

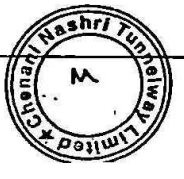
- lighting fixture specifications;
- nominal power of light sources,
- execution of the tunnel tube;
- elevation and lateral location of lighting fixtures inside the tunnel tube;
- spacing of lighting fixtures;
- overswitching regulation of lighting fixtures.

An example of lighting fixture type and spacing can be identified as it is noted in the table bellow:

ZONE	LENGTH of the ZONE (m)	LAMP SPACING (m)	LAMP NOMINAL POWER (W)	TYPE OF LIGHTING FIXTURE
Treshold zone 1 (TH 1)	50	1	400	CBL
Treshold zone 2 (TH 2)	50	1.6	400	CBL
Transition zone 1 (TR 1)	55	2.6	250	CBL
Transition zone 2 (TR 2)	60	10	150	CBL

Through (Transit) Lighting: lighting fixtures are situated in the centre-line of the tunnel tube on the roof. They shall be hanged on cable tray. They lighting characteristic is symmetric and are set for nominal power of lighting source of 150 W. A span of the lighting fixtures is 15 m. Lighting source is HPNL.





Main Tunnel Lighting Calculation: A system of main tunnel lighting shall be calculated on basis of supplier's data with a respect to Guide for Lighting of Road Tunnels and Underpasses CIE 88/1990 (with exception concerning interior lighting).

Control program algorithm: on basis of lighting fixtures supplier's indications. Two CCD cameras of photometric detectors shall be located on poles in front of the tunnel tube portals in distance of 100 m and height of 6 m.

Energy budget: max. power requirement of 167 kW.

Lighting operation: in standard status of the tunnel operation the main tunnel lighting shall be controlled automatically. In the emergency status of the tunnel operation there shall exist possibility to control main tunnel lighting from work place of operators (local control and supervision centre of the tunnel). There is not supposed a local sectional manual control of main tunnel lighting segments.

Power supply: the main tunnel lighting is supplied from the standard main power distribution network of the tunnel complex. There shall not be used a substitutive power supply system (emergency power supply – a diesel generator set, UPS – uninterruptible power source) for the main tunnel lighting. It means that the tunnel entrance shall be closed for the traffic in case of a main tunnel lighting power supply drop-out for a minimum time period of 20 minutes. The time period has to be observed with respect to technical specifications of HPNL light sources.

Civil Works

Civil works design documentation has to consider requirements of spaces for distributors and switch-boards of the main tunnel lighting and to protective cable conduits transversally leading from a backbone electric energy line (longitudinal) to the roof of the tunnel tube.

Technical Accessories

Lighting fixtures: Casings and hanging structures are made from non-corrosive material. Conditions for elimination of electro-galvanic corrosion in mechanical connections have to be accomplished. Fixture reflector is supposed to be made from polished and anodic oxidized aluminium alloy.

Lighting Sources: the high pressure natrium discharge lamps with operating life of min. 16 000 hours.

Cable Trays under a roof of a tunnel tube: galvanised steel (zinc dipping).

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Cables situated under a roof of a tunnel tube: they shall correspond with specifications of European standard EN 50 266 and similar actual ruling – in case of a fire accident they may not propagate flame.

Hanging of cable trays and lighting fixtures: stainless steel (pro-chrome) bolts, nuts, washers and anchors. Anchors with chemical fixation.

Basic Graphical Description

An example of possible spatial solution of the main tunnel lighting is shown on drawing No. ELT/01/E.1.2 in the graphical enclosure hereinafter.

E.1.2.2 Emergency Tunnel Lighting

Functional Description

The emergency lighting is important part of road tunnel technical accesories. It consists of an emergency lighting of unprotected escape ways (for lay-bays, emergency exits, SOS boxes, FF niches and tunnel sidewalks) and an emergency lighting of escape ways in the tunnel complex (for cross adits and escape tunnel, escape ways in technology buildings and rooms).

Power supply of all the emergency lighting fixtures has to be executed by on-line uninterruptible power sources (UPS). By power supply drop-out has to be assured feeding of the fixtures for a minimum time period of 60 minutes.

Basic Specifications

Design

Lay-bay HPNL lighting: roof lighting, lighting fixtures for HPNL 70 W, each LB equipped with 2 lighting fixtures.

Sidewalk lighting: lighting units for LED lighting sources located on both tunnel walls in the elevation of 1 m above sidewalk pavement. Spacing of the lighting fixtures shall be 15 m. They shall assure maintained illuminance of the sidewalk pavement with minimum value of 2 lx and with maximum longitudinal evenness of 40: 1 ratio. The lighting fixtures shall not light to the upper half-plane.

Accentuating lighting (for escape exits and SOS/fire fighting niches) : for the lighting are used lighting units for LED lighting sources with the view of contour accentuation of these objects, with expectant value of maintained illuminance 5 lx for escape side-walk near the objects. Colour nuance of the lighting is recommended such as light green.

Escape way lighting (cross adits to the escape tunnel, escape tunnel lighting): lighting fixtures shall executed for LED lighting sources. Maintained illuminance shall be 15 lx on a floor with min. evenness of the 1: 10 ratio.

Emergency Tunnel Lighting Calculation: A system of the emergency tunnel lighting shall be calculated on basis of supplier's data.

Energy budget: max. power requirement of 53 kW.

Lighting operation: in standard traffic status of the tunnel operation the emergency tunnel lighting for LB, emergency exits and SOS and FF niches shall be permanently switched-on and the one for escape ways shall be switched-off. The emergency lighting for escape ways shall be controlled automatically. In the emergency status of the tunnel operation shall be immediately switched-on. The possibility to control emergency tunnel lighting for escape ways has to exist from work place of operators (local control and supervision centre of the tunnel) in a case of service works. There is supposed a local sectional manual control of emergency tunnel lighting for escape ways.

Power supply: the emergency tunnel lighting is normally supplied from the standard main power distribution network of the tunnel complex through UPS. There shall be used a substitutive power supply system (emergency power supply – on-line UPS – uninterruptible power source).

Civil Works

Civil works design documentation has consider requirements of spaces for distributors and switch-boards of the emergency tunnel lighting located inside escape ways of the tunnel.

Technical Accessories

Lighting fixtures: Casings and hanging structures are made from non-corrosive material. Conditions for elimination of electro-galvanic corrosion in mechanical connections have to be accomplished.

Lighting sources: high intensity Light Emitting Diodes (LED) with white colour for the escape ways and with light green colour for the unprotected escape ways (with exception of HPNL for LB).

Fixing Structures and Cable Trays : galvanised steel (zinc dipping).

Hanging of Cable Trays and Lighting Fixtures : stainless steel (pro-chrome) bolts, nuts, washers and anchors. Anchors with chemical fixation.

Basic Graphical Description

An example of spatial solution of emergency lighting inside the tunnel tube is shown on drawing No. ELT/ 02/ E.1.2 in the graphical enclosure hereinafter.

E.1.3 Communication Systems

E.1.3.1 Wireless Communication System

Functional Description

The wireless communication system serves for communication of emergency intervention teams and service attendance personnel. It should be also equipped by mobile phone operator/operators accessories. It consists of an aerial tower with antennas placed outdoor beside the tunnel, processing unit panel boards and line slot radiating tunnel antenna.

Basic Specifications

Design

Antennas of the aerial tower which location has to be selected attentively in accordance with reception conditions for they should assure reception of all the required frequencies (FM communication bands, broadcasting and TV stations) and casting of emergency, tunnel service and mobile phone operator's frequencies. It is supposed to install two towers at both tunnel portals.

The processing units should make possible synthetize and split up all the communication signals. A slot broadband radiation cable antenna inside the tunnel tube shall be situated under the roof of the traffic profile of the tunnel tube along all the length of the tunnel tube wit exception of about 200 m long sections by the tunnel portals inside the tunnel. It will be divided to four sections, each of them fed from separate ampilifiers, located in correspondent control rooms at the technology portal buildings (2 pcs.) and in the control rooms located in the middle of the tunnel tube (2 pcs.).

A switch board of the wireless communication system is placed on the operator's workplace. It should make possible verbally enter in transmission of broadcasting station by emergency situations. Thereto the system for the transmission of preprepared phonetic messages shall be designed. The similar system has to be in disposal for the evacuative broadcasting system (see par. E.1.3.2).

The fixed traffic signs with introduction of transmitted frequency of broadcasting station shall be placed in front of the tunnel entries.

Basic Graphical Description

See drawing No. ELT/ 01/E.1.3 in the graphical enclosure hereinafter.

E.1.3.2 Evacuative Broadcasting

Functional Description

The evacuative broadcasting system contributes significantly to the tunnel operation safety, esp. in case of emergency situations, e.g. a fire of a vehicle. In case of a fire, drivers have promptly to know that they must immediately leave their cars and leave off the tunnel tube with using of the escape exits. The evacuative broadcasting serves to the effect. Moreover it is used for provision of traffic information, e.g. in case of traffic stopping by traffic lights three coloured with red signal active.

Basic Specifications

Design

The sound distribution inside the tunnel tube shall be established by regularly dislocated horn loudspeakers with spacing of about 50 m. The sound signal feed from the end section amplifiers shall be divided to 29 sections. The sound amplifiers will be installed in every second emergency call niches in reserved spaces of power supply panel boards.

The operator's workplace has to be equipped by microphone entry to make possible verbally enter in transmission of evacuative broadcasting by emergency situations. The system for the transmission of pre-prepared phonetic messages shall be designed as well. In case of a confirmed fire inside the tunnel tube, an appropriate message shall be automatically transmitted. A version could be for example following: "The fire in the tunnel, leave the tunnel immediately!" The message will be repeatedly transmitted in local and English languages.

Basic Graphical Description

See drawing No. ELT/ 02/ C.1 in the graphical enclosure hereinafter.

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C. Technical Accessories Coordination

C.1 Implementation Design Coordination

Functional Description

Within this technological complex there are needs to describe all collective integrated elements of technological systems but mainly those, that don't belong to any system. It is necessary to create logical tunnel division, unambiguous marking and numeration of constituent elements of technological systems, to determine cable run and cable coordination along the tunnel.

In the tunnel complex shall be determined commitment marking and numeration system of tunnel technological parts and elements. It also assumes visible number tunnel section marking with setting out of direction to the nearest escape.

It is necessary to differentiate and also space separate power cables and data cables. The main reason is to eliminate metallic cable paralleling by reason of disturbance. There is no disturbance in optical cables.

The main part of the coordination will be complete cable coordination with unambiguous fixing in protection tubes and all the cable designation in the tunnel complex.

Basic Specifications

Design

Cable run for power cables will be lead under western tunnel footpath all the way to distribution point in control and technology buildings. Cable run for data cables will be lead under eastern footpath. Runs in the tunnel will be solved with enough number of protection tubes. Cables will be lead in block channels.

There will be cable shafts situated on cable lines so that it will be possible to retract needed cables to protection tubes.

In lay-bays, concreted protection tubes shall be located under road pavement so that it was possible cables deviate to secondary distribution point as to escape cross adits.

Basic Graphical Description

See drawings No. ELT/01/C.1, No. ELT/02/C.1 and No. ELT/03/C.1 in the graphical enclosure hereinafter.

C.2 Bill of Quantities - Concept

See enclosure No. ELT/01/C.2

ENCLOSURES

1. Drawing No. ELT/01/T.1.0 - The schematic diagram of the Tunnel Control System
2. Drawing No. ELT/01/T.1.1 - The schematic diagram of the Main Control Centre
3. Leaflet No. ELT/01/T.1.2 - Variable Message Traffic Signs – LED Technology
4. Drawing No. ELT/01/T.1.3 - Spatial solution of the North Control Centre
5. Drawing No. ELT/01/T.1.4 - Spatial solution of the South Control Centre
6. Leaflet No. ELT/02/T.1.2 - Dynamic Road Information Panels – LED Technology
7. Leaflet No. ELT/03/T.1.2 - High Effective Warning or Leading Embedded Lights
8. Drawing No. ELT/04/T.1.2 - Principled Schema of the Dynamic Entrance Traffic Control
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10. Leaflet No. ELT/01/T.1.5 - Emergency Call Station
11. Drawing No. ELT/01/T.1.6 - The schematic diagram of the Video Surveillance System
12. Drawing No. ELT/01/E.1.0 - The schematic diagram of the Power Supply System
13. Drawing No. ELT/01/E.1.1 - The schematic diagram of the Main Ventilation System
14. Drawing No. ELT/01/E.1.2 - Main Tunnel Lighting – schematic lay-out
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20. Drawing No. ELT/01/E.1.3 - The schematic diagram of the Communication System
21. Drawing No. ELT/01/C.1 - Tunnel tube Cross Section Coordination
22. Drawing No. ELT/02/C.1 - Schematic lay-out of the tunnel tube with technical equipment
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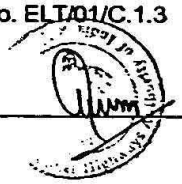
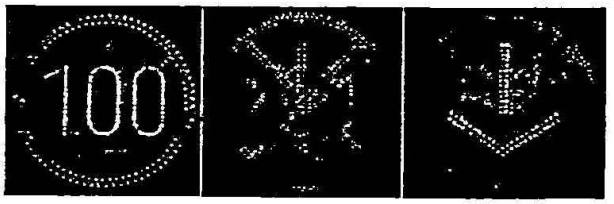
24. Table No. ELT/01/C.1.2 - Bill of Quantities concept
25. Table No. ELT/01/C.1.3 - Cost Estimation



Leaflet No. ELT/01/T.1.2

VARIABLE MESSAGE TRAFFIC SIGNS - LED TECHNOLOGY

VMS LED



Basic Information

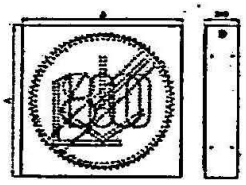
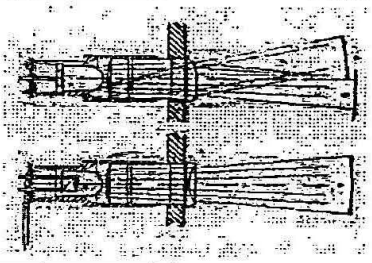
The traffic signs with the variable symbols (VMS) using high effective LEDs (Light-Emitting Diodes) as lighting sources are the active traffic signs using the light points distributed on the front display surface for the forming of traffic sign symbols. They are used on roads and with a road tunnel traffic control where an operational traffic regulation with respect to the momentary situation is required. The advantage of the VMS are good visibility and the possibility of immediate change of traffic sign symbols.

The execution of the traffic sign is in compliance with **EN 12966-1:2005** "Road Vertical Signs – Variable Message Traffic signs" and **EN 12899** "Fixed, Vertical Road Traffic Signs".

The combination of the traffic signs symbols is defined by the approved traffic solution for the respective road section. The VMS symbol range is mostly combined with the symbols of warning, prohibitory and traffic lane control signs. The ordinary applications use 2+10 symbols. The size and form of symbols are proposed according to the place of use in compliance with **STN 0180020** – "Road Traffic Signs".

Technological Description

The body of a VMS is welded from stainless steel sheets or aluminium alloy sheets and profiles. The surface of all parts is protected by powder painting. In the lateral walls of the box are diagonally located vent air openings equipped with dust filters securing the degree of protection of **IP65**. The front plate of a VMS is electrically heated during the decrease of the outside temperature. The service doors are equipped with the contact indicating the opening of it to the superior control system. Inside the box there are located the sources of the constant current for the feeding of LED elements and the electronic device. The electronic device secures the communication with the superior control system, connect the groups of LED elements forming the sign symbols, verifies the function of the individual elements, continually regulates the light intensity of the sign display in relation to the intensity of the outside illumination and maintains the climatic conditions inside the box.

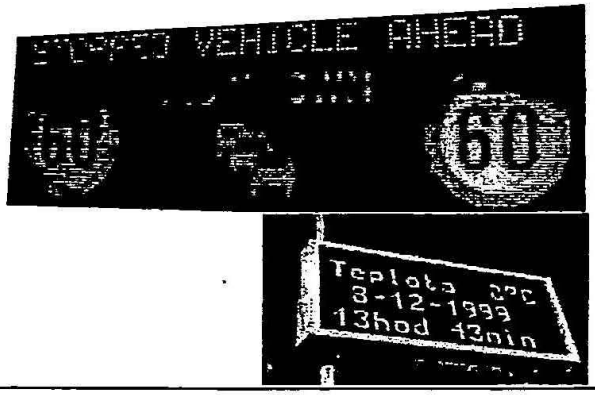
	The individual lighting spots forming on the front plate the symbols of the traffic signs consist of the optical lens, connecting bush and LED elements emitting the respective wave length light. The optical lens is astigmatic which means that the emitted light flux is directed into the defined angles. The material of the lens – borosilicate glass or plexiglass N8 according to the customer demand. The signs are usually fixed on the gantries or other steel structures by the rustfree fastening construction enabling the adjustability in vertical and horizontal directions. The signs can be equipped by the contrast frame for the highlighting of the
Basic Dimensional Sketch	
Detail of Optical Element	
Technical Data	Light Sources: • High Effective LEDs Power Supply: • 230V AC, 20-125W Degree of Protection: • IP65 Operating Temperature: • -30°C .. +55°C Dimensions: • by customer's request Weight: • 11-100kg In Compliance With: • EN12966-1:2005 (α, β, φ) • EN 12899 • STN 0180020

Chenani Nashri Tunnelway Limited

Leaflet No. ELT/02/T.1.2

DYNAMIC ROAD INFORMATION PANNELS - LED TECHNOLOGY

Illustration

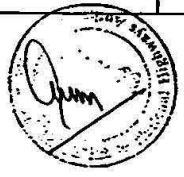


Basic Information

The dynamic road information panels (DRIP) with the variable symbols (VMS) using high effective LEDs (Light-Emitting Diodes) as lighting sources are the active traffic information sources using the light spots distributed on the front plate surface for the forming of the warning messages and traffic sign symbols. They are used on roadways and road tunnels where the operational traffic regulation with respect to the momentary situation is required. The advantages of the DRIP are a good visibility and the possibility of immediate change of information and symbols.

The execution of the traffic sign is in compliance with **EN 12966-1:2005** "Road Vertical Signs – Variable Message Traffic signs" and **EN 12899** "Fixed, Vertical Road Traffic Signs".

The DRIP contains a free programmable one or multicolour display, which can display textual messages or combine messages and traffic sign symbols together. The combination is dependent on operator's or automatic operational control system's choice in relation with the respective traffic situation or road conditions. The warning messages can also be put directly from the keyboard of operational computer in case of any unexpected circumstances of accident danger.



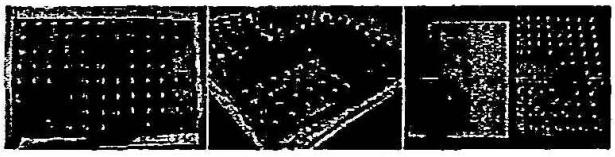
Technological Description

Casing of a DRIP is welded from stainless steel sheets or aluminium alloy sheets and profiles. The surface of all parts is protected by powder painting. In the lateral walls of the box are diagonally located vents equipped with dust filters securing the degree of protection of IP65. The front plate of a DRIP is electrically heated during the decrease of the outside temperature. The service doors are equipped with the contact indicating the opening of it to the superior control system. Inside the box there are located the sources of the constant current for feeding of LED elements and the electronic control device. The electronic device secures communication with the superior control system, connects the groups of LED modules, verifies the functionality of the individual modules, continually regulates the light intensity of LED elements in relation to the intensity of the outside illumination and maintains the climatic conditions inside the box.

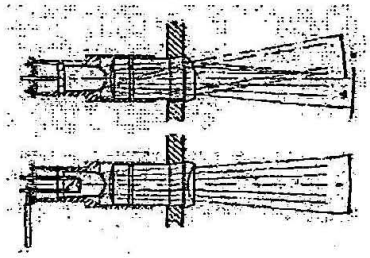
Each individual lighting spot consist of optical lens, connecting bushes and LED element emitting the respective wave length of the light. The optical lens is astigmatic which means that the emitted light flux is directed into the defined angles. The material of the lens – borosilicate glass or plexiglass N8 according to the customer demand.

The signs are usually fixed on the gantries or other steel structures by the rustfree fastening construction enabling the adjustability in vertical and horizontal directions. A DRIP can be equipped by the contrast frame for the highlighting of the information and symbols especially outside of the road tunnels.

LED Module



Detail of Optical Element



Technical Data

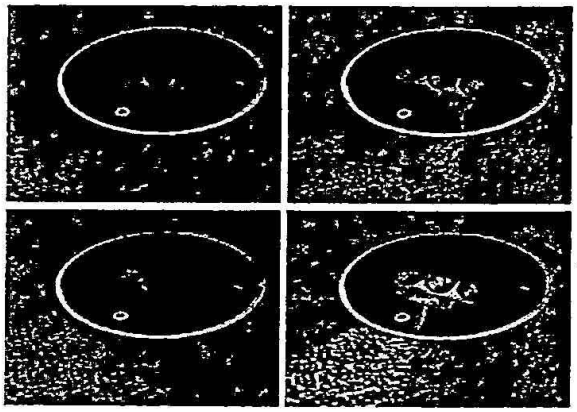
Light Sources:	• High Effective LEDs
Power Supply:	• 230V AC, 20-125W
Degree of Protection:	• IP65
Operating Temperature:	• -30°C .. +55°C
Dimensions :	• by customer's request
Weight:	• 11-250kg
In Compliance With:	• EN12966-1:2005
(α, β, φ)	EN 12899

Chenani Nashri Tunnelway Limited

Leaflet No. ELT/03/T.1.2

HIGH EFECTIVE WARNING OR LEADING EMBEDDED LIGHTS

Illustration



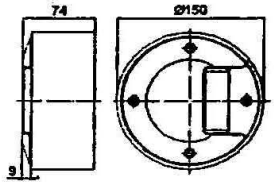
Basic Information

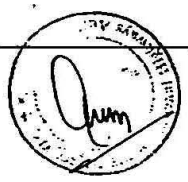
The lighting fixture contributes highly to the enhancement of the traffic safety. The high effective warning lights are determined especially for the installation into the roadway in front of the unprotected railway or tram crossings as well as in front of road tunnels on stop lines of traffic signals. The number of the installed lighting fixtures depends on the local conditions.

Particular bidirectional executions with only one lighting LED source for one lighting direction are dermined for using as tunnel **curbstone lighting** for sideward traffic leading in a tunnel tube or for embedded location in roadway pavement in order to accentuate traffic longitudinal lines. For the last mentioned purposes are white, red and blue (on bridges) colours and less power LEDs used.

The interrupted red light, combined with the flicker frequency of the warning lights which are marking the railway crossings located on the right hand side of the roadway, will warn drivers in sufficient braking distance of the danger of unprotected railway crossings and by its extraordinary location the drivers will prick up their sight. Thanks to high brightness of used LED's the warning effect of the lights is very beneficent with the day sun light as well.

The LED light source and the compact construction of the illumination fixture guarantee the operation life of 50 000 hours and no maintenance attendance. The low height of the illumination fixture located over the road will not prevent the maintenance of the pavement, especially during a snow

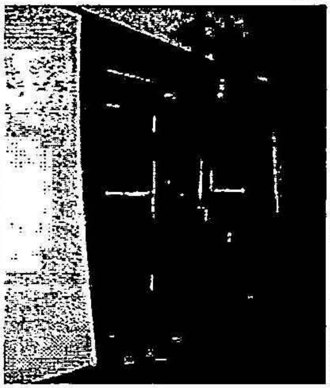
	season.
Technological Description	The body consists of the cylinder bases with the cable bushing foreseen for the installation with the roadway and removable upper part with the light sources. Both parts are interconnected over the packing by use of the counter sunk screws. In the upper part of the illumination fixture is placed the light active part (high luminous LED of the red and orange colours and optical and protection system), filled with the packing material and ensuring degre of protection of IP67. The control electronic is facilitating the regulation of the intensity of the emitted light to be in relation with the daily illumination. It is also the part of the system and it is generally located at the power supply cabinet. The part of the installation is the dusk indicator which controls the intensity change of the emitted light in relation to the brightness of the sky. The optical system concentrates the light stream into the spatial angle of about 10° over the roadway in such a way that light would be visible within the sufficient brake distance of the incoming vehicle drivers and the radiation will not disturb men in other directions. From the construction point of view the illumination fixture is solved as a compact element having very small dimension, determined for the installation into the surface of the pavement and resisting to radial and axial forces of the passing vehicles. The power and control cables have to be placed also into a groove made in the pavement surface. The execution will resist the operation load on the pavement and also to pavement maintenance activities. The operation life of
Basic Dimensional Sketch	
Technical Data	Light sources : • 3 x LED Luxeon STAR-O or by customer's requirements Power Supply : • 24 V DC or 230 V AC



Leaflet No. ELT/01/T.1.5

ROAD TUNNEL
SOS BOXES - EMERGENCY CALL STATIONS

Illustration



Basic Information

Each road tunnel has to provide the highest potential level of the traffic participants security which depends on promptitude of helping intervention by emergency bodies in case of hazardous situation as they are health troubles, stopped vehicles, traffic obstruction, traffic accident or the most dangerous one – a fire.

SOS cabins are the basic elements of the safety system of the road tunnel serving for signalling of emergency situations by pushing of alarm push-buttons and by telephonic connection between a tunnel user and a tunnel operator. They are installed in tunnel side niches one the right hand side in the one way tunnel and in case of two way tunnel on both sides of the tunnel, always at the right hand side in traffic direction. The area of the SOS box provid protestion from traffic noise. It does not provide protection from fire.

Technological Description

The standard cabin material of the SOS box is stainless steel (DIN 1.4435 – heightened corrosion resistance especially against chlorides). The SOS box degree of protection is IP54. The floor space of a SOS box shall be in minimum size of 2 sqm. The door of the cabin has door check and safety glass pane (1/3 of its surface). The door opens up outwards or they are in a sliding execution. The panelling of the door and walls is done by basalt wool because of noise and fire protection of users. The flooring is non-skid. The access detection of the SOS box is done by special door and spatial detectors. The other equipment is listed below.

Chenani Nashri Tunnelway Limited

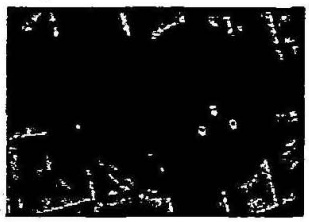
Fire Fighting Equipment		• Fire extinguisher • Pickaxe • Crowbar
Other Equipment		• First-aid kit box • Speaker-phone or head-phone • Four alarm push-buttons for connection to traffic operator with optical indication and for manual signalling of fire • Interior lighting • Electric service outlets 230 V and 3 x 230/400 V
Further Execution		It is also possible to design SOS boxes in compliance with customer's requirements as follows: • Execution of boxes for installation for the installation into especially prepared niches • Signalization of door opening by two flashing yellow lights placed over the boxes • Videotelephone • Acoustic indication of the cabin location in the tunnel in case of the limited visibility caused by smoke • Barrier-free entry, information in Braille type • Outfitting with the protection veils for the handicap people in case of a fire

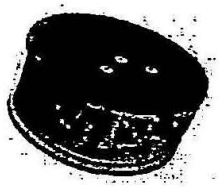
Chenani Nashri Tunnelway Limited

Leaflet No. ELT/03/E.1.2

TUNNEL EMERGENCY LIGHTING FIXTURES

TNS 06 LED



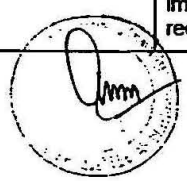


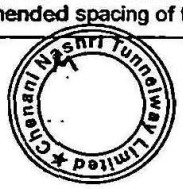
Basic Information

The lighting fixture is determined for the illumination of the un-protected escape ways in the road tunnel tubes. According to the standard of ČSN 737507 a special lighting system is being installed and its lighting fixtures are being located in to the wall alongside the emergency and/or public sidewalk in the tunnel tube with high up to 1.0 m over the level of the surface of the un-protected escape way (emergency sidewalk). This illumination also serves as the guiding illumination for the vehicles drive at the moment of transition in to the emergency tunnel operational mode.

The emergency illumination must secure the minimal value of the lighting E_{min}=2lx measured on the centre line of the un-protected escape way. The middle zone of the un-protected escape way being minimally at least the half of this way width must be illuminated minimally on the 50% of the indicated value. The relation between maximum and minimum illumination along the central line of the un-protected escape way must not be higher than 40:1. Because of the minimisation of the dazzling effect is the limit of the illumination of the emergency lighting fixture 500 cd measured in the upper half-space over the horizontal level, passing through the optical lighting fixture centre.

The lighting fixture contains the complete electric part inside the lighting body. The installation of the illumination fixture at the tunnel wall is simple (without the need of the constructional adaptation of the tunnel walls), which is important for the additional outfit of the existing tunnels. The recommended spacing of these lighting fixtures is 13-15 m.



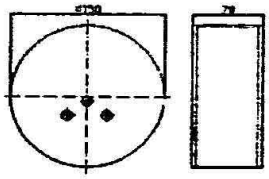


Technological Description

The lighting fixture of the compact form is produced from the light alloys, optical part is covered by transparent PMMA, the connecting material is from the stainless steel. The lighting fixture is hermetically closed and no inside maintenance is needed. The interconnection to the emergency distribution is done via bushing being at the rear part of the lighting fixture body.

The foreseen life of 50.000 operational hours corresponds to the life of the LED luminous elements. The all maintenance of the lighting fixture is just cleaning of the outside surface of the body (mainly the optical part) and this one is foreseen during the regular cleaning of the tunnel.

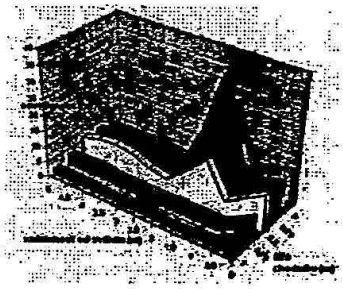
Basic Dimensional Sketch



Orientation Values of the Illumination at the Sidewalk

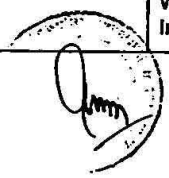
Translation:

- osvětlenost (lx) = illumination (lx)
- lx = lux (illumination unit)
- vzdálenost od svítidla (m) = distance from the lighting fixture (m)
- šíře chodníku (m) = width of the sidewalk (m)



Technical Data

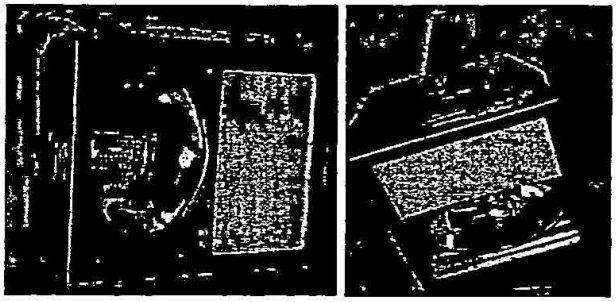
Light Sources:	• 3xLED Luxeon STAR-O or by customer's requirements
Power Supply:	• 230V AC
Degree of Protection:	• IP 66
Operating Temperature:	• -25°C .. +55°C
Dimensions:	• 150x70 mm
Weight:	• 2kg
In Compliance With:	• ČSN 737507



Leaflet No. ELT/04/E.1.2

MAIN TUNNEL CEILING LIGHTING FIXTURES

Illustration



Basic Information

The tunnel ceiling lighting fixture is determined for the illumination of the transitional accommodation and trough (transit) zones of road tunnels. These lighting fixtures are divided into two basic groups :

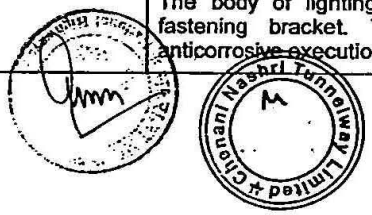
- **Symmetrical** lighting fixtures – equipped with symmetrical reflector offering symmetrical distribution of the light stream, executed especially for illumination of transit zones.
- **Asymmetrical (Counter Beam Lighting - CBL)** lighting fixtures – equipped with asymmetrical reflector offering asymmetrical counter distribution of the light stream, executed especially for illumination of the transitional zones.

Technological Description

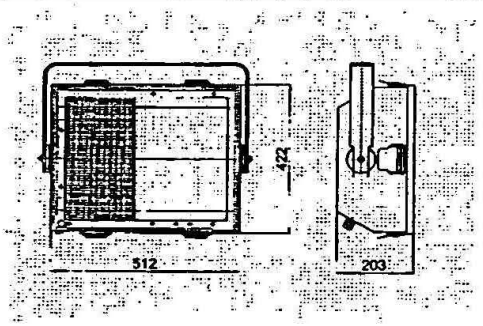
The body of lighting fixture is usually produced from stainless steel. The optical and electrical system is placed inside of the body. The front frame holds tempered glass and secures the degree of protection IP66 via efficient sealing system. The optical part is equipped by symmetrical or asymmetrical reflector from specially burnished aluminium alloy. The lighting fixture is practically maintenance-free during the whole service life and holds the original lighting parameters.

The replacement of a discharge lamp is carried out easily, e.g. by lifting off the front frame. Equally, the electrical part is also easily accessible.

The body of lighting fixture is put together with pivoted fastening bracket. The complete fixing system is in anticorrosive execution as well.



Basic Dimensional Sketch



Detail of Execution

1. Standard execution:
   - High pressure natrium-vapour lamp with appropriate ballast
2. Special execution:
   - Immediate restart system "HOT START"
   - Dimming system

Technical Data

Light Sources

STANDARD:	• High pressure natrium-vapour lamp (HPNL) 70, 100, 150, 250 or 400 W optionally
HOT START:	• High pressure natrium-vapour lamp 150, 250 or 400 W
Power Supply:	• 230V AC
Degree of Protection:	• IP66
Operating Temperature:	• -30°C .. +55°C
Dimensions:	• 512 x 422 x 203mm
Weight:	• 11,5-16kg

Chenani Nashri Tunnelway Limited

Maharashtra Industrial Development Corporation

1. Technical report

The fire fighting installation for Patnitop Tunnel is designed as a fully independent wet pipe system. Water is supplied from two reservoirs, one at each tunnel portal. The reservoirs are connected by fire main DN200 and each of them is able to supply water for any two hydrants, each with flow rate 1200 litres per minute (20l/sec), for one hour according to PIARC-Recommendations.

In order to guarantee a fire combat by means of foam the minimum operation pressure at any point of the system shall be 0.6 MPa. The maximum operation pressure shall not exceed 1.0 MPa what assures controlled handling of flexible hose pipes.

The water storage reservoirs are situated according to these hydraulic requirements.

Filling time of the water storage tank shall not exceed 24 hours.

Fire hydrants inside the tunnel are located with spacing of 150 m. In addition to those, two hydrants at each portal of the tunnel shall be installed.

Foam combat is necessary in case of ignition of light fluids, for example petrol. In this case foam agent recipients must be brought by the fire brigade to the fire location. Additionally to the water hose pipe a second hose pipe must be connected. This pipe conducts the foam agent from the barrel to the water stream. An in-line inductor, which brings together the foam agent and the water, develops the desired water-foam admixture. No additional pump is necessary to conduct the foam agent to the water hose pipe, it will be suctioned by flowing water.

Foam agent recipients must be stored at tunnel portals or at location of the fire-fighting brigade responsible for tunnel operation.

The fire fighting system is also used for the periodical tunnel washing operations. For this purpose the water may be extracted directly from the hydrant outlets by means of the flexible hose pipes.

All the system shall be arranged to permit repair of any section of the system without reducing the fire safety.

1.1. Water supply

The water storage reservoir shall be situated near each portal with a ground elevation of approx. 1299.0 m above sea level, that is app. 72 m above the tunnel carriageway level at the south portal and app. 93 m above that at the north portal.

This elevation guarantees necessary operation pressure for a fire fighting operation in whole system.

1.2. *Water storage reservoir*

The water storage capacity of the reservoir is 150 m^3.

Taking into consideration the maximum filling time of 24 hours the minimum filling rate shall be 125 litres per minute. Water should be captured from neighbouring streams through sedimentation facility.

The water reservoir shall be equipped with a device to automatically prevent overflow, an outlet, an air release valve to allow continuous discharge as well as filling of the fire main and an access shaft with a water-tight cover, 80 cm square, with a ventilation pipe DN 150. In the access shaft steel ladder and a steel landing shall be installed.

Any water level lowering in the reservoir shall be signalized automatically to the Control Centre.

The reservoir shall be filled with water from the adjoining stream.

1.2.1. Water reservoir storage capacity

The total capacity of the reservoir will be determined assuming a possible fire attack necessity. Each reservoir will have got required storage capacity.

Required capacity for fire fighting, according to PIARC: each of two hydrants has to provide 1200 l/min (20l/sec) during one hour.

V_{ff} = 2 x 1200 l/min x 60 min = 144 000 l = 144 m^3

Adopted total water storage capacity of the reservoir: V = 150 m^3

Following dimensions are stated: 10.0 m x 5.0 m x 3.0 m

1.2.2. Water reservoir filling time

Due to operation considerations is adopted a maximum filling time of:

t_{max} = 24 hours

The minimum filling rate will consequently be:

$Q_{f,min}$ = 150 m^3/24 hours = 6,25 m^3/h = 104.2 l/min

1.3. *Fire main*

The tunnel tube is equipped with a single fire main DN 200, PN 16. This size of the pipe assures suitable water velocity 1.27 m/s at flow rate 40 l/s.

The fire main laid in the tunnel tubes shall be situated in a pre-casted concrete duct below the left walkway (station direction). The fixing of the fire main shall be done by means of suitable bolted pipe clamps.

Discharge valves shall be situated at both portals to empty the fire main if necessary.

1.3.1. Flow rate of the system

Minimum flow rate of the system according to the PIARC Requirements is:

Q_{min} = 2 x 1200 l/min = 2400 l/min = 40 l/s

1.3.2. Pressure losses

Due to length of the pipe the major loss is caused by friction so local losses are omitted.

1.3.3. Friction loss

For the calculation of the friction loss is used Darcy-Weisbach equation (eq. 1)

$$Z = \lambda \frac{L}{D} \frac{v^2}{2g} = 0.031 \frac{1000}{0.2} \frac{1.27^2}{2 \cdot 9.81} = 12.69\ m/km \qquad \text{eq. 1}$$

where:

- λ friction factor (0.031,eq. 3)
- L length of the pipe (1 000 m)
- D pipe diameter (0.2 m)
- v velocity of water (1.27 m/s)
- g gravity acceleration (9.81 m/s^2)

Reynolds number (eq. 2) is used for estimation of flow mode.

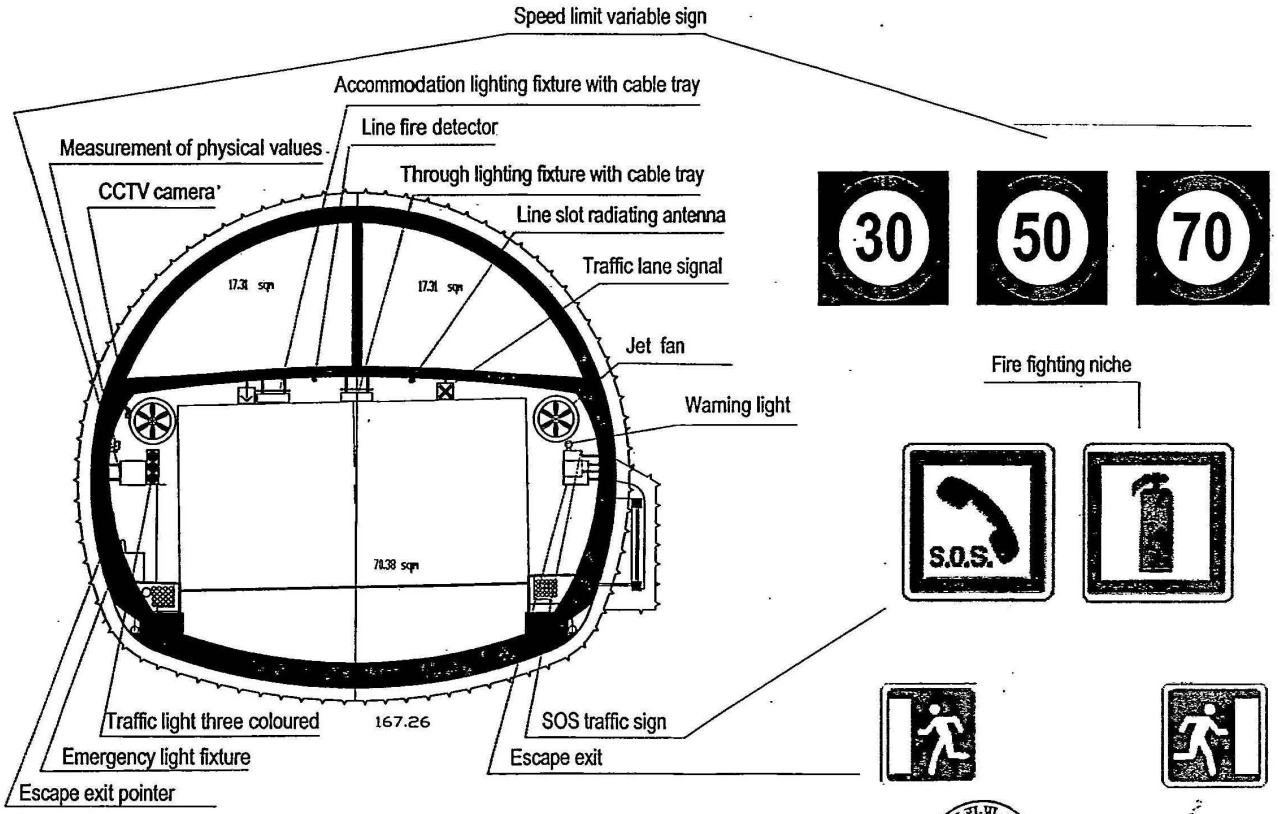
$$\mathrm{Re} = \frac{vD}{\nu} \qquad \text{eq. 2}$$

where:

- ν cinematic viscosity of water ($1.01 \cdot 10^{-6}$ – at 20°C)

Re = $2.1 \cdot 10^5$ respond to turbulent flow mode, so the Colebrook-White equation (eq. 3) is used for friction factor calculation.

$$\frac{1}{\sqrt{\lambda}} = -2\log\left(\frac{2.51}{\mathrm{Re}\sqrt{\lambda}} + \frac{\Delta}{3.71D}\right) \qquad \text{eq. 3}$$



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Karel Kroot	
DESIGN BY	Karel Kroot	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Tunnel tube cross section coordination

SCALE: 1 : 50

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: EL.T/01/C.1

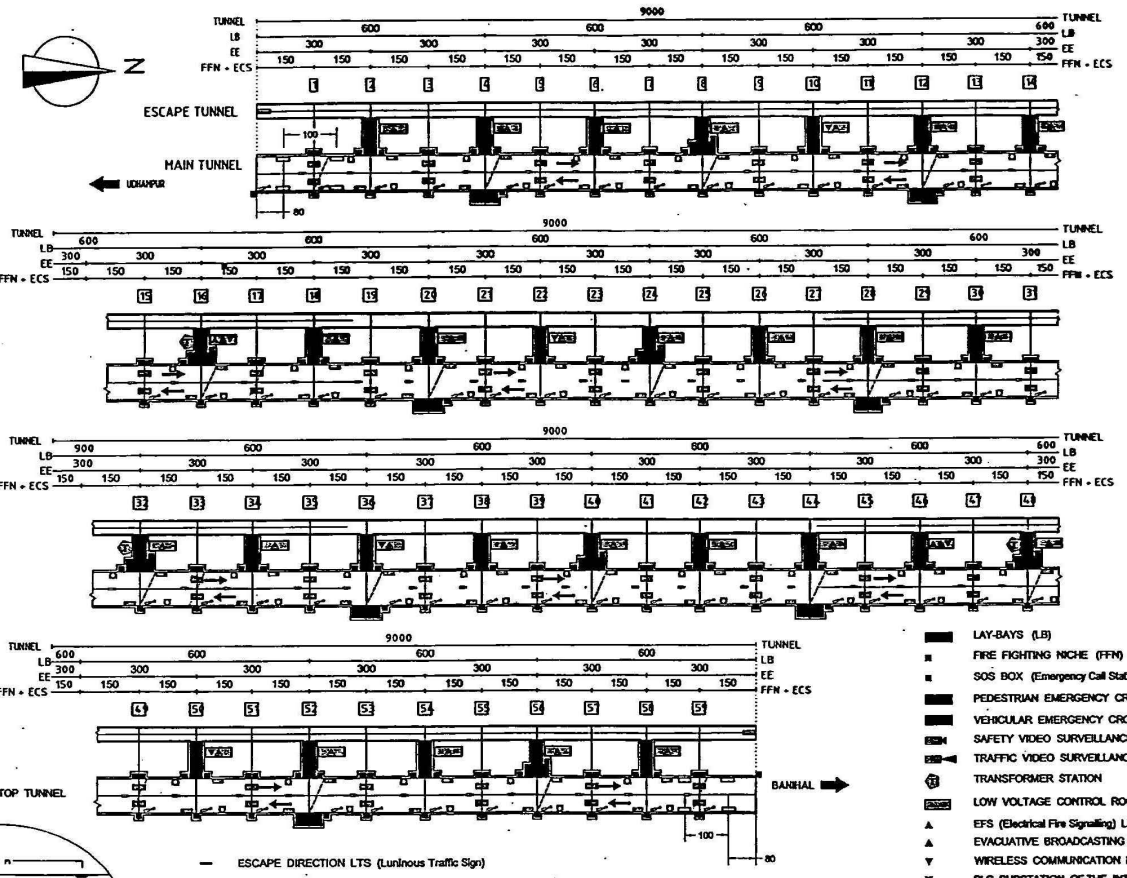
DATE: November 2006

THE Louis Berger Group, Inc. USA
Engineers · Planners · Scientists · Economists

Tunnel Consultant: D2 CONSULT

Jawahar Nashri Tunnelway Limited

M



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Schematic lay-out of the tunnel tube with technical equipment

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: ELT/002/C.1

DATE: November 2006

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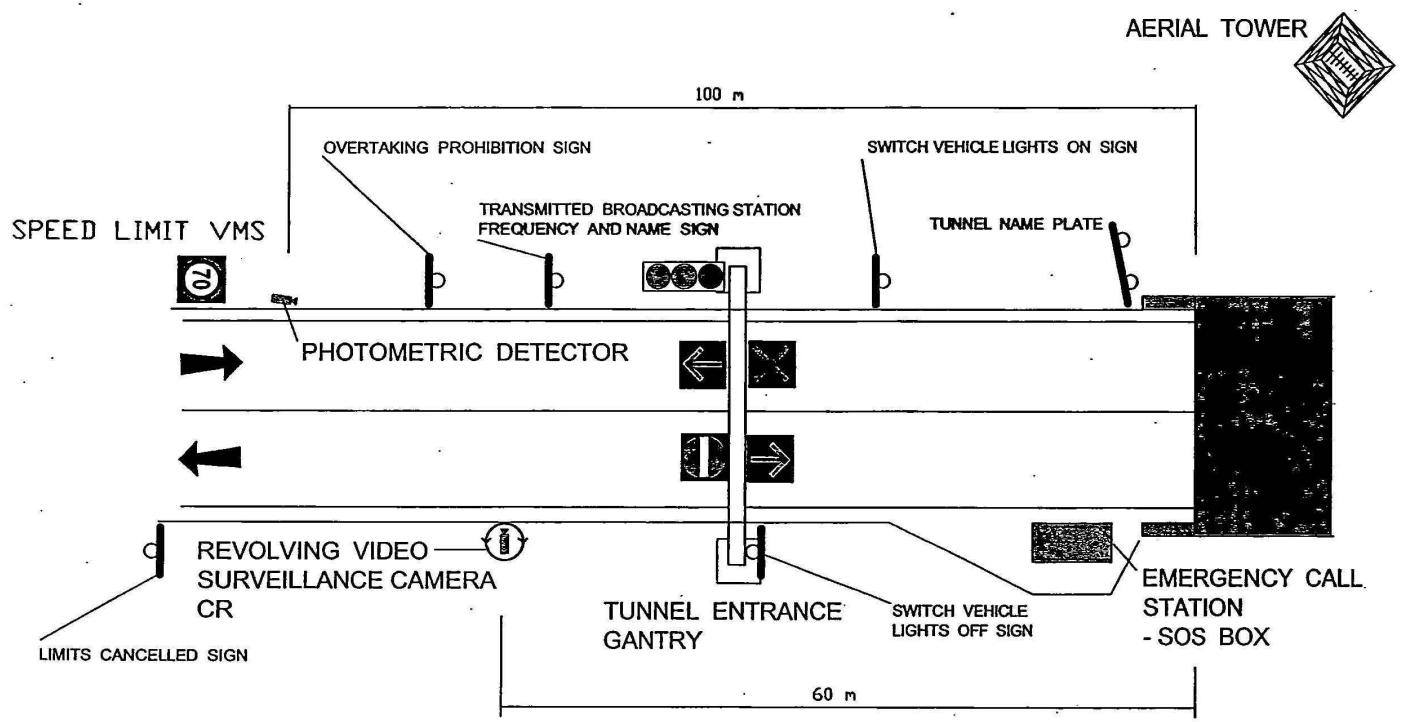
Tunnel Consultant:
D2 CONSULT
EILDOD EG

Chenani Nashri Tunnelway Limited



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SNB	
APPROVED BY	CLOSE	

TITLE: Schematic lay-out of technical equipment in front of the tunnel

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: EL/T/03/C.1

DATE: November 2008

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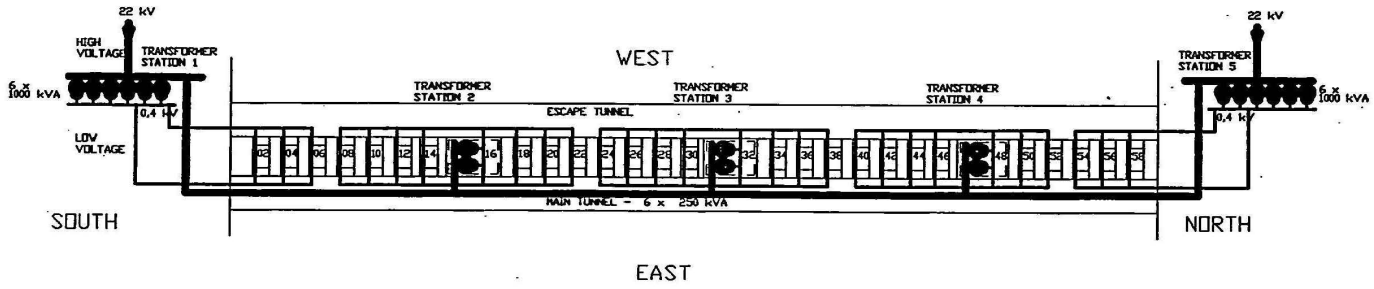
Tunnel Consultant:
D2 CONSULT
Int'l Technical Consultant: ELTODO EG



REV	DATE	PREP.	CHK.	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Schematic diagram of the Power Supply System

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: ELT/04/EL1.0

DATE: November 2006

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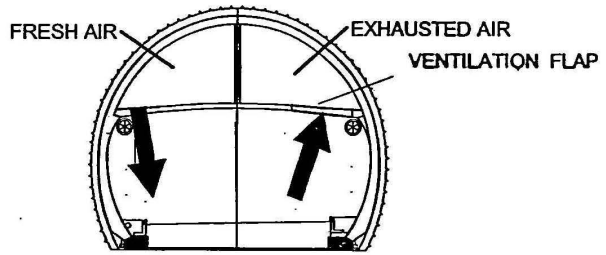
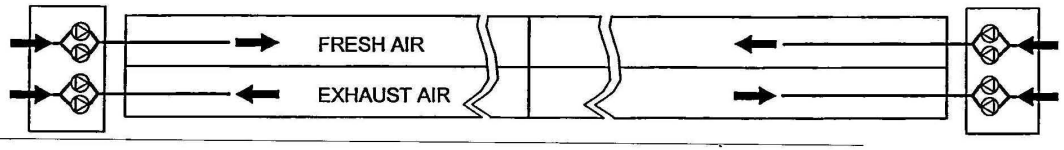
Tunnel Consultant:
D2 CONSULT
In Collaboration with: ELTODO EG

Chennai Tunnelway Limited





Chenani Nashri Tunnelway Limited

REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SMB	
APPROVED BY	CLOSE	

TITLE: Schematic diagram of the main ventilation system

ELEMENT CODE:

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

PICTURE NO.: EL/T/01/EL.1.1

DATE: November 2006

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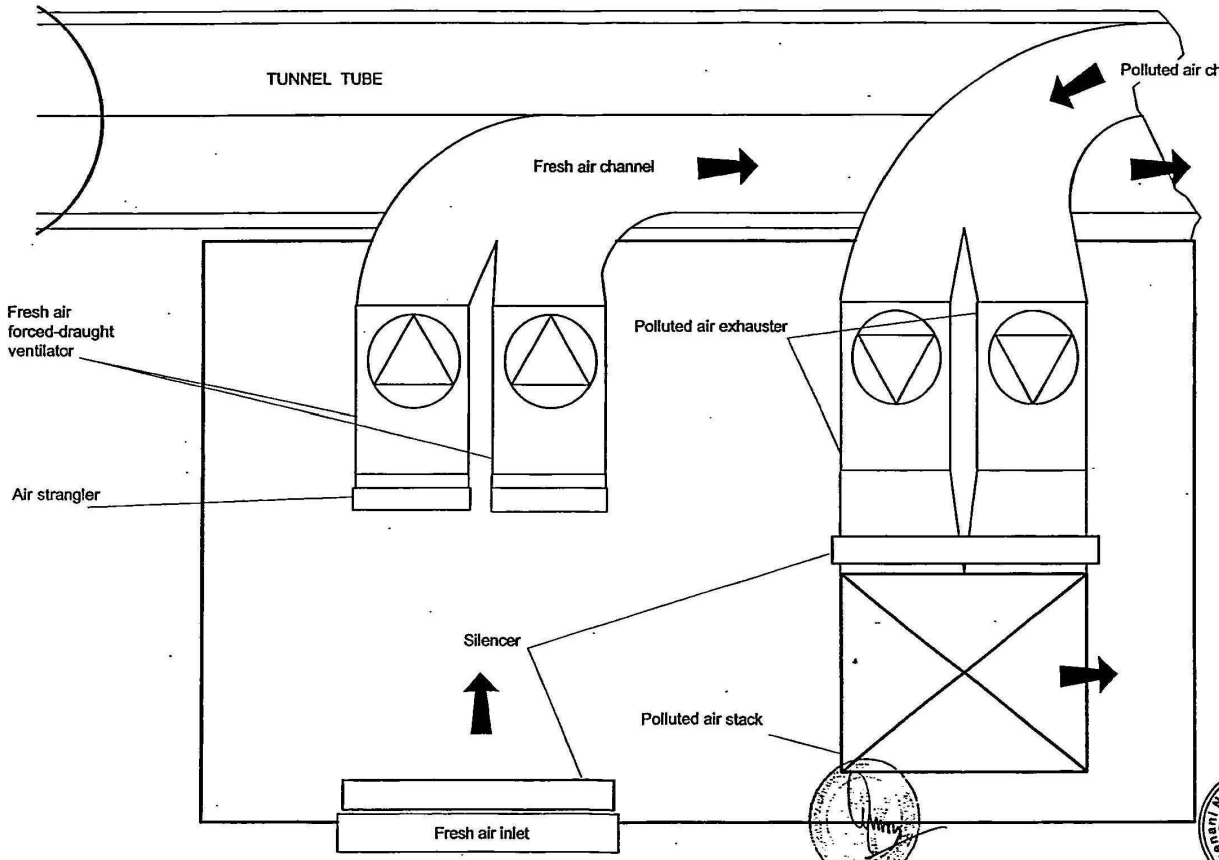
Tunnel Consultant: D2 CONSULT

Tunnel Consultant: ELTODO EG



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SHD	
APPROVED BY	CLOSE	

TITLE: The schematic lay-out of the portal ventilation machine room

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.198) C-III/25, 23

DRAWING NO.: EL7/05/EL.1.1

DATE: November 2006

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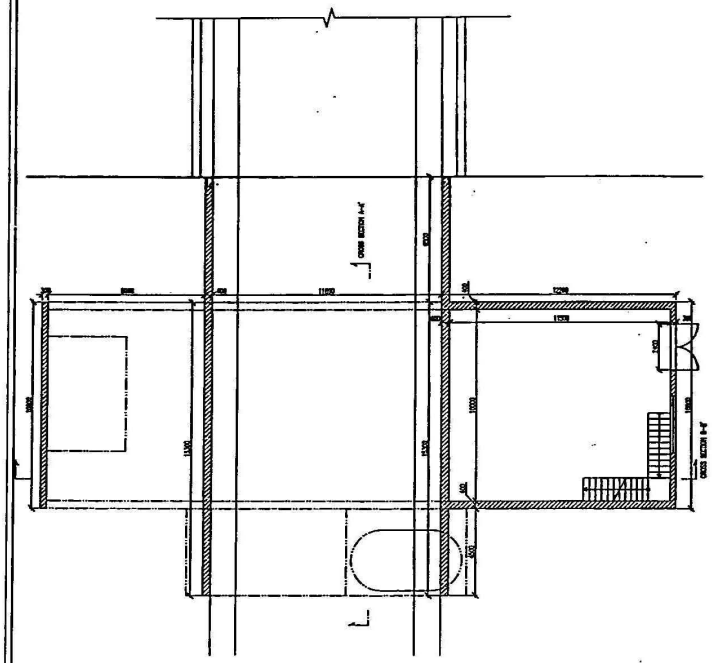
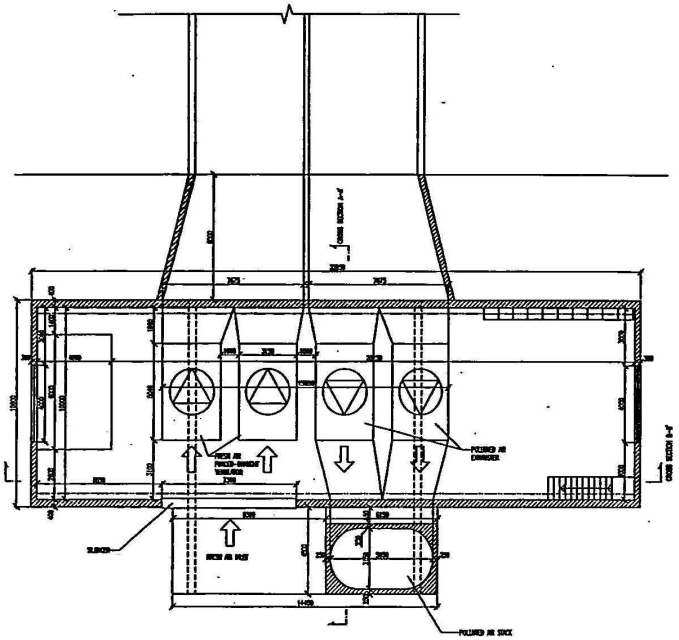
Tunnel Consultant:
D2 CONSULT
Infrastructure: ELIODO EG

Chenani Nashri Tunnelway Limited

GROUND FLOOR



FIRST FLOOR



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SDB	
APPROVED BY	CLOSE	

TITLE : PATNITOP TUNNEL
MAIN TUNNEL
MINED TUNNEL
VENTIALTION BUILDING

SCALE : 1:100

PROJECT : Four laning of NH-1A from Udhampur to Banihal (Km.68 To Km.188) C-III/25, 23

DRAWING NO. : EL7/01/E.1.3

DATE : November 2006

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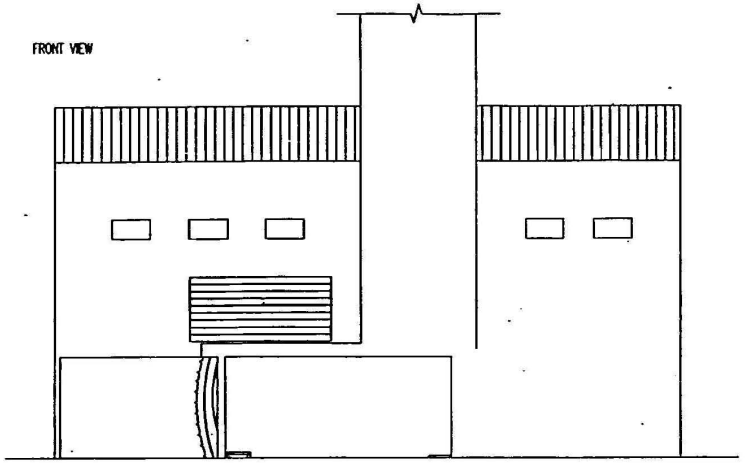
Transit Consultant:
D2 CONSULT

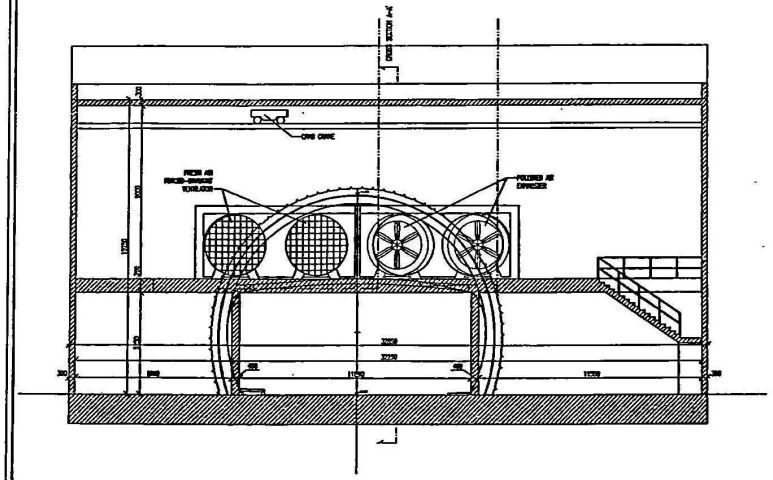
Tunnel Consultant: ELIODO EG

Chenani Nashri Tunnelway Limited

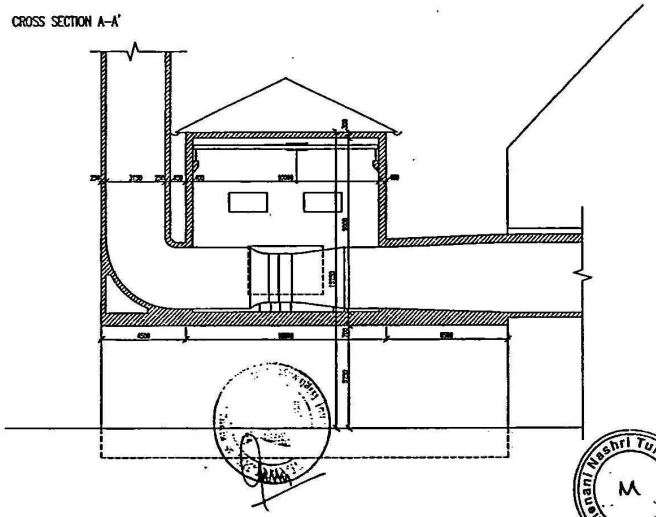
FRONT VIEW



CROSS SECTION B-B'



CROSS SECTION A-A'



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE : PAJNKOP TUNNEL
MAIN TUNNEL
MINED TUNNEL
VENTILATION BUILDING

SCALE : 1:100

PROJECT : Four laning of NH-1A from Udhampur to Banihal (Km.68 To Km.188) C-III/25, 23

DRAWING NO. : EL1703/L1.4

DATE : November 2006

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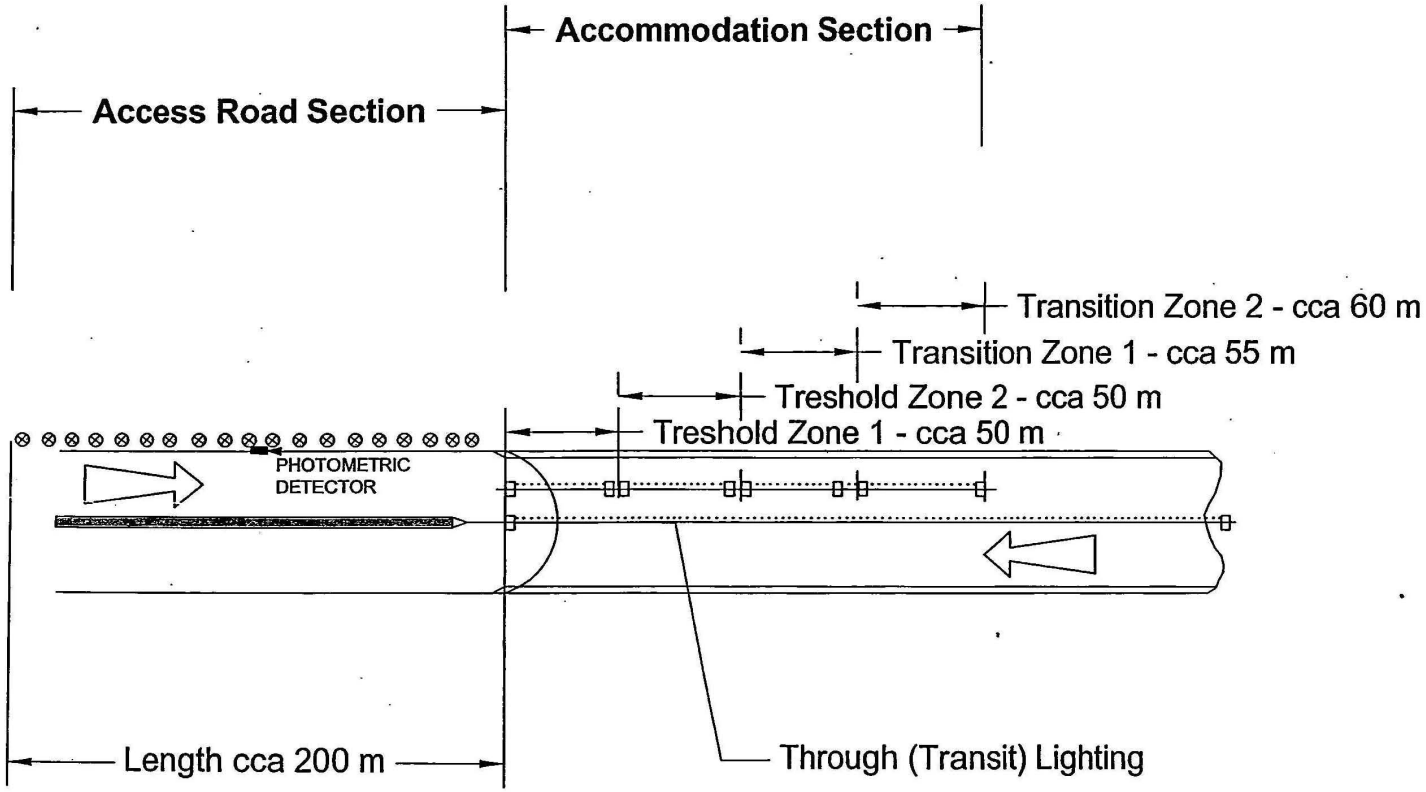
Transit Consultant:
D2 CONSULT
ELYODO EG

Chenani Nashri Tunnel Limited



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi

	NAME	SIGN
DRAWN BY	Karel Kraus	
DESIGN BY	Karel Kraus	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Main Tunnel Lighting - schematic lay-out

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: ELT/01/E.1.2

DATE: November 2006

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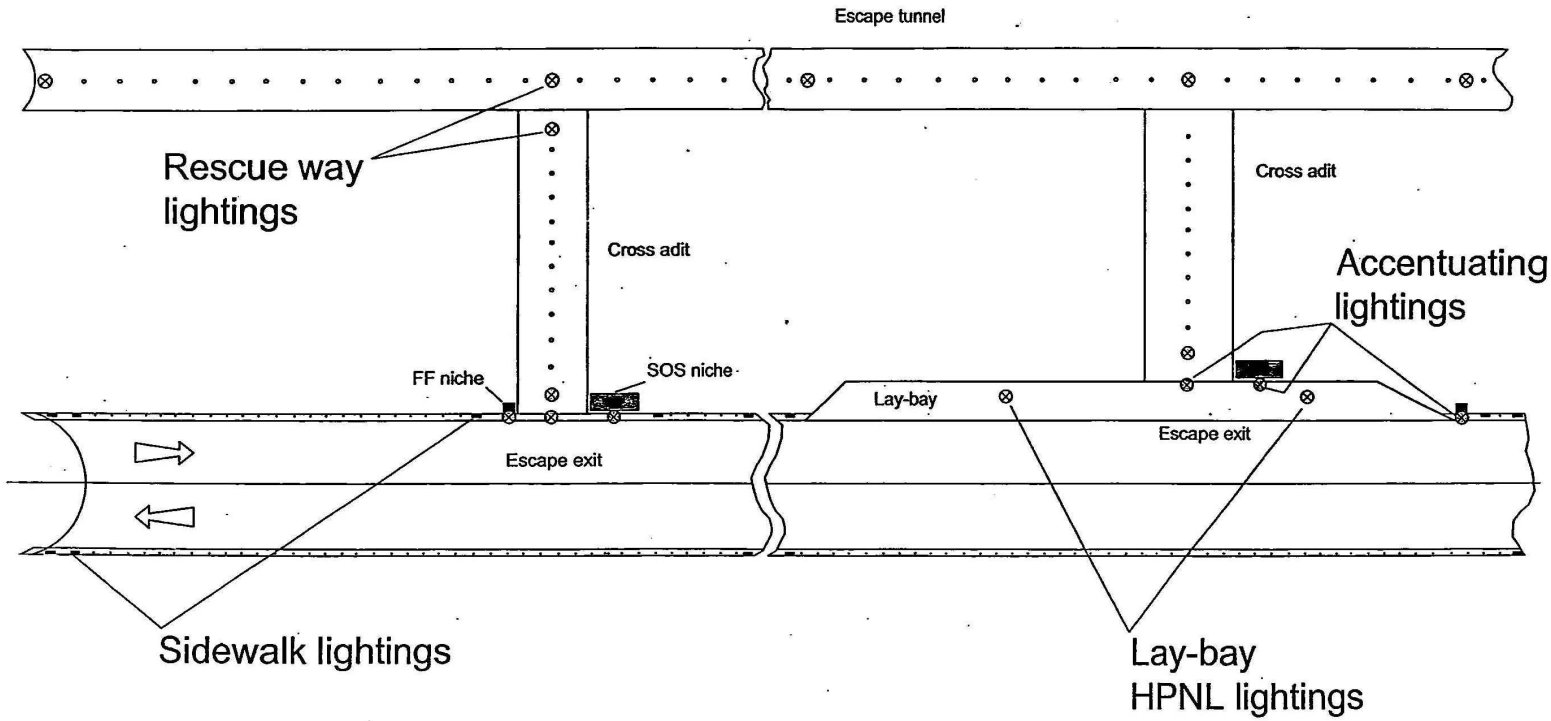
D2 CONSULT

Chenani Nashri Tunnelway Limited

EUFODO EG



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Emergency Tunnel Lighting - schematic lay-out

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: ELT/02/E.1.2

DATE: November 2006

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Tunnel Consultant: D2 CONSULT

ELTODO EG

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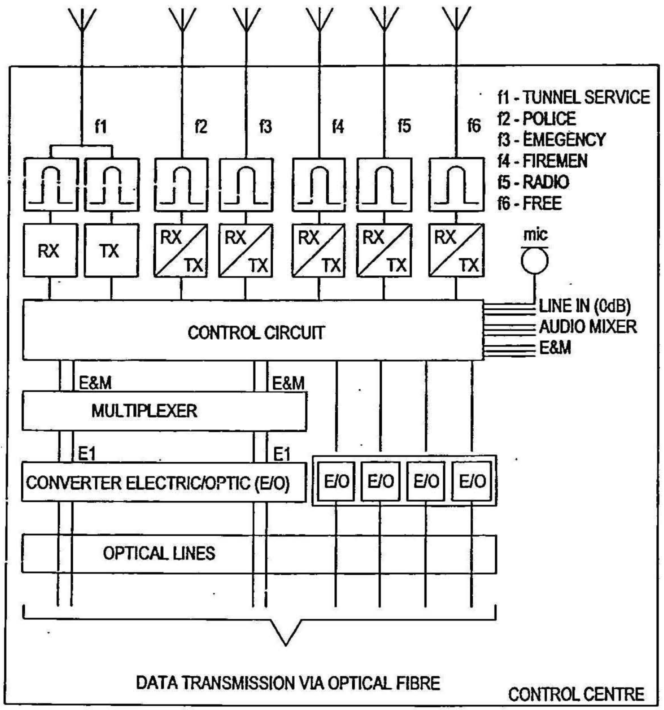

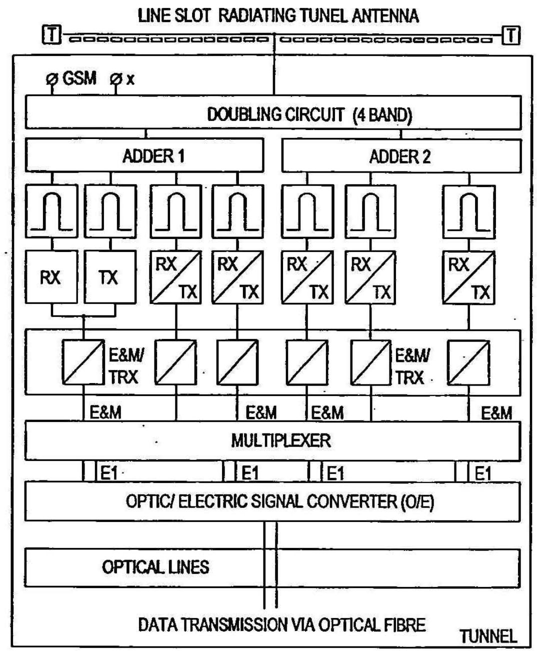

REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	[illegible]	
DESIGN BY	[illegible]	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Schematic diagram of the Communication System

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: ELT/01/E.1.3

DATE: November 2006

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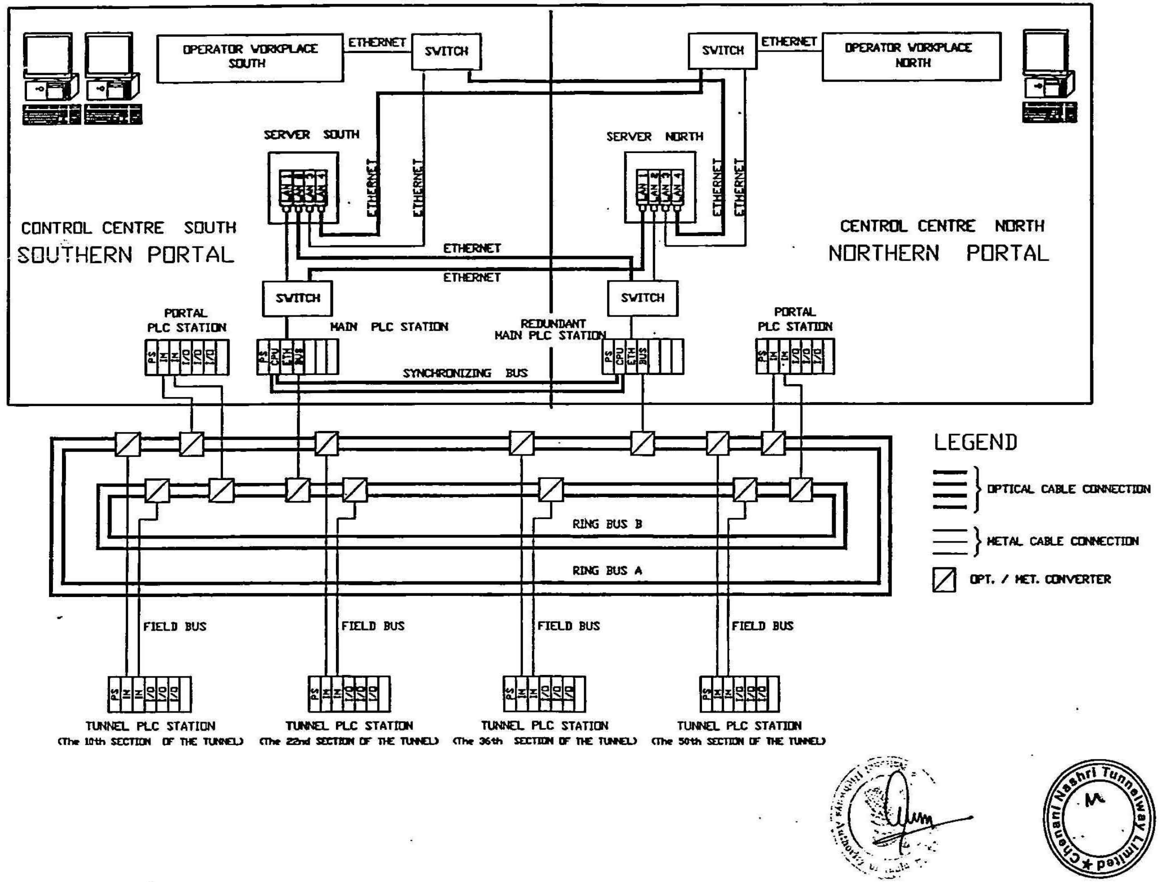
Tunnel Consultant:
D2 CONSULT
ELTODO EG



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Karel Kruse	
DESIGN BY	Karel Kruse	
CHECKED BY	SKB	
APPROVED BY	CLOSE	

TITLE: Schematic diagram of the Integrated Tunnel Control System
SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23
DRAWING NO.: ELT/01/T.1.0
DATE: November 2006

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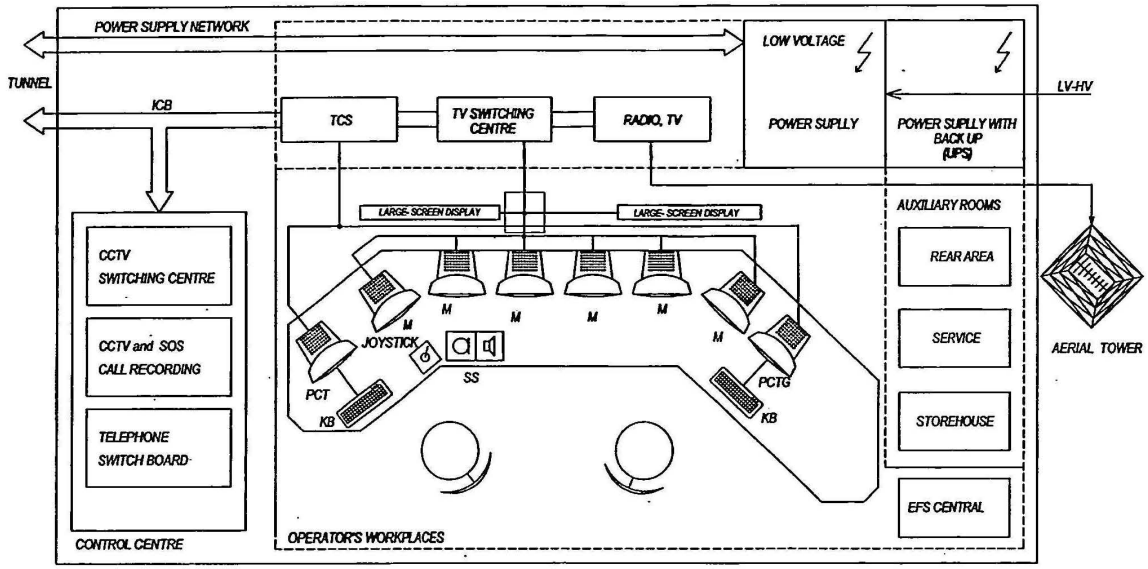
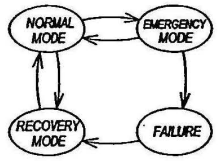
Tunnel Consultant:
D2 CONSULT
ELTODO EG



ICB - INDUSTRIAL CONTROL BUS
TCS - TUNNEL CONTROL SYSTEM
EFS - ELECTRIC FIRE SIGNALLING
M - CCTV MONITOR
KB - KEYBOARD
PCT - TERMINAL FOR TRAFFIC
PCTG - TERMINAL FOR TECHNOGY
SS - SPEAKER/ MICROPHONE SET

BASE TUNNEL OPERATION MODES



REV	DATE	PREP.	CHK.	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE : Schematic diagram of the Main Control Centre

SCALE : W/O SCALE

PROJECT : Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO. : ELT/01/T.1.1

DATE : November 2006

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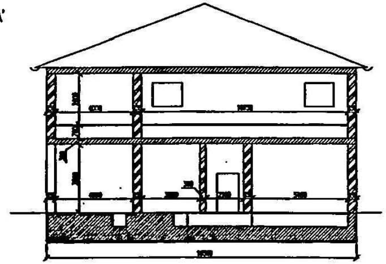
Transit Consultant:
D2 CONSULT

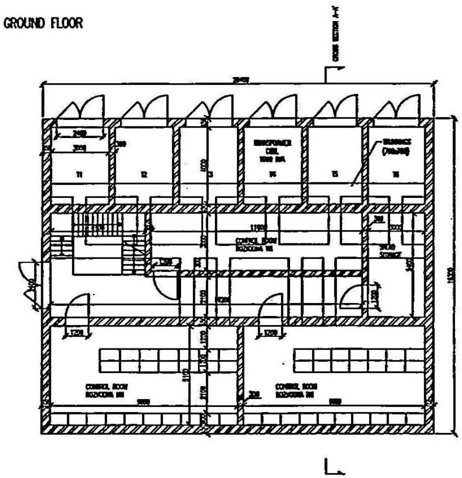
Infrastructure Consultant: EUCODO EG

Chenani Nashri Tunnelway Limited

CROSS SECTION A-A'



GROUND FLOOR



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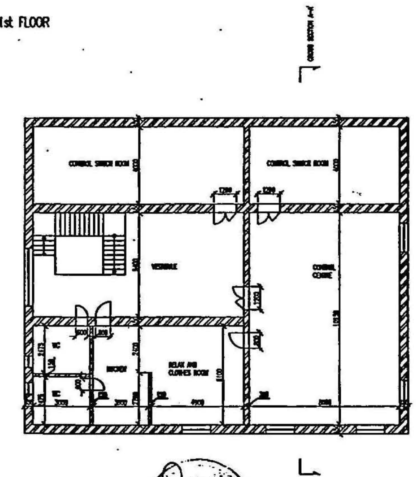


REV	DATE	PREP	CHK.	APPROVED	DESCRIPTION	NATIONAL HIGHWAYS AUTHORITY OF INDIA G-5 & 6, Sector 10, Dwarka, New Delhi.		NAME	SIGN
							DRAWN BY	Karel Kraus	
							DESIGN BY	Karel Kraus	
							CHECKED BY	SRB	
							APPROVED BY	CLOSE	

TITLE :	PATNITOP TUNNEL MAIN TUNNEL MINED TUNNEL NORTH (SECONDARY) CONTROL CENTRE
SCALE :	1:100
PROJECT :	Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23
DRAWING NO. :	ELT/01/T.1.3
DATE :	November 2006

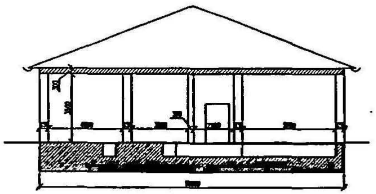
THE Louis Berger Group, Inc., USA

Tunnel Consultant:

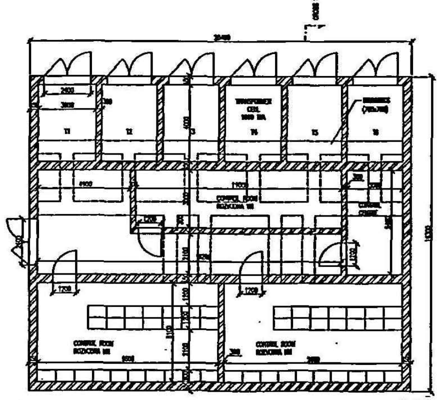
D2 CONSULT

ELIODO EG

CROSS SECTION A–A'



GROUND FLOOR



Chenani Nashri Tunnelway Limited

REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Karel Kraus	
DESIGN BY	Karel Kraus	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: PATNITOP TUNNEL
MAIN TUNNEL
MINED TUNNEL
SOUTH (MAIN) CONTROL CENTRE

SCALE: 1:100

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: ELT/01/T.1.4

DATE: November 2006

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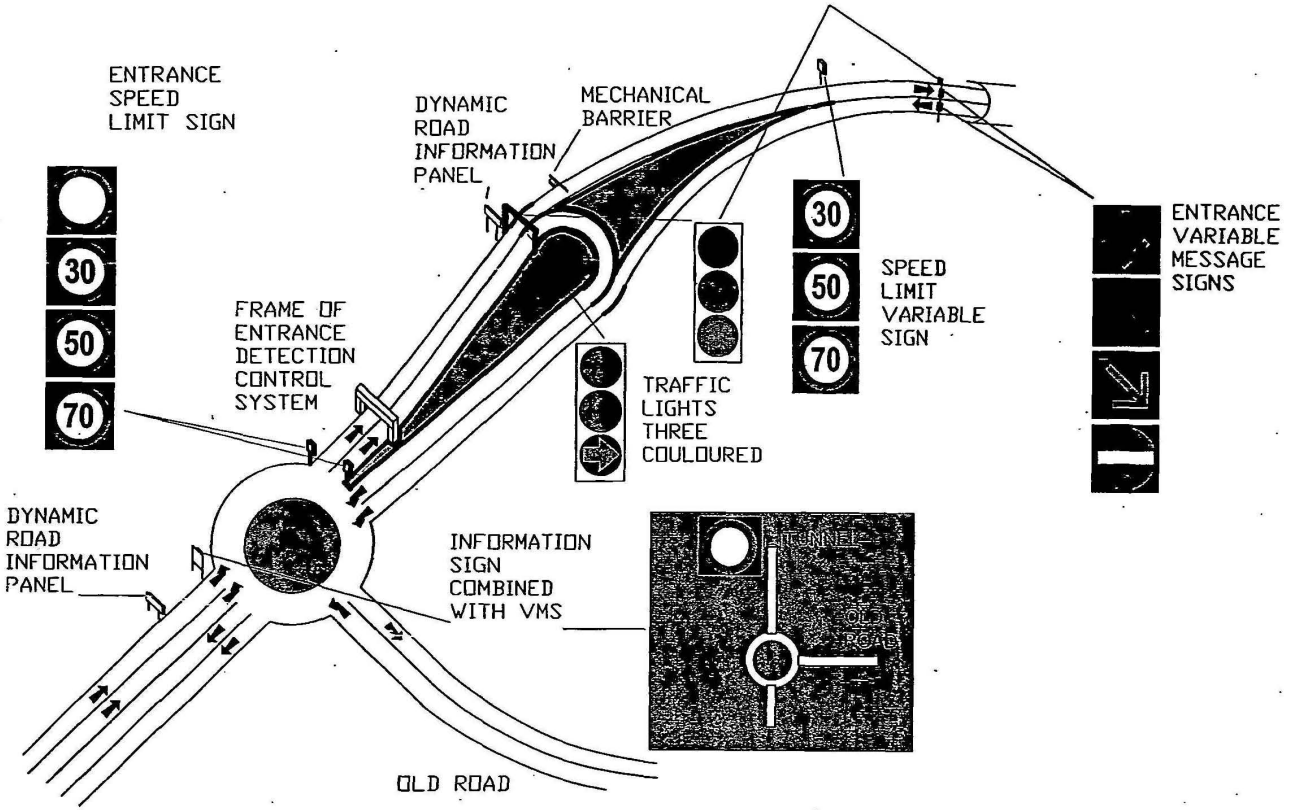
D2 CONSULT
ELTODO EG



REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Principled Schema of the Dynamic Entrance Traffic Control
SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23
DRAWING NO.: ELT/04/T.L.2
DATE: November 2006

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Tunnel Consultant:
D2 CONSULT
Infrastructuredade ELTODO EG

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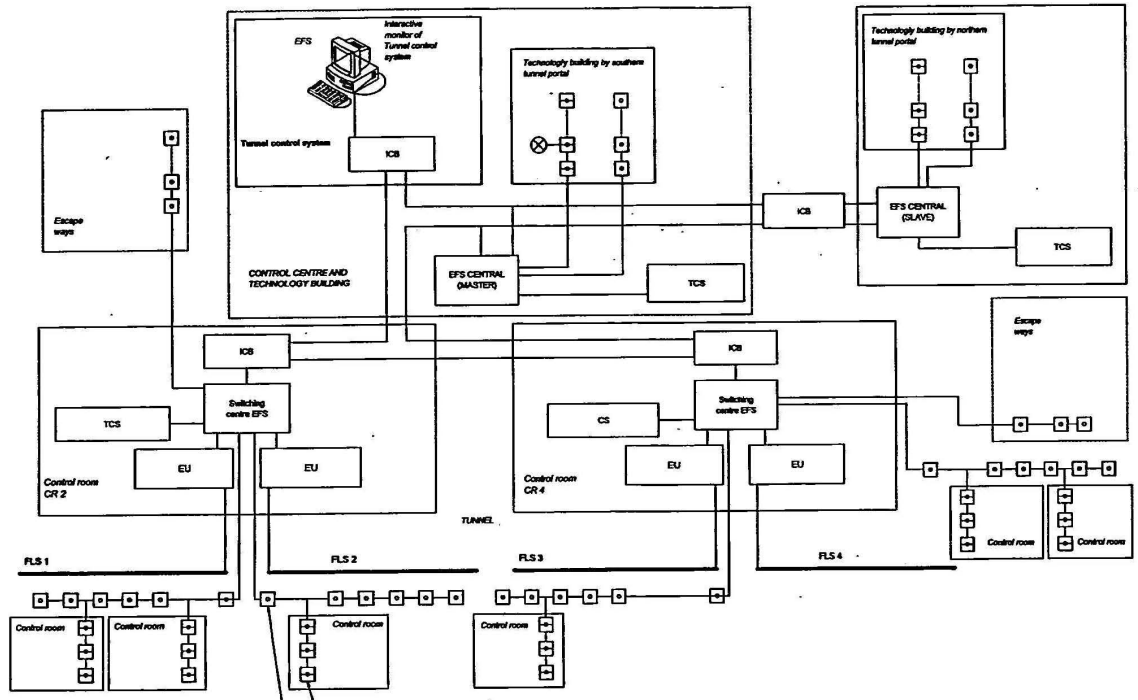

ICB - INDUSTRIAL CONTROL BUS
TCS - TUNNEL CONTROL SYSTEM
EU - EVALUATION UNIT of LINE FIRE DETECTOR
FLS - FIBRE LASER SENSOR of LINE FIRE DETECTOR

REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kunal Kumar	
DESIGN BY	Kunal Kumar	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Schematic diagram of the Electric Fire Signalling System

SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23

DRAWING NO.: EL/T/01/T. 1.4

DATE: November 2006

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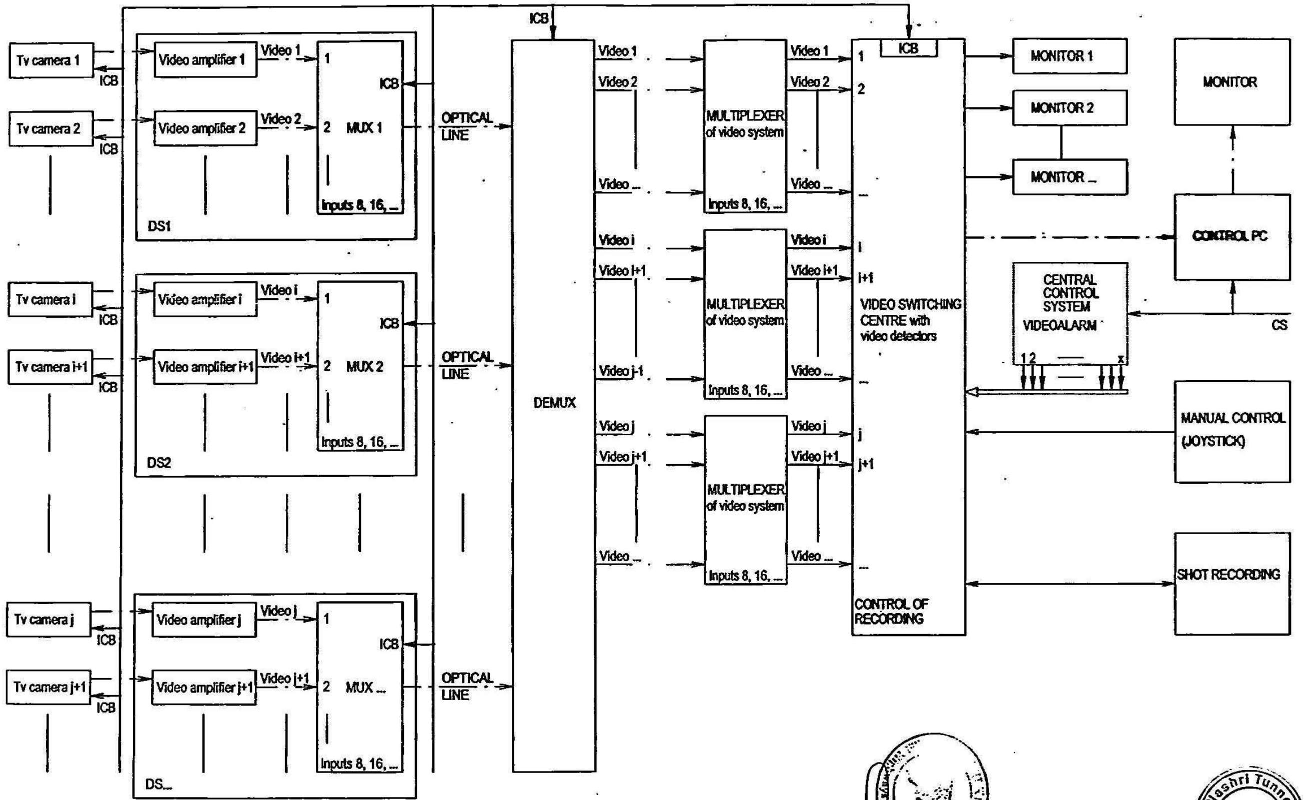
EUTODO EG

Chenani Nashri Tunnelway Limited



MUX - MULTIPLEXER
DEMUX - DEMULTIPLEXER
ICB - INDRIUSTRIAL CONTROL BUS

REV	DATE	PREP	CHK	APPROVED	DESCRIPTION

NATIONAL HIGHWAYS AUTHORITY OF INDIA
G-5 & 6, Sector 10, Dwarka, New Delhi.

	NAME	SIGN
DRAWN BY	Kaud Kraus	
DESIGN BY	Kaud Kraus	
CHECKED BY	SRB	
APPROVED BY	CLOSE	

TITLE: Schematic diagram of the Video Surveillance System
SCALE: W/O SCALE

PROJECT: Four laning of NH-1A from Udhampur to Banihal (Km.66 To Km.188) C-III/25, 23
DRAWING NO.: ELT/01/T.1.6
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THE Louis Berger Group, Inc., USA
Engineers · Planners · Scientists · Economists
Tunnel Consultant: D2 CONSULT
GEODATA / ELTODO EG