

Name of Work : Construction, Operation and Maintenance of 2-Lane Bi-Directional Silkyara Bend - Barkot Tunnel With Escape Passage Including Approaches On Dharasu-Yamunotri Section Between Ch. 25.400 Km And Ch. 51.000 Km Falling Along NH-134 (OLD NH-94)in the State Of Uttarakhand on EPC mode”

**Detailed Project Report -
Technical Specification Ventilation Equipment**

Index of Contents

1	GENERAL.....	3
2	EXHAUST AIR AXIAL FANS.....	5
3	FRESH AIR AXIAL FANS.....	6
4	EXHAUST AIR DAMPERS.....	9
5	JET FANS.....	9

1 GENERAL

In this document the Technical Specifications for the ventilation system equipment are defined. All accessories of the ventilation system shall comply with the Technical Specification as laid down herein.

The following main elements of the ventilation system are defined in this Technical Specification:

- Exhaust air axial fans of the main tunnel transverse ventilation system
- Fresh air axial fans of the main tunnel transverse ventilation system
- Jet fans of the main tunnel longitudinal ventilation system
- Exhaust air dampers of the main tunnel transverse ventilation system

The elements of the ventilation system are developed based on the preliminary tunnel design of Phase II. The final layout of the ventilation system and its elements shall be adapted to the detailed tunnel design as approved by the Employer's Representative. In the following the basic input parameters for the ventilation design of the preliminary tunnel design of Phase II are given.

The preliminary ventilation design is based on the following main International Guidelines and design criteria:

International Guidelines:

- PIARC Committee on Road Tunnels Operation (C3.3): SYSTEMS AND EQUIPMENT FOR FIRE AND SMOKE CONTROL IN ROAD TUNNELS (2007)
- PIARC Technical Committee on Road Tunnel Operation (C5): ROAD TUNNELS: VEHICLE EMISSIONS AND AIR DEMAND FOR VENTILATION (2004)
- FSV Working group tunnel, Section operation and safety equipment - RVS 09.02.31: Tunnel Equipment, Ventilation – basic principles; Vienna 2008
- FSV Working group tunnel, section operation and safety equipment - RVS 09.02.32: Ventilation design – Fresh air demand; Vienna 2005
- FSV Working group tunnel, section operation and safety equipment - RVS 09.02.22: Tunnel Equipment – Tunnel safety; Vienna 2007

General Design Criteria:

- | | |
|---------------------------------------|----------|
| • Annual Average Daily Traffic (AADT) | 2100 pcs |
| • Peak Hour Traffic (PHT) | 5000 pcs |
| • Design Speed | 80 km/h |
| • Wind velocity outside | 6 m/s |

- Pressure difference portals 300 Pa
- Maximum air velocity inside the tunnel: 10 [m/s]
- Tunnel geometry as per Detailed Project Report Drawings

Normal Operation Design Criteria:

- Admissible CO concentration: 100 [ppm]
- Visibility extinction coefficient: 7×10^{-3} [m⁻¹]
- Used vehicle fleet:
 - 10% Euro 0
 - 20% Euro 1
 - 65% Euro 2
 - 3% Euro 3
 - 2% Euro 4
- Idling condition for normal operation air demand

Incident Operation Design Criteria:

- Thermal load of fire 50 MW
- Extraction volume at air density of 1,2 kg/m³ is 120 m³/s
- Thermal increase 90 K over a length of 800m
- 6,0 m/s prevailing wind speed at exit portal of the volume flow
- Barometric pressure of 300 Pa between the two portals
- Smoke transport in direction of the prevailing flow to the next open damper
- Jet-fans running in hot smoke undergo loss in momentum
- Jet-fans located close to the fire has to be deactivated
- Exhaust air dampers every 100 m in the intermediate ceiling
- Clearance of the openings for the exhaust dampers is 3 m x 4 m
- Leakage of the exhaust air duct is 10 m³/s/km
- Pressure depending leakage of the exhaust air dampers is 0,1 m³/s/m² - 0,14 m³/s/m²

2 EXHAUST AIR AXIAL FANS

The exhaust air axial fans of the main tunnel transverse ventilation system shall be in compliance with Table 1 including the Technical Specification of the fan, motor and accessories.

Table 1: Technical Specifications of the exhaust air axial fans

Main Tunnel Transverse Ventilation System – Exhaust Air Fan			
No.	Description	Unit	Technical Particulars
			Specification
1	FAN TECHNICAL DATA		
1.1	Volume flow	m ³ /s	see table 8 (normal operation) and table 10 (incident operation)
1.2	Static pressure increase	Pa	see table 8 (normal operation) and table 10 (incident operation)
1.3	Total fan pressure	Pa	By bidder
1.4	Air density (ρ)	kg/m ³	0.94
1.5	Min. aerodynamic efficiency at operating point	%	0.7
1.6	Mounting method	-	Horizontal
1.7	Impeller type	-	Variable pitch blades (hydraulic)
1.8	Operating temperature - DIN EN 12101-3:2010-06	°C	400 (over 2 hours)
1.9	Installation level (ASL)	m	3105
1.10	Fan test arrangement	-	according to DIN EN ISO 5801:2010-12
1.11	Sound power level - 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz	dB(A)	112, 118, 119, 117, 114, 109, 103, 97
1.12	Running smoothness - ISO 14694	-	R
1.13	Impeller diameter	m	By bidder
1.14	Blade material / type / construction / finish	-	EN-GJS-400-18-LT / Aerofoil / cast / plain
1.15	Inlet nozzle material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C5-I)
1.16	Adapter pieces material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C5-I)
1.17	Compensator material (400°C over 2 hours)	-	By Bidder
1.18	Fan Casing Material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C5-I)

Main Tunnel Transverse Ventilation System – Exhaust Air Fan			
No.	Description	Unit	Technical Particulars
			Specification
1.19	Diffusor Material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C5-I)
1.20	Fan cut-off damper / finish	-	Stainless steel (1.4404) / plain
1.21	Fan insulation with aluminium housing	-	Max. surface temperature 80°C (at 400°C exhaust air temperature)
1.22	Seperate ventilation of the fan (Impeller and Motor cooling)	-	By bidder
1.23	Hydraulic aggregate for variable pitch blades	-	By bidder
1.24	Transmitter enclosures for each fan	-	By bidder
2	MOTOR TECHNICAL DATA		
2.1	Voltage (U)	V	690
2.2	Frequency (f)	Hz	50
2.3	Normal running Current (I)	A	By bidder
2.4	Max. start up current (I _{max})	A	5 x I (in case of direct on-line start)
2.5	Start up (starting circuit)	-	ΔΔ
2.6	RPM switching	-	Dahlander pole changing
2.7	Min. motor efficiency RPM 1 - low speed	%	94
2.8	Min. motor efficiency RPM 2 - high speed	%	92
2.9	Shaft power consumption	kW	see table 8 (normal operation) and table 10 (incident operation)
2.10	Minimum life cycle bearings (L10h)	h	70000
2.11	Startup per hour	s/h	6 starts in 10 minutes
2.12	Insulation class	-	H utilize B
2.13	Protection class	-	IP65
2.14	Temperature (over 2 hours) - DIN EN 12101-3:2010-06	°C	400
2.15	Motor manufacturer	-	West-European or equivalent
2.16	Maximum start up time (standstill to full forward run)	sec	65
3	ACCESSORIES		
3.1	Temperature elements for each bearing	-	PT100
3.2	Temperature element for each winding	-	PT100
3.3	Anti vibration mount	-	Type & Manufactor by Bidder
3.4	Blade position	-	Type & Manufactor by Bidder
3.5	Surge limit control	-	Type & Manufactor by Bidder
3.6	Stall measurement	-	Type & Manufactor by Bidder
3.7	Vibration measurement	-	Type & Manufactor by Bidder
3.8	Direction of rotation measurement	-	Type & Manufactor by Bidder
3.9	Revolution counter	-	Type & Manufactor by Bidder
3.10	Pressure increase measurement	-	Type & Manufactor by Bidder
3.11	Volume flow measurement	-	Type & Manufactor by Bidder
3.12	Lifting lugs - minimum 4	-	Type & Manufactor by Bidder

3 FRESH AIR AXIAL FANS

The fresh air axial fans of the main tunnel transverse ventilation system shall be in compliance with Table 2 including the Technical Specification of the fan, motor and accessories.

Table 2: Technical Specifications of the fresh air axial fans

Main Tunnel Transverse Ventilation System – Fresh Air Fan			
No.	Description	Unit	Technical Particulars
			Specification
1	FAN TECHNICAL DATA		
1.1	Volume flow	m ³ /s	see table 9
1.2	Static pressure increase	Pa	see table 9
1.3	Total fan pressure	Pa	By bidder
1.4	Air density (ρ)	kg/m ³	0.94
1.5	Min. aerodynamic efficiency at operating point	%	0.7
1.6	Mounting method	-	Horizontal
1.7	Impeller type	-	Variable pitch blades (hydraulic)
1.8	Operating temperature	°C	Ambient air temperature
1.9	Installation level (ASL)	m	3105
1.10	Fan test arrangement	-	according to DIN EN ISO 5801:2010-12
1.11	Sound power level - 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz	dB(A)	112, 118, 119, 117, 114, 109, 103, 97
1.12	Running smoothness - ISO 14694	-	R
1.13	Impeller diameter	m	By bidder
1.14	Blade material / type / construction / finish	-	EN-GJS-400-18-LT / Aerofoil / cast / plain
1.15	Inlet nozzle material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C3)
1.16	Adapter pieces material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C3)
1.17	Compensator material (400°C over 2 hours)	-	By Bidder
1.18	Fan Casing Material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C3)
1.19	Diffusor Material / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C3)
1.20	Fan cut-off damper / finish	-	Steel S235JR+AR / Epoxy (corrositivity category C3)
1.21	Hydraulic aggregate for variable pitch blades	-	By bidder
1.22	Transmitter enclosures for each fan	-	By bidder
2	MOTOR TECHNICAL DATA		
2.1	Voltage (U)	V	690
2.2	Frequency (f)	Hz	50
2.3	Normal running Current (I)	A	By bidder
2.4	Max. start up current (I _{max})	A	5 x I (in case of direct on-line start)
2.5	Start up (starting circuit)	-	ΔΔ
2.6	RPM switching	-	Dahlander pole changing
2.7	Min. motor efficiency RPM 1 - low speed	%	94
2.8	Min. motor efficiency RPM 2 - high speed	%	92
2.9	Shaft power consumption	kW	see table 9
2.10	Minimum life cycle bearings (L10h)	h	70000
2.11	Startup per hour	s/h	6 starts in 10 minutes
2.12	Insulation class	-	H utilize B

Main Tunnel Transverse Ventilation System – Fresh Air Fan			
No.	Description	Unit	Technical Particulars
			Specification
2.13	Protection class	-	IP65
2.14	Temperature	°C	Ambient air temperature
2.15	Motor manufacturer	-	West-European or equivalent
2.16	Maximum start up time (standstill to full forward run)	sec	65
3	ACCESSORIES		
3.1	Temperature elements for each bearing	-	PT100
3.2	Temperature element for each winding	-	PT100
3.3	Anti vibration mount	-	Type & Manufacturer by Bidder
3.4	Blade position	-	Type & Manufacturer by Bidder
3.5	Surge limit control	-	Type & Manufacturer by Bidder
3.6	Stall measurement	-	Type & Manufacturer by Bidder
3.7	Vibration measurement	-	Type & Manufacturer by Bidder
3.8	Direction of rotation measurement	-	Type & Manufacturer by Bidder
3.9	Revolution counter	-	Type & Manufacturer by Bidder
3.10	Pressure increase measurement	-	Type & Manufacturer by Bidder
3.11	Volume flow measurement	-	Type & Manufacturer by Bidder
3.12	Lifting lugs - minimum 4	-	Type & Manufacturer by Bidder

4 EXHAUST AIR DAMPERS

The exhaust air dampers of main tunnel transverse ventilation system shall be in compliance with Table 3 including the Technical Specification of the motor and accessories.

Table 3: Technical Specifications of the exhaust air dampers

Main Tunnel Ventilation System - Exhaust air dampers			
No.	Description	Unit	Technical Particulars
			Specification
1	DAMPER TECHNICAL DATA		
1.1	Frame modules	-	Multiple
1.2	Blade construction / material / finish	-	double skin / stainless steel (1.4404) / plain
1.3	Temperature (over 2 hours)	°C	400
1.4	Mounting method	-	Horizontal
1.5	Width	m	3.0
1.6	Length	m	4.0
1.7	Time taken from open to close	s	25
1.8	Limit switch (mechanical)	-	YES
1.9	Free face area per inside of frame	m ²	9.6
1.10	Maximum under pressure	Pa	4000
1.11	Maximum over pressure	Pa	2500
1.12	Installation site	-	Exhaust air duct
2	MOTOR TECHNICAL DATA		
2.1	Voltage (U)	V	400
2.2	Normal running Current (I)	A	By Bidder
2.4	Protection class	-	IP65
2.5	Motor finish	-	Epoxy (corrositivity category C3)
2.6	Temperature	°C	Ambient temperature
2.7	Motor Manufacturer	-	West-European or equivalent

5 JET FANS

The jet fans of the main tunnel longitudinal ventilation system shall be in compliance with Table 4 including the Technical Specification of the fan, motor and accessories.

Table 4: Technical Specifications of the jet fans in jet fan niche

Main Tunnel Longitudinal Ventilation System - Jet Fans in Ventilation Niches			
No.	Description	Unit	Technical Particulars
			Specification
1	FAN TECHNICAL DATA		
1.1	Max. outer diameter (DA)	m	1.76
1.2	Max. overall length (A)	m	6.15
1.3	Distance to ceiling - plane of symmetry of the jet fan to the ceiling (z)	m	1.2
1.4	Min. nominal thrust (full reversible)	N	2660
1.5	Air density (ρ)	kg/m ³	1.2
1.6	Installation factor - Kempf factor (k)	-	0.8
1.7	Min. outlet velocity (v)	m/s	37.6
1.8	Min. volume flow (V)	m ³ /s	66.5
1.9	Max. sound power level - noise	dB(A)	105
1.10	Impeller Pitch Angle	-	By bidder
1.11	Blade Type, construction, Material	-	Aerofoil, Cast, Aluminum Alloy (Al-Si-Mg)
1.12	Shaft Material	-	Stainless steel
1.13	Fan Casing Material	-	Stainless steel (1.4404), plain
1.14	HUB Material	-	Stainless steel
1.15	Inlet & Outlet Silencer	-	2D
1.16	Silencer Material	-	Stainless steel (1.4404), Insulation
1.17	Fan Type	-	Fully Reversible
1.18	Fan Test Arrangement	-	ISO 13350
1.19	Installation level (ASL)	m	3105
1.20	Temperature (over 2 hours) - DIN EN 12101-3:2010-06	°C	400
2	MOTOR TECHNICAL DATA		
2.1	Voltage (U)	V	400 or 690
2.2	Normal running Current (I)	A	By Bidder
2.3	Maximum start up current (I _{max})	A	7 x I (in case of direct on-line start)
2.4	Frequency converter	-	YES
2.5	Start up (starting circuit)	-	Frequency inverter
2.6	Min. cosinus phi (cos ϕ)	-	0.84
2.7	Min. motor efficiency (η)	%	85
2.8	Max. rotational speed (n)	RPM	By Bidder
2.9	Shaft power consumption	kW	90
2.10	Minimum life cycle bearings (L10h)	h	50000
2.11	Start-up per hour	s/h	6 starts in 10 minutes

Main Tunnel Longitudinal Ventilation System - Jet Fans in Ventilation Niches			
No.	Description	Unit	Technical Particulars
			Specification
2.12	Operation mode	-	S1
2.13	Insulation class (designed for fire case F250)	-	H with Class F temperature rise
2.14	Protection class	-	IP65
2.15	Motor finish	-	Epoxy (corrosivity category C5 - I)
2.16	Temperature (over 2 hours) - DIN EN 12101-3:2010-06	°C	400
2.17	Motor Manufacturer	-	West-European or equivalent
2.18	Start up time (standstill to full forward run)	sec	30
3	ACCESSORIES		
3.1	Anti condensation heater elements	-	2×100W
3.2	Temperature elements for each bearing	-	PT100
3.3	Temperature element for each winding	-	PT100
3.4	Anti vibration mount	-	Type & Manufactor by Bidder
3.5	Lifting lugs - minimum 4	-	Type & Manufactor by Bidder
3.6	Vibration monitoring sensor	-	Type & Manufactor by Bidder