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**CLIENT:**



The Chief Employer's  
Representative  
Project BEACON  
Border Roads Organization  
C/O 56 APO

**PROJECT:**

Consultancy Services for Detailed Feasibility Study and Framing up of  
Phasewise proposal (DPR) for construction of two tunnels at Z-Morh and at  
Zojila for all weather connectivity from Srinagar to Leh in Jammu & Kashmir  
State

**ZOJILA TUNNEL**

**TITLE:**

**Phase II: Detailed Project Report - Preliminary Tunnel Design**  
**Volume VII: Cost Estimation**

Prepared by:	Burgstaller, Goricki	Date:	2013-03-31
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## 1 SCOPE OF WORK

The Border Roads Organization (BRO) develops all weather connectivity between Srinagar and Leh in northern India (State of Jammu & Kashmir), which includes the construction of Zojila Tunnel located north-eastern of the city of Srinagar at the National highway 1D close to Baltal.

3G Gruppe Geotechnik Graz ZT GmbH (3G) in JV with Vayam Technologies Ltd. (formerly iBilt Technologies Ltd.) have been awarded for the work of consultancy services to provide a “Detailed Feasibility Study and Framing up of Phasewise proposal (DPR) for construction of the Zojila tunnel” by the Client Border Roads Organization.

This report is part of the Detailed Project Report (DPR), Phase II. It describes the cost estimation of Zojila tunnel based on the Preliminary Tunnel Design of Phase II.

## 2 METHODOLOGY

The cost estimation is developed in three main sections, the assessment of the quantities for each item, the determination of the unit rates for each item and the bill of quantity, which combines the quantities and unit rates assessed for all items.

All three parts of the cost estimation are given within this report.

- Addendum 1: Details of Quantities (DoQ): Assessment of quantities for each item of civil engineering work
- Addendum 2: Details of Rates (DoR): Assessment of unit rates for each item of civil engineering work
- Addendum 3: Bill of Quantities (BoQ): List of items including quantities determined in DoQ and unit rates determined in DoR.

The items are grouped with respect to the construction elements in eight Bills.

- Bill 1: Civil Engineering Main Tunnel
- Bill 2: Civil Engineering Egress Tunnel
- Bill 3: Civil Engineering Ventilation Shaft & Ventilation Cavern
- Bill 4: Civil Engineering Portal West
- Bill 5: Civil Engineering Portal East
- Bill 6: Site Facility and Time-dependent Costs
- Bill 7: Electro & Mechanical Equipment
- Bill 8: Ventilation System

### **3 DETAILS OF QUANTITIES (DOQ)**

The quantities are determined based on the Preliminary Tunnel Design, Phase II. All quantities are calculated, measured in design drawings by CAD methods or estimated from current base of knowledge of the project.

The determination of the quantities is presented comprehensively for each item of the civil works in Addendum 1. These quantities are the basis for the cost estimation presented in the bill of quantity (BoQ).

### **4 DEATAILS OF RATES (DOR)**

The unit rates considering the main cost items (material, labour and machinery) are calculated separately for each item of the works.

The rates for material, labour and machinery are based on the “Standard Data Book for Analysis of Rates” (SoR) of Ministry of Road Transport and Highways published by Indian Road Congress (IRC). The SoR rates do not cover all items for tunnel construction works. Due to this all machinery, labour and/or material rates concerning tunnel construction are determined from international price data of year 2012 and verified with actual Indian highway tunnel projects with similar layout and boundary conditions (such as Pahtnitop Tunnel and Rohtang Tunnel). The Contractor’s profit is included in the machinery, labour and material rates.

#### Machinery:

The rates of special machinery and plants for tunnel construction, which are not included in the “Standard Data Book for Analysis of Rates” of Ministry of Road Transport and Highways, are estimated by general international rates and experience from Indian and international tunnelling projects. These rates are based on the year 2012. Machinery, which cannot be assigned to one specific item, are included in the time-dependent cost of the construction works. This includes accommodation and offices, cranes, trucks etc.

#### Labour rates:

The labour rates for Indian workmanship are based on SoR rates. The determined rates for labour (including mean escalation to 2012) are given in Table 1. The Labour rates for highly qualified Indian and International workmanship specialized in tunnel construction works are based on general International price basis and experience from Indian and International tunnelling projects. All rates are given in Table 1 (price basis 2012).

Table 1: Rates for labour (basis 2012)

Item No.	Description of Item	Rate [INR/h]
Labour Rates as per international tunnel construction practice		
Lab-001	Project Manager Expert	4.286,37
Lab-002	Section Leader	3.716,16
Lab-003	Foreman specialist	3.429,09
Lab-004	Skilled NATM Working Man Underground	2.465,64
Lab-005	Skilled monitoring underground	3.214,78
Lab-006	Skilled unproductive experts	2.588,18
Lab-007	Skilled unproductive personnel	1.294,09
Lab-008	Skilled productive personnel	2.588,18
Labour Rates as per SoR		
Lab-009	Blacksmith (IInd class)	104,17
Lab-010	Blacksmith (Ist class)/ Welder/ Plumber/ Electrician	125,00
Lab-011	Blaster (Stone cutter)	125,00
Lab-012	Carpenter I Class	125,00
Lab-013	Chiseller (Head Mazdoor)	125,00
Lab-014	Driller (Jumper)	125,00
Lab-015	Diver	177,08
Lab-016	Fitter	177,08
Lab-017	Mali	125,00
Lab-018	Mason (IInd class)	125,00
Lab-019	Mason (Ist class) & Skilled	177,08
Lab-020	Mate	125,00
Lab-021	Mazdoor	125,00
Lab-022	Mazdoor/Dresser (Semi Skilled)	104,17
Lab-023	Mazdoor/Dresser/Sinker (Skilled)	104,17
Lab-024	Medical Officer	291,67
Lab-025	Operator(grouting)	177,08
Lab-026	Painter I class	177,08
Lab-027	Para medical personnel	177,08

**Material:**

Material rates are based on the “Standard Data Book for Analysis of Rates” (SoR). The rates are adapted to the year 2012 with respect to escalation. Materials which are required for tunnel works but not included in the SoR are determined by international price basis and verified with Indian tunnel construction works. The carriage cost of each item to the site is estimated and considered within the unit rates of the items. It is assumed, that the main items are provided from Srinagar by truck in the summer period when Zojila western portal and Zojila pass are accessible. During the time period when Zojila western portal and the Zojila pass are not accessible the supply is provided from Leh to Zojila eastern portal only. Due to this the overall estimated and considered transport costs consist of  $\frac{3}{4}$  of the transport costs from Srinagar and  $\frac{1}{4}$  of the transport costs from Leh. Aggregates are assumed to be provided from local sources and/or from suitable tunnel excavation

material. A mean average transport distance of 29 km is assumed for aggregates, including transportation to the site and/or transportation to and from a temporary storage of suitable muck material. The aliquot carriage costs for each item are considered with respect to the transport volume of the item, the costs of each truck load and the mean transport capacity of the truck. These costs are added to the material rates determined by International and Indian tunnel construction material prices and material rates as given in the SoR respectively. The additional costs for transport to site are given in Table 2.

Table 2: Rates for material including transport to the site (basis 2012)

Item No.	Description of Item	Unit	Rate per Unit	Transport	Rate at Site
Material Rates as per international tunnel construction practice					
Mat-001	Explosive including detonator and accessories for d&b	cum	408,66	45,01	453,67
Mat-002	Gasoline for wheel loader	hour	1.362,20	18,00	1.380,20
Mat-003	Gasoline for dumper	hour	2.615,08	27,01	2.642,09
Mat-004	Gasoline for transporter	hour	1.362,20	13,50	1.375,70
Mat-005	Miscellaneous material for tunnel excavation per cum excavation	cum	70,00	at site	70,00
Mat-006	Shotcrete C25/30 (mixing on site)	cum	4.818,64	at site	4.818,64
	Batching plant included in time dependent costs shotcrete cost calculated: [Equation = (a+b+c+d+e)/75]			-	-
	Output capacity = 75m <sup>3</sup> /h			-	-
a	Electricity = 100kW*1h = 110kWh*6,81INR/kWh		825,00	-	-
b	Skilled working man = 6*1h*2465,64INR/h		14.793,87	-	-
c	Aggregates = 67,5 m <sup>3</sup> *1135,75		76.663,13	-	-
d	Water = 0,18 m <sup>3</sup> /m <sup>3</sup> *75m <sup>3</sup> *68.11INR/m <sup>3</sup>		919,49	-	-
e	CEMII/42.5R = 350 kg/m <sup>3</sup> *75m <sup>3</sup> *10.217INR/kg		268.196,25	-	-
Mat-007	No fines concrete (mixing on site)	cum	4.699,59	at site	4.699,59
Mat-008	Concrete C12/15 (mixing on site)	cum	4.103,19	at site	4.103,19
	Batching plant included in time dependent costs concrete cost calculated: [Equation = (a+b+c+d+e)/75]			-	-
	Output capacity = 75m <sup>3</sup> /h			-	-
a	Electricity = 110kW*1h = 110kWh*6,81INR/kWh		825,00	-	-
b	Skilled working man = 6*1h*2465,64INR/h		14.793,87	-	-
c	Aggregates = 67,5 m <sup>3</sup> *1135,75		76.663,13	-	-
d	Water = 0,18 m <sup>3</sup> /m <sup>3</sup> *75m <sup>3</sup> *68,11INR/m <sup>3</sup>		919,49	-	-
e	CEMII/32.5R = 300 kg/m <sup>3</sup> *75m <sup>3</sup> *9.535INR/kg		214.537,50	-	-
Mat-009	Concrete C25/30 (mixing on site)	cum	4.818,64	at site	4.818,64
	Batching plant included in time dependent costs concrete cost calculated: [Equation = (a+b+c+d+e)/75]			-	-
	Output capacity = 75m <sup>3</sup> /h			-	-
a	Electricity = 110kW*1h = 110kWh*6,81INR/kWh		825,00	-	-
b	Skilled working man = 6*1h*2465,64INR/h		14.793,87	-	-
c	Aggregates = 67,5 m <sup>3</sup> *1135,75		76.663,13	-	-
d	Water = 0,18 m <sup>3</sup> /m <sup>3</sup> *75m <sup>3</sup> *68,11INR/m <sup>3</sup>		919,49	-	-
e	CEMII/42.5R = 350 kg/m <sup>3</sup> *75m <sup>3</sup> *10.217INR/kg		268.196,25	-	-
Mat-010	Concrete C30/37 (mixing on site) for cement concrete pavement [Equation = (a+b+c+d+e)/75]	cum	5.263,74	at site	5.263,74

	Batching plant included in time dependent costs			-	-
	Output capacity = 75m <sup>3</sup> /h			-	-
a	Electricity = 110kW*1h = 110kWh*6,81INR/kWh		825,00	-	-
b	Skilled working man = 4*1h*2465,64INR/h		9.862,58	-	-
c	Aggregates = 67,5 m <sup>3</sup> *1135,75		76.663,13	-	-
d	Water = 0,18 m <sup>3</sup> /m <sup>3</sup> *75m <sup>3</sup> *68,11INR/m <sup>3</sup>		919,49	-	-
e	CEMII/42.5R = 400 kg/m <sup>3</sup> *75m <sup>3</sup> *10,217INR/kg		306.510,00	-	-
Mat-011	Electricity	kWh	7,50	at site	7,50
Mat-012	Gasoline	litre	78,00	0,90	78,90
Mat-013	Frictional bolt (Swellex or equivalent 200 kN)	meter	871,81	2,06	873,87
Mat-014	Anchor plate for frictional bolt and wear parts	pcs	323,52	1,80	325,32
Mat-015	Wire mesh (CQS60 or equivalent 3,11 kg/sqm)	kg	140,00	5,79	75,79
Mat-016	Lattice girder	tonne	185.000,00	2.158,23	187.158,23
Mat-017	Lattice girder connections and footing	pcs	68,11	at site	68,11
Mat-018	Grouted bolt	meter	221,36	0,44	221,80
Mat-019	Anchor plate for grouted bolt and wear parts	pcs	323,52	1,80	325,32
Mat-020	Self-drilling bolt	meter	681,10	0,44	681,54
Mat-021	Anchor plate for self-drilling bolt and wear parts	meter	306,50	1,80	308,30
Mat-022	Injection material	tonne	7.492,10	375,09	7.867,19
Mat-023	Explosive including detonator and accessories for excavation with tunnel excavator	cum	68,11	0,90	69,01
Mat-024	Gasoline for tunnel excavator	hour	1.294,09	17,10	1.311,19
Mat-025	Umbrella pipe	meter	442,72	9,18	451,90
Mat-026	Additional material formwork	cum	72,00	at site	72,00
Mat-027	Reinforcement grade S550	tonne	52.000,00	257,21	52.257,21
Mat-028	PVC or PP drainage pipe Ø150mm	meter	1.243,01	15,91	1.258,92
Mat-029	PVC or PP drainage pipe Ø250mm	meter	2.288,50	44,19	2.332,69
Mat-030	PVC or PP drainage pipe Ø400mm	meter	3.776,70	113,13	3.889,82
Mat-031	Drainage Material	cum	1.021,65	at site	1.021,65
Mat-032	PVC or PP pipe Ø150mm	meter	1.467,77	15,91	1.483,68
Mat-033	PVC or PP pipe Ø250mm	meter	2.346,39	44,19	2.390,58
Mat-034	PVC or PP pipe Ø400mm	meter	6.409,15	113,13	6.522,28
Mat-035	Pre-cast concrete slot channel	meter	5.632,70	225,06	5.857,75
Mat-036	Pre-cast concrete slot channel cover of steel	meter	5.435,18	20,26	5.455,43
Mat-037	Protective felt	sqm	119,19	3,60	122,79
Mat-038	Water proofing membrane	sqm	357,58	5,40	362,98
Mat-039	Water stop	meter	497,20	9,00	506,21
Mat-040	Cleaning and inspection chamber DN600 PP or PE-HD for DN150	pcs	11.129,17	180,04	11.309,22
Mat-041	Cleaning and inspection chamber DN600 PP or PE-HD for DN250	pcs	17.027,50	180,04	17.207,54
Mat-042	Cleaning and inspection chamber DN600 PP or PE-HD for DN400	pcs	19.411,35	180,04	19.591,39
Mat-043	Telescope chamber for inspection chamber	pcs	6.129,90	-	6.129,90
Mat-044	Sealing ring	pcs	2.179,52	at site	2.179,52
Mat-045	Inspection chamber iron cover class B	pcs	12.327,91	38,17	12.366,08
Mat-046	Inspection chamber iron cover class D	pcs	19.888,12	38,17	19.926,29
Mat-047	Dimpled sheets	sqm	323,52	9,00	332,52
Mat-048	Yielding elements	pcs	32.425,00	180,04	32.605,04
Mat-049	Injection material for tunnel crown injection	cum	68,11	at site	68,11

Mat-050	Gasoline for concrete pump	hour	856,82	9,00	865,83
Mat-051	Granular sub-base material	cum	1.191,93	at site	1.191,93
Mat-052	Gasoline for vibratory soil compactor	hour	856,82	9,00	865,83
Mat-053	Gasoline for grader	hour	856,82	9,00	865,83
Mat-054	Gasoline for paver	hour	1.713,65	18,00	1.731,65
Mat-055	Dowel rods and tie bars for concrete pavement	tonne	57.893,50	6,30	57.899,80
Mat-056	Mastic asphalt	cum	4.427,15	900,22	5.327,37
Mat-057	PE pipe SDR 26 Ø200 mm	meter	1.747,02	28,28	1.775,30
Mat-058	CEMII/42.5R	kg	7,50	0,75	8,75
Mat-059	CEMII/32.5R	kg	7,00	0,75	8,25
Mat-060	Formwork carriage	pcs	27.925.100,00	48.247,61	27.973.347,61
Mat-061	PVC ventilation duct Ø1800 mm	meter	1.907,08	114,33	2.021,41
Mat-062	Miscellaneous material for PVC ventilation duct	meter	129,41	at site	129,41
Mat-063	Electronic cable for temporary lighting	meter	1.362,20	at site	1.362,20
Mat-064	Halogen lamp 1500 w	pcs	6.078,82	28,81	6.107,62
Mat-065	Lamps	pcs	2.503,04	at site	2.503,04
Mat-066	Stones >1.5 m	cum	350,00	1.125,28	1.475,28
Mat-067	Stone Boulder of size of 240 mm at Crusher Plant	cum	470,00	at site	470,00
Mat-068	Pre-stressed anchors	meter	3.405,50	36,01	3.441,51
Mat-069	Anchor plate for pre-stressed anchors	pcs	647,05	3,60	650,65
Mat-070	3D monitoring targets	pcs	275,00	0,90	275,90
Mat-071	Borehole extensometer	each	12.500,00	79,49	12.579,49
Mat-072	Load cells	each	31.480,00	4,50	31.484,50
Mat-073	Strain gauges	each	4.230,00	0,90	4.230,90
Mat-074	Pressure cells	each	31.590,00	4,50	31.594,50
Mat-075	Temperature gauges	each	1.860,00	0,90	1.860,90
Mat-076	Strip drain 200 mm x 25 mm	meter	140,00	4,50	144,50
Mat-077	Strip drain 200 mm x 40 mm	meter	190,00	7,20	197,20
Mat-078	Steel fibre reinforcement	tonne	129.409,00	450,11	129.859,11
Mat-079	Aggregates	cum	366,00	802,70	1.168,70
Mat-080	GFP self-drilling bolts	meter	817,32	0,44	817,76
Mat-081	Anchor plate for self-drilling bolt and wear parts	meter	306,50	1,80	308,30

The detailed development of the unit rates for civil engineering items is given in Addendum 2. These unit rates are the price basis used for the cost estimation in the bill of quantity.



## 5 BILL OF QUANTITY (BOQ) – COST ESTIMATION

The cost estimation is structured according to Austrian guideline for “Cost determination for traffic infrastructure projects” (Austrian Society for Geomechanics, Kostenermittlung für Projekte der Verkehrsinfrastruktur, 2005). The costs are developed item based with quantities as determined per Addendum 1 and unit rates as per Addendum 2.

In general cost for a tunnel project consists of the following elements: basic cost (B), valorization (G), risks (R), costs for financing (F). This leads to “Total Costs = B + G + R + F”.

The **basic costs** are the construction costs which are presented in this report based on the preliminary tunnel design of Phase II.

**Risks** are the costs which occur due to various unpredicted influences such as additional requirements due to detailed design, risks related to cost estimation, general change of costs, contractual risks, change of state of the art, change of (safety) standards, geological risks, market risks, risks related to financing, license and political risks, force majeure or additional effort during detailed design. The risk costs are generally estimated with a percentage of the basic costs. This percentage should decrease with the development of the project. For an early project stage without detailed design approximately 23% ( $u_E=7\%$ ,  $u_B^A=8\%$ ,  $u_B^B=8\%$ ) are proposed according to the Austrian guideline for the actual project phase. These risk costs are verified with Indian tunnel construction.

**The costs determined in this report represent only the Basic Costs (B) for the Zojila Tunnel.**

The following costs are not included in the cost estimation and have to be added separately:

- cost for detailed design (approx. 2-3%),
- cost for road sections outside the tunnel (highway, bridge, embankment...),
- cost for Client’s project management and supervision (approx. 4-5%),
- costs for land and land use,
- cost for financing and valorisation,
- cost to cover risks (due to unexpected project changes, geology, ground water, non-technical decisions...),
- cost for installations to provide permanent power supply in area of tunnel portals,
- cost for tunnel operation: electricity, staff, materials, vehicles.

A detailed description of the costs for all items is given in the Bill of Quantity (BoQ) enclosed in Addendum 3.

A summary of the estimated construction costs with respect to the construction elements is given in Table 3. The **basic costs** for Zojila Tunnel are determined as per Addendum 3 with **INR 4538.8 Crore**.

Table 3: Summary of estimated construction costs by construction elements / bills

TOTAL OF BILL 1 - CIVIL ENGINEERING MAIN TUNNEL	INR 15.316.101.149,34
TOTAL OF BILL 2 - CIVIL ENGINEERING EGRESS TUNNEL	INR 8.499.278.123,06
TOTAL OF BILL 3 - CIVIL ENGINEERING VENTILATION SHAFT & VENTILATION CAVERN	INR 1.653.090.463,42
TOTAL OF BILL 4 - CIVIL ENGINEERING PORTAL WEST	INR 322.946.707,83
TOTAL OF BILL 5 - CIVIL ENGINEERING PORTAL EAST	INR 376.409.666,69
TOTAL OF BILL 6 - SITE FACILITY AND TIME-DEPENDNENT COSTS	INR 11.383.620.091,77
TOTAL OF BILL 7 - ELECTRO & MECHANICAL EQUIPMENT	INR 5.220.186.741,70
TOTAL OF BILL 8 - VENTILATION SYSTEM	INR 2.616.590.724,30
<b>CONSTRUCTION COSTS</b>	<b>INR 45.388.223.668,12</b>