

## CHAPTER 8 ALMOUT WATER DIVERSION PROJECT

8.1.2	Proposed Water Diversion Plans .....	8.1
8.2.1.1	Profiles of Almout and Taleghan Rivers .....	8.3
8.3.3.1	Project Cost Estimation of Alternative Plan for Comparative Study .....	8.4
8.4.1.1	Probable Flood Peak Discharge at Galinak Gauging Station .....	8.8
8.4.1.2	Probable Flood Peak Discharge at Baghkalyeh Gauging Station .....	8.9
8.4.1.3	Machinery for Removing Deposited Materials in Reservoir .....	8.10
8.4.1.4	Flood Dike Coordinate .....	8.12
8.4.1.5	Necessary Topographic Survey and Geological Investigation .....	8.13
8.5.2	Construction Plan of Diversion Tunnel by T.B.M .....	8.14
8.6	Bill of Quantities .....	8.18

### **1: 8.1.2 Proposed Water Diversion Plans**

There are several alternative water diversion plans proposed in the Master Plan and JICA Team. Advantage and disadvantage of those alternative plans are described as follows;

(1) Alternative Plan 1 and 2, Gravity Flow

- Almout intake site EL 1,800m → Taleghan reservoir, WL 1,780m
- Catchment area of intake site is 142km<sup>2</sup> and annual runoff is 70MCM.
- Estimated diversion water is 70MCM p.a
- Tunnel length is 23km.

The plan is not recommendable due to small diversion water of 70MCM p.a.

(2) Alternative Plan A, Gravity Flow

- Almout intake site EL 1,475m at Khooban village → Ziaran reservoir W.L 1,450m
- Catchment area of intake site is 247km<sup>2</sup> and annual runoff is 120MCM.
- Estimated diversion water is 100MCM.
- Tunnel length is 33.5km.

The plan also is not recommendable due to small diversion water of 100MCM.

(3) Alternative Plan A, Gravity Flow

- Almout intake site EL 1,380m at Kafarkosh village → Qazvin north canal, W.L 1,354m
- Catchment area of intake site is 330km<sup>2</sup> and annual runoff is 160MCM.
- Estimated diversion water is 130MCM.
- Tunnel length is 34.8km.

The plan also is not feasible due to small diversion water of 130MCM.

(4) Alternative C-1, Gravity Flow

- Almout intake site EL 1,299m at Dozdaksar village → Qazvin new central canal, W.L 1,250m
- Catchment area of intake site is 587km<sup>2</sup> consisting of 475km<sup>2</sup> in the Almout and 112km<sup>2</sup> in the Andah tributary.
- Annual runoff is 310MCM.
- Estimated diversion water is 250MCM.
- Tunnel length is 33.8km.

Plan is suitable and high viability, because a rich diversion water of 250MCM is available and tunnel construction could be carried out dividing 33.8km into four construction diversions. The maximum tunnel length per diversion is 12km between the Taleghan river and Qazvin plain, so that the construction period will be minimized.

(5) Alternative C (Direct) Gravity Flow

- Almout intake site and Qazvin outlet is located at the same position as the above C-1. However the tunnel alignment is placed with the direct connection of the Almout inlet and Qazvin outlet and can't introduce the water of Andah tributary.
- Annual runoff is 250MCM at the Almout diversion site.
- Estimated diversion water is 210MCM.
- Tunnel length is 36.8km.

The plan is not recommendable due to the less diversion water of 210MCM as compared with the plan C-1 and tunnel length of 36.8km is longer than C-1. Further this tunnel will cross the Taleghan river about 100m below the Taleghan river bed and require the special access tunnel of 2 to 3km to construct the tunnel by dividing tunnel into 4 construction diversion. Accordingly the tunnel construction cost is high that that of C-1.

(6) Alternative C-2, Gravity Flow for Almout water and pumping of Taleghan Water

- Almout intake site and Qazvin outlet is located at the same position as the above C-1. However the tunnel-crossing site of the Taleghan river is placed at the downstream of Taleghan river due to diversion of the Taleghan water of 20MCM. Tunnel crosses the Taleghan river by siphon and the Taleghan water is pumped up, because of the low elevation of 1,150m at the riverbed of Taleghan river.
- Catchment area is 945km<sup>2</sup> (Almout, 475km<sup>2</sup>, Andah 110km and Taleghan 358km<sup>2</sup>)
- Annual runoff is 350MCM at the crossing point of Taleghan river.
- Estimated diversion water is 270MCM.
- Tunnel length is 31.7km.
- Pumping station with the head of 140m.

Though this plan can divert the water of 270MCM, which is slightly larger than that of C-1, tunnel shall cross the Taleghan river with siphon and pumping station with a high head of 140m to pump up the Taleghan water shall be provided. Accordingly the plan requires the high construction cost and O/M cost and is not recommendable.

(7) Alternative D, Pumping water

- Almout intake site is selected at the conjunction point of the Taleghan river with the elevation of 1,055m.

This plan is not recommendable due to high construction and O/M cost by pumping system.

(8) Possibility of Water Diversion from Pou Hezar and she Hezar river to Almout.

In order to get more diversion water, the possibility of water diversion from Dou Hezar and She Hezar to the Almout river are preliminary studied. However, both plans require the tunnel with a long distance of about 20km but their diversion water amount is small as 50 to 100MCM. Accordingly both plans will not be economical and not be recommendable. All alternative plans mentioned in the above are shown in Figure 8.1.2.1 and 8.1.2.2.

## 2: Table 8.2.2.1 Profiles of Almout and Taleghan Rivers

Profile of Almout River<sup>\*1)</sup>

Location and Elevation		Distance (m)	Accumulated Distance (m)
the Confluence : (Alt-D)	EL. 1,055 m	0	0
	EL. 1,100 m	3,500	3,500
Baghdasht		3,100	6,600
	EL. 1,150 m	300	6,900
Tunnel inlet		2,300	9,200
	EL. 1,200 m	1,100	10,300
Bagh Kalaye		200	10,500
Bagh Kalaye Gauging Station		200	10,700
Pipeline		1,200	11,900
Pipeline		400	12,300
	EL. 1,250 m	700	13,000
Andah Rud river		40	13,040
Bridge (Shahrake)		40	13,080
Dozdaksar Village		2,120	15,200
Dozdaksar Diversion Dam : Alt-C-1, C-2		700	15,900
	EL. 1,300 m	400	16,300
Bridge		400	16,700
Road to Almout		1,200	17,900
	EL. 1,350 m	1,300	19,200
Bridge		1,700	20,900
Haranak		600	21,500
	EL. 1,400 m	400	21,900
Kafarkosh : Alt-B		200	22,100
Storage Dam Site		600	22,700
	EL. 1,450 m	1,500	24,200
Bridge		1,100	25,300
Tributary		200	25,500
	EL. 1,500 m	600	26,100
Khooban : Alt-A		1,600	27,700
	EL. 1,550 m	700	28,400

\*1) : This profile is based on 1/10,000 topographic maps prepared for the Study.

Profile of Taleghan River<sup>\*1)</sup>

Location and Elevation		Distance (m)	Accumulated Distance (m)
the Confluence :	EL. 1,055 m	0	0
	EL. 1,100 m	3,400	3,400
Ameshk		2,100	5,500
	EL. 1,150 m	1,600	7,100
	EL. 1,200 m	2,400	9,500
Dine Kooh		300	10,800
	EL. 1,250 m	1,600	11,100
	EL. 1,300 m	2,500	13,600
	EL. 1,350 m	2,000	15,600
	EL. 1,400 m	2,300	17,900
Asfaran		1,900	19,800
	EL. 1,425 m	500	20,300

\*1) : This profile is based on 1/10,000 topographic maps prepared for the Study.

Table 8.3.3.1 Project Cost Estimation of Each Alternative Plan for Comparative Study

(1) Cost of Diversion Dam on Almout, Andah-rud and Taleghan River

(a) Cost of Each Diversion Dam

Alternative	Diversion Dam		Intake Structures		Sub-Total		Others (Outlet Works, etc)		Total	
	Length (m)	Amount (1,000 US\$)	Amount (1,000 US\$)	Amount (1,000 US\$)	Amount (1,000 US\$)	Amount (1,000 US\$)	Amount (1,000 US\$)	Amount (1,000 US\$)	Amount (10 <sup>6</sup> RIs)	Amount (10 <sup>6</sup> RIs)
1. Diversion Dam on Almout River										
Unit Price	1 m	40,000 US\$ 20,000 US\$ (Andah Rud only)	60% of Diversion Dam				25% of Sub-Total			
Alt-A	70	2,800	1,680		4,480		1,120		5,600	
Alt-A'	70	2,800	1,680		4,480		1,120		5,600	
Alt-B	70	2,800	1,680		4,480		1,120		5,600	
Alt-C-1,C-2	70	2,800	1,680		4,480		1,120		5,600	
Alt-D	140	5,600	-		5,600		1,400		7,000	
2. Diversion Dam on Andah Rud and Taleghan Rivers										
Alt-A' (Andah Rud & Tributary)	40 x 4	800 x 4 = 3,200	-		3,200		200 x 4 = 800		4,000	
C-1,C-2 (Andah Rud)	40	800	-		800		200		1,000	
Alt-C-2 (Taleghan)	40	1,600	960		2,560		640		3,200	
Alt-C-2 (Taleghan)	40	1,600	960		2,560		640		3,200	

(b) Cost of Diversion Dams in Each Alternative Plan

Alternative Plan	Almout Diversion Dam		Andah Rud and Taleghan Diversion Dam		Total	
	(1,000 US\$)	(10 <sup>6</sup> RIs)	(1,000 US\$)	(10 <sup>6</sup> RIs)	(1,000 US\$)	(10 <sup>6</sup> RIs)
Alt-A	5,600				5,600	
Alt-A'	5,600		Andah Rud & Tributary: 4,000		9,600	
Alt-B	5,600		-		5,600	
Alt-C-1	5,600		Andah Rud : 1,000		6,600	
Alt-C-2	5,600		Andah Rud : 1,000 Taleghan : 3,200 Total = 4,200		9,800	
Alt-D	7,000		-		7,000	

Note : 1 US\$ = 8,000 RIs

Alternative	Tunnel			Pipeline			Open Canal @ 200US\$		
	Qmax=22.5m³/sec : D = 4.0m, @2,700 US\$ Qmax<10.0m³/sec : D = 3.5m, @2,200 US\$ <sup>(1)</sup>		Length (m)	Main=@1,400 US\$, Branch = @400 US\$		Length (m)		Amount (1,000 US\$)	Amount (10 <sup>6</sup> RIs)
	Length (m)	Amount (1,000 US\$)		Amount (10 <sup>6</sup> RIs)					
Alt-A	33,500	90,450	-	-	-	5,000	1,000		
Alt-A'	12,000 + 34,300	26,400 + 92,610 = 119,010	Main:300	420		5,000	1,000		
Alt-B	34,800	93,960	Main:300	420		5,000	1,000		
Alt-C-1	33,800	91,260	Main:6,000	8,400		-	-		
			Branch:2,500	1,000					
			Sub-Total	9,400					
Alt-C-2	32,800	88,560	Main:9,100	12,740		-	-		
			Branch:2,500	1,000					
			Sub-Total	13,740					
Alt-D	31,700	69,740	-	-	-	-	-		

### (3) Cost of Pump Station

Alternative	Discharge (m <sup>3</sup> /sec)	Pump Head (m)	Total				Total (10 <sup>6</sup> Rls.)
			Pump Equip. (1,000 US\$)	Delivery Pipeline (1,000 US\$)	Civil Works (1,000 US\$)	Transmission, etc. (1,000 US\$)	
Alt-C-2	1	140	4,310	60	50	4,540	8,960
Alt-D	10	210	28,770	1,110	130	4,540	34,550

Note : 1 US\$ = 8,000 RIs

#### (4) Project Cost

Alternative	Diversion Dam (10 <sup>3</sup> US\$)	Tunnel (10 <sup>3</sup> US\$)	Pipeline (10 <sup>3</sup> US\$)	Open Canal (10 <sup>3</sup> US\$)	Pump Station (10 <sup>3</sup> US\$)	Total (10 <sup>6</sup> Rls)
Alt-A	5,600	90,450	-	1,000	-	97,050
Alt-A'	9,600	119,010	420	1,000	-	130,030
Alt-B	5,600	93,960	420	1,000	-	100,980
Alt-C-1	6,600	91,260	9,400	-	-	107,260
Alt-C-2	9,800	88,560	13,740	-	8,960	121,060
Alt-D	7,000	69,740	-	-	34,550	111,290

Note : 1 US\$ = 8,000 Rls

#### (5) O/M Cost

Alternative	Project Cost (10 <sup>3</sup> US\$)		O/M Cost (10 <sup>3</sup> US\$)			Total (10 <sup>6</sup> Rls)
	① : Pump Station	② : Other Facilities	③ : O/M Cost for Pump Station ③ = ① x 5 %	④ : O/M Cost for Other Facilities ④ = ② x 2 %	Total ⑤=③+④ (10 <sup>3</sup> US\$)	
Alt-A	-	97,050	-	1,940	1,940	
Alt-A'	-	130,030	-	2,600	2,600	
Alt-B	-	100,980	-	2,020	2,020	
Alt-C-1	-	107,260	-	2,150	2,150	
Alt-C-2	8,960	112,100	450	2,240	2,690	
Alt-D	34,550	76,740	1,730	1,530	3,260	

Note : 1 US\$ = 8,000 Rls

**(6) Depreciation Cost of Project Cost**

Alternative	Project Cost (1,000 US\$)			Depreciation Cost <sup>*)</sup> (1,000 US\$)		
	Pump Station	Other Facilities	Total	Pump Station	Other Facilities	Total
Alt-A	-	97,050	97,050	-	7,930	7,930
Alt-A'	-	130,030	130,030	-	10,620	10,620
Alt-B	-	100,980	100,980	-	8,250	8,250
Alt-C-1	-	107,260	107,260	-	8,760	8,760
Alt-C-2	8,960	112,100	121,060	840	9,160	10,000
Alt-D	34,550	76,740	111,290	3,240	6,270	9,510

<sup>\*)</sup> For Pump Station : interest = 8 %, n = 25 years, Amortization rate = 0.0937

For Other Facilities

: interest = 8 %, n = 50 years, Amortization rate = 0.0817

**(7) Water Cost of Each Alternative Plan**

Alternative	Project Cost (1,000 US\$)	Depreciation Cost (1,000 US\$)	O/M Cost (1,000 US\$)	Total (Annual Cost) (1,000 US\$)	Diversion Water Amount (MCM)	Water Cost <sup>*)</sup>	
						US\$/m <sup>3</sup>	RI\$/m <sup>3</sup>
Alt-A	97,050	7,930	1,940	9,870	120	0.0823	660:⑥
Alt-A'	130,030	10,620	2,600	13,220	180	0.0734	590:④
Alt-B	100,980	8,250	2,020	10,270	130	0.0790	630:⑤
Alt-C-1	107,260	8,760	2,150	10,910	250	0.0436	350:①
Alt-C-2	121,060	10,000	2,690	12,690	270	0.0470	380:②
Alt-D	111,290	9,510	3,260	12,770	220	0.0580	460:③

<sup>\*)</sup> not including costs of Qazvin Central canal system, on-farm development, etc.

Note : 1 US\$ = 8,000 RIs



### 3: Table 8.4.1.1 Probable Flood Peak Discharge at Galinak Gauging Station

(prepared by Lar Consulting Engineers)

D.F( 1 ) = NORMAL  
D.F( 2 ) = LOGNORMAL 2  
D.F( 3 ) = LOGNORMAL 3  
D.F( 4 ) = GUMBEL  
D.F( 5 ) = PIERSON III  
D.F( 6 ) = LOGPIERSON III

#### DATA

```
=====
 95.2 172.0 258.0 144.0 103.0 99.4 100.0 220.0 123.8 140.0 155.4 74.0 70.2 102.4
166.0 75.0 194.9 120.3 137.4 77.0 215.0 92.0
```

#### PARAMETERS XM,S,Z,G

```
-----
133.41      52.73      0.40      1.09
```

#### SORTED DATA

```
=====
258.0 220.0 215.0 194.9 172.0 166.0 155.4 144.0 140.0 137.4 123.8 120.3 103.0 102.4
100.0 99.4 95.2 92.0 77.0 75.0 74.0 70.2
```

#### RETURN PERIODS

```
-----
23.0 11.5 7.7 5.8 4.6 3.8 3.3 2.9 2.6 2.3 2.1 1.9 1.8 1.6
1.5 1.4 1.4 1.3 1.2 1.2 1.1 1.0
```

#### LST FOR D.F(1,2,3,4,5,6)

```
-----
+14.8829E+00
+10.1913E+00
+10.3870E+00
+70.5930E-01
+97.1188E-01
+93.2685E-01
```

LST FOR D.F( GUMBEL ) = 7.0593E+00 IS MINNUM

#### DESIGN RETURN PERIODS

```
=====
 2.0 5.0 10.0 20.0 25.0 50.0 100.0 200.0 250.0 500.0 1000.0 2000.0 5000.0 10000.0
```

#### DESIGN DATA WITH D.F(1,2,3,4,5,6)

```
-----
133.4 177.8 201.0 220.2 225.7 241.7 256.1 269.2 273.3 285.2 296.4 306.9 320.1 329.5
124.1 171.0 202.2 232.2 241.8 271.4 301.1 331.1 340.8 371.5 402.7 434.7 478.0 511.7
125.0 172.1 202.6 231.5 240.6 268.5 296.3 324.0 332.9 360.8 389.0 417.6 456.0 485.6
125.7 180.0 216.0 250.5 261.4 295.1 328.5 361.8 372.6 405.8 439.0 472.2 516.1 549.4
124.2 172.5 203.8 232.9 242.0 269.5 296.3 322.5 330.9 356.6 382.1 407.3 440.4 465.4
121.8 170.1 205.0 240.6 252.3 290.1 329.9 372.3 386.5 432.6 481.8 534.5 609.9 671.6
```

```
=====
N= 22      XM= 133.4      S= 52.7      CV= 0.40      G= 1.09
=====
```

#### RETURN PERIODS

```
-----
 2.0 5.0 10.0 20.0 25.0 50.0 100.0 200.0 250.0 500.0 1000.0 2000.0 5000.0 10000.0
```

#### DESIGN DATA WITH D.F( GUMBEL )

```
-----
125.7 180.0 216.0 250.5 261.4 295.1 328.5 361.8 372.6 405.8 439.0 472.2 516.1 549.4
=====
```

#### 4: Table 8.4.1.2 Probable Flood Peak Discharge at Bagh Kalaye Gauging Station

(prepared by Lar Consulting Engineers)

D.F( 1 ) = NORMAL  
D.F( 2 ) = LOGNORMAL 2  
D.F( 3 ) = LOGNORMAL 3  
D.F( 4 ) = GUMBEL  
D.F( 5 ) = PIERSON III  
D.F( 6 ) = LOGPIERSON III

##### DATA

```
=====
211.0  78.0  191.0  76.9  52.1  206.0  116.0  37.1  68.0  50.5  174.0  50.3  174.0  153.2
 46.0  97.3  49.4  160.0  36.5  96.0  130.6  116.5  41.1  71.7  43.5
```

##### PARAMETERS XM,S,Z,G

```
-----
      101.07      58.05      0.57      0.78
```

##### SORTED DATA

```
=====
211.0  206.0  191.0  174.0  174.0  160.0  153.2  130.6  116.5  116.0  97.3  96.0  78.0  76.9
 71.7  68.0  52.1  50.5  50.3  49.4  46.0  43.5  41.1  37.1  36.5
```

##### RETURN PERIODS

```
-----
26.0  13.0  8.7  6.5  5.2  4.3  3.7  3.2  2.9  2.6  2.4  2.2  2.0  1.9
 1.7  1.6  1.5  1.4  1.4  1.3  1.2  1.2  1.1  1.1  1.0
```

##### LST FOR D.F(1,2,3,4,5,6)

```
-----
+17.9571E+00
+16.9559E+00
+14.9860E+00
+13.5247E+00
+14.5826E+00
+16.6097E+00
```

LST FOR D.F( GUMBEL ) = 1.3525E+01 IS MINNUM

##### DESIGN RETURN PERIODS

```
=====
      2.0      5.0     10.0     20.0     25.0     50.0    100.0    200.0    250.0    500.0  1000.0  2000.0  5000.0  10000.0
```

##### DESIGN DATA WITH D.F(1,2,3,4,5,6)

```
-----
101.1  149.9  175.5  196.6  202.7  220.3  236.1  250.6  255.0  268.2  280.5  292.1  306.6  317.0
 87.6  137.3  173.7  211.0  223.2  262.4  303.6  346.8  361.2  407.6  456.4  507.9  580.3  638.4
 94.1  145.9  177.7  206.7  215.7  242.7  268.8  294.2  302.3  327.3  352.0  376.6  409.0  433.5
 92.5  151.6  190.7  228.2  240.1  276.7  313.1  349.4  361.0  397.2  433.3  469.5  517.2  553.3
 93.7  146.3  178.4  207.4  216.3  242.9  268.3  292.8  300.5  324.1  347.2  369.8  399.2  421.1
 84.8  140.5  184.2  231.1  247.1  299.4  356.6  419.0  440.3  510.5  587.2  670.7  792.8  894.5
```

```
=====
N= 25      XM= 101.1      S= 58.0      CV= 0.57      G= 0.78
=====
```

##### RETURN PERIODS

```
-----
      2.0      5.0     10.0     20.0     25.0     50.0    100.0    200.0    250.0    500.0  1000.0  2000.0  5000.0  10000.0
```

##### DESIGN DATA WITH D.F( GUMBEL )

```
-----
 92.5  151.6  190.7  228.2  240.1  276.7  313.1  349.4  361.0  397.2  433.3  469.5  517.2  553.3
=====
```

**5: Table 8.4.1.3 Machinery for Removing Deposited Materials in Reservoir**

(1) Removing work period

Number of month with river flow of less than 5 m <sup>3</sup> /sec	:	6 months
Construction and removal of temporary embankment, etc.	:	1 month
Number of working month for removing deposited materials	:	5 months

(2) Estimated amount of deposited materials to be removed

$$V = 475 \text{ km}^2 \times 700 \text{ m}^3/\text{km}^2/\text{year} \times 60 \% = 200,000 \text{ m}^3/\text{year} = 40,000 \text{ m}^3/\text{month}$$

$$= 1,600 \text{ m}^3/\text{day} = 200 \text{ m}^3/\text{hour}$$

- Working day in month	:	25 days
- Working hour in a day	:	8 hours

(3) Necessary Machinery

Necessary Machinery Works	Machine	Working Capacity (m <sup>3</sup> /hr)	Number of Machine <sup>*1)</sup>
Moving materials	21t Bulldozer	60.4	$200 \times 0.6^{*2}) / 60.4 = 2.0$ = 2 sets
Loading	1.9 m <sup>3</sup> Crawler Type Loader	70.2	$200 / 70.2 = 2.8 = 3$ sets
Hauling	11t Dump Truck	15.4	$200 / 15.4 = 13.0 = 13$ sets
Clearing spoil banks	21t Bulldozer	92.0	$200 \times 0.6^{*2}) / 92.0 = 1.3$ = 2 sets

Note : <sup>\*1)</sup> :Working capacity of machine are shown below., <sup>\*2)</sup> : percent of material treated

(4) Capacity of Machine

(a) 21t Bulldozer (moving materials)

$$Q = (3,600 \times q \times E) / (2.2D + 15)$$

Where

q = 2.72 for 21t Bulldozer (volume of moved materials per 1 cycle)

E = working efficiency = 0.5

D = 30 m (moving distance of materials)

$$Q = (3,600 \times 2.72 \times 0.5) / (2.2 \times 30 + 15) = 60.4 \text{ m}^3/\text{hour}$$

(b) 1.9 m<sup>3</sup> Crawler Type Loader (loading)

$$Q = (3,600 \times q \times f \times E) / C_m$$

Where

$$q = q_0 \times K = 1.9 \times 0.7 = 1.33 \text{ m}^3 \text{ (} q_0 = \text{heaped bucket capacity, } K = \text{efficiency) }$$

$$f = \text{conversion factor of excavated material} = 1.2$$

$$E = \text{working efficiency} = 0.55$$

$$C_m = 45 \text{ sec (cycle time)}$$

$$Q = (3,600 \times 1.33 \times 1.2 \times 0.55) / 45 = 70.2 \text{ m}^3/\text{hour}$$

(c) 11t Dump Truck (Hauling)

$$Q = (60 \times q \times E) / C_m$$

Where

$$q = W / w = 11 / 2.0 = 5.5 \text{ m}^3 \text{ (} W = \text{loading capacity, } w = \text{unit weight of materials) }$$

$$E = \text{working efficiency} = 0.9$$

$$C_m = 3.3 \times D + 16 \text{ sec (cycle time) (} D = \text{hauling distance} = 1 \text{ km)}$$

$$= 3.3 \times 1 + 16 = 19.3 \text{ sec}$$

$$Q = (60 \times 5.5 \times 0.9) / 19.3 = 15.4 \text{ m}^3/\text{hour}$$

(d) 21t Bulldozer (cleaning work)

$$Q = 10 \times E \times (18 \times D + 13) \text{ (for 21 t Bulldozer)}$$

Where

$$E = \text{working efficiency} = 0.5$$

$$D = 0.3 \text{ m (thickness of materials after leveling)}$$

$$Q = 10 \times 0.5 \times (18 \times 0.3 + 13) = 92.0 \text{ m}^3/\text{hour}$$

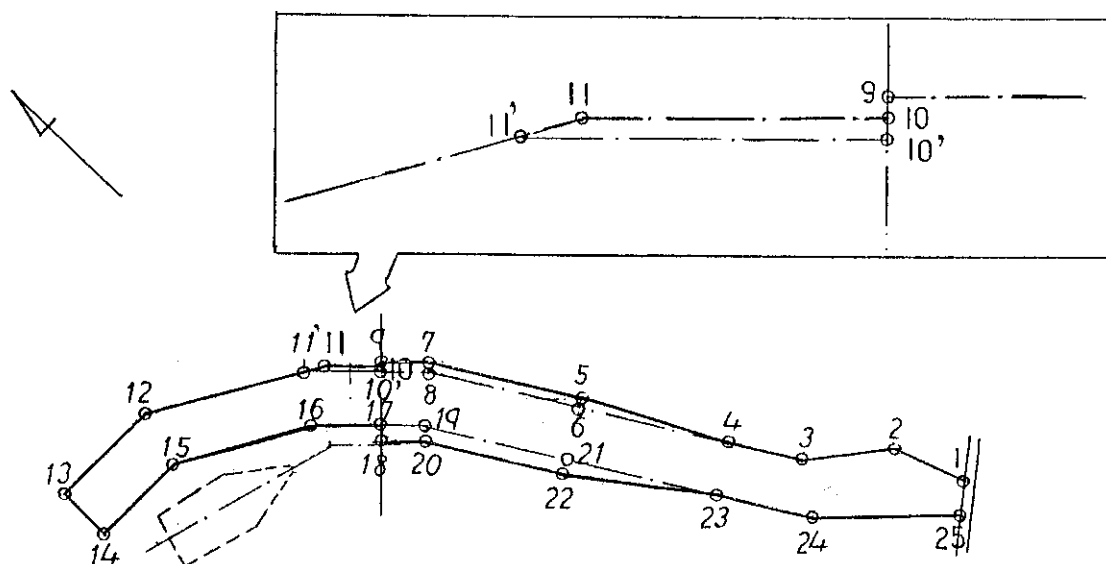
**6: Table 8.4.1.4 Flood Dike Coordinate**

**Flood Dike Coordinate (Distance)**

Location	Distance (m)	Location	Distance (m)	Location	Distance (m)
1-2	115.00	10'-17	70.00	15-16	181.37
2-3	150.00	17-18	19.00	16-17	90.78
3-4	100.00	9-18	100.00	17-19	52.33
4-5	200.30	10-11	80.00	18-20	50.25
4-6	200.00	10'-11'	100.00	19-21	192.33
5-7	201.20	11-12	230.71	20-22	190.25
5-6	11.00	11'-12	210.00	21-23	200.00
6-8	200.00	12-13	150.00	21-22	19.00
7-9	61.20	13-14	70.00	22-23	200.90
8-10	60.00	14-15	130.59	23-24	127.70
9-10	5.64	15-16	181.37	24-25	200.00
10-10'	5.36	14-15	130.59		

**Flood Dike Coordinate (Angle)**

Location	Angle (° )	Location	Angle (° )	Location	Angle (° )
2	30.00	7,8,19,20	12.50	22	5.43
3	21.50	11,16	15.00	24	15.00
5	3.15	12,15	31.00		



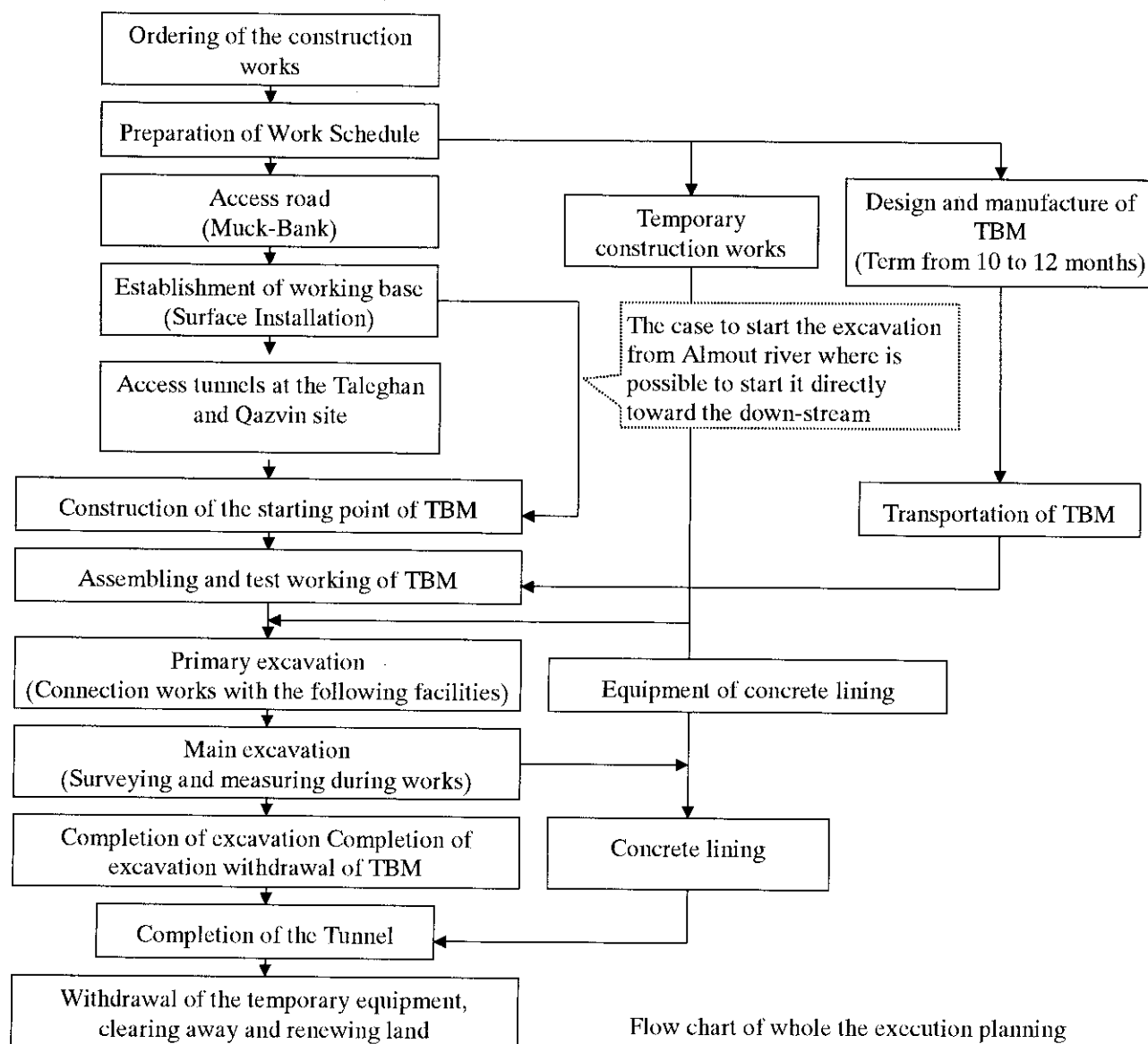
**7: Table 8.4.1.5 Necessary Topographical Survey and Geologic Investigation  
for Feasibility Study on Almout Diversion Dam**

Description	Quantity	Remarks
<b>1. Topographic Survey</b>		
(1) Topographic Surveying of Diversion Damsite (scale 1/1,000)	350 ha	
(2) River Surveying on the Almout between Haranak and the river mouth of Andah Rud river.	36 km	- Longitudinal Leveling = 9 km - Cross Leveling = 90 sections x 300 = 27 km
(3) Route Surveying for Almout Diversion Dam	14 km	- Longitudinal Leveling = 2 km - Cross Leveling = 40 sections x 300 m = 12 km
<b>2. Geologic Investigation</b>		
(1) Core Drilling	250 m	5 holes x 50 m = 250 m
(2) Laboratory Soil Test for Dike Embankment Materials	L.S.	

## 8: 8.5.2 Construction Plan of Diversion Tunnel by T.B.M

### (1) Basic Approach for Tunnel Construction Plan

Tunnel construction plan by T.B.M will be set up with the following step;



Flow chart of whole the execution planning

### (2) Construction Division of Tunnel

As the tunnel length is very long as 33.8km, the tunnel works are carried out with the following four construction divisions.

Division	Name of Tunnel	Length	Excavation Volume	Concrete Volume
Division 1	Almout mountain tunnel	8.0	156,000	38,000
Division 2	Taleghan mountain tunnel	12.0	540,000	58,000
Division 3	Qazvin mountain tunnel	11.4	239,000	59,000
Division 4	Qazvin plain tunnel	2.4	52,000	22,000
<b>Total</b>		<b>33.8</b>	<b>687,000</b>	<b>177,000</b>

- Division 1, Almount mountain tunnel is excavated by T.B.M and from the Almount river site to Taleghan river site.
- Division 2, Taleghan mountain tunnel is excavated by T.B.M and from the Taleghan river site to Qazvin.
- Division 3, Qazvin mountain tunnel is excavated by T.B.M and from Qazvin Plain site to Taleghan river site.
- Division 4, Qazvin plain tunnel is excavated by NATM and from same access tunnel with Division 3 to tunnel outlet.
- Some access tunnel will be constructed at the Division 2 and 3 tunnels.

## (2) Tunnel Structural Section

As the geological investigation works along the tunnel alignment was not carried out due to the pre-feasibility study level, tunnel structural section is assumed as follows based on the surface geological reconnaissance, existing geological information in the Almount and Taleghan mountain and the past excavation data for the existing Taleghan tunnel.

Pattern of Design Ground Support (Per Unit Length of TBM and NATM Excavations)

Grade of Base Rock	Classification of Application Base	Method of Ground Support	Method of Lining	Pattern of Ground Support
$C_H-C_M$ Grade	The base rock with fear of collapse and fall of rocks in the long term, having the development of small cracks in it even though it is still hard	Shotcrete of fiber mortar if necessary	Plain concrete lining	B
$C_M-C_L$ Grade	Having the development of cracks there is a fear of fall of rocks immediately. The base rock with fear of collapse and fall of rocks for a long term	Shotcrete of fiber mortar ( $t = 3\text{cm}$ ) {Rock bolt and steel support H-125 @1.2m with shotcrete of mortar $t=10\text{cm}$ } *2		C
D Grade	The natural ground which needs the ground support to prevent too much variation toward the inner cross-section acting earth pressure by the looseness of the ground	Steel ring ground support with shotcrete (H-100 @1.0) {Rock bolt and steel support H-125 @0.9m with shotcrete of mortar $t=20\text{cm}$ } *2	Reinforced concrete lining	D

Note) 1. The invert liner (invert segment) is applied all through the patterns of ground support of TBM.

2. \*2 applied for NATM excavation.

## (3) Assembling of T.B.M

Total weight of T.B.M to be applied for the Almount tunnel is about 300ton, which shall be transported dividing it into many parts with the weight of 20 to 30 ton and assembling at the site.

It takes about one year to commence the actual tunnel excavation at the site taking into account the period of manufacturing at factory, shipping to Iran, inland transportation to site and assembling works at the site.



#### (4) Excavation Progress by T.B.M and NATM

T.B.M can carry out the tunnel excavation with a high progress as compared with NATM method.

Average excavation progress by T.B.M is about 250m/month, which could be achieved without difficulty taking into account the geological conditions along the tunnel alignment consisting of the consolidated tuff, sand stone, basalt, etc in the Karaj geological formation.

However, the tunnel in Division 4 with a length of 2.4km shall be excavated with NATM because tunnel alignment is composed of consolidated overburden and its progress is estimated at 100m/month.

#### (5) Transportation of Tunnel Muck

Transportation of tunnel muck is one of the most important works to accelerate the tunnel working progress. It is necessary to provide the transportation method to transport the bulk tunnel muck with the high progress corresponding to the excavation progress by T.B.M, otherwise. The excavation by T.B.M is suspended and its progress is delayed. The following transportation plan will be setup.

- Excavated tunnel mucks to be transported per day

$$(2.5 \times 2.5 \times 3.14) \times 1.8 \times 15\text{m} = 530\text{m}^3/\text{day}$$

where, 2.5 is radius of tunnel excavation section

1.8 is swelling factor of rock materials

15m is excavation progress/day by T.B.M

in case of the high progress

- Cycle time of electrical locomotive

$$(12\text{km} \times 2 \text{ times}) \div 10\text{km/hr} = 2.4\text{hr} = 3.0 \text{ hr}$$

where, 12km is the maximum tunnel length

2 times is the return trip of locomotive

10km is the speed of locomotive

3.0 hr include the wasting time of tunnel mucks at spoil bank

- Transportation times of locomotive

$$21 \text{ hr/day} \div 3.0 \text{ hr/time} = 7 \text{ times/day}$$

where, 21 hr/day is working hour/day excluding

one hour/day for changing time of tunnel working crew

- Estimation of number of locomotive and wagon

$$(4\text{m}^3 \times 10 \text{ units}) \times 7 \text{ times/day} \times 2 \text{ sets} = 560\text{m}^3 > 530\text{m}^3$$

where, 4m<sup>3</sup> is wagon volume/unit

2 sets means 2 locomotives with 10 wagons

(6) Other works in Tunnel

- Steel support of H-100 is applied for pattern D of TBM excavation and H-125 for pattern C and D of NATM excavation.
- Shotcrete is carried out on the excavated surface after excavation. Thickness of shotcrete is as shown in Figure 8.4.2.4. of Database Map.

## 8.6 SUMMARY OF PROJECT COST

### Alamut Water Diversion Project

No.	Description	Amount in US \$	Remarks
I	Almout Diversion Dam	4,600,000	
II	Pipeline Works	15,700,000	
III	Tunnel Works		
III-1	Division I	19,200,000	
III-2	Division II	30,700,000	
III-3	Division III	30,800,000	
III-4	Division IV	12,300,000	
IV	O / M Facilities	2,500,000	
	Cost for Construction	115,800,000	
V	Engineering / Administration	5,800,000	
VI	Other cost	2,000,000	
	Sub-total	7,800,000	
	Project Cost	123,600,000	

#### DISBURSEMENT SCHEDULE OF ALMOUT WATER DIVERSION/QAZVIN IRRIGATION PROJECT

	Items	Project Cost	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	Construction Cost										
1	Almout Water Diversion Project										
	Diversion Dam Works	4,600						1,300	1,300	1,300	700
	Pipeline Works	15,700						4,500	4,500	4,500	2,200
	Tunnel Division I	19,200					4,000	4,500	4,500	4,500	1,700
	Tunnel Division II	30,700				5,700	5,000	5,000	5,000	5,000	5,000
	Tunnel Division III	30,800				5,800	5,000	5,000	5,000	5,000	5,000
	Tunnel Division IV	12,300							4,300	4,000	4,000
	O & M Building	2,500								1,000	1,500
	Sub-total	115,800	0	0	0	11,500	14,000	20,300	24,600	25,300	20,100
2	Qazvin Irrigation Project										
	Temporary Works	1,354				354	1,000				
	Rehabilitation Works	3,237	800	1,000	805	632					
	Central Canal Works	32,109				5,000	5,000	6,000	6,000	6,000	4,109
	Sub-total	36,700	800	1,000	805	5,986	6,000	6,000	6,000	6,000	4,109
	Construction Cost Total	152,500	800	1,000	805	17,486	20,000	26,300	30,600	31,300	24,209
2	Other Cost										
1	Engineering /Administration										
	Almout	5,800		700	700	800	800	800	800	800	400
	Qazvin	1,800		300	300	200	200	200	200	200	200
	Sub-total	7,600	0	1,000	1,000	1,000	1,000	1,000	1,000	100	600
2	Land Aquisition										
	Almout	2,000			1,000	1,000					
	Qazvin	3,000				1,500					
	Sub-total	5,000			2,500	2,500					
	Total	12,600	8	1,000	3,500	3,500	1,000	1,000	1,000	1,000	600

# **BILL OF QUANTITY ON ALMOUT WATER DIVERSION PROJECT**

No.	Description	Unit	Quantity	Unit price in US\$	Amount in US\$
<b>I</b>	<b>Almout Diversion Dam</b>				
1	Temporary Works	L.S.		170,000	170,000
	Sub-total				170,000
2	Earth Works				
	Excavation for river bed	cu.m.	40,000	0.78	31,200
	Fill and Backfill	cu.m.	20,000	1.32	26,400
	Riprap	cu.m.	61,000	6.62	403,820
	Sand and gravel layer	cu.m.	31,000	2.7	83,700
	Dike embankment	cu.m.	230,000	1.32	303,600
	Sub-total				848,720
3	Concrete Works				
	Reinforced concrete	cu.m.	17,100	13.75	235,125
	Reinforced bar	ton	855	530.00	453,150
	Formwork	sq.m.	17,100	5.30	90,630
	Plain concrete	cu.m.	1,800	19.00	34,200
	Curtin cut-off wall	sq.m.	2,300	120.00	276,000
	Bridge	sq.m.	540	110.00	59,400
	Sub-total				1,148,505
4	Mechanical Parts				
	Radial gate. 7.5mmheight x 6.0m.w	set	2	101,000	202,000
	Roller gate.3.5m.height x 6.0m.wid	set	2	21,000	42,000
	Sluice gate for bypass canal	set	4	4,500	18,000
	Sub-total				262,000
5	Bypass Canal and River Training				
	Bypass canal Q=5 cum/s. R.C. Flur	m	450	160	72,000
	Ground sill	m	1,200	320	384,000
	Sub-total				456,000
6	Intake and Settling basin				
	Excavation	cu.m.	20,000	0.78	15,600
	Fill and Backfill	cu.m.	63,000	1.32	83,160
	Reinforced concrete	cu.m.	17,700	13.75	243,375
	Reinforced bar	ton	710	530.00	376,300
	Formwork	cu.m.	17,700	5.30	93,810
	Plain concrete	cu.m.	3,200	19.00	60,800
	Gate.2.0m.height x 4.0 m.width	set	5	6,300.00	31,500
	Gate.4.5m.height x 6.0 m.width	set	2	46,000.00	92,000
	Gate.2.0 m.height x 2.0 m.width	set	3	5,000.00	15,000
	Gatc. 1,000 mm. Diameter	set	2	1,100.00	2,200
	Sub-total				1,013,745
7	Control Facilities				
	Stripping for road and yard	cu.m.	5,100	0.78	3,978
	Fill and Backfill	cu.m.	17,600	1.32	23,232
	Asphalt paved road	sq.m.	18,000	4.06	73,080
	Control building	sq.m.	700	90.00	63,000
	Fence, gate and etc.	L.S.		6,000.00	6,000
	Sub-total				169,290

No.	Description	Unit	Quantity	Unit price in US\$	Amount in US\$
	8 Andah-rud Diversion dam	L.S.		410,000	410,000
	Sub-total				410,000
	9 Miscellaneous Work	L.S.		86,000	86,000
	Sub-total				86,000
	<b>Total</b>				4,564,260
					4,600,000
<b>II</b>	Pipeline Works				
	1 Temporary Works	L.S.		590,000	590,000
	Sub-total				590,000
	2 Main pipeline				
	Common excavation	cu.m..	400,000	1	312,000
	Soft rock excavation	cu.m..	9,000	4	34,740
	Sand bed	cu.m..	104,000	3	280,800
	Backfill	cu.m..	294,000	1	388,080
	Concrete	cu.m..	12,800	14	176,384
	Reinforced bar	ton	640	530	339,200
	Formwork	sq.m.	12,800	5	67,840
	Flexible joint 2000mm diameter	set	6	7,500	45,000
	Air valve 150 mm. Diameter	set	39	480	18,720
	Steel pipe ID=2,000mm x 16mm.	ton	14,200	825	11,715,000
	Sub-total				13,377,764
	3 Branch Pipeline				
	Common excavation	cu.m..	75,000	0.78	58,500
	Sand bed	cu.m..	13,000	2.7	35,100
	Backfill	cu.m..	61,000	1.32	80,520
	Concrete	cu.m..	130	13.78	1,791
	Reinforced bar	ton	7	530	3,710
	Formwork	sq.m.	130	5.3	689
	Flexible joint 2000mm diameter	set	2	6100	12,200
	Air valve 150 mm. Diameter	set	6	480	2,880
	Steel pipe ID=2,000mm x 16mm.	ton	1550	825	1,278,750
	Sub-total				1,474,140
	4 Miscellaneous Works	L.S.		300,000	300,000
	Sub-total				300,000
	Total				15,741,904
					15,700,000
<b>III</b>	Tunnel Works				
	III-1 Division I Tunnel				
	1 Temporary Works at Almout Site	L.S.		800,000	800,000
	Sub-total				800,000
	2 Regulating Pond at Bagh Kalaye				
	Soft rock excavation	cu.m.	90,000	3.86	347,400
	Reinforced concrete	cu.m.	1,250	13.75	17,188
	Reinforced bar	ton	320	530	169,600
	Formwork	sq.m.	7,100	5.3	37,630
	Sub-total				571,818
	3 Tunnel Work by T.B.M.				
	Tunnel Type B (45%)	m	3,600	2,010	7,236,000
	Tunnel Type C (35%)	m	2,800	2,110	5,908,000
	Tunnel Type D (20%)	m	1,600	2,620	4,192,000
	Sub-total				17,336,000

No.		Description	Unit	Quantity	Unit price in US\$	Amount in US\$
	4	Miscellaneous Works	L.S.		492,183	492,183
		Sub-total				492,183
		Total				19,200,000
	III-2	Division II Tunnel				
	1	Temporary Works at Taleghan Site	L.S.		1,400,000	1,400,000
		Sub-total				1,400,000
	2	Access Road & Tunnel				
		Road, common excavation	cu.m.	3,000	0.78	2,340
		Road, rock excavation	cu.m.	417,000	3.86	1,609,620
		Road. Asphalt paving	sq.m.	57,000	4.06	231,420
		Road. Guard rail	m.	10,000	30	300,000
		Road. Access tunnel	m.	200	2,500	500,000
		Sub-total				2,643,380
	3	Crossing Structure in Taleghan river				
		Common excavation	cu.m.	7,800	0.78	6,084
		Fill and Backfill	cu.m.	9,500	1.32	12,540
		Riprap	cu.m.	60	6.62	397
		Concrete	cu.m.	800	13.75	11,000
		Reinforced bar	ton	100	530	53,000
		Formwork	sq.m.	3,200	5.3	16,960
		Guard rail	m.	800	30	24,000
		Sub-total				123,980
	4	Tunnel Works by T.B.M.				
		Tunnel Type B (45%)	m.	5,400	2,010	10,854,000
		Tunnel Type C (35%)	m.	4,200	2,110	8,862,000
		Tunnel Type D (20%)	m.	2,400	2,620	6,288,000
		Sub-total				26,004,000
	5	Miscellaneous Works	L.S.		528,640	528,640
		Sub-total				528,640
		Total				30,700,000
	III-3	Division III Tunnel				
	1	Temporary Works at Qazvin site	L.S.		2,000,000	2,000,000
		Sub-total				
	2	Access Road. Tunnel and Spoil area				
		Access Road at Qazvin area	m	4,000	200	800,000
		Access Tunnel to Inlet of III tunnel	m	400	3000	1,200,000
		Transition Chamber at Inlet	cu.m.	2,000	100	200,000
		Spoil bank near tunnel inlet	L.S.		1,000,000	1,000,000
		Sub-total				3,200,000
	3	Tunnel Works by T.B.M.				
		Tunnel Type B (42%)	m.	4,790	2,010	9,627,900
		Tunnel Type C (33%)	m.	3,760	2,110	7,933,600
		Tunnel Type D (25%)	m.	2,850	2,620	7,467,000
		Sub-total				25,028,500
	4	Miscellaneous Works	L.S.		571,500	571,500
		Sub-total				571,500
		Total				30,800,000
	III-4	Division IV Tunnel				
	1	Temporary Works at Qazvin site	L.S.		500,000	500,000
		Sub-total				500,000
	2	Regulating Pond at Tunnel Outlet				
		Common excavation	cu.m.	200,000	0.78	156,000
		Reinforced concrete	cu.m.	21,000	13.75	288,750
		Reinforced bar	ton	1,260	530	667,800

No.	Description	Unit	Quantity	Unit price in US\$	Amount in US\$
	Formwork	sq.m.	1,800	5.3	9,540
	Pipe jacking under railway	L.S.		250,000	250,000
	Sub-total				1,372,090
3	NATM Tunnel				
	Tunnel Type C (54%)	m.	1,300	3,690	4,797,000
	Tunnel Type D (46%)	m.	1,100	4,840	5,324,000
	Sub-total				10,121,000
4	Miscellaneous Works	L.S.		306,910	306,910
	Sub-total				306,910
	Total				12,300,000
IV	O & M Facilities	L.S.		2,500,000	2,500,000
	Sub-total				2,500,000
	Total				115,800,000

## **BASIC RATE FOR COST ESTIMATION**

- 1 Engineering Staff Charge**
- 2 Labor Charge**
- 3 Construction Materials**

## **PREVAILING UNIT PRICE FOR CIVIL AND BUILDING WORKS IN IRAN**

**Data sources:        Lar Consulting Engineering**



## BASIC RATE FOR COST ESTIMATION

### 1 Engineering Staff Charge

Description	Specifications	Unit	Rate in Rls.	Rate in US\$	Escalation 15.90%	Final Price in US\$
Project Engineer	Expearence>20 years	per month	11,100,000	1,387.50	1608.11	1,608.00
Tunnel Engineer	Expearence>15 years	per month				1,900.00
Assist of Tunnel Eng.	Expearence>8 years	per month				1,360.00
Construction Eng.	Expearence>15 years	per month	7,800,000	975.00	1130.03	1,130.03
Const. Supervisor	Expearence>12 years	per month	7,800,000	975.00	1130.03	1,130.03
Laboratory Chief	Expearence>15 years	per month	6,500,000	812.50	941.69	941.69
Laboratory Staff	Expearence>8 years	per month	4,600,000	575.00	666.43	666.43
Electrical Engineer	Expearence>10 years	per month	6,500,000	812.50	941.69	941.69
Mechanical Engineer	Expearence>10 years	per month	6,500,000	812.50	941.69	941.69
Design Engineer	Expearence>10 years	per month	6,500,000	812.50	941.69	941.69
Cost Estimotor	Expearence> 8 years	per month	4,600,000	575.00	666.43	666.43
Hydraulic Engineer	Expearence>10 years	per month	6,500,000	812.50	941.69	941.69
Draft man	Expearence>8 years	per month	4,000,000	500.00	579.50	579.50
Surveing Engineer	Expearence>15 years	per month	6,500,000	812.50	941.69	1,000.00
Sueveyer	Expearence>10 years	per month	4,600,000	575.00	666.43	600.00
Assist. Surveyer	Expearence>8 years	per month	2,300,000	287.50	333.21	333.21

### 2 Labor Charge

No.	Description	Specifications	Unit	Rate in Rls.	Rate in US\$	Escalation 15.90%	Final Price in US\$
L1	Drilling man	Tunnel boring	per day	143,000	17.88	20.717	20.72
L2	Welder	Steel works	per day	143,000	17.88	20.717	20.72
L3	Electrician	Electric works	per day	143,000	17.88	20.717	20.72
L4	Mechanic	Mechanical works	per day	161,000	20.13	23.325	23.32
L5	Block layer	Block works	per day	100,000	12.50	14.488	14.49
L6	Mason	Stone works	per day	120,000	15.00	17.385	17.39
L7	Painter	Painting works	per day	113,000	14.13	16.371	16.37
L8	Concrete worker	Concrete works	per day	113,000	14.13	16.371	16.37
L9	Carpenter	Formwork,scaffolding	per day	113,000	14.13	16.371	16.37
L10	Reinf.bar bender	Concrete works	per day	113,000	14.13	16.371	16.37
L11	Operator	Heavey equipment	per day	143,000	17.88	20.717	20.72
L12	Operator	Light equipment	per day	87,000	10.88	12.604	12.60
L13	Driver	Ordinary car	per day	87,000	10.88	12.604	12.60
L14	Foreman	Normal construction	per day	170,000	21.25	24.629	24.63
L15	Labor	Skilled	per day	113,000	14.13	16.371	16.37
L16	Labor	Unskilled	per day	70,000	8.75	10.141	10.14
L17	Common Labor	Tunnel boring	per month				300.00
L18	Skilled Labor	Tunnel work	per month				490.00
L19	Foreman	Tunnel work	per month				750.00
L20	TBM operator	Tunnel work	per month				700.00
L21	Assist of TBM operator	Tunnel work	per month				490.00
L22	Electriabn	Tunnel work	per month				700.00
L23	Locomotive driver	Tunnel work	per month				620.00
L24	Shovel operator	Tunnel work	per month				620.00
L25	Drainage operator	Tunnel work	per month				380.00
L26	Assist of Mechanician	Tunnel work	per month				490.00

Labour charge for tunnel works is estimated by 120% of ordinary labour charge.

### 3 Construction Materials

Description	Specifications	Unit	Rate in Rls.	Rate in US\$	Escalation 15.90%	Final Price in US\$
Electric charge	Public works	kwh	400	0.050	0.058	0.06
Deisel oil	Public works	liter	110	0.014	0.016	0.02
Gasolin	Public works	liter	380	0.048	0.055	0.06
Lublicating oil	Public works	liter	16,000	2.000	2.318	2.32
Poltrand cement		ton	150,000	18.750	21.731	21.73
Deformed bar	Reinforced concrete	ton	2,300,000	287.500	333.213	333.21
Steel channel/beam	Steel works	ton	2,500,000	312.500	362.188	362.19
Steel plate	6-12mm	ton	3,350,000	418.750	485.331	485.33
Wooden piller	Normal wood	cu.m.	650,000	81.250	94.169	94.17
Wooden piller	Hard wood	cu.m.	1,600,000	200.000	231.800	231.80
Asplalt	For pavement	ton	50,000	6.250	7.244	7.24
Pre-cast con.pipe	D=600mm,L=1.00m	pcs.	308,500	38.563	44.694	44.69
Pre-cast con.pipe	D=800mm,L=1.00m	pcs.	522,600	65.325	75.712	75.71
Pre-cast con.pipe	D=1,000mm,L=1.00m	pcs.	805,300	100.663	116.668	116.67
Formwork	Construction	sq.m.	52,000	6.500	7.534	7.53
Pavement	For road	sq.m.	28,000	3.500	4.057	4.06
Steel manufacturing	For gate	kg	17,500	2.188	2.535	2.54

### 4 Hiring Rate of Construction Equipment

Description	Specifications	Unit	Charge in Rls.	Charge in US\$	Escalation 15.90%	Final cost in US\$
Dump track	10 ton	hour	56,000	7	8.11	8.11
Dump track	16 ton	hour	72,000	9	10.43	10.43
Dump track	35 ton	hour	120,000	15	17.39	17.39
Dump track	50 ton	hour	176,000	22	25.50	25.50
Wheel Loader	CAT.910	hour	72,000	9	10.43	10.43
Wheel Loader	CAT.950	hour	80,000	10	11.59	11.59
Wheel Loader	CAT.966	hour	112,000	14	16.23	16.23
Wheel Loader	CAT.988	hour	144,000	18	20.86	20.86
Bulldozer	CAT.D6	hour	96,000	12	13.91	13.91
Bulldozer	CAT.D7	hour	120,000	15	17.39	17.39
Bulldozer	CAT.D8	hour	160,000	20	23.18	23.18
Bulldozer	CAT.D9	hour	176,000	22	25.50	25.50
Motor Grader	CAT.14G	hour	88,000	11	12.75	12.75
Motor Grader	CAT.16G	hour	112,000	14	16.23	16.23
Compactor	Single dram. CA25C	hour	72,000	9	10.43	10.43
Compactor	Single dram. CA25C	hour	80,000	10	11.59	11.59
Heavy Compactor	Single dram	hour	120,000	15	17.39	17.39
Excavator	HEPCO	hour	112,000	14	16.23	16.23
Track excavator	HERCO	hour	128,000	16	18.54	18.54
Skiders		hour	96,000	12	13.91	13.91
Track skiders		hour	120,000	15	17.39	17.39
Track Crane	5 ton	hour	56,000	7	8.11	8.11
Track Crane	10 ton	hour	72,000	9	10.43	10.43
Track Crane	20 ton	hour	96,000	12	13.91	13.91
Track Crane	50 ton	hour	144,000	18	20.86	20.86
Tower crane	Up to 100 ton-m.	hour	216,000	27	31.29	31.29
Tower crane	Up to 200 ton-m	hour	320,000	40	46.36	46.36
Baching Plant	60 cu.m/hour	hour	360,000	45	52.16	52.16

## Hiring Rate of Construction Equipment

Description	Specifications	Unit	Rate in Rls.	Rate in US\$	Escalation 15.90%	Final Price in US\$
Batching Plant	120 cu.m./hour	hour	760,000	95	110.11	110.11
Track Mixer	6 cu.m. capacity	hour	80,000	10	11.59	11.59
Water Tanker	10 cu.m. capacity	hour	64,000	8	9.27	9.27
Water Tanker	15 cu.m.capacity	hour	80,000	10	11.59	11.59
Aggregate plant	120 ton/hour	hour	480,000	60	69.54	69.54
Aggregate plant	300 ton/hour	hour	1,200,000	150	173.85	173.85
Concrete pump		hour	120,000	15	17.39	17.39
Concrete pump	Mobile pump	hour	144,000	18	20.86	20.86
Pneumatic vibrator	3"	hour	12,000	1.5	1.74	1.74
Pneumatic vibrator	6"	hour	20,000	2.5	2.90	2.90
Shotcrete pump		hour	36,000	4.5	5.22	5.22
Air compressor	400 cft/min	hour	80,000	10	11.59	11.59
Air compressor	900 cft/min	hour	120,000	15	17.39	17.39
Air compressor	250 cft/min.	hour	64,000	8	9.27	9.27
Drill wagon	ROC-512	hour	280,000	35	40.57	40.57
Drill wagon	ROC-452	hour	232,000	29	33.61	33.61
Drill wagon	ROC-642	hour	400,000	50	57.95	57.95
Jumbo	1-boom	hour	240,000	30	34.77	34.77
Jumbo	2-booms	hour	360,000	45	52.16	52.16
Diamac	Type-252	hour	360,000	45	52.16	52.16
Diamac	Type-262	hour	400,000	50	57.95	57.95
Grouting set		hour	160,000	20	23.18	23.18
Generator	Up to 165 KVA	hour	32,000	4	4.64	4.64
Generator	Up to 280 KVA	hour	80,000	10	11.59	11.59
Waterpump	Up to 4 "	hour	24,000	3	3.48	3.48
Water pump	Up to 6 "	hour	48,000	6	6.954	6.95
Bar bending machine		hour	16,000	2	2.318	2.32
Cutting machine		hour	20,000	2.5	2.898	2.90
Welding machine		hour	8,000	1	1.159	1.16
Grouting pump	HV-18	hour	40,000	5	5.795	5.80

## PREVAILING UNIT PRICE FOR CIVIL AND BUILDING WORKS

### CIVIL WORK

Description	Specifications	Unit	Rate in Rls.	Rate in US\$	Escalation 15.90%	Final Rate in US\$
Excavation	Overburden	cu.m.	5,360	0.670	0.78	0.78
Excavation	Rock, Intake	cu.m.	26,640	3.330	3.86	3.86
Excavation	Rock, Tunnel	cu.m.	151,200	18.900	21.91	21.91
Excavation	Rock, Shaft	cu.m.	175,200	21.900	25.38	25.38
Fill	Impervious	cu.m.	9,120	1.140	1.32	1.32
Fill	Filter & transision	cu.m.	18,640	2.330	2.70	2.70
Fill	Rockfill	cu.m.	5,120	0.640	0.74	0.74
Fill	Riprap	cu.m.	45,680	5.710	6.62	6.62
Fill	Compacted random	cu.m.	6,640	0.830	0.96	0.96
Concrete	For tunnel	cu.m.	254,720	31.840	36.90	36.90
Concrete	For control shaft	cu.m.	371,200	46.400	53.78	53.78
Concrete	Power house	cu.m.	114,320	14.290	16.56	16.56
Concrete	Intake bottom	cu.m.	94,880	11.860	13.75	13.75
Formwork	For tunnel	sq.m.	52,800	6.600	7.65	7.65
Formwork	Intake bottom	sq.m.	36,560	4.570	5.30	5.30
Formwork	Intake bottom	sq.m.	36,560	4.570	5.30	5.30
Formwork	Power house	sq.m.	64,000	8.000	9.27	9.27
Reinforcement bar	Tunnel & Complex	ton		740.000	857.66	860.00
Reinforced bar	Normal structure	ton		460.000	533.14	533.00
Shotcrete	Tunnel	cu.m.	698,400	87.300	101.18	101.18
Steel lining	Tunnel	kg	13,600,000	1700.000	1970.30	1,970.30
Rock dowels	Tunnel	m.	52,160	6.520	7.56	7.56
Rock dowels	24 x 3000mm	unit	156,480	19.560	22.67	22.67
Ribbing	Tunnel	kg	4,800	0.600	0.70	0.70
Wire mesh	Tunnel shotcrete	sq.m.	33,280	4.160	4.82	4.82
Steel pipes		ton	5,714,320	714.290	827.86	827.86
Consolidation drilling	Rock	m.	228,160	28.520	33.05	33.05
Consolidation grout		kg	480	0.060	0.07	0.07
Consolidation grout	Filter	kg	320	0.040	0.05	0.05
Curtin drilling	Rock	m.	456,800	57.100	66.18	66.18
Curtin drilling	Alluvium	m.	262,880	32.860	38.08	38.08
Curtin grout		kg	480	0.060	0.07	0.07
Contact drilling		m.	505,200	63.150	73.19	73.19
Contact grout		kg	480	0.060	0.06954	0.07

### BUILDING WORK

Stores		1,500	90,000	12,857	102,857	119211.26
Working building	Welding, bar & etc.	600	36,000	5,400	41,400	47982.60
Power station	2MW	150	9,000	12,857	21,857	25332.26
Repair shop	Equipment, vehicle	600	36,000	5400	41,400	47982.60
Stores	Explosive	200	17,143	1,714	18,857	21855.26
Open stores	Parkings & ,repairs	9,500	122,143	0	122,143	141563.74
Gas station		200	1714	4286	6,000	6954.00
Telephone office	Communication	150	4286	30,000	34,286	39737.47
Security Office		120	6857	0	6,857	7947.26
Laboratory buiding		300	51,429	857	52,286	60599.47
Canteen		480	82,286	71143	153,429	177824.21
Site Clinic		100	8,571	857	9,428	10927.05

## **UNIT PRICE OF CIVIL AND TUNNEL WORKS ESTIMATED BY JICA**

<b>Civil Works</b>	<b>Unit price of Grand Sill</b>
	<b>Unit price of Bypass Canal</b>
	<b>Unit price of Cut-off wall</b>
	<b>Unit price of Andah rud diversion dam</b>
	<b>Unit price of Jack pushing under Existing Railway</b>
	<b>Unit price of Water proofing in Tunnel</b>
	<b>Unit price of Air valve at Pipeline</b>
	<b>Unit price of Expansion Joint at Pipeline</b>
	<b>Unit price of TBM Tunnels</b>
	<b>Unit price of TBM Tunnel Excavation</b>
	<b>Unit price of NATM Tunnels</b>
<b>Building Works</b>	<b>Unit price of NATM Tunnel Excavation</b>
	<b>Unit price of O &amp; M Office</b>

### UNIT PRICE OF GROUND SILL FOR ALMOUT DIVERSION DAM

( Applied for Almout. Diversion Dam)

No.	Description	Specifications	Unit	Quantity	Unit price	Amount
	Excavation	Machinery	cu.m.	24.2	0.78	18.88
	Wet masonry		cu.m.	8.6	14.56	125.22
	Gabion mattless		cu.m.	6	29.81	178.86
	Total					322.95
Unit price of ground sill				322.95 US\$/m		
				320 US\$/m		

### UNIT PRICE OF BY-PASS CANAL

( Applied for Almout. Diversion Dam)

No.	Description	Specifications	Unit	Quantity	Unit price	Amount
	Excavation		cu.m.	6.080	0.780	4.74
	Backfill		cu.m.	2.630	1.320	3.47
	Reinforced concrete		cu.m.	1.650	13.750	22.69
	Leveling concrete		cu.m.	0.150	13.750	2.06
	Formwork		sq.m.	7.250	5.300	38.43
	Reinforced bar		ton	0.165	533.000	87.95
	Total					159.33
					160 US\$/m	

### UNIT PRICE OF CUT-OFF WALL AT ALMOUT DIVERSION DAM

( Applied for Almout. Diversion Dam)

No.	Description	Specifications	Unit	Quantity	Unit Price	Amount
1	Labor charge					
	Foreman		man/day	1	24.63	24.63
	Installator		man/day	2	20.72	41.44
	Labour	Skilled	man/day	1	16.37	16.37
	Labour	Unskilled	man/day	2	10.14	20.28
2	Equipment charge					
	Drilling machine	55 kwx2	Special hour/day	8	32.92	263.33
	Wall treatment equipment		Special hour/day	8	12.04	96.33
	Drilling head	600mm		8	17.19	137.50
	Lod	600mm		8	10.67	85.33
	Plant machine		hour/day	4	52.16	208.64
	Compressor	5 cum/min.	hour/day	6	11.59	69.54
	Generator	350 kw 450 Ps	hour/day	7	11.59	81.13
	Track crane	120 ton	hour/day	7	46.36	324.52
	Backhoe	0.4 cum bucket	hour/day	6	16.23	97.38
	Dump track	8 ton	hour/day	6	8.11	48.66
3	Plug material					
	Cement+bentnite		cu.m.	12	40.00	480.00
	Sub-total	Total				1995.09
	Equipment shifting/transportation/assembling			299.26		299.26
	TOTAL					2294.35
		1808.82/20				
	Unit price of cut-off wall			114.7175	114.72 US\$/sq.m.	
					120 US\$/sq.m.	

# UNIT PRICE OF ON ANDAH RUD DIVERSION DAM

( Applied for Almout Diversion Dam)

Unit: US \$

No.	Description	Specifications	Unit	Quantity	Unit Price	Amount	Remarks
1	Diversion Dam						
	Excavation		cu.m.	40,000	0.78	31,200	
	Fill & backfill		cu.m.	20,000	1.32	26,400	
	Reinforced concrete		cu.m.	17,100	13.75	235,125	
	Reinforced bar		ton	855	533	455,715	
	Formworks		sq.m.	17,100	5.3	90,630	
	Curtin cut-off wall		sq.m.	2,300	114.72	263,856	
	Radial gate		set	2	100,625	201,250	
	Total					1,304,176	
	Sub-total					330,000	
2	Intake						
	Excavation		cu.m.	4,000	0.78	3,120	
	Fill & backfill		cu.m.	2,000	1.32	2,640	
	Reinforced concrete		cu.m.	1,500	13.75	20,625	
	Reinforced bar		ton	75	533	39,975	
	Formwork		sq.m.	1,500	5.3	7,950	
	Gate		unit	1	6325	6,325	
	Sub-total					80,635	
	TOTAL	80,635+330,000=				410,000	US\$

### UNIT PRICE OF AIE VALVE BOX AT PIPELINE

( Applied for Pipeline Works) ID=150mm

Unit\*US\$

No.	Description	Specifications		Unit	Quantity	Unit price	Amount
	Air valve	150mm		set	1.0	315.7	315.70
	Crane track	3 ton		hour	2.0	8.1	16.23
	Labor	Normal	2 units/day	man/day	1.0	10.1	10.14
	Mechanician			man/day	0.5	23.3	11.66
	Installator			man/day	0.5	20.7	10.36
	Concrete	Valve box		cu.m.	1.0	13.8	13.75
	Reinforced bar			ton	0.1	533.0	53.3
	Formwork			sq.m.	8.0	5.3	42.4
	Excavation			cu.m.	2.0	0.8	1.56
	Backfill			cu.m.	1.0	1.3	1.32
	Total						
	Unit price of Air valve & box installation				476.42 US	480 US\$/set	Rials

### UNIT PRICE OF EXPANSION JOINT AT PIPELINE

( Applied for Pipeline Works)

ID=2,000mm

Unit: US\$

No.	Description	Specifications		Unit	Quantity	Unit price	Amount
	Expanion joint	2000mm Closer type		set	1	7,050	7050
	Installation	Crane 25 ton		hour	5	14	69.55
	Skilled labour	4-labour/group		man/day	4	16	65.48
	Installator	Welder		man/day	3	20.72	62.16
	Weilder	2000 mm		man/day	9.6	20.72	198.912
	Forman			man/day	1.3	24.63	32.019
	Tools/equipment	Lobour charge 6 %		LS	1	1.29	21.51
	Total						7499.631
		Unit price of Expansion joint				7,500	US\$
						60,000,000	Rials



### Unit Price of TBM Tunnels

Pattern B				Unit:US\$		
No.	Description	Specifications	Unit	Quantity	Unit price	Amount
1	Rock excavation	Tunnel excavation	m	1	1,580	1,580.00
2	Concrete lining	t=300 mm	cu.m.	3.711	36.9	136.94
3	Segment	Pre-cast conc.	cu.m.	1.311	73.8	96.75
4	Formwork	Steel	sq.m.	12.866	7.65	98.42
5	Miscellaneous	5%				95.61
	Total					2,007.72
	Unit price per meter					2,010 US\$/m

Pattern C				Unit:US\$		
No.	Description	Specifications	Unit	Quantity	Unit price	Amount
1	Rock excavation	Tunnel	m	1	1,580	1,580.00
2	Shotcrete	T=30 mm	cu.m.	0.399	101.18	40.37
3	Concrete lining	t=500 mm	cu.m.	5.619	36.9	207.34
4	Segment	Pre-cast conc.	cu.m.	1.311	73.8	96.75
5	Formwork	Steel	sq.m.	11.288	7.65	86.35
6	Miscellaneous	5%				100.54
	Total					2,111.35
	Unit price per meter					2,110 US\$/m

Pattern D				Unit*US\$		
No.	Description	Specifications	Unit	Quantity	Unit price	Amount
1	Rock excavation	Tunnel	m	1	1,580	1,580.00
2	Shotcrete	T=30 mm	cu.m.	0.399	101.18	40.37
3	Steel support	H100x100	ton	0.229	434	99.39
4	Water proofing		sq.m.	13.7	27.95	382.92
5	Concrete lining	t=500 mm	cu.m.	5.619	36.9	207.34
6	Segment	Pre-cast conc.	cu.m.	1.311	73.8	96.75
7	Formwork	Steel	sq.m.	11.288	7.65	86.35
8	Miscellaneous	5%				124.66
	Total					2,617.78
	Unit price per meter					2,620 US\$/m

## Unit Price of TBM Tunnel Excavation

Estimation of TBM Tunnel Excavation :

### 1 Outline of tunnel excavation

Division	Length in m.	Volume in cu.m.	Progress	Construction period
Division I	8,000	156,000	250m/month	32 months
Division II	12,000	240,000	250m/month	48 months
Division III	11,400	239,000	255m/month	45 months
Total	31,400	635,000		

Estimation of Excavation Cost (Based on Division II Tunnel)

### 2 Labor Cost

Excavated volume = 240,000cu.m. 48 months

Length = 12,000 m

No.	Labor	Man-month 3shift	Unit price US\$/month	Amount in US \$
1	Foreman	144	750	108,000
2	TBM Operator	288	700	201,600
3	Assistant of TBM Operator	288	490	141,120
4	Electrician	288	620	178,560
5	Assistant of Electrician	288	490	141,120
6	Mechanician	288	700	201,600
7	Assistant of Mechanician	288	490	141,120
8	Locomotive Driver	432	620	267,840
9	Assistant of Loc. driver	432	490	211,680
10	Driver for dump truck	288	380	109,440
11	Shovel operator	144	620	89,280
12	Assistant of shovel operator	144	490	70,560
13	Bulldozer operator	144	620	89,280
14	Assistant of Bull. operator	144	490	70,560
15	Drainage operator	144	380	54,720
16	Assistant of drain. operator	144	300	43,200
17	Skilled labor	432	490	211,680
18	Common labor	1440	300	432,000
19	Topo-surveyer	288	800	230,400
20	Assistant of surveyor	288	400	115,200
21	Tunnel Engineer	144	1900	273,600
22	Assistant of tunnel eng.	288	1360	391,680
	Total			3,774,240
	Cost per meter			314.52

Exchange rate

Market rate 8,000 Rls = 1.00 US\$

Official rate for National Project 2,000 Rls=1.00 US \$

Official rate(=2,000 Rls=1.00 US\$) shall be applied for the imported equipment for tunnel construction.

### 3 Estimation of Construction Equipment

Excavated volume = 240,000 cu.m. 48 months

Unit:US\$

No.	Description	Specifications	Iran cost	Quantity	%	Mechanical cost
1	Tunnel Boring Machine TBM	5000 mm	2,627,100	1	1.0	2,627,100
2	Electric locomotive	12ton	68,000	3	0.7	142,800
3	Muck-car 6cu.m.	6.0 cu.m.	5,000	10	1.0	50,000
4	Rail 22 kg	13.2 km	210,360	1	0.7	147,250
5	Air Ventilator 400 cum/min	15.5 kw x 2	62,330	12	1.0	747,960
6	Dust Collector		337,100	2	1.0	674,200
7	Pipe for dust	12 kmx3(@2years)	516,250	1	1.0	516,250
8	Drainage pump	150 mm 9.2 kw	1,295	12	1.0	15,540
9	Water supply for TBM	50mm 35 m	3,040	4	1.0	12,160
10	Water supply pipe 100 mm	12 km	147,000	1	1.0	147,000
11	Light facilities	12 km	60,000	1	1.0	60,000
12	Electric cable	12 km	15,700	1	1.0	15,700
13	High voltage cable	12 km	104,000	1	1.0	104,000
14	Transformer	220-6000 V	11,700	2	0.7	16,380
15	Dust water treatment plant	25-45 cum/h	64,600	1	1.0	64,600
16	Electrical Generator	500 KW	18,750	6	1.0	112,500
	Sub-total					5,453,440
17	Dump track 10 ton	10 ton	8.11 US\$/hr	29,400	hr.	238,430
18	Wheel loader	4 cu.m.	11.59 US\$/hr	14,700	hr.	170,370
19	Bulldozer	21 ton	17.39 US \$/hr.	14,700	hr.	255,630
	Sub-total					664,430
	Total					6,117,870
	Total cost per meter					509.82
4	Repairing Cost of Construction Equipment		5,453,440	100%		5,453,440
	Total cost per meter					454.45
<b>5 Consumption materials &amp; fuel, electric charge</b>						
No.	Description	Specifications	Quantity	Unit price		Amount in US\$
1	Cutter head - cutter ring	For TBM	454	313		142,100
	17" cutter hab		189	3125		590,630
	17" center cutter		23	5625		129,380
2	Fluorescent light	40W for tunnel	4800	20		96,000
	Sub-total					958,110
3	Fuel charge for generator		KWH	Unit price		Amount in US \$
	3000 KWH x 12 hour x 25 day x 49 month		43,200,000	0.06		2,592,000
			829,440	0.06		49,770
	Sub-total					2,641,770
	Total					3,599,880
	Total cost per meter					299.99
<b>Summary</b>						
No.	Description					Amount in US\$
1	Labor charge					314.52
2	Construction Equipment					509.82
3	Repairing Cost of Construction Equipment		150%			454.45
4	Materials & Electric charge					299.99
	Total					1,579
	Unit Price				1580	1,580 US\$/m

### Unit Price of NATM Tunnels

Pattern C				Unit: US\$		
No.	Description	Specifications	Unit	Quantity	Unit price	Amount
1	Excavation	Tunnel excavation	cu.m.	20.944	97	2,031.57
2	Shotcrete		cu.m.	1.204	101.18	121.82
3	Rock bolt	24mm-3,000mm	unit	4.17	22.67	94.53
4	Steel support	H125xH125	ton	0.239	434	103.73
5	Water proofing		sq.m.	12.04	27.95	336.52
6	Grouting		cu.m.	3.01	121.42	365.47
7	Poling plate		cu.m.	0.21	94.17	19.78
8	Concrete lining	t=50 cm	cu.m.	8.331	36.9	307.41
9	Concrete lining	invert	cu.m.	1.08	48.0	51.84
10	Formwork	Steel	sq.m.	10.223	7.65	78.21
11	Drain pipe	ID=100 mm	m	1	2	2.00
12	Miscellaneous	5%				175.64
	Total					3,688.52
	Unit price per meter					3,690 US\$/m

Pattern D				Unit: US\$		
No.	Description	Specifications	Unit	Quantity	Unit price	Amount
1	Excavation	Tunnel excavation	cu.m.	22.199	97	2,153.30
2	Shotcrete		cu.m.	2.439	101.18	246.78
3	Rock bolt	24mm-3,000mm	unit	7.78	22.67	176.37
4	Steel support	H125xH125	ton	0.318	434	138.01
5	Water proofing		sq.m.	12.2	27.95	340.99
6	Grouting		cu.m.	4.879	121.42	592.41
7	Poling plate		cu.m.	0.785	94.17	73.92
8	Concrete lining	t=50 cm	cu.m.	9.586	36.9	353.72
9	Reinforced bar	Deformed bar	ton	0.463	860	398.18
10	Concrete lining	invert	cu.m.	1.08	48.0	51.84
11	Formwork	Steel	sq.m.	10.328	7.65	79.01
12	Drain pipe	ID=100 mm	m	1	2	2.00
13	Miscellaneous	5%				230.33
	Total					4,836.86
	Unit price per meter					4,840 US\$/m

## Unit Price of NATM Tunnel Excavation

### 1 Outline of tunnel excavation

Division	Length in m.	Volume in cu.m.	Progress	Construction period	
Division IV	2,400	52,000	100m/month	24	months
Total	2,400	52,000			

### 2 Labor Cost

Excavated volume = 52,000 cu.m. 24 months

Unit: US\$

No.	Description	Man-month 3 shift	Unit price US\$/month	Amount in US\$
1	Foreman	72	750	54,000
2	TBM Operator	72	700	50,400
3	Assistant of TBM Operator	72	490	35,280
4	Electrician	72	620	44,640
5	Assistant of Electrician	72	490	35,280
6	Mechanician	72	700	50,400
7	Assistant of Mechanician	72	490	35,280
8	Locomotive Driver	216	620	133,920
9	Assistant of Loc. driver	216	490	105,840
10	Driver for dump truck	144	380	54,720
11	Shovel operator	72	620	44,640
12	Assistant of shovel operator	72	490	35,280
13	Bulldozer operator	72	620	44,640
14	Assistant of Bull. operator	72	490	35,280
15	Drainage operator	72	380	27,360
16	Assistant of drain. operator	72	300	21,600
17	Skilled labor	216	490	105,840
18	Common labor	720	300	216,000
19	Topo-surveyer	144	800	115,200
20	Assistant of surveyor	144	400	57,600
21	Tunnel Engineer	72	1900	136,800
22	Assistant of tunnel eng.	144	1360	195,840
	Total			1,635,840
	Cost per meter			681.60

### 3 Estimation of Construction Equipment in Tunnel Excavation

Excavated volume = 52,000 cu.m. 24 months

No.	Description	Specifications	Iran cost	Quantity	%	Mechanical cost
1	Partial face excavator		230,813	1	1.0	230,810
2	Electric Locomotive	8 ton	44,770	2	0.7	62,680
3	Muck-car 4.5 cu.m.	4.5 cu.m.	4,000	8	1.0	32,000
4	Rail 22 kg	2.6 km	41,430	1	0.7	29,000
5	Air Ventilator 400 cum/min	5.5 kw x 2	27,650	5	1.0	138,250
6	Dust Collector		337,100	2	1.0	674,200
7	Pipe for dust	2.4 km	103,250	1	1.0	103,250
8	Drainage pump	150 mm 9.2 kw	1,295	6	1.0	7,770
9	Water supply for Excavator	50mm 35 m	3,040	2	1.0	6,080
10	Water supply pipe 100 mm	2.4 km	29,400	1	1.0	29,400
11	Light facilities	2.4 km	12,000	1	1.0	12,000
12	Electric cable	2.4 km	3,140	1	1.0	3,140
13	High voltage cable	2.4 km	20,800	1	1.0	20,800
14	Transformer	220-6000 V	11,700	2	0.7	16,380
15	Dust water treatment plant	25-45 cum/h	64,600	1	1.0	64,600
16	Electrical Generator	500 KW	18,750	6	1.0	112,500
	Sub-total					1,542,860
17	Dump track 10 ton	10 ton	8.11 US\$/hr	5,880	hr.	47,690
18	Wheel loader	4 cu.m.	11.59 US\$/hr	2,940	hr.	34,070
19	Bulldozer	21 ton	17.39 US \$/hr.	2,940	hr.	51,130
	Sub-total					132,890
	Total					1,675,750
	Total cost per meter					698.23
4	Repairing Cost of Construction Equipment		1,542,860	70%		1,080,000
	Total cost per meter					450.00
5	Consumption materials & fuel, electric charge					
No.	Description		Quantity	Unit price		Amount in US\$
1	Cutter head - cutter ring		600	95		57,000
2	Fluorescent light	40W	1440	20		28,800
	Sub-total					85,800
3	Fuel charge for generator		KWH	Unit price		Amount in US \$
	2000 KHHx20 hours x 25 x 9		9,000,000	0.06		540,000
	40 W x 48 pcs x 24 hours x 30 days x 1/2		4			
			846,720	0.06		50,800
	Sub-total					590,800
	Total					676,600
	Total cost per meter					281.92
Summary						
No.	Description					Amount
1	Labor charge					1,635,840
2	Construction Equipment					1,675,750
3	Repairing Cost of Construction Equipment					1,080,000
4	Materials & Electric charge					676,600
	Total					5,068,190
	Unit price of Tunnel Excavation					97.47
					97	97 US\$/cu.m.

### UNIT PRICE OF JACK PUSHING CULVERT UNDER EXISTING RAILWAY

( Applied for Tunnel- IV Works)

Culvert length= 36.00 m  
Steel pipe ID 2,000mm x 3

No.	Description	Specifications	Unit	Quantity	Unit price	Amount
	Excavation	Normal excavation	cu.m.	4210.00	0.78	3283.8
	Excavation	Tunnel excavation	cu.m.	350.00	21.91	7668.5
	Backfill		cu.m.	1335.00	1.32	1762.2
	Steel pipe	ID 2,000mm,t=22mm	ton	120.00	827.86	99343.2
	Concrete		cu.m.	900.00	16.56	14904.0
	Demolishment	Concrete	cu.m.	265.00	3.86	1022.9
	Reinforced bar		ton	107.00	860.00	92020.0
	Formwork		sq.m.	1230.00	9.27	11402.1
	Jacking works	Steel pipe cost x 5%	L.S.	1.00	4967.16	4,967.2
						236,373.9
Total			236,373.9 US\$		250,000US\$	
Cost per meter			657.6083 658 US\$/m			

### UNIT PRICE OF WATER PROOFING IN TUNNEL

Applied for Tunnel Works)

No.	Description	Specifications	Unit	Quantity	Unit price	Amount
1						
	Water proofing sheet	Imported materials	sq.m.	1	40,000	40000
	Fixing	labour charge	man/day	0.15	130,960	19644
	Total					59644
	Unit price of Water proofing sheet per sq.m.				7.4555	7.46 \$
	Unit price of Wet masonry				27.95 US\$/cu.m.	

## UNIT PRICE OF O & M OFFICE AT DOZDAKSAR

							Unit* US \$
No.	Description	Specifications	Unit	Quantity	Unit Price	Amount	Remarks
1	Civil works						
	Excavation	Stripping	cu.m.	2,000	0.78	1,560	
	Embankment	Leveling	cu.m.	4,800	1.32	6,336	
	Parking area	Gravel pavement	sq.m.	480	14.90	7,152	
	Asphalt road	10 cm.paving	sq.m.	4,050	4.06	16,443	
	Sub-total					31,491	
2	Building works						
	Fence works	1.8 m height	m	710	15.00	10,650	
	Gate works		unit	2	150.00	300	
	Office building		sq.m.	840	88.00	73,920	
	Guard house		sq.m.	105	88.00	9,240	
	Ware house		sq.m.	160	45.00	7,200	
	Fuel stock		sq.m.	40	80.00	3,200	
	Officer's residence		sq.m.	1,380	88.00	121,440	
	Staff residence		sq.m.	720	88.00	63,360	
	Furniture and others		L.S.	1	46060.00	46,060	
	Sub-total					335,370	
3	Living Facilities						
	Electric supply	to O & M yard	L.S.	1	25,000	25,000	
	Electric supply	in O & M yard	L.S.	1	40,000	40,000	
	Drinking water supply		L.S.	1	120,000	120,000	
	Sewage system		L.S.	1	50,000	50,000	
	Tele-communication		L.S.	1	120,000	120,000	
	Sub-total					355,000	
4	O&M Equipment	patrol car,etc.	L.S.	1	896,550	896,550	
5	O&M Instruments	data collection	L.S.	1	846,000	846,000	
	Total					2,464,411	
						2,464,400	