Chapter - 6

Design Aspects

6.0 General

As already discussed, the main objective of the Bedti-Varada link project is to divert the surplus waters of west flowing Bedti river to east flowing Varada, a tributary of Tungabhadra for stabilizing/augmentation of existing irrigation system in the left bank canal of Tungabhadra project in Raichur district of Karnataka state. The link project comprises the following components:

Link-I: Bedti-Varada

1. A 145 m long concrete weir across Pattanadahalla river, a tributary of Sonda river which further joins Bedti river, with FPL 499.00 m and corresponding gross storage capacity of 0.54 MCM.
2. A 202.0 m long concrete weir across river Shalamalahalla, a tributary of Sonda river, with FPL 468.00 m and corresponding gross storage capacity of 4.32 MCM.
3. A tunnel of length 6.5 km, 0.10 km approach channel up to tunnel entry with a designed discharge of 22.33 m^3/sec and a lead canal of 0.3 km after tunnel exit leading to a natural stream that further leads to Shalamalahalla weir.
4. Jackwell cum pumphouse from the foreshore on the right side of Shalamalahalla weir with a discharge capacity of 60.50 m^3/sec.
5. Lifting arrangements to a height of 107.50 m (static) in single stage through a raising main of length 10.15 km and a delivery chamber (DC) at the entry of the tunnel

6. Tunnel of length 6.7 km from D.C
7. A canal of length 1.73 km (after the tunnel exit) which falls into a stream leading to Varada river.

Link-II: Bedti - Dharma - Varada

1. A 165 m long concrete barrage across Bedti river near Suremane villagewith FPL 426.00 m and corresponding gross storage capacity 2.71 MCM.
2. Jackwell cum pump house from the foreshore on the left side of the barrage with a discharge capacity of 76.40 m^3/sec.
3. Lifting arrangements to a height of 185.50 m (static) in two stages through a raising main of length 22.3 km. From DC, an approach canal of 0.35 km will lead to a tunnel of length 4.23 km which falls into a stream that joins Dharma reservoir.

6.1 Geology, seismicity and foundation

6.1.1 Geology

Detailed geological investigations will be carried out at pre-construction stage.

6.1.2 Seismicity

There are only two weirs and one barrage proposed with respective full pond levels limited to river portion/bank and hence no site-specific seismic studies are proposed. From the general seismology, it is seen that the link project area in Uttara Kannada district falls in earthquake zone-II as per IS Code: IS1893 (Part 1): 2002, which is considered as the least vulnerable for

seismic activity and damage. Seismic studies, if required, shall be carried out at pre-construction stage.

6.1.3 Foundation treatment

No detailed study on the geological features and sub strata of the major structures and the soil profiles at head work sites have been carried out. It is however, seen that the hard rock formation is visible at many places and is available in shallow depth. The foundation treatment as would be required shall be assessed during the pre-construction stage.

6.2 Pattanadahalla weir

Pattanadahalla weir is proposed on Pattanadahalla stream, a tributary of Bedti river near Siralabail village. The latitude and longitude of the weir location are14°40' 15"N and 74°41' 18"E respectively. Width of the river at the proposed site is 254.0 m. at RL-499.00m. The design of weir is furnished in the following paragraphs.

6.2.1 Design flood at Pattanadahalla weir

The design flood for the Pattanadahalla weir has been determined using Inglish formula. The Ogee shape broad crested weir is designed for a maximum flood discharge of 824 cumec. Details are given in **Annexure 6.1.1.**

6.2.2 Hydraulic design of the weir

The weir at Pattanadahalla is designed for a flood of 824 cumec for which the waterway is obtained as 130.0 m. A road is proposed over the weir

with 13 spans of 10.0 m, with 1.25 m width piers. The length of the weir will be 145.0 m. A river sluice of size of 1mx1.5m is also proposed.

The weir will pass safely the designed discharge considering an afflux of 0.5 m. The details are furnished in **Table 6.1**.

Table 6.1 Salient features of headworks at Pattanadahalla		
1	FPL (m)	499.00
2	Head over crest (m)	2.0
3	MWL (m)	501.00
4	Afflux (m)	0.5
5	Road level (m)	503.00
6	No. of bays	13
7	River sluice	1no (1.0 m x 1.50m)
8	Length of weir (m)	145.00
9	Discharge allowed (cumec)	834

The layout of headworks showing weir and other appurtenant works is shown in **Plate 6.1.1.** The plan &cross section of the weir are presented in **Plate 6.1.2.**

6.3 Shalamalahalla weir

Shalamalahalla weir is proposed on Shalamalahalla stream, a tributary of Bedti river near Hulgol village. The latitude and longitude of the weir location are 14°42'26"N and 74°48'31"E. Width of the river at the proposed site is 250 m. The design of weir is furnished in the following paragraphs.

6.3.1 Design flood at Shalamalahalla weir

The design flood for the Shalamalahalla weir has been determined using Inglish formula. The Ogee shape broad crested weir is designed for a maximum flood discharge of 1567 cumec. Details are given in **Annexure 6.2.1.**

6.3.2 Hydraulic design of the weir

The weir at Shalamalahalla is designed for a flood of 1567 cumec for which the Lacey's waterway is obtained as 180.0 m. A road is proposed over the weir with 18 spans of 10.0 m, with 1.25 m width piers. A river sluice of size 1mx1.5m is also proposed. The total length of the river will be 202.0 m. The weir will pass safely the designed discharge considering an afflux of 0.5 m. The details are furnished in **Table 6.2.**

Table 6.2 Salient features of headworks at Shalamalahalla

1	FPL (m)	468.00
2	Head over crest	2.50 m
3	MWL	470.5
4	Afflux (m)	0.5
5	No. of bays	18
6	River sluice	1
7	Length of weir (m)	202.0
8	Discharge allowed (cumec)	1601.0

The layout of headworks showing weir and other appurtenant works is shown in **Plate 6.2.1.** The plan &cross section of the weir are shown at **Plate 6.2.2.**

6.4 Suremane barrage

Suremane barrage is proposed on Bedti river near Suremane village. The latitude and longitude of the weir location are 14°52' 53" N and 74°47' 13" E. Width of the river at the proposed site is 130 m. The design of barrage is furnished in the following paragraphs.

6.4.1 Design flood at Suremane barrage

The design flood for the Suremane barrage has been determined using Inglish formula. The barrage is designed for a maximum flood discharge of 5639 cumec. Details are given in **Annexure 6.3.1 to 6.3.7.**

6.4.2 Hydraulic design of the barrage

The barrage at Suremane is designed for a flood of 5639 cumec for which the Lacey's waterway is obtained as 363m. However, a river width of 150 m is considered as waterway. Four bays/sluices proposed in under sluice portion while nine are proposed in river sluice portion. After due provision of 2.0 m wide piers for under sluices as well as river sluices and 2nos of 3.0m thick divide walls, the overall waterway obtained is about 165 m. The weir will pass safely the designed discharge considering an afflux of 1.0 m. The details are furnished in **Table 6.3**.

Table 6.3 Salient features of headworks at Suremane		
1	FPL (m)	426.00
2	Crest level (m) (i) Under sluice (ii) River sluice	 420.00 421.00
3	Afflux (m)	1.0
4	No. of bays	
	Under sluice River sluice	4 9
6	Length of weir (m)	165.00
7	Discharge allowed (cumec)	5670

The layout plan of Suremane barrage is shown in **Plate 6.3.1.** While the plan of the barrage is given in **Plate 6.3.2**, the cross sections of the barrage through under sluice and river sluice are presented in **Plate 6.3.3**. The diagram showing the radial gates installation for river sluice is shown in **Plate 6.3.4.**

6.5 Design of conveyance system

The design of conveyance system comprises design of approach channel, tunnels and lifting arrangements.

Link I: (Pattanadahalla/ Shalamalahalla to Varada)

1. The two weirs are proposed to be connected with a tunnel of length 6.5 km, 0.10 km approach channel up to tunnel entry and a canal of 0.30 km length leading to natural stream after tunnel exit which leads to Shalamalahalla. Design details are given in **Annexure 6.1.2.**
2. A raising main of length 10.15 km from Shalamalahalla with pump house, lifting arrangements and a delivery chamber. Design details are given in **Annexure 6.2.2.**

3. A tunnel of length 6.7 km from DC.
4. A canal of length 1.73 km (after tunnel exit) leading to Varada river.

Design details are given in **Annexure 6.2.3.**

Link II: Suremane to Dharma

1. A raising main of length 22.3 km with pump house and lifting arrangements.
2. An approach canal of length 0.35 km from DC upto the tunnel.
3. A tunnel of 4.23 km which outfalls into a stream that joins Dharma river.

Design details are given in **Annexure 6.3.8 to 6.3.10.**

6.5.1 Link/canal alignment

Link-1

The alignment of the proposed link project is finalized based on DEM derived from toposheets of 1:50,000 scale. Approach channel and the canal at the outfall has been aligned along the contour. The approach channel of length 0.1 km takes off with FSL of 492.00 m from Pattanadahalla weir up to the entry of interconnecting tunnel of length 6.5 km. After the tunnel exit, a canal of 0.3 km length with FSL of 489.783 m off takes at RD 6.6 km and outfalls into a stream leading to Shalamalahalla with FSL 489.753 m.

302 MCM from Shalamalahalla are proposed to be lifted from RL 463.0 m to RL 570.5 m (107.5 m static) from the Jack well/pump house through a raising main of length 10.15 km. Further, the lifted water is proposed to be diverted through a tunnel of length 6.70 km crossing the ridge between Bedti basin and Tungabhadra sub basin. The tunnel takes off with FSL of 570.0 m

and joins a canal at exit with FSL of 568.267 m. The 1.73 km long canal outfalls in to a stream leading to Varada river at RD 18.58 km with FSL 568.094 m. The bed slope of the canal is considered as 1 in 10,000 whereas the same for the tunnels is considered as 1 in 3000 to 1 in 4000.

Link II

The water available at Suremane barrage to the tune of 222 MCM is proposed to be lifted from the Jackwell/pumphouse from RL 420 m to a height of 185.5m (static) in two stages through a raising main of length 22.3km. Further, the water is let into a stream leading to Dharma reservoir through an approach canal of 0.35 km and a tunnel of length 4.23 km. The FSL at tunnel entry and exit are 599.000 m and 597.871 m respectively. The head loss statement of the conveyance system (Link I &II) is given in **Annexure 6.4.**

No field/ topographical surveys are conducted for the present. The topographical details arrived at using DEM data are given in **Chapter 4: Surveys & investigations.** These will be firmed up through actual surveys & investigations at pre-construction stage.

6.5.2 Canal capacity

The divertible quantity in each 10 daily period / month is worked out from the daily simulation at Pattanadahalla weir using net surplus flows. These details are furnished in **Chapter 5: Hydrology and water resources.** The discharge is worked out as 22.33 cumec (designed). On similar lines, divertible quantity in each 10 daily period / month is worked out from the daily simulation at Shalamalahalla weir and Suremane barrage considering net

surplus flows. The discharge at the weir is worked out as 60.50 cumec (designed) and the same from the barrage is worked out to 76.40 cumec. Accordingly, pumps, raising mains, tunnels and canals are designed to carry the same up to Varada river. Details are given in **Annexures 6.1.2, 6.2.2, 6.2.3, 6.3.8 to 6.3.10.**

The designed discharge at off-take of different reaches is given in **Table: 6.4.**

Table 6.4: Carrying capacity at off-take of the three reaches

Sl. No	Reservoir	FSL (m)	Capacity (cumec)
	Link I		
1	Pattanadahalla	499.00	22.33
2	Shalamalahalla	468.00	60.50
	Link II		
3	Suremane	420.00	76.40

6.5.3 Design of canal

The canal has been designed as a trapezoidal section with rounded corners as per provisions of IS Code: 10430 - 2000. Normally, the FSD and bed width have been kept constant in a particular reach. The canal section is designed using Manning's formula. Side slopes of 1.5:1 (H: V) in normal cutting and 0.5: 1 in hard rock portion (deep cut) have been assumed for design of canal sections.

Hydraulic parameters:

Area of Cross section (A) $= bd+d^2 (\theta + \cot \theta)$ - for normal cut (considering r=d)

$=bd+d^2 (\theta/2 + \cot \theta + \text{cosec } \theta)$ - for deep cut

(Considering r=d)

Wetted perimeter (P) $= b + 2d(\theta + \cot\theta)$ - for normal cut

$= b + d(\theta + \cot\theta + \text{cosec}\,\theta)$ - for deep cut

Manning's formula (V) $= (1/n) R^{2/3} S^{1/2}$

Rugosity coefficient = 0.018

Bed slope = 1:10000

Side slope = 1.5 H:1 V (normal cut)

= 0.5 H:1V (deep cut)

Where b= bed width

d= depth of water

θ= Angle of side slope

V=Velocity in m/sec

n=Rugosity coefficient

S=Bed slope &

R=Hydraulic mean depth (A/P)

The hydraulic particulars of link are given in the **Table 6.5.**

Table 6.5

Hydraulic particulars of canal at various reaches

Reach (km)		**Design discharge**	**Bed width**	**FSD (m)**	**Area (Sq.m)**	**Wetted perimeter**	**Velocity (m/sec)**	**Actual discharge**
From	To							

		(cumec)	(m)			(m)		(cumec)
(Interconnecting system between PH &SH)								
0.00	0.1	22.33	7.10	2.75	27.70	14.60	0.85	23.5
6.60	6.90	22.33	7.10	2.75	27.7	14.60	0.85	23.5
Shalamalahalla to Varada								
16.85	18.58	60.50	11.00	3.75	56.50	21.20	1.07	60.50
Suremane to Dharma								
22.30	22.65	76.40	9.50	4.00	71.42	26.21	1.08	77.41

Plain cement concrete (M 15) lining is proposed throughout the length of the link project. Typical canal sections at different normal, deep cutting and embankment reaches of main canal are shown at **Plate 6.4.** Typical details of canal lining and drainage arrangements are presented in **Plate 6.5.1 & 6.5.2.**

6.5.4 Tunnels

There are three tunnels proposed in the link system.

(i) Between Pattanadahalla to Shalamalahalla (6.5 km)

(ii) Between Shalamalahalla to Varada river (6.7 km) &

(iii) Between Suremane to Dharma river (4.23 km)

The tunnels are designed as modified horseshoe type, free flow in nature and concrete lined. The alignment of the tunnels has been finalized on the basis of strip contour maps and depth of cutting involved.

The slope is considered as 1 in 3000 in case of the tunnel between Pattanadahalla & Shalamalahalla and 1 in 4000 in the tunnels for crossing the

ridge between Bedti basin and Tungabhadra sub-basin. The value of Manning's coefficient adopted is 0.014 for all the tunnels.

The tunnels are provided with plain cement concrete lining of M25 grade concrete for ensuring smooth surface for conveyance of envisaged discharge. The lining shall be of RCC at junctions with shafts, very poor rock strata and any other specified reaches as would be identified during construction. The lining has been designed to resist the external and internal water pressure. The entire rock load is assumed to be carried by the rock support system consisting of rock bolts, steel fibre reinforced shotcrete (SFRS) and steel ribs.

The rock support system may need appropriate modifications depending upon the actual rock mass encountered. Also, the design of rock support system is not meant for shear zones, weak zones, cavities and very low cover zones of the tunnel and the design in these zones requires special consideration. Further, the design of the tunnel is valid for full face excavation of tunneling with conventional drill and blast method (DBM).

A typical scheme of contact and consolidation grouting has been proposed. The contact grouting in the tunnels is proposed to fully pack up the space between the concrete lining and the rock surface caused by shrinkage of concrete lining. The consolidation grouting is proposed to fill up the joints and discontinuity in the rock up to a desired depth.

The following assumptions have been considered for the hydraulic design of the tunnels:

a. The minor losses occurring in the tunnel e.g., entrance losses, trash rack loss, transition loss, exit loss; bend losses etc. are of negligible amount in comparison to the friction losses occurring in the tunnels and therefore are not taken into consideration.

b. The flow through the tunnel is free flow and is driven by the head difference between the upper and lower FSL.

c. The maximum velocity in circular tunnels occurs when the depth of flow is 0.94 times of diameter and considered as such in the tunnel designs.

d. The tunnel lining (PCC M25) is considered as 6 cm per m dia. of tunnel.

(i) Tunnel between Pattanadahalla & Shalamalahalla at RD 0.1 km to 6.60 km

The designed discharge of the tunnel of 4.5 m dia is 22.33 cumec. The length of tunnel is 6.5 km with a slope of 1 in 3000. The tunnel is provided with 250 mm thick PCC lining of M25 grade concrete. The hydraulic design of tunnel and support system are furnished at **Annexure: 6.1.2.** The contact and consolidation grouting shall be carried out as per the provisions of BIS-5878(Part-VII) 1972.

(ii) Tunnel between Shalamalahalla to Varada river RD 10.15 km to 16.85 km

The designed discharge of the 6.70 m dia. tunnel is 60.50 cumec. The length of tunnel is 6.7 km with a slope of 1 in 4000. The tunnel is provided with 250 mm thick PCC lining of M25 grade concrete. The hydraulic design of tunnel and support system are furnished at **Annexure: 6.2.3.** The contact and consolidation grouting shall be carried out as per the provisions of BIS-5878 (Part-VII) 1972.

(iii) Tunnel between Suremane to Dharma river RD 22.65km to 26.88km

The designed discharge of the 7.30 m dia tunnel is 76.40 cumec. The length of tunnel is 4.23 km with a slope of 1 in 4000. The link tunnel is provided with 250 mm thick PCC lining of M25 grade concrete for ensuring smooth surface for conveyance of envisaged discharge. The hydraulic design of tunnel and support system are furnished at **Annexure: 6.3.10.** The contact grouting and consolidating grouting shall be carried out as per the provisions of BIS-5878(Part-VII) 1972. The typical diagrams of the tunnels illustrating entry & exit portals, tunnel support system and grouting details are given in **Plates 6.6.1 & 6.6.2.**

6.5.5 Lifting arrangements

In **Link-I**, the 10.15 km raising main takes off from Shalamalahalla weir with an impeller level of pump of 464.00 m and falls into the canal leading to tributary of Varada through the tunnel with an FSL of about 568.267 m. The lifting arrangements are provided in single stage based on the topographical conditions, keeping in view the elevation of Varada river. In all, 10pumps have

been provided including one standby. The static head of the pump houses is 107.5 m. The canal capacity at the offtake is 60.50 cumec.

In **Link-II,** the 10.9 km raising main takes off from Suremane barrage with an impeller level of pump of 420.00 m in Stage-I pumping by 120 m at RD 0.00 km followed by 11.4 km raising main taking off at RD 10.90 km in Stage-II pumping by 65.5 m with an impeller level of pump of 535.00 m. The lifted water are further carried through an approach canal of 0.35 km and a tunnel of 4.23 km to fall into a tributary of Dharma river. The lifting arrangements are provided in two stages and tunnel based on the topographical conditions, keeping in view the elevation of Dharma river. In all, 13 pumps have been provided including one standby. The static head at the pump houses is (120+65.5=185.5) m. The capacity at the offtake is 76.40 cumec.

Assumptions as per guidelines are as follows:

Surface pumphouses have been proposed to house number of vertical shaft single stage radial flow pumps. The structure comprises of RCC columns and beams designed to carry the loads coming from various electro-mechanical equipment. A steel roof truss has been provided at top of the pump house. The location of surface pump house has been selected by studying the ground profile from toposheets/field surveys. However, the location of pump house, type of pumps, electrical and mechanical equipments will be studied in detail during the pre-construction stage. The preliminary details of pumping components are given below:

Sump/ intake well:

A suitable forebay with a sump well is provided with RCC retaining walls to retain the earth pressure. The retaining walls proposed are of RCC cantilever type. The width of the sump is taken at 1 to 1.5 times the dia. of the bellmouth. Plain cement concrete of mix M10 1:4:8 of about 0.2 m thick is proposed for the floor of the bed.

Pumps

It is proposed to install concrete volute pumps with a capacity of 6.75 cumec in Link – I while 6.50 cumec in Link - II for the pump houses. The concrete volute pumps are considered for the following reasons:

(i) Casing and suction draft tube is cast in-situ concrete.

(ii) The rotating parts are metallic.

(iii) Simple mechanical design.

(iv) Pumps are expected to run continuously for prolonged times.

(v) Concrete volute pump guarantees strength and rigidity and virtually eliminates the problems of corrosion and erosion.

(vi) Higher & consistent pump efficiencies over a sustained period of operation.

(vii) As the size of the pump increases, the dimension and weights of the heaviest parts have a large influence on the choice of construction material used. Concrete is, therefore, the natural choice for the pump body.

(viii) Mass casing in concrete provides excellent inertia, anti seismic construction & simple preventive maintenance on yearly schedule.

(ix) Main pump parts can be checked in-situ and without pump dewatering.

(x) Few moving and metallic parts in contact with water.

(xi) Perfect hydraulic design of draft tube and volute eliminates vortices and risks of concrete deterioration and low submergence required.

(xii) Lower crane height & lifting capacity requirement.

(xiii) Easy internal inspection without dismantling. Impeller can be examined from suction elbow and rotor from manhole.

(xiv) Overall expenditure for the complete pumping system is substantially lower.

(xv) No pump casing, therefore total weight of removable components is a small fraction of that of conventional units.

(xvi) No anchoring necessary.

(xvii) Low maintenance equipment and less manpower required. Fewer spare parts to be kept handy

(xviii) Simple to construct volute and draft tube and can be carried out by civil construction company at site.

Electro-mechanical equipment

The electro mechanical components consist of pump turbine, motor, cooling system, transformer connections, inlet valve, surge protection & neutral earthing system, supervisory control and data acquisition system, pipe valves, main step-up transformer, switchyard equipment, control & protection equipment, auxiliary mechanical services, EOT crane for pump house,

electrical lifts and elevators, workshop equipment, test laboratory, telemetry, ventilation & air conditioning, fire protection, auxiliary electrical services etc.

Delivery main

The mild steel raising mains of 2.75 m dia are provided. Hazen Williams equation $V = K\ C\ (D/4)^{0.63}\ S^{0.54}$ has been considered to work out the frictional loss of the pipe, where K is unit conversion factor (0.85),C is Hazen William co- efficient (145), D is dia. of pipe and S is head loss/ length of pipe. The thickness of pipe to withstand the pressure is computed considering 50 % above the working pressure. Extra thickness of 1 to 3 mm for corrosion is also considered. As epoxy painting is considered inside and outside the pipe, the provision for corrosion is limited to 1 mm.

The velocity in the pipes is almost limited to less than 2.5 m/sec. The PCC for bedding and RCC of about 1 m thick surrounding the pipe is also provided for anchoring and supporting the pipeline. The provision for expansion joint, pressure relief valves, air relief valves and water draining arrangement is also provided.

Delivery cistern

The raising main from the pump house is let to fall in the delivery cistern. The raising main is kept in such a way that it is at least one metre above the delivery cistern pond level so that the water from the cistern is not entered into the pipeline. The delivery cistern is of rectangular size with transition to connect with the tunnel/canal. The delivery cistern is provided with RCC retaining walls of suitable size to retain the earth pressure. In case

the cistern is in hard rock strata, a RCC wall of 0.3 m uniform thickness is anchored with the sides. Plain cement concrete of mix M10 1:4:8 of about 0.2 m thick is proposed for the floor of the bed.

The design of lifting arrangements is given in **Annexure 6.2.2, 6.3.8 & 6.3.9.**The salient features of the lifting arrangements are furnished in **Table 6.6.**

Table 6.6

Salient features of lifting arrangements on the main canal

Sl. No	**Description**	**Location of pump house**	
		Shalamalahalla (Link-I)	**Suremane (Link-II)**
1	NSL (m)	472.50	435.00
2	FSL (m)	468.0	426.00
3	Discharge (cumec)	60.5	76.4
4	Static head (m)	107.50	185.50 (120+65.5)
5	Pump capacity (cumec)	6.75	6.50
6	No. of pumps	9+1	12+1
7	Suction pipe dia (m)	1.80	1.80
8	Delivery pipe dia (m)	2.75	2.75
9	Power required (MW)	122	266.5
10	Energy required (MU)	137.9	181.3
11	**Delivery cistern**		
(i)	Length (m)	27.50	27.50
(ii)	Width (m)	25.00	33.00
(iii)	Depth (m)	3.25	3.20

6.5.6 Description of soil profile along the link alignment

No soil samples are collected along the link canal alignment. General description of the soils in the project area is furnished in **Chapter-2: Physical Features.**

6.5.7 Evaluation of design parameters

Detailed Geotechnical investigations will be taken at preconstruction stage for evaluating the various design parameters

6.5.8 Transmission losses

The transmission losses in the canal occur in the form of seepage through the canal lining and evaporation from the surface of water. 0.6 cumec per million square meter of wetted area is to be considered as transmission loss along the canal as per BIS code IS: 10430-1982. However, since the canal is lined and length is only 2.48 km in the entire alignment, both Link-I &II, no transmission losses are considered.

6.6 Canal structures

6.6.1 Cross drainage/cross masonry works / regulators

No CD/CM works are proposed since the length of open channel is insignificant. The conveyance is a combination of lifting through raising mains, tunnels and canals of only small lengths. Raising mains will be laid based on the actual ground profile obtained by field surveys at preconstruction stage. Wherever the raising main crosses the road, it will be taken below the road level. In case of streams, either it will be passed over or below raising main as per the site conditions with suitable protection. However, based on the toposheets, a brief description of no of roads/stream crossings is given below.

In **Link-I,** the reach from Pattanadahalla to Shalamalahalla is mostly tunnel except approach channel of 0.1 km up to tunnel entry and 0.3 km of canal after tunnel exit to lead the water through natural stream to Shalamalahalla. In the reach from Shalamalahalla to Varada 10.15 km of raising main will cross 1 no. state highway, 1no.village road and 10 nos. streams/nallas. In the last reach of 1.73 km of open canal, the alignment will cross 2 no. streams/nallas. Similarly in **Link-II,** the 22.3 km long raising main aligned along the existing state highway between Sirsi & Yellapur will cross 4 nos of state highways, 2 nos. village roads and 6 no's streams/nallas as per topo map study. The design for CD/CM structures, if required, will be taken up at preconstruction stage based on detailed topographical surveys.

6.6.2 Layout and foundation

Detailed laboratory tests for finding the suitability of soils for foundations of cross-drainage works have not been carried out. However, if required it will be taken at pre-construction stage.

6.6.3 Cross drainage works

The type of cross drainage structure to be provided depends on the physical features of the stream crossed such as position of bed level of stream in relation to canal bed level. However, in view of the link alignment being proposed mostly through raising mains & tunnels (with very short lengths of canals), no cross-drainage works i.e., aqueduct/super passage/canal syphon, syphon aqueduct/under tunnel are required to be provided as explained in para 6.6.1.

a) Flood estimation of various streams

Since the alignment is not crossing any major rivers, flood estimation is not carried out.

6.6.4 Bridges

The project area is well developed as far as communications are concerned. There are no. of roadways encountered by the link alignment. Since the alignment is mostly either tunnel or raising main, in tunnel alignment the existing roads will not be disturbed, while the raising main will be passed below roads or it will be crossed over by suitable supporting system based on the actual ground profile obtained by field surveys, during pre-construction stage. As of now, the raising main is proposed to cross all roads below road level. Hence, no bridges are proposed.

6.7 Integration of link canal with the existing Tungabhadra reservoir & TBLBC

The link system (Link – I & II) will be integrated with the Tungabhadra project and its existing canal network under TBLBC for optimum utilization of the created infrastructure and storage capacity.

6.8 Canal automation and branch canals

The canal automation technology being adopted for the contemporary projects considering technological updation, will be adopted for the link project as well.

6.9 Instrumentation

The requirement of special instruments for the construction of barrage, tunnels and pump houses shall be assessed during the pre-construction stage.

6.10 Other studies

The DPR has been prepared using DEM/SOI topo sheets data. The other studies, required if any, which are not covered in the DPR will be carried out at pre-construction stage.