Chapter 12
ConstructionProgram, Manpower Deployment and Plant Planning

12.0 General

The construction of Bedti - Varada link project (Link I& Link II) is proposed to be completed in 5 years. This chapter describes the construction methodology and equipment planning for construction of the main components under Bedti-Varada link project. The construction methodology for major components has been described under the relevant sub sections of this chapter. The type and sizes of the equipment to be used have also been indicated while describing the construction methodology. The number of machines required for construction of each major component of the project has been worked out and total requirement for each type and size of the major equipment has been arrived at after preparing the construction/ deployment schedule for main components of the project. In case, the work is executed through award of contract, the contractors in all probability may suggest their own construction techniques and equipment for execution of the job based on equipment actually available with them. The tentative requirement of machines as worked out herein will help in the analysis of rates of works, cost estimation and in evaluating the reasonableness of the participating bidders' construction techniques and equipment, within the overall construction schedule and cost estimate.

12.1 Objective of the project

The aim of the Bedti - Varadalink project is to divert of 524 MCM of west flowing Bedti river to Raichur districtunder Tungabhadra L.B.C command benefitting about 104900ha.

12.2 Main project components

The project envisages construction of the following components:

Link - I: Bedti - Varada link

1. A 145 m long concrete weir across Pattanadahallastream, a tributary of Sonda river which further joins Bedti river, with FPL 499.00 m, MWL 501.00 m and corresponding gross storage capacity 0.54MCM.
2. A 202m long concrete weir across river Shalamalahalla, a tributary of Sonda,with FPL 468.00 m, MWL 470.50 m and corresponding gross storage capacity 4.32 MCM.
3. Interconnecting conveyance system taking off from the proposed Pattanadahalla weir with a designed discharge capacity of 22.33 m^3/s consisting of 0.10 km long approach channel up to the tunnel entry, 6.5 km long tunnel & a 0.3 km long canal after the tunnel exit which will outfall into the stream leading to Shalamalahalla weir.
4. A jackwell cum pump house on the u/s right bank of Shalamalahalla weir with suitable forebay.
5. Lifting arrangements to a height of 107.5 m (static) in single stage through raising main.
6. Conveyance system taking off from the proposed jackwell cum pump house with a designed discharge capacity of 60.50 m^3/s consisting of 10.15 km long raising main, 6.7 km long tunnel & 1.73 km long canal which will outfall into stream leading to Varada river.

Link-2: Bedti - Dharma link

1. A165 m long concrete barrage across Bedtiriver near Suremanevillagewith FPL 426.00 m, MWL 429.44 m and corresponding gross storage capacity 2.71 MCM.

2. A jackwell cum pump house on theu/s left bank of the barrage withsuitable forebay.
3. Lifting arrangements to a height of 185.5 m (static) in two stages through raising main.
4. Conveyance system taking offfrom the proposed jackwell cum pump house with a designed discharge capacity of 76.40 m^3/sconsisting of 22.3 km long raising main, 0.35 km long delivery chamber cum approach channel &4.23 km long tunnel which will outfall into the stream leading to Dharma river/reservoir.

12.3 Basis for the study

12.3.1 General

Construction of Bedti-Varadalink project has been planned with due consideration of the construction schedule, the compatibility of the construction equipment to site conditions, the quantities and utilization factor of the equipment within the scheduled construction period. Number of machines required for construction of each component of the project has been worked out and the total requirement for each type and size of machine for the project has been arrived at after drawing up the construction/deployment schedule for the main components of the project.

Mechanized construction has been planned for almost all types of construction jobs to achieve consistent quality at a faster rate and also to minimize the requirement of skilled manpower.Moreover, very high degree of quality standards are required to be maintained as underground works are normally not available for regular maintenance after the completion of construction.Sequencing of construction activities, wherever possible, has been attempted in such a way that equipment from one activity, on its completion can be moved to the other. Thus, the total requirement of

equipment at a time would be reduced and also, sufficient utilization of equipment on the project would be ensured.

12.3.2 Construction material sources

Locations of different quarries for construction material with respect to the project location have been described in the **Chapter4: "Surveys& Investigations".**

The proposed weirs are planned to be constructed with concrete.Construction material for concrete, viz. sand/fine aggregate, rock/coarse aggregate, for both non-wearing and wearing surfaces are also located in the vicinity of project site. The averagedistance of the quarries from the project site willbe around 70km.

Total concrete requirement of different grades for the main components of the project has been estimated to be approximately 245727.05 m^3. The area for disposal of excavated material has been considered at an average distance of 30 km from the project site for equipment planning purpose. The abstract of quantities involved for excavation and concreting of various components of the link project is shown in **Annexure: 12.1**.

12.3.3 Basic considerations

Based on the past experience and other projects in the region, about 8 working months in a year are considered to be available in the area where the project is situated. However, all the under-ground works like tunnels can be constructed throughout the year.All the surface works are proposed to be executed intwo shifts and duringworking months.Thetunnellingworks are proposed to be executed in three-shift operation throughout the year.

12.3.3.1 Scheduled working hours

Equipment planning for calculating requirement of equipment is carried out based on the number of working days available, which further depends upon climatic conditions of the project area. In the present scenario, the monsoon sets in during June and continues till October in the project area. For equipment planning purpose the monsoon season has been considered from 15th June to 15th October. Thus, for surface/ over ground works i.e. weir and appurtenant works, a working season of eight months (200 working days) would be available in a year. The tunnelling works are generally not affected by the vagaries of weather and thus, the work has been planned to continue throughout the year. However, since the production capability would be affected during monsoon months especially for the supplies/ services and muck disposal, etc., suitable reduction in the progress has been considered for the year as a whole. The scheduled working hours in a year with 200 working days dulyconsidering 25 working days per month as per guidelines for preparation of DPR of Irrigation and Multipurpose projects -2010 are given in **Table 12.1.**

Table – 12.1
Schedule working hours

Type of work/ shift	Surface/over ground works (hour)	Tunnelling/underground works (hour)
Singleshift work/ day	8x25x6 = 1200	12x25x20= 6000
Two shifts work/ day	8x25x10= 2000	
Three shifts work/ day	8x25x12.5 = 2500	

Two shifts working of equipment is normally considered most economical in view of the high cost of three shifts working on account of low availability of equipment and higher stand-by equipment requirement. Thus, planning for all surface/over groundworks has been carried out based

on two shifts per day working. Tunneling/underground works are planned for three shifts working as these involve cyclic operations, which do not follow normal shift operation.Provision of standby equipment has been considered as follows:

i.	Single shift working	10%
ii.	Two shifts working	20%
iii.	Three shifts working	30%

12.3.3.2 Construction program

A total period of fiveyears has been considered for completion of the project. The additional surveys, design studies, laboratory tests and construction of approach roads etc. are proposed to be taken up during the first two years. Land acquisition, procurement of machinery and T&P are proposed to be taken-up from the first year itself and can be completed by the end of second year. Construction of colonies, approach roads and laying of electric lines for the same shall also be commenced from first year onwards and will be completed by the end of second year. Execution of head works will be started with excavation from the second year and would be completed by the end of third year. Excavation of canal will commence from second year and to be completed by 4th year (including lining). Execution of tunnels is programmed to start from second year and would be completed in the fourth year. Laying of pipelines is programmed to start from second year and would be completed in the fourth year.Erection and commissioning of electrical and mechanical equipment will start from the third year and would be carried till the last fifth year.It is proposed to divide the entire length of the link canal into number of segments and take up the work in all the segments simultaneously so that the total work can be completed within the planned time period.

The detailed construction schedule for the project (Link I and Link II) in the form of bar chartsare attached in **Annexures: 12.2.1 and 12.2.2**.

12.4 Construction methodology and equipment planning

The construction methodology and equipment planning along with construction programme for different components of the project have been described in the succeeding sub-sections:

12.4.1 River diversion works

No formal diversion arrangement has been proposed for the construction of the weirs / barrage. The diversion arrangement during the project construction will be evolved depending upon the requirement. As sufficient width is available, the flow only needs to be channelized through diversion channels which can be decided at construction stage. Also, the sluices proposed atSuremanebarrage can be used for diversion during the construction stage.

12.4.2 Weir / barrage components:

Main activities to be undertaken for construction of weirs / barrage are surface excavation and concreting. Surface excavation will comprise of commonexcavation in overburden and rock excavation.Thetotal quantity of excavationand total quantity of concreting involved is given under the respective components.

(i) Surface / hard rock excavation:

The surface excavation has been planned to be completed within 2 months for common excavation and 8 months for hard rock excavation. The surface excavation for main weirs / barrage involves both common and rock

excavations. The excavated material will be transported to the disposal area using rear dumpers.

The construction methods / equipment for surface / hard rock excavation of main weirs / barrage are as under:

- Excavation of the soft material (common excavation) by 2.0 m^3 hydraulic excavators.
- Spreading the excavated material at disposal site in layers up to 20 cm thick by 275 HP dozers.
- Compaction by 12 passes of 10 T double drum sheep foot roller.
- For rock excavation requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter and 120 cfm capacity.
- Loading of blasted rock by2.3 m^3 front end loader and transportation by 4.5 m^3tippers.
- Transportation to the disposal areas/main weir by 31.75 T rear dumpers.
- Air compressors of 250 / 500 cfm capacity for catering the jack hammers.

(ii) Concreting:

A period of 3.5 working seasons has been planned for the placement of concrete. The concrete required for weirs / barrage is proposed to be produced in a centralized batching and mixing plant ofcapacity 46.25 m^3/hr. The plant shall be located in the vicinity of the weir. The concrete from the plant will be transported with the help of transit mixers of 10m^3 capacity.

Following construction equipment have been considered for concreting of weirs / barrage and appurtenant structures:

- Transportation by transit mixers of 10 m^3 capacity.
- Batching and mixing plant of capacity 46.25 m^3/hr to be located preferably within a radius of 1 km from the concrete weir.

(iii) Construction programme

The sequence of construction of concrete weirs / barragetakes into account the following aspects:

- Surface excavation of concrete weirs / barrage to start during the 1st quarter of the second year.
- The total quantity of excavation to be completed by the end of 3rd quarter of second year for surface excavation and 1st quarter of 3rd year for hard rock excavation.
- Concreting to start in the 2nd quarter of second year and will continue for 1.5 working seasons. The work is expected to be completed by the end of the 3rd quarter of 3rd year.
- Gate installation work in Suremane barrage to start in the beginning of 3rd quarter of 2nd year and will be completed by the end of 4th quarter of 3rd year.

12.4.2.1 Pattanadahalla weir:

The estimated total quantity of weir excavation is about 15198m^3, and total quantity of concreting is about 17407 m^3. Details are indicated in **Table – 12.2**.

Table – 12.2
Quantities involved in construction of Pattanadahallaweir

Unit: m^3

Description of work	Type / material	Quantity,in-situ
Excavation		
	Common soil	1519.8
	Weathered rock	3039.6
	Hard rock	10638.6
	Total excavation	15198.0
Concreting		
	Conventionalconcrete	17406.6

(i) Surface / hard rockexcavation

The hourly quantity of excavation estimated is given in**Table 12.3**.

Table – 12.3
Estimation of hourly quantity of excavation

Type / Description	Common excavation	Rockexcavation
Total volume (m^3)	3040	12158
Time period (months)	1.6	6.4
Shift proposed	2	2
Total operational hours (hour)	400	1600
Work loadto be handled (m^3/hour)	8	8
Peak workload(m^3/hour)	11	11

(ii) Concreting

For concreting of weir and appurtenant structures, total quantity of the order of17407 m^3, will have to be placed.For concreting at surfaces of weir, the placement is considered at9.14m^3/hr.

12.4.2.2 Shalamalahalla weir:

The total quantity of weir excavation is about 25061m^3, and total quantity of concreting is about 24990 m^3. Details are indicated in **Table – 12.4**.

Table – 12.4
Quantities involved in construction of Shalamalahalla weir

Unit: m^3

Description of work	Type / material	Quantity,in-situ
Excavation		
	Common soil	2506.13
	Weathered rock	5012.25
	Hard rock	17542.88
	Total excavation	25061.26
Concreting		
	Concrete	24990.15

(i) Surface/hard rock excavation

The hourly quantity of excavation is given in**Table – 12.5**.

Table – 12.5

Estimation of hourly quantity of excavation

Type / Description	Common excavation	Rockexcavation
Total volume (m^3)	5012	20049
Time period (months)	1.6	6.6
Shift proposed	2	2
Total operational hours (hr)	400	1650
Work loadto be handled (m^3/hr)	13	12
Peak workload(m^3/hour)	19	18

(ii) Concreting

For concreting of main weir and appurtenant structures, total quantity of the order of 24990 m^3, will have to be placed. For concreting at surfaces of weir, the placement is considered at 13.13m^3/hr.

12.4.2.3 Suremanebarrage

The total quantity of Suremane barrageexcavation is about 1160784 m^3, and total quantity of concreting is about 47665m^3. Details are indicated in **Table – 12.6**.

Table – 12.6

Quantities involved in construction of Suremane barrage

Unit: m^3

Description of work	Type / material	Quantity,in-situ
Excavation		
	Common soil	116078.4
	Weathered rock	232156.8
	Hard rock	812548.8
	Total excavation	1160784.0
Concreting		
	Concrete	47664.82

(i) Surface/hard rockexcavation

The hourly quantity of excavation is given in**Table – 12.7**.

Table – 12.7

Estimation of hourly quantity of excavation

Unit: m^3

Type / Description	Common excavation	Rockexcavation
Total volume (m^3)	232157	928627
Time period (months)	1.6	4.82
Shift proposed	2	2
Total operational hours (hr)	400	1205
Work loadto be handled (m^3/hr)	580	771
Peak workload (m^3/hr)	870	1156

(ii) Concreting

For concreting of barrage and appurtenant structures, total quantity of the order of 47664.82 m^3, will have to be placed. For concreting at surfaces of barrage, the placement is considered at 25m^3/hr.

12.4.2.4 Major construction plant and equipment for weirs / barrage

The types of major construction plant and equipment required for construction of the weirs / barrage are listed in **Table – 12.8**.

Table –12.8

Major plant and equipment for construction of weirs / barrage

S. No.	Equipments	Size/capacity
1	Hydraulic excavator	2.0 m^3
2	Crawler dozer	275 HP
3	Front end loader	2.3 m^3
4	Double drum sheep foot roller	10 T
5	Air compressors	250 cfm
6	Air compressors	500 cfm
7	Jack hammer	120 cfm
8	Rear dumper	31.75 T
9	Tippers	4.5 m^3
10	Batching & mixing plant	46.25 m^3/hr
11	Transit mixers	10 m^3

12.4.3 Pumping components:

12.4.3.1 Shalamalahallaweir to Varada river (Link –I)

(i) Excavation and concreting

The work component involves construction of sump, pump house and delivery pipe & rising main. The main activities to be undertaken for construction of pumping component are surface excavation, concreting and laying pipes along with erection of electro-mechanical equipment. The quantities involved in the pump house complex are indicated in **Table – 12.9**.

Table – 12.9
Quantities of excavation in pump house complex at Shalamalahalla weir

Unit:m^3

Description of Work	Type / material	Quantity,in-situ
Excavation		
	Common soil	2726
	Weathered rock	10651
	Hard rock	10424
	Total excavation	23801
Concreting		
	Concrete	12910

The sequence of operations for pump house complex has been kept same as proposed for the weirs / barrage.

- Excavation of the soft material (common excavation) by 2.0 m^3 hydraulic excavators.
- Spreading the excavated material at disposal site in layers up to 20 cm thick by 275 HP dozers.
- Compaction by 12 passes of 10 T double drum sheep foot roller.
- For rock excavation requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter and 120 cfm capacity.
- Loading of blasted rock by 2.3 m^3 front end loader and transportation by 4.5 m^3tippers.

- Transportation to the disposal areas/main weir by 31.75 T rear dumpers.
- Air compressors of 250 / 500 cfm capacity for catering the jack hammers.
- Concrete transportation by transit mixers of 10 m^3 capacity.
- Batching and mixing plant of capacity 46.25 m^3/hr to be located preferably within a radius of 1 km from the concrete weir.

(ii) Major construction plant and equipment for pump house

No separate equipment for construction of pumphouse has been provided as equipment deployed for theweirshall be utilized for construction ofpump house.

(iii) Construction programme

Period of 12months has been planned for excavation which will start from the 1st quarter of 2ndyear. The construction of the concrete structures will begin by the 1stquarter of 3rd year starting from the structures of the erection area. Almost 18 months have been considered necessary to complete the pump house. All works including electro-mechanical works will be essentially completed before one month of completion of the project. Laying of rising main will begin in 1st quarterof 2ndyear and will be completed in all respect of installation of pipeline accessories by the endof 4th year and erection & commissioning by 4thquarter of 5th year.

12.4.3.2 Suremane barrage to Dharma river(Link-II) Stage-I& Stage-II

(i) Excavation and concreting

The work component involves construction of sump, pump house and delivery pipe & rising main. Two pump houses are proposed in this link. Main activities to be undertaken for construction of pump housecomplexes are surface excavation, concreting and laying of rising main along with erection of electro-mechanical equipment. The quantities involved in all twopump house complexes are indicated in **Table 12.10 .**

Table – 12.10
Quantities of excavations in pump house complex at Suremane barrage Stage-I& Stage-II

Unit: m^3

Description of work	Type / material	Quantity,in-situ
Excavation		
	Common soil	5628
	Weathered rock	19356
	Hard rock	27834
	Total excavation	52818
Concreting		
	Concrete	15426

The sequence of operations for pump house complex has been kept same as proposed for the weirs / barrage.

- Excavation of the soft material (common excavation) by 2.0 m^3 hydraulic excavators.
- Spreading the excavated material at disposal site in layers up to 20 cm thick by 275 HP dozers.
- Compaction by 12 passes of 10 T double drum sheep foot roller.
- For rock excavation requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter and 120 cfm capacity.

- Loading of blasted rock by 2.3 m^3 front end loader and transportation by 4.5 m^3tippers.
- Transportation to the disposal areas/main weir by 31.75 T rear dumpers.
- Air compressors of 250 / 500 cfm capacity for catering the jack hammers.
- Concrete transportation by transit mixers of 10 m^3 capacity.
- Batching and mixing plant of capacity 46.25 m^3/hr to be located preferably within a radius of 1 km from the concrete weir.

(ii) Major construction plant and equipment for pump house

No separate equipment for construction of pump house has been provided as equipment deployed for the barrage shall be utilized for construction of pump house.

(iii) Construction programme

The two pump houses activities are proposed to be taken up in parallel. A period of 8 months has been planned, which will start from the 3rdquarter of 2ndyear. The construction of the concrete structures will begin by the 1st quarter of 3rdyear. 18 months have been considered necessary to complete the pump house. All works including electro-mechanical works will be essentially completed before one month of completion of the project. Laying of rising main will begin in 1st quarter of 2ndyear and will be completed in all respect by the end of 4th year and erection & commissioning by 4thquarter of 5th year.

12.4.4 Tunnels

Three tunnels areproposed (i)tointerconnectPattanadahalla and Shalamalahalla weirs, (ii) to cross the ridge from Shalamalahalla weir to the

stream and (iii) to cross the ridge from Suremane to the stream. The tunnels are mainly proposed where deep cut reaches are encountered in the alignment. Therefore, the construction of tunnels involves excavation mainly in rock.The quantityinvolved in excavation and concreting ofthe tunnelsand entry & exit portal has been considered.

12.4.4.1 Pattanadahalla weir to Shalamalahalla

The tunnel from Pattanadahalla toShalamalahalla is 6.50 km long with 4.50 m dia. The quantity involved for the construction of major component of tunnels is given in **Table – 12.11**.

Table12.11
Quantities involved in construction of the tunnel from Pattanadahalla to Shalamalahalla weirs

Unit:m^3

Description of work	Type / material	Quantity,in-situ
Excavation		
	Common soil	305
	Weathered rock	855
	Hard rock	33841
	Tunnel muck	145288
	Total excavation	180289
Concreting		
	Concrete	39795

(i) Excavation of tunnel

Before taking up actual tunnel excavation, portal construction and slope stabilization would be required for which following construction sequence is suggested:

- Excavation of the soft material (common excavation) by 2.0 m^3 hydraulic excavators.

- Spreading the excavated material at disposal site in layers up to 20 cm thick by 275 HP dozers.
- Compaction by 12 passes of 10 T double drum sheep foot roller.
- For rock excavation requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter and 120 cfm capacity.
- Loading of blasted rock by 2.3 m^3 front end loader and transportation by 4.5 m^3tippers.
- Transportation to the disposal areas/main weir by 31.75 T rear dumpers.
- Air compressors of 250 / 500 cfm capacity for catering the jack hammers.
- Slope stabilization using shotcrete machine and anchoring by jack hammer/hydraulic drilling rig.
- Portal concreting by using portable concrete mixer with weigh batches.

The portal excavation and slope stabilization will be completed within 3 months from start of work. Once the same is completed, the excavation of inlet and outlet faces will start. In view of its size, tunnel is proposed to be excavated by full face drill and blast method. For a finish diameter of 4.5m, the minimum excavated diameter of the tunnel shall be 5.0 m to account for 500 mm thick concrete lining and shotcrete. Following construction method for the excavation of tunnel may be adopted.

- Drilling of charge holes by means of single boom hydraulic drill jumbo.
- Driving of each round variable according to the class of rock (approximate 3.5 m for Class I & II, 3.0 m for Class III and 2.5 m for Class IV and V).
- Number of holes per round (including those necessary for carrying out the smooth blasting along the peripheral surface) approximately 30-40.

- Charging operations of explosive to be executed by means of man basket and firing of the rounds using nonel detonators.
- Loading of the muck resulting from blasting by excavator.
- Transport of the muck to the spoil area by 15 T rear end dumpers.
- Shotcrete with the help of 30 m^3/hr capacity concrete pumps.
- Rock bolting using mechanized rock bolting rig.

With the above construction methods and equipment, it is possible to complete a cycle of operation within a period of 10.7 hours. Although the time of each activity within a cycle may vary according to class of rock encountered, the total cycle time for the pull planned as indicated above for different classes of rock will be of the same order. A typical cycle for Class III (pull of 3.00m)is given in **Table – 12.12** .

Table – 12.12
Typical cycle for Class III (Pull of 3.00m)

1	Preparation of job	0.5hr
2	Drilling of charge holes	2.2hr
3	Charging	1.0hr
4	Removal of Jumbo to safe position	0.5hr
5	Blasting and defuming	1.0hr
6	Mucking	2.0hr
7	Scaling	0.5hr
8	Shotcreting and rock bolting	3.0hr
	Total	10.7hr

In whole tunnel, it is assumed that 90% tunneling is in rock class of I, II & III (no –rock support system required) and 10 % tunneling is in rock class IV &V(require rock support system). As per the rock condition of tunnel and with above cycle time, an average sustainable progress of 140 m/month/face can be achieved.

Considering 2 face excavation, all the construction activities of tunnel would be planned and staged for optimum utilization of equipment for planned time period.

(ii) Concrete lining

Concrete lining is to be undertaken after the completion of excavation. Following sequence of operation will be followed for concrete lining.

- Concrete to be placed in three stages viz., kerb, overt, invert.
- Kerb concreting to be placed with the help of 20m form work.
- Installation of rails on kerb for movement of 10m travelling collapsible formwork for overt concreting.
- Pouring of concrete for Overt by 30m^3/hr capacity concrete pump.
- Transportation of concrete by 10 m^3 capacity transit mixers.
- Invert concreting with the help of screed board.
- Pouring of concrete for invert with similar equipment as deployed for overt.
- Batching &mixing plant at head works shall be utilized.
- Excavated material from tunnel excavation is to be utilized as aggregate after crushing & screening.In case material from quarries is to be obtained, tipper, 10 T payload capacity to be utilized for transportation and wheel loader, 1.0 m^3 for loading.

A typical cycle time for overt concreting is in **Table 12.13.**

Table 12.13
Estimated cycle time in overt concreting (10 m)

1	Erection time	16.00 hr
2	Pouring time	8.00 hr
3	Setting time	20.00 hr
4	Dismantling of formwork	4.00 hr
	Total	48.00 hrs

With 48 hr cycle time and two set of shutter form, a progress of 10 m per day or an average progress of about 200m/month/face at each face

can be achieved. Invert concreting is to be undertaken simultaneously with overt concreting with a time lag.

(iii) Construction programme

The sequence of construction of tunneltakes into account the following aspects:

- Open excavation for face and portal construction is to be started in the 1st quarter of 2nd year and wouldbe completed within three months.
- Tunnel excavation to start in 2ndquarter of 2nd year and is to be completedby the end of 3rdquarter of 3rdyear.
- Concrete lining of whole of tunnel to be taken up from all the face simultaneously. Lining to start in the 4th quarter of 3rd yearand to be completed by the end of 2ndquarter of 4th year.
- Contact/consolidation grouting of the tunnel to start simultaneously with the concreting and will finish in three months after concreting.
- Final cleaning of tunnel and other miscellaneous work will be completed in two months after consolidation grouting.

12.4.4.2 Shalamalahalla weirto Varadariver(Link-I)

The tunnel is 6.70 km long with 6.7 m dia.The quantity involved for the construction of major component of tunnels is given in **Table – 12.14**.

Table – 12.14
Quantities involved in the construction of tunnel from Shalamalahalla weir to Varada river

Unit: m^3

Description of work	Type / material	Quantity, in-situ
Excavation		
	Common soil	486
	Weathered rock	1274
	Hard rock	7788
	Tunnel muck	280530
	Total excavation	290078
Concreting		
	Concrete	50048

(i) Excavation of tunnel

Before taking up actual tunnel excavation, portal construction and slope stabilization would be required for which following construction sequence is suggested:

- Excavation of the soft material (common excavation) by 2.0 m^3 hydraulic excavators.
- Spreading the excavated material at disposal site in layers up to 20 cm thick by 275 HP dozers.
- Compaction by 12 passes of 10 T double drum sheep foot roller.
- For rock excavation requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter and 120 cfm capacity.
- Loading of blasted rock by 2.3 m^3 front end loader and transportation by 4.5 m^3tippers.
- Transportation to the disposal areas by 31.75 T rear dumpers.
- Air compressors of 250 / 500 cfm capacity for catering the jack hammers.
- Slope stabilization using shotcrete machine and anchoring by jack hammer/hydraulic drilling rig.

- Portal concreting by using portable concrete mixer with weigh batches.

The portal excavation and slope stabilization will be completed within 3 months from start of work. Once the same is completed, the excavation of inlet and outlet faces will start. In view of its size, tunnel is proposed to be excavated by full face drill and blast method. For a finish diameter of 6.7 m, the minimum excavated diameter of the tunnel shall be 7.2 m to account for 500 mm thick concrete lining and shotcrete. Following construction method for the excavation of tunnel may be adopted.

- Drilling of charge holes by means of single boom hydraulic drill jumbo.
- Driving of each round variable according to the Class of rock (approximate 3.5 m for Class I & II, 3.0 m for Class III and 2.5 m for rock Class IV and V).
- Number of holes per round (including those necessary for carrying out the smooth blasting along the peripheral surface) approximately 30-40.
- Charging operations of explosive to be executed by means of man basket and firing of the rounds using nonel detonators.
- Loading of the muck resulting from blasting, by excavator.
- Transport of the muck to the spoil area by 15 T rear end dumpers.
- Shotcrete with the help of 30 m^3/hr capacity concrete pumps.
- Rock bolting using mechanized rock bolting rig.

With the above construction methods and equipment, it is possible to complete a cycle of operation within a period of 10.7 hours. Although the time of each activity within a cycle may vary according to class of rock encountered, the total cycle time for the pull planned as indicated above for different classes of rock will be of the same order. A typical cycle for Class III (pull of 3.00m) is given in **Table 12.12**.

In whole tunnel, 90% tunneling is in rock class of I, II & III (no – rock support system required) and 10% tunneling is in rock class IV &V (require rock support system). As per the rock condition of tunnel and with above cycle time, an average sustainable progress of 140 m/month/face can be achieved.

Considering 2 face excavation, all the construction activities of tunnel would be planned and staged for optimum utilization of equipment for planned time period.

(ii) Concrete lining

Concrete lining is to be undertaken after the completion of excavation. Following sequence of operation will be followed for concrete lining.

- Concrete to be placed in three stages viz., kerb, overt, invert.
- Kerb concreting to be placed with the help of 20 m form work.
- Installation of rails on kerb for movement of 10 m travelling collapsible formwork for overt concreting.
- Pouring of concrete for Overt by 30 m^3/hr capacity concrete pump.
- Transportation of concrete by 4.5 m^3 capacity transit mixers.
- Invert concreting with the help of screed board.
- Pouring of concrete for invert with similar equipment as deployed for overt.
- Batching &mixing plant installed at head works shall be utilized.
- Excavated material from tunnel excavation is to be utilized as aggregate after crushing & screening.In case material from quarries is to be obtained, tipper, 10 T payload capacity to be utilized for transportation and wheel loader, 1.0 m^3 for loading.

A typical cycle time of 48.0 hrs required for overt concreting is furnished in **Table – 12.13**.With 48 hr. cycle time and two set of shutter form, a progress of 10 m per day or an average progress of about 200 m/month/face at each face can be achieved. Invert concreting is to be undertaken simultaneously with overt concreting with a time lag.

iii) Construction programme

The sequence of construction of tunnel takes into account the following aspects:

- Open excavation for face and portal construction is to be started in the 1st quarter of 2nd year and would be completed within three months.
- Tunnel excavation to start in 2ndquarter of 2nd year and is to be completedby the end of 3rd quarter of 3rd year.
- Concrete lining of whole of tunnel to be taken up from all the face simultaneously. Lining to start in the 4th quarter of 3rd year and to be completed by the end of2nd quarter of 4th year.
- Contact/consolidation grouting of the tunnel to start simultaneously with the concreting and will finish in three months after concreting.
- Final cleaning of tunnel and other miscellaneous work will be completed in two months after consolidation grouting.

12.4.4.3 Tunnel from Suremanebarrage to Dharma river (Link–II)

The tunnel is proposed for4.23 km with 7.3 m dia. The quantity involved for the construction of major componentsof the tunnel is given in **Table 12.15**.

Table 12.15
Quantities involved in the construction of tunnel from Suremane barrage to Dharma river

Unit: m^3

Description of work	Type / material	Quantity,in-situ
Excavation		
	Common soil	364
	Weathered rock	954
	Hard rock	5834
	Tunnel muck	210117
	Total excavation	217269
Concreting		
	Concrete	37486

(i) Excavation of tunnel

Before taking up actual tunnel excavation, portal construction and slope stabilization would be required for which following construction sequence is suggested:

- Excavation of the soft material (common excavation) by 2.0 m^3 hydraulic excavators.
- Spreading the excavated material at disposal site in layers up to 20 cm thick by 275 HP dozers.
- Compaction by 12 passes of 10 T double drum sheep foot roller.
- For rock excavation requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter and 120 cfm capacity.
- Loading of blasted rock by 2.3 m^3 front end loader and transportation by 4.5 m^3tippers.
- Transportation to the disposal areas by 31.75 T rear dumpers.
- Air compressors of 250 / 500 cfm capacity for catering the jack hammers.
- Slope stabilization using shotcrete machine and anchoring by jack hammer/hydraulic drilling rig.
- Portal concreting by using portable concrete mixer with weigh batches.

The portal excavation and slope stabilization will be completed within 3 months from start of work. Once the same is completed, the excavation of tunnel (from inlet and outlet faces) will start. For a finish diameter of 7.3m, the minimum excavated diameter of the tunnel shall be 7.80m to account for 500mm thick concrete lining and shotcrete.

Following construction method for the excavation of tunnel may be adopted:

- Drilling of charge holes by means of single boom hydraulic drill jumbo.
- Driving of each round variable according to the Class of rock (approx. 3.5 m for Class I & II, 3.0 m forClass III and 2.5 m forClass IV and V).
- Number of holes per round (including those necessary for carrying out the smooth blasting along the peripheral surface) approximately 30-40.
- Charging operations of explosive to be executed by means of man basket and firing of the rounds using noneldetonators.
- Loading of the muck resulting from blasting, by excavator.
- Transport of the muck to the spoil area by 15 T rear end dumpers.
- Shotcrete with the help of 30 m^3/hr capacity concrete pumps.
- Rock bolting using mechanized rock bolting rig.

With the above construction methods and equipment, it is possible to complete a cycle of operation within a period of 11.9 hours. Although the time of each activity within a cycle may vary according to class of rock encountered, the total cycle time for the pull planned as indicated above for different classes of rock will be of the same order. A typical cycle for Class III (pull of 3.00m) is given in **Table 12.16**.

Table 12.16
Typical cycle for class III (Pull of 3.00m)

1	Preparation of job	0.5 hr

2	Drilling of charge holes	3.3 hr
3	Charging	1.0 hr
4	Removal of Jumbo to safe position	0.5 hr
5	Blasting and defuming	1.0 hr
6	Mucking	2.1hr
7	Scaling	0.5 hr
8	Shotcreting and rock bolting	3.0 hr
	Total	11.9 hr

In entire tunnel, 99%tunnelling is in rock class of I, II & III (no – rock support system required) and 1% tunnelling is in rock class IV &V (require rock support system). As per the rock condition of tunnel and with above cycle time, an average sustainable progress of 125m/month/face can be achieved. Considering 2 face excavation, all the construction activities of tunnel would be planned and staged for optimum utilization of equipments for planned time period.

(ii) Concrete lining

Concretelining is to be undertaken after the completion of excavation. Following sequence of operation will be followed for concrete lining:

- Concrete to be placed in three stages viz., kerb, overt, invert.
- Kerb concreting to be placed with the help of 20m form work.
- Installation of rails on kerb for movement of 10m travelling collapsible formwork for overt concreting.
- Pouring of concrete for Overt by 30 m^3/hr capacity concrete pump.
- Transportation of concrete by 4.5 m^3 capacity transit mixers.
- Invert concreting with the help of screed board.

- Pouring of concrete for invert with similar equipment as deployed for overt.
- Preparation of concrete in a batching &mixing plant of 46.25 m^3/hr capacity installed near portal of each adit and outlet.
- Excavated material from tunnel excavation is to be utilized as aggregate after crushing & screening.In case material from quarries is to be obtained, tipper, 10 T payload capacity to be utilized for transportation and wheel loader, 1.0 m^3 for loading.

A typical cycle time for overt concreting is shown in **Table 12.13**.With 48 hr cycle time and two set of shutter form, a progress of 10 m per day or an average progress of about 200m/month/face at each face can be achieved. Invert concreting is to be undertaken simultaneously with overt concreting with a time lag.

(iii) Construction programme

The sequence of construction of tunneltakes into account the following aspects:

- Open excavation for face and portal construction is to be started in the 1st quarter of 2nd year and would be completed within three months.
- Tunnel excavation to start in 2ndquarter of 2nd year and is to be completedby the end of 3rd quarter of 3rd year.
- Concrete lining of whole of tunnel to be taken up from all the face simultaneously. Lining to start in the 4th quarter of 3rd year and to be completed by the end of2nd quarter of 4th year.
- Contact/consolidation grouting of the tunnel to start simultaneously with the concreting and will finish in three months after concreting.

- Final cleaning of tunnel and other miscellaneous work will be completed in two months after consolidation grouting.

12.5 Deployment schedule

Based on equipment planning and construction programme described in preceding sections, a construction schedule for whole of the project has been prepared in the form of bar charts and is placed at **Annexure: 12.2.1 & Annexure 12.2.2**. Keeping this construction schedule as one of the major criteria, a deployment schedule of major construction equipment that would be required for the project is arrived at after scheduling the equipment in such a way that minimum number of equipment, in general, would be needed. The basis for planning, indicating the type of equipment to be used, has already been dealt with in the respective sections and sub-sections corresponding to different items of the structures.As the deployment schedule may differ depending upon the number of executing agencies, the total number of equipment required will have to be reviewed at the time of project execution.

12.6 Total requirement of major construction equipment

A list of major construction equipment and plants, which would be required for construction of various components of the project is shown in **Annexure: 12.3**. However, the provision on this account will not be included in the sub-head Q - Special T&P of Cost Estimate since works are proposed to be executed by the contracting agencies.

12. 7 Manpower planning

12.7.1 Organisationset-up

The project will be implemented under an organisation set-up headed by a Chief Engineer stationed at Sirsi to look after all works, viz., head works, canal & tunnels, designs and electrical & mechanical works. Chief Engineer will be supported by five officers of the rank of Superintending Engineer and three officers of rank of Director. The three directors shall look after administration, finance and land acquisition issues pertaining to the project. Among the Superintending Engineers, one will coordinate with other organisations/departments, one will look after the designs of various project components and the remaining three will be heading the field formations of circles, one each for Link-I, Link-II and E & M works. The works will be executed under the overall supervision of three field Superintending Engineers. The Superintending Engineer (Electrical & Mechanical) will look after the electro-mechanical works of the pump houses and erection and commission of the weir/barrage components. Each circle will have two to three division offices which will be headed by the officers of the rank of Executive Engineersto assist Superintending Engineer. The offices of Chief Engineer, Superintending Engineer and Executive Engineer will be assisted by appropriate technical or non-technical subordinate officers and staff. All the offices are proposed to be located inSirsi and Yellapur taluks of Uttara Kannada district. The organisation chart for the project is appended as **Annexure: 12.4**.

12.8 General purpose equipment and inspection vehicles

In case the works are to be executed through award of contract, the general-purpose equipment for infrastructure works and inspection and transport vehicles which are required to be procured and used by the projectauthority for whichthe provision could be taken at 1 % cost of works.

12.9 Programme of year-wise expenditure

The total cost of the link project is estimated to be 2817.62 crore at 2020-2021 price level. The tentative distribution of the year-wise expenditure for construction of link project to complete the same within the proposed period of construction of 5 years in accordance with the proposed construction schedule is given in **Table 12.17**. The financial outlay is shown in **Annexure 12.5.**

Table12.17
Yearly phasing of expenditure
(Rs. Lakh)

Year	Link-I	Link-II	Combined
1st Year	4728	8233	12961
2nd Year	29014	57923	86937
3rd Year	24705	50824	75529
4th Year	23249	46804	70053
5th Year	12930	23352	36282
Total	**94626**	**187136**	**281762**