Chapter - 10

Construction program, manpower deployment and plant planning

10.0 General

This chapter describes the construction methodology and equipment planning for construction of the main components of the project. The construction methodology for each type of structure 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 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 analysis of rates of works, cost estimation and in evaluating the reasonableness of the participating bidders' construction techniques and equipment, within overall construction schedule and cost estimate.

10.1 Objective of the Project

The "Godavari (Janampet) – Cauvery (Grand Anicut)" link project is the first phase of the entire Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai-Gundar link system to divert surplus water available in Godavari basin from a proposed barrage at Janampet on Godavari river and transferring these waters upto Cauvery basin via Krishna and Pennar basins after meeting the requirements of the areas enroute, to the extent possible to serve the areas in Godavari, Krishna, Gundalakamma, streams between Gundlakamma and Pennar, Pennar, streams between Pennar and Palar, Palar, streams between Palar and Cauvery and Cauvery basin .

The proposed Godavari (Janampet) - Cauvery (Grand Anicut) link project envisages diversion of 7000 Mm^3 surplus water including the unutilized waters in Indravati sub-basin of Godavari basin. Nagarjunasagar and Somasila

reservoirs will be used as balancing reservoirs to transfer water to Pennar and Cauvery basins while meeting the enroute requirements in Telangana, Andhra Pradesh and Tamil Nadu.

The project area comprises three states: Telangana, Andhra Pradesh and Tamil Nadu. The link canal will bring additional areas in Telangana and Andhra Pradesh to an extent of 938152 ha annually (137150 ha in Telangana, 492281 ha in Andhra Pradesh and 308721 ha in Tamil Nadu) under irrigation utilising about 5608 Mm^3 besides providing 384 Mcum for drinking and 521 Mcum for industrial water supply. The link canal envisages serving the command areas lying in upper reaches through pumping and feeding storages/tanks, which could not possibly be served through conventional projects.

10.2 Main Components of the Link proposal (DPR stage)

1. Proposed Janampet barrage across river Godavari with FPL of 67 m on downstream of the confluence of Indravati with Godavari.

2. Existing reservoir at Nagarjunasagar with FRL of 179.83 m across river Krishna.

3. Existing reservoir at Somasila with FRL of 100.58 m across Pennar river.

4. Existing Grand Anicut across Cauvery river with FRL of 59.22 m.

5. Main canal of 1251.59 km from Janampet barrage across Godavari to Grand Anicut across Cauvery river

6. Five tunnels for a combined length of 21.87.km (i) 12.50 km long from RD 107.60 km to 120.10 km (ii) 1.27 km long from RD 343.58 km to 344.85 km (iii) 4 km long offtaking tunnel from Somasila (iv) one km long tunnel from RD 741.72 to 742.72 km & (v) 3.10 km long tunnel from RD 867.52 to 870.62 km

7. Lifting arrangements in three stages on main canal at RDs 10.0 km, 334.00 km and 337.0 km with total static head of 140m (each of 36 m, 52 m and 52 m) and subsidiary lift on NSLBC feeder branch at RD 105 km (30m).

8. Several cross drainage and cross masonry works across various streams and roads.

9. 29 branch canals and six under sluices at appropriate locations along the link the canal to provide project benefits.

10. A canal power house of 120 MW installed capacity at the take off from Nagarjunasagar reservoir.

11. Command area (CCA) of about 794733 ha of land with annual irrigation at 938152 ha .

12. Canal top solar power generation arrangement along the alignment

The total diversion of 7000 Mcum under the link system is planned to be utilized through the following three components /reaches judiciously considering the commitments, the need and the techno - economic viability.

1. Godavari (Janampet) - Krishna (Nagarjunasagar) link
2. Krishna (Nagarjunasagar) - Pennar (Somasila) link
3. Pennar (Somasila) - Palar - Cauvery (Grand Anicut) link

10.3 Construction Programme

The construction work of Godavari (Janampet) - Cauvery (Grand Anicut) link project is proposed to be completed in 5 years. It is proposed to complete all the preliminary works such as additional surveys, design studies, laboratory tests, and construction of approach road etc. in the first 2 years. The process of land acquisition and thereafter rehabilitation and resettlement, 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 and approach roads for the same and laying of electric lines shall also be commenced from first year onwards. Execution of head works are to start with excavation from the second year and would be completed by the end of fourth year. Excavation of main canal is to commence from second year and to be completed by 5th year. Construction of the cross drainage and cross masonry (CD and CM) works are also proposed to be taken up from second

year and to be completed by the end of fourth year. Execution of tunnel is programmed to start from second year and would be completed in the fourth year. Execution of pump houses on main canal are to commence from third year and will be completed by the end of fifth year. The construction of canal powerhouse is planned to start from fourth year and would be completed in the fifth year. Lining work of the main canal will be started in second year and the same will be completed by the end of fifth year. The proposed diversion to Nagarjunasagar reservoir will be started by the end of fifth year. The detailed construction schedule for the project in the form of a bar chart is attached as **Annexure-10.1**. The Constriction Schedule for the link project is shown in **Plate 10.1 to Plate 10.3**

10.4 Basis for Study

10.4.1 General

The methodology adopted for construction of "Godavari (Janampet) – Cauvery (Grand Anicut)" link Project takes into consideration the construction schedule, the compatibility of the construction equipment to site conditions and the quantities as well as the 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 as a whole 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 so as 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.

Sequencing of construction activities, wherever possible, has been attempted in such a way that equipment from one activity, on its completion can be shifted to the other. This way, the total requirement of equipment at a time would be reduced and also, optimum utilization of equipment on the project would be ensured.

10.5 Construction material sources

Location of different borrow areas and quarries for construction material with respect to the dam location have been described in the **Chapter - 4** on **"Surveys and Investigations".**

Suitable fill material would be adequately available for all CD/CM structures, intermediate storages, lifting arrangements etc. in the quarries identified along the link canal .

During construction, appropriate decision will be taken to select the borrow areas which meet the requisite specifications. 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 area for disposal of excavated material has been considered at an average distance of 1.0 km from the proposed canal & other structures for equipment planning purpose.

10.6 Basic considerations

Based on past experience, about 8 working months in a year are available in the area where the project is situated. Other projects in the region have also been planned with this consideration.

All the surface works are proposed to be executed in two shifts. All the underground works are proposed to be executed in three-shift operation throughout the year.

10.7 Scheduled working hours

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 over ground works i.e. construction of proposed pond at Janampet and appurtenant works a working season of eight months would be available. The underground works are generally not affected by the vagaries of weather and work has, thus, 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 taken into account for the year as a

whole. The scheduled working hours considering 25 working days per month, accordingly works out as under:

Type of Work/ Type of shift	**Over ground works (hour)**	**Underground works (hour)**
Single shift work/day	8x25x6 =1200	12x25x20=6000
Two shift work/day	8x25x11 =2200	
Three shift work/day	8x25x15 =3000	

Two shifts working of equipment is normally considered most economical in view of the high cost of three shift working on account of low availability of equipment and higher stand-by equipment requirement. Thus planning for all over ground works has been carried out based on two shifts per day working. Underground works in any case, are planned for 20 hours working as these involve cyclic operations, which do not follow normal shift operation.

Provision of stand by equipment has been considered as follows:

1. Single shift working 10%
2. Two shift working 20%
3. Three shift working 30%

10.7.1 Construction period

The Godavari (Janampet) - Cauvery (Grand Anicut) link project is planned to be constructed in a period of 5 years keeping in view the scheduled working hours and the weather conditions in the region. The manpower and plant planning is made accordingly.

10.8 Construction Methodology and Equipment Planning

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

Main activities to be undertaken for construction of the canal system are construction of proposed barrage on Godavari, main canal, cross drainage/cross masonry works, lifts, tunnels, and command area development etc. The construction of the canal system involves excavation, placement of fill materials, spreading and wetting and compaction of the fill materials, concreting of sub surface and super structures.

10.8.1 Proposed barrage

The length of proposed barrage at Janampet on Godavari is about 867.50 m against the river width of 1700 m. Thus the guide bunds are provided for the remaining part of the river portion. Total quantity of foundation excavation for canal is about 13,60,000m^3,out of which soft soil is 8,16,000m^3 and the remaining 5,44,000$m^3$is murum/ weathered rock. The excavated material is partly proposed to be used for the construction of guide bunds and marginal bunds. In absence of topographical investigations of river banks, the quantum of earth work for guide and marginal bunds could not be estimated. However, the quantity of 8,16,000 m^3 of excavated material shall be used for construction of guide and marginal bunds. The dumping site for disposal of excavated material is proposed at an average distance of 1.0 km.The concreting for the barrage is estimated to be 13,09,000m^3. The quantities of different activities for the construction of main canal are shown in **Table -10.1**.

Table 10.1 Quantities of different activities for construction of barrage on Godavari

Description of Work	**Type / Material**	**Quantity, in-situ**	**Unit**
Excavation	Total quantity	13,60,000	m^3
	Soft soil	8,16,000	m^3
	Murum, weathered rock and hard rock	5,44,000	m^3
Fill placement	Total quantity		
	Met from spoils	8,16,000	m^3
Concreting	Concrete from M 15 to M 25	13,09,000	m^3

The earth work involves both common excavation in overburden and weathered rock. Two working seasons have been earmarked for undertaking excavation and three working season is considered for concreting. The details of calculation of machinery requirement are shown in **Annexures :10.2, 10.4, 10.5**. The estimation of hourly quantities of soil/rock involved in surface excavation and concreting for head works for which provision of equipment is to be made is given in **Table 10.2.**

Table 10.2 Estimation of Hourly Quantity for Canal Excavation

Description of work	**Soft Soil+ murum**	**Concreting**
Total Volume(cum)	1360000	13,09,000
Time period(months)	24	36
No. of years/seasons	2	3
Shiftsproposed /day	2	2
Total Operational hours per one season	2,000	2,000
Work load / season (m^3)	680000	436330
Peak work load / season (m^3)	850000	654495
Peak work load / hr (m^3)	425	344

10.8.2 Main Canal Excavation

Total quantity of main canal excavation including the cross drainage structures for 3 reaches is about 1538477103 m^3,out of which soft soil is 230735810 m^3,murum / weathered rock is 422948394 $m^3$and the remaining 120088512 $m^3$is for hard rock. On the other hand, the fill placement is estimated to be about 263716036 m^3, out of which about 771951 m^3 is from Cross drainage structures. The dumping site for disposal of excavated material is proposed at an average distance of 1.0 km. The quantity of concreting is 14931605 m^3 which includes canal lining, sub structures and super structures of CD & CM works of main canal. While calculating the equipments, the quantity for murum and weathered rock is included in soils where as the medium dense rock is included in hard rock. The details of calculation of machinery requirement for carryout constructional activities are shown in **Annexure :10.3, 10.4. & 10.6**. The quantities of different activities for the construction of main canal are shown in **Table -10.3**.

Table 10.3 Quantities of Different Activities for Construction of Main Canal

Description of Work	**Type / Material**	**Quantity, in-situ**	**Unit**
Main canal			
Excavation	Total quantity	764704388	m^3
	Soft soil	224597776	m^3
	Murum and weathered rock	187443134	m^3
	Dense medium rock	234231655	m^3
	Hard rock	118431824	m^3
Fill placement	Total quantity	262944085	m^3
	Full embankment	161465390	m^3
	Partial embankment	101478695	m^3
Concrete	Canal lining	11911938	m^3
CD & CM structures			
Excavation	Total quantity	9840278	m^3
	Soft soil	6138034	m^3
	Murum and weathered rock	1273605	m^3
	Hard rock	1656688	m^3
Fill placement	Embankment	771951	m^3
Concrete	Sub & Super structures	3019667	m^3

The earth work involves both common excavation in overburden and rock. Three working seasons have been earmarked for undertaking excavation whereas 3.5 working season is considered for concreting. The estimation of hourly quantities of soil/rock involved in surface excavation for main canal which provision of equipment is to be made is given in **Table 10.4.**

Table 10.4 Estimation of Hourly Quantity for Canal Excavation and concreting

Description of work	**Soft Soil + Murum&weathered rock**	**Medium dense and hard rock**	**Concrete**
Total Volume(cum)	419452549	354320170	14931605
Time period(months)	36	36	42

No. of years/seasons	3	3	3.5
Shiftsproposed /day	2	2	2
Total Operational hours per one season	2000	2000	2000
Work load / season (m^3)	139817516	118106723	4266173
Peak work load / season (m^3)	1747718951	147633410	5332716
Peak work load / hr (m^3)	87386	73817	2666

10.8.3 Tunnels

The tunnels are mainly proposed where deep cut reaches are encountered in the canal alignment. Therefore, the construction of tunnels involves excavation mainly in rock and followed by the concreting with support or without support subjected to the rock formations and fissures and faults on the strata. 5 tunnels are proposed in the canal system which includes the offtake tunnel at Somasila dam. The estimated muck from the construction of tunnels is estimated to be about 323310515m^3. In addition, in the transition reaches from canal to tunnel and vice versa i.e. near the entry and exit of the tunnels, the excavation comprises of mostly overburden and to some extent weathered/hard rock. The quantity of excavation involved in transitions in I and II reaches of canal is accounted in main canal whereas in IIIrd reach it is 402130 m^3, 443940 m^3 ,and 2563310 m^3 for soil, murum/ weathered rock and hard rock respectively. The equipment requirement for tunnel transitions at reach is included in main canal. The quantity of concrete required for the construction of tunnel is 636366 m^3 . The quantities of different activities for the construction of tunnels are shown in **Table -10.5**.

Table 10.5 Quantities of Different Activities for Construction of Tunnels

Excavation

Description of Work	**Type / Material**	**Unit**	**Quantity**			
			Reach I	Reach II	Reach III	Total
Excavation						
(Transition reaches)	Soft soil	m^3	Included in main canal		402130	
	Murum and weathered	m^3	Included in main canal		443940	

	rock					
	Hard rock	m^3	Included in main canal		2563310	
Muck (Main tunnels)	Total quantity (Hard rock)	m^3	321625000	133350	1552165	3233105 15
Concreting	Concrete	m^3	440150	28510	167706	636366

The detailed equipment planning for the construction of main tunnels has not been carried out in the present DPR, however, equipment requirement for few main items have been attempted. The Tunnel boring machines can be considered in place of conventional blasting method which will be arranged by the firm/company to which the contract is awarded. Three working seasons have been earmarked for undertaking excavation in the tunnels. The details of calculation of machinery requirement for carryout constructional activities are shown in **Annexure :10.7 to 10.13**. The estimation of hourly quantities reachwise of muck and concreting for tunnelsfor which provision of equipment is made is given in **Table 10.6**.

Table-10.6 Estimation of Hourly Quantity of Excavation& Concreting of Tunnels

Description	**Reach I**	**Reach II**	**Reach III**	**Total**
Muck excavation				
Total volume (cum)	321625000	133350	1552165	323310515
Progress @ 2 m in one cycle quantity (cum)	1029	210	955	2194
Time period (months)	19	16	27	27
No. of years/ seasons	2	2	3	3
Shift proposed	2	2	2	2
Total operational hours (hour) for one season	2000	2000	2000	2000
Concreting				
Total volume (cum)	440150	28510	167706	636366
Time required for overt concreting (months)	37	15	47	47
Time required for invert	19	8	24	24

concreting (months)				
Total time required (months)	56	23	71	71

10.8.4 Lifts / power houses

Proposed lift/power houses at six locations are identified in the main canal. The excavation and other construction materials involved in this project are normally very less when compared to other major components. Hence, the requirement of equipments has not been attempted in this DPR. The equipments which are needed may be adjusted from the nearby locations of other major structures when surplus equipments are available.

10.8.5 Branch canals and command area :

In the absence of detailed topographical investigation of branch canals and command area development details, the quantity estimation of material required could not be carried out, as such the equipment planning has not been made in the present DPR.

10.8.6 Proposed Construction Methods

(i) Surface Excavation: Following construction methods are proposed for surface excavations in connection with the major construction activities viz. canal, pipe lines, tunnels and lifts:

- Excavation and loading of soil by 3.0 m^3capacity Hydraulic Excavators assisted by front end loader (shovel).
- Transportation of the excavated material to the disposal area by 18.12 m^3(31.75 Tonnes)capacity Dumper
- Spreading the excavated quantity using Dozers of 275 H.P capacity
- Compaction using Double Drum Sheep foot Rollers of 1.5 m dia of 1.2 m width with 900-100 crawler tractors.

(ii) Hard Rock Excavation: Following construction methods are proposed for excavation in hard rock in connection with the major construction activities viz. canal, pipe lines, tunnels and lifts:

- Drilling by 120 cfm capacity Heavy Duty Jack Hammers

- Providing the air requirements by Air Compressors of 250 cfm / 500 cfm capacity
- Loading and transportation of excavated rock material through Tippers of 4.5 m^3 (6.5 T capacity)

(iii) Placement of Fill Material: Following construction methods are proposed for obtaining and placing the fill material in connection with the major construction activities viz. canal, pipe lines and lifts:

- Excavation and transportation of soil from borrow area using scrapers of 11.50 m^3 and pushers of 250-275 HP
- Spreading the fill material using Dozers of 180 H.P capacity and taking the spread area of 30.48 m (100 ft)
- Wetting the fill by using water tankers of 10,000 litres capacity and water pump of 2,275 litres per minute capacity
- Compaction of the fill by using Self propelled Vibrators Tampering foot Compactors

(iv) Concreting : Following construction methods are proposed for carrying out concreting and placing the material in connection with the major construction activities viz. head works, canal, tunnel, and lifts

- Mixing plant of 2500 litre capacity
- Batching plant with recommended bin sizes for coarse aggregates, fine aggregates and cement
- Aggregate processing unit of suitable sizes
- Ice plant of suitable sizes for head works
- Concrete pumps of 60 cum/hr to 20 cum/hr capacity
- Concrete transit mixer of 10 cum capacity

(v) Tunneling : Following construction methods are proposed for excavation of muck in conventional method of blasting and removal of muck.

- Jack hammers of 120 cfm capacity
- Air compressor of 250 cfm capacity
- Hydraulic excavator/ crawler of 3 cum capacity
- 25 ton capacity dumpers

- Exhaust removal equipment

Based on the above methodology, major construction plant and equipment required for construction of link canal, pipe lines, lifts and tunnel transition reaches have been worked out and are given in **Table-10.7**.

Table-10.7 Major construction equipments

Sl. No	Description	Size/ Capacity	Nos. of Equipments											
			head works	For Canal Excavation		CD structures		Excavation of tunnel	Embankment of		Concreting			Total
				Soil+ Murum	Hard Rock	Soil+ Murum	Hard Rock		Canal	CD works	HW	Canal	Tunnels	
1	Hydraulic Excavator	3.0 m^3	2	422		5		45						474
2	Dumper	18.12 m^3 (31.75 Tonne)	10	1684		25								1719
		25 T capacity						158						158
3	Dozer	275 HP	2	490		6								498
4	Double drum sheep	1.5 m dia., 1.2 m width,	21	861		60			197	1				1140
5	Jack hammer	120 cfm			14812		70	224						15106
6(a)	Air compressor	250 cfm			3703		18	135						3856
6(b)	Air compressor	500 cfm			1851		9							1860
7	Trucks/Tipper	4.5 cum ,^{3}			10456		49							10505
8	Scraper	11.5 m^3	5						1428	4				1437
9	Pusher	250-275 HP	1						286					287
10	Water tankers/ sprinklers	10000 litres	1						328	1				330
11	Dozer 180HP capacity	180 HP	18						356	3				377
12	Compactor (self propelled)								56					56
13	Concrete Mixers 2.5 cum										8	76	45	129
14	Batching plant with 2 concrete mixers										4	38	23	65
15	Concrete pumps 60 cum /hr										5		9	14

16	Concrete pumps 20/25cum /hr											128	8	136
17	Concrete transit mixer 10 Cum capacity										18	177	92	287
18	Iceing plant capacity (MT) for each mixer										21			21
19	Agg processing plant 250tph													
20	Grout pump of 20kg/ sqm													
21	Concrete vibrator (Electric/ Pneumatic)													
22	Vibratory compactor													
23	Crawler/ Wagon drill 600cfs													

10.9 Manpower Planning

10.9.1 Organisation setup

The project will be implemented under an organisation set-up headed by an officer of the rank of Chief Executive officer. The works will be executed under the overall supervision of two Officers of the rank of Chief Engineers /General manager who will report to Chief Executive Officer. In addition, there will be two officers of the rank of Superintending Engineer to assist Engineer-in - Chief/ Chief Engineer and three officers of the rank of Director (Administration), Director (Finance), Director (LA) to assist General Manager: Each will be assisted by appropriate subordinate officers and staff. The organisation chart for the project is appended as **Annexure - 10.14.**

There will be one Chief Engineer and one General manager for the Project to look after the works, viz., Engineer-in-Chief (Designs &quality control), will be supported by 2 officers of the rank of Superintending Engineer who will be heading the field formations of circles. Each circle will have two to three division offices which will be headed by the officers of the rank of Executive Engineers. Executive Engineers in turn will have Assistant Executive Engineers as their subordinate officers who will manage Sub-Divisional offices.

The General Manager will be supported by 3 officers of the rank of Director (Administration), Director (Finance), Director (LA) and other supporting staff like PRO, Labour officer etc.

Engineer-in-Chief will be responsible for execution of works related to construction of the link and lifts, tunnels and power houses. One Superintending Engineer will be responsible for earth work and construction of canal; Second Superintending Engineer will look after the construction of CD/CM structures, Colony and stores.

One Rehabilitation Officer will be taking care of EMP and R&R. They will be supported by appropriate subordinate officers as elaborated under the organisation chart.

The civil designs of all the components of the project will be carried out by the Superintending Engineer (Designs). He will also provide assistance in respect of electrical and mechanical works for whole of the project.

10.10 Year wise allocation of cost

The year wise allocation of cost for the project is given in **Table 10.8.**

Table 10.8
Yearly phasing of expenditure

Year	**Allocation of cost (Rs lakh)**	**Percentage allocation**
1st Year	808836	13.40
2nd Year	1878430	31.12
3rd Year	1385886	22.96
4th Year	1385886	22.96
5th Year	577050	9.56
Total	**6036088**	**100**