# Chapter 12
# Construction Programme, Manpower Deployment and Plant Planning

## 12.0 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.

## 12.1 Objective of the project

The Cauvery (Kattalai) - Vaigai - Gundar link project is the last component (Phase II) of the entire Mahanadi - Godavari - Krishna - Pennar - Cauvery - Vaigai - Gundar link system to divert surplus water available in Himalayan rivers and river Mahanadi to Cauvery, Vaigai and Gundar basins via Krishna and Pennar basins after meeting the requirements of the areas enroute, to the extent possible to serve the areas in Godavari, Krishna, Gundlakamma, streams between Gundlakamma and Pennar, Pennar, streams between Pennar and Palar, Palar, streams between Palar and Cauvery and Cauvery basin .

The proposed link envisages diversion of 2252 $Mm^3$ of water from Kattalai barrage on Cauvery. The project entirely lies in Tamil Nadu State. The link canal will provide new area of 448340 ha under irrigation utilising about 1931 $Mm^3$ besides providing 79 $Mm^3$ for drinking and 139 $Mm^3$ for industrial water supply.

## 12.2 Construction programme

The construction work of Cauvery (Kattalai) - Vaigai - Gundar 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 and laying of electric lines for the same 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 third 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 tunnels is programmed to start from second year and would be completed in the fourth 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 link project will be started in a partial manner by the end of third year. The detailed construction schedule for the project in the form of a bar chart is attached as **Annexure: 12.1**.

## 12.3 Basis for study

The methodology adopted for construction of 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 is 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.

## 12.4 Construction material sources

Location of different borrow areas and quarries for construction material with respect to the canal reaches have been described in the **Chapter 4: Surveys and investigations.**

Suitable construction material would be available adequately for all CD/CM structures 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 spoil banks located on either side of canal and excess quantity, if any may be filled at the borrow area.

## 12.5 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.

## 12.6 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 December in the project area. For equipment planning purpose the monsoon season has been considered from 1st September to 31st December. Thus, for over ground 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, are furnished in **Table 12.1**

**Table 12.1**
**Scheduled working hours**

| 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 | 8x25x10 =2000 | |
| Three shift work/day | 8x25x12.5 =2500 | |

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% |

### 12.6.1 Construction Period

The Cauvery (Kattalai) - Vaigai - Gundar 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 are made accordingly.

## 12.7 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 main canal, cross drainage/cross masonry works, 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.

### 12.7.1 Head works

The head works for the link project includes the head regulator at existing Kattalai barrage and approach channel for drawing water at lean flow from the submergence. The cost and quantum of construction material are being not significant, its activities are included in the main canal.

### 12.7.2 Main canal excavation including the head works and cross drainage structures

Total quantity of main canal excavation including the head works and cross drainage structures is about 75175948 $m^3$ (73654653+1521295), out of which soft soil and murrum is 64616044 $m^3$ (63657635+958409), medium dense rock is 5639956 $m^3$ (5397031+242925) and the remaining 4919948 $m^3$ (4599987+319961) for hard rock. On the other hand, the fill placement is estimated to be about 10827500 $m^3$ (10654546+172954). The quantity of concreting is 1576019 $m^3$ (939217+636802) which includes canal lining, sub structures and super structures of CD & CM works of main canal. While calculating the equipments, the quantity for murum is included in soils where as the medium dense rock is included in hard rock. The details of calculation of machinery requirement to carryout constructional activities are shown in **Annexures: 12.2 to 12.5**. The quantities of different activities for the construction of main canal are shown in **Table 12.2**.

**Table 12.2**
**Quantities of different activities for construction of main canal**

| Description of Work | Type / Material | Quantity, in-situ | Unit |
|---|---|---|---|
| **Main canal** | | | |
| Excavation | Total quantity | 73654653 | $m^3$ |
| | i) Soft soil & Murrum | 63657635 | $m^3$ |
| | ii) Dense medium rock | 5397031 | $m^3$ |
| | iii) Hard rock | 4599987 | $m^3$ |
| Fill placement | Total quantity | 10654546 | $m^3$ |
| | i) Full embankment | 8919684 | $m^3$ |
| | ii) Partial embankment | 1734862 | $m^3$ |

| | | | |
|---|---|---|---|
| Concrete ($M_{10}$) | Canal lining | 939217 | $m^2$ |
| **CD & CM structures** | | | |
| Excavation | Total quantity | 1521295 | $m^3$ |
| | i) Soft soil and Murrum | 958409 | $m^3$ |
| | ii) Dense medium rock & weather rock | 242925 | $m^3$ |
| | iii) Hard rock | 319961 | $m^3$ |
| Fill placement | Embankment | 172954 | $m^3$ |
| Concrete ($M_{15}$ to $M_{25}$) | Sub & Super structures | 636802 | $m^3$ |

The earth work involves both common excavation in overburden and rock. Three working seasons have been earmarked for undertaking excavation whereas 3.5 working seasons are considered for concreting. The estimation of hourly quantities of soil/rock involved in surface excavation for main canal for which provision of equipment is to be made is given in **Table 12.3.**

**Table 12.3**
**Estimation of hourly quantity for canal excavation and concreting**

| **Description of work** | **Soft Soil + Murum & weathered rock** | **Medium dense and hard rock** | **Fill Placement** | **Concrete** |
|---|---|---|---|---|
| Total volume (cum) | 64616044 | 10559904 | 10827500 | 1576019 |
| Time period (months) | 42 | 42 | 36 | 36 |
| No. of years/seasons | 3.5 | 3 | 3 | 3 |
| Shifts proposed /day | 2 | 2 | 2 | 2 |
| Total operational hours per one season | 2000 | 2000 | 2000 | 2000 |
| Work load / season ($m^3$) | 18568890 | 3019930 | 3609170 | 525340 |
| Peak work load / season ($m^3$) | 23211113 | 3774910 | 4511463 | 788010 |
| Peak work load / hr ($m^3$) | 11606 | 18870 | 1800 | 394 |

### 12.7.3 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. 4 tunnels are proposed in the canal system. The estimated muck from the construction of tunnels is estimated to be about 1701620 $m^3$. 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. The equipment requirement for tunnel transitions at each reach is included in main canal. The quantity of concrete required for the construction of tunnel is 347331 $m^3$. The quantities of different activities for the construction of tunnels are shown in **Table 12.4**.

**Table 12.4**
**Quantities of different activities for construction of tunnels excavation**

| **Description of Work** | **Type/ Material** | **Unit** | **Quantity** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **RD 82.3 km** | **RD 104.1 km** | **RD 148.1 km** | **RD 156.3 km** | **Total** |
| **Excavation** | | | | | | | |
| **Muck** (Main tunnels) | Total quantity (hard rock) | $m^3$ | 494391 | 643810 | 368401 | 195018 | 1701620 |
| **Concreting** | Concrete | $m^3$ | 88997 | 125346 | 75524 | 57464 | 347331 |

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 to carryout constructional activities are shown in **Annexures: 12.6 to 12.7**. The estimation of hourly quantities reach wise of muck and concreting for tunnels for which provision of equipment is made is given in **Table 12.5**.

**Table 12.5**
**Estimation of hourly quantity of**
**excavation & concreting of tunnels**

| Description | Total |
|---|---|
| **Muck excavation** | |
| Total volume (cum) | 1701620 |
| Progress @ 2m in one cycle quantity (cum) | 656 |
| Time period (months) | 36 |
| No. of years/ seasons | 3 |
| Shift proposed | 3 |
| Total operational hours for one season | 2000 |
| **Concreting** | |
| Total volume (cum) | 347331 |
| Time required for overt concreting (months) | 23 |
| Time required for invert concreting (months) | 12 |
| Total time required (months) | 35 |

### 12.7.4 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.

### 12.7.5 Proposed construction methods

**(i) Surface excavation**: Following construction methods are proposed for surface excavations in connection with the major construction activities viz. canal and tunnels:

- Excavation and loading of soil by 3.0 $m^3$ capacity 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 and tunnels:

- 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:

- 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 and tunnel:

- 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
- Concrete pumps of 25 cum/hr to 20 cum/hr capacity
- Concrete transit mixer of 10 cum capacity

**(v) Tunnelling:** 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 and tunnel transition reaches have been worked out and are given in **Table 12.6**.

**Table 12.6**
**Major construction equipment**

| Sl. No. | Description | Size/ Capacity | Canal Excavation | | Tunnel boring | Embankment | Concreting | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Soil+ Murum | Hard Rock | | | Canal | Tunnel | |
| 1 | Hydraulic excavator | 3.0 $m^3$ | 56 | | 8 | | | | 64 |
| 2 | Dumper | 18.12 $m^3$ (31.75 T) | 226 | | | | | | 226 |
| | | 25 T capacity | | | 14 | | | | 14 |
| 3 | Dozer | 275 HP | 66 | | | | | | 66 |
| 4 | Double drum sheep foot roller with 900-100 crawler tractors | 1.5 m dia., 1.2 m width, | 132 | | | 8 | | | 140 |
| 5 | Jack hammer | 120 cfm | | 378 | 45 | | | | 423 |
| 6(a) | Air compressor | 250 cfm | | 87 | 29 | | | | 116 |
| 6(b) | Air compressor | 500 cfm | | 47 | | | | | 47 |
| 7 | Trucks/Tipper | 4.5 cum | | 266 | | | | | 266 |
| 8 | Scraper | 11.5 $m^3$ | | | | 59 | | | 59 |
| 9 | Pusher | 250-275 HP | | | | 12 | | | 12 |
| 10 | Water tankers/ sprinklers | 10000 litres | | | | 13 | | | 13 |
| 11 | Dozer 180HP capacity | 180 HP | | | | 16 | | | 16 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 12 | Concrete Mixers | 2.5 cum | | | | | 11 | | 11 |
| 13 | Batching plant with 2 concrete mixers | | | | | | 6 | | 6 |
| 14 | Concrete pumps | 20/25cum /hr | | | | | 16 | 8 | 24 |
| 15 | Concrete transit mixer | 10 Cum capacity | | | | | 22 | 8 | 30 |

## 12.8 Manpower planning

### 12.8.1 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 one officer of the rank of Superintending Engineer to assist Engineer in Chief and three officers of the rank of Director (Administration), Director (Finance), Director (LA) to Chief Executive Officer. Each will be assisted by appropriate subordinate officers and staff. The organisation chart for the project is appended as **Annexure: 12.8.**

Chief Engineer will be responsible for execution of works related to construction of the link canal and tunnels in his jurisdiction. Each Chief Engineer will be assisted by (i) one Superintending Engineer for tunnel and (ii) two Superintending Engineers for canal works. Each Superintending Engineer (Canal / Tunnel) shall be supported by three Executive Engineers of which one Executive Engineer will look after the Quality Control works. Other two Executive Engineers shall supervise canal/tunnel construction. Executive Engineers in turn will have Assistant Executive Engineers as their subordinate officers who will manage Sub-Divisional offices.

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) in CEO office. He will also

provide assistance in respect of electrical and mechanical works for the whole project.

## 12.9 Year wise allocation of cost

The year wise allocation of cost for the project as per 2019-20 price level is given in **Table 12.7.**

**Table 12.7**
**Yearly phasing of expenditure**

| **Year** | **Allocation of cost (Rs lakh)** |
|---|---|
| 1st Year | 82772 |
| 2nd Year | 165543 |
| 3rd Year | 248315 |
| 4th Year | 206929 |
| 5th Year | 124157 |
| **Total** | **827716** |