Chapter - 10
Construction Program, Manpower 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

Par-Tapi-Narmada Link Project has been planned to transfer surplus waters of West flowing Par, Auranga, Ambica and Purna river basins of South Gujarat and neighbouring Maharashtra to provide irrigation facilities to: the areas on its enroute: tribal areas enroute right side of the link canal; tribal dominant districts of Dang and Valsad of Gujarat and Nasik district of Maharashtra; command area of five projects proposed by Government of Gujarat in its initial reaches to caters the water demands for irrigation and drinking purposes in its enroute; and take over the part command area of existing Miyagam Branch Canal of Narmada Canal System. The Narmada waters so saved in Sardar Sarovar Project would be utilized to provide irrigation facilities: in tribal areas of Naswadi, Kavant, Sankheda, Jetpur Pavi, Chhota Udepur talukas of Chhota Udepur district and Halol,

Ghogamba and Kalol talukas of Panchmahal district by lift directly from Narmada Main Canal on substitution basis; and in drought affected Saurashtra region of Gujarat on substitution basis through Narmada Canal System to meet irrigation, domestic and other requirements. In addition to this, all possible Panchayat / village tanks coming in the vicinity of the project will be filled up. The project will also provide drinking water to tribal population in the vicinity.

10.2 Main Project Components

Par-Tapi-Narmada Link Project involves construction of following components:

i) A 808.32 m long composite embankment (concrete face rock fill) cum concrete dam across river Par near village Jheri with FRL 246.00 m and corresponding gross storage capacity 206.03 MCM. The length of concrete face rock fill portion of the dam is 663.32 m and the length of concrete non-overflow section and spill way is 145.00 m. The dam axis is located at Latitude 20°22'25" N and Longitude 73°25'51" E.

ii) A 1431.85 m long composite embankment (concrete face rock fill) cum concrete dam across river Nar (a tributary of Par river) near village Paikhed with FRL 248.00 m and corresponding gross storage capacity of 229.53 MCM. The length of concrete face rock fill portion of the dam is 1310.85 m and the length of concrete non-overflow section and spill way is 121.00 m. The dam axis is located at Latitude 20°27'42" N and Longitude 73°23'37" E;

iii) A power house of 9 MW installed capacity at the toe of Paikhed dam with 3 units each of 3 MW.

iv) A 2781.00 m long composite embankment (concrete face rock fill) cum concrete dam across river Tan (a tributary of Auranga river) near village Chasmandva with FRL 214.00 m and corresponding gross storage capacity of 83.63 MCM. The length of concrete face rock fill portion of the dam is 2703.00 m and the length of concrete non overflow section and spill way is 78.00 m. The dam axis is located at Latitude 20°37'02" N and Longitude 73°22'36" E.

v) A power house of 2 MW installed capacity at the toe of Chasmandva dam with 2 units each of 1 MW.

vi) A 1887.00 m long composite embankment (concrete face rock fill) cum concrete dam across river Ambica near village Chikkar with FRL 210.00 m and corresponding gross storage capacity of 141.99 MCM. The length of concrete face rock fill portion of the dam is 1736.00 m and the length of concrete non overflow section and spill way is 151.00 m. The dam axis is located at Latitude 20°42'00" N and Longitude 73°30'50" E.

vii) A power house of 2 MW installed capacity at the toe of Chikkar dam with 2 units each of 1 MW.

viii) A 1170.00 m long composite embankment (concrete face rock fill) cum concrete dam across river Khapri (a tributary of Ambica river) near village Dabdar with FRL 169.00 m and corresponding gross storage capacity 222.38 MCM. The length of concrete face rock fill portion of the dam is 1035.00 m and the length of concrete non overflow section and spill way is 135.00 m. The dam axis is located at Latitude 20°48'58" N and Longitude 73°32'05" E.

ix) A power house of 3.2 MW installed capacity at the toe of Dabdar dam with 2 units each of 1.60 MW.

x) A 1330.00 m long composite embankment (concrete face rock fill) cum concrete dam across river Purna near village Kelwan with FRL 164.00 m and corresponding gross storage capacity of 282.16 MCM. The length of concrete face rock fill portion of the dam is 1141.00 m and the length of concrete non overflow section and spill way is 189.00 m. The main dam is located at Latitude 20°55'30" N and Longitude 73°32'00" E.

xi) A power house of 2.5 MW installed capacity at the toe of Kelwan dam with 2 units each of 1.25 MW.

xii) A power house of 2 MW installed capacity at the fall of feeder Pipe line connecting Kelwan dam with main link canal with 2 units each of 1 MW.

xiii) A tunnel of about 12.70 km long with 3.00 m diameter (D shape) and bed slope of 1:875 connecting Jheri reservoir with Paikhed reservoir.

xiv) A 147.50 m long barrage in the downstream of Paikhed dam with crest level of 136.00 m.

xv) A 128.00 m long barrage in the downstream of Chasmandva dam with crest level of 123.00 m.

xvi) A 369.043 km long link canal off-taking from Paikhed barrage at FSL 142.800 m.

xvii) A 100 m long tunnel No.1 at RD 14.650 to 14.750 km; A 350 m long tunnel No.2 at RD 24.000 to 24.350 km; A 200 m long tunnel No.3 at RD 32.350 to 32.550 km; A 50 m long tunnel No.4 at RD 37.750 to 37.800 km; and A 450 m long tunnel No.5 at RD 51.500 to 51.950 km;

xviii) A 2.859 km feeder Pipe line connecting main canal with Chasmandva barrage.

xix) A 14.342 km open Pipe line inter connecting Chikkar and Dabdar reservoirs.

xx) A 12.258 km feeder Pipe line connecting main canal with Dabdar dam.

xxi) A 7.616 km feeder Pipe line connecting main canal with Kelwan dam.

xxii) Cross Drainage / Cross Masonry works including Regulators, Escapes, Road/ Railway bridges (469 No).

10.3 Basis for Study

10.3.1 General

Methodology adopted for construction of Par-Tapi Narmada 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, sufficient utilization of equipment on the project would be ensured.

10.3.2 Construction Material Sources

Locations 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 for the concrete face rock fill dam has been found in at different site for each Dam. Borrow areas with minimum lead should be utilized during dam construction.

Location of all Quarry site/Borrow site corresponding to different Dams along with respective Lead Distance has been shown in following table:

Sl. No.	Name of the Project	Location of Quarry/ borrow site	Distance of Quarry/Borrow site
	DAM		
1	Jheri	**Sand**- Confluence of Par & Keng river. **Rock**- Left bank of Keng river on U/S of dam axis.	500 m. 900 m.

2	Paikhed	Sand- on D/S of dam axis. Rock- on D/S of dam axis. .	1 km. 1 km.
3	Chasmandva	Sand- At Mola amba bridge on D/S of dam axis. Rock- At choravani village on U/S of dam axis.	4 km. 1 km.
4	Chikkar	Sand- on D/S of dam axis near Rambhas village. Rock- on D/S of dam axis near Rambhas village .	2 km. 1.5 km.
5	Dabdar	Sand- D/S of Mheskatri-Waghai road bridge. Rock- Near Gira Village.	2.75 km. 2.5 km.
6	Kelwan	Sand- Near Wankan village. Rock- Near Wankan village .	500 m. 1.25 km.

However, during construction, appropriate decision may 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 dam site. The area for disposal of excavated material has been considered at an average distance of 1.0 km from the dam site for equipment planning purpose.

10.3.3 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. However, all underground works like tunnels can be constructed throughout the year.

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

10.3.3.1 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 over ground works i.e. dam 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 standby equipment has been considered as follows:

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

10.3.3.2 Construction Period

A total period of seven years has been considered for completion of the project. The infra-structural development, pre-construction surveys and investigations, preparation of design/ specifications and tender documents are proposed to be taken up during the first two years. In case the works are to be executed through award of contract, it is planned to award contracts for all major works by the 3rd quarter of year 2. However, some of the works like stripping, River diversion and portal formation& slope stabilization for link tunnels may have to be undertaken from the 1st quarter of the 2nd year itself and therefore award of work for these works may be planned accordingly. The work on infrastructure facilities like project colonies, approach roads, workshop, haul roads, stores, office buildings etc. will also start in the second year itself. Some of these activities will continue for some time during the third year also. The construction of all civil structures is proposed to be completed within 3rd quarter of year 7. The erection, commissioning and testing of units would be required to be planned so that full benefits could be accrued at the end of the proposed construction period.

The detailed construction schedule for the project in the form of a bar chart is attached as Annexure-10.1.

10.4 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.

10.4.1 River Diversion Works

No formal diversion arrangement has been provided for the construction of all the six dams. The diversion arrangement during 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 can be used for diversion during construction stage.

The following construction methods have been considered for river diversion works:

- Excavation and loading of the material by 2.0 cum hydraulic excavator.
- Transport to the disposal area by means of 25 t rear dumpers.
- The rock excavation to be undertaken by drilling & blasting.
- Jack hammers and wagon/crawler drill with hole patterns of 1m and 2.75 m c/c respectively to be deployed for drilling of charge holes.

Separate provision of the equipment for this activity has not been kept as some of the equipment to be deployed for CFR dam can be utilized on this activity.

10.4.2 Jheri Dam

10.4.2.1 Concrete Face Rock-Fill Dam (Jheri Dam)

The construction of the dam involves surface excavation, placement of fill material, spreading & wetting and compaction of the fill material. Total quantity of Jheri dam excavation excluding OF and NOF section is about 951200 cum. The excavation of 411800 cum quantity which does not involve blasting operation is considered as common excavation and remaining 539400 cum which requires blasting is considered as rock excavation. Following table describes quantities of different activities for the construction of dam:

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	69,600	cum
Excavation	Common	342200	cum
	Rock	539400	cum

Fill placement	Impervious material (1B)	63224	cum
	Processed fine filter (2A)	3949	cum
	fine grained with particle size upto 150 mm (1A)	24049	cum
	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	126969	cum
	300mm or less graded stone (3A)	169,086	cum
	800mm or less graded stone (3B)	2,192,914	cum
	1000mm or less graded stone (3C)	1,244,732	cum
	1000mm or more graded stone (3D)	57,808	cum
	rock-toe	6081	cum
	Below and Behind rock-toe	3041	cum

10.4.2.1 (a) Surface Excavation

The surface excavation for main dam involves both common and rock excavations. The volume of required excavation is given below.

Volume of Surface Excavation

Type Description	Common excavation (cum)	Rock excavation (cum)
Stripping	69,600	Nil
River Bed Excavation	342200	539400
Total	411,800	539400

Duration of 2 months has been earmarked for undertaking stripping and a period of 6 months has been provided to undertake surface excavation pertaining to main dam. Although work in the river bed can be undertaken only after completion of river diversion work, the work of stripping can be taken up earlier. The requirement for which provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation for Stripping

Type Description	Common Excavation (stripping)
Total volume (cum)	69,600
Time period (months)	2
Shift proposed	2
Total operational hours (hour)	550
Volume to be handled in-situ (cum/hr)	127
Volume to be handled loose (cum/hr)	158

Total quantity= 158cum/hr

Estimation of hourly quantity of excavation (for River bed)

Type Description	Common Excavation (River bed excavation only)	Rock Excavation
Total volume (cum)	342,200	539400
Time period (months)	6	6
Shift proposed	2	2
Total operational hours (hour)	1650	1650
Volume to be handled in-situ (cum/hr)	208	326
Volume to be handled loose (cum/hr)	260	523
Total quantity=		**260+523**
Peak quantity =	**783**	**cum/hour**

Following construction methods are proposed for surface excavations:

- Stripping and excavation for trenching & preparation of base of dam and loading of the soft material (earth and alluvium) by 2.0 cum hydraulic excavators assisted by 180 HP crawler dozer.
- Transportation to the disposal area by 25 t capacity rear dumper.
- A 180 HP bulldozer is also considered to stay in the disposal area for spreading of the unloaded materials.
- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1m c/c and 2.75 m c/c respectively to be deployed for drilling of charge holes.

10.4.2.1 (b) Fill Placement

The construction of earth fill dam involves placement of 3891853 cum of fill materials. As per construction schedule the fill placement is to be undertaken in period of 24 months. The break-up of total quantity into different types of fill material to be placed in different zones and their expected source of supply is given below:

Quantities and source of fill material

Sr. No.	Fill Material	Quantity (compacted) (cum)
1	Impervious material (1B)	63224
2	Processed fine filter (2A)	3949
3	fine grained with particle size upto 150 mm (1A)	24049
4	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	126969
5	300mm or less graded stone (3A)	169,086
6	800mm or less graded stone (3B)	2,192,914
7	1000mm or less graded stone (3C)	1,244,732
8	1000mm or more graded stone (3D)	57,808
9	rock-toe	6081
10	Below and Behind rock-toe	3041
	TOTAL =	**3891853**

The fill placement will require excavation and loading of material at the borrow areas/quarries, transportation of the material to the placement site and unloading. It is necessary that various alternative methods and equipment are evaluated and appropriate construction methods and suitable construction equipment are selected.

Hydraulic excavator-rear dumper combination is the most commonly used method of material transportation in a river valley project. The selection of hydraulic excavators depends on the quantities to be handled, limitations of space at the site and the availability of standard equipment. Matching rear dumpers are estimated taking into account the distance to be

traveled, the load ratings of haul roads and traffic intensity. This method is considered quite flexible as this allows introduction of additional equipment to supplement the capacity, if required. These equipments are available as standard items and most of the sizes which may be required on river valley projects are manufactured indigenously.

Belt conveyor system is considered a good alternative for transportation of material over long distances. In this method the capital cost of equipment is high, but the disadvantage is offset by the low running and maintenance costs. However, some limitations are posed by the maximum lump size, which can be transported through these belt conveyors.

In the present case, since fill material is available within a distance of 1 kilometer and borrow areas are scattered over different locations, the conventional method of material transportation, i.e., hydraulic excavator-dumper combination has been considered for material transportation.

As mentioned above, the fill quantities are to be placed in one working seasons. The hourly placement quantities for hearting material have been worked out and indicated below:

(i) Impervious Material (Zone 1A,1B and 2A)

Estimation of hourly quantity of hearting material placement

SN	Description	Quantity	Unit
1.	Total volume	91,222	cum
2.	Time period	8	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	2200	hour
6.	Volume to be handled (in-situ)	41	cum/hour
7.	Volume to be handled (loose)	66	cum/hour
8.	Peak quantity	83	cum/hour

The following construction methods have been considered for hearting fill:

- Excavation and loading by means of 2.0 cum hydraulic excavator.
- Transport to the embankment by means of 25 t capacity Rear end dumpers.
- Spreading in layers up to 30 cm thick by 180 HP bulldoze.
- Moisture adjustment by 8000 L water sprinklers.

- Compaction by 8 passes of 10t pad foot vibrating roller.

An average distance of 0.5 km from dam site has been considered for the borrow areas for impervious material.

(ii) Fine Filter material Placement (zone 2B, 3A)

The fine filter will have a total volume of 296,055 cum. The sand and gravel material is used to fill 2B, 3A zone of CFRD Dam. This quantity will be brought from quarries located at an average distance of 2 km from dam site. The material will be processed in a processing plant located suitably near the quarry itself. The sand and gravel material will be processed and brought to the dam site for placement.

As the quantity of filter material is comparatively less, so single shift work/day has been proposed for filter placement. The hourly rate at which placement of filter is to be carried out has been estimated below.

Estimation of hourly quantity of fine filter material placement

SN	Description	Quantity	Unit
1.	Total volume	296,055	cum
2.	Time period	32	month
3.	Shift proposed	1	-
4.	Operational hours/month	150	hour
5.	Total operational hours	4800	hour
6.	Volume to be handled (in-situ)	62	cum/hour
7.	Volume to be handled (loose)	78	cum/hour
8.	Peak quantity	97	cum/hour

The following construction methods have been considered for the placement of fine filter:

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 200 TPH installed near the quarry.

- Loading by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading on the embankment in layers up to 30 cm thick by bulldozer with flywheel power of 180 HP.
- Compaction with 6 passes of 10t smooth drum vibratory roller.

(iii) Coarse Filter (Zone 3B)

The requirements of coarse filter which is going to be used in zone 3B filling is approximately 2,192,914 cum. The same will be met from rock quarries. The rock will be transported to the placement site. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter material placement

SN	Description	Quantity	Unit
1.	Total volume	2,192,914	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8800	hour
6.	Volume to be handled (in-situ)	249	cum/hour
7.	Volume to be handled (loose)	400	cum/hour
8.	Peak quantity	500	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.

- Processing at the filter processing plant of 2 no. of 500 TPH installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 50 cm to 70cm layer thickness, by means of 180 HP flywheel power bulldozer.
- Compaction by 6 pass of 10t smooth drum vibrating rollers.

(iv) Rock material for Zone 3C,3D, Rock toe

The requirements of coarse filter which is going to be used in Rock toe and below Rock toe is approximately 1,311,662cum. The same will be met from rock quarries. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter and rock-toe material placement

SN	Description	Quantity	Unit
1.	Total volume	1,311,662	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8,800	hour
6.	Volume to be handled (in-situ)	149	cum/hour
7.	Volume to be handled (loose)	238	cum/hour
8.	Peak quantity	298	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 500 TPH installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 100 cm to 150cm layer thickness, by means of 324 HP flywheel power bulldozer.
- Compaction by 6 passes of 10t smooth drum vibrating rollers.

Concreting work on CFRD Dam like concreting of face slab, plinth etc can be done with the help of concrete pump of capacity 15 cum/hr with boom length of 25m. One moving type batch and mixing plant of capacity 18cum/hr may be deployed to meet the requirement of concrete.

10.4.2.1(c) List of Major Construction Plant and Equipment for CFRD Dam

Based on above methodology and equipment planning the list of equipment required for construction of Concrete Face Rock Fill Dam (Jheri Dam) is given in the following table.

S. No.	Description	Size/capacity		Quantity
1.	Hyd. Excavator	2.0	cum	9
2.	Hyd. Excavator	1.0	cum	2
3.	Loader, frnt end	2.5	cum	9
4.	Loader, frnt end	1.5	cum	2
5.	Dumper	25	T	53
6.	wagon drill	550	cfm	5
7.	Jack hammer	120	cfm	21
8.	Air requirement		cfm	4200
9.	Filter Processing plant	200	TPH	1
10.	Filter Processing plant	500	TPH	3

S. No.	Description	Size/capacity		Quantity
11.	Dozer	180	HP	14
12.	Dozer	324	Hp	1
13.	Vibratory roller (Padfoot)	10	T	1
14.	Vibratory roller (smoothpad)	10	T	3
15.	Water Sprinkler	8000	liters	10
16.	Transit mixer	4.5	cum	2
17.	Concrete vibrator			3
18.	B&M plant(moving)	18	Cum/hr	1
19.	Concrete Pump	15	Cum/hr	1
20.	Grout Pump	20	Kg/cm^2	4
21.	Mobile crane	16	Ton	4
22.	Truck	8/10	Ton	8

10.4.2.1 (d) Construction Programme

The excavations for the dam will start from the abutments above river bed level in the 2nd quarter of year 2 and will be completed within ten months working period. Excavations in the river bed will start as soon as the work area in the river bed becomes dry. The dam foundation treatment, which includes consolidation grouting and curtain grouting, will start locally as the excavation is completed in that area.

Embankment construction will start by 3rd quarter of year 3, once the excavation and foundation preparation works in the river bed are sufficiently advanced. The period before the beginning of the embankment construction shall be devoted to the preparation of the haul roads and development of the borrow area.

A total period of 32 months (4 season), excluding the monsoon period has been allowed for the completion of the dam embankment with the aim to reach crest elevation by the end of 2nd quarter of year 7.

10.4.2.2 Concrete Dam (Jheri Dam)

Main activities to be undertaken for construction of concrete dam (over flow & non-over flow sections) are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden and rock excavation. The total quantity of concrete dam excavation is about 263601 cum, and total quantity of concreting is about 300190 cum.

Quantities involved in construction of concrete dam (over flow & non-over flow)

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	-	cum
Excavation	Common	69200	cum
	Rock	194401	cum
	Total excavation	263601	cum
Concreting		300190	cum

10.4.2.2 (a) Surface Excavations

The surface excavations have been planned to be completed within 1 working seasons (8 months). The surface excavation for main dam involves both common and rock excavations. The excavated material will be transported to the disposal area using conventional excavator and rear dumper combination. The provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation

Type / Description	Common Excavation	Rock Excavation
Total volume (cum)	69200	194401
Time period (months)	5	5
Shift proposed	2	2
Total operational hours (hour)	1,375	1,375
Volume to be handled in-situ (cum/hour)	50	141
Volume to be handled loose	63	224

(cum/hour)		
Total quantity	**= 63 + 224 ~ 287** cum/hour	

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0 cum hydraulic excavators assisted by 180 hp bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 m^2 and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.0cum hydraulic excavator, shovel attachment and assisted by 180 hp dozers.
- Transportation to the disposal areas/main dam by 25t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.2.2 (b) Concreting

For concreting of main dam and appurtenant structures, total quantity of the order of 300190 cum, will have to be placed. A period of 27 months has been planned for the placement. The peak rate of placement works out to 32 cum/hour approximately. The concrete required for main dam is proposed to be produced in a centralized Batching and Mixing Plant of capacity 60 cum/hour. The plant shall be located in the vicinity of the dam. In addition, one numbers mobile batching & mixing plant of capacity, 18 cum/hour will be provided. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity.

Following construction equipments have been considered for concreting of main dam and appurtenant structures:

- Placing of concrete with the help of 2 Nos. tower cranes, 6 ton @ 40 metre radius are proposed to be deployed at suitable locations. In addition, 2 Nos. 25 cum/hr concrete pumps with 25 m boom will be used for concrete placement.

- Concrete transportation by transit mixers of 4.5 cum capacity.
- Batching and mixing plant of capacity 40 cum/hr to be located preferably within a radius of 1 km from the concrete dam.
- The aggregate crushing and screening plant of 150 TPH for preparation of coarse and fine aggregates.

10.4.2.2(c) List of Major Construction Plant and Equipment for Concrete Dam

Based on above construction methodology, major construction plant and equipment required for construction of concrete dam are listed below.

S. N0.	Equipments	Size/capacity		Quantity
1.	Hyd. Excavator	2	cum	2
2.	Hyd. Excavator	1	cum	0
3.	Loader, side dump	1.5	cum	1
4.	Dumper	25	T	8
5.	wagon drill	550	cfm	2
6.	Jack hammer	120	cfm	8
7.	Air requirement		cfm	1800
8.	Tower Crane	6T@40m		2
9.	Dozer	180	HP	2
10.	B&M Plant	60	cum/hr	1
11.	mobile B&M Plant	18	cum/hr	1
12.	APP	180	TPH	1
13.	Transit Mixer	4.5	cum	3
14.	Concrete pump	25	cum/hr	2
15.	Grout Pump	20	Kg/cm^2	2
16.	Mobile crane	16	Ton	2
17.	Truck	8/10	Ton	3

10.4.2.2 (d) Construction Programme

The sequence of construction of concrete dam takes into account the following aspects:

- Surface excavation of concrete dam to start during the 3rd quarter of Year 2.
- The total quantity of excavation to be completed in a period of 5 months. The activity to be completed by the end of 4th quarter of year 2.
- Concreting to start in the 1st quarter of Year 3 and will continue for 3 working seasons and to be completed by the end of the 2nd quarter of year 6.
- Since a part of over-flow section (two blocks) is to be used for diversion of river during construction of earth dam, the phasing of concerting is to be planned in such a way that the work of these two blocks is completed during lean season.
- Gate installation work to start in the beginning of 1st quarter of year 6 and will be completed by the end of 3rd quarter of Year 7.

10.4.3 Paikhed Dam

10.4.3.1 Concrete Face Rock-Fill Dam (Paikhed Dam)

The construction of the dam involves surface excavation, placement of fill material, spreading & wetting and compaction of the fill material. Total quantity of Paikhed dam excavation excluding OF and NOF section is about 1121451 cum. The excavation of 616798 cum quantity which does not involve blasting operation is considered as common excavation and remaining 504653cum which requires blasting is considered as rock excavation. Following tables describes the quantities of different activities for the construction of dam:

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	134,574	cum
Excavation	Common	482224	cum
	Rock	504653	cum
Fill placement	Impervious material (1B)	111389	cum
	Processed fine filter (2A)	4267	cum
	fine grained with particle size upto 150 mm (1A)	47848	cum

	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	240057	cum
	300mm or less graded stone (3A)	291,064	cum
	800mm or less graded stone (3B)	4,351,098	cum
	1000mm or less graded stone (3C)	2,561,827	cum
	1000mm or more graded stone (3D)	96,960	cum
	rock-toe	12,762	cum
	Below and Behind rock-toe	6,381	cum

10.4.3.1 (a) Surface Excavation

The surface excavation for main dam involves both common and rock excavations. The volume of required excavation is given below

Volume of Surface Excavation

Type Description	**Common excavation (cum)**	**Rock excavation (cum)**
Stripping	134,574	Nil
River Bed Excavation	482224	504653
Total	616,798	504653

Duration of 2 months has been earmarked for undertaking stripping and a period of 4 months has been provided to undertake surface excavation pertaining to main dam. The requirement for which provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation for Stripping

Type Description	**Common Excavation (stripping)**
Total volume (cum)	134,574

Time period (months)	2
Shift proposed	2
Total operational hours (hour)	550
Volume to be handled in-situ (cum/hr)	245
Volume to be handled loose (cum/hr)	306

Estimation of hourly quantity of excavation (for River bed)

Type Description	**Common Excavation (River bed excavation only)**	**Rock Excavation**
Total volume (cum)	482,224	504653
Time period (months)	4	4
Shift proposed	2	2
Total operational hours (hour)	1100	1100
Volume to be handled in-situ (cum/hr)	438	458
Volume to be handled loose (cum/hr)	548	734
Total quantity=		**548+734**
Peak quantity =	**1282**	**cum/hour**

Following construction methods are proposed for surface excavations:

- Stripping and excavation for trenching & preparation of base of dam and loading of the soft material (earth and alluvium) by 2.0 cum hydraulic excavators assisted by 180 HP crawler dozer.
- Transportation to the disposal area by 25 t capacity rear dumper.
- A 180 HP bulldozer is also considered to stay in the disposal area for spreading of the unloaded materials.
- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1m c/c and 2.75 m c/c respectively to be deployed for drilling of charge holes.

10.4.3.1 (b) Fill Placement

The construction of earth fill dam involves placement of 7723653 cum of fill materials. As per construction schedule the fill placement is to be undertaken in period of 24 months. The break-up of total quantity into different types of fill material to be placed in different zones and their expected source of supply is given below:

Quantities and source of fill material

Sr. No.	Fill Material	Quantity (compacted)
1	Impervious material (1B)	111389
2	Processed fine filter (2A)	4267
3	fine grained with particle size upto 150 mm (1A)	47848
4	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	240057
5	300mm or less graded stone (3A)	291,064
6	800mm or less graded stone (3B)	4,351,098
7	1000mm or less graded stone (3C)	2,561,827
8	1000mm or more graded stone (3D)	96,960
9	rock-toe	12,762
10	Below and Behind rock-toe	6,381
	TOTAL=	**7723653cum**

In the present case, since fill material is available within a distance of 1 kilometer and borrow areas are scattered over different locations, the conventional method of material transportation, i.e., hydraulic excavator-dumper combination has been considered for material transportation.

As mentioned above, the fill quantities are to be placed in one working seasons. The hourly placement quantities for hearting material have been worked out and indicated below:

(i) Impervious Material(Zone 1A,1B and 2A)

SN	Description	Quantity	Unit
1.	Total volume	163,504	Cum
2.	Time period	8	Month
3.	Shift proposed	2	-
4.	Operational hours/month	275	Hour
5.	Total operational hours	2200	Hour

6.	Volume to be handled (in-situ)	74	cum/hour
7.	Volume to be handled (loose)	118	cum/hour
8.	Peak quantity	150	cum/hour

Estimation of hourly quantity of hearting material placement

The following construction methods have been considered for hearting fill:

- Excavation and loading by means of 2.0 cum hydraulic excavator.
- Transport to the embankment by means of 25 t capacity Rear end dumpers.
- Spreading in layers up to 30 cm thick by 180 HP bulldoze.
- Moisture adjustment by 8000 L water sprinklers.
- Compaction by 8 passes of 10t pad foot vibrating roller.

An average distance of 0.5 km from dam site has been considered for the borrow areas for impervious material.

(ii) Fine Filter material Placement(zone 2B, 3A)

The fine filter will have a total volume of 531,121 cum. The sand and gravel material is used to fill 2B, 3A zone of CFRD Dam. This quantity will be brought from quarries located at an average distance of 2 km from dam site. The material will be processed in a processing plant located suitably near the quarry itself. The sand and gravel material will be processed and brought to the dam site for placement.

Estimation of hourly quantity of fine filter material placement.

SN	Description	Quantity	Unit
1.	Total volume	531,121	Cum
2.	Time period	36	Month
3.	Shift proposed	2	-
4.	Operational hours/month	275	Hour
5.	Total operational hours	9900	Hour
6.	Volume to be handled (in-situ)	54	cum/hour
7.	Volume to be handled (loose)	67	cum/hour
8.	Peak quantity	84	cum/hour

The following construction methods have been considered for the placement of fine filter:

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 200 TPH installed near the quarry.
- Loading by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading on the embankment in layers up to 30 cm thick by bulldozer with flywheel power of 180 HP.
- Compaction with 6 passes of 10t smooth drum vibratory roller.

(iii) Coarse Filter (Zone 3B)

The requirements of coarse filter which is going to be used in zone 3B filling is approximately 4,351,098 cum. The same will be met from rock quarries. The rock will be transported to the placement site. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter material placement

SN	Description	Quantity	Unit
1.	Total volume	4,351,098	Cum
2.	Time period	36	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	9900	hour
6.	Volume to be handled (in-situ)	440	cum/hour
7.	Volume to be handled (loose)	703	cum/hour
8.	Peak quantity	880	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of 2 no. of 750TPH and 1 no. of 250TPH capacity installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 50 cm to 70cm layer thickness, by means of 180 HP flywheel power bulldozer.
- Compaction by 6 pass of 10t smooth drum vibrating rollers.

(iv) Rock material for Zone 3C,3D, Rock toe

The requirements of coarse filter which is going to be used in Rock toe and below Rock toe is approximately 2,677,930cum. The same will be met from rock quarries. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter and rock-toe material placement

SN	Description	Quantity	Unit
1.	Total volume	2,677,930	cum
2.	Time period	36	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	9900	hour
6.	Volume to be handled (in-situ)	270	cum/hour
7.	Volume to be handled (loose)	432	cum/hour
8..	Peak quantity	541	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 1 no. 750TPH and 1 no 250TPH installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 100 cm to 150cm layer thickness, by means of 324 HP flywheel power bulldozers.
- Compaction by 6 passes of 10t smooth drum vibrating rollers.

Concreting work on CFRD Dam like concreting of face slab, plinth etc can be done with the help of concrete pump of capacity 15 cum/hr with boom length of 25m. One moving type batch and mixing plant of capacity 18cum/hr may be deployed to meet the requirement of concrete.

10.4.3.1(c) List of Major Construction Plant and Equipment for CFRD Dam

Based on above methodology and equipment planning the list of equipment required for construction of CFR Dam is given in the following table.

S. No.	Description	Size/capacity		Quantity
1.	Hyd. Excavator	2.0	cum	13
2.	Hyd. Excavator	1.0	cum	2
3.	Loader, frnt end	2.5	cum	15
4.	Loader, frnt end	1.5	cum	2
5.	Dumper	25	T	89
6.	wagon drill	550	cfm	7
7.	Jack hammer	120	cfm	29
8.	Air requirement		cfm	6000
9.	Filter Processing plant	200	TPH	1
10.	Filter Processing plant	250	TPH	2
11.	Filter Processing plant	750	TPH	3
12.	Dozer	180	HP	21
13.	Dozer	324	Hp	2
14.	Vibratory roller (Padfoot)	10	T	1
15.	Vibratory roller	10	T	6

S. No.	Description	Size/capacity		Quantity
	(smoothpad)			
16.	Water Sprinkler	8000	liters	16
17.	Transit mixer	4.5	cum	2
18.	Concrete vibrator			3
19.	B&M plant(moving)	18	Cum/hr	1
20.	Concrete Pump	15	Cum/hr	1
23.	Grout Pump	20	Kg/cm^2	4
24.	Mobile crane	16	Ton	4
25.	Truck	8/10	Ton	8

10.4.3.1 (d) Construction Programme

The excavations for the dam will start from the abutments above river bed level in the 2nd quarter of year 2 and will be completed within two months working period. Excavations in the river bed will start as soon as the work area in the river bed becomes dry. The dam foundation treatment, which includes consolidation grouting and curtain grouting, will start locally as the excavation is completed in that area.

Embankment construction will start by 1st quarter of year 3, once the excavation and foundation preparation works in the river bed are sufficiently advanced. The period before the beginning of the embankment construction shall be devoted to the preparation of the haul roads and development of the borrow area.

A total period of 36 months, excluding the monsoon period has been allowed for the completion of the dam embankment with the aim to reach crest elevation by the end of 2nd quarter of year 7.

10.4.3.2 Concrete Dam (Paikhed Dam)

Main activities to be undertaken for construction of concrete dam (over flow & non-over flow sections) are surface excavations and concreting. Surface excavations will comprise of common excavation in

overburden and rock excavation. The total quantity of concrete dam excavation is about 233199 cum, and total quantity of concreting is about 331967 cum.

Quantities involved in construction of concrete dam (over flow & non-over flow)

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	-	cum
Excavation	Common	65138	cum
	Rock	168061	cum
	Total excavation	233199	cum
Concreting		331967	cum

10.4.3.2 (a) Surface Excavations

The surface excavations have been planned to be completed within 1 working seasons (3 months). The surface excavation for main dam involves both common and rock excavations. The excavated material will be transported to the disposal area using conventional excavator and rear dumper combination. The provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation

Type Description	Common Excavation	Rock Excavation
Total volume (cum)	65138	168061
Time period (months)	4	4
Shift proposed	2	2
Total operational hours (hour)	1100	1100
Volume to be handled in-situ (cum/hour)	59	153
Volume to be handled loose (cum/hour)	75	245
Total quantity	**= 74+245~ 320** cum/hour	

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0 cum hydraulic excavators assisted by 180 hp bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with

hole patterns of about 2.75 m^2 and drilling the accessible areas by crawler drill.

- Loading of blasted rock by 2.0 cum hydraulic excavator, shovel attachment and assisted by 180 hp dozers.
- Transportation to the disposal areas/main dam by 25t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.3.2 (b) Concreting

For concreting of main dam and appurtenant structures, total quantity of the order of 331967 cum, will have to be placed. A period of 27 months excluding monsoon period has been planned for the placement. The peak rate of placement works out to 35 cum/hour approximately. The concrete required for main dam is proposed to be produced in a centralized Batching and Mixing Plant of capacity 60 cum/hour. The plant shall be located in the vicinity of the dam. In addition, one numbers mobile batching & mixing plant each of capacity, 18 cum/hour will be provided. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity.

Following construction equipments have been considered for concreting of main dam and appurtenant structures:

- Placing of concrete with the help of 2 Nos. tower cranes, 6 ton @ 40 metre radius are proposed to be deployed at suitable locations. In addition, 2 Nos. 25 cum/hr concrete pumps with 25 m boom will be used for concrete placement.
- Concrete transportation by transit mixers of 4.5 cum capacity.
- Batching and mixing plant of capacity 60 cum/hr to be located preferably within a radius of 1 km from the concrete dam.
- The aggregate crushing and screening plant of 180 tph for preparation of coarse and fine aggregates.

10.4.3.2(c) List of Major Construction Plant and Equipment for Concrete Dam

Based on above construction methodology, major construction plant and equipment required for construction of concrete dam are listed below.

S. N0.	Equipments	Size/capacity		Quantity
1.	Hyd. Excavator	2	cum	3
2.	Hyd. Excavator	1	cum	0
3.	Loader, side dump	1.5	cum	1
4.	Dumper	25	T	11
5.	wagon drill	550	cfm	2
6.	Jack hammer	120	cfm	8
7.	Air requirment		cfm	1800
8.	Tower Crane	6T@40m		2
9.	Dozer	180	HP	3
10.	B&M Plant	60	cum/hr	1
11.	mobile B&M Plant	18	cum/hr	1
12.	APP	180	TPH	1
13.	Transit Mixer	4.5	cum	3
14.	Concrete pump	25	cum/hr	2
15.	Grout Pump	20	Kg/cm^2	2
16.	Mobile crane	16	Ton	2
17.	Truck	8/10	Ton	3

10.4.3.2 (d) Construction Programme

The sequence of construction of concrete dam takes into account the following aspects:

- Surface excavation of concrete dam to start during the 3rd quarter of Year 2.
- The total quantity of excavation to be completed in a period of 4 months. The activity to be completed by the mid of 4th quarter of year 2.
- Concreting to start in the 1st quarter of Year 3 and will continue for 3 working seasons and to be completed by the the 3rd quarter of year 6.
- Since a part of over-flow section (two blocks) is to be used for diversion of river during construction of earth dam, the phasing of

concerting is to be planned in such a way that the work of these two blocks is completed during lean season.

- Gate installation work to start in the beginning of 1st quarter of year 6 and will be completed by the end of 3rd quarter of Year 7.

10.4.3.3 Paikhed Dam Power House

10.4.3.3(a) Excavation and Concreting

Main activities to be undertaken for construction of power house are surface excavations and concreting along with erection of electro-mechanical equipment. The quantities involved in the dam power house complex are indicated below:

S. No.	Description	Quantity (cum)
1	Surface excavations	
	a) Common Excavation	10,320
	b) Rock excavation	433,037
2	Concreting	31,582

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 25t rear end dumpers.
- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.

- Concrete production in a moving Batching and mixing plant of capacity 18 cum/hr.

- The aggregate crushing and screening plant of 180 tph for preparation of coarse and fine aggregates.
- Mobile crane of 16t is to be utilized for handling of construction material, shutter forms etc.

10.4.3.3(b) List of Major Construction Plant and Equipment for Power House

No separate equipment for construction of powerhouse complex has been provided as equipment deployed for concrete dam shall be utilized for construction of power house.

10.4.3.3 (c) Construction Programme

As the excavation quantities are not much, a period of 6 months has been planned beginning in the 3rd quarter of year 6. The construction of the concrete structures will begin by mid of 4th quarter of Year 6 starting from the structures of the erection area. Almost 15 months have been considered necessary to complete the powerhouse.

All works including electro-mechanical works will be essentially completed by 3rd quarter of year 7.

10.4.4 Chasmandva Dam

10.4.4.1 Concrete Face Rock-Fill Dam (Chasmandva)

The construction of the dam involves surface excavation, placement of fill material, spreading & wetting and compaction of the fill material. Total quantity of Chasmandva excavation excluding OF and NOF section is about 1416844 cum. The excavation of 720418 cum quantity which does not involve blasting operation is considered as common excavation and remaining 696426 cum which requires blasting is considered as rock excavation. Following table describes quantities of different activities for the construction of dam:

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	179,078	cum

Excavation	Common	541340	cum
	Rock	696426	cum
Fill placement	Impervious material (1B)	282915	cum
	Processed fine filter (2A)	4267	cum
	fine grained with particle size upto 150 mm (1A)	103144	cum
	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	306011	cum
	300mm or less graded stone (3A)	499,141	cum
	800mm or less graded stone (3B)	3,461,531	cum
	1000mm or less graded stone (3C)	1,813,197	cum
	1000mm or more graded stone (3D)	143,722	cum
	rock-toe	22,941	cum
	Below and Behind rock-toe	11,470	cum

10.4.4.1 (a) Surface Excavation

The surface excavation for main dam involves both common and rock excavations. The volume of required excavation is given below

Volume of Surface Excavation

Type Description	Common excavation (cum)	Rock excavation (cum)
Stripping	179,078	Nil
River Bed Excavation	541340	696426
Total	720,418	696426

Duration of 2 months has been earmarked for undertaking stripping and a period of 6 months has been provided to undertake surface excavation pertaining to main dam. Although work in the river bed can be undertaken only after completion of river diversion work, the work of stripping can be taken up earlier. The requirement for which provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation for Stripping

Type Description	**Common Excavation (stripping)**
Total volume (cum)	179,078
Time period (months)	2
Shift proposed	2
Total operational hours (hour)	550
Volume to be handled in-situ (cum/hr)	326
Volume to be handled loose (cum/hr)	407

Estimation of hourly quantity of excavation (for River bed)

Type Description	**Common Excavation (River bed excavation only)**	**Rock Excavation**
Total volume (cum)	541,340	696426
Time period (months)	6	6
Shift proposed	2	2
Total operational hours (hour)	1650	1650
Volume to be handled in-situ (cum/hr)	348	422
Volume to be handled loose (cum/hr)	410	675
Total quantity=		**410+675**
Peak quantity =	**1085**	**cum/hour**

Following construction methods are proposed for surface excavations:

- Stripping and excavation for trenching & preparation of base of dam and loading of the soft material (earth and alluvium) by 2.0 cum hydraulic excavators assisted by 180 HP crawler dozer.
- Transportation to the disposal area by 25 t capacity rear dumper.
- A 180 HP bulldozer is also considered to stay in the disposal area for spreading of the unloaded materials.
- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1m c/c and 2.75 m c/c respectively to be deployed for drilling of charge holes.

10.4.4.1 (b) Fill Placement

The construction of earth fill dam involves placement of **6648339** cum of fill materials. As per construction schedule the fill placement is to be undertaken in period of 24 months. The break-up of total quantity into different types of fill material to be placed in different zones and their expected source of supply is given below:

Quantities and source of fill material

Sr. No.	Fill Material	Quantity (compacted)
1	Impervious material (1B)	282915
2	Processed fine filter (2A)	4267
3	fine grained with particle size upto 150 mm (1A)	103144
4	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	306011
5	300mm or less graded stone (3A)	499,141
6	800mm or less graded stone (3B)	3,461,531
7	1000mm or less graded stone (3C)	1,813,197
8	1000mm or more graded stone (3D)	143,722
9	rock-toe	22,941
10	Below and Behind rock-toe	11,470
	TOTAL=	**6648339**

In the present case, since fill material is available within a distance of 1 kilometer and borrow areas are scattered over different locations, the conventional method of material transportation, i.e., hydraulic excavator-dumper combination has been considered for material transportation.

As mentioned above, the fill quantities are to be placed in one working seasons. The hourly placement quantities for hearting material have been worked out and indicated below:

(i) Impervious Material(Zone 1A,1B and 2A)

SN	Description	Quantity	Unit
1.	Total volume	390,326	cum
2.	Time period	8	month
3.	Shift proposed	2	-

4.	Operational hours/month	275	hour
5.	Total operational hours	2200	hour
6.	Volume to be handled (in-situ)	177	cum/hour
7.	Volume to be handled (loose)	284	cum/hour
8.	Peak quantity	354	cum/hour

Estimation of hourly quantity of hearting material placement

The following construction methods have been considered for hearting fill:

- Excavation and loading by means of 2.0 cum hydraulic excavator.
- Transport to the embankment by means of 25 t capacity Rear end dumpers.
- Spreading in layers up to 30 cm thick by 180 HP bulldoze.
- Moisture adjustment by 8000 L water sprinklers.
- Compaction by 8 passes of 10t pad foot vibrating roller.

An average distance of 0.5 km from dam site has been considered for the borrow areas for impervious material.

(ii) Fine Filter material Placement (zone 2B, 3A)

The fine filter will have a total volume of 805,152cum. The sand and gravel material is used to fill 2B, 3A zone of CFRD Dam. This quantity will be brought from quarries located at an average distance of 2 km from dam site. The material will be processed in a processing plant located suitably near the quarry itself. The sand and gravel material will be processed and brought to the dam site for placement.

Estimation of hourly quantity of fine filter material placement.

SN	Description	Quantity	Unit
1.	Total volume	805,152	cum
2.	Time period	32	month

3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8,800	hour
6.	Volume to be handled (in-situ)	92	cum/hour
7.	Volume to be handled (loose)	114	cum/hour
8.	Peak quantity	143	cum/hour

The following construction methods have been considered for the placement of fine filter:

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 250 TPH installed near the quarry.
- Loading by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading on the embankment in layers up to 30 cm thick by bulldozer with flywheel power of 180 HP.
- Compaction with 6 passes of 10t smooth drum vibratory roller.

(iii) Coarse Filter (Zone 3B)

The requirement of coarse filter which is going to be used in zone 3B filling is approximately 3,461,531cum. The same will be met from rock quarries. The rock will be transported to the placement site. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter material placement

SN	Description	Quantity	Unit
1.	Total volume	3,461,531	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8,800	hour
6.	Volume to be handled (in-situ)	394	cum/hour

7.	Volume to be handled (loose)	630	cum/hour
8.	Peak quantity	787	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of 2 no. of 750 TPH capacity installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 50 cm to 70cm layer thickness, by means of 180 HP flywheel power bulldozer.
- Compaction by 6 pass of 10t smooth drum vibrating rollers.

(iv) Rock material for Zone 3C,3D, Rock toe

The requirements of coarse filter which is going to be used in Rock toe and below Rock toe is approximately 1,991,330cum. The same will be met from rock quarries. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter and rock-toe material placement

SN	Description	Quantity	Unit
1.	Total volume	1,991,330	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8,800	hour

6.	Volume to be handled (in-situ)	226	cum/hour
7.	Volume to be handled (loose)	362	cum/hour
8.	Peak quantity	453	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.0cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 2 500 TPH installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 100 cm to 150cm layer thickness, by means of 324 HP flywheel power bulldozer.
- Compaction by 6 passes of 10t smooth drum vibrating rollers.

Concreting work on CFRD Dam like concreting of face slab, plinth etc can be done with the help of concrete pump of capacity 15 cum/hr with boom length of 25m. One moving type batch and mixing plant of capacity 18cum/hr may be deployed to meet the requirement of concrete.

10.4.4.1(c) List of Major Construction Plant and Equipment for CFRD Dam

Based on above methodology and equipment planning the list of equipment required for construction of Concrete Face Rock Fill Dam is given in the following table.

S. No.	Description	Size/capacity		Quantity
1.	Hyd. Excavator	2.0	cum	12
2.	Hyd. Excavator	1.0	cum	2
3.	Loader, frnt end	2.5	cum	14
4.	Loader, frnt end	1.5	cum	2
5.	Dumper	25	T	78
6.	wagon drill	550	cfm	6
7.	Jack hammer	120	cfm	25
8.	Air requirement		cfm	5200
9.	Filter Processing plant	200	TPH	1
10.	Filter Processing plant	250	TPH	1
11.	Filter Processing plant	750	TPH	3
12.	Dozer	180	HP	20
13.	Dozer	324	Hp	2
14.	Vibratory roller (Padfoot)	10	T	1
15.	Vibratory roller (smoothpad)	10	T	6
16.	Water Sprinkler	8000	liters	16
17.	Transit mixer	4.5	cum	2
18.	Concrete vibrator			3
19.	B&M plant(moving)	18	Cum/hr	1
20.	Concrete Pump	15	Cum/hr	1
26.	Grout Pump	20	Kg/cm^2	4
27.	Mobile crane	16	Ton	4
28.	Truck	8/10	Ton	8

10.4.4.1 (d) Construction Programme

The excavations for the dam will start from the abutments above river bed level in the 2th quarter of year 2 and will be completed within two months working period. Excavations in the river bed will start as soon as the work area in the river bed becomes dry. The dam foundation treatment, which includes consolidation grouting and curtain grouting, will start locally as the excavation is completed in that area.

Embankment construction will start by 3rd quarter of year 3, once the excavation and foundation preparation works in the river bed are sufficiently advanced. The period before the beginning of the embankment

construction shall be devoted to the preparation of the haul roads and development of the borrow area.

A total period of 32 months, excluding the monsoon period has been allowed for the completion of the dam embankment with the aim to reach crest elevation by the end of 2nd quarter of year 7.

10.4.4.2 Concrete Dam (Chasmandva)

Main activities to be undertaken for construction of concrete dam (over flow & non-over flow sections) are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden and rock excavation. The total quantity of concrete dam excavation is about 403659 cum, and total quantity of concreting is about 249153 cum.

Quantities involved in construction of concrete dam

(over flow & non-over flow)

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	-	cum
Excavation	Common	104476	cum
	Rock	299183	cum
	Total excavation	403659	cum
Concreting		249153	cum

10.4.4.2 (a) Surface Excavations

The surface excavations have been planned to be completed within 1 working seasons (5 months). The surface excavation for main dam involves both common and rock excavations. The excavated material will be transported to the disposal area using conventional excavator and rear dumper combination. The provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation

Description / Type	Common Excavation	Rock Excavation

Total volume (cum)	104476	299183
Time period (months)	5	5
Shift proposed	2	2
Total operational hours (hour)	1,375	1,375
Volume to be handled in-situ (cum/hour)	76	218
Volume to be handled loose (cum/hour)	95	345
Total quantity	**= 95+ 345 ~ 440** cum/hour	

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0 cum hydraulic excavators assisted by 180 hp bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 m^2 and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.5 cum hydraulic excavator, shovel attachment and assisted by 180 hp dozers.
- Transportation to the disposal areas/main dam by 25t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.4.2 (b) Concreting

For concreting of main dam and appurtenant structures, total quantity of the order of 249153 cum, will have to be placed. A period of 27 months excluding of monsoon period been planned for the placement. The peak rate of placement works out to 32 cum/hour approximately. The concrete required for main dam is proposed to be produced in a centralized Batching and Mixing Plant of capacity 60 cum/hour. The plant shall be located in the vicinity of the dam. In addition, one mobile batching & mixing plant of capacity, 18 cum/hour will be provided. The concrete from

the plant will be transported with the help of transit mixers, 4.5 cum capacity.

Following construction equipments have been considered for concreting of main dam and appurtenant structures:

- Placing of concrete with the help of 2 Nos. tower cranes, 6 ton @ 40 metre radius are proposed to be deployed at suitable locations. In addition, 2 Nos. 25 cum/hr concrete pumps with 25 m boom will be used for concrete placement.
- Concrete transportation by transit mixers of 4.5 cum capacity.
- Batching and mixing plant of capacity 60 cum/hr to be located preferably within a radius of 1 km from the concrete dam.
- The aggregate crushing and screening plant of 180 TPH for preparation of coarse and fine aggregates.

10.4.4.2(c) List of Major Construction Plant and Equipment for Concrete Dam

Based on above construction methodology, major construction plant and equipment required for construction of concrete dam are listed below.

S. N0.	Equipments	Size/capacity		Quantity
1.	Hyd. Excavator	2	cum	4
2.	Hyd. Excavator	1	cum	0
3.	Loader, side dump	1.5	cum	1
4.	Dumper	25	T	13
5.	wagon drill	550	cfm	3
6.	Jack hammer	120	cfm	14
7.	Air requirment		cfm	2500
8.	Tower Crane	6T@40m		2
9.	Dozer	180	HP	3
10.	B&M Plant	60	cum/hr	1
11.	mobile B&M Plant	18	cum/hr	1
12.	APP	180	TPH	1
13.	Transit Mixer	4.5	cum	3
14.	Concrete pump	25	cum/hr	2
15.	Grout Pump	20	Kg/cm^2	2
16.	Mobile crane	16	Ton	2

17.	Truck	8/10	Ton	3

10.4.4.2 (d) Construction Programme

The sequence of construction of concrete dam takes into account the following aspects:

- Surface excavation of concrete dam to start during the 3rd quarter of Year 2.
- The total quantity of excavation to be completed in a period of 6 months. The activity to be completed by the end of 4th quarter of year 2.
- Concreting to start in the 1st quarter of Year 3 and will continue for 3 working seasons and to be completed by the 3rd quarter of year 6.
- Since a part of over-flow section (two blocks) is to be used for diversion of river during construction of earth dam, the phasing of concerting is to be planned in such a way that the work of these two blocks is completed during lean season.
- Gate installation work to start in the beginning of 1st quarter of year 6 and will be completed by the end of 3rd quarter of Year 7.

10.4.4.3 Chasmandva Dam Power House

10.4.4.3(a) Excavation and Concreting

Main activities to be undertaken for construction of power house are surface excavations and concreting along with erection of electro-mechanical equipment. The quantities involved in the dam power house complex are indicated below:

S. No.	Description	Quantity (cum)
1	Surface excavations	
	a) Common Excavation	3,851
	b) Rock excavation	54,994
2	Concreting	6,060

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 25t rear end dumpers.
- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a moving Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 180 tph for preparation of coarse and fine aggregates.
- Mobile crane of 16t is to be utilized for handling of construction material, shutter forms etc.

10.4.4.3 (b) List of Major Construction Plant and Equipment for Power House

No separate equipment for construction of powerhouse complex has been provided as equipment deployed for concrete dam shall be utilized for construction of power house.

10.4.4.3 (c) Construction Programme

As the excavation quantities are not much, a period of 3 months has been planned beginning in the 3rd quarter of year 6. The construction of the concrete structures will begin by the 4th quarter of Year 6 starting from the structures of the erection area. Almost 15 months have been considered necessary to complete the powerhouse.

All works including electro-mechanical works will be essentially completed by 3rd quarter of year 7.

10.4.5 Chikkar Dam

10.4.5.1 Concrete Face Rock-Fill Dam (Chikkar)

The construction of the dam involves surface excavation, placement of fill material, spreading & wetting and compaction of the fill material. Total quantity of Chikkar excavation excluding OF and NOF section is about 1397914 cum. The excavation of 582464 cum quantity which does not involve blasting operation is considered as common excavation and remaining 815450 cum which requires blasting is considered as rock excavation. Following table describes the quantities of different activities for the construction of dam.

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	109,212	cum
Excavation	Common	473252	cum
	Rock	815450	cum
Fill placement	Impervious material (1B)	176925	cum
	Processed fine filter (2A)	9785	cum
	fine grained with particle size upto 150 mm (1A)	74393	cum
	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	215816	cum
	300mm or less graded stone (3A)	331,434	cum
	800mm or less graded stone (3B)	2,868,597	cum
	1000mm or less graded stone (3C)	1,566,138	cum
	1000mm or more graded stone (3D)	98,396	cum
	rock-toe	22,941	cum
	Below and Behind rock-toe	11,470	cum

10.4.5.1 (a) Surface Excavation

The surface excavation for main dam involves both common and rock excavations. The volume of required excavation is given below:

Volume of Surface Excavation

Type Description	Common excavation (cum)	Rock excavation (cum)
Stripping	109,212	Nil
River Bed Excavation	473252	815450
Total	582,464	815450

Duration of 2 months has been earmarked for undertaking stripping and a period of 7 months has been provided to undertake surface excavation pertaining to main dam. Although work in the river bed can be undertaken only after completion of river diversion work, the work of stripping can be taken up earlier. The requirement for which provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation for Stripping

Type Description	Common Excavation (stripping)
Total volume (cum)	109,212
Time period (months)	2
Shift proposed	2
Total operational hours (hour)	550
Volume to be handled in-situ (cum/hr)	198
Volume to be handled loose (cum/hr)	250

Estimation of hourly quantity of excavation (for River bed)

Type Description	Common Excavation (River bed excavation only)	Rock Excavation

Total volume (cum)	473,252	815450
Time period (months)	7	7
Shift proposed	2	2
Total operational hours (hour)	1925	1925
Volume to be handled in-situ (cum/hr)	246	424
Volume to be handled loose (cum/hr)	307.3	677.8
Total quantity=		**307.3+677.8**
Peak quantity =	**985.1**	**cum/hour**

Following construction methods are proposed for surface excavations:

- Stripping and excavation for trenching & preparation of base of dam and loading of the soft material (earth and alluvium) by 2.0 cum hydraulic excavators assisted by 180 HP crawler dozer.
- Transportation to the disposal area by 25 t capacity rear dumper.
- A 180 HP bulldozer is also considered to stay in the disposal area for spreading of the unloaded materials.
- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1m c/c and 2.75 m c/c respectively to be deployed for drilling of charge holes.

10.4.5.1 (b) Fill Placement

The construction of earth fill dam involves placement of **5375895** cum of fill materials. As per construction schedule the fill placement is to be undertaken in period of 24 months. The break-up of total quantity into different types of fill material to be placed in different zones and their expected source of supply is given below:

Quantities and source of fill material

Sr. No.	Fill Material	Quantity (compacted)	Average distance of borrow area/quarry (km)

1	Impervious material (1B)	176925	2
2	Processed fine filter (2A)	9785	2
3	fine grained with particle size upto 150 mm (1A)	74393	2
4	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	215816	1
5	300mm or less graded stone (3A)	331,434	2
6	800mm or less graded stone (3B)	2,868,597	2
7	1000mm or less graded stone (3C)	1,566,138	2
8	1000mm or more graded stone (3D)	98,396	2
9	rock-toe	22,941	1
10	Below and Behind rock-toe	11,470	1
	TOTAL=	**5375895**	**cum**

In the present case, since fill material is available within a distance of 1 kilometer and borrow areas are scattered over different locations, the conventional method of material transportation, i.e., hydraulic excavator-dumper combination has been considered for material transportation.

As mentioned above, the fill quantities are to be placed in one working seasons. The hourly placement quantities for hearting material have been worked out and indicated below:

(i) Impervious Material(Zone 1A,1B and 2A)

SN	Description	Quantity	Unit
1.	Total volume	261,103	cum
2.	Time period	8	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	2200	hour
6.	Volume to be handled (in-situ)	118	cum/hour
7.	Volume to be handled (loose)	188	cum/hour
8.	Peak quantity	236	cum/hour

Estimation of hourly quantity of hearting material placement

The following construction methods have been considered for hearting fill:

- Excavation and loading by means of 2.0 cum hydraulic excavator.
- Transport to the embankment by means of 25 t capacity Rear end dumpers.
- Spreading in layers up to 30 cm thick by 180 HP bulldoze.

- Moisture adjustment by 8000 L water sprinklers.
- Compaction by 8 passes of 10t pad foot vibrating roller.

An average distance of 0.5 km from dam site has been considered for the borrow areas for impervious material.

(ii) Fine Filter material Placement (zone 2B, 3A)

The fine filter will have a total volume of 547,250 cum. The sand and gravel material is used to fill 2A zone of CFRD Dam. This quantity will be brought from quarries located at an average distance of 2 km from dam site. The material will be processed in a processing plant located suitably near the quarry itself. The sand and gravel material will be processed and brought to the dam site for placement.

The hourly rate at which placement of filter is to be carried out has been estimated below.

Estimation of hourly quantity of fine filter material placement.

SN	Description	Quantity	Unit
1.	Total volume	547,250	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8800	hour
6.	Volume to be handled (in-situ)	63	cum/hour

7.	Volume to be handled (loose)	78	cum/hour
8.	Peak quantity	99	cum/hour

The following construction methods have been considered for the placement of fine filter:

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 250 tph installed near the quarry.
- Loading by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading on the embankment in layers up to 30 cm thick by bulldozer with flywheel power of 180 HP.
- Compaction with 6 passes of 10t smooth drum vibratory roller.

(iii) Coarse Filter (Zone 3B)

The requirement of coarse filter which is going to be used in zone 3B filling is approximately 2,868,597cum. The same will be met from rock quarries. The rock will be transported to the placement site. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter material placement

SN	Description	Quantity	Unit
1.	Total volume	2,868,597	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8800	hour
6.	Volume to be handled (in-situ)	326	cum/hour
7.	Volume to be handled (loose)	522	cum/hour
8.	Peak quantity	652	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of 1 no. of 750 TPH and 1 no. of 500TPH capacity installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 50 cm to 70cm layer thickness, by means of 180 HP flywheel power bulldozer.
- Compaction by 6 pass of 10t smooth drum vibrating rollers.

(iv) Rock material for Zone 3C, 3D, Rock toe

The requirements of coarse filter which is going to be used in Rock toe and below Rock toe is approximately 1,698,945 cum. The same will be met from rock quarries. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter and rock-toe material placement

SN	Description	Quantity	Unit
1.	Total volume	1,698,945	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	8,800	hour
6.	Volume to be handled (in-situ)	193	cum/hour
7.	Volume to be handled (loose)	308	cum/hour
8.	Peak quantity	395	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.5 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.

- Processing at the filter processing plant of capacity, 1 no. 750 TPH installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 100 cm to 150cm layer thickness, by means of 324 HP flywheel power bulldozer.
- Compaction by 6 passes of 10t smooth drum vibrating rollers.

Concreting work on CFRD Dam like concreting of face slab, plinth etc can be done with the help of concrete pump of capacity 15 cum/hr with boom length of 25m. One moving type batch and mixing plant of capacity 18cum/hr may be deployed to meet the requirement of concrete.

10.4.5.1(c) List of Major Construction Plant and Equipment for CFRD Dam

Based on above methodology and equipment planning the list of equipment required for construction of Concrete Face Rock Fill Dam (Chasmandva) is given in the following table.

S. No.	Description	Size/ capacity		Quantity
1.	Hyd. Excavator	2.0	cum	11
2.	Hyd. Excavator	1.0	cum	2
3.	Loader, frnt end	2.5	cum	13
4.	Loader, frnt end	1.5	cum	2
5.	Dumper	25	T	74
6.	wagon drill	550	cfm	5
7.	Jack hammer	120	cfm	21

S. No.	Description	Size/ capacity		Quantity
8.	Air requirement		cfm	4600
9.	Filter Processing plant	200	TPH	1
10.	Filter Processing plant	500	TPH	1
11.	Filter Processing plant	750	TPH	2
12.	Dozer	180	HP	18
13.	Dozer	324	Hp	2
14.	Vibratory roller (Padfoot)	10	T	1
15.	Vibratory roller (smoothpad)	10	T	4
16.	Water Sprinkler	8000	liters	14
17.	Transit mixer	4.5	cum	2
18.	Concrete vibrator			3
19.	B&M plant(moving)	18	Cum/hr	1
20.	Concrete Pump	15	Cum/hr	1
21.	Grout Pump	20	Kg/cm^2	4
22.	Mobile crane	16	Ton	4
23.	Truck	8/10	Ton	8

10.4.5.1 (d) Construction Programme

The excavations for the dam will start from the abutments above river bed level in the 2nd quarter of year 2 and will be completed within three months working period. Excavations in the river bed will start as soon as the work area in the river bed becomes dry. The dam foundation treatment, which includes consolidation grouting and curtain grouting, will start locally as the excavation is completed in that area.

Embankment construction will start by 3rd quarter of year 3, once the excavation and foundation preparation works in the river bed are sufficiently advanced. The period before the beginning of the embankment construction shall be devoted to the preparation of the haul roads and development of the borrow area.

A total period of 32 months, excluding the monsoon period has been allowed for the completion of the dam embankment with the aim to reach crest elevation by the end of 2nd quarter of year 7.

10.4.5.2 Concrete Dam (Chikkar)

Main activities to be undertaken for construction of concrete dam (over flow & non-over flow sections) are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden and rock excavation. The total quantity of concrete dam excavation is about 553819 cum, and total quantity of concreting is about 311774 cum.

Quantities involved in construction of concrete dam (over flow & non-over flow)

Description of Work	**Type / Material**	**Quantity, in-situ**	**Unit**
Stripping	-	-	cum
Excavation	Common	143855	cum
	Rock	409964	cum
	Total excavation	553819	cum
Concreting		311774	cum

10.4.5.2 (a) Surface Excavations

The surface excavations have been planned to be completed within 1 working seasons (6 months). The surface excavation for main dam involves both common and rock excavations. The excavated material will be transported to the disposal area using conventional excavator and rear dumper combination. The provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation

Type **Description**	**Common Excavation**	**Rock Excavation**
Total volume (cum)	143855	409964
Time period (months)	6	6
Shift proposed	2	2
Total operational hours (hour)	1650	1650
Volume to be handled in-situ (cum/hour)	87	248
Volume to be handled loose (cum/hour)	109	397

Total quantity	**= 109 + 397 ~ 506** cum/hour

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0 cum hydraulic excavators assisted by 180 hp bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 m^2 and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.5 cum hydraulic excavator, shovel attachment and assisted by 180 hp dozers.
- Transportation to the disposal areas/main dam by 25t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.5.2 (b) Concreting

For concreting of main dam and appurtenant structures, total quantity of the order of 311774 cum, will have to be placed. A period of 27 months excluding monsoon period been planned for the placement. The rate of placement works out to 33 cum/hour approximately. The concrete required for main dam is proposed to be produced in a centralized Batching and Mixing Plant of capacity 60 cum/hour. The plant shall be located in the vicinity of the dam. In addition, one numbers mobile batching & mixing plant of capacity, 18 cum/hour will be provided. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity.

Following construction equipments have been considered for concreting of main dam and appurtenant structures:

- Placing of concrete with the help of 2 Nos. tower cranes, 6 ton @ 40 metre radius are proposed to be deployed at suitable locations. In addition, 2 Nos. 25 cum/hr concrete pumps with 25 m boom will be used for concrete placement.
- Concrete transportation by transit mixers of 4.5 cum capacity.

- Batching and mixing plant of capacity 60 cum/hr to be located preferably within a radius of 2 km from the concrete dam.
- The aggregate crushing and screening plant of 180 tph for preparation of coarse and fine aggregates.

10.4.5.2 (c) List of Major Construction Plant and Equipment for Concrete Dam

Based on above construction methodology, major construction plant and equipment required for construction of concrete dam are listed below.

S. No.	Equipments	Size/capacity		Quantity
1.	Hyd. Excavator	2	cum	4
2.	Hyd. Excavator	1	cum	0
3.	Loader, side dump	1.5	cum	1
4.	Dumper	25	T	17
5.	wagon drill	550	cfm	3
6.	Jack hammer	120	cfm	16
7.	Air requirment		cfm	3000
8.	Tower Crane	6T@40m		2
9.	Dozer	180	HP	3
10.	B&M Plant	60	cum/hr	1
11.	mobile B&M Plant	18	cum/hr	1
12.	APP	180	TPH	1
13.	Transit Mixer	4.5	cum	4
14.	Concrete pump	25	cum/hr	2
15.	Grout Pump	20	Kg/cm^2	2
16.	Mobile crane	16	Ton	2
17.	Truck	8/10	Ton	3

10.4.5.2 (d) Construction Programme

The sequence of construction of concrete dam takes into account the following aspects:

- Surface excavation of concrete dam to start during the 4^{th} quarter of Year 2.

- The total quantity of excavation to be completed in a period of 6 months. The activity to be completed by the end of 1st quarter of year 3.
- Concreting to start in the 1st quarter of Year 3 and will continue for 3 working seasons and to be completed by the 3rd quarter of year 6.
- Since a part of over-flow section (two blocks) is to be used for diversion of river during construction of earth dam, the phasing of concerting is to be planned in such a way that the work of these two blocks is completed during lean season.
- Gate installation work to start in the beginning of 1st quarter of year 6 and will be completed by the end of 3rd quarter of Year 7.

10.4.5.3 Chikkar Dam Power House

10.4.5.3 (a) Excavation and Concreting

Main activities to be undertaken for construction of power house are surface excavations and concreting along with erection of electro-mechanical equipment. The quantities involved in the dam power house complex are indicated below:

S. No.	Description	Quantity (cum)
1	Surface excavations	
	a) Common Excavation	5,287
	b) Rock excavation	201,763
2	Concreting	7,540

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.

- Transportation to the disposal areas by 25t rear end dumpers.
- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a moving Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 180 tph for preparation of coarse and fine aggregates.
- Mobile crane of 16t is to be utilized for handling of construction material, shutter forms etc.

10.4.5.3 (b) List of Major Construction Plant and Equipment for Power House

No separate equipment for construction of powerhouse complex has been provided as equipment deployed for concrete dam shall be utilized for construction of power house.

10.4.5.3(c) Construction Programme

As the excavation quantities are not much, a period of 3 months has been planned beginning in the 3rd quarter of year 6. The construction of the concrete structures will begin by the 4th quarter of Year 6 starting from the structures of the erection area. Almost 15 months have been considered necessary to complete the powerhouse.

All works including electro-mechanical works will be essentially completed by 3rd quarter of year 7.

10.4.6 Dabdar Dam

10.4.6.1 Concrete Face Rock-Fill Dam (Dabdar)

The construction of the dam involves surface excavation, placement of fill material, spreading & wetting and compaction of the fill material. Total quantity of Dabdar excavation excluding OF and NOF section is about 2376516 cum. The excavation of 789459 cum quantity which does not involve blasting operation is considered as common excavation and

remaining 1587057 cum which requires blasting is considered as rock excavation. Following Table describes the quantities of different activities for the construction of dam.

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	97,665	cum
Excavation	Common	691794	cum
	Rock	1587057	cum
Fill placement	Impervious material (1B)	104811	cum
	Processed fine filter (2A)	5938	cum
	fine grained with particle size upto 150 mm (1A)	39976	cum
	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	217022	cum
	300mm or less graded stone (3A)	280,812	cum
	800mm or less graded stone (3B)	3,455,102	cum
	1000mm or less graded stone (3C)	1,942,842	cum
	1000mm or more graded stone (3D)	98,029	cum
	rock-toe	22,941	cum
	Below and Behind rock-toe	11,470	cum

10.4.6.1(a) Surface Excavation

The surface excavation for main dam involves both common and rock excavations. The volume of required excavation is given below:

Volume of Surface Excavation

Type Description	Common excavation (cum)	Rock excavation (cum)
Stripping	97,665	Nil
River Bed Excavation	691794	1587057
Total	789,459	1587057

Duration of 2 months has been earmarked for undertaking stripping and a period of 12 months has been provided to undertake surface excavation pertaining to main dam. The requirement for which provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation for Stripping

Type **Description**	**Common Excavation (stripping)**
Total volume (cum)	97,665
Time period (months)	2
Shift proposed	2
Total operational hours (hour)	5500
Volume to be handled in-situ (cum/hr)	178
Volume to be handled loose (cum/hr)	222

Estimation of hourly quantity of excavation (for River bed)

Type **Description**	**Common Excavation (River bed excavation only)**	**Rock Excavation**
Total volume (cum)	691,794	1587057
Time period (months)	12	12
Shift proposed	2	2
Total operational hours (hour)	3300	3300
Volume to be handled in-situ (cum/hr)	209	481
Volume to be handled loose (cum/hr)	262	770
Peak	315	925
Total quantity=		**315+925**
Peak quantity =	**1240**	**cum/hour**

Following construction methods are proposed for surface excavations:

- Stripping and excavation for trenching & preparation of base of dam and loading of the soft material (earth and alluvium) by 2.0 cum hydraulic excavators assisted by 180 HP crawler dozer.
- Transportation to the disposal area by 25 t capacity rear dumper.

- A 180 HP bulldozer is also considered to stay in the disposal area for spreading of the unloaded materials.
- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1m c/c and 2.75 m c/c respectively to be deployed for drilling of charge holes.

10.4.6.1 (b) Fill Placement

The construction of earth fill dam involves placement of 6178943 cum of fill materials. As per construction schedule the fill placement is to be undertaken in period of 24 months. The break-up of total quantity into different types of fill material to be placed in different zones and their expected source of supply is given below:

Quantities and source of fill material

Sr. No.	Fill Material	Quantity (compacted)	Average distance of borrow area/quarry (km)
1	Impervious material (1B)	104811	2
2	Processed fine filter (2A)	5938	2
3	fine grained with particle size upto 150 mm (1A)	39976	2
4	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	217022	1
5	300mm or less graded stone (3A)	280,812	2
6	800mm or less graded stone (3B)	3,455,102	2
7	1000mm or less graded stone (3C)	1,942,842	2
8	1000mm or more graded stone (3D)	98,029	2
9	rock-toe	22,941	1
10	Below and Behind rock-toe	11,470	1
	TOTAL=	**6178943**	**cum**

In the present case, since fill material is available within a distance of 1 kilometer and borrow areas are scattered over different locations, the conventional method of material transportation, i.e., hydraulic excavator-dumper combination has been considered for material transportation.

As mentioned above, the fill quantities are to be placed in one working seasons. The hourly placement quantities for hearting material have been worked out and indicated below:

(i) Impervious Material (Zone 1A,1B and 2A)

SN	Description	Quantity	Unit
1.	Total volume	150,725	cum
2.	Time period	8	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	2200	hour
6.	Volume to be handled (in-situ)	69	cum/hour
7.	Volume to be handled (loose)	109	cum/hour
8.	Peak quantity	135	cum/hour

The following construction methods have been considered for hearting fill:

- Excavation and loading by means of 2.0 cum hydraulic excavator.
- Transport to the embankment by means of 25 t capacity Rear end dumpers.
- Spreading in layers up to 30 cm thick by 180 HP bulldoze.
- Moisture adjustment by 8000 L water sprinklers.
- Compaction by 8 passes of 10t pad foot vibrating roller.

An average distance of 0.5 km from dam site has been considered for the borrow areas for impervious material.

(ii) Fine Filter material Placement(zone 2B, 3A)

The fine filter will have a total volume of 497,834 cum. The sand and gravel material is used to fill 2B, 3A zone of CFRD Dam. This quantity will be brought from quarries located at an average distance of 2 km from dam site. The material will be processed in a processing plant located suitably near the quarry itself. The sand and gravel material will be processed and brought to the dam site for placement.

The hourly rate at which placement of filter is to be carried out has been estimated below.

Estimation of hourly quantity of fine filter material placement.

SN	Description	Quantity	Unit
1.	Total volume	497,834	cum
2.	Time period	28	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	7700	hour
6.	Volume to be handled (in-situ)	64	cum/hour
7.	Volume to be handled (in-situ)	80	cum/hour
8.	Peak quantity	101	cum/hour

The following construction methods have been considered for the placement of fine filter:

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 200 TPH installed near the quarry.
- Loading by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading on the embankment in layers up to 30 cm thick by bulldozer with flywheel power of 180 HP.
- Compaction with 6 passes of 10t smooth drum vibratory roller.

(iii) Coarse Filter (Zone 3B)

The requirement of coarse filter which is going to be used in zone 3B filling is approximately 3,455,102cum. The same will be met from rock quarries. The rock will be transported to the placement site. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter material placement

SN	Description	Quantity	Unit
1.	Total volume	3,455,102	cum
2.	Time period	28	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour

5.	Total operational hours	7700	hour
6.	Volume to be handled (in-situ)	448	cum/hour
7.	Volume to be handled (in-situ)	718	cum/hour
8.	Peak quantity	897	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of 2 no. of 750 tph and 1 no. of 250 Tph capacity installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 50 cm to 70cm layer thickness, by means of 180 HP flywheel power bulldozer.
- Compaction by 6 pass of 10t smooth drum vibrating rollers.

(v) Rock material for Zone 3C,3D, Rock toe

The requirements of coarse filter which is going to be used in Rock toe and below Rock toe is approximately 2,075,282. The same will be met from rock quarries. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter and rock-toe material placement

SN	Description	Quantity	Unit
1.	Total volume	2,075,282	cum
2.	Time period	29	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour

5.	Total operational hours	7,700	hour
6.	Volume to be handled (in-situ)	269	cum/hour
7.	Volume to be handled (in-situ)	432	cum/hour
8.	Peak quantity	540	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 2 nos 500 PH installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 100 cm to 150cm layer thickness, by means of 324 HP flywheel power bulldozer.
- Compaction by 6 passes of 10t smooth drum vibrating rollers.

Concreting work on CFRD Dam like concreting of face slab, plinth etc can be done with the help of concrete pump of capacity 15 cum/hr with boom length of 25m. One moving type batch and mixing plant of capacity 18cum/hr may be deployed to meet the requirement of concrete.

10.4.6.1(c) List of Major Construction Plant and Equipment for CFRD Dam

Based on above methodology and equipment planning the list of equipment required for construction of Concrete Face Rock Fill Dam is given in the following table.

S. No.	Description	Size/capacity		Quantity
1.	Hyd. Excavator	2.0	cum	13
2.	Hyd. Excavator	1.0	cum	2
3.	Loader, frnt end	2.5	cum	16
4.	Loader, frnt end	1.5	cum	2
5.	Dumper	25	T	96
6.	wagon drill	550	cfm	7
7.	Jack hammer	120	cfm	29
8.	Air requirement		cfm	6000
9.	Filter Processing plant	200	TPH	2
10.	Filter Processing plant	500	TPH	2
11.	Filter Processing plant	750	TPH	2
12.	Dozer	180	HP	22
13.	Dozer	324	Hp	2
14.	Vibratory roller (Padfoot)	10	T	1
15.	Vibratory roller (smoothpad)	10	T	6
16.	Water Sprinkler	8000	liters	16
17.	Transit mixer	4.5	cum	3
18.	Concrete vibrator			3
19.	B&M plant(moving)	18	Cum/hr	1
20.	Concrete Pump	15	Cum/hr	1
21.	Grout Pump	20	Kg/cm^2	4
22.	Mobile crane	16	Ton	4
23.	Truck	8/10	Ton	8

10.4.6.1 (d) Construction Programme

The excavations for the dam will start from the abutments above river bed level in the 2th quarter of year 2 and will be completed within two months working period. Excavations in the river bed will start as soon as the work area in the river bed becomes dry. The dam foundation treatment, which includes consolidation grouting and curtain grouting, will start locally as the excavation is completed in that area.

Embankment construction will start by 4th quarter of year 3, once the excavation and foundation preparation works in the river bed are sufficiently advanced. The period before the beginning of the embankment

construction shall be devoted to the preparation of the haul roads and development of the borrow area.

A total period of 28 months, excluding the monsoon period has been allowed for the completion of the dam embankment with the aim to reach crest elevation by the end of 2nd quarter of year 7.

10.4.6.2 Concrete Dam (Dabdar)

Main activities to be undertaken for construction of concrete dam (over flow & non-over flow sections) are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden and rock excavation. The total quantity of concrete dam excavation is about 311336 cum, and total quantity of concreting is about 400926 cum.

Quantities involved in construction of concrete dam (over flow & non-over flow)

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	-	cum
Excavation	Common	83719	cum
	Rock	227617	cum
	Total excavation	311336	cum
Concreting		400926	cum

10.4.6.2 (a) Surface Excavations

The surface excavations have been planned to be completed within 1 working seasons (3 months). The surface excavation for main dam involves both common and rock excavations. The excavated material will be transported to the disposal area using conventional excavator and rear dumper combination. The provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation

Type Description	Common Excavation	Rock Excavation
Total volume (cum)	83719	227617
Time period (months)	5	5
Shift proposed	2	2
Total operational hours (hour)	1375	1375
Volume to be handled in-situ (cum/hour)	61	166
Volume to be handled loose (cum/hour)	76	265
Total quantity	**= 76 + 265 ~ 341** cum/hour	

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0 cum hydraulic excavators assisted by 180 hp bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 m^2 and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.5 cum hydraulic excavator, shovel attachment and assisted by 180 hp dozers.
- Transportation to the disposal areas/main dam by 25t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.6.2 (b) Concreting

For concreting of main dam and appurtenant structures, total quantity of the order of 400926 cum, will have to be placed. A period of 27 months excluding monsoon period has been planned for the placement. The peak rate of placement works out to 48 cum/hour approximately. The concrete

required for main dam is proposed to be produced in a centralized Batching and Mixing Plant of capacity 60 cum/hour. The plant shall be located in the vicinity of the dam. In addition, two numbers mobile batching & mixing plant each of capacity, 18 cum/hour will be provided. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity.

Following construction equipments have been considered for concreting of main dam and appurtenant structures:

- Placing of concrete with the help of 2 Nos. tower cranes, 6 ton @ 40 metre radius are proposed to be deployed at suitable locations. In addition, 2 Nos. 25 cum/hr concrete pumps with 25 m boom will be used for concrete placement.
- Concrete transportation by transit mixers of 4.5 cum capacity.
- Batching and mixing plant of capacity 60 cum/hr to be located preferably within a radius of 2 km from the concrete dam.
- The aggregate crushing and screening plant of 250 tph for preparation of coarse and fine aggregates.

10.4.6.2(c) List of Major Construction Plant and Equipment for Concrete Dam

Based on above construction methodology, major construction plant and equipment required for construction of concrete dam are listed below.

S. N0.	Equipments	Size/capacity		Quantity
1.	Hyd. Excavator	2	cum	3
2.	Hyd. Excavator	1	cum	0
3.	Loader, side dump	1.5	cum	1
4.	Dumper	25	T	13
5.	wagon drill	550	cfm	2
6.	Jack hammer	120	cfm	9
7.	Air requirment		cfm	1800
8.	Tower Crane	6T@40m		2
9.	Dozer	180	HP	3
10.	B&M Plant	60	cum/hr	1
11.	mobile B&M Plant	18	cum/hr	2
12.	APP	250	TPH	1

13.	Transit Mixer	4.5	cum	5
14.	Concrete pump	25	cum/hr	2
15.	Grout Pump	20	Kg/cm^2	2
16.	Mobile crane	16	Ton	2
17.	Truck	8/10	Ton	3

10.4.6.2 (d) Construction Programme

The sequence of construction of concrete dam takes into account the following aspects:

- Surface excavation of concrete dam to start during the 4th quarter of Year 2.
- The total quantity of excavation to be completed in a period of 5 months. The activity to be completed by the end of 4th quarter of year 2.
- Concreting to start in the 1st quarter of Year 3 and will continue for 3 working seasons and to be completed by the 3rd quarter of year 6.
- Since a part of over-flow section (two blocks) is to be used for diversion of river during construction of earth dam, the phasing of concerting is to be planned in such a way that the work of these two blocks is completed during lean season.
- Gate installation work to start in the beginning of 1st quarter of year 6 and will be completed by the end of 3rd quarter of Year 7.

10.4.6.3 Dabdar Dam Power House

10.4.6.3(a) Excavation and Concreting

Main activities to be undertaken for construction of power house are surface excavations and concreting along with erection of electro-mechanical equipment. The quantities involved in the dam power house complex are indicated below:

S. No.	Description	Quantity (cum)
1	Surface excavations	
	a) Common Excavation	1,308
	b) Rock excavation	10,724

2	Concreting	9,491

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 25t rear end dumpers.
- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a moving Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 250 tph for preparation of coarse and fine aggregates.
- Mobile crane of 16t is to be utilized for handling of construction material, shutter forms etc.

10.4.6.3(b)List of Major Construction Plant and Equipment for Power House

No separate equipment for construction of powerhouse complex has been provided as equipment deployed for concrete dam shall be utilized for construction of power house.

10.4.6.3(c) Construction Programme

As the excavation quantities are not much, a period of 3 months has been planned beginning in the 3rd quarter of year 6. The construction of the concrete structures will begin by the 4th quarter of Year 6 starting from the structures of the erection area. Almost 15 months have been considered

necessary to complete the powerhouse.

All works including electro-mechanical works will be essentially completed by 3rd quarter of year 7.

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10.4.7 Kelwan Dam

10.4.7.1 Concrete Face Rock-Fill Dam (Kelwan Dam)

The construction of the dam involves surface excavation, placement of fill material, spreading & wetting and compaction of the fill material. Total quantity of Jheri dam excavation excluding OF and NOF section is about 1827000 cum. The excavation of 675990 cum quantity which does not involve blasting operation is considered as common excavation and remaining 1151010 cum which requires blasting is considered as rock excavation. Following assumptions have been made while working out the quantities of different activities for the construction of dam

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	109,620	cum
Excavation	Common	566370	cum
	Rock	1151010	cum
Fill placement	Impervious material (1B)	112890	cum
	Processed fine filter (2A)	6757	cum
	fine grained with particle size upto 150 mm (1A)	42185	cum
	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	210780	cum
	300mm or less graded stone (3A)	289,590	cum
	800mm or less graded stone (3B)	3,159,590	cum
	1000mm or less graded stone (3C)	1,757,670	cum
	1000mm or more graded stone (3D)	99,134	cum

	rock-toe	22,941	cum
	Below and Behind rock-toe	11,470	cum

10.4.7.1 (a) Surface Excavation

The surface excavation for main dam involves both common and rock excavations. The volume of required excavation is given below:

Volume of Surface Excavation

Type Description	Common excavation (cum)	Rock excavation (cum)
Stripping	109,620	Nil
River Bed Excavation	566370	1151010
Total	675,990	1151010

Duration of 2 months has been earmarked for undertaking stripping and a period of 12 months has been provided to undertake surface excavation pertaining to main dam. Although work in the river bed can be undertaken only after completion of river diversion work, the work of stripping can be taken up earlier. The requirement for which provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation for Stripping

Type Description	Common Excavation (stripping)
Total volume (cum)	109,620
Time period (months)	2
Shift proposed	2
Total operational hours (hour)	550
Volume to be handled in-situ (cum/hr)	199
Volume to be handled loose (cum/hr)	249

Estimation of hourly quantity of excavation (for River bed)

Type Description	Common Excavation (River bed excavation only)	Rock Excavation
Total volume (cum)	566,370	1151010
Time period (months)	12	12
Shift proposed	2	2
Total operational hours (hour)	3300	3300
Volume to be handled in-situ (cum/hr)	171	348
Volume to be handled loose (cum/hr)	215	558
Peak quantities	258	698
Total quantity=		268+669
Peak quantity =	926	cum/hour

Following construction methods are proposed for surface excavations:

- Stripping and excavation for trenching & preparation of base of dam and loading of the soft material (earth and alluvium) by 2.0 cum hydraulic excavators assisted by 180 HP crawler dozer.
- Transportation to the disposal area by 25 t capacity rear dumper.
- A 180 HP bulldozer is also considered to stay in the disposal area for spreading of the unloaded materials.
- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1m c/c and 2.75 m c/c respectively to be deployed for drilling of charge holes.

10.4.7.1 (b) Fill Placement

The construction of earth fill dam involves placement of 5713007 cum of fill materials. As per construction schedule the fill placement is to be undertaken in period of 24 months. The break-up of total quantity into different types of fill material to be placed in different zones and their expected source of supply is given below:

Quantities and source of fill material

Sr. No.	Fill Material	Quantity (compacted)
1	Impervious material (1B)	112890
2	Processed fine filter (2A)	6757
3	fine grained with particle size upto 150 mm (1A)	42185
4	sand and gravel particles in grade of 0.074 to 76.2 mm (2B)	210780
5	300mm or less graded stone (3A)	289,590
6	800mm or less graded stone (3B)	3,159,590
7	1000mm or less graded stone (3C)	1,757,670
8	1000mm or more graded stone (3D)	99,134
9	rock-toe	22,941
10	Below and Behind rock-toe	11,470
	TOTAL=	**5713007**

In the present case, since fill material is available within a distance of 1 kilometer and borrow areas are scattered over different locations, the conventional method of material transportation, i.e., hydraulic excavator-dumper combination has been considered for material transportation.

As mentioned above, the fill quantities are to be placed in one working seasons. The hourly placement quantities for hearting material have been worked out and indicated below:

(i) Impervious Material(Zone 1A,1B and 2A)

Estimation of hourly quantity of hearting material placement

Sl.No	Description	Quantity	Unit
1.	Total volume	161,832	cum
2.	Time period	8	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	2200	hour
6.	Volume to be handled (in-situ)	74	cum/hour
7.	Volume to be handled (loose)	117	cum/hour
8.	Peak quantity	147	cum/hour

The following construction methods have been considered for hearting fill:

- Excavation and loading by means of 2.0 cum hydraulic excavator.
- Transport to the embankment by means of 25 t capacity Rear end dumpers.
- Spreading in layers up to 30 cm thick by 180 HP bulldoze.
- Moisture adjustment by 8000 L water sprinklers.
- Compaction by 8 passes of 10t pad foot vibrating roller.

An average distance of 0.5 km from dam site has been considered for the borrow areas for impervious material.

(ii) Fine Filter material Placement (zone 2B, 3A)

The fine filter will have a total volume of 500,370cum. The sand and gravel material is used to fill 2B, 3A zone of CFRD Dam. This quantity will be brought from quarries located at an average distance of 2 km from dam site. The material will be processed in a processing plant located suitably near the quarry itself. The sand and gravel material will be processed and brought to the dam site for placement.

The hourly rate at which placement of filter is to be carried out has been estimated below

Estimation of hourly quantity of fine filter material placement.

SN	Description	Quantity	Unit
1.	Total volume	500,370	cum
2.	Time period	28	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	7,700	hour
6.	Volume to be handled (in-situ)	65	cum/hour
7.	Volume to be handled (loose)	81	cum/hour
8	Peak quantity	101	cum/hour

The following construction methods have been considered for the placement of fine filter:

- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 200 TPH installed near the quarry.
- Loading by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading on the embankment in layers up to 30 cm thick by bulldozer with flywheel power of 180 HP.
- Compaction with 6 passes of 10t smooth drum vibratory roller.

(iii) Coarse Filter (Zone 3B)

The requirement of coarse filter which is going to be used in zone 3B filling is approximately 3,159,590 cum. The same will be met from rock quarries. The rock will be transported to the placement site. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter material placement

SN	Description	Quantity	Unit
1.	Total volume	3,159,590	cum
2.	Time period	24	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	7,700	hour
6.	Volume to be handled (in-situ)	410	cum/hour
7.	Volume to be handled (loose)	657	cum/hour
8.	Peak quantity	820	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.

- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.0 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of 2 no. of 750 TPH capacities installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 50 cm to 70cm layer thickness, by means of 180 HP flywheel power bulldozer.
- Compaction by 6 pass of 10t smooth drum vibrating rollers.

(iv) Rock material for Zone 3C,3D, Rock toe

The requirements of coarse filter which is going to be used in Rock toe and below Rock toe is approximately 1,891,215cum. The same will be met from rock quarries. The tables below shows the estimation of hourly quantities involved.

Estimation of hourly quantity of coarse filter and rock-toe material placement

SN	Description	Quantity	Unit
1.	Total volume	1,891,215	cum
2.	Time period	28	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hour
5.	Total operational hours	7,700	hour
6.	Volume to be handled (in-situ)	246	cum/hour
7.	Volume to be handled (loose)	393	cum/hour
8.	Peak quantity	492	cum/hour

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.

- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.5 cum hydraulic excavator and transportation up to filter processing plant by 25t capacity rear dumper.
- Processing at the filter processing plant of capacity, 750 tph installed at about 1 km to Dam Site.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 25t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 100 cm to 150cm layer thickness, by means of 324 HP flywheel power bulldozer.
- Compaction by 6 passes of 10t smooth drum vibrating rollers.

Concreting work on CFRD Dam like concreting of face slab, plinth etc can be done with the help of concrete pump of capacity 15 cum/hr with boom length of 25m. One moving type batch and mixing plant of capacity 18cum/hr may be deployed to meet the requirement of concrete.

10.4.7.1(c) List of Major Construction Plant and Equipment for CFRD Dam

Based on above methodology and equipment planning the list of equipment required for construction of Concrete Face Rock Fill Dam is given in the following table.

S. No.	Description	Size/capacity		Quantity
1.	Hyd. Excavator	2.0	cum	13
2.	Hyd. Excavator	1.0	cum	2
3.	Loader, frnt end	2.5	cum	14
4.	Loader, frnt end	1.5	cum	2
5.	Dumper	25	T	81
6.	wagon drill	550	cfm	6
7.	Jack hammer	120	cfm	26
8.	Air requirement		cfm	6500
9.	Filter Processing plant	200	TPH	1
10.	Filter Processing plant	500	TPH	2
11.	Filter Processing plant	750	TPH	2

S. No.	Description	Size/capacity		Quantity
12.	Dozer	180	HP	22
13.	Dozer	324	Hp	2
14.	Vibratory roller (Padfoot)	10	T	1
15.	Vibratory roller (smoothpad)	10	T	6
16.	Water Sprinkler	8000	liters	16
17.	Transit mixer	4.5	cum	3
18.	Concrete vibrator			3
19.	B&M plant(moving)	18	Cum/hr	1
20.	Concrete Pump	15	Cum/hr	1
21.	Grout Pump	20	Kg/cm^2	4
22.	Mobile crane	16	Ton	4
23.	Truck	8/10	Ton	8

10.4.7.1 (d) Construction Programme

The excavations for the dam will start from the abutments above river bed level in the 2nd quarter of year 2 and will be completed within two months working period. Excavations in the river bed will start as soon as the work area in the river bed becomes dry. The dam foundation treatment, which includes consolidation grouting and curtain grouting, will start locally as the excavation is completed in that area.

Embankment construction will start by 4th quarter of year 3, once the excavation and foundation preparation works in the river bed are sufficiently advanced. The period before the beginning of the embankment construction shall be devoted to the preparation of the haul roads and development of the borrow area.

A total period of 28 months, excluding the monsoon period has been allowed for the completion of the dam embankment with the aim to reach crest elevation by the end of 3rd quarter of year 7.

10.4.7.2 Concrete Dam (Kelwan Dam)

Main activities to be undertaken for construction of concrete dam (over flow & non-over flow sections) are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden and rock excavation. The total quantity of concrete dam excavation is about 264617 cum, and total quantity of concreting is about 317156 cum.

Quantities involved in construction of concrete dam (over flow & non-over flow)

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	-	cum
Excavation	Common	77657	cum
	Rock	186960	cum
	Total excavation	264617	cum
Concreting		317156	cum

10.4.7.2 (a) Surface Excavations

The surface excavations have been planned to be completed within 1 working seasons (5 months). The surface excavation for main dam involves both common and rock excavations. The excavated material will be transported to the disposal area using conventional excavator and rear dumper combination. The provision of equipment for the surface excavation is to be made is estimated below:

Estimation of hourly quantity of excavation

Type / Description	Common Excavation	Rock Excavation
Total volume (cum)	77657	186960
Time period (months)	5	5
Shift proposed	2	2
Total operational hours (hour)	1,100	1,100
Volume to be handled in-situ (cum/hour)	56	135
Volume to be handled loose (cum/hour)	71	218

Total quantity	**= 71 + 218 ~ 289** cum/hour

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0 cum hydraulic excavators assisted by 180 hp bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 m^2 and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.5 cum hydraulic excavator, shovel attachment and assisted by 180 hp dozers.
- Transportation to the disposal areas/main dam by 25t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.7.2 (b) Concreting

For concreting of main dam and appurtenant structures, total quantity of the order of 317156 cum, will have to be placed. A period of 27 months excluding monsoon period has been planned for the placement. The peak rate of placement works out to 33 cum/hour approximately. The concrete required for main dam is proposed to be produced in a centralized Batching and Mixing Plant of capacity 60 cum/hour. The plant shall be located in the vicinity of the dam. In addition, one number mobile batching & mixing plant of capacity, 18 cum/hour will be provided. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity.

Following construction equipments have been considered for concreting of main dam and appurtenant structures:

- Placing of concrete with the help of 2 Nos. tower cranes, 6 ton @ 40 metre radius are proposed to be deployed at suitable locations. In addition, 2 Nos. 25 cum/hr concrete pumps with 25 m boom will be used for concrete placement.
- Concrete transportation by transit mixers of 4.5 cum capacity.

- Batching and mixing plant of capacity 60 cum/hr to be located preferably within a radius of 2 km from the concrete dam.
- The aggregate crushing and screening plant of 180 tph for preparation of coarse and fine aggregates.

10.4.7.2 (c) List of Major Construction Plant and Equipment for Concrete Dam

Based on above construction methodology, major construction plant and equipment required for construction of concrete dam are listed below.

S. N0.	Equipments	Size/capacity		Quantity
1.	Hyd. Excavator	2	cum	3
2.	Hyd. Excavator	1	cum	0
3.	Loader, side dump	1.5	cum	1
4.	Dumper	25	T	11
5.	wagon drill	550	cfm	2
6.	Jack hammer	120	cfm	9
7.	Air requirment		cfm	1800
8.	Tower Crane	6T@40m		2
9.	Dozer	180	HP	3
10.	B&M Plant	60	cum/hr	1
11.	mobile B&M Plant	18	cum/hr	1
12.	APP	180	TPH	1
13.	Transit Mixer	4.5	cum	4
14.	Concrete pump	25	cum/hr	2
15.	Grout Pump	20	Kg/cm^2	2
16.	Mobile crane	16	Ton	2
17.	Truck	8/10	Ton	3

10.4.7.2 (d) Construction Programme

The sequence of construction of concrete dam takes into account the following aspects:

- Surface excavation of concrete dam to start during the 4^{th} quarter of Year 2.

- The total quantity of excavation to be completed in a period of 1 working seasons(5 months). The activity to be completed by the end of 1st quarter of year 3.
- Concreting to start in the 1st quarter of Year 3 and will continue for 3 working seasons and to be completed by the 3rd quarter of year 6.
- Since a part of over-flow section (two blocks) is to be used for diversion of river during construction of earth dam, the phasing of concerting is to be planned in such a way that the work of these two blocks is completed during lean season.
- Gate installation work to start in the beginning of 1st quarter of year 6 and will be completed by the end of 3rd quarter of Year 7.

10.4.7.3 Kelwan Dam Power House

10.4.7.3(a) Excavation and Concreting

Main activities to be undertaken for construction of power house are surface excavations and concreting along with erection of electro-mechanical equipment. The quantities involved in the dam power house complex are indicated below:

S. No.	Description	Quantity (cum)
1	Surface excavations	
	a) Common Excavation	492
	b) Rock excavation	1,292
2	Concreting	6,629

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket

shovel attachment and assisted by 180 HP dozers.

- Transportation to the disposal areas by 25t rear end dumpers.
- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a moving Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 180 tph for preparation of coarse and fine aggregates.
- Mobile crane of 16t is to be utilized for handling of construction material, shutter forms etc.

10.4.7.3(b) List of Major Construction Plant and Equipment for Power House

No separate equipment for construction of powerhouse complex has been provided as equipment deployed for concrete dam shall be utilized for construction of power house.

10.4.7.3 (c) Construction Programme

As the excavation quantities are not much, a period of 3 months has been planned beginning in the 3rd quarter of year 6. The construction of the concrete structures will begin by the 4th quarter of Year 6 starting from the structures of the erection area. Almost 15 months have been considered necessary to complete the powerhouse.

All works including electro-mechanical works will be essentially completed by 3rd quarter of year 7.

10.4.8 Barrages

This project envisages the construction of following barrages:

a) Paikhed Barrage

b) Chasmandva Barrage

The construction of the above said barrages involves surface excavation and concreting. The quantities involved in construction of the barrages are shown in the table below.

Quantities involved in construction of barrages

S. No.	Description	Excavation (cum)	Filling (Cum)	Concreting (cum)
1.	Paikhed barrage	1,041,093	11386.4	105,136
2.	Chasmandva barrage	325,095	11386.4	96,807
	Total	1,366,188	22772.7	201,943

10.4.8 (a) Paikhed Barrage & Head Regulator

10.4.8.(a). 1. Surface Excavation

Main activities to be undertaken for construction of Paikhed barrage are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden. The quantities involved and requirement for which provision of equipment for the surface excavation is to be made is given in table below.

Estimation of hourly quantity of excavation

Type Description	Excavation (cum)	Filling (cum)
Total volume (cum)	1,041,093	11386.35
Time period (months)	11	11
Shift proposed	2	2
Total operational hours (hour)	3025	3025
Volume to be handled in-situ (cum/hour)	344	4
Volume to be handled loose (cum/hour)	481	6
Peak Volume to be handled (cum/hour)	578	10
Total quantity	= 578+10=578 cum/hour	

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0cum hydraulic excavators assisted by 180 HP bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 sq.m and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.5 cum hydraulic excavator, shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas/main dam by 18/20T rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.8.(a). 2 Concreting

For concreting of Paikhed barrage, total quantity of the order of 105,136 cum, will have to be placed. A period of 12 months has been planned for the placement. The average rate of placement works out to 20 cum/hour approximately. The concrete required for the barrages is proposed to be produced in 2 nos of Batching and Mixing Plant of capacity 18 cum/hour. The plants shall be located in the vicinity of the barrages. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity. The Placement of the concrete will be done with the help of 20cum/hr capacity concrete pump.

10.4.8.(a).3. List of Major Construction Plant and Equipment for Paikhed Barrage

Based on above construction methodology, major construction plant and equipment required for construction of Paikhed Barrage are given in table.

S. N0.	Equipments	Size/ capacity	Quant ity
1.	Hydraulic excavator	2.0 cum	5
2.	Crawler dozer	180 hp	4
3.	Crawler dozer	90 hp	4

4.	Front End Loader	1.5 cum	4
5.	Crawler/wagon drill	600 cfm	2
6.	Jack hammer	120 cfm	9
7.	Rear dumper	18/20T	20
8.	Tippers	4.5 cum	10
9.	Aggregate processing plant	50 tph	2
10.	Mobile Batching & mixing plant	18 cum/hour	2
12.	Transit mixers	4.5 cum	6
13.	Concrete pump with 25m boom	20cum/hour	4
14.	Concrete Vibrator (electrical/pneumatic)		8
15.	Compressed air	cfm	2000
16.	Grout pump	20 kg/m^2	4
17.	Trucks	8/10 ton	6
18.	Vibratory compactor (pad foot)	10t	2
19.	Vibratory compactor (smooth drum)	10t	2
20.	Water sprinklers	8000	6

10.4.8.(b). Chasmandva Barrage & Head Regulator

10.4.8.(b).1. Surface Excavation

Main activities to be undertaken for construction of Chasmandva barrage are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden. The quantities involved and requirement for which provision of equipment for the surface excavation is to be made is given in table below.

Estimation of hourly quantity of excavation

Type **Description**	**Excavation (cum)**	**Filling (cum)**
Total volume (cum)	325,095	11386
Time period (months)	3	3
Shift proposed	2	2
Total operational hours (hour)	825	825
Volume to be handled in-situ (cum/hour)	394	14
Volume to be handled loose (cum/hour)	552	20
Peak Volume to be handled	550	20

(cum/hour)		
Total quantity	= 550+20=570 cum/hour	

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.0 cum hydraulic excavators assisted by 180 HP bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 sq.m and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.5 cum hydraulic excavator, shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas/main dam by 25t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

10.4.8.(b).2 Concreting

For concreting of Chasmandva barrage, total quantity of the order of 96807.296 cum, will have to be placed. A period of 12 months has been planned for the placement. The average rate of placement works out to 18 cum/hour approximately. The concrete required for the barrages is proposed to be produced in two no. of Batching and Mixing Plant of capacity 18 cum/hour. The plants shall be located in the vicinity of the barrages. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity. The Placement of the concrete will be done with the help of 20cum/hr capacity concrete pump.

10.4.8.(b).3 List of Major Construction Plant and Equipment for Chasmandva Barrage

No separate equipment for construction of powerhouse complex has been provided as equipment deployed Paikhed Barrage shall be utilized for construction of power house.

Construction Programme

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

- Surface excavation of Paikhed barrages to start during the 2nd quarter of Year 3 to complete within 10 months. First two months will be used for stripping.
- Concreting of Paikhed barrages to start in the 3rd quarter of year 4. Concreting of will be completed in months and will be completed by the end of 2nd quarter of year 5.
- Surface excavation of Chasmandva barrages to start after the completion of surface excavation of Paikhed barrages. It start during the 4th quarter of Year 4. First two months will be used for stripping. Surface excavation of balance quantity will be completed in another 3 months and will be completed by the end of 1st quarter of year 5.
- Concreting of Chasmandva barrages to start in the 3rd quarter of year 5. Concreting will be completed in 12 months and will be completed by the end of 2nd quarter of year 6.
- Gate installation work of Paikhed barrages to start in the beginning of 1st quarter of year 5 and will be completed within 6 months.
- Gate installation work of Chasmandva barrages to start in the beginning of 1st quarter of year 5 and will be completed within 6 months.

It is proposed to carry out work in non-monsoon period for at least till the floor for full length of Barrage. A coffer dam of suitable height (say 4 m) may be required to enclose the work area in non-monsoon season.

10.4.9.1 (a) Chasmandva Pipe line

Main activities to be undertaken for execution work of Feeder Pipe lines are excavation of trenches according to the levels to accommodate feeder pipe lines, followed by lowering and laying of pipe lines along with construction of Pipe line bridges and other structures as necessary. Earth work comprises of both the common excavation in overburden and rock excavation. For fill reaches, spreading & wetting and compaction of the fill

material will have to be undertaken. The quantities involved in construction of the Chasmandva Pipe line are shown in the table below.

Quantities involved in construction of the Chasmandva Feeder Pipe line

Description of Work	Quantity, in-situ	Unit
Excavation	160666	cum
Fill placement	194346	cum
Pipe line	2859	m

Estimation of hourly quantity excavation

Type Description	Excavation	Fill Placement
Total volume (cum)	160666	194346
Time period (months)	8	8
Shift proposed	2	2
Total operational hours (hour)	2200	2200
Volume to be handled in-situ (cum/hour)	73	89
Volume to be handled loose (cum/hour)	102	124
Peak Volume to be handled (cum/hour)	102	124
Total quantity	=102+124=226 cum/hour	

The sequence of operations for Chasmandva Feeder Pipe lines is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq.m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq.m.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.

- For fill reaches spreading by 180 HP bulldozers. Moisture adjustment by 8000 L water sprinklers and compaction by 8 passes of 10t pad foot vibrating roller.
- For concreting works, placing of concrete by 15 cum/hr concrete pumps with 20 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a mobile Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 50 tph for preparation of coarse and fine aggregates.
-

10.4.9.1 (b) List of Major Construction Plant and Equipment for Chasmandva Feeder Pipe line

No separate equipment for construction of powerhouse complex as well as Feeder pipe lines has been provided as equipment deployed Chasmandva Barrage shall be utilized for construction of power house.

10.4.9.1 (c) Construction Programme

A construction period of 2 working seasons has been planned starting from beginning of 3rd quarter of year 5. A period of 20 months excluding the monsoon period have been considered necessary to complete the laying of Pipe lines along with the all Pipe line bridges.

10.4.9.2 (a) Chikkar-Dabdar Feeder Pipe line

Main activities to be undertaken for execution work of Pipe lines are excavation of trenches according to the levels to accommodate feeder pipe lines, followed by lowering and laying of pipe lines along with construction of pipe line Bridges, and other structures as necessary. Earth work comprises of both the common excavation in overburden and rock excavation. For fill reaches, spreading & wetting and compaction of the fill material will have to be undertaken. The quantities involved in construction of the Chikkar Feeder Pipe lines are shown in the table below.

Quantities involved in construction of the Chikkar Feeder Pipe line

Description of Work	Quantity, in-situ	Unit
Excavation	1097689	cum
Fill placement	1823188	cum
Pipe line	14342	m

Estimation of hourly quantity excavation

Type Description	Excavation	Fill Placement
Total volume (cum)	1097689	1823188
Time period (months)	40	40
Shift proposed	2	2
Total operational hours (hour)	11000	11000
Volume to be handled in-situ (cum/hour)	99	166
Volume to be handled loose (cum/hour)	140	232
Peak Volume to be handled (cum/hour)	174	290
Total quantity	**=174+290=464** cum/hour	

The sequence of operations for Chikkar Feeder Pipe lines is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq.m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq.m.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.
- For fill reaches spreading by 180 HP bulldozer. Moisture adjustment by 8000 L water sprinklers and compaction by 8 passes of 10t pad foot vibrating roller.
- For concreting works, placing of concrete by 15 cum/hr concrete

pumps with 20 m boom.

- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 18 cum/hr(mobile).
- The aggregate crushing and screening plant of 50 tph for preparation of coarse and fine aggregates.

10.4.9.2 (b) List of Major Construction Plant and Equipment for Chikkar - Dabdar Feeder Pipe line

Based on the above methodology, major construction plant and equipment required for execution work of Feeder Pipe lines have been worked out and given in table.

S. No.	Equipments	Size/capacity	Quantity
1.	Hydraulic excavator	2.0 cum	4
2.	Front End Loader	2.5 cum	2
3.	Front End Loader	1.5 cum	1
4.	Crawler/ wagon drill	600 cfm	1
5.	Jack hammer	120 cfm	6
6.	Rear dumper	18/20t	12
7.	Tipper	4.5 cum	4
8.	Crawler dozer	180 HP	2
9.	Crawler dozer	90 HP	3
10.	Aggregate processing plant	50 tph	1
11.	Mobile concrete mixers	18 cum/hr	1
12.	Transit mixers	4.5 cum	4
13.	Concrete Vibrator (electrical/pneumatic)		4
14.	Grout pump	20 kg/m^2	2
15.	Mobile crane	16t	2
16.	Compressed air	Cfm	4000
17.	Trucks	8/10 ton	4
18.	Vibratory compactor (pad foot)	10 t	1
19.	Vibratory compactor (smooth drum)	10 t	3
20.	Water sprinklers	8000 L	10

10.4.9.2 (c) Construction Programme

As the main canal stretches over a significant distance, sufficient time is required to carry out detail surveys for main canal, branch canals, distributaries, minors and to finalize portions of canals for irrigation along with specific emphasis on time required for land acquisition. The contracts for all major works are to be awarded by the second year itself so that the entire basic infrastructure required for the canal construction can be completed by the end of 3rd quarter of second year itself.

A construction period of 5 working seasons has been planned starting from beginning of 3rd quarter of year 2. A period of 40 months excluding the monsoon period have been considered necessary to complete the all Pipe line structures. An additional 3 months have been provided for grouting and cleaning activity.

10.4.9.3 (a) Dabdar Feeder Pipe line

Main activities to be undertaken for execution work of Pipe lines are excavation of trenches according to the levels to accommodate Feeded pipe lines, followerd by lowering and laying of pipe lines and pipe line Bridges as well as other structures as necessary..Earth work comprises of both the common excavation in overburden and rock excavation. For fill reaches, spreading & wetting and compaction of the fill material will have to be undertaken. The quantities involved in construction of the Dabdar Feeder **Pipe line** are shown in the table below.

Quantities involved in construction of the Dabdar Feeder Pipe line

Description of Work	Quantity, in-situ	Unit
Excavation	443597	cum
Fill placement	4348862	cum
Pipe line	12258	m

Estimation of hourly quantity excavation

Type Description	Excavation	Fill Placement
Total volume (cum)	443597	4348862
Time period (months)	40	40

Shift proposed	2	2
Total operational hours (hour)	11000	11000
Volume to be handled in-situ (cum/hour)	40	395
Volume to be handled loose (cum/hour)	56	553
Peak Volume to be handled (cum/hour)	70	692
Total quantity	**=70+692=762** cum/hour	

The sequence of operations for Dabdar **Pipe lines** is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq.m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq.m.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 25t rear end dumpers.
- For fill reaches spreading by 180 HP bulldozer. Moisture adjustment by 8000 L water sprinklers and compaction by 8 passes of 10t pad foot vibrating roller.
- For concreting works, placing of concrete by 15 cum/hr concrete pumps with 20 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 18 cum/hr (mobile).
- The aggregate crushing and screening plant of 50 tph for preparation of coarse and fine aggregates.

10.4.9.3(b) List of Major Construction Plant and Equipment for Dabdar Feeder Pipe line

Based on the above methodology, major construction plant and equipment required for execution work of pipe lines have been worked out and given in table below.

Major construction plant and equipment required for construction of Dabdar Feeder Pipe line

S. No.	Equipments	Size/capacity	Quantity
1.	Hydraulic excavator	2.0 cum	6
2.	Front End Loader	2.5 cum	4
3.	Front End Loader	1.5 cum	2
4.	Crawler/ wagon drill	600 cfm	2
5.	Jack hammer	120 cfm	10
6.	Rear dumper	18/20t	30
7.	Tipper	4.5 cum	10
8.	Crawler dozer	180 HP	4
9.	Crawler dozer	90 HP	5
10.	Aggregate processing plant	50 tph	1
11.	Mobile concrete mixers	18 cum/hr	1
12.	Transit mixers	4.0 cum	3
13.	Concrete Vibrator (electrical/pneumatic)		4
14.	Grout pump	20 kg/m^2	2
15.	Mobile crane	16t	2
16.	Compressed air	Cfm	2000
17.	Trucks	8/10 ton	4
18.	Vibratory compactor (pad foot)	10 t	1
19.	Vibratory compactor (smooth drum)	10 t	4
20.	Water sprinklers	8000 L	12

10.4.9.3 (c) Construction Programme

As the main canal stretches over a significant distance, sufficient time is required to carry out detail surveys for main canal, branch canals, distributaries, minors and to finalize portions of canals for irrigation along

with specific emphasis on time required for land acquisition. The contracts for all major works are to be awarded by the second year itself so that the entire basic infrastructure required for the canal construction can be completed by the end of 3rd quarter of second year itself.

A construction period of 5 working seasons has been planned starting from beginning of 3rd quarter of year 2. A period of 40 months excluding the monsoon period have been considered necessary to complete all pipe line structures. An additional 3 months have been provided for grouting and cleaning activity.

10.4.9.4(a) Kelwan Feeder Pipe line

Main activities to be undertaken for execution work of Pipe lines are excavation of trenches according to the levels, followed by lowering and laying of pipe lines and pipe line Bridges and other structures as necessary. Earth work comprises of both the common excavation in overburden and rock excavation. For fill reaches, spreading & wetting and compaction of the fill material will have to be undertaken. The quantities involved in construction of the Kelwan Feeder Pipe lines are shown in the table below.

Quantities involved in construction of the Kelwan Feeder Pipe line

Description of Work	Quantity, in-situ	Unit
Excavation	356021	cum
Fill placement	142118	cum
Pipe line	7616	m

Estimation of hourly quantity excavation

Type Description	Excavation	Fill Placement
Total volume (cum)	356021	142118
Time period (months)	8	8
Shift proposed	2	2
Total operational hours (hour)	2200	2200
Volume to be handled in-situ (cum/hour)	162	65
Volume to be handled loose (cum/hour)	202	81
Peak Volume to be handled	253	101

(cum/hour)		
Total quantity	=253+101=304 cum/hour	

The sequence of operations for Kelwan Feeder Link **Pipe lines** is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq.m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq.m.
- Loading of the blasted rock by 2.5 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.
- For fill reaches spreading by 180 HP bulldozer. Moisture adjustment by 8000 L water sprinklers and compaction by 8 passes of 10t pad foot vibrating roller.
- For concrete lining and concreting works, placing of concrete by 20 cum/hr concrete pumps with 20 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 50 tph for preparation of coarse and fine aggregates.

10.4.9.4(b) List of Major Construction Plant and Equipment for Kelwan Feeder Pipe line

No separate equipment for construction of powerhouse complex as well as Feeder pipe lines has been provided as equipment deployed Chasmandva Barrage shall be utilized for construction of power house.

10.4.9.4 (c) Construction Programme

A construction period of 2 working seasons has been planned starting from beginning of 3rd quarter of year 5. A period of 20 months excluding the monsoon period have been considered necessary to complete the all Pipe line structures.

10.4.10 Kelwan Dam Power House at the drop of Feeder Pipe line From Kelwan Reservoir

10.4.10(a) Excavation and Concreting

Main activities to be undertaken for construction of power house are surface excavations and concreting along with erection of electro-mechanical equipment. The quantities involved in the dam power house complex are indicated below:

S. No.	Description	Quantity (cum)
1	Surface excavations	
	a) Common Excavation	3,525
	b) Rock excavation	6,093
2	Concreting	8,878

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 20t rear end dumpers.
- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a moving Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 50 tph for preparation of coarse and fine aggregates.
- Mobile crane of 16t is to be utilized for handling of construction

material, shutter forms etc.

10.4.10(b) List of Major Construction Plant and Equipment for Power House

No separate equipment for construction of powerhouse complex has been provided as equipment deployed for Kelwan feeder Pipe lines shall be utilized for construction of power house.

10.4.10 (c) Construction Programme

As the excavation quantities are not much, a period of 3 months has been planned beginning in the 2nd quarter of year 7. The construction of the concrete structures will begin by the 3rd quarter of Year 7 starting from the structures of the erection area. Almost 9 months have been considered necessary to complete the powerhouse.

All works including electro-mechanical works will be essentially completed by 4th quarter of year 7.

10.4.11 (a) Par-Tapi Link Canal

Main activities to be undertaken for construction of canal are main canal, branch canals, distributaries and other canal structures like siphons, bridges, railway crossings, super passages along with concrete lining of the main canal. Earth work comprises of both the common excavation in overburden and rock excavation. For fill reaches, spreading & wetting and compaction of the fill material will have to be undertaken. The quantities involved in construction of the Par-Tapi Canal (except CDs) are shown in the table below:

Quantities involved in construction of the Par Tapi Link Canal

Description of Work	Quantity, in-situ	Unit
Excavation	24853903	cum
Fill placement	19599774	cum
Lining	512455	cum

It is proposed to divide the entire length of canal into eight segments and take up the work in all the segments simultaneously so the work can be completed within the stipulated time period. The **e**stimation of hourly quantity is given in table below.

Estimation of hourly quantity excavation

Type **Description**	**Excavation**	**Fill Placement**
Total volume (cum)	24853903	19599774
Av. Volume in each of 8 segments	3106737	2449971
Time period (months)	40	40
Shift proposed	2	2
Total operational hours (hour)	11000	11000
Volume to be handled in-situ (cum/hour)	282	222
Volume to be handled loose (cum/hour)	395	312
Peak Volume to be handled (cum/hour)	495	390
Total quantity	=495+390=1180 cum/hour	

The sequence of operations for Par-Tapi Canal is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq.m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq.m.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.
- For fill reaches spreading by 180 HP bulldozer. Moisture adjustment by 8000 L water sprinklers and compaction by 8 passes of 10t pad foot vibrating roller.
- For concrete lining and concreting works, placing of concrete by 20 cum/hr concrete pumps with 20 m boom.

- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 18 cum/hr.
- The aggregate crushing and screening plant of 50 tph for preparation of coarse and fine aggregates.

10.4.11(b) List of Major Construction Plant and Equipment for Par-Tapi Link Canal

Based on the above methodology, major construction plant and equipment required for construction of link canal including upper level tunnel have been worked out and given in table.

Major construction plant and equipment required for construction of Par-Tapi Link canal

S. No.	Equipments	Size/capacity	Quantity
1	Hydraulic excavator	2.0 cum	56
2	Front End Loader	2.5 cum	24
3	Front End Loader	1.5 cum	8
4	Crawler/ wagon drill	600 cfm	16
5	Jack hammer	120 cfm	72
6	Rear dumper	18/20t	248
7	Tipper	4.5 cum	32
8	Crawler dozer	180 HP	32
9	Crawler dozer	90 HP	24
10	Aggregate processing plant	50 tph	8
11	Filter Processing Plant	400TPH	16
12	Concrete pump	15 cum/hr	8
13	Mobile concrete mixers	18 cum/hr	8
14	Transit mixers	4.5 cum	40
15	Concrete Vibrator (electrical/pneumatic)		32
16	Grout pump	20 kg/m^2	16
17	Mobile crane	16t	16
18	Compressed air	Cfm	11200
19	Trucks	8/10 ton	24
20	Vibratory compactor (pad foot)	10 t	8
21	Vibratory compactor	10 t	24

	(smooth drum)		
22	Water sprinklers	8000 L	64

10.4.11 (c) Construction Programme

As the main canal stretches over a significant distance, sufficient time is required to carry out detail surveys for main canal, branch canals, distributaries, minors and to finalize portions of canals for irrigation along with specific emphasis on time required for land acquisition. The contracts for all major works are to be awarded by the first year itself so that the entire basic infrastructure required for the canal construction can be completed by the end of 2nd quarter of second year itself.

A construction period of 5 working seasons has been planned starting from beginning of 3rd quarter of year 2. A period of 40 months excluding the monsoon period have been considered necessary to complete the lining of link canal along with the all canal structures. An additional 3 months have been provided for grouting and cleaning activity. All other components planned in the DPR of Par-Tapi-Narmada link project, as suggested by Government of Gujarat, like providing net work of pipe line as distribution system in the command areas under the proposed five projects including command areas in all Tribal areas will be taken care by Government of Gujarat at the pre-construction stage of the project.

10.4.12 (a) Tapi- Narmada Link Canal

Main activities to be undertaken for construction of canal are main canal, branch canals, distributaries and other canal structures like siphons, bridges, railway crossings, super passages along with concrete lining of the main canal. Earth work comprises of both the common excavation in overburden and rock excavation. For fill reaches, spreading & wetting and compaction of the fill material will have to be undertaken. The quantities involved in construction of the Tapi Narmada Canal (except CDs) are shown in the table below.

Quantities involved in construction of the Tapi Narmada Main Canal

Description of Work	Quantity, in-situ	Unit
Excavation	23729633	cum
Fill placement	15159482	cum
Lining	624754	cum

It is proposed to divide the entire length of canal into eight segments and take up the work in all the segments simultaneously so the work can be completed within the stipulated time period. The **e**stimation of hourly quantity is given in table below.

Estimation of hourly quantity excavation

Type Description	Excavation	Fill Placement
Total volume (cum)	23729633	15159482
Av. Volume in each of 6 segments	2966204	1894935
Time period (months)	40	40
Shift proposed	2	2
Total operational hours (hour)	11000	11000
Volume to be handled in-situ (cum/hour)	270	172
Volume to be handled loose (cum/hour)	378	241
Peak Volume to be handled (cum/hour)	472	302
Total quantity	=472+302=774 cum/hour	

The sequence of operations for Tapi-Narmada Link Canal is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq.m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq.m.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.

- For fill reaches spreading by 180 HP bulldozer. Moisture adjustment by 8000 L water sprinklers and compaction by 8 passes of 10t pad foot vibrating roller.
- For concrete lining and concreting works, placing of concrete by 20 cum/hr concrete pumps with 20 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 18 cum/hr(mobile)..
- The aggregate crushing and screening plant of 50 tph for preparation of coarse and fine aggregates.

10.4.12 (b) List of Major Construction Plant and Equipment for Tapi-Narmada Canal

Based on the above methodology, major construction plant and equipment required for construction of link canal including upper level tunnel have been worked out and given in table.

Major construction plant and equipment required for construction of Tapi-Narmada canal

S. No.	Equipments	Size/capacity	Quantity
1	Hydraulic excavator	2.0 cum	48
2	Front End Loader	2.5 cum	24
3	Front End Loader	1.5 cum	8
4	Crawler/ wagon drill	600 cfm	16
5	Jack hammer	120 cfm	48
6	Rear dumper	18/20t	208
7	Tipper	4.5 cum	24
8	Crawler dozer	180 HP	32
9	Crawler dozer	90 HP	16
10	Aggregate processing plant	50 tph	9
11	Filter Processing Plant	300TPH	16
12	Concrete pump	20 cum/hr	8
13	Mobile concrete mixers	18 cum/hr	8
14	Transit mixers	4.5 cum	40
15	Concrete Vibrator (electrical/pneumatic)		32
16	Grout pump	20 kg/m^2	16
17	Mobile crane	16t	16

18	Compressed air	Cfm	10400
19	Trucks	8/10 ton	12
20	Vibratory compactor (pad foot)	10 t	8
21	Vibratory compactor (smooth drum)	10 t	16
22	Water sprinklers	8000 L	48

10.4.12 (c) Construction Programme

As the main canal stretches over a significant distance, sufficient time is required to carry out detail surveys for main canal, branch canals, distributaries, minors and to finalize portions of canals for irrigation along with specific emphasis on time required for land acquisition. The contracts for all major works are to be awarded by the first year itself so that the entire basic infrastructure required for the canal construction can be completed by the end of 2nd quarter of second year itself.

A construction period of 5 working seasons has been planned starting from beginning of 3rd quarter of year 2. A period of 40 months excluding the monsoon period have been considered necessary to complete the lining of link canal along with the all canal structures. An additional 3 months have been provided for grouting and cleaning activity. All other components planned in the DPR of Par-Tapi-Narmada link project, as suggested by Government of Gujarat, like providing net work of pipe line as distribution system in the command areas in all Tribal areas will be taken care by Government of Gujarat at the pre-construction stage of the project.

10.4.13(a) Jheri to Paikhed Link Tunnel

The Jheri to Paikhed Link Tunnel having 3.0m diameter (finish) is of 12700m length. 1 No. of construction adit has been proposed for construction of J-P link tunnel. The provision of 1 no. of adit provides opportunity to excavate tunnel from 4 faces simultaneously; provided deployment of equipment sets is feasible at all the faces at a time. The RD of each adits and distance between them is given as under:

RD of each adits and distance between them

Adit	Length of Adit(m)	RD from Intel Portal(m)	Length of Tunnel		Distance B/w adits
			Face Number	Length served through Face	
Inlet Portal	-	0.0	F1	3150	6300
Adit	408.60	6300	F2 F3	3150 3200	
Outlet Portal	-	12700	F4	3200	6400
		Total		12700	12700

Max length to be excavated = 0.5*(408.60+6400) ~ 3410 m

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 and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.
- Slope stabilization using shotcrete machine and anchoring by jack hammer/hydraulic drilling rig
- Portal concreting by using potable concrete mixer with weigh batches.

The portal excavation and slop stabilization will be completed within three month from start of work. Once this work is completed, the excavation of adits and tunnel (from inlet and outlet faces) will be start. In view of its size, both adits and tunnel are proposed to be excavated by full face drill and blast method. For a finish diameter of 3.0m, the minimum excavated diameter of the tunnel shall be 4.0m to account for 500mm thick concrete lining and shotcrete.

Following construction method for the excavation of tunnel and adits may be adopted.

- Drilling of charge holes by means of Jack hammers.
- Driving of each round variable according to the Class of rock (approx. 3.5 m for the Class I & II, 3.0 m for the Class III and 2.5 m for the rock Class IV and V).
- Number of holes per round (including those necessary for carrying out the smooth blasting along the peripheral surface) approximately 25 - 35.
- 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 Railway Hydraulic mucker/rock loader (50 cum/hr output capacity).
- Transport of the muck to the spoil area by Granby-type Side dump cars (6 to 9 cum capacity) mounted on rail system.
- Shotcrete with the help of 4-6cum/hr capacity wet shotcreting machine.
- 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 9.7 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 the same order.

A typical cycle for Class III (pull of 3.00m)is given below:

i)	Preparation of job	0.5hr
ii)	Drilling of Charge Holes	5.2hr
iii)	Charging	1.0hr
iv)	Removal of Jumbo to safe position	0.5hr
v)	Blasting and defuming	1.0hr
vi)	Mucking	1.8hr
vii)	Scaling	0.5hr
viii)	Shotcreting and rock bolting	2.0hr
	Total	**12.5hr**

As per the rock condition of tunnel and with above cycle time, an average sustainable progress of 102m/month/face can be achieved. Considering 4 face excavation, all the construction activities of J-P link tunnel would be planned and staged for optimum utilization of equipments for planned time period. Accordingly the time required for excavation 34 months

10.4.13 (b) Concrete Lining

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

- 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 20cum/hr capacity concrete pump.
- Transportation of concrete by 4.5cum 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 30cum./hr capacity installed near Portal of each adit and outlet.
- An Aggregate Crushing & Screen Plant of 70tph to be installed near each adit location for preparation of coarse aggregate. A tertiary crusher for preparation of crushed fine aggregate is also to be provided as river sand is to be blended with crushed
- Excavated material form tunnel excavation 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 cum for loading .

A typical cycle time for overt concreting is as under:

Estimated Cycle Time in Overt Concreting (10m)

i.)	Erection time	16.00 hr

ii.)	Pouring time	8.00 hr
iii.)	Setting time	20.00 hr
iv.)	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 concrete to be undertaken simultaneously with overt concreting with a time lag. Total time required for concreting 18 months.

Based on the above methodology, major Construction Plant & Equipment required for construction of Jheri-Paikhed Link Tunnel have been listed out in following table:

10.4.13 (c) List of Major Construction Plant & Equipment for Construction of Jheri- Paikhed Link Tunnel

S. No.	Item	Qty./ No.
1.	Heavy Duty Rock Drill, 120 cfm (jack Hammers)	12
2.	Railway Hydraulic mucker/rock loader	3
3.	Wagon Drill	3
4.	Muck cars 4.50 cum capacity	20
5.	Crawler Dozer, 180 hp	4
6.	Loader-cum-Excavator, 1.0 cum./ 0.24 cum.	4
7.	Shotcrete m/c, 4-6 cum	3
8.	Shotcrete m/c with Robot Arm, 10 cum	3
9.	Air Compressor, 500 cfm, Electric	3
10.	Aggregate Crushing & Screening Plant, 70 tph	3
11.	Concrete Batching & Mixing Plant, 30 m^3/hr	3
12.	Collapsible Shutter Form with Traveller	4
13.	Transit Mixer, 4.5 m^3	16
14.	Concrete Pump, 25 m^3/hr	4
15.	Concrete Mixer, 14/10 cft	4
16.	Tipper, 16 t	32
17.	Wheel Loader 1.0 Cum	4
18.	Grout pump	4

An average distance of 5.0 km from quarry site has been considered for calculating the no of tipper required.

10.4.13 (d) Construction Program

The sequence of Construction of J-P Link Tunnel takes into account the following aspects:

- Open excavation for face and portal construction is to be started in the 3rd quarter of year 2 and will completed within three months.
- Adits/Tunnel excavation to start in 4th quarter of year 2 and are to be completed by the end of 3rd quarter of year 4.
- Concrete lining of whole of tunnel to be taken up from all the face simultaneously. Lining to start in the 4th quarter of year 3 and to be completed by the end of 1st quarter of year 6.
- Contact/consolidation grouting of the tunnel to start simultaneously with the concreting and will finish in three month after concreting.

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

10.4.14 Tunnels in Main Canal

5 No. of tunnels of diameter 5.5 m has been proposed in the main Canal. The Details of each tunnel is given as under:

Tunnel No. 1 between RD 14.650-14.750 km)	
Length (m)	100
Tunnel No. 2 between RD 24.000-24.350 km)	
Length (m)	350
Tunnel No. 3 between RD 32.350-32.550 km)	
Length (m)	200
Tunnel No. 4 between RD 37.750-37.800 km)	
Length (m)	50
Tunnel No. 5 between RD 51.500-51.950 km)	
Length (m)	450

10.4.14 (a) 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 and loading of the soft material by 2.0 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 m^2 and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 m^2.
- Loading of the blasted rock by 2.0 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.
- Slope stabilization using shotcrete machine and anchoring by jack hammer/hydraulic drilling rig
- Portal concreting by using potable concrete mixer with weigh batches.

The portal excavation and slop stabilization will be completed within three month from start of work. Once this work is completed, the excavation of tunnel (from inlet and outlet faces) will be start. In view of its size, tunnels are proposed to be excavated by full face drill and blast method. For a finish diameter of 5.5m, the minimum excavated diameter of the tunnel shall be 6.4 m to account for 300mm thick concrete lining and shotcrete.

Following construction method for the excavation of tunnel and adits 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 the Class I & II, 3.0 m for the Class III and 2.5 m for the rock Class IV and V).
- Number of holes per round (including those necessary for carrying out the smooth blasting along the peripheral surface) approximately 60 - 70.

- 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 2.5 cum side dump loader.
- Transport of the muck to the spoil area by 10T dumper
- Shotcrete with the help of 4-6cum/hr capacity wet shotcreting machine.
- 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 9.7 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 the same order.

A typical cycle for Class III (pull of 3.00 m)is given below:

ix)	Preparation of job	0.5hr
x)	Drilling of Charge Holes	4.2hr
xi)	Charging	1.0hr
xii)	Removal of Jumbo to safe position	0.5hr
xiii)	Blasting and defuming	1.0hr
xiv)	Mucking	1.8hr
xv)	Scaling	0.5hr
xvi)	Shotcreting and rock bolting	3.0hr
	Total	**11.5hr**

In whole tunnel, 99% tunneling is in rock class of 1, II & III (no – rock support system required) and 1% 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 110m/month/face can be achieved.

Considering 5 tunnels of different length, all the construction activities of tunnel in Main Canal would be planned and staged for optimum utilization of equipments for planned time period.

10.4.14 (b) Concrete Lining

Concrete lining is to be undertaken after the completion of

excavation. Following sequence of operation will be followed for concrete lining of the head race tunnel.

- 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 25cum/hr capacity concrete pump.
- Transportation of concrete by 4.5cum 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 30cum./hr capacity installed near Portal of each adit and outlet.
- An Aggregate Crushing & Screen Plant of 70tph to be installed near each adit location for preparation of coarse aggregate. A tertiary crusher for preparation of crushed fine aggregate is also to be provided as river sand is to be blended with crushed.
- Excavated material form tunnel excavation 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 cum for loading .

A typical cycle time for overt concreting is as under:

Estimated Cycle Time in Overt Concreting (10m)

v.)	Erection time	16.00 hr
vi.)	Pouring time	8.00 hr
vii.)	Setting time	20.00 hr
viii.)	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 concrete to be undertaken simultaneously with

overt concreting with a time lag.

Based on the above methodology, major Construction Plant & Equipment required for construction of Link Tunnels have been listed out in following table:

10.4.14(c) List of Major Construction Plant & Equipment for Construction of tunnel in Main Canal

S. No.	Item	Qty./ No.
1.	Single Boom hydraulic Drill Jumbo with working platform	1
2.	Rock Bolting Jumbo	1
3.	Side dump loader, 2.5 cum	1
4.	Wagon Drill	1
5.	Heavy Duty Rock Drill, 120 cfm	3
6.	10T dumper	6
7.	Crawler Dozer, 180 hp	1
8.	Loader-cum-Excavator, 1.0 cum./ 0.24 cum.	1
9.	Shotcrete m/c, 4-6 cum	1
10.	Shotcrete m/c with Robot Arm, 10 cum	1
11.	Air Compressor, 500 cfm, diesel	1
12.	Aggregate Crushing & Screening Plant, 100 tph	1
13.	Concrete Batching & Mixing Plant, 30 m^3/hr	1
14.	Collapsible Shutter Form with Traveller	1
15.	Transit Mixer, 4.5 m^3	4
16.	Concrete Pump, 25 m^3/hr	1
17.	Concrete Mixer, 14/10 cft	1
18.	Tipper, 10 t	8
19.	Wheel Loader 1.0 Cum	1
20.	Grout pump	1

An average distance of 5.0 km from quarry site has been considered for calculating the no of tipper required.

10.4.14 (d) Construction Program

The sequence of Construction of Tunnel in Main Canal is given in construction schedule attached at Annexure-10.1.

10.5 Construction Programme & 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 a Bar Chart and is placed at Annexure:10.1. Keeping this construction schedule as one of the major criteria, a deployment schedule of major construction equipment required for the project is placed at Annexure:10.2. The number of equipment shown in the list has been 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.

10.6 Manpower Planning

10.6.1 Organisation Setup

The project will be implemented under an organisation set-up headed by an officer of the rank of General Manager. The works will be executed under the overall supervision of six Officers of the rank of Chief Engineers who will report to General Manager. In addition, there will be six officers of the rank of Superintending Engineer to assist General Manager: Director (Administration), Director (Finance), Director (Technical Coordination) and Director (EMP and R&R) and Public Relation Officer and Labour Welfare Officer. Each will be assisted by appropriate subordinate officers and staff. The organisation chart for the project is appended as Annexure - 10.3.1 to 10.3.7 in Volume - II.

There will be six Chief Engineers for the Project to look after the works, viz., Engineer (Designs), Chief Engineer (Head works-I), Chief Engineer (Head works-II), Chief Engineer (E&M), Chief Engineer (Canal-I) and Chief Engineer (Canal-II). Chief Engineer (Designs) will be supported by 5 officers of the rank of Superintending Engineer; Chief Engineer (Head works-I) and (Head works-II) will be supported by 4 officers of the rank of

Superintending Engineer; Chief Engineer (Canal-I and II) and Chief Engineer (E&M) will be supported by 3 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 Chief Engineer (Designs) will be supported by five officers of the rank of Superintending Engineer: three for design units, one for Quality control, and one Superintending Engineer for EMP and R&R. These SEs will be further supported Executive Engineers/ Assistant Executive Engineers and other supporting staff.

Chief Engineer (Head Works-I) will be responsible for execution of works related to construction of Jheri, Paikhed and Chasmandva dams, Power Houses and Barrages. One of the Superintending Engineers under him will be responsible for construction of Jheri dam and Jheri to Paikhed tunnel; one Superintending Engineer will be responsible for construction of Paikhed dam, Power House and Barrage; one Superintending Engineer will be responsible for construction of Chasmandva dam, Power House and Barrage; and one Rehabilitation Officer for EMP and R&R. They will be supported by appropriate subordinate officers as elaborated under the organisation chart.

Similarly, Chief Engineer (Head Works-II) will be responsible for execution of works related to construction of Chikkar, Dabdar and Kelwan dams and Power Houses. One of the Superintending Engineers under him will be responsible for construction of Chikkar dam and Power house; one Superintending Engineer will be responsible for construction of Dabdar dam and Power House; one Superintending Engineer will be responsible for construction of Kelwan dam and Power House and Kelwan Feeder Pipe line Power house; and one Rehabilitation Officer for EMP and R&R. They will be supported by appropriate subordinate officers as elaborated under the organisation chart.

Chief Engineer (Canal-I) will be responsible for execution of works related to construction of Canal-I i.e Par-Tapi reach of Par-Tapi-Narmada link canal. He will be supported by three Superintending Engineers. One Superintending Engineer will be responsible for Earth work and construction of canal; Second Superintending Engineer will look after the construction of CD structures; and another Superintending Engineer will look after the distribution works and Colony and stores.

Similarly Chief Engineer (Canal-II) will be responsible for execution of works related to construction of Canal-II i.e. Tapi-Narmada reach of Par-Tapi-Narmada link canal. He will be supported by three Superintending Engineers. One Superintending Engineer will be responsible for Earth work and construction of canal; Second Superintending Engineer will look after the construction of CD structures; and another Superintending Engineer will look after the distribution works and Colony and stores.

The civil designs of all the components of the project will be carried out by the Chief Engineer (Designs). The Chief Engineer (Electrical & Mechanical) will look after the electro-mechanical works of the 6 dams, 6 power houses, and 2 barrages both design and field executions. His formation will also provide assistance in respect of electrical and mechanical works for whole of the project.

Detailed manpower requirement has been indicated in Annexures - 10.4 to 10.5 in Volume - II.

10.7 Year Wise Allocation of Cost

The year wise allocation of cost for the project is given below and the details are at Annexure - 10.6 in Volume – II.

Yearly phasing of Expenditure

Year	Allocation of cost (lakh Rs.)
1st Year	87816
2nd Year	86795
3rd Year	153168
4th Year	153168
5th Year	194013
6th Year	194013
7th Year	152148
Total	1021121