Chapter 6
Design Aspects

6.0 Engineering assessment

As already discussed in the foregoing chapters, the main objective of Cauvery - Vaigai - Gundar link project is to divert the surplus waters of Mahanadi and Godavari river basins that are delivered at Grand Anicut on Cauvery on substitution basis for augmentation of irrigation, domestic and industrial needs in the region covered between Cauvery to Gundar rivers.

6.1 General

Cauvery - Vaigai - Gundar link project comprises the following components:

1. An existing barrage across Cauvery river at Kattalai with pond level of 101.20 m on the U/s of Grand Anicut and about 138km downstream of the existing Mettur dam.
2. A head regulator on the right flank of the barrage with discharge capacity of 180.30 cumec.
3. A link canal of 256.82 km taking off from the Kattalai barrage with FSL of 100.75 m and design capacity of 180.30 cumec.
4. Four tunnels of total length 15.54 km, located at 82.300 km (3.940 km), RD 104.100 km (6.040 km) RD 148.100 km (3.630 km), and RD 156.300 km (1.930 km)
5 12 branch canals and 25 direct sluices to facilitate irrigation in the command area.
6 464 Nos. of cross drainage/ cross masonry and regulating works across the link canal.
7 New command of about 4.48 lakh ha at 100% intensity in Karur, Tiruchirappalli, Pudukkottai, Sivaganga, Ramanathapuram, Virudhunagar and Thoothukudi districts.

6.2 Geology, seismicity and foundation treatment

6.2.1 Geology

The Geological Survey of India (GSI) was entrusted with the work of carrying out preliminary regional geological survey of the proposed link canal. The report was prepared by the Engineering Geology Division, GSI, Chennai after field visits.

GSI reported that in the initial 130 km of the canal, the main geological formations observed is metamorphic hard rock and the remaining stretch is dominated by sedimentary domain consisting of sand, clay and shale, capped by laterite. In metamorphic terrain, top soil and weathered migmatite gneiss form the media. The sedimentary formations consisting of sand and clay exposed in canal route appear to have poor shear strength. Based on the finding of GSI that this formation may pose stability problems in deep cuttings, the canal was realigned from RD 210 km to till its tail end. In general, no adverse geological features are noticed by GSI along the canal alignment. The report on regional geology is enclosed as **Appendix 4.1.**

6.2.2 Geophysical investigation

The geophysical investigation to ascertain the subsurface strata along the canal alignment was carried out through electric resistivity method along the canal alignment other than embankment reaches at 1 km interval to a depth of 2m below the canal bed level. The soundings were also taken at the location of important CD structures with one sounding in the case of minor structures and at 200 m interval in the case of major/medium structures. Geophysical investigation was carried out by the Pune University. The sub surface details of the link alignment obtained from Geophysical investigation is shown as **Plate 4.7.1** to **4.7.7.** The detailed report on Geo Physical investigation is furnished as **Appendix 4.3.**

6.2.3 Sub surface exploration

The Geo-technical investigation through sub surface explorations was carried out by Department of Geology, College of Engineering, Pune. Fourteen

bore holes have been drilled during feasibility report stage at various places at indicated at **Table 6.1** below:

Table 6.1
Drilled boreholes along the canal

Sl.No	Name of river/ Location	Type of structure	Location of drill hole	R.D/ chainage in km
1L	Cauvery river	Barrage	250m from the left bank within Cauvery	
1C	Cauvery river	Barrage	Centre of Cauvery river	
1R	Cauvery river	Barrage	83m from the right bank within Cauvery	
2	Napalli river	Aqueduct	Centre	34.46
3	Koraiyar river	Aqueduct	Centre	58.97
4	Deep cut	-	-	83.60
5	Deep cut	-	-	104.60
6L	Vellar river	Aqueduct	Left	115.43
6C	Vellar river	Aqueduct	Centre	115.60
6R	Vellar river	Aqueduct	Right	115.80
7	Deep cut	-	-	136.80
8	Deep cut	-	-	149.00
9	Virisalar river	Canal syphon	Centre	164.90
10	Deep cut	-	-	209.30
11	Gundar river	Aqueduct	Center	256.20

The diamond core drilling of NX size using double tube core barrel was carried out for the drilling purposes. The standard penetration test and permeability tests were also carried out at bore holes. Core logging to depict the lithology was also carried out. From the sub surface explorations, it is seen that Precambrian crystalline rocks cover 80 percent of the terrain and Paleozoic sedimentary rocks cover the eastern coastal terrain and the river valley account for the rest. In the deeply eroded Precambrian terrain rocks of the Khondalite and Charnockite Groups and migmatites derived from them are extensively traced within this west array of crystalline rocks, igneous emplacements of anorthosites, granites, ultrarnafic bodies and basic sills and dykes are defined. The geological setup of the Cauvery - Vaigai - Gundar link is as follows:

a) Charnockites

The nature of occurrence of charnockites as stupendous masses, constituting hill ranges and are similar to that of granite. The Homogeneity of charnockites has no parallel in sedimentary formation. The irregular and testicular shapes of charnockites in some localities suggest pinching outcrop.

b) Migmatic rocks

Migmatites are by and large grey in colour in places, some pink colored migmatites with well defined gneissosity and folds are also traced. Basic dykes, traced along N-S, NE-SW, NW-SE and E-W direction are known. In general, the dyke rocks in the area are fine to medium grained, black in colour and are traced over 0.3 to 1 km in the study area. In the central part of the link meta dolerite dykes, meta gabbros and dark green dolerites traverse ultra basic and ultramafic rocks. The occurrence of dykes in the southern part of the link is poor in comparison to the profusion of dykes in the northern tip.

c) Granite

The Pudukkottai and Pulanckurichi granites are coarse grained holocrystalline rock, with occasional patches of migmatite. In places, major rich layer alternate with feldspar rich and mafic poor layers with joints in WNW - ESE direction is traced. Granite, Pegmatite veins and Dolerite dykes traverses the granite, which in places is marked by greasy patches akin to the appearance of charnockites. The banded granite, varying in width from a few centimeters to as much as 10 m is seen in the gneisses.

d) Tertiary Sediments

Within the Cauvery basin the rocks of this age are essentially coarse to fine - grained brown sandstones, associated with ferruginous and pebbly sandstones, clays and thin beds of limestone are also seen.

e) ***Quaternary Sediments***

Quaternary sediments in the link are traced along the major river valleys and along the coast. These quaternary sediments are by and large arenaceous and calcareous, with patches of murrum like laterite red soils, patches of black clayey soils in places with nodules of kankar and gypsum.

f) Black Soil

All along the link extension patches of black soil are traced on the surface. The soil is clayey and greyish black in colour when dry. On wetting, the black colour deepens. Nodules of kankar in places, nodules of gypsum are seen in black soils where as some nodules are entirely of gypsum, some nodules are partly of Kankar and partly of gypsum. The clayey soil swells up when wet and on drying is reduced in volume with the development of cracks.

The detailed geo technical investigations carried out at feasibility report stage is shown in **Appendix 4.2.**

6.2.4 Seismicity

The proposed project area falls in the Zone II (least active) as per the bureau of Indian standards (IS: 1893 - 2002). The preparation of DPR of the project comprises only the water conductor system but not water retaining structures as such, the site-specific Seismic study of the project area has not been carried out.

6.2.5 Foundation treatment

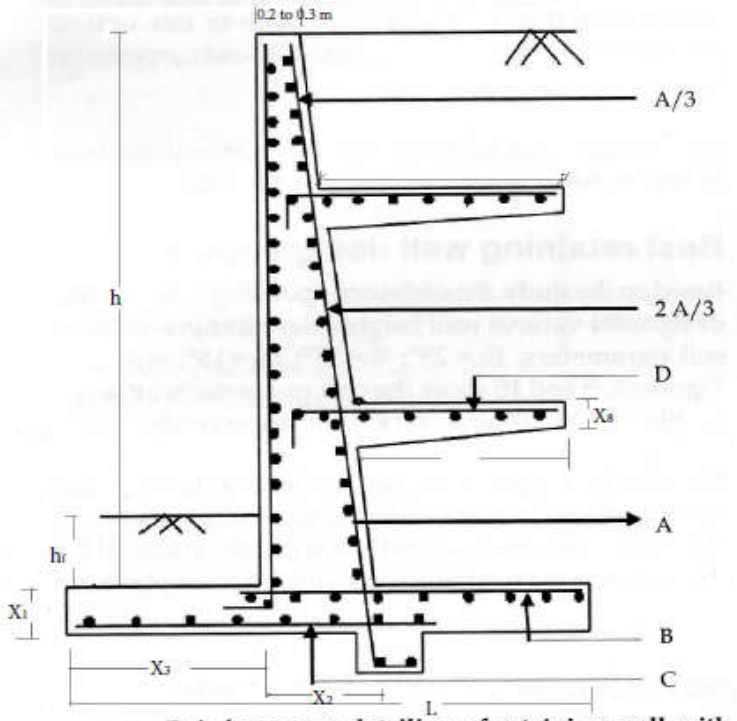
The link canal offtakes from the existing barrage and water retaining structures are not planned in its enroute. The link project is purely a water conductor system. However, based on the surface and sub-surface investigations it may be interpreted that the friction pile / well foundations will be necessary for cross drainage structures. The recommendations on the type of foundations for cross drainage structures are shown in Geo technical report which is shown as **Appendix 4.2**.

6.3 Head regulator

The offtake for the link canal proposed from the foreshore of proposed Kattalai barrage during the feasibility report stage is considered at DPR stage also. The Govt. of Tamil Nadu constructed a new barrage as envisaged in the feasibility report and presently exists. The pond level of the barrage is 101.20 m. The offtake is proposed at river protection bund on foreshore which is situated far away from the submergence area necessitates an approach channel up to the offtake regulator.

The head regulator with 4 bays of 4.25 m wide each is proposed. The piers will be RCC of 1.5 m thick. The abutment foundation lies over the hard rock strata. In case, the hard strata are available above the crest level of the regulators, the base of abutment is proposed above the crest level. An RCC wall of 0.3 m thick is provided at sides of abutment to provide smooth surface which will be anchored with the hard rock. The crest level of the regulator is 96.50 m against the pond level of 101.20 m. The FSL of the link canal is 100.75 m. The floor length of the regulator considered is 30.0 m to accommodate U/S and D/s glacis, crest width, aprons and road bridge.

The return/wing walls of the regulators are proposed with RCC cantilever type. If the height of the soil to be supported is more than 6.0 m, the RCC stem is provided with 2 relieving platforms. In case of excessive depth of soil, the soil pressure can be reduced by the use of relieving platform, provide an economical light weight design. The relieving platform make the pressure diagram discontinuous at the level of platform. Also, relieving platform carries the weight of soil above it and any surcharge loading, transferring them as relieving moment to the vertical stem. The relieving platforms are designed such that they intersect the plane of rupture from the soil above and behind the platforms preventing any load from the soil to act on the wall. The optimal design of reinforced concrete retaining walls published in the Indian Concrete Journal, April 2012 authored by Dr. Devdas Menon, Professor, IIT, Madras and co-authored by Miss. Shravya Donkada, IIT Madras, has been made use for dimensioning of return/ wing walls. The published article is placed at **Annexure 6.1**. The typical section of RCC retaining wall with relieving platforms is shown below:



Reinforcement detailing of retaining wall with relieving platforms. (A, B, C and D are area of reinforcement in mm²/m)

Identical vertical lift type fixed wheel service gate in each bay for opening size of 4.25 m wide x 4.70 m high, are proposed to control the discharge into canal. Sill level / Crest level is EL 96.50 m. The gate shall be designed for water head corresponding pond level of 101.2 m. These gates will be operated by means of rope drum hoist of 8.0 T capacity (tentative) mounted on steel bridge supported on trestles above top of pier EL 106.5 m. The weight of service gate for each bay is 4.8 T.

One set of wheel type stop logs of size 4.25 m x 4.7 m (over all height) (consisting of 4 units of 1.17 m high each) is proposed. The units of stop logs shall be interchangeable. These units shall be designed for pond level of 101.20 m water head corresponding to pond level of barrage. Each stop log units are provided with u/s skin plate and u/s sealing arrangement with music note type Teflon cladded side seal and wedge type rubber seal at the bottom. The stop logs units shall be lowered and lifted by means of a monorail crane of 8.0 T capacity (tentative), with automatic engaging/disengaging device. The stop logs units shall be stored at top of pier at EL 106.5 m through suitable latches. The total weight of stop log gate is 4.4 T. The plan, sectional elevation and cross-sectional elevation of Head Regulator are furnished at

Plate **6.1.** The Hydraulic design details of Head Regulator and Service Gate are at **Annexure: 6.2.** The salient feature of head regulator is shown in **Table 6.2**.

Table 6.2
Salient features of head regulator

Sl. No	**Details**	**HR for link canal**
1	Pond level (m)	101.2
2	Crest level (m)	96.50
4	No. of bays	4
5	Width of bays (m)	4.25
6	Length of regulator (m) (abutment to abutment)	21.5
7	U/S floor level (m)	96.0
8	D/S floor level (m)	95.00
9	Crest width (m)	6.3
10	U/S floor	
(i)	length (m)	7.45
(ii)	Glacis (m)	0.5
(iii)	Cutoff pile level (m)	93.0
11	D/S floor	
(i)	D/S Glacier slope	3:1
(ii)	D/S horizontal (m)	11.25
(iii)	Cistern level (m)	95.0
(iv)	Glacis length (m)	4.5
(v)	Ramp (m)	1.25
12	D/S cutoff pile level (m)	87.75
13	Top of operating platform (m)	106.5
14	Top of road level	103.2
15	Abutment foundation level	88.5
16	Top of abutment width	1.0
17	Bottom width of abutment	7.08
18	Pier width at top	1.5
19	Pier foundation level	88.5

6.4 Design aspects of link canal

In planning and design of canal system of link project, the open canal, tunnels and pipe line systems are studied to optimize the cost of main canal.

6.4.1 Canal alignment

The topographical survey for the link canal alignment was carried out during feasibility report stage. The topographical survey for the longitudinal section was done with double levelling at 100 m interval whereas for cross section the same was taken at every 400 m distance with single leveling at 50 m interval. In addition, the Govt of Tamil Nadu carried out topographical and geo technical investigations at certain CD structures. The topographical survey was conducted for entire link canal alignment by taking cross section at 100 m interval and levels along the cross section at 10 m interval.

The joint inspection for the CVG link alignment was carried out during 27th July to 1st August 2019 by the Chief Engineer (South), NWDA, Hyderabad along with the State Government officers in view of the urbanization and developmental activities that has taken place since the Feasibility Report was circulated in 2004. It was found that vast developmental activities have come up along the link alignment at the outskirt of Trichy, Pudukkottai and Karaikudi towns. The following modifications were suggested to improve the canal alignments which are given below:

(i) *The Off-take of CVG link was proposed foreshore of barrage*: A number of houses constructed and other development activities have taken place along the proposed alignment as well as at off-take site. Three canals off-take from the barrage on the right-side barrage. Chief Engineer (south), NWDA suggested to explore the possibilities of integrating the existing 3 canals with the proposed CVG Link canal.

(ii) Changes of alignment:
At RD 66.00 Km, the alignment crosses Trichy - Pudukkottai National Highway and passes through the Institutional areas of

Bharathidasan University, Indian Institute of Management and Anna University (Trichy campus). Re-aligning the canal in this stretch if possible or keep the original alignment with modified section so that the land acquisition is minimum.

From RD 103.00 Km to 109.00 Km, the link alignment passes through the outskirts of Pudukkottai town in deep cutting. Realigning the canal with tunnel or cut and cover canal further west of Pudukkottai town to avoid urbanization even if the depth of cutting will increase further.

From RD 109.0 Km to RD 123.0 Km, the link alignment encounters the Tiruchirappalli - Rameswaram national highway at several places. Shifting the alignment further west as proposed by Govt. of Tamil Nadu.

From RD 144.00 Km to 155.00 Km, urbanization of Kottaiyur and Karaikudi towns extent beyond the link canal alignment. Deviation of alignment as proposed by Govt. of Tamil Nadu west up to Managiri village

From RD 174.00 Km to 206.00Km, the alignment passes through the outskirts of Sivaganga town. The Chief Engineer (south) suggested to modify the alignment slightly to avoid cluster of houses.

(iii) Geological aspects: The sedimentary formations consisting of sand and clay exposed in canal route appear to have poor shear strength. Based on the finding of GSI that this formation may pose stability problems in deep cuttings from RD 210 km to till its tail end.

The Govt. of Tamil Nadu had shown interest to implement the link project as a flood flow canal and prepared the draft DPR of this link project by carrying out topographical survey of the link project during 2008. The Govt. of Tamil Nadu had now initiated action for tendering for execution of link project

for the reach from Cauvery to Vellar and for the remaining reaches in phased manner at later date.

The alignment of link canal proposed by Govt. of Tamil Nadu is almost same but with little deviations at certain locations. The topographical survey carried out by Tamil Nadu Govt. for longitudinal section was at 100 m interval and cross sections at every 100 m with levelling at 10 m interval. The details of the topographical survey could not be made available to NWDA by Govt. of Tamil Nadu.

The proposed link canal alignment at feasibility stage was reviewed once again using the images of Google earth for ascertaining developmental activities on its enroute and it is seen that vast activities had taken place around the urban areas. As Govt. of Tamil Nadu have initiated action for implementation in phased manner and due to time constraint, it is proposed to study the topographical conditions of the link alignment through remote sensing technology. The accuracy of the elevation of GDSM/ DEM was verified with the ground truth verification considering 46 locations as obtained from Bhuvan (India) and Jaxa Global Alos (Japan) web portals. The accuracy for elevation in respect of GDSM as obtained from Jaxa Global Alos web portal was found to be better than DEM obtained from Bhuvan web portal. The contours of 2 m interval have been generated using the Globe Digital Surface Model (GDSM) of 1 arc obtained from Jaxa Global Alos portal. The alignment is deviated at RD 62.53 km to 69.00 km to avoid passing through the institutional area.

The cross drainage / cross masonry structures along the canal such as aqueducts, syphon aqueducts, canal syphons, super passages, bridges, direct sluices, branch canals, regulators, under tunnels and overpasses have been also considered duly accounting head losses for each structure. In the present alignment, the alignment has been drawn from turning point to turning point. The alignment is refined with straight lines and circular curves as per Clause 6.4 of IS 5968: ‘Guidelines for planning and layout of canal system’. The range of radius for circular curves shall be as given in **Table 6.3.**

Table 6.3.
Radii of curves for canal

Discharge (m^3/s)		Radius, Min(m)
280 and above		900
Less than	280 to 200	750
Less than	200 to 140	600
Less than	140 to 70	450
Less than	70 to 40	300
Less than	40 to 10	200
Less than	10 to 3	150
Less than	3 to 0.3	100
Less than	0.3	50

Based on the field surveys/generation of contours, the strip contour plan and longitudinal section of the link canal is plotted adopting a horizontal scale of 1: 38450 and vertical scale of 1:1850. The Plates show the plan of the link canal alignment along with the topographical features such as contour, rivers, towns, villages and roads. The longitudinal section indicates the important cross drainage and cross masonry works enroute along with the sub-surface profile. The longitudinal section of canal alignment is measured at 100 m interval. The NSL at 100 m interval and at CD/CM structures of the canal are furnished as head loss statement and shown at **Annexure: 6.3.** The strip contour maps along with longitudinal section of canal alignment is shown in **Plates 4.4.1 to 4.4.26.**

The general topography of the area through which the Cauvery (Kattalai) - Vaigai - Gundar link canal traverses is mostly plain with a few hillocks. The canal runs in south-east direction up to 80.70 km and takes a right turn and runs in south- south easterly direction up to 141.0 km. Further it turns in right and runs south to south - west direction up to the tail end. The alignment of link canal runs in cutting to balanced sections. Maximum depth of cutting in the entire reach of the canal is 40.25 m and maximum height of filling is 12.64 m. Tunnels are proposed at deep cut reaches.

A uniform bed slope of 1 in 20000 up to RD 189.9 km and 1:15000 for the remaining length of canal is adopted. The canal is designed as a trapezoidal section with bottom corners rounded and is proposed to be lined.

The velocity at the head and tail end of the link canal are 1.0 m/s and 0.65 m/s respectively. Sections of the canal at head and tail end are 21.5 m x 5.50 m and 4.5 m x 2.65 m respectively. The canal section is flumed wherever in deep cutting having considerable length. The discharge at head and tail end of the link canal are 180.30 cumecs and 17.0 cumecs respectively. The canal has been designed for 1.1 times the peak discharge. A free board of 0.75 m is provided throughout the length of the link canal. The canal curves are provided with radius of curve ranging from 600.0 m to 200.0 m as per the canal discharge capacity specified in IS Codes at turning points. The total length of canal is 256.82 km whereas on introduction of curve, the canal length is 256.20 km. For calculation of estimate and other purposes, the canal with curves is considered. The turning points along the link canal have been geo-referenced for future reference and are shown in **Annexure**: **6.4.**

The reach-wise brief description of the link alignment is described in the following paragraphs.

i) Reach from RD 0 to 34.56 km (Topo Maps 58 J/1, J/5)

This reach is shown in **Plate 4.3.1 and 4.3.2**. The link canal takes-off from the foreshore of the existing barrage, with FSL 100.750 m. The link canal traverses generally in south east direction and occasionally from west to east for small portion. In this reach, the link canal passes parallel to the existing New Kattalai high level canal, thus the benefit of link canal in this reach is limited. The link canal in this reach is mostly in balanced section followed by cutting and embankment where it crosses ridges and valley portions. A total of 87 Nos. of CD/CM structures are identified of which the rivers Pungar and Napali are prominent one. One four lane road and a railway line connecting the Tiruchirappalli and Karur crosses in this reach. The command area in this reach is benefitted through 13 Nos. of direct sluices. The link canal is not passing through any forest area. The number of houses likely to be affected by the link in this reach is 563. FSL of the canal at the end of the reach is 97.177 m.

ii) Reach from RD 34.56 to 45.56 km (Topo Map 58 J/9)

This reach is shown in **Plate 4.3.3**. The link canal traverses generally in south east direction. The link canal in this reach is mostly in balanced section

followed by cutting and embankment where it crosses ridges and valley portions. 28 Nos. of CD/CM structures are identified in this reach. The command area in this reach is benefitted through 4 Nos. of direct sluices. The link canal is not passing through any forest area. The number of houses likely to be affected by the link in this reach is 134. FSL of the canal at the end of the reach is 96.086 m.

iii) Reach from RD 45.56 to 69.34 km (Topo Map 58 J/10)

This reach is shown in **Plate 4.3.4.** The link canal traverses generally in south east direction. The link canal in this reach is mostly in balanced section followed by cutting and embankment where it crosses ridges and valley portions in the initial reach. In this reach the original alignment of link canal is deviated at RD 62.53 km to RD 70.0 km to avoid the institutional area. 50 Nos. of CD/CM structures are identified of which the rivers Ariyar and Korayar are prominent one. Three four lane road bridges connecting Tiruchirappalli with Dindigul, Madurai and Pudukkottai are also provided in this reach. One railway bridge for Tiruchirappalli - Dindigul railway line is also proposed. The command area in this reach is benefitted through 8 Nos. of direct sluices. The link canal is not passing through any forest area in this reach also. The number of houses likely to be affected by the link in this reach is 102. FSL of the canal at the end of the reach is 93.607m.

iv) Reach from RD 69.34 to 96.85 km (Topo Map 58 J/14)

This reach is shown in **Plate 4.3.5**. The link canal traverses generally from west to east direction for some portion and turns north to south direction and follow in the same direction till end of the reach. This reach is mostly in cutting to deep cutting. A tunnel at RD 82.3 km to negotiate deep cut reach is provided. a total of 44 Nos. of CD/CM structures are identified of which the River Agni ar is prominent one. A cross regulator is proposed at 96.0 km to deliver water to Gandarvakottai and Alangudi Branch canals. The command area in this reach is benefitted through Gandarvakottai Branch canal. The link canal is not passing through any forest area in this reach. The number of houses likely to be affected by the link in this reach is 65. FSL of the canal at the end of the reach is 90.364 m.

v) Reach from RD 96.85 km to 127.24 km (Topo Map 58 J/15)

This reach is shown in **Plate 4.3.6.** The link canal traverses generally south west direction to its entire length in this reach. A tunnel is proposed between RD 104.100 km to 110.137 km to avoid the urban area of Pudukkottai town. The link canal in this reach is passing mostly in cutting and occasionally in balanced sections. 41 Nos. of CD/CM structures are identified of which the Vellar and Pambanar Rivers are prominent one. Four four lane bridges for road connecting Tiruchirappalli to Ramanathapuram are provided. Thirumayam Br. Canal offtakes at RD 116.55 km. The command area in this reach is benefitted through Alangudi and Thirumayam branch canals. The link canal is not affected any forest area. 535 nos. of houses are likely to be affected by the link canal in this reach. FSL of the canal at the end of the reach is 86.723 m.

vi) Reach from RD 127.24 to 153.75 km (Topo Map 58 J/16)

This reach is shown in **Plate 4.3.7.** The link canal traverses generally in south east direction in first half and south west direction in the remaining half. The link canal in this reach is mostly in cutting and in balanced sections. A tunnel is proposed between RD 148.1 km to 151.73 km to avoid the deep cutting. 51 Nos. of CD/CM structures are identified in this reach. A cross regulator is proposed at RD 142.0 km to deliver water to Pallatur Branch canal. Another Branch canal namely Karaikudi offtakes at RD 147.8 km. 2 railway bridges for Tiruchirappalli - Karaikudi railway line is also provided. The command area in this reach is benefitted through Tirumayam, Pallatur and Karaikudi branch canals. The link canal is passing through Reserved forest from RD 139.33 to 141.32 km affecting about 30.0 ha. The number of houses likely to be affected by the link in this reach is 446. FSL of the canal at the end of the reach is 83.738 m.

vii) Reach from RD 153.75 to 177.54 km (Topo Map 58 J/12)

This reach is shown in **Plate 4.3.8.** The link canal traverses generally in east to west for three fourth of the length and north to south direction for the remaining length. The link canal in this reach passes mostly in cutting. A tunnel is proposed between RD 156.30 km to 158.23 km to avoid the deep cutting. The number of CD/CM structures identified in this reach are 39. Manimuttar river is the prominent river in this reach. Two Branch canals

namely Devakottai and Tiruvadanai are proposed to offtake at RD 158.5 km and 177.20 km respectively. The command area in this reach is benefitted through Devakottai branch canal. The number of houses likely to be affected by the link in this reach is 295. FSL of the canal at the end of the reach is 80.895 m.

viii) Reach from RD 177.54 to 203.93 km (Topo Map 58 K/9)

This reach is shown in **Plate 4.3.9.** The link canal traverses generally in south west direction and occasionally in south east direction. The link canal in this reach passes almost in cutting. A total of 45 Nos. of CD/CM structures are identified in this reach. One four lane road bridge for Kochi – Thondi NH and 2 railway bridges for Karaikudi to Rameswaram railway line are also provided. A cross regulator is proposed at RD 189.9 km to deliver water to Kalaiyarkovil Branch canal. The command area in this reach is benefitted through, Devakottai, Tiruvadanai and Kalaiyarkovil branch canals. The link canal is passing through reserved forests from RD 179.50 km to 180.4 km, 186.28 km to 186.80 km, 187.46 km to 188.30 km, 195.08 km to 195.94 km and 198.01 km to 198.58 km affecting about 77.0 ha. The houses likely to be affected by the link in this reach is 94. FSL of the canal at the end of the reach is 78.389 m.

ix) Reach from RD 203.93 to 222.42 km (Topo Map 58 K/5)

This reach is shown in **Plate 4.3.10.** The link canal traverses from east to west direction for the first half and south west direction in the remaining half. The link canal in this reach passes in cutting and occasionally in balanced section. A total of 27 Nos. of CD/CM structures are identified, of which the Vaigai river is the prominent one. One four lane road connecting Madurai to Rameswaram crosses the alignment. The command area in this reach is benefitted through Manamadurai branch canal. The link canal is not passing through any reserved forest. The number of houses likely to be affected by the link in this reach is 71. FSL of the canal at the end of the reach is 76.306 m.

x) Reach from RD 222.42 to 245.11 km (Topo Map 58 K/6)

This reach is shown in **Plate 4.3.11.** The link canal traverses generally in southwest direction. The link canal in this reach is in cutting to deep cutting and in balanced section almost equally. Totally 90 Nos. of CD/CM structures are identified of which the Gridhamal river is prominent one. Three cross regulators at RD 222.50 km, 232.65 km and 236.3 km are proposed to deliver water for the Manamadurai, Paramakudi and Narikudi branch canals. The command area in this reach is benefitted through Manamadurai, Paramakudi and Narikudi branch canals. The link canal is not passing through any reserved forest. The houses likely to be affected by the link in this reach numbers 90. FSL of the canal at the end of the reach is 73.313 m.

xi) Reach from RD 245.11 to 256.82 km (Topo Map 58 K/2)

This reach is shown in **Plate 4.3.12.** The link canal traverses generally in northwest initially and turns into southwest direction. The link canal in this reach is ideal type of section. In total 16 Nos. of CD/CM structures are identified. The link canal tail end is located on Gundar river. The Tiruchuli branch canal offtake from the tail end. The command area in this reach is benefitted through Narikudi and Tiruchuli branch canals. The link canal is not passing through any reserved forest. No houses are likely to be affected by the link in this reach. FSL of the canal at the end of the reach is 72.048 m.

In general, it is seen that the link canal is found to be in cutting for more than 6 m for a length of 187 km followed by 52 km in balanced section and 16 km in embankment. The reach wise type and number of CD/CM structures is given in **Table 6.4** below:

Table 6.4
Reach wise type and number of CD/CM structures

RD upto (km)	34.56	45.56	69.34	96.85	127.2	153.8	177.5	203.9	222.4	245.1	256.82	Total
Aqueduct	1	1	2	0	0	0	0	0	0	0	2	**6**
Sy Aqueduct	3	1	3	0	0	2	0	0	0	1	0	**10**
Canal Syphon	6	1	3	5	4	3	3	2	0	7	2	**36**
Super Passage	0	0	0	0	1	0	4	1	5	0	1	**12**
Cross regulator	0	0	0	1	0	2	0	1	0	3	0	**7**
Canal escape	0	0	1	0	1	0	1	0	0	1	0	**4**

Single lane road	27	8	8	12	11	12	6	11	5	6	4	**110**
Double lane road	4	3	2	3	5	4	5	2	4	3	0	**35**
Four lane road	1	0	3	0	4	0	0	2	1	0	0	**11**
Railway line	1	0	1	0	0	2	0	2	0	0	0	**6**
Direct sluice	13	4	8	0	0	0	0	0	0	0	0	**25**
Branch canal	0	0	0	2	1	2	2	1	0	3	1	**12**
Over pass	5	2	5	7	9	14	16	23	10	3	1	**95**
Under tunnel	26	7	14	14	5	11	2	0	1	8	7	**95**
Total	**86**	**28**	**50**	**44**	**41**	**52**	**39**	**45**	**26**	**35**	**18**	**464**

6.4.2 Canal capacity

The 256.82 km long link canal, off takes from Kattalai barrage with FSL of 100.75 m. In the initial reaches, the canal has a carrying capacity of 180.30 cumec. As the canal moves west and south wards, it releases water at various locations to feed the direct sluices and branch canals. Thus, the capacity of canal decreases at the respective RDs where the feeder canals/direct sluices are proposed. 12 branch canals and 25 direct sluices have been proposed along the canal. The tail end canal capacity is 17 cumec.

6.5. Hydraulic designs

The length of the canal as proceeds from the off taking point at barrage releases water to direct sluices and branch canals and hence the capacity of the canal discharge gets reduced. However, it is not practicable to change the section of the canal at each and every off-take point of direct sluices and branch canals. Hence the canal is divided into suitable reaches and canal sections are designed to carry the required discharges in the particular reaches. The peak discharge requirement at various reaches has been estimated taking into consideration of irrigation, domestic and industrial needs and transmission losses along the canal and is shown in **Annexure: 6.5.**

6.5.1 Link canal / open canal

The section of the canal has been selected as trapezoidal with rounded corners as per provisions of IS 10430. The Full Supply Depth (FSD) of canal ranging from 5.5 m at offtake to 2.65 m at tail end is considered. The FSD is increased by 0.5 m in deep cutting reaches to increase the velocity and

to minimize cutting area. To prevent losses and to reduce the required section of canal, plain cement concrete lined canal is proposed throughout the reaches of link project.

The canal section is designed using Manning's formula. As the available head for the main canals was inadequate, effort was made to make the canal section as hydraulically efficient as possible. Therefore, trapezoidal lined canal with rounded corners was provided to improve hydraulic radius of section. The side slope of 1.5:1 (H: V) on soil portion and 0.5: 1 on hard rock portion have been assumed for design of canal section. Outer side slopes in embankment is considered as 2: 1 (H: V). Berms of 2.0 m wide on each side wherever, the height of embankment exceeds 6.0 m is provided. In hard rock, the berms are provided either at free board level or at 6.0 m whichever is more on inner side of cutting. Longitudinal slopes for canal were provided between 1 in 20,000 to 1 in 15000. However, other factors like topography, available head between various reaches and expected head losses due to canal and various cross drainage structures along the length of canal were deciding factors in finalizing the slopes.

Velocity to be adopted depends upon the type of lining and maximum / minimum permissible velocities for the section. Due to restraint of available head, steeper slopes to provide higher velocities near to permissible velocity in cement concrete lining and thereby avail the benefit of cement concrete lining could not be made. The hydraulic parameters for design of canal sections is furnished below:

Hydraulic parameters:

Area of cross section (A)	$= bd+d^2 (\theta + \cot \theta)$	
Manning's formula (V)	$= (1 / n) R^{2/3} S^{1/2}$	
Rugosity coefficient (n)	=0.018	
Bed slope (s)	= 1 :20000 (RD 0 to 189.80 km)	
	= 1 :15000 (189.8 to 256.2 km)	
Side slope (H: V)	1.5 :1	On soil section
	1 :1	On weathered Rock
	0.5 :1	On hard rock section
Wetted perimeter P	$= b+2d (\theta + \cot \theta)$	

= θ = 0.588 Radian in soil section
= θ = 0.7854 Radian in weathered rock
= θ = 1.107 Radian in hard rock

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

Table 6.5
Hydraulic particulars of link canal

Reach (km)		Designed discharge	Bed width (m)	FSD (m)	Area in sq.m	wetted perimeter (m)	Velocity (m/sec)	actual discharge (cumec)
From	To							
On soil section								
0.00	96.00	180.30	21.50	5.50	181.40	44.50	1.00	181.40
96.00	142.00	156.90	20.00	5.25	162.60	41.90	0.97	157.30
142.00	177.20	150.17	19.00	5.25	157.30	40.90	0.96	151.00
177.20	189.80	127.27	17.25	5.00	138.45	38.13	0.92	127.37
189.80	222.50	117.89	16.75	4.50	117.66	35.54	1.01	118.80
222.50	232.65	90.01	15.60	4.00	95.81	32.30	0.94	90.06
232.65	239.20	59.87	12.60	3.50	69.68	27.22	0.86	59.92
239.20	256.20	42.26	10.00	3.25	54.55	23.57	0.79	43.10
On weathered rock								
0.00	96.00	180.30	17.75	6.00	170.80	39.20	1.06	181.05
96.00	142.00	156.90	16.50	5.75	153.90	37.00	1.02	157.00
142.00	177.20	150.17	15.75	5.75	149.60	36.30	1.01	151.10
177.20	189.80	127.27	14.10	5.50	131.56	33.74	0.97	127.60
189.80	222.50	117.89	13.25	5.00	110.89	31.10	1.07	118.65
222.50	232.65	90.01	12.25	4.50	91.28	28.32	0.99	90.37
232.65	239.20	59.87	9.50	4.00	66.57	23.78	0.90	59.90
239.20	256.82	42.26	8.40	3.50	51.27	20.90	0.84	43.07
On hard rock section								
0.00	96.00	180.30	21.75	6.00	169.59	38.10	1.07	181.50
96.00	142.00	156.90	20.50	5.75	153.77	36.13	1.04	159.90
142.00	177.20	150.17	20.00	5.75	150.90	35.60	1.02	153.92
177.20	189.80	127.27	17.50	5.50	129.10	32.45	0.99	127.80
189.80	222.50	117.89	16.75	5.00	110.89	30.39	1.07	118.65
222.50	232.65	90.01	15.00	4.50	89.48	27.23	1.01	90.38
232.65	239.20	59.87	12.00	4.00	65.36	22.87	0.92	60.13
239.20	256.82	42.26	11.00	3.50	51.79	20.51	0.84	43.51

Typical canal sections at full cutting and deep cutting reaches of main canal are shown at **Plates 6.2.1**. The typical canal sections at partial cutting & filling and embankment reaches of main canal are shown at **Plate 6.2.2**.

6.5.2 Tunnels

The Tunnels are designed as modified horse type, free flow in nature and concrete lined. The alignment of the link tunnel and construction of audit has been finalized on the basis of strip contour maps and depth of cutting.

The hydraulic designs of the tunnels have been carried out for conveying actual discharge available at that location. The slope of the link tunnel is considered as 1 in 5000. The value of Manning's coefficient adopted is 0.014 for the concrete lined tunnel. The tunnels proposed at RD 82.3 km, 104.10 km, 148.10 km and 156.3 km are having length of 3.94 km, 6.04 km, 3.63 km and 1.93 km respectively.

The link tunnel is provided with PCC lining of M25 grade concrete for ensuring smooth surface for conveyance of envisaged discharge. The lining shall be of RCC at junctions with shafts in very poor rock strata and any other specified reaches identified during construction. The lining has been designed to resist the external and internal water pressure. The entire rock load is assumed to be carried by the rock support system consisting of rock bolts, steel fiber reinforced shotcrete (SFRS) and steel ribs. The link tunnel is proposed to be excavated by conventional drill and blast method (DBM).

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

A typical scheme of contact and consolidation grouting has been proposed. The contact grouting in the tunnel is proposed to fully pack up the space between the concrete lining and the rock surface caused by shrinkage of

concrete lining. The consolidation grouting is proposed to fill up the joints and discontinuity in the rock up to a desired depth.

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

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

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

c. The tunnels are designed for free flow conditions and waters are regulated at Head regulators as such no gates are provided.

d. The maximum velocity in circular tunnels occurs when the depth of flow is 0.94 times of diameter. In this tunnel designs also, the depth of flow is considered at 0.94 times of the dia. of tunnel.

e. The tunnel lining (PCC M25) is considered as 6 cm per m dia. of tunnel subject to a minimum of 30 cm for good rocks.

(i) Tunnel at RD 82.30 km

The designed discharge of the canal is 179.84 cumec, however, the tunnel is designed for 180.30 cumec capacity. The tunnel diameter is 10.4 m. The tunnel length is 3940 m. The slope of the tunnel is 1 in 5000. The link tunnel is provided with 300 mm thick PCC lining of M25 grade concrete for ensuring smooth surface for conveyance of envisaged discharge. The hydraulic design of tunnel and support system are furnished at **Annexure: 6.6**. The contact grouting and consolidating grouting shall be carried out as per the provisions of BIS-5878 (Part-VII). The typical excavation and rock support system, concrete lining and grouting details are shown at **Plate 6.3.1 to 6.3.4.** The details of inlet and outlet portals are given in **Table 6.6.**

Table 6.6
Inlet outlet portal details

Sl.No.	Details	Inlet portal	Outlet portal
1	RD (km)	82.30	86.24
2	NSL (m)	107.325	108.469
3	HR level (m)	74.320	84.580
4	Soffit level (m)	92.972	92.086
5	Bed level (m)	82.670	81.786

The hard strata for the tunnel is available only at exit of tunnel and hence the suitability of type of structure such as tunnel or cut and cover tunnel or open cut canal will be decided during the construction period after carrying out the sub surface exploration.

(ii) Tunnel at RD 104.10 km

The designed discharge of the canal is 179.84 cumec, however, the tunnel is designed for 180.30 cumec capacity considering the upstream release of water. The tunnel diameter is 9.5 m. The tunnel length is 6040 m. The slope of the tunnel is 1 in 5000. The link tunnel is provided with 300 mm thick PCC lining of M25 grade concrete for ensuring smooth surface for conveyance of envisaged discharge. The details of inlet and outlet portals are given **Table 6.7.**

Table 6.7
Inlet outlet portal details

Sl.No.	Details	Inlet portal	Outlet portal
1	RD (km)	104.10	110.14
2	NSL (m)	106.170	104.200
3	HR level (m)	84.480	80.500
4	Soffit level (m)	90.490	89.187
5	Bed level (m)	80.990	79.687

The hard strata for the tunnel is available only for negligible height and hence the suitability of type of structure such as tunnel or cut and cover tunnel

or open cut canal will be decided during the construction period after carrying out the sub surface exploration.

(iii) Tunnel at RD 148.10 km

The designed discharge of the canal is 150.17 cumec, however, the tunnel is designed for 150.60 cumec capacity considering the upstream release of water. The tunnel diameter is 9.0 m. The tunnel length is 3630 m. The slope of the tunnel is 1 in 5000. The link tunnel is provided with 300 mm thick PCC lining of M25 grade concrete for ensuring smooth surface for conveyance of envisaged discharge. The details of inlet and outlet portals are given **Table 6.8.**

Table 6.8
Inlet outlet portal details

Sl.No.	Details	Inlet portal	Outlet portal
1	RD (km)	148.10	151.73
2	NSL (m)	105.076	102.527
3	HR level (m)	66.414	56.982
4	Soffit level (m)	85.585	84.780
5	Bed level (m)	76.585	72.780

The tunnel portion is lying on the soil strata and hard rock is available well below the tunnel bed and hence the suitability of type of structure such as tunnel or cut and cover tunnel or open cut canal will be decided during the construction period after carrying out the sub surface exploration.

(iv) Tunnel at RD 156.30 km

The designed discharge of the canal is 150.17 cumec, however, the tunnel is designed for 150.60 cumec capacity considering the upstream release of water. The tunnel diameter is 8.8 m. The tunnel length is 1930 m. The slope of the tunnel is 1 in 5000. The link tunnel is provided with 300 mm thick PCC lining of M25 grade concrete for ensuring smooth surface for conveyance of envisaged discharge. The details of inlet and outlet portals are given **Table 6.9.**

Table 6.9
Inlet outlet portal details

Sl.No.	Details	Inlet portal	Outlet portal
1	RD (km)	156.30	158.23
2	NSL (m)	97.425	98.012
3	HR level (m)	52.545	58.520
4	Soffit level (m)	84.421	83.970
5	Bed level (m)	73.629	75.147

The tunnel portion is lying on the soil strata and hard rock is available well below the tunnel bed and hence the suitability of type of structure such as tunnel or cut and cover tunnel or open cut canal will be decided during the construction period after carrying out the sub surface exploration.

6.5.3 Details of lining provided

Lining is provided for the entire length of main Canal to minimize seepage. Lining with CC 1:2:4 (M15) is proposed in canal bed as well as in side slopes. The thickness of lining varies from 100 mm to 75 mm according to canal capacity as per IS code 3873-1978: Laying cement concrete/stone slab lining on canals. However, lining of 100 mm thickness is assumed for most of the reaches. Typical cross section of lining of canal is indicated in the drawings. At places where ground water table or otherwise water table is higher, suitable drainage arrangement has been suggested, including provision of non-return valves, in staggered pattern, at the rate of 1 pressure release valve (PRV) for every 40 m^2 of lining along the side slopes and at every 100 m^2 of lining in canal bed. Typical details of canal lining and drainage arrangement under the lining are shown at **Plate 6.4.**

6.5.4 Transmission losses

The transmission losses in the canal occurs in the form of seepages through the lining and evaporation from the surface of water. 0.6 cumec per million square meter area is considered as transmission loss along the canal.

6.6 Description of soil profile along the canal alignment based on Geo-physical investigations

The geo physical investigations carried out during the Feasibility report stage indicates that the reaches 0 to 6 km and 217.0 to 238 km is covered by black cotton soils, Reach 75 to 217 km by Red lateritic sandy soil and rest of the reach by red sandy soil. The characteristic of soils is given below:

(i) Red sandy soils

The red soils have come into existence due to weathering of ancient crystalline and metamorphic rocks. The main parent rocks are acid granites and gneisses, quartzitic and felspathic. The colour of these soils is generally red, often grading into brown, chocolate, yellow, grey or even black. The red colour is due more to the wide diffusion rather than to high percentage of iron content. By and large, the red soils are poor in lime, magnesia, phosphates, nitrogen and humus, but are fairly rich in potash. In their chemical composition they are mainly siliceous and aluminous; with free quartz as sand the alkali content is fair, some parts being quite rich in potassium. The texture of these soils varies from sand to clay, the majority being loams. On the uplands, the red soils are thin, poor and gravelly, sandy or stony and porous, but in the lower areas they are rich, deep dark and fertile. The red soils respond well to the proper use of fertilizers and irrigation and give excellent yields of cotton, wheat, rice, pulses, millets, tobacco, oil seeds, potatoes and fruits.

(ii) Red lateritic sandy soil

The word ‘laterite’ (from Latin letter meaning brick) soils formed as to 90-100 per cent of iron, aluminium, titanium and manganese oxides. They also occur at lower levels and in valleys. Due to intensive leaching and low base exchange capacity, typical laterite soils generally lack fertility and are of little use for crop production. But when manured and irrigated, some laterites and lateritics are suitable for growing plantation crops like tea, coffee, rubber, cinchona, coconut, etc. In low lying areas paddy is also grown.

Laterite and lateritic soils have a unique distinction of providing valuable building material. These soils can be easily cut with a spade but hardens like iron when exposed to air. Because it is the end-product of weathering, it cannot be weathered much further and is indefinitely durable.

(iii) Black cotton soil

The black soils and black cotton soils have been formed due to the solidification of lava spread over large areas during volcanic activity in the Deccan Plateau. Most of the black soils are derived from two types of rocks, the Deccan and the Rajmahal trap, and ferruginous gneisses and schists occurring in Tamil Nadu. The former is sufficiently deep while the later is generally shallow.

The black colour of these soils has been attributed by some scientists to the presence of a small proportion of titaniferous magnetite or even to iron and black constituents of the parent rock. The black colour of this soil may even be derived from crystalline schists and basic gneisses such as in Tamil Nadu and parts of Andhra Pradesh. Various tints of the black colour such as deep black, medium black, shallow black or even a mixture of red and black may be found in this group of soils.

The black soil is very retentive of moisture. It swells greatly and becomes sticky when wet in rainy season. However, in the hot dry season, the moisture evaporates, the soil shrinks and is seamed with broad and deep cracks, often 10 to 15 cm wide and up to a meter deep. This permits oxygenation of the soil to sufficient depths and the soil has extraordinary fertility.

6.7 Canal structures across link canal

6.7.1 Cross drainage works / regulators

As per the available data, various canal structures, Bridges and Cross drainage structures have been proposed. The reach wise type and number of CD/CM structures is shown in **Table 6.4.**

6.7.2 Layout and foundation

Detailed laboratory tests for finding the suitability of soils for foundations of all cross-drainage works have not been carried out except for few major rivers. However, based on the soil samples collected, it is inferred that hard rock can be met with at reasonable depths below the stream bed levels. This is required to be confirmed at pre-construction stage.

6.7.3 Cross drainage works

The type of cross drainage structure to be provided depends on the physical features of the stream crossed such as position of bed level of stream in relation to canal bed level. Loss of head at each structure is computed based on the 100 years design flood derived based on the method enumerated in flood estimation reports of east coast Zone (4 (c)) by the Central Water Commission and the drain/canal details. Though head loss in the structure mainly depend upon the length and fluming adopted, more the length and fluming more is the head loss. Fluming of canal at the structures are considered to an extent of 60 to 70% wherever possible to achieve economy in cost of structure. The RCC will be used of mix M20 grade in cross drainage works.

The piers of the structures will be of RCC of 1.25 m thick. The abutment foundation lies over the hard rock strata. In case, the hard strata are available above the river bed level, the base of abutment is proposed above the river bed level. An RCC wall of 0.3 m thick is provided at sides of abutment to provide smooth surface which will be anchored with the hard rock. The return/wing walls are proposed with RCC cantilever type. If the height of the soil to be supported is more than 6.0 m, the RCC stem is provided with 2 relieving platforms. The optimal design of reinforced concrete retaining walls published in the Indian Concrete Journal, April 2012 authored by Dr. Devdas Menon, Professor, IIT, Madras and co-authored by Miss. Shravya Donkada, IIT Madras, has been made use for dimensioning of return/wing walls. The computed head loss likely to occur at the cross-drainage structures are shown at **Annexures: 6.7.1 to 6.7.5.**

Aqueducts

Aqueducts have been proposed along the link canal at the crossings of major streams where the bed level of the link canal is above the highest flood level of the drain with sufficient free board. 6 nos. of aqueducts are proposed in the link alignment.

Height of piers vary depending upon the depth of drainage bed from bottom of aqueduct. However, considering average conditions, RCC Piers of 1.00 m width with spread footing were assumed in analysis. Since aqueduct portion were not flumed, length of piers with assumed width were sufficient enough to keep foundation pressures quite low. General layout of Aqueduct at RD 34.46 km is shown at **Plate 6.5.** and typical design details of Aqueduct at RD 34.46 km are appended at **Annexure: 6.8.**

Super Passages

Super Passages have been proposed along the link canal at the crossings of major/medium streams where the bed level of the drain is above the FSL level of the drain with sufficient free board. A total of 12 numbers of Super passages are proposed. General layout of Super passages at RD 101.75 km is shown at **Plate 6.6**. and typical design details of Super Passage at RD 101.75 km are furnished at **Annexure: 6.9.**

Syphon Aqueducts

Syphon Aqueducts have been proposed along the link canal at the crossings of major/medium streams where the bed level of the link canal is just at the highest flood level of the drain. The bed of the drain is depressed to an extent of about 1.0 m below the actual drain bed level. 10 nos. of syphon aqueducts are proposed.

Height of piers vary depending upon the depth of drainage bed from bottom of syphon aqueduct. However, considering average conditions, RCC Piers of 1.0 m width with spread footing were assumed in analysis. Since aqueduct portion were not flumed, length of piers with assumed width were sufficient enough to keep foundation pressures quite low. General layout of

Syphon Aqueduct at RD 23.35 km is shown at **Plate 6.7** and typical design details of Syphon Aqueduct at RD 23.35 km are given at **Annexure: 6.10.**

Canal Syphons

Canal syphons have been proposed along the link canal at the crossings of major streams where the full supply level of the link canal lie between the drain bed and the highest flood level of the drain. However, the choice of canal syphon depends upon the discharge capacity of canal vis-a-vis the design flood and physical characteristic of drain. It is advantageous to consider canal syphons then the syphon aqueducts, since the canal flow is free from silt and floating debris. The head loss in canal syphon is more than the syphon aqueduct as such due consideration for economy should be kept in mind. The top of the canal syphon barrel is kept about 1.0 m below the river bed to avoid damages from the rolling stone. A total of 36 canal syphons are proposed in the entire canal alignment. Slopes of inlet and outlet portion of Syphon are proposed as 1 in 3 (V:H). General layout of Canal syphon at RD 5.53 km is shown at **Plate 6.8**. and typical design details of Canal Syphon at RD 5.53 km are given at **Annexure: 6.11.**

Cross Regulators

Cross regulators are provided at regular intervals in order to ensure effective water regulation to the branch canals as well as when there is change in canal sections. 7 cross regulators are proposed along the link canal. The loss of head of 150 mm is considered at each regulator. Typical design details of Cross regulator cum head regulator proposed at RD 96.0 km is furnished at **Annexure: 6.12.** The general layout and typical details of Cross regulators at RD 96.00 km is shown at **Plate 6.9**.

Regulators

Regulators can be categorized into, (i) Head regulators from where the canal offtakes from the head works such as reservoir or barrages, (ii) regulators from where the branch canal/ distributaries draw water from main canal and (iii) outfall regulators to prevent the back flow of water from head works such as barrages/reservoirs.

The branch canals and direct sluices were identified along the link canal to derive the maximum benefits. Twenty-five direct sluices and 12 branch canals are identified. Suitable vents are proposed for direct sluices whereas regulators are proposed for branch canals. The location and capacity of vent/regulators are shown in **Table 6.10** below:

Table 6.10
Direct sluices and branch canal

Sl.No.	RD (Km)	Description	Peak discharge (December)	
			Mcum	Cumec
A. Direct Sluices				
1	5.50	DS 1	0.07	0.03
2	7.86	DS 2	0.10	0.04
3	8.80	DS 3	0.12	0.05
4	9.70	DS 4	0.15	0.06
5	12.40	DS 5	0.18	0.08
6	15.50	DS 6	0.21	0.09
7	17.30	DS 7	0.24	0.10
8	17.90	DS 8	0.27	0.11
9	20.70	DS 9	0.30	0.12
10	23.95	DS 10	0.32	0.13
11	26.10	DS 11	0.35	0.15
12	30.50	DS 12	0.38	0.16
13	33.15	DS 13	0.41	0.17
14	35.80	DS 14	0.44	0.18
15	39.50	DS 15	0.47	0.19
16	42.80	DS 16	0.49	0.21
17	43.90	DS 17	0.52	0.22
18	45.95	DS 18	0.55	0.23
19	48.10	DS 19	0.57	0.24
20	51.00	DS 20	0.61	0.25
21	54.00	DS 21	0.62	0.26
22	57.30	DS 22	0.67	0.28
23	59.60	DS 23	0.68	0.28
24	61.15	DS 24	0.69	0.29
25	64.45	DS 25	0.69	0.29

B. Branch canal				
1	96.00	Gandarvakottai	20.34	5.68
2	96.00	Alangudi	27.00	11.09
3	116.55	Thirumayam	8.52	2.32
4	142.00	Pallatur	8.11	3.33
5	147.80	Karaikudi	6.49	1.86
6	158.50	Devakottai	16.56	6.80
7	177.20	Tiruvadanai	32.71	13.43
8	189.90	Kalaiyarkovil	22.85	9.13
9	222.50	Manamadurai	67.89	27.27
10	232.65	Paramakudi	73.37	29.96
11	239.30	Narikudi	42.90	17.53
12	256.16	Tiruchuli	102.90	42.10
		Total	**438.0**	

Outfall regulators

These regulators are similar to cross regulators which are provided to avoid the back flow of water from the barrages / reservoirs when the water level in head works are above the FSL of the canal or to keep the canal dry during the maintenance. No outfall regulators are provided as Tiruchuli branch canal offtakes at tail end.

Canal escapes

The canal escapes are provided to release the water from the canal to streams to safe guard the canal during emergency conditions like breaching of canal, excess water flow in the canal. The canal escapes are designed to drain 50 % of canal discharge. The escapes are usually to be provided at the U/S of aqueducts/ Syphon aqueducts or at the U/S of HR/CR junction where sufficient head is available to discharge the water. The canal escape regulators are similar to branch canal regulators. There are 4 nos. of canal escapes provided in the link canal.

Bridges

Overall, 162 nos. of bridges are proposed along the length of the canal to negotiate roads and railway lines of which 110 nos. are SLRBs, 36 nos. are DLRBs, 10 nos. are FLRBs and 6 nos. are Railway bridges. In case, canal FSL is just above railway track level, the canal syphons are provided for railway crossing. Loss of head of 0.015 to 0.006 m is considered at each bridge, due to piers located in canal bed. The canal is not flumed at bridge sites to preserve available head. Typical designs and drawings published by IRC for T-beam RCC bridges having spans larger than 10.5 m have been adopted. Foundations of pier shall be at depths equal to greater than scour depth as per strata available. General layout of Road bridges (double lane) at RD 19.45 km is shown at **Plate 6.10.** Typical design details of Road bridges are shown at **Annexure: 6.13.**

Falls

Canal falls are provided wherever, the ground profile is steeper than the bed slope of canal and to avoid high embankment. Canal falls are not identified in this link project.

Under tunnels/over pass

The link on its enroute crosses 190 nos. of streams/existing canals of smaller in nature. Suitable structures are to be provided at these crossings to avoid water logging in the area. Under tunnels are provided if the bank level of stream /canal lie below the free board of the main canal. Box type culverts are proposed for under tunnels for which head loss is not considered. The detailed design of under tunnel at RD 34.68 km is shown at **Annexure: 6.14** and the drawings are depicted at **Plate 6.11.**

Overpasses are provided when the stream/ canal bed level lie well above the free board of canal. The water conduit of the stream/ canal is either pipe or trough depending upon the discharge of stream/ canal. The trough or pipe is supported by piers. Thus, there will be reduction in the area of canal flow that leads to loss of head in canal. The loss of head for overpass is considered equivalent to SLRB.

6.8 Study of integrated network of canal system and its operation

The canal system will be operated in an integrated network along with the existing tanks in the proposed command for optimum utilization of available waters.

6.9 Broad outline of canal automation and branch canals up to 8 Cumec

The canal automation technology adopted for Sardar Sarovar Project canal system shall be adopted for this link canal system also.

6.10 Other studies

The studies required at DPR stage have been carried out and included in this report. The other studies which are not covered in the DPR will be carried out at pre-construction stage.