Chapter 6
Designs and Layout

6.1 Structure, layout and design features of the head works

6.1.1 Location of the head works

The link canal proposes to connect the existing Nagarjunasagar reservoir on Krishna and the Somasila reservoir on Pennar. As such, the Nagarjunasagar is at its head and the Somasila reservoir is at its tail end.

6.1.1.1 Nagarjunasagar project and the link canal off-take

The Nagarjunasagar project is an existing multi-purpose project on Krishna River located about 1.5 km downstream of Nandikonda village in Nalgonda district of Andhra Pradesh with two main canals, Nagarjunasagar Right Bank Canal (NSRBC) called Jawahar Canal and Nagarjunasagar Left Bank Canal (NSLBC) called Lalbahadur Canal. NSRBC takes off from the right flank of the dam and NSLBC takes off from the foreshore of the reservoir. The project has three hydro-powerhouses, one below the main dam and the other two at the canal heads. The project provides irrigation to about 8.95 lakh ha of land and generates 960 MW of seasonal hydroelectric power besides providing for navigation, pisci-culture, recreation and mitigation of flood hazards.

The total length of the dam is 4863 m, comprising of masonry dam with overflow and non-overflow sections and earth dams on both the flanks. The length of the spillway is 470.92 m and the non-overflow portion 978.71 m. The length of the earth dam on the left is 2560.32 m and on the right 853.44 m.

The maximum height of the masonry dam is 124.66 m. The FRL of the reservoir is 179.83 m and the MWL 181.05 m. The gross storage capacity of the reservoir is 11560 Mm^3. The live storage capacity is 5733 Mm^3 above the MDDL of 155.45 m.

The Nagarjunasagar – Somasila link canal is proposed to take off from the right flank of the Nagarjunasagar dam. The required discharging capacity of the link canal has been worked out to be 488 cumec. It has been proposed to have a canal head powerhouse at the head of the link canal similar to the existing NSRBC canal head powerhouse. The

power generating capacity of the link canal powerhouse has been estimated to be around 80 MW and it is proposed to install four generating units of 30 MW each including one standby unit. The powerhouse is proposed to be of size 67 m x 39 m.

The existing non-overflow masonry section on the right flank of the Nagarjunasagar dam consists of a power block housing the three penstocks for the canal head powerhouse and a head regulator through which the NSRBC takes off. The NSRBC joins the tailrace of the powerhouse on the downstream of the powerhouse. It is proposed to have a similar arrangement for the new link canal also. A similar power block for accommodating four penstocks and a head regulator are proposed to be constructed in masonry beyond the existing head regulator.

The existing power block housing three penstocks is of 48 m length. The proposed power block to house four penstocks will be of 70 m length. The existing head regulator designed to pass 595 cumec consists of nine vents of size 3.05 m x 4.575 m at a sill level of 149 m EL. The proposed link canal head regulator has to pass 488 cumec. It is proposed to construct the new head regulator with eight vents of size 3.05 m x 4.575 m.

For constructing the proposed new power block and the head regulator of the link canal it will be necessary to cut open and remodel the existing earth dam (of height about 26 m) on the right flank of Nagarjunasagar dam. Although theoretically this can be accomplished by constructing a coffer dam on the upstream, this may lead to certain technical and operational problems. Construction of a coffer dam on the upstream of the existing head regulator of NSRBC will interfere with the existing supplies through NSRBC. There may also be technical difficulty in tying the new masonry section with the existing masonry section.

As against the proposal of constructing the link canal head regulator just by the side of the existing head regulator, an alternative proposal is also considered. In this proposal the link canal will take off from the offshore of the Nagarjunasagar reservoir through a 0.75 km long tunnel. The proposed powerhouse can be located immediately after the tunnel exit and the tailrace channel would meet the original alignment at RD 1.83 km. The length of the alternate alignment including the tunnel will be 1.275 km, thus reducing the total length of the link canal by 0.555 km. This will help in compensating to some extent the additional cost involved in construction of the tunnel.

In this report, cost estimates have been made only for the original proposal. No estimate has been carried out for the above alternative proposal. However, as indicated above, cost for the alternative proposal may not be significantly different from the cost of the original proposal owing to the reduction in the length of the link canal.

6.1.1.2 Somasila project

Somasila project is an ongoing multi-purpose project constructed across river Pennar near Somasila village in Nellore district of Andhra Pradesh. The catchment area upto the dam site is 50492.50 km^2. Total length of the dam is 760.7 m with a maximum height of 38 m from ground level. The water spread area of the reservoir is 212.28 km^2.

The full reservoir level and the maximum water level are 100.58 m and 101.80 m respectively with a gross storage capacity of 2208 Mm^3. The minimum draw down level is 82.30 m and the live storage capacity above MDDL is 1994 Mm^3.

The Somasila reservoir, which is at the tail end of the link canal, is also a very important component in the Telugu Ganga project. This being the terminal reservoir on Pennar and since the flows of Pennar river are erratic, the capacity of the reservoir is kept at 2208 Mm^3 against the designed requirement of 1360 Mm^3. In addition, the surplus flows in good years are proposed to be diverted to Kandaleru reservoir situated at a distance of 45 km from the Somasila project along the alignment of Telugu Ganga Canal.

There are two main canals taking-off from the Somasila reservoir viz. i) North feeder channel and ii) Somasila-Kandalelru flood flow canal (Telugu Ganga canal).

6.2 Design features of Krishna (Nagarjunasagar) – Pennar (Somasila) link canal

6.2.1 Description of the canal system

The proposed link canal off takes from the right flank of the existing Nagarjunasagar dam through a canal head regulator. From its off take point and upto RD 202.75 km, where the proposed link canal runs adjacent and parallel to the NSRBC, varying bed slopes ranging from I in 2200 to 1 in 18000 have been proposed to keep the FSL of the link canal with same as that of NSRBC. From RD 202.75 km to the tail end, a uniform bed slope of 1 in 20000 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 2.158 m/s and 1.165 m/s respectively. The full supply depth is 7.0 m at the head. Sections of the canal at head and tail end are 21.3 m x 7.0 m and 58.9 m x 6.0 m respectively. The discharge at head, at the point of merging with NSRBC and tail end of the link canal are designed to be 488 cumec, 565 cumec and 498 cumec respectively. The canal has been designed for 1.1 times the peak discharge. A free board of 1.0 m is provided throughout the length of the link canal.

6.2.2 Design of canal section

a) Formulae used

The canal sections for various reaches are designed using Manning's formula for velocity,

$$V = (1/n)\, R^{2/3}\, S^{1/2}$$

where

V = Velocity
n = Rugosity co – efficient
S = Bed slope
R = Hydraulic mean depth (A/P)
A = Area of cross section = $bd + d^2 (\varnothing + \cot \varnothing)$
P = Wetted perimeter = $b + 2d (\varnothing + \cot \varnothing)$
b = bed width
d = depth of water
$\varnothing$ = Angle of the side slope

The formula adopted for critical velocity is $V_o = 0.55\, d^{0.64}$

The Rugosity co-efficient for the lined canal is taken as 0.018. Side slope of 1.5H: 1V is adopted except for deep cutting in hard rock where the slope adopted is 0.25H: 1V.

b) Design of canal sections in various reaches

The canal sections are designed for the peak discharge increased by a capacity factor of 1.1 to take care of any future eventualities. The designed discharge at the head works out to 488 cumec for the link canal.

As the canal advances from the reservoir, the discharge in the canal gets reduced at every off-take point due to drawl of water into the

branch canals to meet the requirement of enroute command, resulting in scope for reduction in the canal section. Hence the canal is broadly divided into suitable hydraulic reaches depending on the reduction in the discharge and the sections have been designed accordingly.

The entire canal along its length is divided into 19 reaches for designing the canal section, considering the following.

1) Taking-off a major branch canal,
2) Discharge of canal falling by 10%,
3) Canal running in full cutting in hard rock.

Salient features of the link canal at its head and enroute tunnel are given in Table 6.1.

Table 6.1
Salient features of the link canal and tunnel

A	**Link canal at head**	
	Type of canal	Lined (Trapezoidal with rounded corners)
	Design discharge	488 cumec
	Bed width	21.30 m
	Full supply depth	7.0 m
	Velocity	2.158 m/s
	Bed slope	1 in 6000
	Side slope	0.25 H to 1 V
	Manning's 'n'	0.018
B	**Tunnel**	
	Shape	Modified Horse – shoe
	Design discharge	488 cumec
	Diameter of the tunnel	10.0 m
	Velocity	6.035 m/s
	Bed slope	1 in 486
	Manning's 'n'	0.014

The values of head loss provided at different structures are given in Table 6.2.

Table 6.2
Head losses provided at different structures

S.No.	Name of structure	Head loss (m)
1	Aqueduct / canal syphon	0.30
2	Super passage	0.03
3	Road bridge	0.03
4	Regulator	0.20
5	Under tunnel	Nil

The total head loss due to structures worked out to be 16.78 m in the entire 393.02 km length of the canal and that due to bed fall is 33.783 m.

6.2.3 Lining

100 mm thick CC (1:3:6) lining is proposed for both bed and sides throughout the length of the canal.

6.2.4 Transmission losses

The transmission losses are assumed as 0.60 cumec per million km^2 of wetted area as per Bureau of Indian Standard Code IS: 10430 – 1982.

6.2.5 Description of soil profile along the canal alignment

The details of sub-surface strata for the initial reach, i.e., upto RD 202.75 km along the link alignment have been taken from the detailed classification of soils done by the Government of Andhra Pradesh for the existing NSRBC since the proposed link canal is aligned adjacent to the existing NSRBC. Similar details of sub-surface strata for the remaining reach, i.e., from RD 202.75 to 393.02 km are derived by measurement in 72 open wells in and around the vicinity of the link alignment. The soils mostly are ordinary gravel and loamy soil for the top 1.2 m to 1.5 m depth below ground level, soft rock from 1.5 m to 3.0 m, medium rock from 3.0 to 7.0 m and hard rock is generally met with at depths of more than 7.0 m.

6.3 Canal structures

6.3.1 General

The link is aligned as a contour canal and it crosses a number of major and minor rivers / streams enroute. It crosses several roads as it passes through fairly developed and densely populated areas. It also crosses two railway tracks of the South Central Railway. The type of

cross drainage work is decided based upon the physical features of the stream such as its catchment area and bed level with reference to the bed and full supply levels of the link canal at the crossing.

Based on field survey, the locations of the cross drainage works and cross masonry works have been identified. In general, aqueducts have been proposed across major rivers / streams and under tunnels across small drains. Super passages have been provided where the drains are to be taken over the canal. Cross regulators have been proposed at the off-take points of the branch canals and the points of change in the section of the canal to facilitate negotiation of variation in the bed width and levels.

6.3.2 Cross drainage works

In its entire run of 393.02 km, the link canal has been provided with 213 cross drainage works, of which 21 are aqueducts, 7 are canal syphons, 76 are super passages and the rest 109 are under tunnels. The design flood value of each drain has been worked out using the empirical formulae given in Table 6.3, which were adopted by the Irrigation Department of the Government of Andhra Pradesh.

Table 6.3
Formulae for computing design flood

S.No.	Catchment area (km^2)	Design flood value (cumec)
1	<2.6	$19.50\ A^{3/4}$
2	2.6 to 78	$16.70\ A^{3/4}$
3	78 to 1300	$14.75\ A^{3/4}$
4	>1300	$123.20\ A^{1/2}$
	Where A is the catchment area of the drain.	

Source: Inchampalli Project Report, Irrigation Department, Govt. of AP

6.3.2.1 Typical hydraulic designs of cross drainage works

Typical hydraulic designs of (1) Aqueduct across Musi river (2) Super passage across Peddavagu (3) Canal siphon across Paleru nadi tributary and (4) under tunnel have been carried out to assess the reasonable head loss for CD works.

6.3.3 Cross masonry works

6.3.3.1 Bridges

A total of 88 road bridges have been proposed across the link canal, of which 24 are double lane and 64 are single lane bridges. Head loss of 0.03 m has been provided for each of these bridges.

The link canal crosses two railway lines of the South Central Railway line one connecting Guntur and Macherla and the other Guntur - Dronachalam line. Single-track railway bridges are proposed at these crossings.

6.3.3.2 Cross / escape regulators

In all, 14 cross regulators inclusive of those required at the Buggavagu reservoir and at tail end are proposed along the link canal. Out of the above 14, single or double lane road bridges-cum-cross regulators are proposed at 5 places.

Similarly 6 escape regulators are also proposed along the canal where natural streams are available to accommodate the surplus discharges of the link canal. The discharging capacity of the escape regulator has been considered at half the discharge of the canal at that point. A head loss of 0.2 m has been considered for each of the regulators.