Chapter 6
Design and layout

6.1 Structure, layout and design features of the headworks

The Godavari (Inchampalli) – Krishna (Pulichintala) link canal proposes to connect the contemplated Inchampalli dam on river Godavari at its head with the proposed Pulichintala project on river Krishna.

6.1.1 Inchampalli project and the link canal off-take

The Inchampalli dam is a proposed project across river Godavari and the proposed dam site is located near village Bhanderigudem in Mahadevpur mandal of Karimnagar district in Andhra Pradesh about 12 km downstream of the confluence of Indravati with Godavari river. The project comprises a reservoir with FRL 112.77m, a power house of capacity 975 MW and the canal taking off on right bank with FSL of 106.68 m. The Inchampalli project contemplates construction of spillway, non–overflow dam, power block and earthen bund making a total length of 1701m. A spillway of length 1075.5m, in the deep course of river, the non-overflow dam of length 49m on the left side, a power block of length 371m on the right side and earthen dam of 205.5m on the right flank are proposed to be constructed. A dyke of length 430m, on the left side is proposed with an earthen bund. The highest recorded flood level is 97.935m. The gross storage capacity at FRL is 10374 Mm^3.

It has been proposed to have a powerhouse with pumped storage facilities at dam toe to tap the power potential available and also through the spills from the reservoir. The power house will generate the power during the peak hour needs. It is also proposed to pump back the waters into the reservoir through the reversible turbine units during non-peak hours. The power house will have an installed capacity of 13 units of 75 MW each including two as stand by units. The powerhouse is proposed to be of size 346 m x 24 m.

The Godavari (Inchampalli) – Krishna (Pulichintala) link canal is proposed to take off from the right flank of the proposed Inchampalli dam. The required discharging capacity of the link canal at head has been worked out to be 304 cumecs.

6.1.2 Pulichintala project

Pulichintala project has been contemplated by the state of Andhra Pradesh with an objective of stabilization of existing ayacut in Krishna delta for paddy crop. The erstwhile Andhra Pradesh State Electricity Board was formulating proposals for hydel power generation also under the project. The gross storage capacity of reservoir will be 1296 Mm^3 at FRL of 53.34m.

The dam is proposed to be constructed near Pulichintala village about 30 km from Jaggayyapet town in the Rajupalem mandal of Guntur district. The project comprises of the spillway portion of 466.3m length which is proposed to dispose off the maximum flood discharge of 39530 cumecs, non-overflow sections of 91.4m and 182.9m length on the right and left flanks respectively and earth dam on left flank of 859.5m length. The State Government has already initiated necessary action for the construction of the project.

6.2 Design features of Godavari (Inchampalli) – Krishna (Pulichintala) link canal

6.2.1 Description of the canal system

The link canal takes off from the right flank of the proposed Inchampalli dam with FSL 106.68 m. from where the canal runs by gravity. In the initial reach, the canal runs in southeast direction upto RD 125km and then turns towards southwest to cross river Kinnerasani at RD 149.6km and runs upto Palleru crossing at RD 278km. Then the link canal runs further east upto Krishna River before it outfalls into the proposed Pulichintala with FSL 55.442 m at RD 312.20 km. A tunnel of length 12.5km is also provided from RD 186.6 km to 199.1km for crossing the Godavari-Krishna ridge. The general topography of the area through which the link canal traverses is mostly plain with few local high mountains, occasional forest patches and sporadic hills.

The alignment of canal runs mostly in cutting and the embankments are limited to the places where the link canal crosses the river valleys formed by the major rivers. Maximum depth of cutting in the entire reach of the canal is 33m and the maximum height of filling is 18m.

For the entire length, the canal has been provided with bed slope of 1 in 20000 except for the tunnel reach of 12.5km for which the bed slope of 1 in 6000 is proposed. The canal is designed to be a trapezoidal section with rounded bottom corners and is proposed to be lined. The velocity at

the head is 1.104m/sec and at the tail end 1.030m/sec. The full supply depth is 6.0m at head. Section of canal at head is 33.40 m bed width and 6.00m full supply depth. The designed discharge at head is 304 cumecs at 1.1 times the peak discharge. A free board of 1.0m is provided throughout the length of the canal. 3 canal power houses are proposed near the outfall point to use the head available in canal falls.

6.2.2 Description of soil profile along the canal alignment

The details of subsurface strata for the initial reach along the link canal alignment from RD 0.0km to 149.6km (i.e. upto Kinnerasani river) have been taken from the available information in the literature. Similar details of sub-surface strata for the remaining reach, i.e., from RD 149.6km to 312.20km are taken from the data of geophysical investigations carried out by the National Geophysical Research Institute, Hyderabad . With the help of these details, the sub-surface profile was drawn for the entire alignment. The soils are shallow on the hill slopes, while they are moderately deep-to-deep in the lower portions. The soils are of mostly ordinary gravel and loamy soil for the top 1.2 to 1.5m depth below ground level, soft rock from 1.5m to 3.0m, rock with medium hardness from 3.0m to 7.0m and hard rock generally met with at depths more than 7.0m.

6.2.3 Evaluation of the design parameters based on samples collected en route

The canal alignment generally runs in balanced section in the first half of the length except for the tunnel portion and mostly in cutting for the remaining half of the length with filling sections in the vicinity of the drainages. The soils as available from cutting and adjoining identified borrow areas are considered to be generally suitable for filling purpose.

6.2.4 Lining

Lining of 100 mm thick with CC (1:2:4) is proposed for both bed and sides throughout the length of the canal.

6.2.5 Transmission losses

The transmission losses are assumed at 0.60cumec per million sq. metres of wetted area as per Bureau of Indian Standard Code IS: 10430-1982.

6.2.6 Design calculations for adequacy of canal section

a) Formulae

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

V = Velocity of flow in canal = $(1/n)\, R^{2/3}\, S^{1/2}$

	Normal Section	Deep Cut
A = Area of cross section	$bd+d^2\,(\theta+\cot\theta)$	$bd+\frac{d^2}{2}\,(\theta+\cot\theta+\mathrm{Cosec}\,\theta)$
P = Wetted perimeter	$b+2d\,(\theta+\cot\theta)$	$b+d\,(\theta+\cot\theta+\mathrm{Cosec}\,\theta)$

V_o = Critical velocity = $0.55d^{0.64}$

Where
V = Velocity
n = rugosity coefficient
R = Hydraulic mean depth (A/P)
b = bed width
d = depth of water
θ = Angle of side slope

The rugosity coefficient 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 0.50H: 1V. The bed slope is considered as 1 in 20000 throughout the canal except for the tunnel length.

(b) Design of canal sections in various reaches

The Godavari (Inchampalli) - Krishna (Pulichintala) link canal is planned to divert annually a total quantity of 4370 Mm^3. The maximum diversion proposed is 739 Mm^3 during the month of August based on simulation studies. The peak discharge works out to 275.91 cumec. However, the canal sections are designed for the above 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 304 cumec.

The canal is designed for the above discharges adopting a trapezoidal section with rounded corners and to be lined for its entire length. The hydraulic design is done as per Manning's formula using roughness coefficient of 0.018. The typical section of the canal as given in IS 10430-1982 "Criteria for design of lined canals and guidelines for selection of type of lining" is adopted.

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 en route requirements, 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 three 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 en route 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	304
	Bed width	33.40 m
	Full supply depth	6.00 m
	Velocity	1.104m/sec
	Bed slope	1 in 20000
	Side slope	1.5 H: 1V
	Manning's 'n'	0.018
B.	**Tunnel from RD 186.6km to 199.1km (12.5km)**	
	Shape	Modified Horse-shoe
	Design discharge	275
	Radius of tunnel	6.5 m
	Velocity	2.266m/sec
	Bed slope	1 in 6000
	Manning's 'n'	0.014

The loss of head in canal at various cross drainage and cross masonry works is provided judiciously keeping in view the experience with the existing structures. These values 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 / Sy. aqueduct	0.15
2	Super passage	0.03
3	Cross Regulator	0.20
4	Road /Railway bridge	0.01
5	Under tunnel / Inlet	Nil

The total head loss due to structures worked out to be 7.170 m in the entire 312.20 km long link canal and that due to bed fall is 17.068 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 en route. It crosses several roads as it passes through fairly developed and densely populated areas. It also crosses three railway tracks of the South Central Railway. The type of cross drainage structure is decided based upon the physical features of the stream such as its catchment area and bed & full supply levels of the link canal at the crossing.

The location of the cross drainage and cross masonry works have been identified based on the field surveys for the reach from RD 149.6km (Kinnerasani river crossing) to RD 312.20km and based on toposheet studies for the reach from RD 0.0km to 149.6km. In general, aqueducts have been proposed across major rivers/ streams and under tunnels are preferred across small drains. Super passages have been proposed where the drains are to be taken over the canal. Cross regulators have been proposed at the off-take points of branch canals and the escape regulators are proposed suitably at the major stream crossings.

6.3.2 Cross drainage works

In its entire course of 312.20km, the link canal has been provided with 110 cross drainage works, of which 12 are aqueducts, 4 are syphon aqueducts, 32 are super passages and the rest 62 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	$19.50A^{3/4}$
2	2.6 to 78	$16.70A^{3/4}$
3	78 to 1300	$14.75A^{3/4}$
4	>1300	$123.20A^{1/2}$
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 design of (1) Aqueduct across Mureru river (2) Super passage across Nasarapu vagu (3) Syphon aqueduct across Palleru river and (4) Under tunnel at RD 155.6 km have been done to verify the adequacy of head loss so provided.

6.3.3 Cross masonry works

6.3.3.1 Bridges

The link canal crosses a few district roads and a number of village roads at various points. In order to facilitate free flow of traffic on these roads, double lane bridges and single lane bridges are proposed depending upon the type and importance of the road. Double lane road bridges are proposed for interstate and district roads whereas single lane road bridges are proposed for all existing village roads crossing the canal alignment.

A total of 49 road bridges have been proposed across the link canal, of which 7 are double lane and 42 are single lane bridges. Head loss of 0.01m has been provided for each of these bridges.

The link canal crosses the three South Central Railway lines namely KTPS-Kottagudem, Singareni-Kottagudem and Bonakal-Khammam. Single-track railway bridges are proposed at these crossings.

6.3.3.2 Cross/escape regulators

In all, 13 regulators including the head regulator are proposed along the link canal, out of which, 10 cross regulators are proposed at the off-take points of the branch canals.

Similarly 2 escape regulators in combination with cross regulator are also proposed along the canal at suitable places at RDs 31.5 km and 149.0 km where natural streams are available to accommodate the surplus discharge 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 0.2m has been considered for each of the regulators.

6.3.4 Design of powerhouse on link canal fall

The Inchampalli - Pulichintala link canal experiences about 27m gradual falls during its transit at RD 307.75km before it falls into Pulichintala reservoir. The drop is divided into three parts of 9m each and three powerhouses of 9MW each are proposed, thus making the total power capacity as 27MW.

6.4 Lifting arrangements in the link canal system.

The Godavari (Inchampalli) – Krishna (Pulichintala) link canal system is supported by number of lifts on its main course. The total power requirement is worked out to be 95 MW. The details are furnished in the following articles.

6.4.1 Lifting at RD 200.0km for NSLBC.

The FSL of the main canal is 90.112m at RD 200.0km against the ground level of 117.582 m in the vicinity of the Godavari-Krishna ridge. To meet the requirements of the command under NSLBC up to and beyond Tammileru, the water is proposed to be lifted to a level of 122.5m which involves a static lift of 39m. Accommodating the impeller at 91m, the suction and delivery heads would be 7.41 m and 31.25 m respectively. 10 cumec capacity pumps are proposed and no. of pump required would be 10 excluding 2 additional pumps proposed as standby. Assuming the pump efficiency at 80%and operational pumping head as 43.96 m, the requirement of power would be 59 MW.

6.4.2 Lifting from Pulichintala reservoir for NSRBC command

The FRL and MDDL of the Pulichintla reservoir are 53.34m and 42.71m respectively whereas the ground level near by vicinity is about 55.0m. As such the off take FSL of the PRBC is assumed at around ground level of about 55.0m to cover more area from Pulichintla reservoir. This necessitates a static lift of 12.3m from the MDDL of the reservoir. The topographical condition at right bank of the reservoir does not permit for pumping. A sump and pump house is proposed about 250m away from the reservoir.

The impeller level of pump is fixed at 46.0m by which the suction and delivery head would be in the order of 3.29m and 9.34m respectively. 17 pumps of 10 cumec capacity including 2 as stand by are provided in the pump house. Assuming the efficiency at 80% for the computed

operational pumping head of 18.07m, the requirement of power would be 36 MW.

6.5 Alternative proposal to avoid lifting from Pulichintala reservoir to meet part requirement of NSRBC command

As mentioned in para 6.3.5, there is a rapid fall of about 27m along the link canal alignment between RD 307.75km and link canal outfall into the Pulichintala reservoir at RD 312.20km. As such the water requirement of NSRBC part command can be met by the link canal itself without resorting to the act of dropping water into the Pulichintala reservoir and again lifting into the Pulichintala Right Bank Canal (PRBC), as the link canal can be taken across the Krishna river downstream of Pulichintala dam by an aqueduct and joining the alignment of PRBC.