Chapter III

Planning and Execution of Tunnels and Feeder Canal

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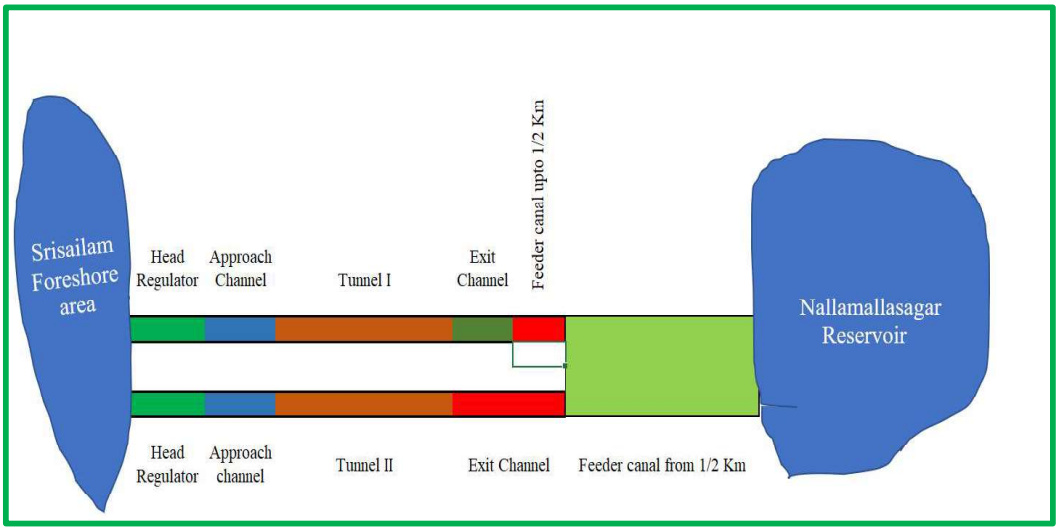
Planning process was not adequate as Project of such a large scale was taken up without scientifically assessing the availability of number of flood days and sufficiency of flood water with required water head level for creation of contemplated ayacut. Different bed levels for connecting link canal and Tunnel II exit point were adopted which leads to stagnation of water in Tunnel II. The feeder canal was under designed with 32 *per cent* less discharge capacity than the maximum discharge capacity of the tunnels thereby restricting the free flow of water into feeder canal. Frequent change of contractors, in execution of Tunnels using the same TBM led to additional financial burden in excavation of the tunnel and subsequently delay in completion of Tunnels. Due to change in Tunnel I excavation methodology from TBM to manual drill and blast method there was wasteful expenditure towards segments manufactured and cutters procured for TBM.

To draw 43.50 TMC of water from the foreshore (near Kollam vagu) of Srisailam reservoir, two tunnels[24] were proposed to be excavated. Excavation of these tunnels was grounded[25] by using latest technology *viz.,* TBMs. Further, to draw water up to tunnel entry point, separate approach channels, Head Regulators[26] and separate exit channels to transfer water to the feeder canal were proposed.

The water drawn from these two tunnels was to be transferred to Nallamallasagar reservoir through an unlined[27] feeder canal with 23.360 Km length and 328 cumecs (cubic meter per second) discharge capacity (Stage II). The components of tunnel system and feeder canal involved in the project are depicted in the following line diagram (***Not to scale***).

[24] stage I: one tunnel with 7.0 m diameter with a length of 18.800 Km and Stage II: another tunnel with 9.2 m diameter with a length of 18.800 Km
[25] tunnel - I in 2005 and tunnel - II in 2007
[26] to regulate the water inflows into tunnel
[27] a canal for which concrete lining was not made

Line Diagram 1 : Components involved in tunnel system and feeder canal



Source: Prepared by audit based on understanding of the project

3.1 Planning for tunnels and feeder canal

To develop 1.19 lakh acres of ayacut in Stage I, 10.70 TMC of water requirement was assessed in 2005. The required water was planned to be drawn in 45 flood days with an average discharge capacity of 85 cumecs through Tunnel I. Subsequently, Government revised[28] (April 2005) the number of flood days to 30 from 45. Accordingly, the Department envisaged maximum discharge (at water head[29] of 19.5 m) capacity of 160.64 cumecs from an average of 85 cumecs, without change in design of tunnel.

In Stage II, to develop an additional ayacut of 3.19 lakh acres, 32.80 TMC (43.50 TMC– 10.70 TMC) of water requirement was assessed/planned to be drawn in 45 days with an average discharge capacity of 243 cumecs and in 30 days with a maximum discharge capacity of 322.68 cumecs, through Tunnel II.

Initially, for feeder canal, it was proposed to carry out investigation/survey for both Stage I (85 cumecs) and Stage II (328 cumecs) and excavation of canal for only Stage I. The design and execution of structures (Cross Masonry (CM) and Cross Drainage (CD) works) were proposed for Stage II. The discharge capacity of feeder canal was increased to 328 cumecs in Stage II by widening it to transfer additional water up to 43.50 TMC. Further, it was proposed to execute lining to canal only after serving for two to three kharif crop seasons.

3.1.1 Grounding of project without assessing availability of water

To draw required water from Srisailam Reservoir, a detailed analysis for the availability of water and the number of days for which flood flow is available is to be undertaken without effecting the requirement of water for other projects availing the same facility. The Technical Expert Committee appointed by the State Government stated that number

[28] G.O.Ms.No.170 dated 13.04.2005
[29] maximum water height available at the location from where water was drawn for this project

of flood days and availability of water head of 19.5 m at Srisailam Reservoir has to be arrived scientifically to take up the Veligonda project.

However, there was no evidence in the records made available to audit regarding conduct of any such study or analysis prior to grounding the project. Such an analysis or study is vital in assessing the chances of success of the project, which is proposed to be solely dependent on flood water. In the absence of such studies, the availability of required water at Srisailam for creation of contemplated ayacut could not be ensured.

The Government replied (January 2023) that 800 TMC of water was allocated to Combined Andhra Pradesh State, by Krishna Water Dispute Tribunal (KWDT), considering the 75 *per cent* dependability. The surplus water flowing into sea at Vijayawada, during 1962 to 1982, is assessed as 150 to 2600 TMC. The project was taken up based on above surplus water, which was allowed by KWDT also. Further, the details of surplus flood days of Srisailam Reservoir between 1984 to 2022 was also made available to Audit.

The reply is not acceptable, as it speaks about the total allocation of Krishna water to combined State of Andhra Pradesh and availability of surplus water flowing into sea during the period 1962 to 1982. Out of 800 TMC allocated to combined State of Andhra Pradesh, the actual quantity of water allocated to Veligonda Project considering the requirement of water for other dependable project was not assessed. Further, no report was furnished in support of availability of flood surplus days.

Thus, even after incurring an expenditure of ₹4,323.72 crore towards works component, the availability of required quantity of water was not ensured which may lead to wasteful expenditure in case sufficient water does not flow out of Krishna River.

3.1.2 Stagnation of water due to variation in bed levels of link canal and tunnel II exit point

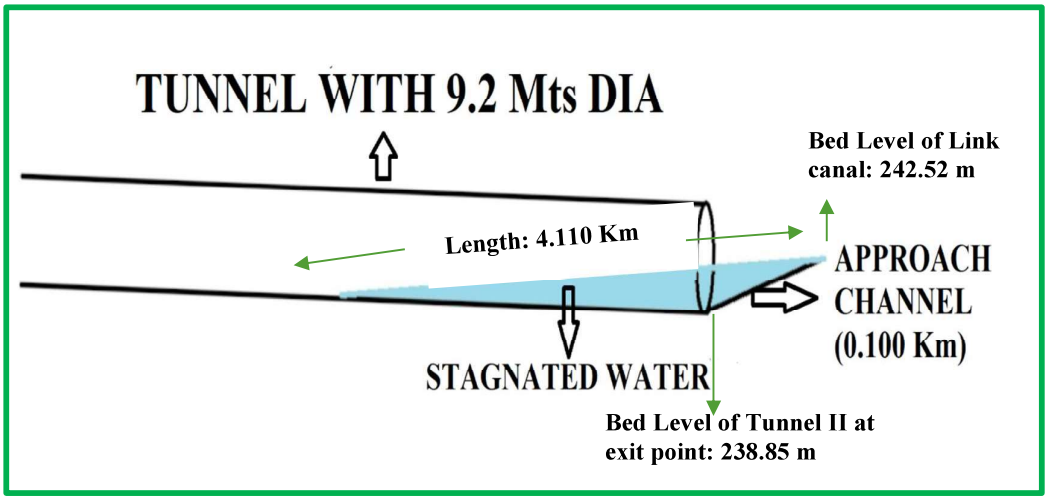
As per International Standard (IS) Code[30], all tunnels should preferably have a positive gradient (free flow) in the direction of flow. Accordingly, in Tunnel II, one meter fall in flow of water for every 1096 m of tunnel length was proposed. The link canal (exit channel) at the end of Tunnel II should be so designed that the water discharged from the tunnel enters link canal without any obstruction or stagnation at the point of contact and subsequently water flows into the feeder canal.

Scrutiny of designs of Tunnel II revealed that there was variation of 3.67 m[31] in height of bed level between the Tunnel II exit point and the exit point of link canal. As calculated by Indian Institute of Technology[32] (IIT) Madras, the difference in bed level would cause stagnation (when inflow of water is stopped) of water for a length of approximately 4.110 Km in Tunnel II. Provision for dewatering of stagnated water was not contemplated by the Department.

A line diagram ***(Not to scale)*** is exhibited below to show stagnation of water.

[30] 4880 (Part III) - 1976 vide Para 2.2.1
[31] link canal bed level : 242.52 m, Tunnel II exit point bed level : 238.85 m
[32] engaged by Audit for technical opinion and guidance

Line Diagram 2: Stagnation of water due to higher elevation of link canal than Tunnel II



The Government replied (January 2023) that the stagnation of water at the exit of tunnel acts as energy dissipation arrangement and safeguards the link channel from scouring. It was also replied that the stagnated water would recede through percolation and evaporation or could be utilised by way of pumping.

The reply is not acceptable, as difference in bed levels would ultimately result in stagnation of water.

3.1.3 Designing of feeder canal with insufficient discharge capacity

As per approved design, the total quantum of water discharged from both the tunnels should flow into feeder canal through the link canals. The tunnels were designed with a maximum total discharge capacity of 483.32 cumecs (Tunnel I - 160.64 cumecs and Tunnel II - 322.68 cumecs) to draw 43.50 TMC of water in 30 days. As such, feeder canal should have been planned for a discharge capacity of 483.32 cumecs for 30 flood days.

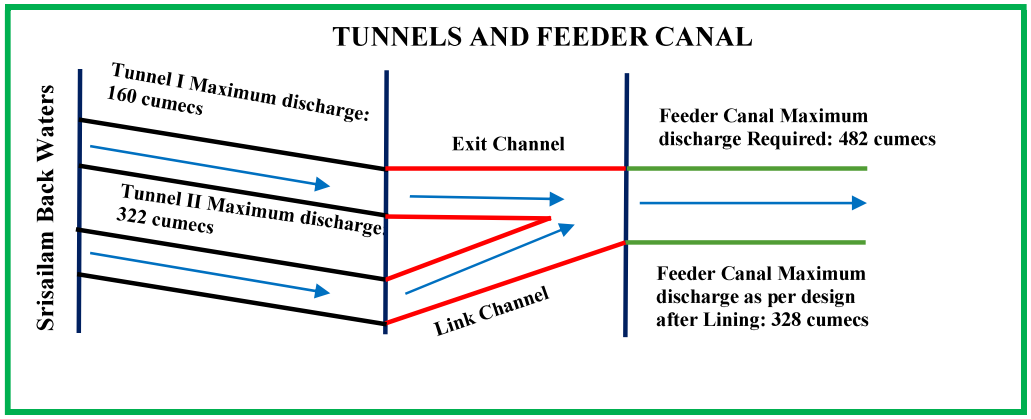
However, as against the discharge requirement of 483.32 cumecs, the feeder canal was designed with a discharge capacity of 328 cumecs (with lining), short by 155.31 cumecs (32.14 *per cent*). Though, the feeder canal was designed as lined canal, the execution was made for unlined canal and it was proposed to take up lining after serving for two to three Kharif crop seasons.

As per calculations made by Audit, without lining, the discharge capacity of feeder canal would be 214.64 cumecs[33] **(a*s detailed in Appendix-I)*** with a shortfall of 268.67 cumecs (55.19 *per cent*) of discharge capacity till completion of lining. This would have an adverse effect on drawal of contemplated water and would result in shortage of contemplated ayacut of 1.41 lakh acres[34] after completion of lining and 2.42 lakh acres[35] without completion of lining. Thus, it is evident that at planning stage, the Department had not designed the capacity of feeder canal in line with the total

[33] by using Manning's equation as per Annexure D of IS Code 7112-2002 below note under Table 3
[34] 4.38 lakh acres x 32.14 *per cent*
[35] 4.38 lakh acres x 55.19 *per cent*

discharge capacities of two tunnels. A line diagram ***(Not to scale)*** is exhibited below to show the difference of discharge capacities.

Line Diagram 3: Showing the discharges of Tunnels and Feeder Canal



The Government replied (January 2023) that the feeder canal was designed to carry a discharge of 328 cumecs, duly considering 45 flood days and subsequently the flood days were reduced to 30 days in July 2005. It was further stated that the feeder canal, if required, would be improved to 483 cumecs. The Government admitted the audit observation and stated that the feeder canal would be improved.

3.2 Execution of tunnels and feeder canal

The excavation of two tunnels along with approach and exit channel and construction of Head Regulators was taken up under Package I and Package V. The works of Packages I and V were awarded under EPC system. As of March 2022, the Head Regulator and approach channel of Tunnel I was completed. However, in respect of Tunnel II, the works were still in progress. The details of entrustment of works to various contractors at different stages under both packages is detailed in ***Appendix-II (A), (B) and (C)***. Scrutiny of records showed the following lapses in execution of tunnels and feeder canal.

3.2.1 Avoidable additional financial burden due to entrustment of balance work to another contractor

(a) The excavation of tunnels under Package I and V were first awarded (August 2005/June 2007) under EPC system to two different agencies[36]. While tunnels excavation was in progress, the Executive Engineer, without approval of Government, deleted certain components[37] worth ₹29.35 crore[38] from the scope of work of Package I (Tunnel I) and V (Tunnel II) stating that the respective contractors did not turn up to mobilise their men and machinery to execute the Head Regulator works. As per the

[36] M/s. Sabir Sew Prasad (JV) in August 2005 for Package I and M/s. HCC-CPPL (JV) in June 2007 for Package V

[37] construction of Head Regulator including approaches along with pickup weir and certain portion of tunnel (Tunnel I: 21.51 m and Tunnel II: 51m) with allied works, O&M of Head Regulator, etc.

[38] package I: ₹14.91 crore plus package V: ₹14.44 crore

instructions of Government, the IBM for deleted works was revised (May 2017) to ₹91.15 crore, based on Standard Schedule of Rates (SoR) 2016-17 by allowing water lead for transportation of men and machinery. The deleted works were awarded (August 2017) to another contractor[39] under EPC contract for an amount of ₹95.44 crore. Subsequently, the Government ratified (October 2018) the above action of the Department.

Audit noticed that despite deletion of works and entrustment of balance works to new contractors, the works could not be completed even after a lapse of five years from the date of awarding of balance works. The deletion of works from scope of first contractor and entrustment of balance work to another contractor had resulted in additional financial burden of ₹66.09 crore (₹95.44 crore – ₹29.35 crore) without achieving the intended purpose.

The Government replied (January 2023) that due to separation of components, both Tunnel I excavation and Head Regulator construction were completed in March 2021 and are ready to impound water into the reservoir during the next monsoon. Timely decisions taken by the Government in separating the works yielded results and any delay in execution increases the project cost due to cost escalations resulting in delay of benefits. Further, Government admitted that the additional cost was due to change in parameters of Head Regulator and provision of extra lead to dump the excavated material away from forest land.

The reply is not convincing, as the objective of impounding water into the reservoir cannot be achieved unless excavation of the Head Regulator and the approach channel of Tunnel II are completed, which are in progress at present. Further, feeder canal, along with its structures such as bridges, aqueduct etc., on feeder canal, and distributary system are still in progress. Thus, decision of the Department to delete the work from scope of original contractors and entrusting the same to another had resulted in additional financial burden without achieving the desired objective.

(b) The TBM excavates the tunnel and executes segment lining simultaneously. The rate of execution of work by TBM depends on the strata of rock to be excavated, periodicity of repairs and maintenance of TBM, etc.

The excavation of Tunnel I with segment lining using TBM was completed for a length of 15.200 Km (out of 18.800 Km) in 3050 days[40] at a cost of ₹754.67 crore. The contractor had completed more than 80 *per cent* of the work and fifth Extension of Time (EoT) was granted up to August 2018 to complete the balance work. Meanwhile, the balance length of tunnel works, and balance components were deleted (March 2018) from the scope of the contractor by the Department stating slow progress of work. The balance work was revised (March 2018) based on Schedule of Rates (SoR) 2017-18. The work was awarded (October 2018) to a new contractor[41] on LS contract with an

[39] M/s. RK Infracorp Private Limited with a tender premium of 4.7119 *per cent*
[40] excluding days lost due to geological accident-492 days, due to deletion of work-61 days
[41] M/s. Mega Engineering and Infrastructure Limited (MEIL)

additional financial commitment of ₹117.97 crore[42] and with a condition to complete the work by October 2019 by using the existing TBM.

Audit noticed that the nature of work entrusted to new contractor was excavation of tunnel by using the existing TBM. As the pace of work depends upon the functioning of TBM and the nature of rock strata to be excavated, the role of the contractor was limited to funding towards operation of TBM and to carrying out repairs. Further, there is no scope to split the work as the tunnel excavation could be done in only one direction, i.e., from tunnel exit to entry. As such, the progress of work cannot be geared up, by using the same TBM, even if there is change in contractor.

The Government replied (January 2023) that the contractor failed to achieve the targets as per milestone programme and failed to restart the works. To derive early benefits, the balance execution was entrusted to new contractors. The increase in cost of the work was due to TBM cost reimbursement, burial cost of TBM, etc. Further, it was also replied that the additional burden was less than the price variation to be payable to the original contractor.

The reply is not tenable, as the new contractor has to complete the balance 3,600 m of tunnel excavation in one year as per the agreement. However, the contractor completed tunnel excavation for a length of 2,547 m in 24 months period (November 2018 to November 2020). The balance 1,053 m tunnel was excavated by using manual drill and blast method, by another contractor. As such, change in contractor with additional financial commitment did not yield any early benefits. Further, as stated in Para 3.2.1(a) above, the benefits could not be derived without completion of other components of the project.

Thus, there was an unnecessary additional financial commitment of ₹117.97 crore.

3.2.2 Wasteful expenditure on manufacture of segments used for tunnel lining and procurement of cutters

Excavation using TBM requires cutters to excavate tunnel. Further, concrete lining (using premanufactured segments) would be done simultaneously along with excavation of tunnel. As such, the contractor has to manufacture segments necessary to execute concrete lining and also to procure cutters in advance for uninterrupted excavation/boring. Accordingly, a quantity of 22,034.20 cum of segments were manufactured at a cost of ₹8,682.12 per cum. Similarly, 1,761 cutters were procured at a cost of ₹37,192.69 per cutter.

Manufactured segments for Tunnel lining

The Government ordered (November, 2020) to change the method of excavation of Tunnel-I (from Km 17.747 to Km 18.800) from TBM to manual drill and blast method. The Department instructed

[42] value of balance work at agreement rates of second contractor (₹234.42 crore) minus value of work as per agreement rates deleted from the scope of first contractor (₹116.45 crore)

(November 2020) to stop excavation of Tunnel by using TBM and to dismantle it. Out of the manufactured segments, 19,194.95 cum was erected leaving a balance of 2,839.25 cum valuing ₹2.47 crore unutilised. Similarly, 1,629 cutters were utilised leaving a balance of 132 cutters valuing ₹0.49 crore unutilised. This resulted in wasteful expenditure of ₹2.96 crore ***(as detailed in Appendix-III)*** towards cost of cutters and segments.

The Government replied (January 2023) that due to cost of maintenance of old TBM, non-availability of spares, stoppage of work owing to repairs to conveyor belt there was change in method of excavation from TBM to manual drill and blast method. Further, it was replied that these unused segments would be utilised in future, whenever repairs occur to the already fixed segments and cutters would be used in Tunnel II with little modifications.

The reply is not acceptable, as the TBMs of both the tunnels were of different make and the suitability to use the leftover cutters of Tunnel I in Tunnel II TBM was not established. Further, the actual requirement of segments at the time of repairs to already fixed segments could not be foreseen.

3.2.3 Variation in component cost between agreement and schedule of payment resulted in excess payment

The components involved in Package V were excavation of Tunnel II, approach channel, Head Regulator and exit channel. As per agreement condition[43], the contract price of the total work is divided into different percentages[44] among components of works. The payments to contractors would be made based on above percentages. As per agreement conditions (Para 13.04.4 and 13.04.6), the bid offer shall be for the whole work. The contractor has to submit the component wise cost details based on and limited to the provision shown in Schedule of Payments (SoP). The SoP has to be approved by the department for the purpose of interim payments.

The total contract price of contractor[45] was ₹735.21 crore. After execution of tunnel for a length of Km 10.703 out of total length of Km 18.800, the balance length was entrusted (September 2018) to another contractor stating slow progress of work. Based on the SoPs, the value of executed components as worked out by the Department was ₹475.83 crore. The balance components worth ₹313.92 crore[46] (at agreement rates) was deleted from the scope of contractor and entrusted to a new contractor.

Audit noticed that the value of executed components as worked out by Department was ₹421.29 crore (based on agreement value) as against the ₹475.83 crore (based on approved SoP). It indicates that the Department had approved the SoP in excess of agreement value for certain components and less than the agreement value for the other components. Meanwhile, an amount of ₹470.78 crore was paid (November 2017) to the contractor. Failure to match the SoP with the agreement rates resulted in excess payment

[43] clause 37.4 of General Conditions of Contract
[44] specified in Annexure-II to 'Schedule of Payments (SoP)'
[45] M/s. HCC -CPPL (JV)
[46] total contract value: ₹735.21 crore– Cost of executed components at agreement rates: ₹421.29 crore

of ₹49.49 crore (₹470.78 crore-₹421.29 crore), besides a committed liability of ₹5.05 crore towards value of works executed but not paid.

The Government replied (January 2023) that the excavation using TBM is a specialised work involving mechanical, electrical, electronics and automation items leading to huge investments prior to commencement of excavation. Hence, IBM estimate components could not be compared with actual items of work in execution. Further, it was replied that the value of deletion was recommended as per the Code for EPC Contracts (G.O. Ms. No. 50 dated 02.03.2009).

The reply is not acceptable, as there was no mention regarding value of deletion in the above said Government Order.

3.2.4 Avoidable expenditure towards rehandling of excavated earth

As per the scope of work of Package II, survey and investigation of feeder canal has to be made for both the stages[47], however initially, the excavation of the canal has to be made for Stage I. While the excavation of canal was in progress, the Government instructed[48] (April 2007) to widen the canal for Stage II. The cost of additional quantities was arrived based on the original agreement rates and component of work was entrusted to the same contractor as additional item.

Scrutiny of records[49] revealed that an amount of ₹2.00 crore[50] was included towards rehandling of earth which was deposited within the boundaries of canal proposed to be widened. Had the excavated earth been dumped outside the boundary of proposed widening, the expenditure of ₹2.00 crore could have been avoided.

The Government replied (January 2023) that as per original agreement the investigation of feeder canal has to be made for Stage I. Accordingly, land acquisition proposals were made. While works were in progress, it was decided to widen the feeder canal for Stage II. Hence, it was inevitable to rehandle the earth.

The reply is not acceptable, as the investigation of feeder canal, as per original agreement, has to be made for both Stages I and II and execution was for Stage I. As such, had the initial deposit of earth was made outside the boundaries considering Stage II parameters, the expenditure on rehandling of earth could have been avoided.

[47] Stage I (85 cumecs discharge) and Stage II (328 cumecs discharge)
[48] G.O. Ms. No. 105 I&CAD Department dated 19.04.2007
[49] 3rd Supplemental agreement No. 1/2010-11 dated 03.04.2010
[50] 8,00,958 cum x ₹25 per cum