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பொறியாளர்

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ஏப்ரல் 2026
April 2026

12.04.2026 அன்று ஒடிசா மாநிலத்தின் தலைநகரான புவனேஸ்வரில் நடைபெற்ற அகில இந்திய பொறியாளர் கூட்டமைப்பின் பொதுக்குழுக் கூட்டத்தில் தமிழ்நாடு பொறியாளர் கூட்டமைப்பினர் கலந்து கொண்டு சிறப்பித்தனர்



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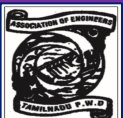
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Article – “A case study of distress analysis in Anaikuttam dam and possible remedial measures”:-

The International Conference on Dam Safety 2026 (ICDS-2026) was held in Bangalore on 13-14 February 2026. During the conference, Er.K.Lavaniya, Assistant Engineer and Er.M.Malini Preetha, Assistant Engineer from the Soil Mechanics & Research Division, WRD, presented a technical paper titled “A Case Study of Distress Analysis in Anaikuttam Dam and Possible Remedial Measures” under the theme “Dam Failure Case Studies: Lessons Learnt.”



Continued in Page No.11

பேரன்பிற்கினியர், பெருமதிப்பிற்குரியர் வணக்கம்.

- ✍ பொதுப்பணித்துறை மற்றும் நீர்வளத்துறையில் உதவிச்செயற்பொறியாளர், செயற்பொறியாளர், கண்காணிப்புப் பொறியாளர் மற்றும் தலைமை பொறியாளர்களின் 2026-27க்கான காலிப்பணியிட மதிப்பீடு கருத்துருக்கள் அனுப்பப்படவும், அரசு மட்டத்தில் ஒப்புதல் பெறவும் நடவடிக்கைகள் எடுக்கப்பட்டு வருகின்றன என தெரிவித்துக்கொள்ளப்படுகிறது.
- ✍ நீர்வளத்துறையில் சிறப்புத் தலைமைப் பொறியாளர் பதவியினை வழங்கியது போலவே, சிறப்பு கண்காணிப்புப் பொறியாளர் மற்றும் சிறப்புச் செயற்பொறியாளர் பதவி உயர்வுகளை, பொதுப்பணித்துறையில் வழங்கப்பட்ட பதவி உயர்வு ஆணைகளின் முறைப்படி பெற்றிட நடவடிக்கைகள் எடுக்கப்பட்டு வருகின்றன என தெரிவித்துக்கொள்ளப்படுகிறது.
- ✍ 12.04.2026 அன்று ஒடிசா மாநிலம் புவனேஸ்வரில் இந்திய பொறியாளர் கூட்டமைப்பின் பொதுக்குழுக் கூட்டத்தில் தமிழ்நாடு பொறியாளர் கூட்டமைப்பின் ஒரு அலகான நமது சங்கங்களின் சார்பில் உறுப்பினர்கள் கலந்துகொண்டனர் என்பதை மகிழ்வுடன் தெரிவித்துக்கொள்ளப்படுகிறது.
- ✍ 6-வது ஊதிய குழுவின் படி உதவிபொறியாளர், உதவிச்செயற்பொறியாளர் மற்றும் செயற்பொறியாளர் பதவி இனங்களுக்கான ஊதிய விகித நிர்ணயம் தொடர்பான வழக்குகள், பதவி உயர்வில் ஊதிய நிர்ணயம் தொடர்பான வழக்குகள் என அனைத்து வழக்குகளும் நீதிமன்றத்தின் கோடை விடுமுறைக்குப் பின் விரைந்து நடத்திட வழக்கறிஞரிடம் வலியுறுத்தப்பட்டது. போதிய நிதி ஆதாரத்திற்கு உறுப்பினர்கள் அனைவரும் வழக்கு நிதி வழங்குமாறு கேட்டுக்கொள்ளப்படுகிறது.
- ✍ மாநில தேர்தலில் வாக்கு பதிவு மூலம் ஜனநாயக கடமை ஆற்றிய அனைத்து உறுப்பினர்களுக்கும் பாராட்டுக்களைத் தெரிவித்துக்கொள்கிறோம். அத்துடன் 2026 - 28ம் ஆண்டிற்கான தலைமைச் சங்க பொறுப்பாளர்களை தேர்வு செய்வதற்கான தேர்தலையும் சிறப்புடன் நடத்திட உரிய ஒத்துழைப்பினை வழங்கிடவும் கேட்டுக்கொள்கிறோம்.

சங்கத் தேர்தல் என்ற நேர்வின் அடிப்படையில் நமது சங்கங்களின் மாநில மையச் செயற்குழு கூட்டம் விரைவில் நடத்தப்படவுள்ளது என்பதை தெரிவித்துக்கொள்கிறோம்.

நமது சங்கங்களின் சார்பில் நடத்தப்பட்டு வரும் தொடர் பயிலரங்கமாக "கற்றல் கருத்தரங்கின்" 3-வது பாகம் வருகின்ற 16.05.2026 சனிக்கிழமை அன்று நடைபெறவுள்ளது.

பொறியாளர்கள் அனைவருக்கும் உழைப்பாளர் தின வாழ்த்துகளைத் தெரிவித்துக்கொள்கிறோம்.

மிக்க அன்புடன்,

பொறிஞர்.H.வேலன்,

பொறிஞர்.மு.தனசேகரன்,

பொதுச் செயலாளர், உதவிப் பொறியாளர் சங்கம்

பொதுச் செயலாளர், பொறியாளர் சங்கம்

"INDEF Federal Council Meet in Bhubaneswar: Engineers Demand All India Service Status & Structural Reforms"



Bhubaneswar, 13/4 (tet): The Indian Engineers' Federation (INDEF) successfully held its Federal Council Meeting in Bhubaneswar, hosted by the Odisha Engineers' Service Association. The event saw participation from over 120 senior representatives representing 25 states, showcasing strong unity within the engineering community.

The meeting focused on long-standing issues affecting engineering services across India, with a major emphasis on structural reforms and enhancing the role of engineers in governance and nation-building.

A key highlight was the demand for a unified service rule for engineers across India, similar to

other All India Services. The Council strongly advocated that engineering departments should be led and managed by qualified engineering professionals rather than generalist administrators.

INDEF emphasized the crucial role engineers play in developing infrastructure sectors such as irrigation, water supply, roads, energy, and urban systems, and called for greater recognition and representation in policymaking.

Several pressing concerns were also discussed, including: Lack of professional recognition Disparities in service conditions across states Issues in cadre management, transfers, and seniority

Challenges in career progression Administrative hurdles in implementing reforms

The Council urged the Government of India to consider establishing an Engineering Commission to strengthen coordination among state engineering bodies and present a unified national voice.

During the meeting, new office bearers were elected:

Abinash Roul as Chairman Ashis Yadav as Secretary General

The successful marks a significant step towards strengthening unity among engineers nationwide and reinforces INDEF's commitment to advancing the dignity and interests of the engineering profession.

Letter No.005/GS-AOE/2026

Dated: 02.04.2026

To
The Commissioner of Treasuries and Accounts,
3rd Floor, Integrated Office Complex for
Finance Department, Veterinary Hospital Campus,
Anna Salai, Nandanam, Chennai-600035.

Respected Sir,

Sub: Water Resources Department - Tamil Nadu Engineering Services
–Assistant Engineer - Selection Grade –Instruction to PAOs &
Treasuries as per letter - Finance Department dated 05.01.2023
– Requested - Regarding.

Ref: 1. Lr.No.36432/CMPC/2022-2, dated 05.01.2023
2. Letter from ATO, Sub Treasury, Tirunelveli dated
06.01.2026
3. Written of Audits from ATO, Sub Treasury, Kovilpatti dated
13.02.2026.

We invite your kind attention on the issue of admitting bills submitted for claiming the benefits of Selection Grade of Assistant Engineers in Water Resources Department.

The fixation of Pay Scale for Assistant Engineers in 6th Pay Commission is directed by the Court through its Judgment in WP20401/2020 dated 04.04.2024, in which the Court also set aside the G.O.Ms.No.71 dated 26.02.2011, G.O.Ms.No.242 dated 22.07.2013 and G.O.Ms.No.399 dated 12.11.2020 issued earlier in connection with the Pay Scale for Assistant Engineers.

Before the Judgment, Finance secretary vide letter 1st cited in reference, issued an instruction in which the Assistant Engineers are allowed to draw the benefits of Selection Grade, Additional Charge Allowances,

Annual Increments and Promotional Increments, even though the Pay Scales as per One Man Commission 2009 is not admitted.

According to the Service Rules and Fundamental Rules of Tamil Nadu Government Servants the Selection Grade and Annual Increments are connected with years of service and No-where connected with the Pay Scales of Pay Commission.

But, the ATOs of Sub Treasury offices at Tirunelveli & Kovilpatti are refusing to admit the bills for Selection Grade without understanding the instruction of Finance Secretary, even after it was approved by the Heads of the Department. In this way this ATOs are violating Service Rules, Court Orders and instruction of their HODs which amounts to take action under the Conduct Rules 1973 and Disciplinary Appeal 2013.

Even so, we request you to kindly consider the instruction of Finance Secretary, Service Rules, and Sanction of HOD and instruct the ATO accordingly, to admit the bills of Selection Grade for the Engineers.

Yours truly,

Er.M.Dhanasekaran,
General Secretary, AOE

SPECIAL CONTRIBUTIONS

Sl.No	Name	Amount	Remarks
1	Er.P.Arumugam Former Spl. CE, WRD, Ground Water Circle, Thanjavur	14,685	Special Contribution on the eve of his retirement from ENGIBEF retirement benefit
2	Er.M.Vasudevan Former Superintending Engineer, PWD, P&D Circle, Chennai	2,000	Special Contribution for the welfare of Association

We thank the above Engineer for their valuable contribution – Editor

To
Engineer-in-Chief & Chief Engineer (General),
Public Works Department,
Chepauk, Chennai-600005

Sir,
Sub: TNES – Assistant Engineer - Estimate of vacancy -Direct
requirement through TNPSC –Regarding

Ref: i. Tamil Nadu Engineering Services (TNES)
ii. Tamil Nadu Engineering Sub Ordinate Services (TNESS)
iii. Tribunal Judgment in OA 3348/1994 dated 17.04.1997
iv. Hon'ble Supreme Court Order in OA 995 / 2009 dated
14.09.2017

We invite your kind attention to the subject of Direct Recruitment of Assistant Engineer through TNPSC.

As per the Service Rules and Court Orders cited in reference 1 to 4 while deriving the estimate of vacancy in the post of section level of PWD for every year, the ratio of 3:1 is being earmarked between Assistant Engineer (AE) & Junior Engineer (JE). Further, there is no provision in Service Rules allows to carry forward the unfilled vacancies of particular category to next year while calculating Estimate of Vacancy of that category.

Accordingly every year Estimate of vacancy for entire section post shall be arrived freshly where 3:1 ratio shall be maintained between AE and JE. This is carefully formulated in service rules in order to avoid accumulation of vacancies when the ratio 3:1 is misconceived as cadre strength.

Hence, we request our Engineer-in-Chief & Chief Engineer (General), PWD to call for the TNPSC for recruiting the Assistant Engineers every year for the Estimate of Vacancy derived as stated above.

Yours truly,

Er.M.Dhanasekaran,
General Secretary, AOE

WRD - RETIREMENT ON 30.03.2026

1	பொறி.P.ஆறுமுகம்	சிறப்புத் தலைமை பொறியாளர்
2	பொறி.K.சின்னதுரை	உதவிச் செயற்பொறியாளர்
3	பொறி.S.சிவராஜன்	உதவிச் செயற்பொறியாளர்
4	பொறி.P.பார்த்திபன்	உதவிச் செயற்பொறியாளர்
5	பொறி.S.ராஜதிலகா	உதவிச் செயற்பொறியாளர்
6	பொறி.M.B.தங்க ஜெய்லாணி	உதவிச் செயற்பொறியாளர்

அரசாணை (வாலாயம்) எண்.206, நீர்வளத்(டி2)துறை, நாள்: 30.03.2026

We wish them a happy, peaceful & pleasant retired life - Editor

இரங்கல்:

திரு.G.துரை, வயது 75, (பொறி.D.மோகன், உதவிச் செயற்பொறியாளர், நீ.வ.து. மத்திய பெண்ணையாறு வடநில உபகோட்டம், செய்யாறு) அவர்களின் அன்புத் தந்தையார் அவர்கள் 27.03.2026 அன்று முத்துகிருஷ்ணாபுரம் கிராமம், பண்டுட்டியில் காலமானார் என்பதை மிகுந்த வருத்தத்துடன் தெரிவித்துக்கொள்கிறோம். தனது அன்புத் தந்தையாரை இழந்து வருந்தும் பொறி.D.மோகன் அவர்களுக்கும் அவர்தம் குடும்பத்தாருக்கும் நமது ஆழ்ந்த இரங்கலைத் தெரிவித்துக்கொள்கிறோம்.

திரு.ஆ.வல்லத்தரசு, வயது 89, (பொறி.V.T.நீள்முடியோன், செயற்பொறியாளர், நீ.வ.து. கீழ் வைகை வடநில வட்டம், பரமக்குடி) அவர்களின் அன்புத் தந்தையார் அவர்கள் 10.04.2026 அன்று திண்டிவனத்தில் காலமானார் என்பதை மிகுந்த வருத்தத்துடன் தெரிவித்துக்கொள்கிறோம். தனது அன்புத் தந்தையாரை அன்னாரை இழந்து வருந்தும் பொறி.V.T.நீள்முடியோன் அவர்களுக்கும் அவர்தம் குடும்பத்தாருக்கும் நமது ஆழ்ந்த இரங்கலைத் தெரிவித்துக்கொள்கிறோம்.

திருமதி.அர்ச்சனா (பொறி.ஆர்த்தி ஸ்ரீவிஜய், உதவிபொறியாளர், நீ.வ.து. தரக்கட்டுப்பாடு கோட்டம், சேப்பாக்கம், சென்னை-5 மற்றும் பொறி.ஐஸ்வர்யா, உதவிபொறியாளர், நீ.வ.து. மாநில அணை பாதுகாப்பு இயக்கம், தரமணி, சென்னை-113) ஆகியோர்களின் அன்புத் தாயார் அவர்கள் 11.04.2026 அன்று சென்னையில் காலமானார் என்பதை மிகுந்த வருத்தத்துடன் தெரிவித்துக்கொள்கிறோம். தனது அன்புத் தாயாரை இழந்து வருந்தும் பொறி.ஆர்த்தி ஸ்ரீவிஜய் மற்றும் பொறி.ஐஸ்வர்யா ஆகியோர்களுக்கும் அவர்தம் குடும்பத்தாருக்கும் நமது ஆழ்ந்த இரங்கலைத் தெரிவித்துக்கொள்கிறோம். - ஆசிரியர்

ENGIBEF PHASE-V SCHEME

S.No.	ENGIBEF No.	Receipt No & Amount	Name & Address
1	V-847-CUD&VM	R.No.904 Rs.10,500	Er.V.GOWTHAMAN AE,WRD, O/o EE, Coleroon Basin Div. Chidambaram
2	V-848-SLM	R.No.905 Rs.10,500	Er.M.K.VIJAYARAGAVAN AE, WRD, O/o EE, Lower Bhavani Basin Division, Erode
3	V-849-ERD	R.No.906 Rs.10,500	Er.C.MALATHI AEE, PWD, O/o EE, Buildings (C&M) Division, Gobichettipalayam
4	V-850-SLM	R.No.907 Rs.10,500	Er.P.VINOTHKUMAR AE, PWD, Building (C&M) Sec.1, Thalaivasal, Salem
5	V-851-TVM	R.No.908 Rs.10,500	Er.S.CHANDRAVADANI AE, WRD, O/o AEE, WRD, Ground Water Sub Div. Tiruvannamalai
6	V-852-TVM	R.No.909 Rs.10,500	Er.N.SELVI AEE, WRD, Ground Water Sub Div. Tiruvannamalai
7	V-853-SLM	R.No.910 Rs.10,500	Er.A.ARUL AEE, PWD, Buildings (C&M) Sub Div.2, Karur
8	V-854-CHE	R.No.911 Rs.10,500	Er.P.SUBHATHRA AE, WRD, O/o AEE, KWSP Sub Div.2, Chennai-5
9	V-855-CHE	R.No.912 Rs.3,000	Er.S.NAGAJOTHI AEE, WRD, O/o EE, Designs Division, Chennai-5
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23	Part Payment	R.No.926 Rs.5,000	Er.M.MUGILVENDAN AE, WRD, Proj. Management Unit, Trichy-20
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25	Part Payment	R.No.928 Rs.5,000	Er.K.MONISHA AE, WRD, Proj. Management Unit, Trichy-20
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A case study of distress analysis in Anaikuttam dam and possible remedial measures

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Abstract:

Virudhunagar in Tamil Nadu is a drought prone district without any perennial river. Majority of the total population of the district is dependent on agriculture and its allied occupations. Apart from few dams which aids storage of surface water, well irrigation and rain dependent tanks are the source for agriculture in this district. Anaikuttam Dam is one such dam built on Arjuna River in the year 1989 which is a seasonal river originating from Sathuragiri hills. This dam is situated at Anaikuttam Village in Sivakasi Taluk of Virudhunagar District in Tamil Nadu. It is a composite dam consisting of concrete spillway and earthen embankment. Distress in the form of sink holes were observed on the crest of earthen bund near the right abutment of the Anaikuttam Dam in the year 2021. Geotechnical investigations were carried out to ascertain the causes for the formation of sinkholes. Exploratory test bore holes were drilled from the crest of the bund which depict that the earthen embankment of Anaikuttam dam rest on calcareous deposits which are prone to dissolution when acidic water (*often containing dissolved CO₂*) dissolves limestone, creating sinkholes. Since rehabilitation measures are needed to ensure storage, the critical stretch of the earthen embankment located on both the sides of spillway portion, requires detailed geotechnical investigations. As destructive drilling of test bores along the already distressed critical stretch of earthen embankment is not advisable non-destructive investigation methods viz. ERT (Electrical resistivity tomography) and MASW (Multi-channel analysis of surface waves) were carried out during August 2025, to compare the results with that were obtained from test bore holes. The relative compaction of the earthen bund is arrived based on the interpretation of 'N' Value from the shear wave velocity and the weak zones in this critical stretch of earthen bund is identified. From the combined exploratory geotechnical and non - destructive geophysical survey, the remedial measures to be taken up to rehabilitate the distressed section of the embankment has been suggested.

Keywords: Geophysical investigation, ERT, MASW, earthen embankment, test bore holes, sink holes.

1. Introduction:

Anaikuttam Dam, completed in 1989 in Tamil Nadu's Virudhunagar district, is situated across Arjuna River within a drought-prone, semi-arid tropical region. The region faces high temperatures and hydrological droughts and is devoid of dependable irrigation sources like perennial rivers. This area is mostly covered by black cotton soil with underlying kankar (lime nodules) followed by calc-gneiss rock strata. Kankar is the weathered product of calc-gneissic rock outcrops, containing CaO content more than 30% which is mined for cement manufacturing and various other purposes. Agriculture is the predominant occupation of Virudhunagar district. Assured irrigation is available through wells and by rainfed tanks and six reservoirs viz. Kulloorsanthai, Vembakottai, Anaikuttam, Golvarpatti, Periyar & Kovilar and Sasthakoil are important irrigation sources. Paddy and Cotton are the predominant crops of this district. The northeast monsoon mainly contributes to the rainfall in the district. Average rainfall of Virudhunagar district is 811mm which is less than the National average. Anaikuttam Dam is constructed on Arjuna River, a seasonal river to store the water contributed by the North East monsoon. Though the capacity of Anaikuttam Dam is 0.13 TMC only, it is a lifeline for the people of Virudhunagar as they rely on the storage of the Dam for their agriculture and drinking water needs.

2. Features of Anaikuttam Dam:

Anaikuttam dam (Fig 1), is a composite Dam to store 0.13TMC, consisting of an earthen dam for a length of 2823m and concrete spill way of Breast wall type regulator of 117m length with 9 shutters to discharge 60309 cusecs of surplus flow and is founded on a stratum consisting of black cotton soil with underlying lime kankar. A Tower Head sluice to draw 41.14 cusecs for irrigation is provided on the right side of the spill way which irrigates 1821 Ha of Ayacut in Virudhunagar district. Maximum depth of storage is 7.5 m at LS 1178m. Maximum height of earthen bund is 9.5 m at LS 1350m. The Earthen dam is formed as a zoned embankment with distinct casing and hearting zones. The upstream slope of the casing is protected with a layer of rip-rap of stone over a layer of filter bed and the downstream slope is protected with turfing. A free board of 2.20m is available above the FRL throughout the length of the Dam and the crest is laid with a layer of murum to enable vehicle movement. Necessary chute drains and cross drains provided on the downstream of the bund serve the purpose of rain water drain and as such the bund slope surface were found visually intact without any rain-cut or gullies.



Figure 1. Aerial view of Anaikuttam Dam with earthen bund and spillway

3. Noticing of Distress:

The distress in the form of depression / sinkhole, was noticed on the earthen bund near the right abutment of the Anaikuttam Dam during the year 2021. On 26.11.2021 Anaikuttam Dam and its catchment areas witnessed a rainfall of 6.5 cm, with 6m depth of water storage in the shutter portion of the Dam. During this period, vibration/noises were heard in the shutter portions. Further depressions / sink holes were formed (Fig. 2) on the crest of the earthen bund near to the right abutment. In this connection, the dam was inspected by the Phase I, 6th Cycle Inspection Committee of State Dam Safety Organisation, Tamil Nadu on 01.03.2022. As a temporary measure, water in the reservoir was maintained at a safer limit and the sink hole was filled up with the locally available earth. However, sinking was continuing with the soil particles coming out on the downstream through the weep holes of the right abutment (Fig. 3).



Figure 2. Formation of sinkhole



Figure 3. Weep Holes showing lime deposits

4. Geotechnical investigation:

To ascertain the causes for the formation of sinkholes, laboratory and field investigation was carried out by Soil Mechanics & Research Division of Tamil Nadu Water Resources Department. Exploratory boreholes were drilled using hand auger in the locations (Fig. 4) as mentioned in Table 1, on the embankment and soil samples (disturbed and undisturbed) were collected to determine their index and engineering properties. Standard Penetration test was conducted to understand the relative compaction/denseness of the various layers that constitute the earthen bund.

Table 1. Location of Boreholes

S. No	Borehole No.	Location
1.	BH I	LS 1070m on top of the left embankment
2.	BH II	LS 1070m on upstream slope of the left embankment
3.	BH III	LS 1326m top of the right embankment
4.	BH IV	LS 1299m near right abutment top
5.	BH V	LS 1140m on top of the left embankment
6.	BH VI	LS1299m downstream portion beyond toe

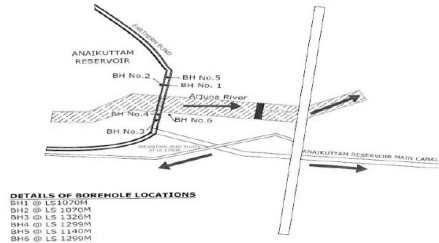


Figure 4. Schematic diagram of Anaikuttam Dam showing the location of Bore Holes and sink hole formation

5. Interpretation of Field and Lab Analysis:

The earthen portion of Anaikuttam dam is a zoned embankment. The exploratory bore holes in the embankment reveal that the casing portion is made up of SC/GC soil (Clayey Sand / Clayey gravel) and hearting is made up of CH (Clay of High Plasticity) soil.

However, bore holes drilled on the right earthen bund (LS 1299m), where the sink hole formation was observed, reveal that the soil type from the crest is predominantly made up of clayey sand upto a depth of 5.0 m. The stratum is highly loose in state from a depth of 3.5m to 4.0m, which was confirmed during boring operation by the sudden downward movement of auger. The corresponding 'N' values of SPT test before the auger movement, also indicate that the bund is relatively in a loose state with 'N' value of 10. Normally during construction, the bund layers will be compacted to 90% to 95% of maximum dry density which will give a higher 'N' value but the low 'N' value obtained in present case suggests that the underlying disturbance (might be due to the subterranean channel caused by dissolution leaching) is causing loosening of earthen bund along this critical stretch on both sides of the abutment. This reduced 'N' value represents the unsound / relatively loose earthen bund matrix which necessitates its complete removal and replacement. In this critical portion, it is evident that due to the escape of clay fraction at the sink hole location, emergent filling had been resorted on the top of the embankment with the immediately available clayey sand material.

The Undisturbed soil sample collected at a depth of 5m visually indicate the presence of limestone that readily reacts with dil. Hcl and liberates brisk effervescence and proves presence of calcium carbonate. On advancing the test bores, it was found that disintegrated rock strata (calcareous rock) was encountered at 7m below the top of the bund.

Field and Laboratory Investigation (Figs 5 – 7) (Soil and Chemistry) confirm that the formation of sinkholes in the earthen embankment is due to the existence of kankar /calcrete strata in the foundation. Outcrops of calcrete or Kankar could be visually seen on the reservoir bed, upstream and downstream side of the Anaikuttam Dam and continuous extension of this calcrete layer even beyond the downstream side confirms the findings. Further the weep holes provided on the wing wall of the right abutment was found clogged with whitish lime deposits which show the continuous dissolution and deposition of lime happening through the earth being retained by the wing walls.



Figure 5. Field testing



Figure 6. UDS sample collected at 7.0 m depth

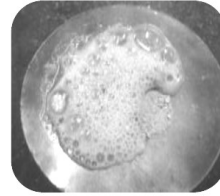


Figure 7. Action with dil. HCl- Brisk effervescence of soil sample

6. Inspection by DSRP on 26.09.2023

The DSRP (Dam Safety Review Panel) members accompanied by the State Project Management Unit Officials carried out inspection of Anaikuttam Dam on 26.09.2023 and recommended that the embankment material and its foundation may be tested for dispersivity and hydraulic fracture before coming to any conclusion. Consequently, the soil samples from right side bund, left side bund and reservoir bed were collected and tested for dispersivity analysis which is tabulated below as Table 2.

Table 2. Dispersivity test on soil samples

Sl. No	LS details	Location of sample collection	Physical test*	Chemical test**	Consensus
1	Right bank LS 1313m	Upstream slope under revetment	Non Dispersive	Non Dispersive	Non Dispersive
2	Right bank LS 1690m	At bed of Reservoir 18.00m from the U/s Toe	Non Dispersive	Non Dispersive	Non Dispersive
3	Right bank LS 1313m	At Downstream slope	Non Dispersive	Non Dispersive	Non Dispersive
4	Left bank LS 1140m	At Upstream slope	Non Dispersive	Non Dispersive	Non Dispersive
5.	Left bank LS 1153m	At Downstream slope	Dispersive	Intermediate	Moderately Dispersive
6	Left bank LS 1140m	At bed of Reservoir 10m from U/s Toe	Dispersive	Intermediate	Moderately Dispersive

* Physical test based on crumb test, Pin hole and double hydrometer

** Chemical test based on SAR value and Percentage Sodium Vs TDS

7. Findings of geotechnical investigation

- The soil layers of earthen bund in the critical stretches are relatively in a loose state with poor 'N' value, indicating unsound soil matrix of the earthen bund that threatens its structural integrity, stability, and impermeability.
- The soil strata below the bund at the right side of abutment consists of a distinct layer of calcrete/ kankar deposits which is soluble in water whenever its pH becomes mildly acidic ($pH < 7$).
 - Rainwater absorbs carbon di oxide from the air and becomes mildly acidic. This acidic rain water seeps into superficial cracks in the crest of the bund, and reacts with calcrete/kankar deposits in the foundation level
 - Whenever fresh rain water flows into the reservoirs and comes in contact with calcrete / kankar layer, it has a tendency to dissolve this layer and creates fissures and cavities. Over a period of time, this acidic water slowly dissolves the calcrete / kankar deposits (Figs 8 – 10) and widens the fissures/cracks into channels or leakage paths and enlarges the underground voids. This leakage path will carry the dissolved lime particles.

3. It is evident from the lime leachate clogged weep hole deposits of wing wall that lime dissolution and deposition is occurring on the RHS of Abutment which is a rare occurrence for a retaining wall meant to retain earth.
4. The loss of lime from the substrata combined with leakage resulted in localized subsidence of overlying soil and caused SINKHOLES.



Figure 8. Kankar / calcrete strata on upstream side of the dam

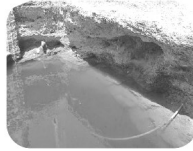


Figure 9. Open well - showing groundwater erosion causing distinct canopy in kankar strata



Figure 10. Superficial kankar strata on the reservoir bed

8. Geophysical investigation

Considering the limitations of drilling exploratory test bores in a live storage dam for conducting a detailed field investigation, the Non-destructive methods (Figs. 11-13) viz., Electrical Resistivity Tomography (ERT) and Multichannel Analysis of Surface Waves (MASW) were used to investigate embankment soundness and the subsurface conditions. ERT images the subsurface by measuring electrical resistivity variations, which indicate differences in moisture, rock, and soil properties by measuring electrical resistivity to map subsurface materials, while MASW is used to determine shear wave velocity (V_s) profiles, mapping soil stiffness, bedrock depth, and stratigraphy focuses on measuring surface waves that travel along the Earth's surface. These methods are often used in combination to provide a more comprehensive understanding of the subsurface. Hence both ERT and MASW were carried out in the critical stretches of Anaikuttam dam to ascertain the conditions of earthen embankment and underlying strata to correlate with the field and lab investigations and to arrive at possible remedial measures.



Figure 11. Instrument used for the 2D resistivity test



Figure 12. Geophone coupled to the ground



Figure 13. Source of vibration - Hammer

The locations (Figs. 14-16) of geophysical investigation are tabulated as Table 3.

Table 3. Locations of geophysical investigation

ER01	MASW-01	Upstream of the reservoir at a distance of 20 m from the heel of the right embankment
ER02	MASW-02 MASW-03 MASW-04	Upstream of the reservoir at a distance of 60 m from the heel of the right embankment
ER03	Nil	Upstream of the reservoir along the heel of the right embankment
ER04	MASW-06 MASW-07 MASW-08	Top of the right embankment
ER05	MASW-05	Downstream of the reservoir at a distance of 5 m from the toe drain
ER06	Nil	Transverse profile of the reservoir across the right abutment
ER07	MASW-09 MASW-10	Upstream of the reservoir at a distance of 10m from the heel of the left embankment
ER08	MASW-11 MASW-12	Top of the left embankment



Figure 14. Locations of Geophysical resistivity survey and Multi-Channel Analysis of Surface wave



Figure 15. Right flank Earthen Embankment



Figure 16. Left flank Earthen Embankment

9. Combined Geotechnical and Geophysical investigation

9.1 Right embankment

1. Rapid advancement of Hand Auger during boring operation was observed at LS 1299m (Earthen embankment close to right Abutment) from a depth of 3.50m to 4.0m representing a loose stratum of soil at this LS.
2. The ‘N’ Value observed at a depth of 3.00m in LS 1299m is 10, which indicates the loose stratum of soil as per IS 6403:1981 (Reaffirmed 2021). Similarly, at LS 1326m, the ‘N’ Value observed up to a depth of 6.50m is 20, which denotes that the relative density of the strata is medium as per IS 6403:1981 (Reaffirmed 2021).
3. The soil samples from LS 1299m are predominantly of clayey sand. Similarly, soil sample from LS 1326m is predominantly of stratified deposits of sandy layer. From this, it is evident that due to the escape of clay fraction from the sinkhole location, emergent filling has been resorted to from the top of the embankment with immediately available clayey sand material.
4. The Laboratory test on samples from this bore hole (LS 1299m), implies that the soil is predominantly of “Clayey Sand” up to 5.00 m depth from the top of the bund, beyond which hard strata was encountered (White Gravel – Limestone formation). This depth corresponds to the

foundation level of the embankment and implies that the embankment rests on the kankar/calcrete which is a limestone formation prone to dissolution.

5. From the Direct shear test on the soil sample (White Gravel - Limestone formation) a peculiar type of stress strain behavior was observed. This is because the white gravel - limestone formation encountered at this depth (6.5m), when subjected to higher normal loads under undrained conditions exhibits very poor shear strength since the rock has a tendency to dissolve in water.
6. Similarly, the geophysical investigation (Fig. 17. Refer page No.19) substantiates the presence of weaker zones up to a depth of 11m from the crest of the bund. This weak zone stretch is extending to a length of 55m from the right abutment as the shear wave velocity of this stratum is less than 230m/sec.
7. Further, highly polarized pockets (high permeable zones HPZ) are also observed within this weak zone.

9.2 Left embankment

1. At LS 1070m, the 'N' Value observed at a depth of 3.00m is 7, which indicates loose stratum of soil. The 'N' value observed at 6.00m is 24 which indicates that the relative density of the strata is medium as per IS 6403:1981 (Reaffirmed 2021).
2. At LS 1140m, the 'N' Value up to a depth of 3.00m is 9, which indicates loose stratum of soil. The 'N' value observed at 6.00m is 13 which indicates that the relative density of the strata is medium as per IS 6403:1981 (Reaffirmed 2021).
3. Similar to the right embankment, white gravel (limestone formation) was encountered at a depth of 6.00m from the top of the embankment. This kankar/calcrete (limestone formation) in the foundation of earthen embankment has a tendency to dissolve in water.
4. The geophysical investigation (Fig. 18. Refer page No.20) substantiates the presence of weaker zones up to a depth of 11m from the crest of the bund. This weak zone stretch is extending for a length of 115 m from the left abutment since the shear wave velocity of the strata is less than 350m/sec.
5. Further, highly polarized pockets (high permeable zones HPZ) are also observed within this weak zone.

10. Suggested possible remedial measures

The root cause for the distress in the earthen embankment of Anaikuttam dam is formation of "Dissolution sinkhole" which happens at the reservoir bed level and needs to be addressed. The following are the suggested possible measures (Table 4) for the rehabilitation of earthen bund of Anaikuttam Dam

- 1) Based on the Geophysical and Geotechnical investigation it is ascertained that the following stretch of earthen bund portion of Anaikuttam dam needs complete removal as the relative compacted density is very less, due to the recurrent phenomena of sinkhole formation and subsequent subsidence.

Table 4. Proposed remedial measures

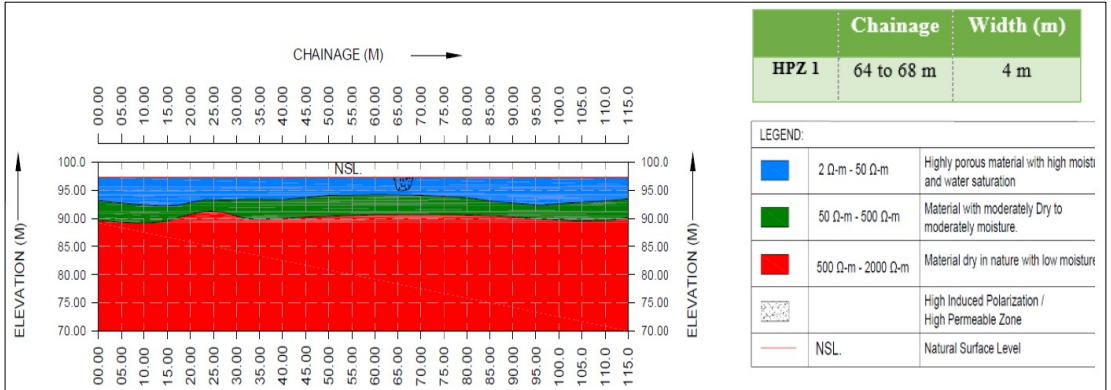
S.No.	Earthen Bund	LS	N Value	Remarks	Suggestions
1	Right Side	1295m to 1350m(55m)	Upto 5m depth 'N' value is 15 Beyond that upto 11 m depth 'N' value is 41	E.L 97.2 to 92.2m E.L 92.2 to 86.2m	Earthen Embankment to be removed completely and new zoned embankment to be formed.
2	Left Side	1063m to 1178m (115m)	Upto 3m depth 'N' value is 9 – 11 Beyond that upto 6m depth 'N' value is 13 - 17	E.L 97.2 to 94.2m E.L 94.2 to 91.2m	

- 2) Conducting field permeability tests at the level of cutoff trench of the earthen bund and identifying proper cutoff mechanism viz., COT with clay filling for entire 'D' depth or COT with concrete diaphragm wall below the impervious core, considering the porous lime stone formation (kankar/calcrete) of reservoir bed.

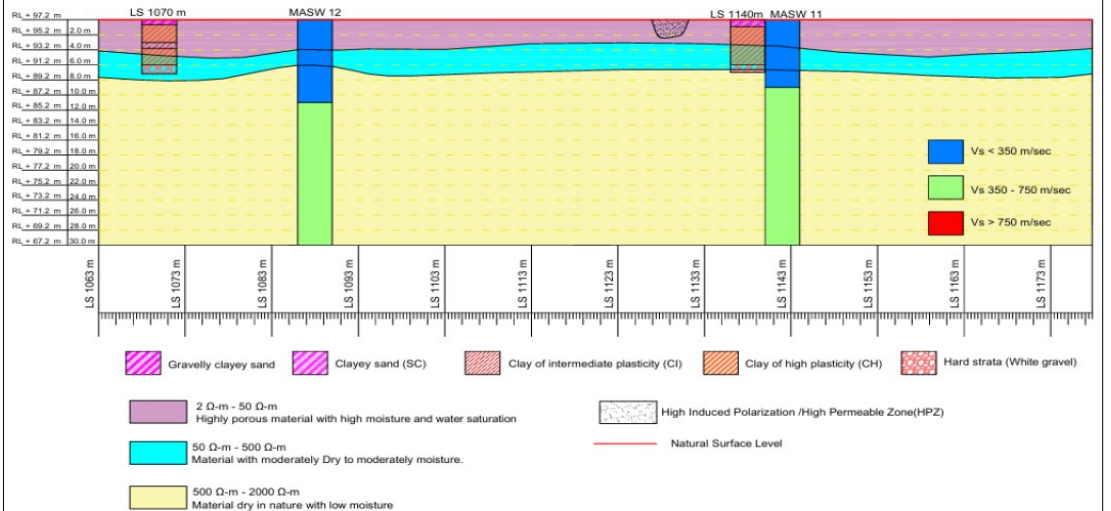
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Left Embankment - Figure No.18



Combined analysis of geotechnical and geophysical carried out on the left embankment at Anaikuttam dam



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