



SOIL-CEMENT-BENTONITE CUTOFF WALL FOR SEEPAGE REMEDIATION AT THE CONDUIT-EMBANKMENT CONTACT ZONE

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ABSTRACT: Seepage concentrated along the conduit–embankment contact zone is a critical dam safety problem because this interface is prone to preferential flow and is difficult to treat reliably under constrained construction conditions. This study investigates the use of a soil-cement-bentonite (SCB) cutoff wall as a practical and field-verifiable remedial measure for this type of seepage problem at Da Si Dam, Lam Dong Province, Vietnam. Site investigation and quality verification during construction identified a high-permeability band adjacent to the outlet conduit. In response, an SCB cutoff wall was constructed parallel to the conduit on the downstream side under bentonite slurry support. The adopted backfill, consisting of local soil, 7% bentonite, 2% cement, and a superplasticizer, was selected through laboratory trial testing to achieve both low hydraulic conductivity and adequate workability for trench placement. Post-construction in-situ borehole permeability tests yielded hydraulic conductivity values from 8.93×10^{-7} to 3.56×10^{-6} cm/s, all below the design criterion of $k \leq 1 \times 10^{-5}$ cm/s. Subsequent field inspections during reservoir operation showed no visual evidence of seepage, localized wetting, or abnormal moisture on the downstream slope surface above and adjacent to the treated conduit zone, confirming the effectiveness of the SCB cutoff wall for remediation of this difficult soil–structure contact zone.

Keywords: Soil-cement-bentonite cutoff wall; Seepage remediation; Conduit-embankment interface; Hydraulic conductivity; Internal erosion prevention.

1. INTRODUCTION

Seepage and internal erosion are widely recognized as major threats to the safety of embankment dams and remain among the most common mechanisms associated with dam incidents and failures [1,2]. Recent studies have also shown that internal erosion may develop through different mechanisms, including concentrated leak erosion, contact erosion, suffusion, and backward erosion piping, and that appropriate remedial treatment is essential for dam safety management [2,3].

Previous studies have shown that seepage problems are often concentrated at vulnerable soil–structure interfaces, particularly where rigid concrete structures such as conduits and appurtenant works meet compacted earthfill [4,5]. At such locations, differences in material properties, construction sequence, differential deformation, and limited access for compaction may create unfavorable contact conditions and facilitate the development of concentrated leakage paths [4–6]. These findings indicate that conduit–embankment contact zones require particular attention in dam safety assessment and rehabilitation design.

In engineering practice, several remedial approaches have been used to control seepage in

embankment dams, including excavation and replacement of defective fill, grouting, filters and drains, upstream impervious blankets, and positive seepage barriers such as cutoff walls [2,7–9]. However, previous studies have also shown that no single method is universally optimal, and the suitability of each approach depends strongly on the geometry and continuity of the defect, construction access, quality control requirements, and the feasibility of verifying post-treatment performance [2,7–9]. For conduit-side defects in particular, the key challenge is not merely to reduce permeability, but to create a seepage barrier that can be formed reliably along a narrow and difficult soil–structure contact zone and whose as-built quality can be verified with sufficient confidence. This requirement is especially important where localized treatment methods may reduce seepage but provide less confidence in the uniformity and verifiability of the treated zone. In this context, a cutoff wall formed from an engineered backfill material is attractive because its material properties and as-built hydraulic performance can be checked more systematically.

Among positive seepage barriers, slurry trench cutoff systems have been widely applied in dam rehabilitation [8,10]. SCB cutoff walls are of particular interest because they can provide low

hydraulic conductivity, moderate strength, and practical constructability, while allowing excavated soil to be reused as backfill [10]. Recent studies have also shown that bentonite-based low-permeability materials can be effective in seepage control applications in reservoirs and embankments [11]. Nevertheless, detailed case-based documentation of SCB cutoff walls specifically applied to conduit–embankment contact zones, together with post-construction hydraulic verification under field conditions, remains limited [10].

The Da Si Reservoir in Lam Dong Province, Vietnam, provides a representative case of this problem. During construction, quality verification identified a high-permeability band adjacent to the outlet conduit, indicating a defective contact zone with potential for concentrated seepage during reservoir operation. Under these conditions, the required remedial measure needed not only to reduce permeability, but also to form a more uniform and reliable barrier along the treated zone and allow post-construction hydraulic performance to be verified with greater confidence. In response, a SCB cutoff wall was designed and constructed parallel to the conduit on the downstream side.

This paper presents a case study on the identification, design, construction, and post-construction verification of the SCB cutoff wall used to remediate this conduit-side seepage problem; the following sections describe the significance of the study, the Da Si case, the adopted design and construction procedure, and the resulting field performance. The objectives are to: (i) document the construction-stage evidence used to identify the defective contact zone; (ii) describe the material selection, mix design, trench layout, and quality control procedures adopted for the SCB cutoff wall; and (iii) evaluate the post-construction hydraulic performance of the remedial system based on in-situ permeability testing and subsequent operational observations. The study contributes field-based evidence from Vietnam to the limited literature on SCB cutoff walls applied at conduit–embankment contact zones and provides practical experience for similar dam rehabilitation problems.

2. RESEARCH SIGNIFICANCE

Seepage concentrated at the conduit–embankment contact zone is a critical dam safety concern because it creates preferential flow paths and accelerates internal erosion. This paper provides field-based evidence from Da Si Dam, Vietnam, showing that a SCB cutoff wall is a practical remediation measure for this vulnerable zone. The documented approach is applicable to similar

contact-zone seepage problems in aging earthfill dams.

3. CASE DESCRIPTION

The Da Si Reservoir (Lam Dong Province) has a storage capacity of 20.5 million m³ and supplies irrigation (~2,500 ha), domestic water, and environmental flows. The headworks comprise a main earthfill dam (Hmax 24.73 m; crest length 861.40 m) and a spillway system including a central gated spillway (crest elevation +159.5 m, width 5.0 m) and two piano-key spillways (crest elevation +162.5 m). The outlet works are situated on a mid-valley hill located within the dam alignment (Fig. 1). They consist of a pressure steel pipe housed within a reinforced concrete gallery, with the conduit foundation at approximately elevation +142.0 m.

According to the design requirements, the compacted fill in direct contact with hydraulic structures must satisfy strict seepage-control criteria, with hydraulic conductivity $k \leq 1 \times 10^{-5}$ cm/s. These requirements aim to prevent contact erosion and concentrated leakage along the soil structure interface, which is widely considered a vulnerable zone in earthfill dams.

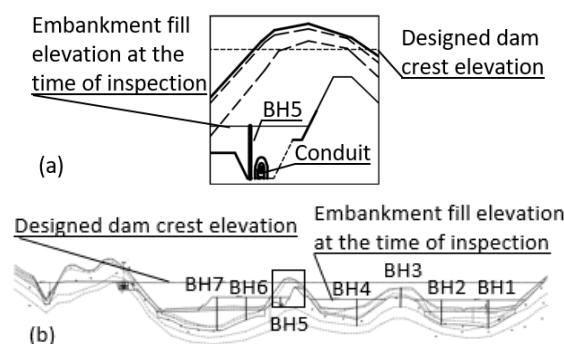


Fig. 1. (a) Enlarged view of the conduit and QA borehole BH5; (b) General layout of the conduit and QA investigation boreholes.

During construction, when the embankment fill reached elevation +154.5 m, the project owner commissioned an independent quality assurance (QA) assessment. This QA program was undertaken during the first stage of embankment construction to verify construction quality at selected locations rather than to provide a full site investigation of the seepage zone. According to the QA verification report dated 21 April 2020 issued by the Design Appraisal and Construction Quality Inspection Consultancy Office, drilling, sampling, in-situ inspection, and falling-head permeability tests were conducted in the embankment fill surrounding the

outlet conduit. The QA borehole shown in Fig. 1 was deliberately located adjacent to the conduit to verify fill quality at this critical interface, which was recognized as particularly susceptible to construction defects. The results indicated that the fill did not satisfy the specified compaction and seepage criteria. The degree of compaction (K), defined as the ratio of field dry density to maximum dry density, ranged from 0.92 to 0.96, which is lower than the specified requirement ($K \geq 0.97$). In addition, the measured hydraulic conductivity ranged from 6.4×10^{-4} to 4.3×10^{-3} cm/s, far exceeding the design limit. These findings indicate a localized defect in the embankment fill adjacent to the conduit.

A technical review meeting involving the project owner, QA consultant, design consultant, and contractor was therefore convened. Three remedial options were considered: (i) complete excavation and replacement of the fill surrounding the buried conduit; (ii) pressure grouting in the vicinity of the conduit; and (iii) construction of a SCB cutoff wall along the conduit alignment to form a continuous low permeability seepage barrier. Following the joint technical review, Option (iii) was selected as the most suitable solution under the prevailing project constraints. The detailed design and construction methodology of the SCB cutoff wall are presented in the following section.

4. DESIGN AND CONSTRUCTION OF THE SCB CUTOFF TRENCH

4.1 Design Requirements and Objectives

The remediation was designed to eliminate the concentrated seepage pathway developing along the conduit-embankment interface and to restore seepage control performance in accordance with the design criteria. Accordingly, the SCB cutoff wall was specified to achieve a target hydraulic conductivity of $k \leq 1 \times 10^{-5}$ cm/s. The cutoff system was required to form a continuous low permeability barrier with adequate embedment below the conduit foundation in order to maintain vertical continuity and reduce the potential for bypass seepage.

In addition, the remediation scheme was required to minimize disturbance to the existing outlet works and surrounding embankment, while ensuring safe construction conditions. Given that the rainy season in Lam Dong typically begins in May, the remedial works were required to be completed within a tight time window immediately following the QA field verification conducted in late April 2020. The overall implementation period was therefore constrained to approximately one month, as SCB trench excavation and slurry wall construction become significantly

more difficult during the peak rainy season.

4.2 Material Selection and SCB Mix Design

4.2.1. Bentonite

Table 1. Main properties of the Vietnamese bentonite used in the SCB mixture

No	Properties	Unit	Value
1	Density	g/cm ³	1.05
2	Viscosity (marsh funnel)	s	39
3	Sand Content	%	0.5
4	Filter Cake Thickness (after 30 min)	mm	2.5
5	pH value		9.0

The bentonite used in the SCB mixture was a locally produced sodium bentonite supplied by Hung Ngoc Co., Ltd. (Vietnam), and its main properties are summarized in Table 1.

4.2.2. Soil

The soil used in the SCB mixture was obtained directly from trench excavation at the Da Si site. The particle size distribution shown in Fig. 2 indicates a well-graded soil suitable for SCB backfill.

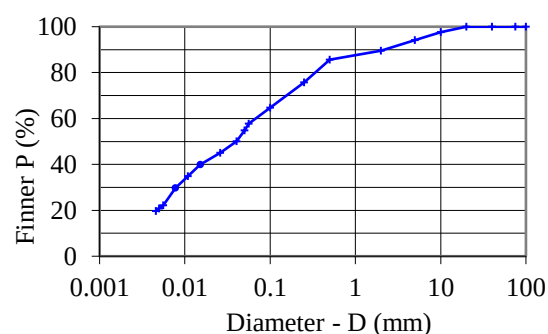


Fig. 2. The particle size distribution curve of soil

4.2.3. Cement

Table 2. Physical and chemical properties of the Portland cement used in the SCB mixture

No	Parameter	Unit	Value
1	Specific gravity	-	3.1
2	Blaine fineness	cm ² /g	3,200
3	Initial setting time (without retarder)	min	125

4	Final setting time (without retarder)	min	195
5	Compressive strength (28 days)	MPa	42.5
6	pH (cement paste, w/c = 0.5)	-	12.5

The cement used in the SCB mixture was a locally manufactured Portland cement (PCB40), and its main properties are summarized in Table 2.

4.2.4. Chemical admixture

A chemical admixture was incorporated into the cement slurry to extend the cement setting time during field placement. The admixture used was PLACC-02A, a superplasticizer produced by SIKA Vietnam.

4.3 Design of the SCB cutoff wall

4.3.1. SCB mix proportion

Table 3. Trial SCB mix proportions (bentonite and cement contents, % by dry soil mass)

Mix ID	Bentonite (%)	Cement (%)
Mix 1	5	2
Mix 2	7	2
Mix 3	10	2

The constituent materials of the SCB backfill are described in Section 4.2. Based on prior practical experience, three trial mix proportions were proposed for laboratory verification. In all trial mixes, the cement content was fixed at 2%, while the bentonite content was varied at 5%, 7%, and 10%, all expressed as percentages of the dry soil mass. The 2% cement content was adopted to provide a modest increase in strength and to improve backfill stability by reducing the potential washout of fine particles during service, especially under higher reservoir water levels. The laboratory trial program therefore focused on varying the bentonite content (Table 3).

Permeability tests were conducted on laboratory specimens prepared from each trial mix and consolidated under a vertical pressure of 0.5 kg/cm². The results, summarized in Table 4 and illustrated in Fig. 3, show that hydraulic conductivity decreased consistently with curing time (7, 14, and 28 days) and with increasing bentonite content. A sharper reduction was observed during the early curing stage, particularly from 7 to 14 days, whereas the subsequent decrease became smaller as curing progressed. This trend can be attributed to the combined effects of continued hydration and swelling of dry bentonite in the soil matrix, cement hydration,

and consolidation under the applied vertical pressure. In the early stage, these processes act more strongly on the initially larger and more connected void network, leading to a relatively rapid reduction in hydraulic conductivity. With time, the SCB matrix becomes denser and more stable, and the rate of reduction decreases. In addition, increasing bentonite content enhanced the sealing of pore spaces and increased the tortuosity of seepage paths, resulting in lower hydraulic conductivity. Even the mix with 5% bentonite and 2% cement satisfied the design requirement, whereas the mix with 10% bentonite exhibited the lowest permeability, with k decreasing from 4.10×10^{-7} cm/s at 7 days to 9.30×10^{-8} cm/s at 28 days. Considering the project requirements and the expected variability of full-scale field production, where quality control is inherently less stringent than under laboratory conditions, the project team selected 7% bentonite and 2% cement as the adopted SCB mix proportion.

The water content was adjusted during mixing to achieve a target slump of 150 to 170 mm for the fresh SCB backfill mixture, ensuring adequate workability for continuous trench backfilling (Section 4.4.2). The resulting water content ranged from approximately 45% to 52% of the dry soil mass.

Table 4. Laboratory hydraulic conductivity (k) of trial SCB mixes versus consolidation time

Mix ID	k (cm/s) at 7 days	k (cm/s) at 14 days	k (cm/s) at 28 days
Mix 1	2.20×10^{-6}	9.70×10^{-7}	6.50×10^{-7}
Mix 2	6.30×10^{-7}	4.70×10^{-7}	2.70×10^{-7}
Mix 3	4.10×10^{-7}	1.10×10^{-7}	9.30×10^{-8}

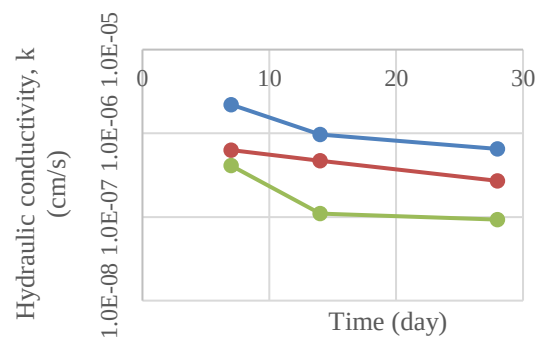


Fig. 3. Variation of hydraulic conductivity of trial SCB mixes with curing time

4.3.2 Trench layout and design parameters

Based on the seepage risk assessment, the cutoff wall was positioned on the downstream side of the

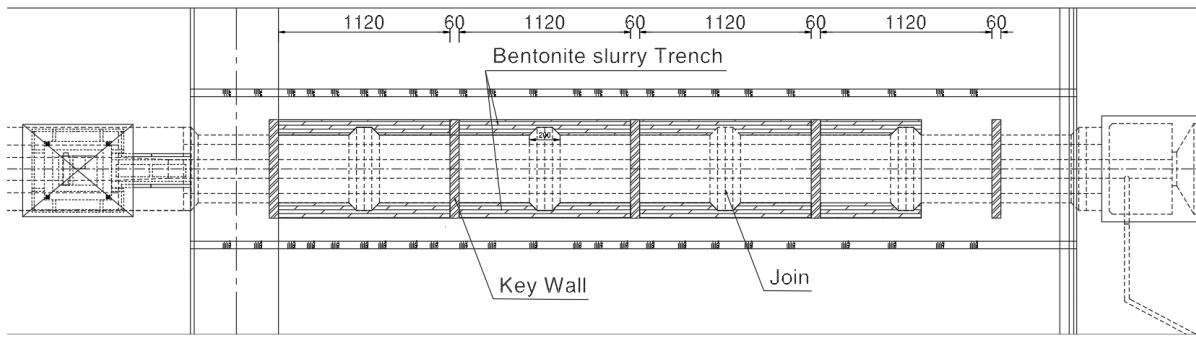


Fig. 5. Plan view of slurry trench

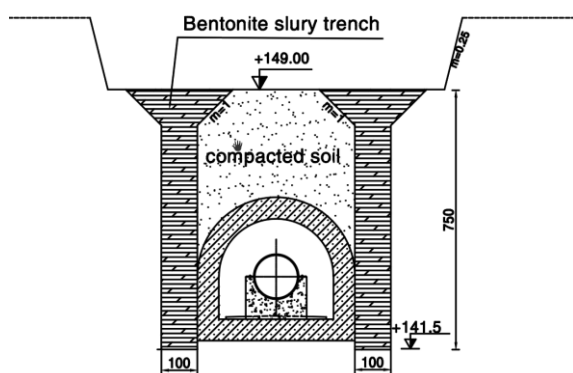


Fig. 6. The section crossing the conduit body

outlet conduit, where higher hydraulic gradients were expected during reservoir operation. The wall was aligned parallel to the conduit axis and extended along the entire section identified for treatment. The upstream end was located approximately one conduit section downstream of the intake tower, and the downstream end terminated two conduit sections upstream of the outlet structure (Fig. 4, 5). This configuration ensured full coverage of the potential seepage zone.

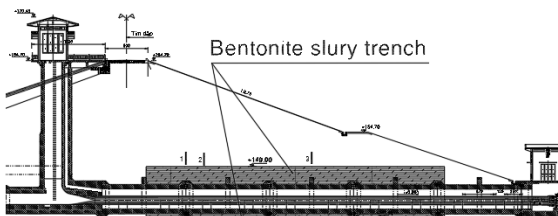


Fig. 4. Longitudinal cross section of slurry trench

At the section crossing the conduit body (Fig. 6), the trench was excavated from elevation +149.0 m down to +141.5 m, providing approximately 0.5 m of embedment into the underlying soil beneath the lower boundary of the defect zone. This depth was

sufficient to ensure vertical continuity of the seepage barrier.

The wall had a design width of 1.0 m, matching the width of the soil zone adjacent to the conduit. Between elevations +148.0 m and +149.0 m, the cross-section was slightly widened to improve contact between the SCB backfill and the overlying compacted embankment soil, enhancing the interface condition in the transition zone.

With this alignment and geometric configuration, the SCB cutoff wall formed a continuous and effective seepage barrier fully compatible with the topographic and structural conditions of the Da Si Dam, while avoiding interference with the existing concrete conduit.

4.4 Construction and quality control of the SCB cutoff wall

4.4.1. Construction

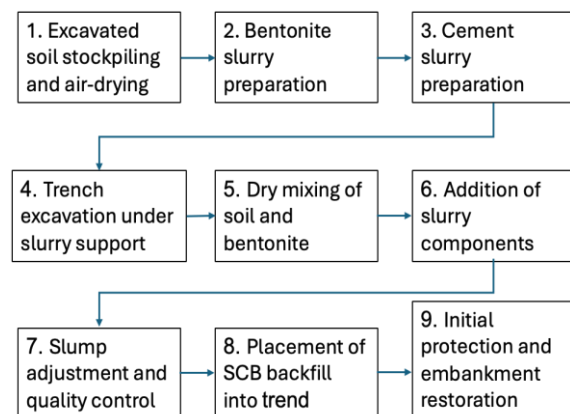


Fig. 7. Block diagram of SCB backfill fabrication and placement procedure.

Construction of the SCB cutoff wall involved trench excavation under slurry support, fabrication of the SCB backfill, placement into the trench, and post-placement protection, as summarized in Fig. 7.

A working corridor approximately 6 m wide was

prepared along the trench alignment to ensure safe and stable operation of excavation and mixing equipment. Excavated soil was stockpiled for reuse. Upon excavation, the soil was transported to a nearby staging area and spread in thin lifts to air dry and reduce its natural moisture content, facilitating efficient blending. Bentonite storage areas and slurry mixing pits were located at least 10 m away from the trench edge to avoid surcharge loading and minimize the risk of trench wall instability during excavation.

The bentonite slurry was prepared by blending 50 kg of dry bentonite per cubic meter of water using a high speed mixer for about 15 minutes, followed by at least 24 hours of hydration with intermittent agitation. Before use, slurry consistency and stability were verified in accordance with API RP 13B-1. The Marsh funnel viscosity ranged from 34 to 40 seconds, and no visible settlement or phase separation was observed during stability checks. Only slurry meeting these acceptance checks was used for trench excavation.

The cement slurry was prepared on site in a high speed colloidal mixer with a batch capacity of approximately 500 L. Clean water was first mixed with the PLACC-02A superplasticizer to ensure uniform dispersion. Portland cement (PCB40) was then added gradually to the water admixture solution at a water to cement ratio of 1.5 (i.e., 150% water by weight of cement) while the mixer operated continuously. Mixing was continued for at least 10 minutes until a smooth and homogeneous slurry was obtained. The cement slurry was discharged and used immediately after mixing.

The trench was excavated continuously within each panel bounded by two key (stop end) walls, with a panel length of 11.2 m, to the design depth under slurry support. The slurry level was maintained at approximately 0.6 m below the ground surface to provide sufficient hydraulic head for trench wall stability while avoiding surface overflow. Excavation and slurry replenishment were performed simultaneously.

Air dried soil from the staging area was transported to the mixing pit (approximately 8 m×4 m×1.5 m) and placed in thin lifts, alternating with layers of dry bentonite according to the predetermined proportions. The material was mixed dry using an excavator until visual inspection confirmed a relatively uniform distribution of bentonite throughout the soil.

After the dry soil-bentonite blend became uniform, the pre-batched cement slurry was added in a single controlled addition at the specified dosage. Bentonite slurry was introduced concurrently and adjusted as needed to regulate workability. In field production, because direct water measurement and

control are inherently less precise than in laboratory mixing, the initial added water (from the slurries) was first kept at approximately 36 to 41% of the dry soil mass to avoid excess water addition. Additional bentonite slurry (i.e., water) was then added incrementally to reach the target workability, with the final total water content typically falling within the laboratory derived range of approximately 45 to 52% of the dry soil mass. The mixture was continuously blended until it appeared uniformly mixed and sufficiently plastic; each adjustment was recorded.

Slump testing was performed in accordance with ASTM C143, and the mixture was released for placement only when the slump fell within the target range of 150 to 170 mm. If the slump was lower, additional bentonite slurry was added; if higher, portions of the dry soil-bentonite mix were incorporated to restore consistency. Once the required workability was achieved, the SCB mixture was immediately placed into the trench.

The prepared SCB mixture was placed into the trench using an excavator bucket lowered close to the bottom or onto the previously placed lift to prevent free-fall discharge that could cause air entrapment or stratification. Backfilling proceeded continuously along the excavation direction to maintain uniformity of the barrier.

After trench backfilling, a 1.5 m thick layer of fine-grained soil was placed over the SCB trench to limit moisture loss, protect the fresh backfill, and provide surcharge loading to accelerate consolidation. This temporary cover was maintained for a minimum of 2 weeks, after which it was removed and the trench crest was trimmed and corrected for any minor settlements. Once the SCB backfill attained adequate short-term stability, the embankment was restored by placing and compacting fill in successive lifts along the trench alignment, integrating the cutoff wall with the surrounding embankment. Subsequent site restoration included grading of the working platform, removal of temporary mixing areas, and disposal of excess excavated soils. Movement of heavy equipment across the trench area was permitted only after completion of embankment restoration.

4.4.2 Quality Control

A comprehensive quality control (QC) program was implemented during construction to verify that the properties of the bentonite and cement slurries, the SCB backfill, and the trench geometry met the project requirements.

For the bentonite slurry used to support trench excavation, testing was conducted twice per shift, once at the mixing pit and once in the trench. QC checks included viscosity, density, and stability.

Viscosity was measured using a Marsh funnel in accordance with API RP 13B-1 and ranged from 34 to 40 seconds. No visible settlement or phase separation was observed during stability checks. Only slurry meeting the acceptance criteria was permitted for use.

For the cement slurry, quality was verified by controlling the water to cement ratio and checking slurry density using a mud balance. Each batch was also inspected visually to confirm uniformity prior to introduction into the mixing pit.

Each batch of SCB backfill (approximately 30 m³) was tested for slump in accordance with ASTM C143, with measured values ranging from 156 to 168 mm, satisfying the target range of 150 to 170 mm. Two field samples were taken per working shift to verify workability and mixture uniformity. QC records documented the number of batches, slump results, and estimated batch volumes based on excavator bucket counts.

Trench depth was measured and recorded for each 11.2 m panel at three locations, namely the start, mid length, and end, and the measured depths remained within the specified tolerance of ± 5 cm.

4.4.3 Field verification of hydraulic performance

To verify the post-construction effectiveness of the SCB cutoff wall, an in-situ permeability testing program was carried out approximately six months after completion of construction. The tests followed the borehole water pouring and water bailing procedure specified in TCVN 8731:2024 for field determination of hydraulic conductivity. This approach is consistent in principle with borehole infiltration and permeameter methods described in ASTM D6391 and with the general field testing framework summarized in ASTM D5126.

Table 5. In-situ Permeability Test Results

BH ID	Segment	Elevation (m)	K (cm/s)
BH1.1	1	148.0 to 145.0	1.85×10^{-6}
BH1.2	2	145.0 to 142.2	1.15×10^{-6}
BH2.1	1	148.0 to 145.2	2.01×10^{-6}
BH2.2	2	145.2 to 142.1	8.93×10^{-7}
BH3.1	1	148.0 to 145.0	1.54×10^{-6}
BH3.2	2	145.0 to 142.3	1.37×10^{-6}
BH4.1	1	148.0 to 145.1	2.25×10^{-6}
BH4.2	2	145.1 to 142.2	3.56×10^{-6}

Four verification boreholes (BH1 to BH4) were drilled adjacent to the cutoff trench, with two boreholes on the left side and two on the right side. The boreholes extended through the full thickness of

the SCB zone to depths of approximately 6 to 7 m. Each borehole was tested in two depth segments, yielding a total of eight test sections. The detailed results are presented in Table 5.

The post-construction in-situ permeability results are presented in Table 5 and Fig. 8. The measured hydraulic conductivity values ranged from 8.93×10^{-7} cm/s to 3.56×10^{-6} cm/s. As shown in Fig. 8, all measured values were lower than the design criterion of $k \leq 1 \times 10^{-5}$ cm/s specified for the embankment–conduit contact zone. The relatively limited variation among the eight test sections also suggests that the constructed SCB cutoff wall formed a hydraulically effective and reasonably uniform low-permeability barrier along the treated conduit-side zone. Overall, the in-situ test results confirm that the cutoff wall achieved the intended hydraulic performance under field conditions.

Since reservoir impoundment and operation, the downstream conduit zone has been regularly inspected, with particular attention to the downstream slope surface above and adjacent to the conduit–embankment contact zone. No signs of seepage, localized wetting, or abnormal moisture have been observed at these inspected locations to date.

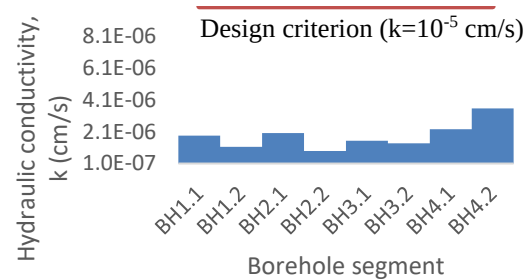


Fig. 8. Comparison of in-situ hydraulic conductivity results with the design criterion

5. RESULTS AND DISCUSSION

5.1 Performance of the SCB Cutoff Wall

The combined laboratory and field results indicate that the adopted SCB cutoff wall satisfied the design objective of seepage control at the conduit–embankment contact zone. The selected mix, containing 7% bentonite and 2% cement, provided low hydraulic conductivity together with adequate workability for trench placement, while the field verification results confirmed that the constructed cutoff wall met the design criterion along the treated conduit-side zone.

A comparison between the laboratory and post-

construction field results shows that the in-situ hydraulic conductivity was generally higher than the values obtained from laboratory specimens of the adopted mix. This difference is expected because laboratory specimens are prepared, mixed, and consolidated under more controlled conditions, whereas field production is subject to greater variability in soil moisture condition, mixing uniformity, slurry addition, trench placement, and local construction disturbances. Nevertheless, the field results remained well within the design requirement, indicating that the selected mix proportion and construction procedure provided sufficient robustness for full-scale application.

The results also highlight the importance of workability control in achieving satisfactory field performance. In this project, the target slump range of 150–170 mm allowed the SCB mixture to be placed continuously into the trench while maintaining adequate plasticity and reducing the risk of segregation or hydraulic discontinuity. Together with the control of bentonite slurry properties and trench geometry, this contributed to the formation of a reasonably uniform low-permeability barrier along the conduit-side contact zone.

From an engineering perspective, the Da Si case shows that the effectiveness of the SCB cutoff wall did not depend solely on achieving very low laboratory permeability, but also on selecting a mix and construction procedure that could be implemented reliably under field conditions. In this sense, the adopted SCB cutoff wall provided a practical balance between hydraulic performance, constructability, and quality control, which is critical for seepage remediation at narrow and difficult soil–structure contact zones.

5.2 Lessons Learned

The design and construction of the SCB cutoff wall at Da Si Dam provided several lessons applicable to seepage remediation at interfaces between the conduit and the embankment. A key lesson is that accurately identifying the preferential seepage path and the extent of the defective zone is essential for selecting an appropriate treatment method. In this case, site investigation, construction-stage quality verification, and post-construction hydraulic measurements supported the decision to adopt an SCB cutoff wall rather than more localized remedial measures.

The project also highlighted the suitability of SCB materials for contact zones between compacted earthfill and adjacent concrete structures. The swell sealing behavior typical of bentonite based barriers, combined with the added stability provided by a

small cement content, enabled the backfill to accommodate minor deformations and reduce the likelihood of voids or weak planes developing along the soil concrete interface. In addition, trench geometry and working space proved decisive for constructability. The limited corridor along the conduit made large-scale or rigid construction methods impractical, whereas a 1.0 m wide slurry supported trench, matching the key wall spacing adopted in the design, was technically efficient and logistically feasible.

Finally, the project confirmed that rigorous field quality control is critical to achieving uniformity and long-term performance.

6. CONCLUSION

This paper presented a detailed case study on the design, construction, and verification of a SCB cutoff wall for remediation of concentrated seepage at the conduit embankment interface of Da Si Dam. Laboratory trial tests conducted during mix design and post-construction in-situ verification tests showed that the adopted SCB trench provided a continuous low permeability barrier and satisfied the design criterion for the contact zone.

The use of locally available materials, including Vietnamese bentonite and a small cement content, proved technically effective and practical for field implementation. During construction, the SCB mixture achieved stable workability, with slump consistently controlled within the specified range, enabling homogeneous mixing and continuous placement. Post-construction measurements and subsequent field inspections during reservoir operation indicated sustained low permeability performance under operational conditions. These results demonstrate that an SCB cutoff trench is a reliable and adaptable seepage-control measure for earthfill dams where concrete conduits create potential preferential seepage paths and construction access is limited.

The Da Si case highlights the importance of accurate identification of seepage pathways, appropriate trench geometry, and rigorous quality control in achieving reliable field performance. Overall, it provides field-based evidence and practical experience supporting the application of SCB cutoff technology to conduit–embankment contact zones, which remain relatively underreported in the literature.

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