C.R. Coll. Int. Renforcement des Sols. Paris 1979.

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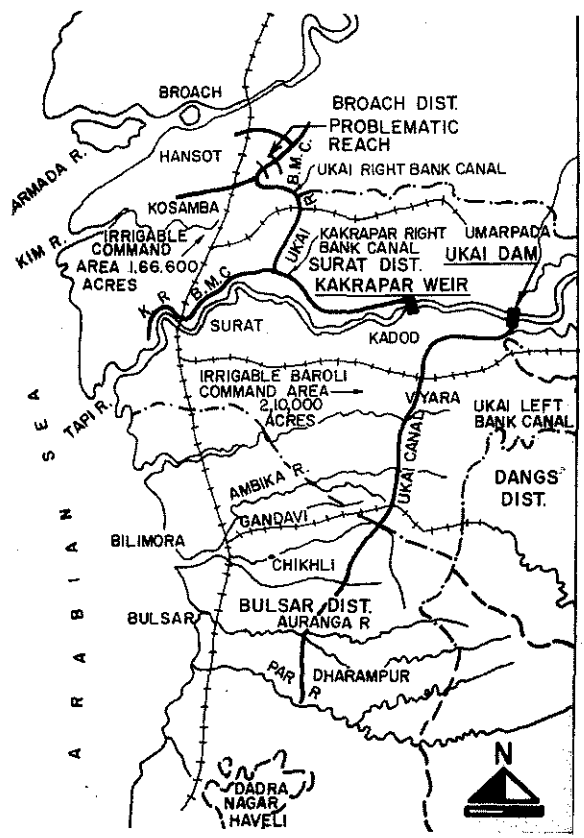
Use of reinforced earth walls in canals

Utilisation de murs en terre armée pour des canaux

Dans le plan d'aménagement du barrage Makrapan, le canal principal de la rive droite du fleuve UKAI voit sa capacité réduite de 45 m/3/s à 22,6 m/3/s sur un parcours d'environ 35 km. La stabilité des pentes de ce canal qui a une profondeur de 12 m a posé d'importants problèmes. Des études de stabilité ont été refaites à la suite d'un grand glissement de près de 71 m à partir du centre du canal survenu en mai 1976. En outre de petits glissements continuent de se produire. La coupe du sol de cette région montre une superposition de couches d'argiles silteux et de sable silteux.
Jusqu'à présent les mesures prises consistent essentiellement en une élévation du lit du canal, un élargissement de sa largeur avec des pieux entretoisés, des contreforts en pierre pour maintenir la stabilité.
Cet article montre les avantages techniques et économiques de l'utilisation de renforcements de sol pour stabiliser la rive droite d'UKAI.

GENERAL

Kakrapar weir scheme in Gujarat has the Ukai right bank main canal offtaking from Kakrapar right bank canal as shown in Figure 1. Design for the canal is made for 45 cumecs at its head and after its run for a distance of 35 km. Kosamba branch offtakes from this canal and the capacity gets reduced to 22.6 cumecs. Typical problem of stability of slopes for this canal was noted in its range from 35.06 km. to 37.65 km. wherein the canal has a maximum depth of cutting of 12 m. The dimensions of the canal for this reach reveal bed width of 8m. and initial side slopes of 2:1 changing to 1.5 : 1 above the berm. Canal gradient is 1:6000 with n = 0.0225 and full supply depth of 2.8m. Borchole details at the site revealed top 1.5m. black layer of silty clay, layers of silty sands, silty clays and sandy silts. Typical details for the site bore hole are shown in Figure 2 and the shear characteristics of a few selected soil samples are given in Table I.



OCCURANCE OF SLIPS

In 1972 when the work started for the canal it was observed that soils met with at the site are quite heterogenous. When the excavation programme was undertaken for this canal in July 1972, horizental cracks

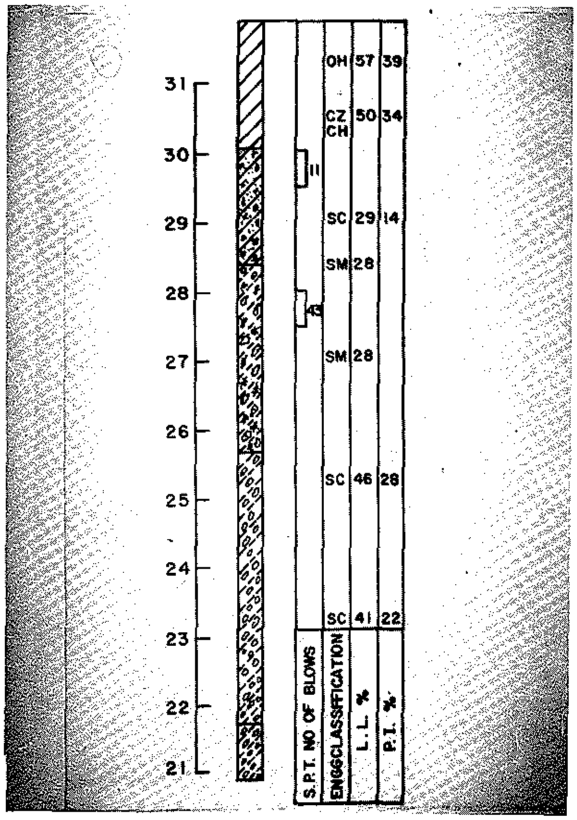


Figure 2 Typical Bore Hole Details

Figure 3 L.H.S. Slip at 37.50 km.

TABLE - I

SHEAR PARAMETERS OF TYPICAL SOIL SAMPLES

Serial No.	Lab.No.	Chainage Km	Depth m	Visual classification	Cohesion kg/cm^2	Friction Angle
1	674	36.33	0.33	Blakish top soil	0.04	23°
2	680	36.33	2.00	Yellow sand with clay	0.04	31°
3	757	36.33	3.30	Ash coloured silt-clay	0.22	19°
4	763	37.14	2.25	Moist clay-sand with Kankar	0.22	18°

were observed at number of places. Failure patterns for the slopes in this reach of the canal as observed on 21st July 1972 are shown in Figures 3-5. Canal section details before and after the formation of the slip are shown in Figure 6.

Public Works Department engineers jointly with the consultants to the Department carried out detailed investigations in this problematic reach of the canal for the stability of slopes. While undertaking the remedial measures on trial basis with performance checks, a major slip occured on 12th May 1976 between 36.61 km and 37.00 km reach of the canal wherein the edge of slip was observed at a distance of about 71m from the centre line of the canal and extending right upto the spoil bank as shown in Figure 7-8.

Detailed investigations carried for the problematic stretch of the canal revealed that severe fissurisation and loss of shear strength under hydrostatic pressures or on partial drying due to time lag in construction programme seem to have contributed for the formation of slips. Failure arising out of strain incompatibility between the different horizons of the soil profile with similar characteristics have also been experienced for the power channel of Laktak Hydel Project as well as for the power channel of Rishikesh Hardwar Hydro-electric scheme (1, 1976).

Additional points which deserve attention in analysing the formation of the slips will now be presented. The initial slopes adopted for the construction work of the canal can be considered as steep as the final slopes observed after the formation of slip were of the order of 4:1 to 5:1.

Figure 4 R.H.S. Slip at 37.50 Km

Figure 5 Typical Slip Characteristics at 37.20 Km.

Excavated material dumped in the spoil banks very near to the top of the slopes further aided in actuation of slips. Fissured clay on exposure lost its strength and thereby increased the instability of slopes.

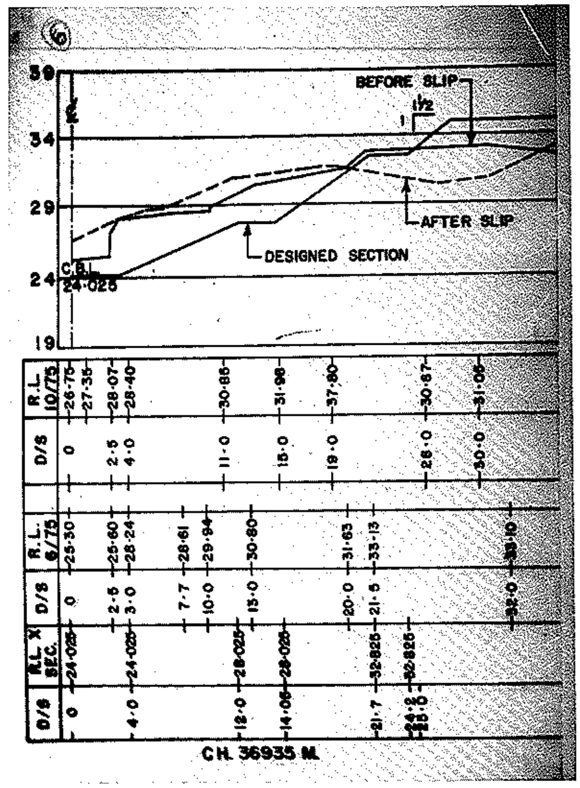


Figure 6 Canal Section Modification

Presence of rain cuts were noticed during the inspection and this might have helped initiating the formation of the slips. These observations revealed very many factors to have contributed collectively for the formation of slips for the Ukai right bank main canal.

ANALYSIS

The study of the investigations carried out for the failure mechanism of the slips revealed overstraining of fissured clays and additional strains to superimposing layers resulting into failures characterised by vertical tension cracks accompanied with horizontal movements leading to formation of circular slips of the canal slopes. To improve upon the performance the remedial measures considered for the problem were:

(i) Widening the bed of the canal and raising the canal bed.

(ii) Easing considerably the canal slope

(iii) Stabilising the slope by horizontal sand drains.

(iv) Adopting counterfor drain system

(v) Providing counterfort walls

(vi) Using under-reamed sand piles

(vii) Providing R.C.C. piles with bracing system

(viii) Designing R.C.C. trough for the canal.

Figure 7 Major Slip L.H.S. Front View at 37.20 km.

Figure 8 Major Slip Bank Details at 36.90 km.

Examination of these remedial measures reveal that a few of these measures are prohibitive on consideration of the costs while others when adopted on trial basis could not come up to the expectations in their performance. For instance, the first measure of widening the bed of the canal and raising the canal bed may not meet with the functional requirements. Considerable easing of the slopes of the canal from 2:1 to 5:1 was not desirable since the weaker layers below were already overstrained and had undergone the loss in strength. Attempts were made on trial basis to stabilise the canal slopes by adopting horizontal sand drains but the performance could not show significant improvement. Keeping in view the operational aspects, involved in the counterfort drain system, this measure was not undertaken for the trial run of the canal.

Of the remaining four alternatives, the proposition of providing R.C.C. trough to get permanent solution for the canal slope stability was examined and the details of the same are finalised for its possible implementation in a short stretch of the problematic reach of the canal.

REINFORCED EARTH WALLS

For the Ukai right bank canal in its problematic reach where the soils have been observed as heterogeneous and looking to its characteristics the foundation conditions can well be considered as poor in accepting the solution of R.C.C. trough for the canal, it was considered desirable to adopt reinforced earth walls for the canal to achieve the stability (2,1975). As necessitated at the site a dewatering system can also be established to make the area dry and operative for the construction programme of reinforced earth walls for this canal.

The present proposition hence consists of providing on both the banks of the canal reinforced earth walls with water proofing linings for the problematic reach extending from 35.06 km to 37.65 km of the Ukai right bank canal. An appropriate drainage system can also be provided to relieve the hydrostatic pressures for these reinforced earth walls. Figure 9 reveals the section for the reinforced earth walls to be adopted for the canal. Details for an optimal design are worked out taking into consideration the soils met with on the canal banks for steel plate sizes and their spacings (3,1977). This project when visualised with the proposition of reinforced earth walls on both the banks of the canal help reducing the expenditure.

Hence for the canal in its problematic reach a trial stretch is being considered with reinforced earth walls on both the banks and this will be fully instrumented

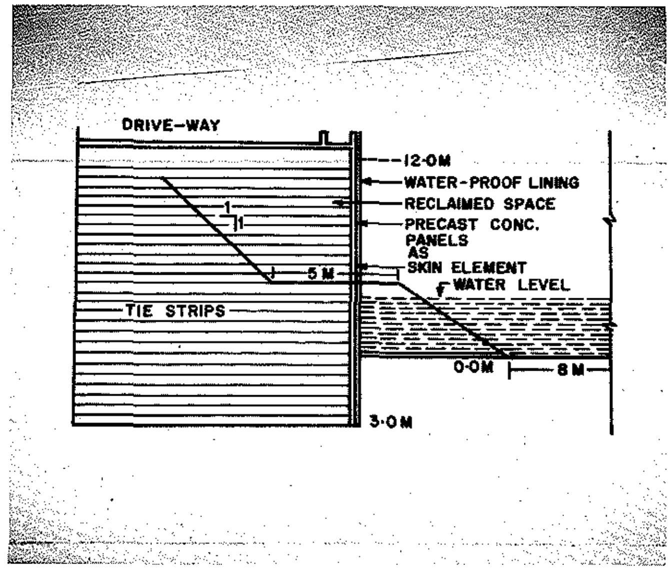


Figure 9 Proposed Soil Reinforcing System

to obtain data for comparing with the analysis. A trial study will help checking the performance and revising the design if necessary prior to its final adoption for the complete stretch of the problematic reach of the canal.

CONCLUSION

The study based on the flow characteristics of the Ukai river bank main canal and also the Geotechnical data of the region in the problematic stretch between 35.06 km to 37.65 km reveal the proposition of having reinforced earth walls on both the banks of the canal to deal appropriately the stability requirements and such a proposition further helps reducing the cost of the project. A trial stretch in the problematic reach with full instrumentation will help checking the performance of the proposed system.

REFERENCES

1 INSPECTION REPORT (1976), Slope Failure of Ukai Right Bank Canal, Central Water Commission, New Delhi.

2 GENDNEY, DAVID S. and Mc KITTRICK, DAVID P.; (1975), Reinforced Earth : A New Alternative for Earth Retention Structures; Civil Engineering, A.S.C.E., Vol.45, No.10, pp. 58-61.

3 SONPAL, R.C. (1977) Engineering Aspects Related to Sabarmati River Bank Structures, Speciality Session, II/8, IX International Conference on Soil Mechanics and Foundation Engineering, Tokyo, Japan, pp. 201-214.