Construction of embankments and retaining walls on black cotton soil deposits using geosynthetics

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ABSTRACT: Construction of embankments and retaining walls often pose problems for engineers over weak soft soils. The paper describes some of the case histories and construction highlights of the Geosynthetic reinforced structures constructed in Southern India over the last two decades on black cotton soil.

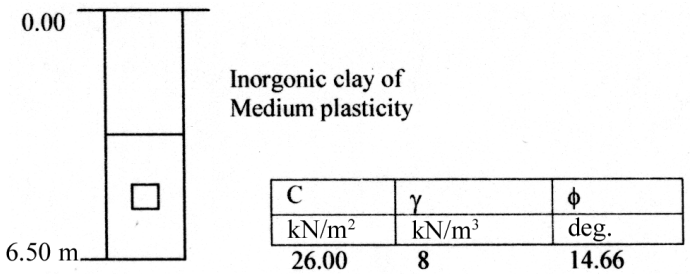
1 INTRODUCTION

Nearly half of the Indian subcontinent consists of black cotton soils occurring as residual soils in central India and transported soils in the coastal belt. The structures in this region are subjected to high swelling due to the presence of montmorillonite. Over the last two decades geosynthetic reinforced structures have been constructed in many parts of Andhra Pradesh in South India in the form of Geocell for foundation Improvement and Geogrid reinforced soil walls. This paper describes the highlights of these structures.

2 EMBANKMENT IN BRIDGE APPROACHES ON BHIMAVARAM – LOSARI ROAD

A foot-bridge was to be constructed across a 100 m drain in the Bhimavaram Town of West Godavari Dist. Andhra Pradesh and approaches on one side run parallel to the drain i.e., the approach takes a 90^0 bend. The existing road was at low level and a canal was running parallel to the road on other side. The road was to be raised by 2.50 m. already constructed gravity/RCC walls on pile foundations were existing upto present road level both on drain side and canal side. The existing road width was only 4 m and the same was to be widened to maximum extent for easy flow of traffic duly encroaching to the maximum extent in to canal. The existing wall on canal side cannot be extended for raised height. The bearing capacity of soil was only 80 kPa where as the bearing pressure on soil with conventional wall was calculated 110 kPa for a base width requirement of 3.90 m. The soil profile is shown in Figure 1. The geosynthetics soil reinforced wall was worked out to be economical and most amenable solution for the site conditions. The site plan and typical arrangement of the wall is shown in Figures 2, 3 and 4. As bearing capacity was not a major problem the reinforced soil wall was founded on a well-compacted granular base reinforced with a biaxial geogrid.

The work was completed in the year 1999 and the structure is behaving satisfactorily.



C	γ	ϕ
kN/m²	kN/m³	deg.
26.00	8	14.66

Figure 1. Typical Soil profile at Bhimavaram-Losari Road

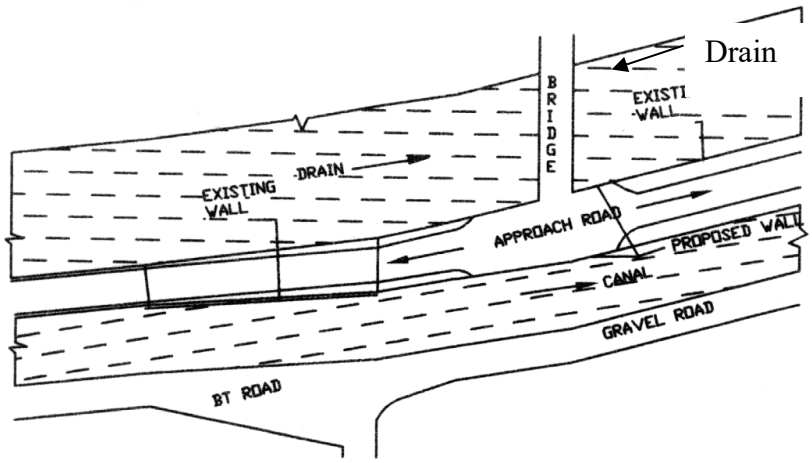


Figure 2. Site plan of foot bridge approach at Bhimavaram – Losari Road

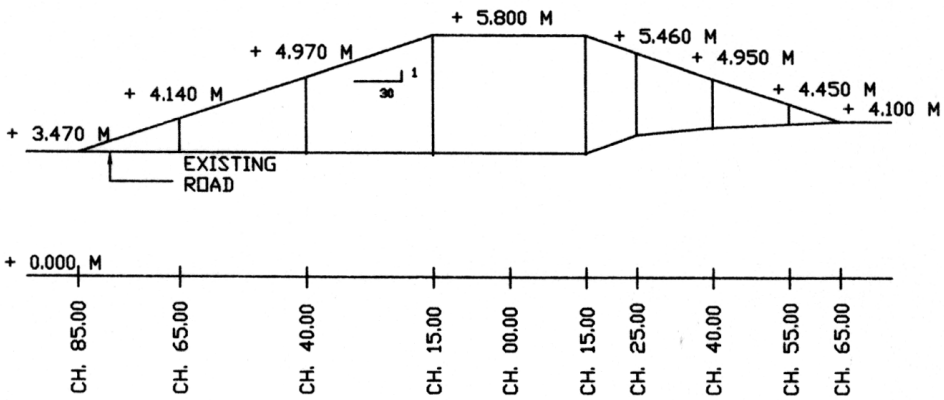


Figure 3. Longitudinal section of geosynthetic reinforced soil wall

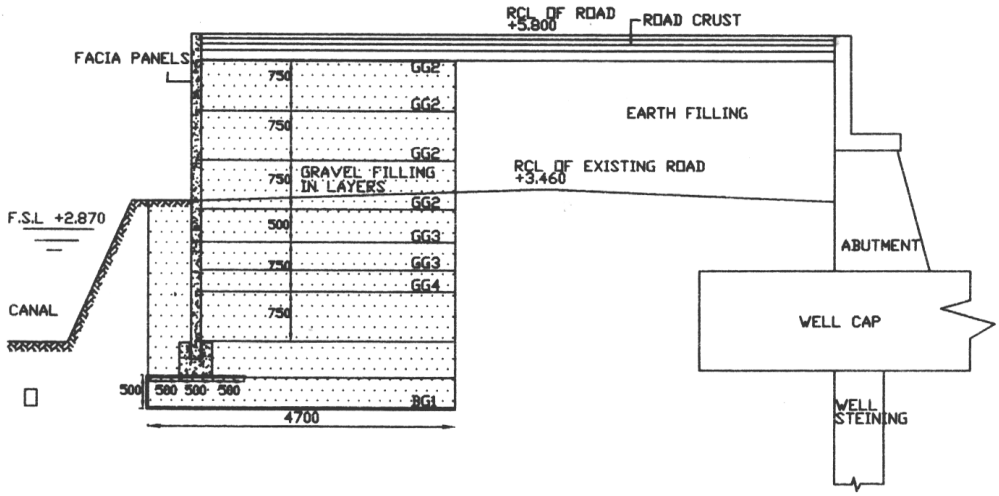


Figure 4. Sectional view of geosynthetics reinforced soil wall at Bhimavaram – Losari road

3 GEOSYNTHETIC REINFORCED SOIL WALL AT VIJAYAWADA

A road portion in Vijayawada Municipal Limits of NH-9 in Andhra Pradesh collapsed due the failure of the retaining wall on the canal side (Krishna Eastern Main Canal). An immediate part restoration of the slipped carriageway was done using sand bags. Despite this the road width in this extremely busy commercial area got reduced and called for immediate restoration.

3.1 Sub-soil profile

Four numbers of boreholes were drilled in the canal bed up to a depth of 15 m. The geotechnical investigations revealed the following soil profile : the soil in the top 2 m was clay (CH or CI type) and was

very soft. Beyond this depth, the soil was generally CI and sometimes CH, but in between there were alternate layers of sand (SM). In one of the bore holes, the soil appeared to be improving with depth and the field dry unit weight was about 13.73 kN/m^3 and value of undrained cohesion was 30 kPa, at a depth of around 6 m. Even below a depth of 9 m, up to 15 m depth the soil was clayey.

3.2 Design philosophy

The road carriageway level was +21.860 m. The full supply level of the Canal was +17.220 m and the canal bed level was +12.360 m, hence the required height of the retaining structure above the canal bed level was 8.5 m. With a wall height of 8.5 m above the canal bed level, and a 2 m thick soft soil near the canal bed, a gravity wall was not feasible. Pile foundations need to be at least 15 to 20 m deep and hence were likely to be prohibitively expensive. Also, previous construction using under-reamed pile foundations was not encouraging. In addition, the road was located in a busy commercial area; there was little space available for conventional construction. Further the major work of foundation and as well as wall up to full supply level was necessarily to be constructed during the 30 days closure of the canal. Keeping the above in view, the best solution thought was to be geosynthetics reinforced soil wall with stone filled basal mattress. The detailed design has been carried out using BS 8006 (1995) and AASHTO (1998) and the overall principles of geotechnical engineering. A sectional view of geosynthetic reinforced soil wall with basal mattress is shown in Figure 5.

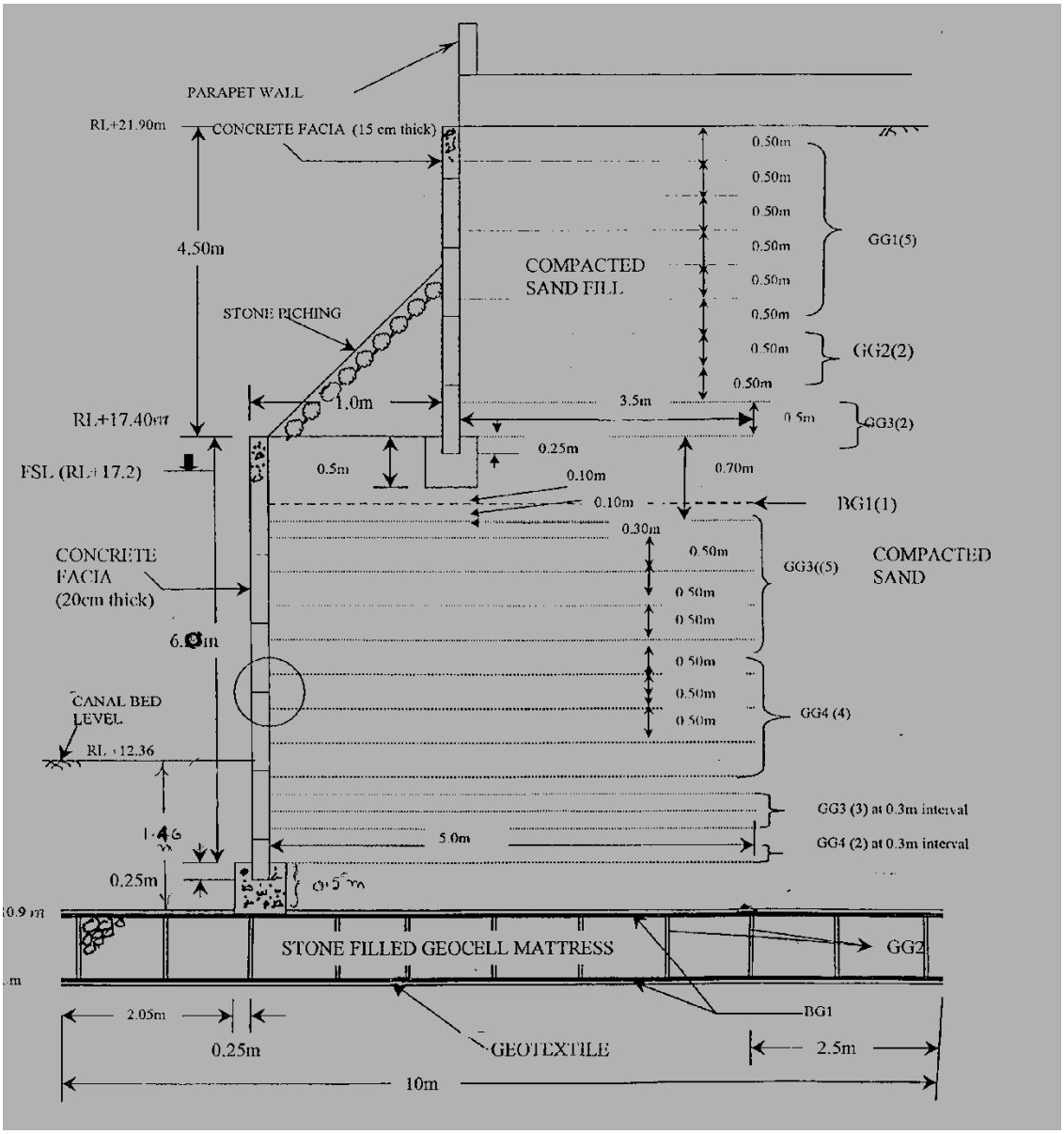


Figure 5. Sectional view of geosynthetics reinforced soil wall with basal mattress.

It consisted of 1 m thick basal mattress formed 1.4 m below the bed level of the canal. Over this the first tier of the wall was 6.5 m high the top of which was 1 m above the FSL of the canal. The second tier was

then constructed with an offset of 1.5 m and was 4.5 m high. The work began in summer of 2002 (when the canal was partially closed). Figure 6 shows a view of the wall under construction. The overall length of the wall constructed was 400 m, completed in 2004. Figure 7 depicts a view in the year 2014.

Figure 6. The wall under construction

Figure 7. A view of the completed wall adjoining the canal

4 GEOSYNTHETIC REINFORCED SOIL WALL AT MARTAIR-PRAKKILANKA ROAD

4.1 General

The Martair - Prakkilanka road in West Godavari District., Andhra Pradesh was running parallel to an irrigation canal and because of poor nature of soil under the pavement and unstable slopes, bank erosion was taking place and carriageway of the pavement got damaged (Figure 8). To safeguard the pavement and prevent bank erosion and widen the formation of road, a retaining wall was proposed. Under the given soil conditions reinforced soil retaining wall with stone filled basal mattress was adopted (Figure 9). The salient features are given below and final wall section is shown in Figure 10. Figures 11 and 12 show the views of the wall just after construction in 2000 and again in 2016.

Figure 8. The canal road under severe distress

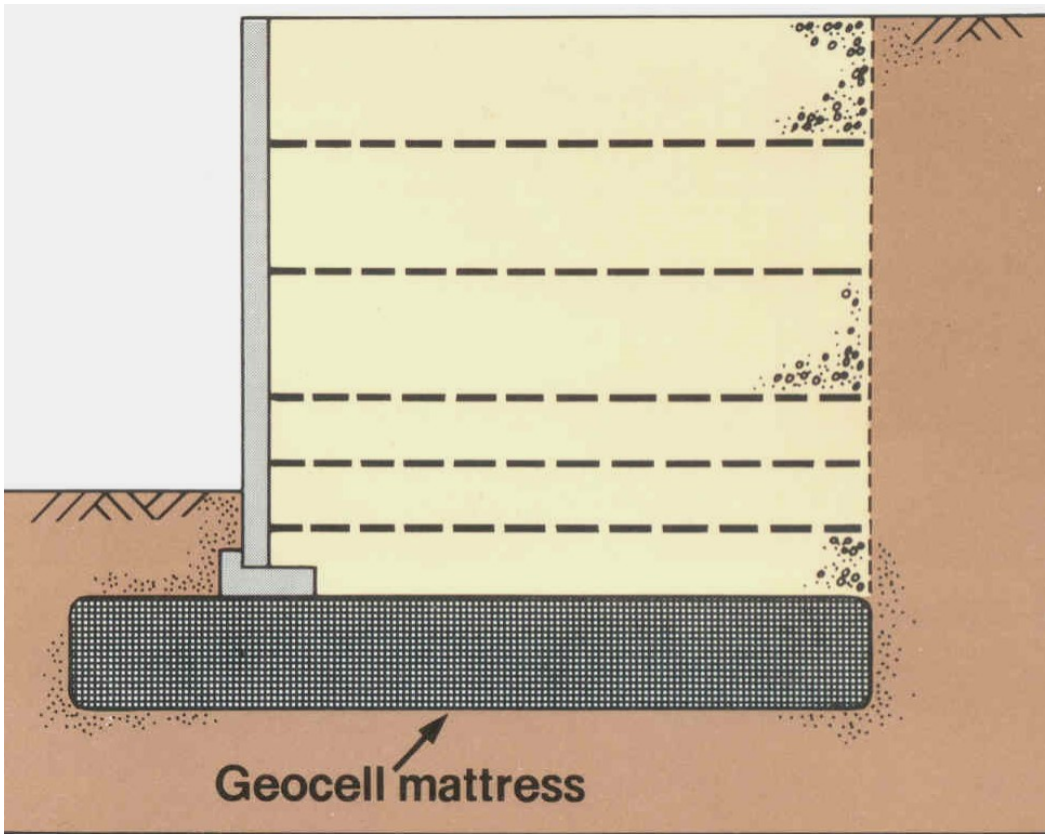


Figure 9. The solution adopted

4.2 Geogrid reinforced soil wall details

Length	Total 450 m in stretches varying from 25 m to 75 m
Height	3.4 m to 4.2 m
Allowable bearing capacity	50 kN/sqm
Fill material	Gravel
Foundation	Geocell filled with stone
Reinforcement	Uniaxial geogrids
Facia Panel	150 mm M20 grade RCC panel 1.4 m x 1.8 m

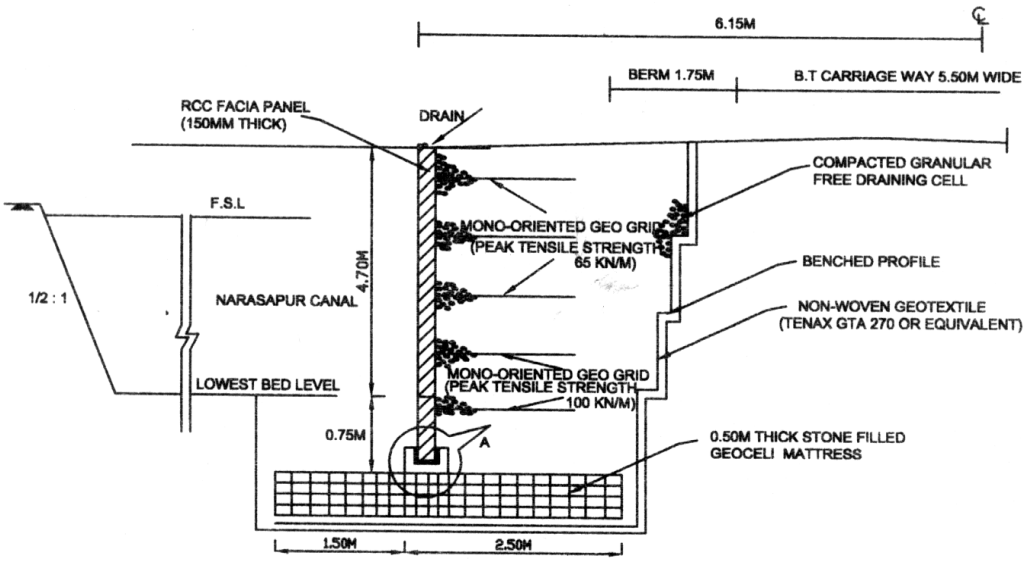


Figure 10. Typical cross section of retaining wall at Martair-Prakkilanka road

Figure 11. The Wall just after completion

Figure 12. The wall in the year 2016, adjacent to the canal

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