Case study

GEO-ENVIRO ENGINEERS

USE OF PRE-FABRICTED VERTICAL DRAINS (PVD) IN EMBANKMENT CONSTRUCTION OVER SOFT CLAY

INTRODUCTION

High embankment construction over weak saturated clays and silts requires some form of ground improvement to speed up construction and to avoid failure. Without strengthening the ground these soils do not have the strength to support such embankments by itself. Long periods are required for their construction without such initial strengthening and even if possible long term post construction settlement and or failure are common in such cases. Ground improvement using Prefabricated Vertical Drains (PVD) or Band drains has been found to be one of the most cost-effective solutions for such ground improvement. The case study of high embankment construction included here illustrates successful completion of a project saving considerable time and cost.

RAILWAY EMBANKMENT

Additional land had to be reclaimed from the sea at Ennore, Tamil Nadu to construct new railway lines. The area reclaimed was approximately 45m wide and about 1000m long. Earth fill embankment had to be constructed over the land thus reclaimed to a height of 4m before the additional railway lines could be constructed

SUBSOIL CONDITION

Within the reclamation area very soft marine clay existed from the creek bed level to depths varying from 10m to max.15m. Below the very soft clay, stiff clay up to depth more than 20m was present. The very soft marine clay had very low shear strength not exceeding 20 kN/m2 classified as highly compressible CH soil with high moisture content.

PREFABRICATED VERTICAL DRAINS (PVD)

Since the very soft clay extended to large depths, it was not possible to construct the embankment within a reasonable period without ground improvement. After careful consideration of several methods, the method finally chosen was to install PVD and construct the embankment in two stages.

Pre-fabricated vertical drains were installed up to the full depth of the soft clay at design spacing 1.25m c/c over the entire area of reclamation to accelerate the consolidation of the soft marine clay under imposed load.

The PVD was installed with a hydraulic drain stitcher and steel mandrel using constant rate of penetration. Maximum depth of installation was 17m below the reclamation level.

EMBANKMENT CONSTRUCTION

As the underlying very soft marine clay had low bearing capacity, it was clear that the embankment construction could only be carried out in two stages. Minimum U=70% degree of consolidation was necessary at the end of stage-1 construction to support the stage-2 embankment. The period required to achieve this consolidation under stage-1 with PVD was predicted to be 4-5 months. Without PVD this would have taken more than a year to achieve. Accordingly the embankment was constructed in 2m lifts for each stage of construction after PVD installation.

A sand drainage blanket approx 300mm thick was placed on top of the installed PVD to allow free drainage of expelled pore water from the band drains. A non-woven geotextile filter fabric was provided over the sand drainage blanket to prevent any contamination of the sand drainage blanket from the earth fill during embankment construction.

GEOTECHNICAL INSTRUMENTATION

The progress of clay consolidation was monitored by settlement observations using platform type settlement gauges. The settlement observations are presented in

settlement-time plot in FIG.1. SG-14 represents the gauge at the deepest marine clay layer at the marine end of the embankment, SG-9 at about the middle and SG- 1 close to landward end.

ANALYSIS OF SETTLEMENT DATA

Degree of Consolidation achieved at site was determined employing the method proposed by Asaoka (1978) based on observed settlement. The Degree of Consolidation–time plot is included in FIG.2. FIG.2 also shows the predicted consolidation of soft clay layer without PVD considering only vertical drainage. The plot clearly demonstrates the importance of PVD in reducing consolidation period in such cases.

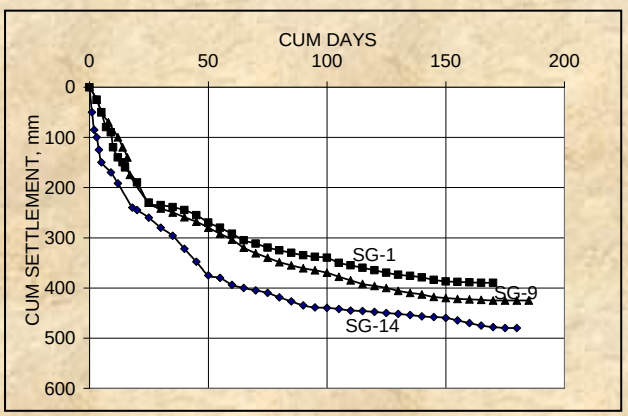

Fig. 1. Observed Settlement Record

It may be noted that the required degree of consolidation (U=70%) was actually obtained under stage-1 embankment within less than 2 months instead of 4-5 months as predicted. It may be seen readily that allowing only vertical drainage (without PVD) it would have taken several years to achieve this consolidation. Thus it may be readily seen that taking advantage of the faster radial flow and shorter drainage paths in the case of PVD, consolidation period can be considerably reduced.

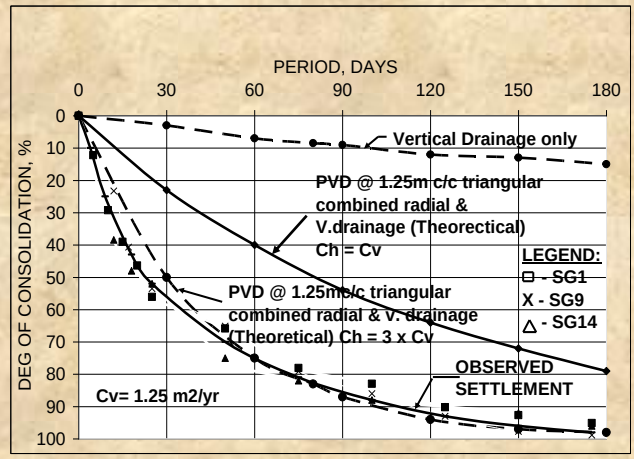

Fig. 2 Deg of Consolidation Vs Time

CONCLUSIONS

The construction of a 4m high railway embankment on land reclaimed over very soft clay 15m deep was achieved satisfactorily within a short period of time by installing prefabricated vertical drains (PVD) and adopting a two stage construction procedure. Due to the urgency for the completion of the new railway line, embankment construction had to proceed immediately after land reclamation and had to be completed within the shortest period possible. Without ground improvement it was not possible to achieve this as the clay deposits were deep and in very soft and compressible condition.

(Work carried out under Bharat Geosystems Pvt Ltd)

Refeference: Radhakrishnan, R & Suriyanarayanan, N.S, 'Embankment Construction over Reclaimed Land Using Pre-Fabricated Vertical Drains. IGC (2010), Mumbai.

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