Design of container yards paving using geocells

Suraj Vedpathak, Yashodeep Patil, Gautam Dalmia & Shahrokh Bagli
Strata Geosystems (India) Pvt. Ltd., India

ABSTRACT: The Authors present a case study of a container yard near Kidderpore Docks, Kolkata, India on the banks of the Hooghly River. The surface stratum comprises of ±3m thick fill, construction debris in clay matrix with significant voids. This is underlain by soft marine clay. Standard loaded containers will be placed maximum four-high in close clusters. To effectively reduce imposed pressures at the fill and subsoil levels, two layers of HDPE geocells, two layers of rigid biaxial PP geogrids and nonwoven geotextiles have been judiciously designed and placed, along with concrete paver blocks at the surface.
By avoiding the conventional layer of dense lean concrete, there is considerable savings in capital costs and construction time. The proposed cross section of the paving system also minimises differential settlement besides reducing imposed bearing pressures. With this system, the maintenance cycle is extended which not only reduces downtime, but also life cycle costs.

Keywords: Reclaimed area, HDPE geocells, biaxial geogrids, nonwoven geotextiles, paver blocks, load spread

1 INTRODUCTION

With increase in maritime container cargo traffic, there is a need for increased capacity for container transit storages at existing ports. With ports invariably required in marine and riverine environments, container terminals are located on land reclaimed from mudflats of rivers, sea and estuaries. Owing to geographical and environmental constraints, suitable material is not available for such reclamations. Besides, the natural deposits would be weak. Weak founding sub-strata invariably pose a challenge to developing container yards alongside ports. Several ground improvement techniques have been used in the past which change the mechanical characteristics of the subsoil strata.

Yet another method to support heavy loads over weak soils is to distribute the imposed pressures to an extent that these pressures can be borne by the subsurface safely and without deformations that could cause distress to the systems being supported. This can be achieved by judicious use of geosynthetics.

2 THE OVERVIEW

All Cargo Logistics Ltd. has set up a logistic park in the Kolkata Port area, comprising essentially of a container yard. Figure 1. shows the site location. Besides minor light structures, the container yard area provides for container stacks four high, arranged in blocks over the subgrade. The subgrade also supports stackers operating adjacent to the container stacks.

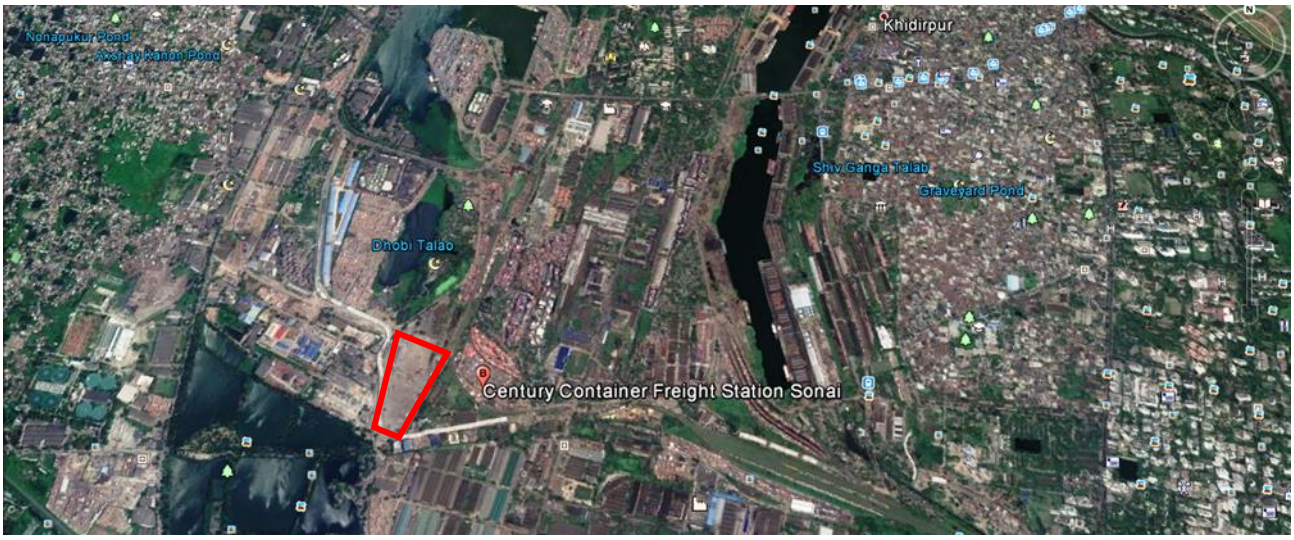

Figure 1(a). Site location (marked red) at Kidderpore Dock

Figure 1(b). The Site

The area is low lying and in a congested locality near Kidderpore Dock. The subsoil includes 7 to 8m of riverine deposits of very soft to soft clay, topped by about 3m of heterogeneous fill (See Figure 2).

Figure 2. Original Ground Condition (Heterogeneous Fill)

3 THE PROBLEM

The primary concern was adequacy of bearing capacity for the heavy container loads. It was essential to either improve the safe bearing capacity, or ensure that the imposed bearing pressures are low enough to be sustained by the subsoil strata. Under container loads, non-uniform settlements were yet another concern to be addressed.

The conventional solution considered by the Client and Consultant was to install prefabricated vertical drains, or PVDs. The process of ground consolidation with PVDs requires surcharging, which requires

large quantities of earthwork to achieve the final load. In order to develop the safe bearing capacity, this surcharging would have to be carried out stage-wise to ensure that the bearing capacity progressively developed adequately to take the next load of surcharge. This is a slow process requiring, close monitoring of settlements and sub-soil pore water pressures. However the Client did proceed with PVDs for the lightly loaded two storied structures.

In the container stack-yard, the loads are heavier considering various loading combinations of sustained container stacks and intermittent stackers. While PVDs with appropriate surcharge would have improved the safe bearing capacities, for the stacking area, PVDs required wasteful surcharging equivalent to the anticipated container stack loads. For 90% consolidation, the time required with PVDs was estimated at five months only. However, for the stack yard, the magnitude of surcharge, time involved for stage-wise retaining of surcharge to develop the required bearing capacities, cost of earthworks and its redundancy after surcharging, was a daunting thought and not practical.

4 THE ANALYSIS

In view of the negatives out-weighing the pros of the PVD process, the Consultant approached Strata for an innovative solution. Strata carried out a detailed analysis, considering worst case scenarios for loading, and due deliberation on settlements. The Strata solution incorporated StrataWeb® geocells using the guidelines of the INTERPAVE Manual (1).

It was thought prudent to judiciously place the geocells within the paving to reduce the bearing pressures onto the subgrade by effectively spreading the imposed loads over a larger area. This provided a leaner design for the pavement section. The load-spread attribute provided yet another advantage. With the limited thickness of the consolidating stratum, settlement under sustained load is reduced. As a consequence, differential settlements would be within acceptable limits.

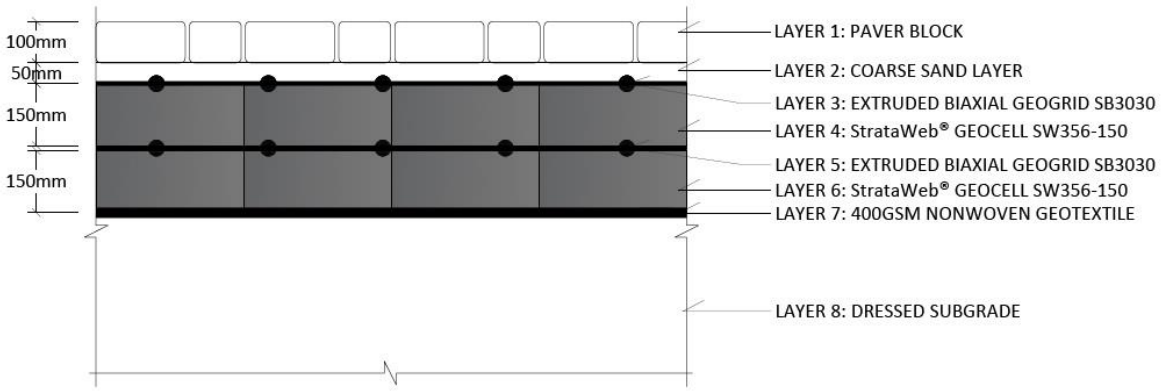

Figure 3. Section adopted

The section illustrated in Figure 3. is designed to consider the worst case scenarios of four-stack high containers and stackers. Top down, the system comprises:

I Concrete paver blocks of thickness 100mm;
II Sand 50mm thick;
III Rigid biaxial geogrid placed at the base of the sand layer and atop infilled geocell;
IV Geocells infilled with 10mm down gravel, of height 150mm;
V Rigid biaxial geogrid placed between the two geocells within gravel;
VI Geocells infilled with 10mm down gravel, of height 150mm;
VII 400GSM PET / PP nonwoven geotextile.

Analyses showed that imposed pressures with the section proposed in Figure 3, using StrataWeb® SW356-150mm are well within the safe bearing capacity. Two layers of geocells were found necessary for adequate load spread. Vertical deformations for sections with geocells are also less than those for a conventional section.

The soft consistency of the top fill required laying a nonwoven geotextile as a separation layer before placing lowest layer of geocells. Considering the paucity of material qualifying as “Wet Mix Macadam” (WMM) in the region, 10mm down-graded gravel was used as infill as well as topping for the geocells. Construction sequence of the geocells is shown in Figure 4. Visual inspection has been carried out after

one year to evaluate the performance of the geocells. Figure 5 shows no distress indicating overall good performance of the section.

Figure 4(a). Dressed fill surface

Figure 4(b). First layer of geocells laid over nonwoven

Figure 4(c). Infilling of geocells

Figure 4(d). Completed paving with geocells

Figure 5. Completed paving with geocells after one year

5 CONCLUSIONS

For the container yard, a section incorporating two layers of geocells of style StrataWeb® SW356-150 was considered. The geocell layers were in-filled with non-plastic granular material to reduce stresses on the foundation subgrade to within the limits of safe bearing capacity of the soil.
Apart from the direct cost savings, the long term benefits and indirect cost savings include:

a) Savings in project construction time

b) Reduction in differential settlements leading to improved operational efficiency and reduced downtime

c) Reduction in life cycle maintenance cost owing to the flexible nature of the pavement and reduced differential settlements.

REFERENCES

INTERPAVE Manual “The Structural Design of Heavy Duty Pavements for Ports and Other Industries” Edition 4