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EMBANKMENTS ON SOFT GROUNDS — INDIAN EXPERIENCES

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INTRODUCTION

The present day emphasis has been on infrastructure development. The exploding population and the need for rapid industrial growth have all resulted in scarcity of land and necessitated construction on poor ground. Soft ground improvement for construction of embankments and other infrastructural facilities has become the necessity of the day. The various conventional options available are excavation and replacement of the soft soil when the depth of soft soil is small or the use of piles when the depth of soft soil is large, chemical stabilization methods etc. The conventional solutions although successfully adopted over a period of time are not preferred today in view of the need for economy and shorter project times available. The project cost is directly dependent on the time taken to complete the project. The use of geogrid reinforcement as a solution to soft soil problems is of relevance today and a significant headway has been made the world over in the design and construction of embankments and other structures with reinforced soil foundations on poor ground.

GEOGRID OPTIONS

Ground improvement for embankment foundations with the help of basal mattress reinforcement popularly known by the generic name geocell is normally adopted. The geocell foundation is used for soft soils with shallow depth. For embankments and other structures to be constructed on soft soils of large depths, a combination of geocell with encapsulated stone column is adopted. Load distribution platforms, which are multiple layers of geogrids, are used to transfer load to piles of VCC Heads.

BASAL MATTRESS REINFORCEMENT

A basal mattress is a three dimensional honey combed structure formed from a series of interlocking cells. These cells are fabricated directly on soft foundation soil from grid or mesh reinforcement and then filled with granular material resulting in a structure usually 1m deep.

DESIGN PHILOSOPHY

The incorporation of basal mattress reinforcement interacts with the embankment to produce :
i. a good adhesive interface between the soft foundation and the contained granular fill of the mattress;
ii. a relatively stiff platform to ensure both an even distribution of load on to the foundation and more uniform stress field within the soft foundation.

These properties enable the basal mattress to influence the deformation of the soft foundation and hence mobilize its maximum shear strength and bearing capacity. The plastic deformation of the soft foundation soil is examined using the slip line fields and the ultimate bearing capacity calculated The overburden stresses and the available bearing capacity are then compared to ensure that equilibrium conditions are satisfied. The geocell technique is particularly effective where the ratio of embankment width to depth of soft soil is greater than four. After the bearing capacity condition is satisfied the tensile loads in the reinforcement forming cellular mattress are determined.

ENCAPSULATED STONE COLUMNS

The encapsulated stone columns or geogrid piles derive their load carrying capacity from the jacketing effect of geogrid immediately after installation. The tensile strength of the geogrid provides the required diagonal tensile strength to the aggregate to carry the compressive stress in the initial stage. The piles can intercept the slip circle and avert failure by its shear strength derived mainly by virtue of tensile strength of geogrid as also by stabilization of surrounding strata.

LOAD TRANSFER PLATFORMS

Multilayer grids spanning across the pile caps may be used to transfer the embankment loading onto piles. The reinforcement permits the spacing of piles to be increased and the size of the pile caps to be reduced or eliminated. In addition the reinforcement counteracts the horizontal thrust of the embankment fill. The grids mobilize the maximum shear strength of the granular layer and enhance arching in addition to providing long-term support to the fill mass below the arch.

CASE HISTORIES

FOUNDATION FOR BOX CULVERTS

Since 1989 onwards in New Bombay in various arteries adjoining Nhava Sheva port the encapsulated stone column technique with geocell fabricated by using integrally extruded polymer meshes manufactured by Netlon India has-been constructed. As of 1996 almost 21 such constructions haven completed in a marine clay strata varying upto a maximum of 20m depth. All the structures are functioning without any sign of distress or settlement. The products used for this application are as follows :

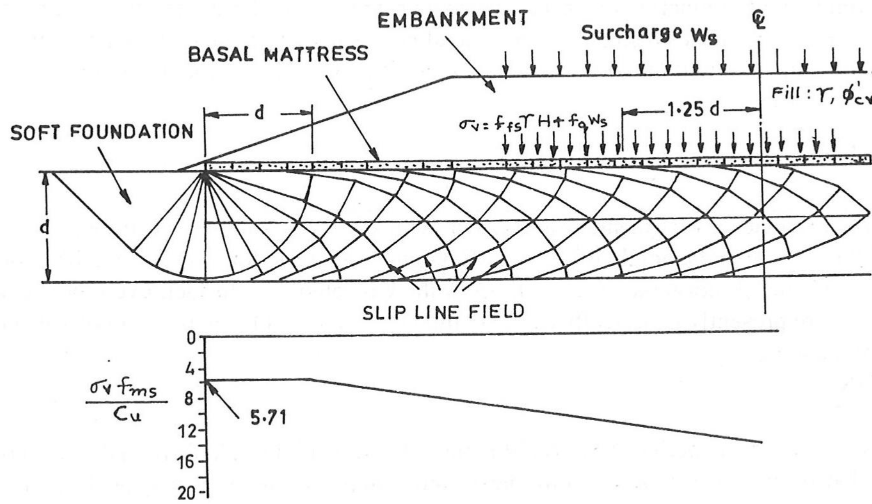
Application	Product Used	Width	Aperture Size (mm)	Tensile Strength (kN/m)	Max. Elongation (%)
Geogrid Piles	NETLON CE 131	2m	28x28	5.8	16.5 %
Geocell	NETLON CE 121	2m	8x6	7.68	20.2%
	NETLON CE 153	1m	50x50	4.82	23.2%

EMBANKMENT FOUNDATIONS WITH GEOCELL

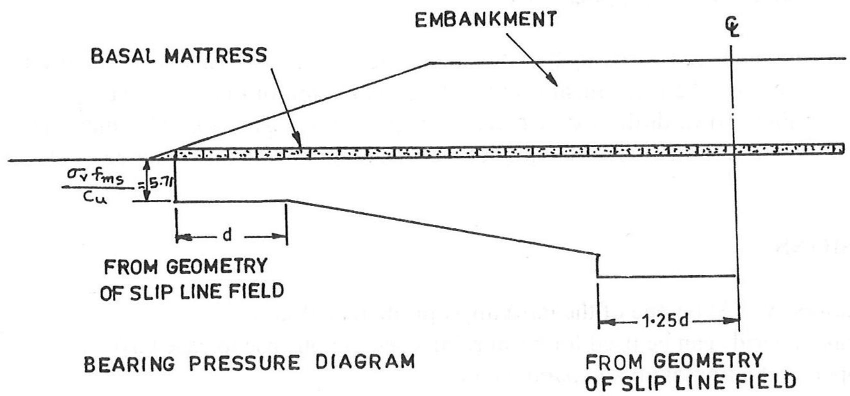
CASE I

During 1992-93, an embankment for holding pond at Vashi Node with the following dimensions was constructed using the geocell concept. Bottom width : 28 m, Height : 4 m, Length : 800 m

The contractors and the engineers concerned were able to proceed with the planned activity without any distress except for a small stretch of 25m where it was found necessary to use additional layers of geocell

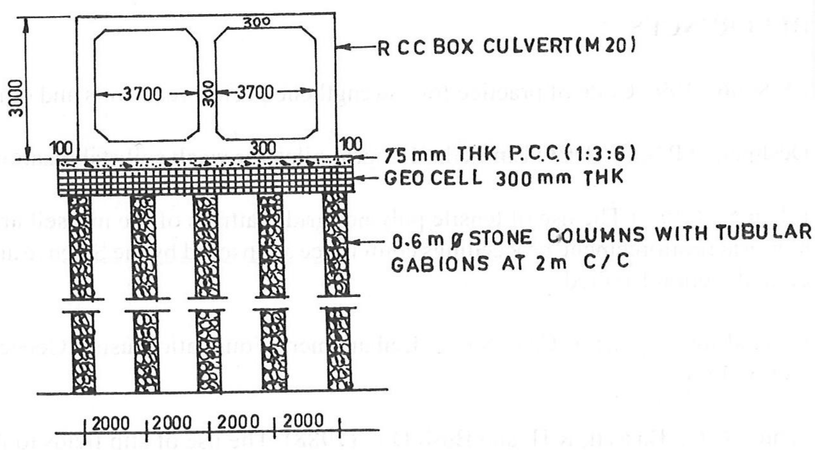


GENERATION OF SLIP LINE FIELDS BENEATH BASAL MATTRESS REINFORCEMENT



BEARING PRESSURE DIAGRAM

CROSS SECTION OF BOX CULVERT



due to the fact that depth of marine clay was much higher than anticipated during the design stage. However even at this stretch the examination of CE 121 geogrid i.e. the bottom horizontal layer revealed that the grid was subjected to a very uniform stress resulting in almost oriented product which had infact much higher tensile strength compared with the original product specification. This structure is functioning very effectively even after 5 years.

CASE II

Based on this experience a second site was taken up with similar product for a different embankment with a bottom width of 18 m and a height of 4.5 m at Belapur Promenade for CIDCO, Navi Mumbai.
Here also the product performance was well up to the expectations. In fact, even the weak geogrids or geonets as they are presently generically called could be used to tackle the problem of various soft ground improvement techniques.

DISCUSSION

The above case study and experience clearly illustrates the basic philosophy behind the basal reinforcement principles and also supports the view that for these kind of applications creep may not be a limiting factor as long as the strength is sufficient and the construction sequence is well organized to provide a very small time required for the soil to mobilize its shear strength. Even in South-East Asia biodegradable materials were also being tried for these applications .

The approach adopted here is strongly based on theoretical assumption and has been tried and proved in the field. However the precise mechanisms and further evaluation of mathematical models are essential for better understanding. Towards this extent currently some modeling and experimentations are under progress in collaboration with IIT, Madras so that the full benefit of the theory and practice can be put to appropriate use.

CONCLUSIONS

1. Basal mattress would be one of the most appropriate techniques.
2. Even weak geogrids can be used for basal reinforcement on case to case basis after proper evaluation of all site parameters.
3. It is not always necessary to use the grid with maximum strength and creep tested for all geotechnical application.
4. For a practicing engineer a viable solution that is cost economic and meets the short term or long term requirement depending on the criticality of the structure are the only deciding criteria.

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SESSION II

REINFORCED SLOPES AND RETAINING WALLS

Discussion Papers

Communication Papers