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STUDY ON FAILURE OF HIGH EMBANKMENT IN ROAD WORK ON MARSHY AREA AND RECTIFICATION WORKS BY IMPLEMENTATION OF GROUND IMPROVEMENT TECHNIQUES SPECIFIC TO THE GROUND CONDITION

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ABSTRACT

The rapid urbanization and industrial development have resulted in scarcity of prime land. Some road works having a new alignment have to transverse at locations which are not suitable on foundation criteria. The success of geotechnical works on soft ground relies on important factors such as proper planning, analysis, design, construction control and supervision. In case of failure to comply with any one of the above or the combination of the above factors, there are failures of geotechnical works such as embankment, approaches to bridges and culverts. The embankment in case of a high fill in a marshy area need to be reinforced by ground improvement techniques. Several ground improvement techniques widely used are vibro compaction, vibro displacement compaction techniques which are area specific. Other than additional measures like reinforcement, filter, drainage, separation layer using Geo-synthetics is also employed. A combination of both may also be utilized on case to case basis.

In this study, the project area is a marshy water logged area having very low SBC value (almost nil) and which needs to be filled with earthen embankment for the purpose of approach road connectivity joining an ROB crossing Konkan Railway. The high embankment was earlier compacted and filled for a length of 75 m, but failed due to shear cracks. The aim of the project is to improve the foundation of the embankment, considering its weak nature by utilizing multiple ground improvement techniques like stone column and geo-grid in combination.

The study revealed that the embankment rested on the foundation of stone column and geo-grid in a marshy area has withstood the failure of the high fill embankment without any deformations.

***Key words:* Embankment, Geo-Grid, Stone Column.**

I. INTRODUCTION:

India has a very long coastline from the Gulf of Kutch to Sunderbans for an approximately length of 7500 kms. Recently large scale development has been observed in the coastal due to the emergence of new ports, expansion of ports with the entry of private players into the otherwise controlled government market. The ports form the basis for cheapest form of transportation for long haulages of goods and seamless connectivity to ports is of prime importance to reduce haulage time on land. The coastal regions also inhibit a particular kind of soft deposits in the sub profile particularly along the coast in narrow tidal area and swamp area. These deposits occur in the backwater areas which are soft clays have low shear strength and high compressibility. In some instances, due to shortage of land or other constraints, construction activity have to be carried out in such areas which can lead to construction failures and danger to human life and property if proper precautions are not taken.

In order to make soil suitable for use of construction activity, ground improvement techniques need to be employed depending on the usability of the service, site condition, surrounding environment, time constraints and budgetary constraints. The generally adopted ground improvement practices are stabilization by mechanical, chemical and cementing means, compaction, drainage methods, vibration methods, grouting, compaction, pre-compression, use of geo-synthetics etc. depending on the above mentioned factors. In certain scenarios, a combination of more than one ground improvement technique may be adopted to achieve desired result.

This project study pertains to development of a 2-lane road from Kana Junction in Surathkal area to Jokatte. It is reported that the embankment was sinking and remedial measures need to be undertaken to address the issue. The road being built is traversing through marshy land near Jharandaya temple in Thokur and thereafter on western side of Konkan Railway till Jokatte. This marshy land is caused due to the backwater of Gurpur river which exhibit heavy salt content due to the presence of the Arabian sea in the vicinity. While constructing the earthen embankment, the soil in about 75 m stretch on one side of the road has sunk to an extent of 3 m and some cracks are also seen on balance portion of this stretch. Since the cost of embankment by reinforcing the ground conditions or construction of bridge in marshy area was uneconomical, the constructed embankment was re-laid by spreading and compacting the existing embankment soil and then increasing the width of embankment base by additional 30-50m and construct the embankment by doing proper compaction layer by layer and providing horizontal berm with extra earth to prevent sliding on the edges. However the embankment failed due to development of shear cracks being developed in spite of additional width of the base width of the embankment formation.

Embankment snapshot and photos after embankment failure after initial construction activity

Site Photo of Embankment failure for Normal Embankment toe width


Snapshot after embankment failure after additional widening of the base

Site Photo of Embankment failure for Additional Embankment toe width


Site Photo of Embankment failure (Sliding & Shear) for Additional Embankment toe width


II. OBJECTIVES:

The main objective of the project is

- To determine the causes for failure of the embankment in spite of providing additional base width to counter the sliding of the embankment
- Suggest suitable measures to arrest the failure and stabilize the embankment by application of suitable ground improvement technique.

III. MATERIALS AND TESTING:

The materials used for execution of the work were fine aggregates (river sand), soil (Lateritic), coarse aggregates (crushed granite) & biaxial geo-grid.

Fine aggregates (river sand)

The material use as fine aggregate is river sand sourced from Adyar, Netravati River in Mangaluru. The river sand was used to form a drainage blanket layer which had the following geo-technical properties. 1) Specific Gravity: 2.6, 2) Sieve Analysis : Zone-II criteria, 3) Deleterious Material: Nil, 4) Clay lumps : 2.5 %, 5) Material finer than 75 micron : 1 %.

Soil

The materials used for embankment purpose were lateritic soil sourced from two nearby locations (borrow pits) near Kodikere area (Source 1) which had the following properties 1) OMC : 15 %, 2) MDD : 1.82 gm/cc, 3) Free Swell Index : 23 %, Soaked CBR Value : 14.5 % and Jokatte area (Source 2) which had the following properties 1) OMC : 14 %, 2) MDD : 1.80 gm/cc, 3) Free Swell Index : 8 %, Soaked CBR Value : 15.8 %.

Coarse aggregates (crushed granite)

The material used were primarily 40 mm downsize aggregates sourced from stone quarries near Permude and was used as the main ingredient of stone column with a fineness modulus of 7.42.

Bi-axial geogrids

A woven Bi-Axial Geo-grid sourced from MACCAFERRRI was used based on the requirements with the following characteristics.

Characteristics	Test Method	Unit of	Observed Average
Tensile Strength-MD	EN ISO 10319	KN/m	127.70
Strain at max Strength-MD	EN ISO 10319	%	12.00
Tensile Strength-CMD	EN ISO 10319	KN/m	129.50
Strain at max Strength-CMD	EN ISO 10319	%	12.50

Table 3.1 Properties of Woven Geo-grid (Ref IRC 113-2013)

IV. METHODOLOGY

4.1 Problem Identification

This marshy land is caused due to the backwater of Gurpur river which exhibit heavy salt content due to the presence of the Arabian sea in the vicinity. While constructing the earthen embankment, the soil in about 75 m stretch on one side of the road has sunk to an extent of 3 m and some cracks are also seen on balance portion of this stretch. In the present situation it is not possible to take any heavy equipments or vehicles on top of the embankment and do the remedial measures. It is required to strengthen/improve the foundation soil below the embankment.

4.2 Collection Of Sample And Testing & Analysis Of Failure:

Borehole samples were collected from two locations at original ground level on extreme ends to determine the cause.

Fig 4.1 Borehole Location Map

The Borehole location is as follows:

BH1 - 12°57'50.28"N 74°50'11.86"E (NEAR BRIDGE)

BH2 - 12°57'45.96"N 74°50'17.84"E (NEAR RAILWAY TRACK EMBANKMENT)

The bore log near the approach area (**BH1**), indicate very low 'N' values (observed blow counts from SPT test) up to almost 10 m depth. This low blow Count values indicate that the soil at top 10m is very weak (meaning very very low bearing capabilities and high compressibility's), soft and under-consolidated; and water table indicated is also high (1 m below the existing ground level). The soils are identified as fine grained soils, clayey/silty. The height of embankment constructed is 10 to 11 m, with side slopes of l.5H:1V. This imposes a load on the weak foundation soil in excess of 200 kN/m2 which the weak foundation soil cannot sustain. This is reflected as a bearing capacity (shear) failure as seen from the large settlements of nearly 3 metre beneath the embankment, and also very significant ground heave at the toe.

4.3 Suggestions

It is suggested to remove the entire embankment soil for this stretch and do the ground improvement of the foundation soil by stone columns and drainage layer and layer separation by using geo-synthetics.

4.4 Remedial Measures Undertaken

i) **Excavation of entire embankment soil by mechanical means using hydraulic excavator of 1.0 cum capacity and disposal by tippers of not less than 10 cum capacity.**

ii) Marking of co-ordinates on field and boring of 1.0m dia pile using casagrande B 170 rotary drill at 3.0 d spacing centre to centre in a triangular pattern (713 piles).

iii) Driving of retractable mild steel liner casing of 6.0 mm thickness with top collar with derick and winch machinery.

iv) Stockpiling of granite metal of varying size aggregates from 40 mm downsize.

v) Providing & filling bored pile with granite metal of varying size from 40 mm downsize with top feed system using backhoe loader.

vi) Compaction of granite metal aggregates using 2.0 t hammer with derick and winch machinery with simultaneous retrieval of casing.

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vii) Laying of bi-axial geo-grids.


viii) Laying of drainage blanket of 0.45m thick consisting of clean sand.

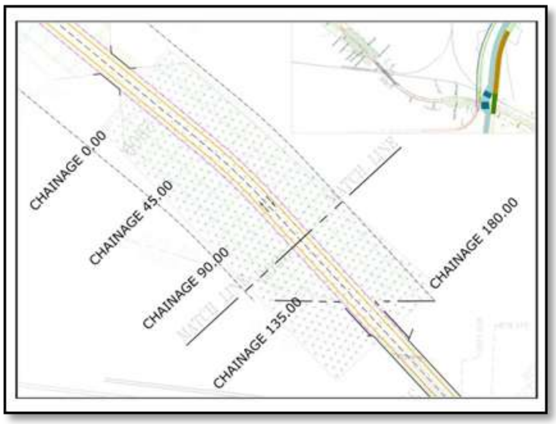

ix) Construction of embankment with compacting in layers of 200mm thick using good quality lateritic soil.


x) Overall Progress View of different stages of construction

xi) Providing horizontal berms at every 6.0 vertical heights with width of berm at 2.0 m.

xii) Turfing of embankment slope as additional protection measure.

Area layout drawing



General Cross-section of Embankment

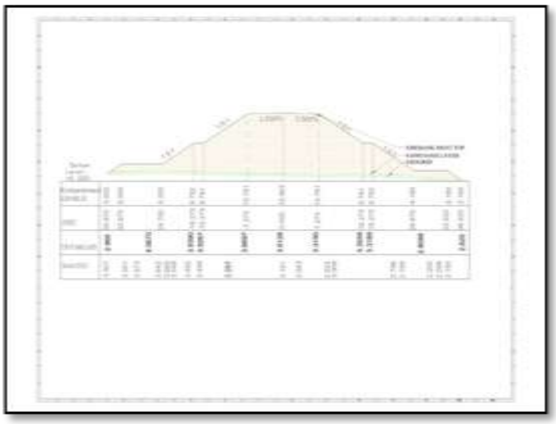


Fig 4.2 Location Map of Embankment after execution of work

V. RESULTS

5.1 General

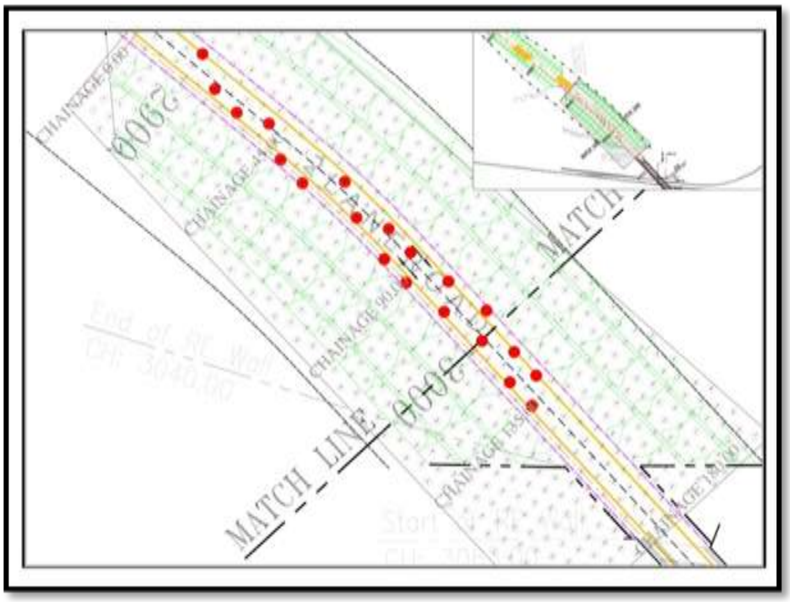
To assess the efficiency of ground improvement techniques the conventional in situ test are used. The most popular tests in situ test to assess the efficiency of ground improvement are SPT test, CPT test and Plate load test. The SPT tests are carried out all along the longitudinal direction of the carriageway to determine the stability of the filled up embankment on the stone column and Geo grid against sliding and shear failure. The SPT results will enable us to determine the type of compaction and the range of relative density and the friction angle achieved in the compacted embankment fill.

Correlation between SPT-N value, Friction angle and Relative Density (Meyerhoff 1956)

SPT	Soil Packing	Relative Density (%)	Friction angle(°)
< 4	Very Loose	< 20	<30
4 – 10	Loose	20 – 40	30 -35
10 – 30	Compact	40 – 60	35 – 40
30 – 50	Dense	60 – 80	40 – 45
>50	Very Dense		

Table 5.1 Correlation Data

5.2 Standard Penetration Test at various locations along the road alignment



Average "N" value recorded across all 20 bore holes in SPT test

LVL	N value
0.00	19.90
1.50	19.90
3.00	22.40
4.50	23.00
6.00	23.80
7.50	23.50
9.00	24.80#
10.50	25.50*

Table 5.2 Average N Value across all Boreholes in Road Alignment

#5 boreholes

*4 boreholes

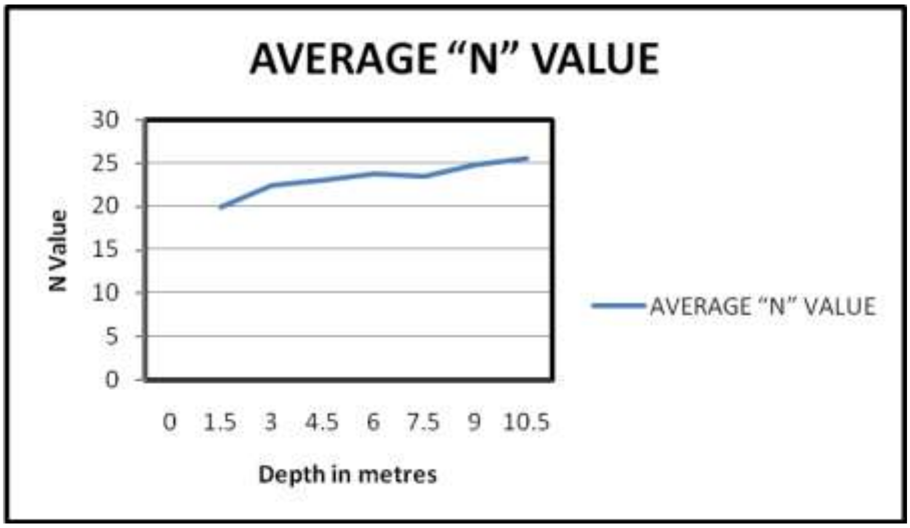


Fig 5.1 Average "N" value Chart for depth of filling

As detailed in Table 5.1 pertaining to relation between SPT-N value, Friction angle and Relative Density the following inference is made based on the average N value.

The N Value average across 20 boreholes indicate a compacted soil packing with a range of 40-60 % in relative density and friction angle ranging from 35 -40° .

VI. CONCLUSION & FUTURE SCOPE

The aim of this project was to determine the suitability of ground improvement techniques in combination of stone columns and Geo-grid application. The emphasis was to determine the applicability of this combination in a water logged salt intrusion area susceptible to change in water level.

Based on the in-situ analysis performed at site after the construction of the embankment on the improved ground sub-surface conditions, the following conclusions are arrived at.

a) The ground improvement technique has substantially increased the "N value" and the S.B.C of the sub-surface soil.

b) The use of intermediate sand layer has been able to thwart the effect of high water table.

c) The use of Woven Geo-grid as a basal reinforcement layer has provided sufficient resistant to tension and has withheld the embankment fill intact preventing it from shear failure and sliding which had occurred in earlier instances without the use of ground improvement technique.

d) The combination of this ground improvement technique with embankment filling is far more economical than road on structural components.

The ground improvement technique combination of stone column with Geo-grid can be modified with alternate forms of Geo-synthetic membranes as per the site condition & the purpose to be served.

REFERENCES

[1]. A.P. Ambily, S.R. Gandhi, "Experimental & Theoretical Evaluation of Stone Column in Soft Clay" – ICGGE 2004.

[2]. Kul Bhushan et.al, "Ground Improvement by Stone Columns and Surcharge at a Tank Site", International Conference on Case Histories in Geotechnical Engineering Apr 13th - Apr 17th (2004).

[3]. Georg Heerten, "Improving the Bearing Capacity of Soils with Geo synthetics", Improvement of Soil Properties, Bratislava on June 4 – 5, 2007.

[4]. Gohil D.P. et.al, "APPLICATION OF GEOSYNTHETICS FOR GROUND IMPROVEMENT: AN OVERVIEW", IGC 2009, Guntur, INDIA.

[5]. Kousik Deb, "A mathematical model to study the soil arching effect in stone column-supported embankment resting on soft foundation soil", Applied Mathematical Modeling, April 2011.

[6]. Ahmed Farouk , Marawan M. Shahien, "Ground improvement using soil–cement columns: Experimental investigation", Alexandria Engineering Journal- September 2013.

[7]. Sneha P. Hirkane, N. G. Gore, P. J. Salunke, " Ground Improvement Techniques", International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319–9598, Volume-2, Issue-2, January 2014.

[8]. Gaafer,Manar, Bassioni,Hesham, Mostafa,Tareq, "Soil Improvement Techniques", International Journal of Scientific & Engineering Research, Volume 6, Issue 12, December-2015.

[9]. Dr. P. Purshotham Raj, Text Book on Ground Improvement Techniques.