COMPARISON OF PROPERTIES OF COHESIVE SOILS ALONG EAST COAST OF INDIA

Annam Madan Kumar
Technical Manager, Keller India, 7th floor, Centennial Square, Kodambakkam, Chennai – 600 024
madankumar@kellerindia.com, madanannam@gmail.com

N Kumar Pitchumani
Technical Director, AECOM India Pvt. Ltd., VBC Solitaire, T Nagar, Chennai – 600 017
Nkumar.pitchumani@aecom.com, kpitchumani@gmail.com

ABSTRACT: The coastline of India is speckled with a large number of ports (major and minor). In connection with the construction of new ports and upgradation of existing ports a lot of construction has taken place over a decade or two. This involved jetties, container yard, railway connectivity to existing railway network, deepening of berth pockets and channels etc. On the geotechnical front these involved reclamation, embankment construction, pile foundations, deep excavations etc.

The east coast of India is characterised by silty clay over a large distance from West Bengal to Tamil Nadu cutting across Odisha and Andhra Pradesh. A few kilometres inland from the coast, the region also comprises silty clay, probably residual deposits arising out of weathering of volcanic rocks.

In this paper, laboratory test data from many of the sites are analysed to look for any behavioural pattern. The compression properties of the cohesive soils are looked into and compared with correlations available in literature. It is seen that the compression characteristics do follow a definite trend although there is scatter.

The aim of publishing this field data is to help designers in selecting parameters in the preliminary design stage before any detailed investigations are carried out. This could also help in estimating quantities for tender preparations with a fair amount of certainty on the primary consolidation settlements resulting from reclamation, embankment construction and also the extent of ground improvement required, if any.

KEYWORDS: East Coast, compression index, compression ratio, design parameters, ground improvement

1 Introduction

The East or Coromondal coast of India has seen a lot of activity in the past 2 decades in the form of major and minor ports, starting from Haldia to Tuticorin. Marine Clay is encountered at most of the coastal locations. However at the mouths of rivers like Ganga, Mahanadi, Dhamra, Godavari etc. more of silty deposits of alluvial type are encountered.

During preliminary designs, lack of data inhibits designers to come up with relatively aggressive designs, especially in cohesive soils. The design assumptions of compressibility start with the use of Terzaghi’s equation of compression index based on Liquid Limit which may not be applicable for Indian clays. This results in over estimation of primary consolidation settlements. This overestimation directly affects fill/reclamation quantities. Further, the contractor/bidder adds additional costs for risks resulting from variations in parameters. This risk is a result of insufficient data. On the whole the cost of a project gets escalated unreasonably.

Various consultants and contractors have been working on projects along this coast and a lot of data on the strata is available. To mitigate such cost escalations and to help clients/owners/contractors to arrive at a reasonably accurate estimation of primary consolidation settlements, data from various sites along the east coast are compiled in this paper and the compression characteristics are presented.

2 Description of sites

Compressive soils from various places comprising of non-marine and marine sites as described in Table 1 were studied. The laboratory test data are taken from various consultancy projects carried out by the authors in the last 10 to 15 years. It is to be noted that the geotechnical investigations were conducted by various agencies. Some data that were found to be erroneous for various reasons have been discarded. Data is also collected from various published and unpublished literature. Data for Visakhapatnam is taken from Satyanarayana and Satyanarayana (2009), and Guru Vittal et.al (2006).

The soils at Dhamra are predominantly residual deposits of Basalt from the Deccan. The data presented are along the railway alignment from Bhadrak to Dhamra. The silty clay deposits at Koyambedu are from the Depot for Chennai Metro and are believed to be lacustrine deposits originated from shale. The deposits at Haldia and Paradip are alluvial in nature and are fluvial deposits from rivers.

Table 1 Sites considered for study

Non-Marine sites	Dhamra (Odisha), Haldia (West Bengal) Koyambedu (Chennai, TN), Paradip (Odisha)
Marine Sites	Visakhapatnam, Krishnapatnam, Bheemunipatnam (all in Andhra Pradesh)

The Location of non-marine and marine sites are shown in Figure 1.The classification of the soil for the non-marine and marine sites on the A line are shown in Figures 2 and 3 respectively.

Fig. 1 Marine and non marine site locations

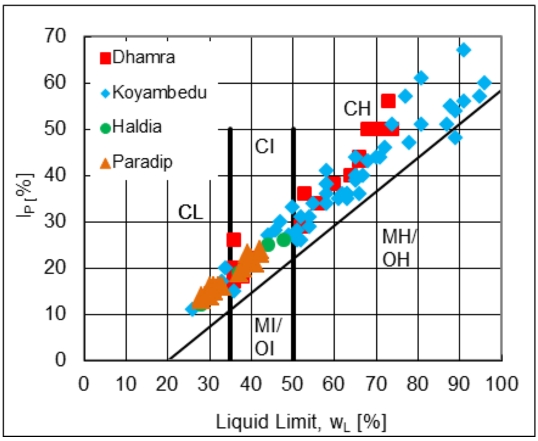

Fig. 2 Soil Classification: Non-marine Sites

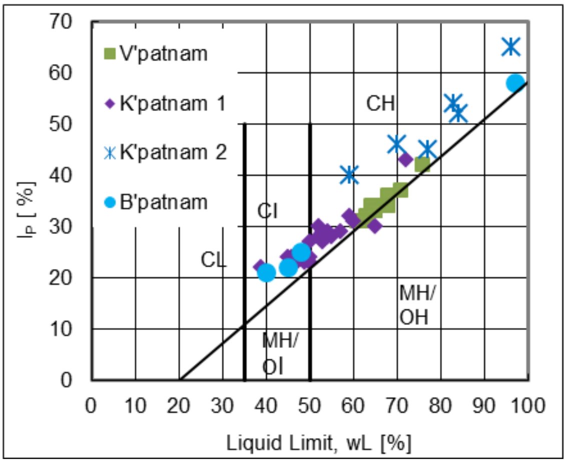

Fig. 3 Soil Classification: Marine Sites

The plots depict that the non-marine deposits are Silty Clay of low, medium and high compressibility while the Silty Clay of marine deposits are of medium to high compressibility.

3 Soil Behavior

Laboratory test results for the two groups of soils are plotted with various parameters as given in literature.

The most commonly studied and compared parameter is the Compression Index (C_c) with Index properties. A number of empirical equations are available in literature (Satyanarayana and Satyanarayana, 2009, Sridharan and Nagaraj, 2000).

Lambe and Whitman (1969) and Cox (1970) have equations for the Compression Ratio CR = $C_c/(1+e_0)$. From all these literature it is clear that cohesive soils from different places show different variations. One equation from a particular site may not be suitable for another site.

Hence, the compression parameters are only plotted without fitting any trend line in this paper.

3.1 Compression Ratio

The Compression ratio, CR is plotted against Liquid Limit for the deposits of non-marine and marine sites in Figure 4 and Figure 5 respectively. Although there is scatter, there appears to be a trend. The marine deposits of different sites occupy a distinct spot on the plot.

The plot of CR with Natural Moisture Content (NMC) is presented in Figure 6 and Figure 7 for the deposits of non-marine and marine sites. Here again there is scatter, nevertheless a trend is observed.

Another important parameter is the Consistency Index I_c = (LL-NMC)/PI%. The plot of CR versus I_c is presented in Figure 8 and Figure 9 respectively for the non-marine and marine sites.

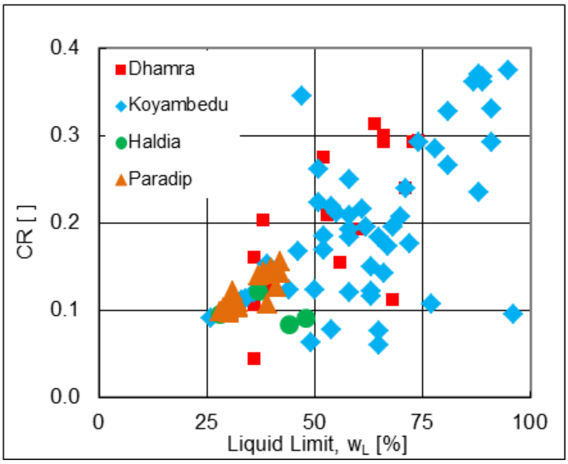

Fig. 4 Plot of Compression Ratio with Liquid Limit: Non-marine Sites

It is seen that the non-marine and marine clays follow a similar pattern, and hence plot of CR versus Liquid limit and Natural Moisture Content for all sites combined is presented in Figure 10 and Figure 11.

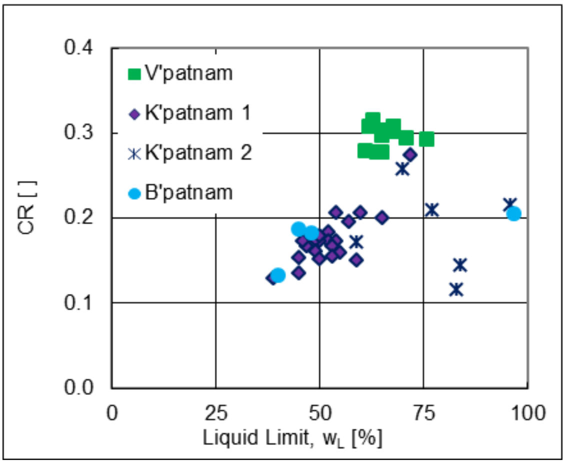

Fig. 5 Plot of Compression Ratio with Liquid Limit: Marine Sites

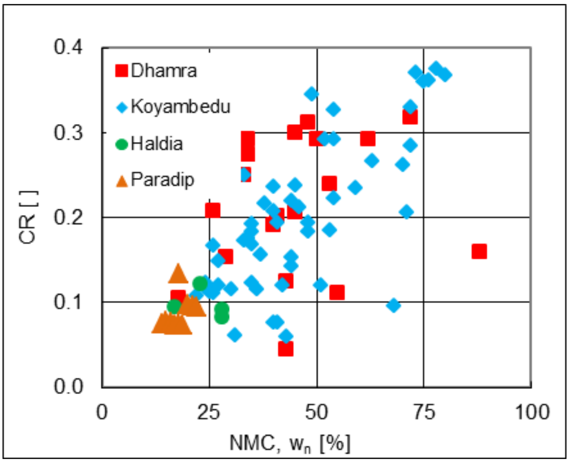

Fig. 6 Plot of Compression Ratio with Natural Moisture Content: Non-Marine Sites

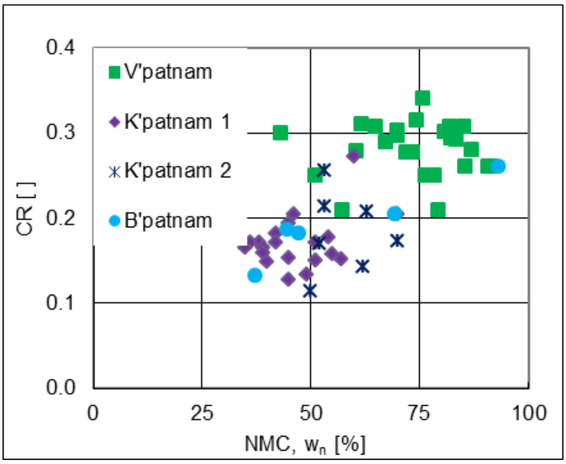

Fig. 7 Plot of Compression Ratio with Natural Moisture Content: Marine Sites

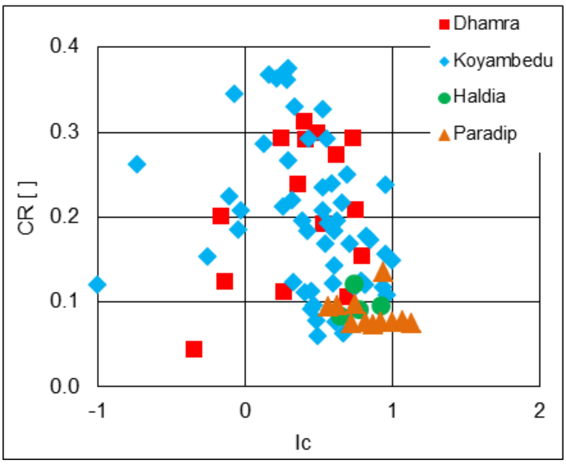

Fig. 8 Plot of Compression Ratio with Consistency Index: Non-Marine Sites

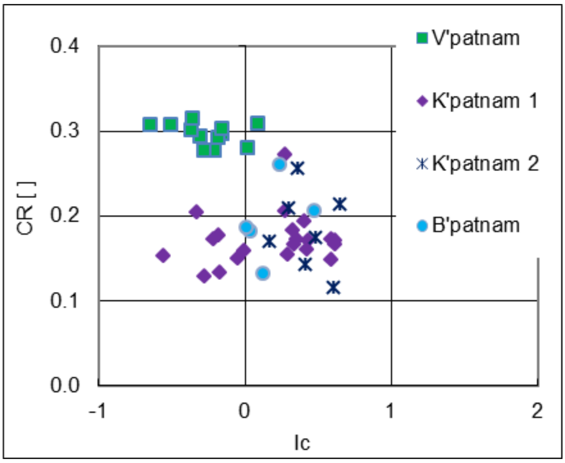

Fig. 9 Plot of Compression Ratio with Consistency Index: Marine Sites

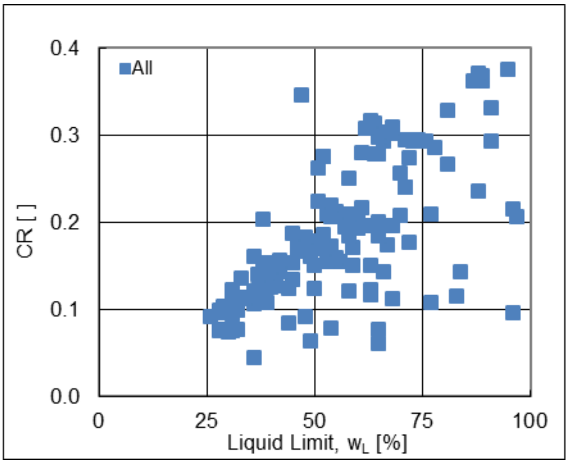

Fig. 10 Plot of Compression Ratio with Liquid Limit: All Sites

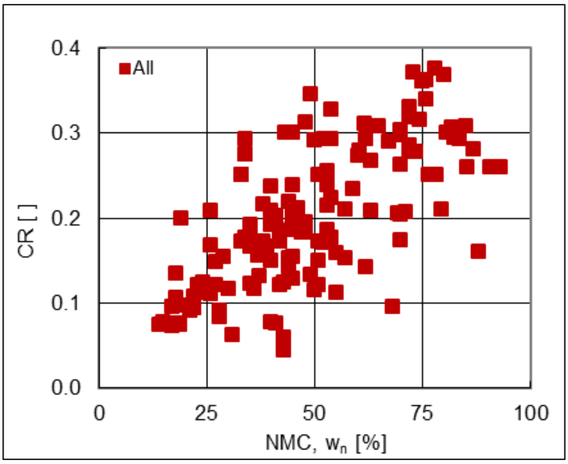

Fig. 11 Plot of Compression Ratio with Natural Moisture Content: All Sites

4 Conclusions

The aim of this paper is to present compression data from various sites along the east coast. The data presented are the compression ratio with various index properties generally published in literature. The idea of presenting these data is to benefit the engineers to adopt more realistic parameters for designs either in the preliminary design stage or tender stage. This would help in arriving at a more pragmatic techno-commercial proposal for any project on soft soils along the east coast.

References

Cox, J.B (1970), Shear Strength Characteristics of the Recent Marine Clays in South East Asia, *Jl. of the southeast Asian society of Soil Engineering*, Vol. 1 pp. 1-28.

Guru Vittal U.K., Subramanya Prasad P., Sudhir M (2006), 'Geotechnical Properties of Visakhapatnam Marine Clay', *Indian Geotechnical Conference,* 14-16, Chennai, India, pp. 329-330.

Lambe, T.W. and Whitman, R.V. (1969), *Soil Mechanics*, John Wiley & sons, Inc., New York.

Satyanarayana, B and Satyanarayana Reddy, C.N.V. (2009), Emperical correlations of Compressibility of Marine Clays – a Review' *Indian Geotechnical Conference,* Guntur, India, pp. 65-70.

Sridharan, A. and Nagaraj, H.B. (2000), 'Compressibility behavior of Remoulded, Fine Grained Soils and Correlations with Index Properties', Can. Geotech Jl., 37, pp. 712-722.