Construction and Building Materials 154 (2017) 658–674

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Review

Geocell reinforced foundation beds-past findings, present trends and future prospects: A state-of-the-art review

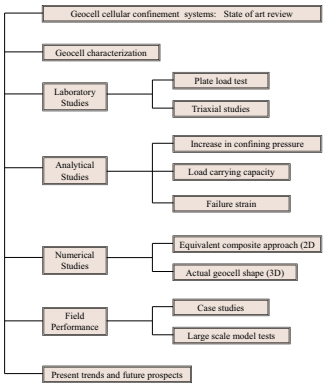
A. Hegde

Department of Civil and Environmental Engineering, Indian Institute of Technology Patna, 801103, India

HIGHLIGHTS

- Presented current state-of-the-art regarding geocells.
- Reviewed past studies related to geocells.
- Documented studies related to field performance of geocells.
- Discussed future prospects of the geocells in geotechnical engineering.
- Geocell found to be very promising ground reinforcement technique.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 13 November 2016
Received in revised form 21 June 2017
Accepted 31 July 2017
Available online 9 August 2017

Keywords:
Geocells
Plate load test
Soft clay
Foundations
Simulations
Pavements

ABSTRACT

In the last few years, the use of geocell reinforcements in various infrastructural projects has gained importance due to its positive benefits. This paper reviews the developments and state-of-the-art pertinent to geocell research and field practices. The geocell studies covering, experimental, numerical, analytical and field performances have been reviewed. Characterization of the geocell has been discussed in detail. The field investigations of the test sections and the performance of the in-service geocell supported structures have been reviewed. A note has been presented on current research trends and the future prospects. A summary of the past research findings has been presented with a discussion on the research gaps in the subject area. It is evident from the past studies that the geocell is evolving as a promising sustainable ground reinforcement technique. Due to an increased use of geocells in the infrastructure projects, there exists an expansive scope for further research to understand the material better.

Contents

Abbreviations: CTE, Coefficient of Thermal Expansion; ECA, Equivalent composite Approach; ESCR, Environmental Stress-Cracking Resistance; HDPE, High-density polyethylene; NPA, Novel Polymeric Alloy; OIT, Oxidative induction Time; PRS, Percentage reduction in the footing settlement.

E-mail address: ahegde@iitp.ac.in

http://dx.doi.org/10.1016/j.conbuildmat.2017.07.230
0950-0618/

Nomenclature

B	footing width (m)
C_r	apparent cohesion (kPa)
D	equivalent diameter of the geocell pocket opening (m)
D_r	depth of the reinforcement (m)
E_i	initial tangent modulus of the geocell layer (kPa)
I_f	improvement factors (dimensionless)
K_p	coefficient of passive earth pressure (dimensionless)
K_r	Young's modulus parameter of the geocell-reinforced sand (dimensionless)
K_e	Young's modulus parameter of the unreinforced sand (dimensionless)
k_1, k_2, k_3	resilient modulus parameters (dimensionless)
M	secant stiffness of the geocell (kN/m)
M_r	resilient modulus (kPa)
n	modulus exponent (dimensionless)
N_{limit}	limiting number of cycles (dimensionless)
P	active earth pressure (kPa)
p_a	atmosphere pressure (kPa)
q_r	bearing pressure of the reinforced bed (kPa)
q_o	bearing pressure of unreinforced bed (kPa)
q_{ult}	ultimate bearing capacity (kPa)
R_a	surface roughness (μm)
S_o	settlement of the unreinforced foundation bed (m)
S_r	settlement of the reinforced bed (m)
T	tensile strength of the basal geogrid material (kN/m)
α	horizontal angle of the tensional force (degrees)
β	load dispersion angle (degrees)
σ_1	normal stress (kPa)
σ_3	confining stress (kPa)
σ_h	hoop stress (kPa)
$\Delta\sigma_3$	increase in the confining stress (kPa)
ξ_a	axial strain (percentage)
ψ	dilation angle (degrees)
θ	bulk stress (kPa)
τ_{oct}	octahedral shear stress (kPa)
ν_g	Poisson's ratio of geocell (dimensionless)
ε_h	hoop strain (percentage)
ε_3	percentage radial strain (percentage)
ε_c	circumferential strain (percentage)
ε_l	volumetric strain (percentage)

1. Introduction

Due to the rapid urbanization in the 21st century, construction in weak ground has become inevitable. In recent years, ground improvement techniques like vibro stone columns and prefabricated vertical drains have gained the popularity for their wide range of application in soft soils. However, engineers and scientists are constantly looking for new techniques which are faster and cheaper to the traditional techniques. As a result of this, geocell applications are increasing at a rapid rate. Nowadays, geocells are being widely used in many geotechnical engineering applications. Geocells are the cost-effective, sustainable materials used to enhance the performance of soft soil. These are three-dimensional in shape and are made up of ultrasonically welded high strength polymers or the polymeric alloy such as Polyethylene, Polyolefin etc. Due to its 3-dimensional nature, geocell offers all-round confinement to the encapsulated soil, which leads to the overall improvement in the performance of the foundation beds [36].

Geocell was originally developed by the US army corps of engineers in the early 1970s for military applications. Later on, many researchers in the past have contributed to the development of the geocell technology. The majority of the past studies were laboratory in nature and these studies were carried out mainly to understand the efficacy of the geocells in enhancing the performance of the soil beds (e.g. [79,10,68,20,21,22,23,83,93,66,24,25,32,36,37]). Mid 1990 onward, numerical simulation techniques were adopted to understand the behaviour of the geocells. Over the years, many researchers have contributed in enhancing the knowledge about the geocells by means of the numerical simulations (e.g. [67,12,63,29,66,80,95,32,36,38,39,40]). Based on the experimental and numerical simulation observations, many researchers have developed the analytical formulations for calculating the bearing capacity of the geocell reinforced foundation beds (e.g. [58,74,99,9,85,42]). The latest trend is to carry out the large scale model tests or the actual field tests to understand the behaviour of the geocells (e.g. [27,31,96,89,70]). Further, the actual