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Procedia Engineering 51 (2013) 250 – 258

Procedia Engineering

www.elsevier.com/locate/procedia

Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University International Conference

Optimum Utilization of Fly Ash for Stabilization of Sub-Grade Soil using Genetic Algorithm

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Abstract: Sub-grade soil stabilization is one of the primary and major processes in the construction of any highway. The aim of this research paper is to formulate a model based on Genetic Algorithm which can be used to predict variation in the values of CBR of the Sub-grade Soil with the addition of a specific percentage of Fly Ash. The input values for this study were those which directly affect the CBR values i.e., directly proportional to CBR. It includes Liquid Limit (LL), Plasticity Index (PI), Optimum Moisture Content (OMC) & Fraction of Fly Ash added (F.A in %).For analysis of stabilization of soil using fly ash, Evolver 5.7 an add-in software of excel is used. Properties used for analysis are Liquid Limit, Plastic Limit, Optimum Moisture Content and California Bearing Ratio. This model will help all types of agencies involved in road construction like NHAI, Infrastructure Developers and Construction Contracting Organizations to pre-determine the soil stabilization achieved due to fly ash for a particular type of sub-grade soil.

Selection and peer-review under responsibility of Institute of Technology, Nirma University, Ahmedabad.

Keywords: Optimization; genetic algorithm; fly ash; soil stabilization.

1. Introduction

Emerging trend of using waste material in soil stabilizing or soil strengthening is being operational all over the world in present days. The main reason behind this trend is the excessive production of waste like fly ash, plastics, rice husk ash which is not only hazards but also creating deposition problems. Using some of these waste materials in construction practice will reduce the problem in a great extent.

The history of stabilization of soil has a long background with hundreds of research results. Several research results with waste materials such as fly ash, plastics; rice husk ash has also been published with their benefits. Some of the recent relevant research work has briefly mentioned here, Alhassan (2008)[8] has shown the potential benefits of using RHA with the natural soil. It has been reported that both CBR as well as unconfined compression values has increased with the addition of RHA with natural soil. Also the OMC (Optimum Moisture Content) increase while MDD (Maximum Dry Density) has decreased due to RHA mixed with natural soil. Brooks (2009) [8] reported the soil stabilization with RHA and fly ash mixed with natural soil. In this study also showed improvement in CBR values and unconfined compression strength. The effect of marble dust with RHA in a mix with expansive soil has been studied by Sabat and Nanda (2011). It has been seen that with addition of RHA and marble dust with soil, the MDD deceases and OMC increases. Also the CBR and UCS values increase substantially due to adding these two with the natural soil. The study of Yulianto and Mochtar

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1877-7058
Selection and peer-review under responsibility of Institute of Technology, Nirma University, Ahmedabad.
doi:10.1016/j.proeng.2013.01.034

(2010) [15] shows the effectiveness of using rice husk ash (RHA) and lime as a pozzolanic material with natural soil. The results showed good improvement on its physical and engineering behaviour of the stabilized peat soil. The values of wet unit weight and specific gravity increase while the water content and void ratio decrease with the increase of curing period. The increment of curing period is also altered its engineering behaviour that is increasing the soil strength and reducing its compressibility.

In this study the objectives are; Evaluation of Compressive Strength (CBR) of Fly Ash Stabilized Sub-Grade Soil, to identify factors affecting Compressive Strength (CBR) of Stabilized Sub-Grade Soil containing Fly Ash and Sensitivity Analysis of Sub-Grade Soil CBR is using Genetic Algorithm.

Fly Ash is the residual remains after the combustion of coal which is made up of very fine particles of Silicon Dioxide (SiO_2) (Amorphous & Crystalline), Aluminium Oxide (Al_2O_3), Iron Oxide (Fe_2O_3) and Calcium Oxide (CaO). It has various applications in the field of Construction such as Concrete Production, in Cement Clinkers, Substitute Material in Brick Manufacturing, Mineral Filler in Bituminous Concrete, etc. One such application is Sub-grade Soil Stabilization for Road Construction.

Fly Ash Mix with Lime and/or Cement can be used for stabilizing of sub-grade soil having poor compressive strength for Road Construction. After it has been added the reactions that take place between fly ash, lime and water gives rise to cementitious products which bonds the soil particles together. Soils having high amounts of clay in their composition require a high lime/fly ash ratio to ensure an abundant supply of lime for the lime-fly ash reaction and for lime-clay stabilization.

Pavement engineers have long recognized long term benefits of increasing the strength and durability of pavement subgrade soil by mixing in a cementitious binder during reconstruction or new construction. Millions of dollars can be saved by soil subgrade stabilization in comparison to cutting out and replacing the unstable subgrade soil. When included in pavement design, stabilizing the subgrade can result in reducing the thickness of other pavement layers.

Finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones. In comparison, maximization means trying to attain the highest or maximum result or outcome without regard to cost or expense. Putting together a portfolio in such a way that return is maximized for a given risk level, or risk is minimized for a given expected return level. An optimization tool that allows us to generate an entire tradeoff curve in a single iteration will be more useful to the decision-making process that generates just a single point at a time [3].

Many human inventions were inspired by nature. Artificial neural networks are one example. Another example is Genetic Algorithms (GA). Genetic Algorithms search by simulating evolution. It starts from an initial set of solutions or hypotheses, then generating successive generations of solutions. This particular branch of Artificial Intelligence was inspired by the way living things evolved into more successful organisms in nature. Thus Identifying different factors that affect the strength of soil by the addition of fly ash in different proportion of sand and then inserting the data into Evolver will result into prediction of soil strength is the present scope of the study.

2. Literature Review

Subgrade soils are an essential component of pavement structures, and inadequate subgrade performance is the cause of many premature pavement failures. Clay subgrades in particular may provide inadequate support, particularly when saturated. Soils with significant plasticity may also shrink and swell substantially with changes in moisture conditions. These changes in volume can cause the pavement to shift or heave with changes in moisture content, and may cause a reduction in the density and strength of the subgrade, accelerating pavement deterioration. There is a substantial history of use of soil stabilisation admixtures to improve poor subgrade soil performance by controlling volume change and increasing strength. Lime and cement have been used successfully for many decades, and more recently Class C fly ash has been used as an economical alternative to improve subgrade performance.

The benefits of Class C fly ash may be divided into three categories (adapted from Ferguson, 1993)[12]:
(a) Drying agent. Fly ash hydrates when exposed to water. As a water consumer, it can be used as a drying agent for wet soils when acceleration of the drying process is desired.