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Spatial Analysis of Soil for Geotechnical Engineering Purposes Using GP

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ABSTRACT

In construction field knowledge of nature of the soil is essential at a site proposed for new structure. For a new structure type of foundation and its performance depend on the characteristics of underlying soil. The three important parameters of the soil at which the foundation can be laid are depth, allowable bearing pressure and swell potential require for general suitability of the site. To estimate the required three parameters a soil characteristics prediction GP model is suggested. The model involves multiple regression equation.

KEYWORDS: *Free Swell, N Value, Foundation Depth, Regression, GP*

I. INTRODUCTION

Many factors of the nature effects the newly start construction project at any construction site and it's vary place to place, out of them soil nature is one of the factor of the proposed construction site at which foundation can be laid. For the design of foundation three important parameters allowable bearing pressure of soil, the swell potential of the soil and the depth at which the foundation can be laid, are to be determined. The design of foundation will also depend on the detrimental effects (swelling and settlement) and the bearing capacity of soil. The cost of project will also affected by the depth and the type of foundation. Subsoil investigation works is expensive and time consuming process. The Swell potential can be judged from differential free swell. Allowable bearing pressure is calculated by N value from shear strength failure consideration and also settlements consideration, which is obtained from Standard Penetration Test.

Many researchers carried out their research work in order to predict the important geotechnical related parameters such as N value, differential free swell and the depth of foundation. Fayer et al. [1] used GIS to identify all possible combinations of soil type and vegetation and to assign to each combination, an appropriate estimate of recharge. Rahman et al. [2] evaluated an alternative methodology for producing soil maps through a process of model construction and projection into a map base using ARC/INFO geographical information system. Burrough P.A. et al. [3] find GIS integrating different elements like automated mapping, facilitates management, Remote sensing, Land information systems and spatial statistics. Paul.F.Anderson et al. [4] has done GIS descriptive modeling of soil suitability for agriculture.

Trefor Williams et al. [5] have conducted a successful pilot study to investigate the development of geographic information system (GIS) to better manage and disseminate soils information as developed from test boring results. The pilot study resulted in a GIS system that makes it easier to obtain information regarding soil types at a specific project location. Alaeddinne El Jamassi et al. [6] their research aims to investigate the development of a Geographic Information

System (GIS) to better collect, manage, analyze and visualize soils data and the research provides engineers with the necessary geotechnical information for designing construction in the different projects as buildings. Player et al. [7] introduces GIS and applications of the technology to identify potential geological hazards, plan and track field work, create maps and figures, and improve communication. According to ESRI et al. [8] Customized GIS applications for habitat mapping, natural landslide searching, air pollutant monitoring was developed to facilitate engineering work. Gandhimathi et. Al. [9] SCPM is developed to estimate the soil parameters at locations for Coimbatore city. Mojaradi et. al. [10] the goal their study is to assess the efficiency of methods for estimating the sediments yield and erosion intensity within short term and long-term timeframes over two sub-basins of Dez watershed, west of Iran.

Regression analysis is used to understand the statistical dependence of one variable on other variables. Linear regression is the oldest and most widely used predictive model in decision making. This technique can show what proportion of variance between variables is due to the dependent variable, and what proportion is due to the independent variables. The earliest form of regression was the method of least squares, which was published by Legendre [11] and by Gauss [12]. The linear regression can be classified into two types, simple linear regression and multiple linear regressions (MLR). The simple linear regression describes the relationship between two variables and MLR analysis describes the relationship between several independent variables and a single dependent variable. Hassonpour et. al. [13] pro-posed a linear programming model based on goal programming to calculate regression coefficient. Multiple Objective optimization techniques provides more realistic solutions for most of the problems as it deals with multiple objective whereas single objective optimization techniques provides solutions to the problems that deals with single objective. Goal programming (GP) is a type of multiple objective optimization technique that converts a multi objective optimization model into a single objective optimization model. GP model has been proven a valuable tool in support of decision making. The first publication using GP was the form of a constrained regression model was used by Charnes et. al. [14]. This tool often represents a substantial improvement in the modeling and analysis of multi-objective problems Ignizio [15]. By minimizing deviation the GP model can generate decision variable values that are the same as the beta values in some types of multiple regression models. Tamiz et. al. [16] presents the review of current literature on the branch of multi criteria decision modeling known as Goal Programming (GP).

Goal programming model is an important tool for studying various aspects in different areas and its extension to the findings. Sharma et. al. [17] [18], this paper is focused on study of the Pre-emptive Goal Programming Multiple Non-Linear Regression Model with two way Interaction Effect.

The GIS will be used to manage the database and to develop thematic maps for depth, N value, free swell, liquid limit, plastic limit, plastic index, percentage gravel, percentage sand and percentage slit and clay. Field and laboratory studies can be done in different locations and are compared with the predicted values. The suggested model will be useful for the prediction of the parameters at any locations for the given Latitude – Longitude values.

II. MULTIPLE REGRESSION

Multiple regression is a technique that allows additional factors enter in the regression analysis separately, so that the effect of each can be estimated.

In other words a linear regression model that contains more than one predictor variable is called a multiple regression model.

Let $X_{i0} = 1$ for $i = 1,2,\dots,n$. Let $X_{i1}, X_{i2}, \dots, X_{im}$ be m independent variables. Then a linear relationship can be modeled as:

$$Y_i = \sum_{j=0}^{m} b_j X_{ij} + e_i$$

Where $b_0, b_1, \dots, b_m$ are the parameters to be estimated and e_i is the error components which are assumed to be normally and independently distributed with zero mean and constant variance. The linear absolute residuals method requires us to estimate the values of the unknown parameters $b_0, b_1, \dots, b_m$ so as to

Minimize $\sum_{i=1}^{n} |Y_i - \hat{Y}_i|$

Where

$$\hat{Y}_i = \sum_{j=0}^{m} \hat{b}_j X_{ij}$$

$j = 0,1,\dots,m$

Where estimated values of the unknown parameters are represent by $\hat{b}_j$.

The least squares principle requires us to choose $b_0, b_1, \ldots, b_m$ which

$$\text{Minimize} \sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2$$

III. GOAL PROGRAMMING MODEL FORMULATION

Let Y_{iG} be the ith goal, d_i^+ be positive deviation from the ith goal and d_i^- be the negative deviation from the ith goal.

$$\text{Minimize} \sum_{i=1}^{m} (d_i^+ + d_i^-) \qquad \ldots (1)$$

Subject to:

Predication of N value

$$a_0 + a_1X_{i1} + a_2X_{i2} + a_3X_{i3} + a_4X_{i4} + a_5X_{i5} + d_i^- - d_i^+ = Y_{N\ value} \qquad \ldots (2)$$

Prediction of Depth

$$a_0 + a_1X_{i1} + a_2X_{i2} + a_3X_{i3} + a_4X_{i4} + a_5X_{i5} + d_i^- - d_i^+ = Y_{Depth} \qquad \ldots (3)$$

Prediction of Free Swell

$$a_0 + a_1X_{i1} + a_2X_{i2} + a_3X_{i3} + a_4X_{i4} + a_5X_{i5} + d_i^- - d_i^+ = Y_{Free\ Swell} \qquad \ldots (4)$$

Non-negativity constraint,

$X_{i1}, X_{i2}, X_{i3}, X_{i4}, X_{i5} \geq 0$

$d_i^+ \geq 0$, $d_i^- \geq 0$

Complementary constraints

$d_i^+ \times d_i^- = 0$

$i = 1,2, \ldots, m$

Where $a_0, a_1, a_2, a_3, a_4, a_5$ are coefficients of the respective independent variables, which will be determined from the input data, these are contribution of decision variables X_{i1} (Sand), X_{i2} (Gravel), X_{i3} (Silt and Clay), X_{i4} (Liquid limit), X_{i5} (Plastic limit), X_{i6} (Plasticity Index), X_{i7} (Depth), X_{i8} (N value), X_{i9} (Free Swell) or independent variables expected to be related to Y and expected to explain or predict Y. Here $Y_{N\ value}$, Y_{Depth} and $Y_{Free\ Swell}$ taken as dependent variable to formulate the multiple regression problem with goal programming model.

IV. CONCLUSION

The present research was undertaken to suggest a model in order to predict the important geotechnical related parameters such as N value, differential, free swell and the depth of foundation. A soil characteristics predication GP model is developed for the predication of the parameters required for foundation design. It gives the predicated values of the parameters. This model has flexibility to include additional parameters and additional data for any other specific purpose oriented studies. Important characteristics like depth value, free swell and Index properties like sand, silt, clay, Liquid limit, plastic limit and plasticity index, can be developed using GIS. The values obtained from the spatial variation maps and also from GP can be compared.

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