Chapter 46
Application of Meta-Models (MPMR and ELM) for Determining OMC, MDD and Soaked CBR Value of Soil

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ABSTRACT

This chapter examines the capability of Minimax Probability Machine Regression (MPMR) and Extreme Learning Machine (ELM) for prediction of Optimum Moisture Content (OMC), Maximum Dry Density (MDD) and Soaked California Bearing Ratio (CBR) of soil. These algorithms can analyse data and recognize patterns and are proved to be very useful for problems pertaining to classification and regression analysis. These regression models are used for prediction of OMC and MDD using Liquid limit (LL) and Plastic limit (PL) as input parameters. Whereas Soaked CBR is predicted using Liquid limit, Plastic limit, OMC and MDD as input parameters. The predicted values obtained from the MPMR and ELM models have been compared with that obtained from Artificial Neural Networks (ANN). The accuracy of MPMR and ELM models, their performance and their reliability with respect to ANN models has also been evaluated.

INTRODUCTION

Developing countries, especially India, are experiencing a current boom in infrastructure update. Many of the old structures are getting redeveloped and also encroachment on open land for new structures has become a routine. With the rapid growth in world population and limited land availability, the need for

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quickly developing and delivering infrastructure projects is at its peak. From highways to runways, from houses to multi-storey buildings, each project has a limited schedule and failure to deliver within the time frame causes immense losses. Project managers and planners seek to reduce the amount of time required in each and every step and activity in order to bring down the total time required to complete the project. Many new projects are surfacing in Mumbai in a bid to emulate the excellent Shanghai road network. The Eastern Freeway is the perfect example of this. Even the golden quadrilateral connecting Mumbai, Kolkata, Delhi and Chennai is undergoing widening and redevelopment. All these past year projects and even the newer upcoming projects are just short on one realm - time. This "time" is a major shortcoming of most undergoing projects. For example the Eastern Freeway project in Mumbai was supposed to be completed by the 2011 but finally got completed in 2013 (a two year delay). The cost spike was more than seventy percent- from an original estimate of Rs 847 crore to a final cost of Rs 1463 crore. Thus we learn that time and economy in a project can be a real issue in its efficient delivery. The new Indian government, under the guidance of Prime Minister Narendra Modi, planning to build or update a 100 smart cities with a plan to build 15000kms of road networks. This is simply a dream to complete in the coming years if correct measures and newer, more efficient technologies are not soon introduced into daily practice. This chapter is focused on giving an alternate method, which is reliable and can save significant amount of time, in one of the most important and preliminary stages of a project – Soil Testing.

Pavement is a road surface made of durable material that will be able to resist foot and/or vehicular load. It is a relatively stronger and stable surface designed in layers of subgrade, sub-base course, base course and the surface course. Pavements are designed keeping in mind the various load that will act in the complete duration of a structures life and how much resistance the subgrade layer is able to offer. Thus the design and performance of a flexible pavement is highly dependent on the resistance the compacted subgrade layer will offer. Due to this it is important to assess the strength of the sub-base layer. For this assessment the California Department of Transportation developed a technique of penetration for mechanical strength evaluation of the subgrade layer. This technique called the California Bearing Ratio test was developed before World War 2 and soon it came to use widely in the construction world. The test procedures can be obtained from *ASTM standards D1883-05 (lab prepared samples), D4429 (for soils in place in field) and IS2720 Part 16 (1979)* for soaked California Bearing Ratio test. It is important to note the difference and significance of using soaked CBR over normal CBR test. This will be describe later in the chapter.

The tests used to determine the engineering properties of soil are time consuming, expensive and are extremely prone to human error. If not double checked, these tests may give wrong values. Also the equipment required to carry out these tests are not readily available on site and soil samples need to be sent to laboratory for testing. On the other hand, the index properties of soil are lot easier to determine and although the tests are equally prone to human error, they are not at all time consuming and double even triple checking the properties is very much possible during the preliminary analysis of the site. Also, during preliminary analysis and testing of soil samples taking samples along the entire stretch of a major long road construction and then testing it for its index properties and finally soaked CBR value can be really difficult. Even if attempted such amount of work would take days of laboratory testing for just a single sample. This can cause major delay in the work resulting in late delivery of the final completed project by the concerned contractor. Delay in work will eventually lead to cost spikes. This is where a model with the ability to predict CBR value, by using index properties like Liquid and Plastic Limit, and engineering properties like OMC and MDD as inputs, may contribute immensely to save time and thus save the project from cost spikes.