Preface

An important function of the Transportation Research Board (TRB) is to stimulate research that addresses problems facing the transportation community. In support of this function, TRB technical committees identify problems, and develop and disseminate research problem statements for use by practitioners, researchers, and others. The problem statements listed below were developed by the TRB committee noted above. These problem statements should not be considered comprehensive; they may only represent a portion of overall research problems identified by committee members.

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I. Problem 1: Intelligent Compaction for Embankments and Pavements: Implementation Needs and Challenges

II. Research Problem Statement

Intelligent Compaction (IC) is a “state-of-the-art” technology which provides Continuous Compaction Control (CCC) through automatic sensing and control of the amplitude, frequency and speed of the vibratory roller drum, thus achieving optimum compaction level by avoiding both insufficient and over-compaction, and providing an instantaneous and complete evaluation of the zones being compacted for any needed remedial measures during the construction process. Generally the output parameter is a soil density, stiffness or modulus, which is calculated continuously on the basis of the monitored drum acceleration. The concept of Intelligent Compaction was first introduced in Europe in the late seventies, and during the period 1990 – 2004, the technique was fully developed and implemented in several European countries such as Germany, Switzerland, Sweden, and France in the form of contract specifications related to both soil and asphalt constructions. A number of case histories have also been documented regarding the use of Intelligent Compaction both in Europe and the U. S. (1, 2, 3). However, the use of this
technique in the U. S. is still in its experimental stages. During the 2002 International Scanning Tour sponsored by the AASHTO and the FHWA, Intelligent Compaction was identified as the next generation of compaction systems to be used in the accelerated construction of bridge and embankment foundations. The knowledge gained during the Scanning Tour was followed up by a TRB Session during the 83rd Annual Meeting (2004) where the Swedish, German and Swiss experts presented technical papers about intelligent systems for quality assurance and quality control in soil compaction. It is known that several DOTs across the U. S. are currently evaluating the Intelligent Compaction technology for future implementation purposes. For example, the Switzerland based company AMMANN-America Inc. has recently performed Intelligent Compaction demonstration projects in New England, North Carolina, Florida, Texas, and Nevada for asphalt and soil compaction. Similarly, Germany based company BOMAG performed Intelligent Compaction demonstrations on a road embankment at the MnROAD facility in Minnesota in 2004.

Although Intelligent Compaction was successfully incorporated in the national specifications of some European countries, there are some fundamental issues that need to be addressed before it can be implemented in the U. S. One of the key issues is related to the departure from the density based specification to a stiffness/modulus based specification when using the Intelligent Compaction techniques. Since compaction specifications have been carried out for decades in terms of density and water content, the complex relationship between density and modulus, and modulus and water content need to be thoroughly investigated. Due to the fact that the upcoming mechanistic pavement design methods will exclusively use resilient modulus to characterize soils and foundation materials, there may be an additional motivation to move towards stiffness or modulus based compaction. If properly implemented, Intelligent Compaction can readily yield the as-constructed in-situ modulus of the pavement foundation layers which can then be used as a QC/QA indicator. Essentially, the shape of the modulus versus the water content curve for various types of pavement and embankment soils need to be established (3). These fundamental relationships should preferably be determined from a simple laboratory test (to be developed as part of this research program) analogous to the use of Proctor method for density-moisture content relationships. Field compaction specification can then be developed by identifying a target modulus, and defining the Percent Relative Compaction in terms of a modulus, rather than the density. Similar to the European countries where Continuous Compaction Control has been integrated in the national specifications, the existing density-based specifications in the U.S. need to be thoroughly studied, and modulus based specifications need to be incorporated and drafted as a necessary step towards implementation of the Intelligent Compaction technique in the U. S.

III. Research Objective

The specific objectives of this research endeavor are: (i) to investigate the fundamental relationships between the modulus and water content of unbound and stabilized soils used in pavements, foundations and embankments; (ii) to develop a laboratory testing protocol for routinely characterizing the relationships between the modulus and water content, and
establishing target values for field specifications; and (iii) prepare modulus-based draft specification for soil compaction in accordance with the findings of (i) and (ii).

IV. Estimate of Problem Funding and Research Period

Estimated cost for this research will be $450,000, with a research period of 3 years.

V. Urgency, Payoff Potential, and Implementation

Intelligent Compaction will largely automate the compaction process, essentially eliminate the possibilities of under or over-compaction, and will provide continuous on the fly assessment of the job quality during the construction work. These capabilities are currently non-existent with the conventional techniques, and if implemented properly, will tremendously improve efficiency and maximize productivity during field compaction. The proposed research is an essential step towards implementing the Intelligent Compaction techniques in the U. S.

VI. References


I. Problem 2: Enhancing Effectiveness of Cement Stabilizers For Deep Mixing in Organic Soils with Chemical Additives

II. Research Problem Statement

Future expansion of transportation routes will find that the only available rights-of-way pass through less than desirable terrain where organic soil deposits will often be found. This fact, coupled with today’s needs for accelerated construction of transportation facilities often does not allow for the time needed to consolidate soft soils in deposits having high organic contents. Furthermore, previous practice to excavate out and dispose of the organic soils, and replace with granular soils, has fallen out of favor as an environmentally unfriendly solution, which often entails high costs for disposal of the organic soils. However, stabilizing soils of high organic content and peat is well-known to be problematic, and experience with traditional lime and cement stabilizers demonstrates that very low strengths occur. This leads to use of pile-supported structures and embankments for crossing deposits of very soft organic soils, which often is not an economical solution, rather it is one of last resort. When deep mixing methods have been applied to treat highly organic soils, the usual recourse is to increase the amount of
cement injected; but this can lead to generation of excess amount of spoils in the wet mixing methods. The need therefore is to determine what chemical additives can be applied to neutralize or substantially reduce the deleterious aspects of organic soils to enable deep mixing methods to be used in an economic manner to develop required strength of the resulting soil-cement. There is a distinct need for research into economical means of chemically altering these soils to then permit a cost effective deep cement mixing program of ground improvement to produce stable foundations for transportation facilities.

III. Research Objective

The objectives of this study should be to perform extensive literature search both through the grouting and deep mixing industries, and in areas of agriculture and food processing to determine current means for treating waste organic matter that can/may be applicable to treating organic soils and peat in-situ. Of these methods, several would be chosen for laboratory mixing study, and criteria for selection of methods would be adaptability to field implementation in the deep mixing industry. Following laboratory trials, the three most successful methods would be selected for prototype study at actual construction sites, or sites previously treated with traditional deep mixing methods, but which are still available for trial in-situ deep mixing.

IV. Estimate of Problem Funding and Research Period

The estimated cost will be about $800,000 over a four year period.

V. Urgency, Payoff Potential, and Implementation

The urgency of this technology is evidenced in well-documented problems in Scandinavian countries and in European countries in lowland areas planned for high speed rail construction. The difficulty of deep mixing in highly organic clay soils has recently been an issue on the I-95/U.S.Route 1 project in Alexandria, VA where the remedy was to use excess amounts of cement.