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The Application of Dynamic Cone Penetrometer (DCP) to Estimate Structural Properties of Soils Road Pavement
Correlating Miniaturized Pressuremeter and Dynamic Cone Penetrometer Data for Unbound Pavement Layers
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Dynamic Cone Penetrometer Criteria for Evaluation of Subgrade and Aggregate Base Courses
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Probabilistic Model for the Analysis of Dynamic Cone Penetrometer Test Values in Pavement Structure Evaluation

A Potential Model for Compaction Evaluation of Piedmont Soils Using Dynamic Cone Penetrometer (DCP)

Oral Biblical Criticism

Use of Dynamic Cone Penetrometer in Subgrade and Base Acceptance

For the site investigation of stiff soils, dynamic penetration testing, such as standard penetration testing (SPT) and dynamic cone penetration testing (DCP), has been performed. The dynamic cone tip responses, however, have not yet been evaluated. The objective of this study is the development and application of an instrumented dynamic cone penetrometer (IDCP) to evaluate the dynamic cone tip responses by considering the energy transferred into the cone tip. As the preliminary study on the development of the IDCP, the energy losses caused by the rod connection are experimentally estimated and numerically analyzed by considering the transmission and reflection coefficients. Strain gauges and accelerometers are installed in the cone tip and rod head of the IDCP to detect dynamic responses during penetration. Design concerns include the shape of the IDCP, the installation of strain gauges and accelerometers, and the mechanical resistance calibration. The developed IDCP was driven into compacted weathered soils in the chamber to measure the dynamic responses at the rod head and cone tip. From the measured responses, the energy transferred into the rod head and the cone tip was calculated. The experimental and numerical energy loss studies show that the energy loss increases with an increase in the number of rod connections. The penetration-test results show that the energy transferred into the cone tip is significantly smaller than that transferred into the rod head. Furthermore, the energy corrected dynamic responses at the cone tip clearly detected soil layers. This study suggests that energy losses caused by rod connections should be considered and that the IDCP may be a useful tool for the characterization of stiff soils.

Use of the Dynamic Cone Penetrometer (DCP) in the Design of Road Structures

Evaluation of the Dynamic Cone Penetrometer and Its Correlations with Other Field Instruments
Access Free Use Of Dynamic Cone Penetrometer In Subgrade And Base

Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications

Assessment of Material Strength Using Dynamic Cone Penetrometer Test for Pavement Applications

The Apostle Paul expected the vast majority of the recipients of his letters to hear, not read, them. He structured his compositions for the ear rather than the eye. Pauline audiences would hear clues to meaning and structure because they had learned to communicate in a world where those clues were essential to understanding. Recognizable structures and patterns were essential for listeners to organize what they heard, to follow, to predict and to remember the flow of communication. Oral Biblical Criticism examines Paul’s Epistle to the Philippians in light of recent study of oral principles of composition and interpretation.

Cone Penetration Testing in Geotechnical Practice

Problem Statement: In 1998 Iowa State faculty, Dr. Kenneth Bergeson and Dr. David White conducted a study to evaluate the quality of Iowa's highway embankments. They concluded that the construction practices and embankment quality control were insufficient resulting in slope instability and uneven pavement surfaces. They later determined that existing tools and methods for construction quality control (specifically, the Dynamic Cone Penetrometer - DCP) needed to be adapted to more precisely and more efficiently evaluate engineering parameters of compacted embankment fills. DCP had not widely been used as a quality control tool in fine-grain soils that characterize most of Iowa's highways. They proposed two solutions: 1) adopting DCP to fine-grain materials in embankments; and 2) using Iowa State University (ISU)-developed Geotechnical Remote Acquisition of Data System (G-RAD) to collect and analyze data from the DCP. Goal of the thesis project: Given the opportunity to improve embankment construction, it is important to test and document uses of new and existing tools and technologies. The goals of this thesis project are: 1) To demonstrate and document how DCP is used as a quality control tool in testing strength and uniformity of cohesive soils. 2) To demonstrate and document how G-RAD can be used to make DCP data collection and processing more effective. This thesis clearly reviews the demonstration activities, presents the results of those activities, and documents a methodology for utilizing DCP in conjunction with G-RAD to measure and collect data to improve embankment construction. Conclusions: Based on the data gathered, it has been established that the use of DCP in Iowa's cohesive soil embankments improves construction methods by providing data that ensures adequate soil strength is achieved during construction. Traditionally, in-situ measurement of soil strength has been time consuming and impractical. This project demonstrates that G-RAD in conjunction with DCP improves not only the quality of construction but the accuracy and efficiency of the quality control processes. Future use of the DCP and G-RAD system are recommended as a quality control tool for construction of cohesive soil embankments of Iowa.
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Description and Application of Dual Mass Dynamic Cone Penetrometer

Proper design life of road network system requires adequate quality control measures during the construction process to ensure proper material quality and sufficient strength in between the materials. Laboratory tests are often time consuming and sometimes, are not practical while the construction work is going on, in-situ techniques can efficiently evaluate the material properties through simple and less time consuming procedures. Dynamic Cone Penetrometer and Geogauge can play a vital role as an in-situ testing equipment because both have the potential to measure the change in material properties through field tests being performed in the field. Both in-situ techniques was not extensively used in North Texas area. Frequent use of these two equipment during the construction process can expedite the whole construction process because both are handheld devices and can be conducted within a short amount of time, often in minutes. For this study, Dynamic Cone Penetrometer and Geogauge was used to assess the material properties from the tests performed on five construction sites of Horseshoe Project around Dallas, TX. Several points across the width of the pavement have been considered to perform these in-situ tests along with Nuclear Density Gauge test in two of these sites. A thorough analysis has been conducted for the material properties to be determined. Dynamic Cone Penetrometer and Geogauge both were consistent to measure the change in inplace material characteristics of the pavement materials. The design thickness of cement treated base layer where the tests were being performed was 6”. DCP was efficient enough to detect the layer thickness up to a proximity of 0.5 inch and was also able to distinguish layer anomalies between the pavement layers. Cement stabilized base layer provided with a DCPI value which ranges from 0.5 mm/blow to 8 mm/blow whereas, DCPI values were observed to remain within a range of 2 mm/blow to 22 mm/blow. For the top 6" cement treated base layer, unconfined compressive strength was found vary between 210 psi to 1023.5 psi. The highest resilient moduli value was found at the middle of the cement stabilized base layer where it varied from 40,500 psi - 623,285 psi. Young's moduli values for cement stabilized base layer measured with Geogauge also followed the same trend of resilient moduli obtained from the measurements taken with Dynamic Cone Penetrometer.

Soil Liquefaction During Earthquakes

Pressuremeters have commonly been used in the geotechnical engineering discipline for piles and shallow foundations design. Recently, much effort has been put forth to use this device in the design of pavement layers, but has not been accepted. The pressuremeter developed for airport pavements, PENCEL pressuremeter, cannot be used in the roadways due to its probe being too long, and it does not yield a bearing ratio that Department of Transportation employs to determine if a layer is acceptable. With the creation of the 6 inch miniaturized pressuremeter probe, research was conducted in the base and subgrade material in Brevard County, Florida. Along with the miniaturized pressuremeter, the use of the dynamic cone penetrometer was utilized. This device produces a bearing ratio of the soil through its penetration index. The dynamic cone penetrometer is generally used in the pavement realm for quality control of the layers' bearing ratio. By using the dynamic cone penetrometer data around the pressuremeter's probe, linear correlations were created and analyzed with the
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pressuremeter parameters including: liftoff pressure, initial elastic modulus, elastic modulus range, initial reload modulus, final reload modulus, average reload modulus, and limit pressure. The liftoff and limit pressure both correlated well with the bearing ratio of the subgrade and base layer. However, the elastic modulus of the pressuremeter only correlates well with the subgrades' bearing ratio due to the dynamic cone penetrometer's inadequacies. The maximum California Bearing Ratio the device can yield is 100 when typically the base layer material is much stronger than that. Therefore, the dynamic cone penetrometer yields more accurate California Bearing Ratio in the subgrade layers whose bearing ratios are much smaller than 100. The reload modulus parameters did not correlate due to the variance in the pressure of the tests when conducting cyclic loads. Through this research, strong linear correlations were developed between the parameters of the pressuremeter and the pavement layers' bearing ratio. Due to smaller probe and strong correlations being developed, the miniaturized pressuremeter should be accepted into the pavement design discipline.

Nondestructive Testing of Pavements and Backcalculation of Moduli

In Situ Testing Methods in Geotechnical Engineering covers the field of applied geotechnical engineering related to the use of in situ testing of soils to determine soil properties and parameters for geotechnical design. It provides an overview of the practical aspects of the most routine and common test methods, as well as test methods that engineers may wish to include on specific projects. It is suited for a graduate-level course on field testing of soils and will also aid practicing engineers. Test procedures for determining in situ lateral stress, strength, and stiffness properties of soils are examined, as is the determination of stress history and rate of consolidation. Readers will be introduced to various approaches to geotechnical design of shallow and deep foundations using in situ tests. Importantly, the text discusses the potential advantages and disadvantages of using in situ tests.

In Situ Foundation Characterization Using the Dynamic Cone Penetrometer

A Correlation Between Dynamic Cone Penetrometer Values and Pavement Layer Moduli

Use of the Dynamic Cone Penetrometer (DCP) in the Design of Road Structures

The Dynamic Cone Penetrometer (DCP) is one of the least expensive testing devices able to characterize base and subgrade properties. To fully use the DCP in pavement evaluation, an empirical relationship between DCP penetration rate and layer modulus is required. However, the literature on this correlation is limited. This study incorporates a total of 198 DCP and Falling Weight Deflectometer (FWD) tests done over 8 years on various types of highways (Interstate Highway, US, and Farm-to-Market). The computer program MODULUS was employed to backcalculate the layer moduli from the FWD results to build a correlation with
DCP results. A comparison was made with the widely-used model by Powell et al. (1984). It is found that the difference between the two models decreases as the Penetration Rate (PR) increases. For a PR of less than 10 mm/blow, the difference between these two models was over 10%. The difference is only about 1.7% when the PR is 80 mm/blow. Without knowing the true moduli, it is impossible to tell which equation is better. The correlation developed here provides another option and allows researchers to recognize the range of variability.

In Situ Testing Methods in Geotechnical Engineering

Application of the Dynamic Cone Penetrometer to Minnesota Department of Transportation Pavement Assessment Procedures

Feasibility of Using Hand-held Dynamic Cone Penetrometer for Analyzing Soft Subgrade Quickly

Instrumented Dynamic Cone Penetrometer Corrected with Transferred Energy Into a Cone Tip

Use of the Dynamic Cone Penetrometer to Verify and Correlate with Soil Subgrade and Aggregate Base CBR Values for the Purposes of Design of Low Volume Traffic Asphalt Concrete Roadways

The Dynamic Cone Penetrometer in Compaction Verification on a Model Road Pavement

The potential use of the Dynamic Cone Penetrometer (DCP) as a compaction quality control tool is investigated in this study. The DCP is a simple device and relatively inexpensive to operate. Results from a laboratory testing program performed on three piedmont residual soils with appreciable fine content (>60%) yielded correlation patterns for the estimation of moisture content (w) and dry unit weight (\(\gamma_{dry}\)), based on the DCP penetration rate (PR). The PR-liquidity index (LI) data were best correlated with an equation in the form of \(LI = A \log PR - Bm\). For the test soils, \(A = 0.65\) and \(Bm = 1.2\). On the other hand, the PR-degree of saturation (S) data were best correlated with the equation in the form of \(S = 1 - e^{Cm*PR}\) with the \(Cm\) coefficient estimated equal to -0.065. Using the principles of soil mechanics, \(w\) and \(\gamma_{dry}\) are calculated based on the predicted LI and S values, respectively. Using the water content and unit weight models, and on the average, the water content was underpredicted by 0.2% and the dry unit weight was overpredicted by 0.3 kN/m³. The
developed model parameters are expected to vary for different soil types as well as compaction effort and a field calibration procedure in which moisture contents and dry densities are evaluated by alternative means, on a limited scale, is recommended.

Guidelines Towards the Use of a Rehabilitation Design Method Based on Dynamic Cone Penetrometer (DCP) Measurements as Developed in South Africa

The Use of the Dynamic Cone Penetrometer (DCP)

The dynamic cone penetrometer data had been conventionally used for estimating the base and subgrade California bearing ratio. In recent years, a need for developing mechanistic pavement design procedures has been emphasized. However, to develop mechanistic pavement design procedures, measuring engineering properties of pavement layers is essential. Two modifications to the existing dynamic cone penetrometer have been proposed in this paper for obtaining engineering properties of pavement layers.

Use of Instrumented Dynamic Cone Penetrometer in Pavement Characterization

The Use of the Dynamic Cone Penetrometer to Evaluate Forest Roads

The Application of Dynamic Cone Penetrometer (DCP) to Estimate Structural Properties of Soils Road Pavement

The Minnesota Department of Transportation (Mn/DOT) began testing the dynamic cone penetrometer (DCP) in 1991, finding the DCP an effective tool in the assessment of subsurface pavement conditions and strength. Researchers conducted extensive DCP testing and research on both the Minnesota Road Research Project (Mn/ROAD) and several pilot project sites in an effort to understand its useful applications in Minnesota. Mn/DOT currently specifies two applications of DCP testing in its pavement assessment procedure. One application involves using the DCP as a quality control device during the backfill compaction of pavement edge drain trenches. The second application involves its use in quality control of granular base layer compaction. This report details these applications and includes a copy of both specifications in the appendices.

Correlating Miniaturized Pressuremeter and Dynamic Cone Penetrometer Data for Unbound Pavement Layers
The Dynamic Cone Penetrometer (DCP) is a simple device for measuring the stiffness of unbound materials. The DCP works by driving a steel rod into bases and soil with a preset amount of energy; the stiffness of unbound materials at different depths can be measured by continuously monitoring the rate of penetration, yielding a stiffness profile. With its ability to collect and analyze data quickly and easily, the DCP compares favorably with other devices used to evaluate an in-situ base and subgrade during construction. The DCP is also the only device available today that can evaluate subgrade quality in all three dimensions. Most highway agencies accept unbound materials in base and subgrade based on density tests. But density is not a measurement of the strength (stiffness) of these materials. Field data collected in this study indicated that accepting the subgrade based on density tests did not guarantee the strength met design requirements. Accepting the base and subgrade based on density is thus one of the weak links in the process of designing and constructing pavement. During the 2003 and 2004 construction seasons, the Ohio Research Institute for Transportation and the Environment (ORITE) collected DCP data from 10 road projects in Ohio. Experience from this study proves that the DCP is a viable alternative device to evaluate in-situ base and subgrade materials during construction. Data collected shows that engineers can use the DCP to quantify the construction quality of the as-built materials. Based on this study, ORITE concludes that adopting DCP testing in unbound material acceptance specifications can greatly improve the monitoring of final product quality and thus enhance pavement performance. This report describes the ORITE study. The report also provides a construction site DCP testing procedure and proposes a set of DCP unbound material acceptance criteria and standards.

Evaluation of the Dynamic Cone Penetrometer (DCP) and Geo-technical Remote Acquisition of Data System (G-RAD) for Earthwork Quality Control Testing for Cohesive Soils

Use of Dynamic Cone Penetrometer in Subgrade and Base Acceptance

This book provides guidance on the specification, performance, use and interpretation of the Electric Cone Penetration Test (CPU), and in particular the Cone Penetration Test with pore pressure measurement (CPTU) commonly referred to as the "piezocone test".

Dynamic Cone Penetrometer Criteria for Evaluation of Subgrade and Aggregate Base Courses

Colorado Department of Transportation (CDOT) does not have evidence how the Dynamic Cone Penetrometer (DCP) test results correlate to other test methods (say, R-value) for Colorado's pavement subgrade. Even, the correlation between single-mass, and dual-mass DCP (which are two ways of conducting DCP test) is still unknown. Pavement Mechanistic Empirical Design (P MED) guide provides some correlations among different subgrade tests. However, those correlation are derived from national data. Research was thus needed to investigate the correlation between single-mass, and dual-mass DCP, and determine
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correlations among other subgrade tests for Colorado’s pavement soils.

The Use of Dynamic Cone Penetrometer for Determining the Strength of Existing Pavements and Subgrades

Rapid Determination of CBR with the Portable Dynamic Cone Penetrometer

This report describes the dynamic cone penetrometer (DCP), its use, and the application of data obtained by its use. Procedures are presented for using the DCP to measure soil strength and correlating DCP index with CBR strength values required for operation of aircraft and military vehicles on unsurfaced soils. Procedures are also presented for using the DCP to evaluate aggregate surfaced roads and airfields for military operations based on the existing soil strength conditions. Aggregate airfields, Penetrometers, Aggregate roads, Unsurfaced soils.

Methods of Test for Soils for Civil Engineering Purposes

Specification target values for granular materials and fine grained soils are proposed. For granular material, the grading number and field moisture content are used to select the dynamic cone penetrometer (DCP) and light weight deflectometer (LWD) target values. A sieve analysis is used to determine the grading number and an oven dry test to determine the field moisture content. For compacted fine grained soil, the plastic limit and field moisture content are used to determine the target values. The plastic limit is used to classify the soil and to estimate the optimum moisture content for compaction. This report also provides further standardization of the LWD and DCP testing procedures and recommends three seating drops to ensure greater uniformity during testing. The DCP and LWD estimate the strength and modulus of compacted materials. More specifically, they measure the penetration and deflection. When measuring penetration and deflection, the moisture content remains a critical quality control parameter for all compaction operations. Therefore, the moisture content needs to be measured, or estimated confidently, at each location. The LWD and DCP are performance related construction quality assurance tests that are expected to: increase compaction uniformity, lower life cycle pavement costs, increase inspector presence at the construction site, improve documentation, and increase inspector safety and productivity.

Description and Application of Dual Mass Dynamic Cone Penetrometer

The Use of a Dynamic Cone Penetrometer to Design a Flexible Pavement for a Forest Haul Road in the Noonan Forest

Use of a Light Dynamic Cone Penetrometer in Malaysia
Compaction verification studies were conducted on a model site during a road construction project. Three compaction plants of different capacities were used on model pavements constructed using loose lifts of lateritic gravel measuring 120, 170, and 220-mm thick. After every two passes of the roller the dynamic cone penetrometer (DCP) test was conducted on the compacted layer alongside the sand replacement test to determine the level of compaction. A correlation was made between the sand replacement and the DCP tests resulting in a calibration equation of the general form $\log(LC) = \gamma - \xi \log(DPI)$ between the DCP penetration rate, DPI, and the level of compaction (LC) achieved as measured by the sand replacement method. $\gamma$ and $\xi$ were found to be 2.184 and 0.337, respectively. The level of compaction values was back-calculated across the depth of the pavement using the DPIs. These values indicated that the sand replacement method gives the average degree of compaction over the depth tested whereas the DCP test allows the detection of low-level compaction pockets deeper within the layer.

Use of the Dynamic Cone Penetrometer to Estimate the California Bearing Ratio of Aggregate Base Courses

Reliable analysis and interpretation of the results obtained under testing in pavement design and evaluation require consideration of the nature of the values under study, including construction of the probabilistic model that describes their statistical behavior. The investigation has been focused on the testing data peculiarities related to the dynamic cone penetrometer (DCP), which has become one of the extensively used testing devices in pavement evaluation. Application of the probabilistic models containing the stochastic components in pavement design and evaluation is determined by the nature of the pavement component characteristics, including subgrade soils, formed under the influence of various factors. The probability distribution model for the DCP values has been described based on the analysis of the statistical peculiarities of the observed data. The model reflects the main features and physical essence of the DCP values. Some differences in statistical conclusions based on the models under study have been demonstrated. Models can be recommended that have a positive influence on studying relationships between the DCP characteristics and various pavement design parameters and increase the reliability of estimates and solutions in pavement structure evaluation.

Using the Dynamic Cone Penetrometer and Light Weight Deflectometer for Construction Quality Assurance