Research and Communication Services
Wisconsin Department of Transportation
608-261-8198
wisdotresearch@dot.state.wi.us
Request a TSR: pat.casey@ctcandassociates.com

Intelligent Compaction of Soils

Prepared for
Technical Oversight Committee on Geotechnics
Wisconsin Highway Research Program

Prepared by
CTC & Associates LLC
WisDOT Research & Communication Services
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Transportation Synthesis Reports are brief summaries of currently available information on topics of interest to WisDOT technical staff. Online and print sources for TSRs include NCHRP and other TRB programs, AASHTO, the research and practices of other transportation agencies, and related academic and industry research. Internet hyperlinks in TSRs are active at the time of publication, but changes on the host server can make them obsolete.

Request for Report

The Wisconsin Highway Research Program's Technical Oversight Committee on Geotechnics requested a synthesis report on the state of the practice and research on intelligent compaction systems for soils and bases. The TOC also requested a literature search on the same topic.

Summary

Since a joint FHWA and AASHTO scan tour of Europe in June 2002, the impetus to examine and implement intelligent compaction technology in the United States has gained momentum. Our literature search of databases for the years 2000 to present found 11 documents that pertain to intelligent compaction of soil, all published in 2002 or since, including five from 2006.

Intelligent compaction entails the use of sensing equipment that reads subgrade strength, density, stiffness, or modulus based on compaction equipment behavior. Its use on subgrade is at a more mature stage than its use on asphalt pavement. It is credited by manufacturers researchers as useful in creating uniformly stiff subgrades; identifying weak or soft spots in subgrade; and, depending on calibration and data analysis, providing real-time modulus, stiffness, or density data. Intelligent compaction promises QA/QC applications that improve on current methods of in-situ field testing because it delivers qualitative data for the entire coverage area of compaction, not just the incremental points gathered currently and sometimes used to project conditions for an entire field site.

Common technical concerns include the interaction of moisture with compactors and intelligent compaction instrumentation, and research frequently addresses calibration or data adjustment based on regression analyses for moisture content.

FHWA and Minnesota DOT drive much of the research. FHWA recently approved a Transportation Pooled Fund study that currently includes 12 participating agencies. Mn/DOT has active research as well as several finished studies, demonstrations, and presentation listed below that deal with intelligent compaction of soils; the technology plays a prominent role in MnDOT's mechanistic-empirical design implementation efforts, in part because of the real-time modulus feedback the equipment gives.

We start here with a **Primer** on intelligent compaction, including industry news about the technology and models on the horizon, as well as a detailed 2003 study from the University of Idaho of the emerging technology. Then we turn to **FHWA** and its pooled fund project and the scan tour. We then look at work in **Minnesota** and **Iowa**, before turning to our **Literature Search**, which we present in the format of our Transportation Literature Searches. We conclude with **Research in Progress** that may interest WisDOT. When possible, we provide contact information of persons familiar with particular reports or active studies.

Intelligent Compaction – A Primer

The following articles offer a quick, broad-brush look at the technology as it has developed over the last few years, including recent industry-based news pieces and a detailed technical study from the University of Idaho.

"Intelligent Compaction: Outsmarting Soil and Asphalt," Walt Moore, *Construction Equipment*, April 1, 2006. This article offers a detailed survey of current and coming technology and technical issues. http://www.constructionequipment.com/article/CA6321917.html.

- Three manufacturers have intelligent compaction machines for soil and aggregate in the U.S., including Ammann (which may begin marketing soil machines under another manufacturer's name), Bomag, and Dynapac.
- Caterpillar will have one in 2007, and Sakai will add one in 2008.
- Machines for asphalt have also been or will be introduced.
- Cost of IC models will run 20 to 30 percent higher than conventional compacters.
- Most questions of technology concern asphalt stiffness measurement.

"Compaction: Continuing developments may bring more sophistication in monitoring and testing your compaction results," Peter Hildebrandt, *Grading & Excavation Contractor*, July/August 2005. This article gives a broad look at intelligent compaction technology for earthwork and paving, including machinery from Bomag, Ammann America, and Ingersoll-Rand. http://www.gradingandexcavation.com/gx_0507_compaction.html.

Intelligent Compaction: Overview and Research Needs, Jean-Louis Briaud and Jeongbok Seo, December 2003. This detailed technical study supports intelligent compaction as effective in addressing weak subgrade spots without over-compaction, in providing soil modulus data where rolled, and in producing uniform compaction layers. Research needs identified include performance comparisons of conventional and intelligent compactors, studies of compaction depth of various rollers for various soils, draft specifications, development of a simple target modulus test, and analysis of the interdependence of modulus and water content. http://www.webs1.uidaho.edu/bayomy/trb/afh60/IntCompaction_Briaud_September2004_.pdf.

FHWA

FHWA in 2006 completed a *Strategic Plan for Intelligent Compaction*, a report not available on the Internet. The document clearly influences recent FHWA investigations of intelligent compaction, particularly the new Transportation Pooled Fund study, below. Please consult John Cherney at the WisDOT Library to secure a copy; 608.266.0724 or john.cherney@dot.state.wi.us.

Pooled Fund Study TPF-5 (128), Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base and Asphalt Pavement Material. This FHWA-led group currently involves 12 states and was approved in the summer of 2006. Efforts are based on the FHWA report, *Strategic Plan for Intelligent Compaction*, and will focus on developing data from European experience rather than manufacturer claims, developing specifications for QC/QA use, and conduct IC construction in several states. http://www.pooledfund.org/projectdetails.asp?id=359&status=4. (Original solicitation at http://www.pooledfund.org/documents/solicitations/954.pdf.)

Contact. John D'Angelo, FHWA, 202.366.0121 or john.d'angelo@fhwa.dot.gov.

"A Long-Life Future for Concrete Pavements," *Focus*, October 2006. While focused on concrete pavement, this article notes that FHWA has recommended a five-year study of intelligent compaction based on its *Strategic Plan*, and the recently approve pooled fund study will contribute to that effort. http://www.tfhrc.gov/focus/oct06/02.htm.

Innovative Technology for Accelerated Construction of Bridge and Embankment Foundations in Europe, FHWA-PL-03-014, Chris Dumas, et al., September 2003. The FHWA/AASHTO Scan Team report outlines findings from a tour of demonstrations of accelerated construction technologies and methodologies in Sweden, the Netherlands, Germany, Italy, and Belgium, joined by technical experts from those countries as well as Finland and the United Kingdom. http://international.fhwa.dot.gov/bridgeemb/BridgeEmbankment.pdf.

- Considered 30 technologies, 15 processes.
- Intelligent compaction measures dynamic modulus in real time.
- Intelligent compaction provides 100 percent quality control coverage for performance-based specifications, could key implementation of warrantees and guarantees for earthwork and pavement work.
- Germany uses real-time, automatic controlled variable roller compaction with equipment from Bomag; measures stiffness, density (pp. 18-19).

Minnesota

A champion of intelligent compaction for both soils and asphalt pavement, Mn/DOT situates its interest in the technology in its mechanistic-empirical design implementation program. This site includes links to studies completed and ongoing, some highlighted in this report, and includes several slideshows and presentations as well as research documents. http://www.mrr.dot.state.mn.us/research/mnpave/meresource.asp. We consider here a handful of the documents.

Intelligent Compaction: A Minnesota Case History, F. Camargo, et al., University of Minnesota Geotechnical Conference, February 17, 2006. This study entailed comparing data from intelligent compactors manufactured by Ammann, Bomag, and Caterpillar against data from hand-held field-testing devices. http://www.mrr.dot.state.mn.us/research/mnpave/MnGeotechIC011006final.pdf. Findings include:

- The Bomag roller proved capable of classifying modulus for the entire lift in the field, and provides 100 percent verification of the area.
- Researchers developed preliminary plan employing GIS technologies for converting data into usable formats for field inspectors.
- Suggested several system data improvements to manufacturers.

Evaluating Thick Lift Limerock-Base Course, SR-826 Miami Florida, Draft Final Report, April 2005. This study employs intelligent compaction equipment and analysis toward its investigation of thick lift embankments. Specific sections of interest are 2.3 in Chapter 2, discussion of base stiffness results in 4.5 in Chapter 4, and in the conclusions, Chapter 5.
http://www.dot.state.fl.us/construction/Engineers/Research/Base%20Thick%20Lift%20Report.pdf.

Intelligent Compaction – Mn/DOT Demonstrations 2005, Slideshow, December 2005, John Siekmeier, Mn/DOT.
http://www.mrr.dot.state.mn.us/research/mnpave/Iowa_Geotech_JohnS_revised.pdf
This slideshow offers content on machinery used and 2006 plans and demonstrations, shows some data from German studies, and notes goals of the pooled fund study and other efforts.

Contact. John Siekmeier, Research Project Engineer, 651.366.5417 or john.siekmeier@dot.state.mn.us.

Iowa

Iowa's Center for Transportation Research and Education at Iowa State University has conducted a number of field investigations of intelligent compaction equipment, including a study with Mn/DOT that we cite in the Research in Progress section of this report. The following studies originate with the Iowa Department of Transportation.

Field Evaluation of Compaction Monitoring Technology, Phases I and II. CTRE evaluated Caterpillar, Inc., equipment for intelligent compaction. A preliminary study was followed by extensive field evaluation in Phase II. The machinery calculates compaction based upon machine power output during compaction adjusted with the help of GPS for sloping grade, acceleration, gravity, and internal machine power loss. The goal of the study was to compare such data to in situ measurements of soil properties, including density, strength, stiffness, and more.

Phase I – See full study, *Field Evaluation of Compaction Monitoring Technology, Phase I (TR-495),* September 2004, http://www.ctre.iastate.edu/reports/tr495.pdf. See *Tech Transfer Summary: Soil Compaction Monitoring Technology*, September 2004, http://www.ctre.iastate.edu/PUBS/t2summaries/compaction.pdf. Findings included

- The CAT equipment is promising for QC/QA.
- Relatively good accuracy, with 100 percent coverage results in real time.
- Including water content in regression analysis of equipment data and field measurements improves accuracy.

Phase II – See full study, *Field Evaluation of Compaction Monitoring Technology, Phase II*, March 2006, http://www.ctre.iastate.edu/reports/compaction_2.pdf. See *Tech Transfer Summary: Field Evaluation of Compaction Monitoring Technology*, March 2006, http://www.ctre.iastate.edu/pubs/t2summaries/compaction_2.pdf.

- Researchers developed a compaction model that accurately predicts dry unit weight form compaction energy and moisture content regardless of soil type.
- Including moisture content and moisture-energy interaction in regression analysis, high correlation coefficients were achieved.
- Dry density predictions from machine power data were more accurate than soil strength or stiffness predictions.

- Subgrade depth greater than typical lift thicknesses influence machine power readings.
- Intelligent compaction equipment identified accurately areas of weak or poorly compacted soil on project sites.

Contact. David White, Principal Investigator, 515.294.1463, djwhite@iastate.edu.

Literature Search

Our literature search of academic and transportation databases for intelligent compaction and soils located the following citations. We include the abstracts found in the databases that featured the citations and, when available, links to full documents or summaries. Please contact John Cherney at the WisDOT Library for assistance in securing documents.

Summary. We found 11 English-language documents treating intelligent compaction of soils, including three research studies for Mn/DOT; four articles in academic and trade journals (including conference proceedings); and four articles in transportation agency or industry news publications (one of which was also drawn from Mn/DOT work). Of these 11 documents, five were published in 2006, and two each in 2005, 2004, and 2002, respectively.

Title: Intelligent compaction: The next big thing?
Author(s): Dick Kronick
Date: Fall 2006
Doc ID/URL: *Technology Exchange* (Newsletter of the Minnesota Local Technical Assistance Program), Vol. 14 (4), Fall 2006: 1, 4. http://www.mnltap.umn.edu/publications/exchange/2006-4/2006-4-1-1.html.
Description: 2 pp.
Contents: This article describes three methods and equipment for intelligent compaction of soil and asphalt at sites in Minnesota, and its information is drawn from pages 12-13 of *Minnesota Pavement Conference: Session Summaries* (St. Paul, Minn.: University of Minnesota, LTAP, Feb. 16, 2006), which can be viewed at http://www.mnltap.umn.edu/pdf/2006PaveConSummary.pdf.

Title: Award of Excellence: Dwayne McAninch: Iowa's Largest Earthmoving Contractor Risked Millions on Digital Control and Pushed an Industry into the Future
Author(s): Tudor Hampton
Date: April 2006
Doc ID/URL: *Engineering News Record*, Vol. 256 (14), April 10, 2006: 34-41.
Description: 8 pp.
Contents: This article presents a biographical description of Iowa's largest earthmoving contractor, Dwayne McAninch, recipient of the 2006 Engineering News Record Award of Excellence. McAninch has headed up a movement in digitizing construction equipment and equipping them with GPS receivers in order to allow for precision, economy, and speed. This technology also allows for additional technological developments in the design phase, where architects can provide three-dimensional renderings and feed them directly into the construction equipment. The article also discusses some possible future directions for McAninch, such as studying "intelligent" soil compaction in which machine controls are tied into GPS receivers.

Title: Intelligent compaction control
Author(s): M. Hossain, J. Mulandi, L. Keach, M. Hunt, S. Romanoschi
Date: 2006
Doc ID/URL: *Proceedings of the 2006 Airfield and Highway Pavement Specialty Conference*, Vol. 2006: 304-316.
Description: 13 pp.
Contents: The Intelligent Compaction Control (ICC) consists of continuous compaction control/monitoring compaction using rollers with adjustable compaction energy (amplitude, frequency, and roller speed). In ICC, a number of parameters are measured: displacements/amplitude of the roller (up and down) using the drum mounted accelerometer, frequency, roller speed, and various relative bearing capacity or equivalent stiffness/density values. This paper gives an introduction to ICC and application of ICC for highway embankment projects in Kansas. Three test sections on two routes were compacted using a Bomag Variocontrol (BVC) intelligent roller that produces real time stiffness values of compacted soil. Traditional compaction control measurements included density testing using a nuclear gage, moisture measurements using a speedy moisture tester, and soil bearing capacity measurements using a Dynamic Cone Penetrometer (DCP). The results showed that the intelligent compaction (IC) roller continuously measured the stiffness of soil under compaction and thus, was able to identify locations with lower stiffness in the spatial direction. In general, density increased with multiple passes of the IC roller. The IC roller stiffness was fairly sensitive to the moisture content and the percent compaction obtained in the field. Poor correlation was observed between the BVC stiffness and the CBR values calculated from the DCP results.

Title: Intelligent compaction and in-situ testing at Mn/DOT TH53
Author(s): D. Lee Petersen, Ryan Peterson
Date: 2006
Doc ID/URL: Final report, MN-RC-2006-13, St. Paul, Minn.: Minnesota Department of Transportation, Office of Research Services, 2006. http://www.lrrb.org/PDF/200613.pdf.
Description: 50 pp.
Contents: This report describes an intelligent compaction demonstration project on Mn/DOT TH 53 in Duluth, MN, and the associated field and laboratory testing. The project was conducted during September 2005, using a Caterpillar Model CS-563E vibratory soil compactor, equipped with Intelligent Compaction (both Compaction Meter Value (CMV) and energy or power) and global positioning system (GPS) technology. A Prima light-weight deflectometer (LWD), dynamic cone penetrometer (DCP) and Humboldt GeoGauge were used to collect in situ companion test data at 42 locations. Mn/DOT conducted gradation, moisture content and Procter tests. Location and Compaction Meter Value (CMV) were downloaded for comparison with the in situ testing. CMV data was compared to the in situ data on a point-by-point basis and on the basis of the overall distribution. In general, poor correlations were obtained on a point-by-point basis, likely due to the depth and stress dependency of soil modulus, and the heterogeneity of the soils. Good correlations were obtained between CMV values and DCP measurements for depths between 8-inches and 16-inches deep. The Caterpillar Compaction Viewer software, although still in development at the time of testing, is functional and is well integrated with GPS. It is easy to extract data and do more sophisticated analyses. Surface-covering documentation adds value by identifying potential problem areas where compaction is limited by material, moisture or subgrade deficiencies. LWD testing protocol must be followed to obtain useful results, since measurements vary significantly between successive tests. Relatively good correlations were obtained between LWD and GeoGauge. The GPS technology used for the demonstration is not adequate to distinguish between lifts.

Title: Intelligent Soil Compaction: Technology, Results, and Roadmap
Author(s): Charles R. Nelson, David Lee Petersen, John Siekmeier, Ryan L. Peterson
Date: 2006
Doc ID/URL: Report No. 06-2914, TRB Annual Meeting 2006 CD-ROM. http://www.mdt.mt.gov/research/docs/trb_cd/Files/06-2914.pdf. See slideshow, http://www.mrr.dot.state.mn.us/research/ictgi/trb_Presentation_2006_version4.pdf.
Description: 14 pp.
Contents: Intelligent Compaction, also called Continuous Compaction Control, is a new technique in the United States construction market that uses an instrumented compactor to control soil or asphalt compaction in real time. This paper focuses on compaction of unbound materials. This technology provides one of the first opportunities to apply process control to civil construction. Intelligent Compaction (IC) is based on measuring the mechanical characteristics of the compacted soil, commonly soil stiffness but other properties are also used. Initiatives in both the U.S. and Europe, started more than 10 years ago, have demonstrated the technical viability of measuring in situ soil stiffness. The measured soil stiffness is used to estimate or compute in situ soil modulus, based on assumptions about soil behavior and the interaction between the compaction machine and the soils. Intelligent Compaction offers immense potential benefits in embankment, buried structure, dam and pavement construction. These benefits, including improved quality, reduced compaction cost, reduced life-cycle cost and the integration of design with construction and maintenance, arise from surface-covering documentation and process control of the compaction operation.

Title: Vibratory plate loading of compacted and instrumented field soil beds
Author(s): Michael A. Mooney, Cyril O Bouton
Date: May 2005
Doc ID/URL: *Geotechnical Testing Journal*, Vol. 28 (3), May 2005: 221-230.
Description: 10 pp.
Contents: The paper reports on full scale vibratory plate loading tests that were performed to investigate nonlinear plate and soil acceleration response when subjected to various plate loading frequencies and amplitudes. The focus of this paper is on characterizing the vibration response upon compacted soil, a reference state for intelligent compaction.

Title: Continuous compaction control: MnROAD demonstration
Author(s): D. Lee Petersen
Date: 2005
Doc ID/URL: Final report, MN-RC-2005-07, St. Paul, Minn.: Minnesota Department of Transportation, Office of Research Services, 2005. http://www.lrrb.gen.mn.us/PDF/200507.pdf.

Description: 132 pp.
Contents: In September 2004, engineers conducted a Continuous Compaction Control (CCC) demonstration at MnROAD, an outdoor pavement test facility. Continuous Compaction Control (CCC), also called Intelligent Compaction (IC), is a new technique in the United States construction market that uses an instrumented compactor to measure soil or asphalt compaction in real time and adjusts compactive effort accordingly to control the level of compaction. This demonstration used the BOMAG Compactor and focused on Young's soil modulus as the soil parameter of interest. CCC may potentially provide substantial benefits, including improved quality due to more uniform compaction, reduced compaction costs because effort is applied only where necessary, reduced life-cycle cost due to longer pavement life, and a stronger relationship between design and construction. State departments of transportation have expressed interest in exploring this method as a way of meeting quality-assurance requirements within a tight budget environment. In general, this study found CCC to be an effective quality-control mechanism for soil compaction. However, further questions arose as a result of the study and certain variables affected the results and measurements, including moisture content and the use of different measurement tools. Further research is needed to determine the level of uniformity in using CCC and the extent of reliability in achieving target values when using this method.

Title: Never guess again: Intelligent compaction making precision commonplace at the jobsite
Author(s): B. Wilson
Date: August, 2004
Doc ID/URL: *Roads and Bridges*, Vol. 42 (8): 22-25.
http://www.roadsbridges.com:80/rb/index.cfm/powergrid/rfah=|cfap=/CFID/3211407/CFTOKEN/89068603/fuseaction/showArticle/articleID/5396.
Description: 4 pp.
Contents: This article focuses on intelligent compaction systems that take the guesswork out of soil or asphalt compaction. These systems automatically measure and control the energy output of a roller's drum. Although each manufacturer's system has its own specific method of execution, they all generally function in the same way by measuring and reacting to the changing stiffness of the material being compacted. The compaction systems use devices such as accelerometers to measure both the horizontal and vertical reaction of the drum to the material it is compacting. The systems then actually control the output of the drum. The process, which is known as vectoring, involves a microprocessor that calculates the accelerometer's gathered data and then redirects the energy of the drum to avoid over-compaction. Several of these intelligent compaction systems also include an asphalt mat temperature sensing capability that help (sic) in achieving error-free applications. Additional benefits associated with intelligent compaction systems include a longer service life for equipment, increased efficiency, and the documentation of jobsite results through on-board printers.

Title: Intelligent compaction with vibratory rollers: feedback control systems in automatic compaction and compaction control
Author(s): Roland Anderegg, Kuno Kaufmann
Date: 2004
Doc ID/URL: *Transportation Research Record No. 1868: Soil Mechanics,* 2004: 124-134.
Description: 11 pp.
Contents: Dynamic compactors with parameters that adjust automatically to the condition of the subgrade form the basis for intelligent compaction. Dynamic soil compactors create nonlinear vibrations, and the typical characteristics of these vibrations are taken as the basis for the feedback control system for intelligent compaction. With the model of the machine and the soil as the starting point, the periodic loss of contact between the drum and the subgrade is postulated to be the main nonlinear effect. This nonlinearity leads to near periodic and subharmonic vibration phenomena, and it can bring about unstable drum dynamics. The machine behavior can be investigated with the help of the chaos theory. Feedback control systems for rollers are based on the results from the theory of nonlinear oscillations, and they allow optimal compaction performance thanks to continuous adjustment to the compaction status. Starting with large amplitudes and low frequencies, the automatic control system ensures a good depth effect. As the compaction increases, the frequencies rise and the amplitudes are automatically reduced; those actions lead to optimal surface layer compaction at the end of the process. The soil stiffness measurement, which is performed in parallel with the automatic control, is directly correlated with the plate-bearing test to enable continuous compaction control. In conjunction with a documentation system, intelligent compaction makes it possible to prove the homogeneity and the achieved compaction degree. In the field, intelligent compaction ensures that compaction jobs are completed in a minimum number of passes and allows monitoring of results as work progresses. In addition to optimal compaction with no risk of overcompaction, laboratory costs are reduced and process reliability is maximized.

Title: Making a difference
Author(s): A. Peterson
Date: 2002
Doc ID/URL: *World Highways/ Routes du Monde*, Vol. 11 (8): 34-35, 38, 41-42.
Description: 5 pp.
Contents: Proper compaction is essential in ensuring a durable road surface. This article describes the major types of compaction rollers available, and the benefits and drawbacks of each. Vibratory asphalt compaction rollers are the most widely used. Although vibratory rollers work well for the normal thickness of a traditional asphalt wearing course, they are less suitable for compacting thinner stone mastic asphalt wearing courses. The combination of low frequency and high amplitude needed to achieve the desired density and depth of compaction for thicker layers has a tendency to over-compact thinner layers and crush their larger aggregates. An oscillating roller, which provides a horizontal alternating sheer force to achieve faster compaction, has been developed for bridge decks and other surfaces where the power of a vibratory roller can be harmful. Static rollers are also available. One promising new development is an "intelligent" roller that can monitor and adjust the amplitude according to the soil type and desired degree of compaction.

Title: Health monitoring during vibratory compaction of soil
Author(s): Michael A. Mooney, Essam F. Tawfik, Godfrey B. Chan, Jie L. Pan
Date: 2002
Doc ID/URL: *Proceedings of SPIE, The International Society for Optical Engineering, Smart Structures and Materials 2002: Smart Systems for Bridges, Structures, and Highways,* March 18-20, San Diego, Calif., Vol. 4696, 2002: 112-123.
Description: 12 pp.
Contents: Vibratory compaction is a proven and commonly adopted densification technique applicable for a wide variety of soil types and compositions. There is a clear need to develop performance-based intelligent vibratory soil compaction techniques wherein the state of the soil is determined during compaction (i.e., health monitoring, continuous quality control). The application of vibration-based structural health monitoring strategies utilized in damage detection applications to the problem of soil compaction appears promising. A vibratory compactor (plate or drum) operating on a soil mass constitutes a coupled dynamic system. As the soil densities and its mechanical properties change, the dynamic response of the compactor will change. This paper examines the changes in dynamic response of a vibratory plate during compaction. The analysis of vibration data taken from sensors on the plate and embedded within the soil reveals clear changes in both amplitude and frequency components that provide insight into the evolving nonlinear response of the system.

Research in Progress

The following three active projects investigate intelligent compaction for geotechnical applications.

NCHRP Project No. 21-09, Intelligent Soil Compaction Systems. With roughly a $600,000 budget, this NCHRP project investigates investigations many aspects of intelligent compaction of subgrades and base courses. The project began in August of 2006, and is to conclude in February of 2009, with an aim of developing standard specifications for use of intelligent compaction systems in the United States. http://www.trb.org/trbnet/projectdisplay.asp?projectid=672 or http://rip.trb.org/browse/dproject.asp?n=11206.

- Project will build on specifications from Finland, Germany, Japan, Sweden, Switzerland, other countries.
- Background investigation will include literature search, discussions with manufacturers, identification with state DOTs of study sites, construction projects that will employ intelligent compaction.
- Phase I will focus on background investigation, field study of one site, determine importance of physical conditions on accuracy, and will produce preliminary specifications.
- Phase II will focus on field study of multiple sites, data collection, evaluation of Phase I preliminary specifications, and will yield final specifications in a final report.

Contact. Timothy Hess, TRB, Project Manager, 202.334.2049 or timhess@nas.edu. Michael Mooney, Colorado School of Mines, Principal Investigator, 303.273.3650, mooney@mines.edu.

Demonstration of Intelligent Compaction Control for Embankment Construction in Kansas. Sponsored by the Kansas Department of Transportation, this study seeks to demonstrate the use of intelligent compaction for performance-based specifications and quality control of highway embankments. The study began in July of 2005, and was funded $52,000. http://rip.trb.org/browse/dproject.asp?n=11029.

Contact. Morris M. Hunt, Kansas DOT, Project Manager, 785.296.3008, or mhunt@ksdot.org. Mustaque Hossain, Kansas State University, Principal Investigator, 785.532.1576 or mustak@ksu.edu.

Field Validation of Intelligent Compaction Monitoring Technology for Unbound Materials and HMA. This study entails evaluation of several Minnesota test sites at which intelligent compaction is being used on earthwork and on asphalt pavement for quality control and assurance. Begun in October of 2005 for Mn/DOT, the study will conclude in February 2007. http://rip.trb.org/browse/dproject.asp?n=11386 or http://www.ctre.iastate.edu/research/detail.cfm?projectID=724838391.

Contact. Michelle Regenold, Iowa State University, Center for Transportation Research and Education, Project Manager, 515.296.0835 or mregenol@iastate.edu. David White, Iowa State University, CTRE, Principal Investigator, 515.294.1463 or djwhite@iastate.edu.