Topic: Quantifying Benefits of Improved Compaction (Idea 121)

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Prepared for: Omar Fateh
Prepared by: Marilee Tuite, x3797

Resources searched: MnDOT Library catalog, TRID, RiP, Transport, ASCE Civil Engineering database

Summary: Results were found using terms from the Ideascale description: compaction, intelligent compaction, air voids, longitudinal joints, asphalt pavement, pavement performance, benefits, data. They are divided into most relevant and less relevant.

Most Relevant Results:

Title: Enhanced Compaction to Improve Durability and Extend Pavement Service Life: A Literature Review
Source: FHWA and National Center for Asphalt Technology at Auburn University (2016)
Abstract: This literature review was conducted to provide information to support the Federal Highway Administration Asphalt Pavement Technology Program strategic direction on extending pavement service life through enhanced field compaction. The results from the past studies clearly indicate the effect of low in-place air voids on the fatigue and rutting performance of asphalt pavements. A 1% decrease in air voids was estimated to improve the fatigue performance of asphalt pavements between 8.2 and 43.8% and the rutting resistance by 7.3 to 66.3%. In addition, a 1% reduction in in-place air voids can extend the service life by conservatively 10%. Based on these results, a life cycle cost analysis (LCCA) was conducted on two alternatives in which the exact same asphalt overlay would be constructed to 93% and 92% densities to illustrate the effect of in-place air voids on the life cycle cost of asphalt pavements. The LCCA results show that the user agency would see a net-present-value cost savings of $88,000 on a $1,000,000 paving project (or 8.8%) by increasing the minimum required density by 1%. Due to its significant effect, the cost of providing increased in-place density can be significantly less than the operation, maintenance, and road user cost savings realized due to extended service life of the pavements. In an AASHTO survey of state agencies' targets for field compaction conducted in 2007, the majority of states responding to the survey had a compaction target of 92%, but over one-third of the responding agencies had compaction targets less than 92%. Most of these in-place density requirements currently adopted by states were determined based on what levels of in-place density could be achieved in the past using prior construction technologies. Since in-place density has a significant impact on the performance of asphalt pavements, agencies may consider implementing a higher in-place density requirement that can be
achievable by following best practices and adopting new asphalt pavement technologies and knowledge gained from recent research. Some of these technologies and knowledge, including warm mix asphalt, intelligent compaction, improved construction joints, and improved agency specifications to incentivize achieving higher in-place densities, are briefly discussed in this report.

Full-text PDF: http://eng.auburn.edu/research/centers/ncat/files/reports/2016/rep16-02.pdf

Research Project in Process:
Title: Best Construction Practices for Longitudinal Joint Construction and Compaction
Sponsor and Performing Organizations: South Carolina DOT; Clemson University
Expected Completion: Sept. 15, 2017
Abstract: The overall goal of this research is to identify best practices for construction of longitudinal joints in asphalt pavements in South Carolina. The final product of the research will include a guide of best practices for construction of longitudinal joints and recommendations for revisions to the current specification related to joint construction. These products will have the potential to enhance the quality of South Carolina’s transportation infrastructure at a lower life-cycle cost than under the present practices by minimizing premature pavement failure at longitudinal joints. The results from this project will provide South Carolina Department of Transportation (SCDOT) and asphalt paving contractors with information that can be used to construct longer-lasting asphalt pavements by improving the integrity of longitudinal joints.

RiP record: https://trid.trb.org/View/1420922

Title: Finite element modelling of field compaction of hot mix asphalt. Part II: Applications
Abstract: A constitutive model is developed and implemented in the finite element system three-dimensional computer-aided pavement analysis for the simulation of hot mix asphalt field compaction. This model was used to study the influence of frequency and amplitude of vibratory compaction rollers on the level of compaction. In addition, it was used to analyze the influence of various methods for compacting longitudinal joints on the percent air voids near these joints. The model was used to simulate the compaction of asphalt pavements with different structures and compacted using various equipment and patterns. The finite element results of the level of compaction and percent air voids were in reasonable agreement with the measurements. The model offers the opportunity to simulate and predict the compaction of asphalt mixtures under various rolling patterns and for different pavement structures.

Full text: Contact library to obtain full text.
Title: Improving Pavement Density  
Abstract: This article discusses strategies that can improve pavement density, focusing on how proper compaction is related to proper lift thickness and mix design. The author reviews the use of improved specifications and how they can provide better density. The article first outlines how increasing the density of a pavement will improve its fatigue life, rutting resistance, and overall durability. Other topics include compaction standards as set up by various states, maintenance projects, lift thickness, the costs of improving compaction, good mix design from quarry to the lab to construction site, and the role of asphalt binder in the mix. One illustration provides the specifications for average and improved pavement durability.  
https://trid.trb.org/View/1408361  
Full text: Contact library to obtain full text.

Title: A Study on Intelligent Compaction and In-Place Asphalt Density  
Source: FHWA and Transtec (2014)  
Abstract: Intelligent Compaction (IC) technology is an innovation of roller technology that can be used to improve quality control of the asphalt pavement compaction process. Asphalt IC technology uses accelerometer-based methods to collect IC measurement values (ICMV) that relate to the stiffness of the compacted materials. Across the U.S., in-place asphalt density measurement is still the de facto method for acceptance as the in-place densities relate to long-term performance of asphalt pavements. Past limited research has not been successful in finding a strong correlation between ICMV and measured in-place density. To accelerate the implementation of IC technology, it is essential to further study the relationship between IC measured data and core density to assess the use of IC measurements beyond quality control. This project includes extensive field studies and data analysis and modeling in order to investigate the relationship between IC measurement values and other IC measurements (such as pass counts, temperatures, vibration frequencies/amplitudes, direction, speed, etc.) and asphalt in-place densities. The pass-by-pass ICMV correlate well with nuclear density gauge measurements during breakdown compaction. As the final ICMV does not correlate well with core densities, the final ICMV data is not recommended to replace cores for acceptance. An IC-based nonlinear panel data model was also developed to reasonably predict asphalt in-place density as an enhanced quality control tool. Recommendations are also provided regarding future research and implementation to maximize the potential benefits of IC.  

Title: Improving quality control of hot-mix asphalt paving with intelligent compaction technology  
Authors: Robert D. Horan (Asphalt Institute), et al.  
Source: Transportation Research Record, no. 2268, pp. 82-91 (2012)  
Abstract: This paper answers whether existing intelligent compaction (IC) technology can be used in a practical way to improve the quality control process for hot-mix asphalt (HMA) paving projects. Specifically, the paper investigates the use and the benefits of IC technology for tandem drum vibratory rollers used to construct HMA materials. There
is a need to improve quality control practices for most typical HMA paving operations. This paper identifies and discusses major shortcomings in conventional compaction equipment and current quality control practices. The use of IC technology can address these shortcomings and provide innovative quality control tools to contractors and agencies. The paper is based on the findings of the Intelligent Compaction Pooled Fund (ICPF) project that included 16 field demonstration projects in 12 participating states. The ICPF projects were actual highway construction projects in which various pavement materials were placed and compacted with both conventional compaction equipment and rollers that were equipped with IC technology from various suppliers. Eight of the projects included placement and compaction of HMA materials. On these projects, IC was used for only a portion of the project. A case study of the Wisconsin project illustrates the benefits that could have been obtained if IC technology and specifications had been used for the entire project from beginning to end.

Full-text PDF: http://trrjournalonline.trb.org/doi/10.3141/2268-10

Less Relevant Results:

Title: Optimizing Laboratory Mixture Design as It Relates to Field Compaction to Improve Asphalt Mixture Durability
Source: Purdue University and Indiana DOT (2015)
Abstract: The objective of this research was to optimize the asphalt mixture design in order to increase in-place asphalt pavement durability without sacrificing the permanent deformation characteristics of the mixture. Three asphalt mixtures were designed using the standard Superpave design method at 100 gyrations of the Superpave Gyratory Compactor, suitable for traffic levels of 3 to 30 million Equivalent Single Axle Loads. Each mixture was then used as a starting point to design three additional mixtures using 70, 50, and 30 gyrations, with optimum binder content chosen at 5 percent air voids, rather than the currently specified 4 percent. The effective asphalt content was held constant for the original and re-designed mixtures. Permanent deformation characteristics of the sets of four mixtures were determined by measuring the dynamic modulus and flow number. The results suggest that the mixture designs produced using 70, 50, and 30 gyrations had permanent deformation characteristics equal to or better than the original 100-gyration mixtures. Based on the laboratory test results, two field trials were placed to evaluate the design method, ease of construction and to compare the construction results of the re-designed and original mixtures. Samples from both projects were collected during construction, test specimens compacted, and additional physical testing completed. The field trial results suggest that it is possible to place a mixture at 5 percent air voids and that mixtures designed at 5 percent air voids should have equivalent performance to those designed at the conventional 4 percent air voids.

Full-text PDF: http://docs.lib.purdue.edu/jtrp/1597/

Note: A variation of this research was also published in Road Materials and Pavement Design after the 90th Association of Asphalt Paving Technologists' conference in 2015.
Title: Influence of Field Compaction Pattern on Asphalt Pavement Uniformity (With Discussion)
Source: Asphalt Paving Technology 2008 conference
Abstract: An important process influencing asphalt pavement performance is field compaction of asphalt mixtures. The relationship between the uniformity of air void distribution and different field compaction patterns in asphalt pavements is evaluated in this study. After compaction, cores were taken at different locations from a number of projects with different hot mix asphalt (HMA) types. To capture air void distributions in these cores, the X-ray Computed Tomography system was used. The images were used in air void distribution across pavement depth and surface and development that were useful to study air void distribution uniformity. There was further quantification of these distributions through computation of a uniformity index and differences in air void percentage across the depth. That air void distribution uniformity has a high relationship to compaction pattern and sequence of different compaction equipment use has been shown in analysis results. More importantly, compaction efficiency at a point was found to be a function of this point's location with respect to the width of the roller compactor. Developing the "compaction index (CI)" is supported by the results in this paper, which quantifies the field compaction degree. The CI is a function, at a point, of a number of passes, and, with respect to the compaction roller width, position of the point. There was reasonably good correlation between this index and pavement air void percentage. There was more uniform air void distribution in pavement compacted to have more uniform CI. There was a good relationship with the compaction curve slope obtained from the Superpave gyratory compactor and the field compaction calculated CI. The opportunity to redirect field compactability based on laboratory measurements is offered by this relationship. Longitudinal joint compaction was investigated, and joint compaction improvement recommendations were put forward.
https://trid.trb.org/View/890241
Full text: Contact library to obtain full text.