

Transportation Literature Search



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Elastic-Layer Theory, Top-Down Cracking, And Deep Strength HMA Pavements

Prepared for
Bureau of Highway Construction
WHRP Flexible Pavements Technical Oversight Committee

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Transportation Literature Searches are prepared for WisDOT technical staff in highway development, construction and operations. The bibliography below is representative, rather than exhaustive, of available studies on the topic. Primary online resources for the literature searches are the Transportation Libraries Catalog ([TLCat](#)), the Transportation Research Information Service ([TRIS Online](#)), and various academic and scientific databases. Online copies of publications are noted when available. Hard copies of all cited literature may be obtained through the WisDOT Library.

KEYWORDS

Search terms effective in finding these sources included: asphalt pavement; asphalt; pavement; deep-strength; elastic layer theory; top-down.

CROSS-REFERENCES

Cited sources included the following terms for cross-reference: pavement cracking; top-down cracking.

LIBRARY OF CONGRESS DESCRIPTORS

The only Library of Congress descriptor to emerge from useful citations was: Pavements, Asphalt.

CITATIONS

Title: Perpetual Bituminous Pavements

Author(s): TRB Committee on General Issues in Asphalt Technology (corporate author); Joe W. Button, et al

Date: December, 2001

Doc ID/URL: Transportation Research Circular No. 503;

http://gulliver.trb.org/publications/circulars/circular_503.pdf

Description: 117 pages

Contents: A collection of papers, this circular includes an opening paper on perpetual pavement concepts in which deep-strength asphalt pavement is discussed. Contents include: Concepts of perpetual pavements / David E. Newcomb, Mark Buncher, Ira J. Huddleston -- Development and uses of high-grade asphalt and of high-modulus asphalt mixes in France / Jean-François Corté -- Design and assessment of long-life flexible pavements / Michael Nunn and Brian W. Ferne -- Long-life rehabilitation design and construction : I-710 Freeway, Long Beach, California / Jim St. Martin ... [et al.] -- Hot-mix asphalt layer thickness design for longer-life bituminous pavements / Harold L. Von Quintus -- Evaluation of top-down cracking in thick asphalt pavements and the implications for pavement design / Leslie Ann Myers, Reynaldo Roque -- Study of long-lasting pavements in Washington State / Joe P. Mahoney -- Development of long-life overlays for existing pavement infrastructure projects with surface cracking in New Jersey / Geoffrey Rowe ... [et al.] -- Illinois extended-life hot-mix asphalt pavements / Eric Harm.

Title: Flexible Pavements – Results of VicRoads Pavement Performance Monitoring Program

Author(s): ARRB Transport Research, Ltd., and Road Engineering Association of Asia and Australasia (corporate author); A. Papacostas and A. Bowman

Date: May, 2003

Doc ID/URL: Proceedings of the 21st ARRB and 11th REAAA Conference. Transport: Our Highway to a Sustainable Future

Description: 32 pages

Contents: In the late 1990's, VicRoads reestablished its long term Strategic Pavement Monitoring Program with the principal objective of reporting general trends in pavement condition using roughness, rutting, pavement deflection and visual condition as the principle indicators of pavement performance. The program incorporates monitoring of heavily trafficked unbound granular pavements at 9 sites varying in age from 10-23 years. These pavements are surfaced with a sprayed seal and typically incorporate up to 400 mm of high quality crushed rock placed over lower quality crushed rock and select fill materials. Considerable data is now available which clearly confirms the excellent performance of these pavements, particularly in relation to pavement roughness and rutting. Trends in the data confirm that these pavements will continue to provide satisfactory long-term performance. Also included within the program are five deep strength asphalt pavement sites that were established initially under the Strategic Highway Research Program (SHRP) long term pavement performance (LTPP) studies. Monitoring of the 5 sites began in 1994. Deep strength asphalt pavements in Victoria typically consist of not less than 175 mm of asphalt overlying a high quality cement treated subbase. In expansive subgrade environments, a thick non-expansive capping layer is placed beneath the cement treated subbase. Trends in roughness, rutting and pavement deflection are now available and this data may ultimately assist with establishing performance based specification criteria.

Title: Seasonal and Spatial Variation of Subgrade Response

Author(s): American Society of Civil Engineers (corporate author); M. Hossain, S. Romanoschi, and A.J. Gisi

Date: August, 2000

Doc ID/URL: pp. 140-166, report GSP No. 98, GeoDenver 2000; Proceedings of Sessions of GeoDenver 2000

Description: 17 pages

Contents: The major objective of this research project was to evaluate and quantify the effect of seasonal variation in material properties on the FWD (Falling Weight Deflectometer) measured deflections. Temperature, subgrade moisture content, and deflection data were collected monthly on four asphalt pavement test sections in Kansas for a year. This paper discusses the seasonal and spatial variation of the subgrade layer moduli that was back-calculated from the FWD measured deflections using the elastic layer theory.

Title: PACCAR Full-Scale Pavement Tests, Final Report

Author(s): Michigan State University, Great Lakes Center for Truck and Transit Research (corporate authors); K. Chatti, K.K. Yun, H.B. Kim, and R. Utamsingh

Date: April 1995

Doc ID/URL: Report no. GLCTTR 75-95/01

Description: 180 pages

Contents: An asphalt concrete section on a test track in the PACCAR Technical Center in Mount Vernon, Washington, was instrumented with strain gauges at the surface and in pavement cores, and tested using a Falling Weight Deflectometer (FWD) as well as trucks at different speeds and tire pressures. This report presents results from the analysis of the field tests using SAPSI, a computer program for the dynamic analysis of asphalt concrete pavements by the linear visco-elastic layer theory and the finite element method. The report also investigates the accuracy of SAPSI and includes some numerical criteria to be used when running the program.

Title:

Author(s): Texas Transportation Institute, Texas Department of Transportation, and Federal Highway Administration (corporate authors); F.J. Jooste and E.G. Fernando

Date: October, 1994

Doc ID/URL: FHWA/TX-94/1335-1; Res Rept 1335-1; TTI: 0-1335

Description: 86 pages

Contents: The Texas Department of Transportation (TxDOT) has been issuing an increasing number of permits for movement of superheavy loads. TxDOT has funded a research project with the Texas Transportation Institute (TTI) with the objective of developing a procedure to evaluate the potential for pavement damage on a proposed superheavy load route, as well as to determine whether temporary strengthening measures are needed. This report describes the data collection and analysis results for a superheavy load move which took place in Victoria during December, 1992. The move involved the transport of two superheavy loads. A Multi-Depth Deflectometer measured pavement deflection under the superheavy loads. This study used the deflection data to evaluate the applicability of linear elastic layered theory to predict pavement response under the loading. Predicted displacement from the theory compared favorably with corresponding measurements. To evaluate the effects of multiple wheel loads, an analysis was done to establish how predicted pavement response varies with distance from a given load and with different load configurations. The results indicate that stresses based on a single-axle model yield conservative estimates of the potential for pavement damage. This analysis showed that the road had adequate structural capacity to sustain the superheavy loads without developing visible distress.

Title: Micromechanics Study on Top-Down Cracking

Author(s): Transportation Research Board (corporate author); L.B. Wang, L.A. Myers, L.N. Mohammad, and Y.R. Fu

Date: 2003

Doc ID/URL: pp. 121-133, Transportation Research Record No. 1853

Description: 13 pages

Contents: Recent studies of the causes of top-down cracking have focused on identifying the mechanisms that induce tensile stresses at the surface by applying different combinations of surface tractions and the finite element method. Asphalt concrete is treated as a uniform linear elastic material. A new and different approach is presented for investigating the causes of top-down cracking by means of micromechanics. In this approach, asphalt concrete is viewed as a bonded granular material, and the microstructure, including aggregate particle configuration and mastic stiffness, is considered. Theories that predict the existence of tensile stress under compressive loading were reviewed. Both qualitative and quantitative experimental methods were developed to observe the location of top-down cracking and to measure the tensile strains in the pavement. The experimental results indicate the following: (a) top-down cracking may initiate not only at the pavement surface but also at some distance down from the surface; (b) both tensile-type and shear-type cracking could initiate top-down cracking; and (c) top-down cracking may most likely initiate when the mastic is weaker or the pavement temperature is higher. Therefore, a mix sensitive to rutting may also be sensitive to cracking.

Title: Mechanistic Analysis of Top-Down Cracks in Asphalt Pavements

Author(s): Transportation Research Board (corporate author); T. Svasdisant, M. Schorsch, G.Y> Baladi, and S. Pinyosunun

Date: 2002

Doc ID/URL: pp. 126-136, Transportation Research Record No. 1809

Description: 11 pages

Contents: Top-down cracks (TDCs) in flexible and rubblized pavements constitute a distress that has been reported in the United States and other countries. Researchers have reached different conclusions regarding the causes of TDCs. In this study, field and laboratory investigations were conducted on conventional flexible and rubblized pavements exhibiting TDCs. The engineering characteristics of the pavement layers were obtained from the analysis of field data and laboratory test results. Detailed mechanistic analyses were then conducted using these characteristics to determine the potential for TDCs. The results of such analyses were compared with field data and are presented and discussed in this paper. The results and field data show that (a) surface radial tensile stress induced by wheel loads and enhanced by differential stiffness due to construction, temperature, and aging can cause TDCs, (b) aging of the asphalt binder decreases the tensile strength and the tensile strain at failure of the asphalt mix, and (c) the locations of the maximum surface tensile stress predicted by the mechanistic analysis correspond very well to the locations of the TDCs observed in the field.

Title: Top-Down Crack Propagation in Bituminous Pavements and Implications for Pavement Management

Author(s): Association of Asphalt Paving Technologists (corporate author); L.A. Myers and R. Roque

Date: March, 2002

Doc ID/URL: pp. 651-670, Journal of the Association of Asphalt Paving Technologists, Vol. 71

Description: 20 pages

Contents: This study serves as complementary follow-up to the research presented on initiation of top-down cracks, as it explores and explains the mechanisms for propagation of top-down cracks and attempts to forecast the implications for pavement design. It may be concluded that designing and analyzing pavements using the current approach that employs averaged pavement conditions and equivalent single axle loads will neither predict nor address longitudinal wheel path cracks that initiate and grow down from the surface. Research was performed that showed that existing design and evaluation methods that use averaged conditions are inadequate for predicting this type of surface cracking. It was proven that the propagation of surface-initiated longitudinal cracks advances only under critical conditions and that crack development is highly dependent on differential pavement temperature gradients. This factor is addressed in the conventional approach to pavement analysis; therefore, an alternative approach to designing and rehabilitating pavement should be formulated, or the existing approach adjusted, to include surface-initiated longitudinal wheel path cracks. A concept formulated to identify crack length stages in terms of time, in order to better describe crack growth, may be the initial step in addressing top-down cracking using pavement management.