CE 743
Advanced Pavement Analysis and Design
Course Syllabus, Grading, Procedures, and Policies
Spring 2014

Department of Civil Engineering
Jordan University of Science and Technology

Lecture	Sun and Tue 2:15PM-3:45PM-DRN Hall *Be There!!*
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	Office visits outside office hours are allowed by appointments.

I. Course Description and Objectives:

The description of the course "Advanced Pavement Analysis and Design" includes the following major subjects:
Rheology in Superpave, Rheology Master Curves, HMA Performance Testing, Viscoelasticity, Applications of Viscoelastic Models for HMA Testing, Analysis and Design of Flexible Pavements, Computer Applications in Pavement Analysis and Design.

In this advanced pavement engineering course, students will indeed have actual opportunity to learn imperative subjects including the behavior and performance of asphalt pavements, the rheology of asphalt materials and its relationship with pavement performance, the theory of viscoelasticity and its applications to characterize and model the behavior of asphalt materials, and the use of computer programs and software to analyze and design pavements. At the end of this course, the following objectives should be achieved:

1. To understand the meaning of rheology, rheology of asphalt binders, and the different types of tests used to measure rheology of asphalt materials.
2. To understand the definition of durability and aging of asphalt binders, and to get to know the different types of testing for durability and aging of asphalt binders including the rotating thin-film oven (TFO) test, rolling thin-film oven (RTFO) test, and pressure aging vessel (PAV) test.
3. To analyze rheology and flow data, construct flow curves, select master temperature, and construct master curves using William-Landel-Ferry (WLF) equations for shift factors and the glass transition temperature.

4. To learn the different types of HMA performance testing for fatigue, rutting, and low-temperature cracking including static and dynamic testing.
5. To understand the theory of viscoelasticity and the behavior of elastic, viscous, and viscoelastic materials.
6. To differentiate between the different behaviors of asphalt materials such as elastic, viscous, viscoelastic, linear, non-linear, Newtonian, non-Newtonian, thixotropic, shear-thinning, shear-thickening, rheopectic, …etc.
7. To be able to model behaviors of asphalt materials using viscoelastic models at wide range of temperatures.
8. To apply the theory of viscoelasticity on asphalt binders and mixtures.
9. To review the AASHTO design method for analysis and design of flexible pavements.
10. To use mechanistic-empirical pavement design methods in the design of flexible pavements.
11. To use several available computer programs and software in the analysis and design of pavements.

II. Course Outline:

1. Rheology in Superpave: Definition, Rheological Properties, Rheology of Asphalt Binders, Different Types of Rheology Testing, How to Measure Rheology of Asphalt Materials at Wide Range of Temperatures, Durability and Aging of Asphalt Binders, Durability Tests: RTFO Test and PAV Test.

2. Master Curves in Rheology: Rheology Data Analysis, Flow Curves, Master Temperature and Glass Transition Temperature, Shift Factors, WLF Equations, Construction of Master Curves.

3. HMA Performance Testing: Significance to Pavement Design, Rutting, Types of Rutting, Rutting Performance Tests (Hamburg Wheel-Tracking Device (WTD) Test, French Permanent Rut Test (PRT), Indirect Tensile Test (IDT) for Resilient Modulus, Superpave Shear Test (SST), Simple Performance Test (SPT) for Rutting, and Other Tests), Fatigue, Types of Fatigue, Fatigue Performance Tests (Bending Beam (Flexural) Fatigue Test, SPT for Fatigue, and IDT for Strength), Low-Temperature Cracking, Types of Low-Temperature Cracking, Low-Temperature Performance Tests (IDT for Creep Compliance, IDT for Tensile Strength, Thermal Stress Restrained Specimen Test (TSRST) , and Hollow Cylinder Test (HCT)).

4. Viscoelasticity: Definition, Types of Viscoelasticity, Examples of Viscoelastic Materials, Elastic vs. Viscous, Elastic vs. Viscoelastic, Stress-Strain Curves, Ductile Behavior, Brittle Behavior, Linearity vs. Nonlinearity, Newtonian Behavior, Non-Newtonian Behavior, Thixotropic Behavior, Pseudoplastic Shear-Thinning Behavior, Pseudoplastic Shear-Thinning versus Thixotropic Material, Dilatant Shear-Thickening Behavior, Rheopectic Behavior, Rheopectic versus Dilatant Material, Viscoelastic Models, Maxwell Model,

Kelvin-Voigt Model, Burgers Model, Standard Linear Solid (SLS) Model, Maxwell-Weichert Model, Generalized Maxwell Model, Generalized Kelvin Model.

5. Applications of Viscoelastic Models for HMA Testing: Constant Stress Static Creep Test, Constant Strain Relaxation Test, Indirect Tensile Test (IDT) for Creep, Other Types of Asphalt Testing.

6. Analysis and Design of Flexible Pavements: Analysis of Flexible Pavements for Stresses and Strains Using Different Theories, One-Layered System versus Two-Layered System versus Three-Layered System, Review of the AASHTO Design Method.

7. Computer Applications in Pavement Analysis and Design.

III. Grading:

Course grades will be based upon the following breakdown:

Item	Contribution
Midterm Exam	25%
Homework Assignments and Quizzes	10%
Term Paper	15%
Final Exam	50%

IV. Submission of Homework Assignments:

All homework assignments are due one week after the homework is handled to the students. Homework assignments turned in after this time will be considered late and will be subjected to the deduction policy shown below:
0-1 day = 15%, 1-2 days = 30% and so on. If you cannot submit the homework on time and you have a strong valid excuse, please see me to make other arrangements for new date of homework submission.

V. Submission of Term Paper:

The term paper will be a research-styled project or study. It can be experimental, theoretical, analytical, or even literature review type. The subject of the term paper will be decided and provided to you in a timely manner later in the semester. Several subjects will be probably provided to you so that you will be able to select the most appropriate subject that fits your interests, skills, and background. The term paper will be submitted at least two weeks from the start date of the final exams. You will also present your work in a 15-minute power-point presentation that summarizes objectives, methodology, results, analysis, and conclusions of the study. This will be conducted in the last lecture of the course. Discussion will take place throughout the presentations and questions will be raised by me and other students. Evaluation of your work will be based on the quality

of your work as well as your capabilities to present your work and answer the questions that will be raised.

VI. Formatting Requirements for Homework Assignments and Term Paper:

Homework assignments and term paper should be submitted and presented in a professional manner by following the points below:

- It is strongly encouraged to use Microsoft Word or other convenient word processors in writing and Microsoft Excel (spreadsheets) or other graphical/data analysis software/program for analysis and plotting.
- Writing should be only on one side of the sheet.
- Use a cover sheet and include on the cover sheet your name, university, faculty, department, course number (CE 743), homework number / project, brief title of the homework / project / term paper, submitted to:, submitted by:, and the date of submission.
- Pay attention to consistency, neatness, page layout, and page numbering. Consistency in graphs/charts should be considered particularly in units, chart size, numbering, axis, and titles.
- For graphs/charts, use proper titles, proper font and type for the text inside the graph, and a legend and different symbols for different data series.
- Use black and white coloring in your graphs/charts, as this color type is the standard one used for most professional and academic communications, technical reports, proposals, papers, and publications. However, if you feel you still need to use colored graphs/charts, use it only when it has stronger advantages over black and white coloring or/and when it provides clearer idea and picture of what you need to present.
- The term paper should include the following items and headings: Abstract, Background or Introduction, Literature Review, Methodology, Analysis of Data, Results, Conclusions, Acknowledgment or Recognition, Recommendations (if any), and References.

VII. Exams:

There will be two exams during the semester: midterm exam normally after 8 weeks, and final exam, which will be scheduled by the office of admissions and records and conducted at the end of the semester. The exact date of the midterm exam will be determined during the semester. The room and time will be announced later during the class. The midterm exam could be conducted in the same classroom at the same time of the lecture or outside the classroom at a different scheduled time based upon arrangements with all students to fit students' schedules.

VIII. Classroom Manners:

Classroom lectures will be informal to the extent that you are encouraged to ask questions and participate in any discussion at any time. However, side discussions

between students during lectures will not be tolerated due to the fact that this kind of discussions distracts other students. Good conduct of students is very important and include: attending all classes, being on-time, not doing other tasks, not responding to cellular phones (turning off cellular phones is alternatively recommended), respecting other students, …etc. All these behaviors will provide a healthy classroom and comfortable environment to all students. Although good classroom manners do not affect your grade, providing a favorable impression during classroom may impact a pass/fail grade.

IX. References:

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2. Y. H. Huang, Pavement Analysis and Design, Prentice Hall, 1993.
3. N. J. Garber and L. A. Hoel, Traffic and Highway Engineering, Thomson Learning, Inc., 2002.
4. E. J. Yoder and M. W. Witczak, Principles of Pavement Design, John Willey, Inc., 1975.
5. F. L. Roberts, P. S. Kandhal, E. R. Brown, D-Y Lee, and T. W. Kennedy, Hot-Mix Asphalt Materials, Mixture Design and Construction, 2nd Edition, NAPA Research and Education Foundation, 1996.
6. R. Horonjeff and F. X. Mckelvey, Planning and Design of Airports, McGraw Hill, Inc., 4th Edition, 1994.
7. The Asphalt Institute (AI) Superpave Series No. 2 (SP-2), Superpave Mix Design, 1996.
8. The AI Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types, 1996.
9. The AI Manual Series No. 4 (MS-4), The Asphalt Handbook, 1989 Edition.
10. F. L. Roberts, P. S. Kandhal, E. R. Brown, D-Y Lee, and T. W. Kennedy, Hot-Mix Asphalt Materials, Mixture Design and Construction, 2nd Edition, NAPA Research and Education Foundation, 1996.
11. The AI Report, Superpave Asphalt Binder Test Methods: An Illustrated Overview, Project Sponsored by the Federal Highway Administration (FHWA), the US Department of Transportation, Publication No. FHWA-SA-94-068, July 1994.
12. The AI Report, Background of Superpave: Asphalt Binder Test Methods, Project Sponsored by the Federal Highway Administration (FHWA), the US Department of Transportation, Publication No. FHWA-SA-94-069, July 1994.
13. Nhan Phan-Thien, Understanding Viscoelasticity: Basics of Rheology, Springer, Verlag Berlin Heidelberg New York, 2002.
14. A. V. Shenoy, Rheology of Filled Polymer Systems, Kluwer Academic Publishers, Netherlands, 1999.
15. C. P. MacDermott and A. V. Shenoy, Selecting Thermoplastics for Engineering Applications, Marcel Dekker Inc., New York, 1997.
16. A. V. Shenoy and D. R. Saini, Thermoplastic Melt Rheology and Processing, Marcel Dekker Inc., New York, 1996.