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Flexible Pavement: Superpave Mix Design

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Abstract-The papers mainly focus on the new flexible pavement topology as SUPERPAVE (Superior performance asphalt pavement) mix design. The study consists of a brief history of the Superpave mix design followed by a general outline of the actual method. This outline emphasizes general concepts & overview on specific procedures. It also includes proposed mix design for warm and high traffic area. Grading of various asphalt binder can be studied by viscometer. The pumpability of asphalt binder during delivery and plant operations can also be studied using Brookfield Viscometer.

Finally it concludes desired advantages and future scope of Superpave which can play main role in the development of transportation technology.

Keywords-Superpave, Mix Design, Binder Performance Grading

I. INTRODUCTION

Superpave, a principal product of the Strategic Highway Research Program (SHRP), is a system of standard specifications, test methods, and engineering practices that enable the appropriate materials selection and mixture design of hot mix asphalt to meet the climatic and traffic conditions of specific roadway paving projects. Through use of this system, highway engineers and constructors can build pavements that last longer, require less maintenance and have a lower life-cycle cost than pavements designed using previous engineering methods.

The Superpave mix design method was designed to replace the Hveem and Marshall methods. The volumetric analysis common to the Hveem and Marshall methods provides the basis for the Superpave mix design method. The Superpave system ties asphalt binder and aggregate selection into the mix design process, and considers traffic and climate as well. The compaction devices from the Hveem and Marshall procedures have been replaced by a gyratory compactor and the compaction effort in mix design is tied to expected traffic.

II. BACKGROUND

Superpave stands for SUperior PERforming asphalt PAVEments.Superpave is the outcome of the asphalt research portion of a 5-year, $150 million applied research program between 1987 and1992 to improve the performance, durability, safety, and efficiencyof the United States (US) highway system.

The program was called the Strategic Highway Research Program(SHRP). One of the major developments in the resultingSuperpave system was performance grading (PG) system of asphaltbinders, and new asphalt binder tests and specifications.Under the Strategic Highway Research Program (SHRP), an initiative was undertaken to improve materials selection and mixture design by developing:

A new mix design method that accounts for traffic loading and environmental conditions.

2.1 A new method of asphalt binder evaluation.

2.2 New methods of mixture analysis.

When SHRP was completed in 1993 it introduced these three developments and called them the Superior Performing Asphalt Pavement System (Superpave). Although the new methods of mixture performance testing have not yet been established, the mix design method is well-established.

III. SUPERPAVE MIX DESIGN

Superpave is a performance-related asphalt binder and mixture specification. Superpave is not just a computer software package, nor just a binder specification, nor just a mixture design and analysis tool. Superpave is a systemwhich is inclusive of all these parts.

Superpave mixture design provides for a functional selection, blending, and volumetric analysis of proposed materials, along with an evaluation of moisture sensitivity. There are four stepsin mixture design:

3.1 Selection of Materials,

3.2 Selection of a Design Aggregate Structure,

3.3 Selection of the Design Asphalt Binder Content, and

3.4 Evaluation of Moisture Sensitivity of the Design Mixture.

Criteria for materials selection and compaction are a function of three factors:

3.1.1. Environment,

3.1.2. Traffic, and

3.1.3 .Pavement Structure

Binder selection is based on environmental data, traffic level and traffic speed.

Aggregate selection is based upon layer location, traffic level, and traffic speed.

Selection of the design aggregate structure(design blend) consists of determining the aggregate stockpile proportions and corresponding combined gradations of the mix design. The design aggregate structure, when blended at the optimum asphalt binder content, should yield acceptable volumetric properties based on the established criteria.

Selection of the design (optimum) asphalt binder content consists of varying the amount of asphalt binder in the design aggregate structure to obtain acceptable volumetric properties when compared to the established mixture criteria. It also provides a feel for the sensitivity of the design properties to changes in the asphalt binder content during production.

Evaluation of moisture sensitivity consists of testing the design mixture by AASHTO T-283, or other State specified method, to determine if the mixture will be susceptible to moisture damage.

Now days developing countries requires the mix design for high traffic area which has high durability and validity. In order to design the Superpave for high traffic area, the main factor comes in to consideration the design and analyze is Performance Grading for Superpave which is also known as *Superpave Performance Grading.*

IV. SUPERPAVE PERFORMANCE GRADING

Superpave uses its own asphalt binder selection process, which is, of course, tied to the Superpave asphalt binder*Performance grading (PG) system* and its associated specifications. Superpave PG asphalt binders are selected based on the expected pavement temperature extremes in the area of their intended use. Superpave software (or a standalone program such as LTPP

Bind) is used to calculate these extremes and select the appropriate PG asphalt binder using one of the following three alternate methods [1],

4.1 Pavement temperature.The designer inputs the design pavement temperatures directly.

4.2 Air temperature. The designer inputs the local air temperatures, then the software converts them to pavement temperatures.

4.3 Geographic area.The designer simply inputs the project location (i.e. state, county and city). From this, the software retrieves climate conditions from a weather database and then converts air temperatures into pavement temperatures.

Once the design pavement temperatures are determined they can be matched to an appropriate PG asphalt binder.

V. DESIGN PAVEMENT TEMPERATURE

The Superpave mix design method determines both a high and a low design pavement temperature. These temperatures are determined as follows:

5.1 High pavement temperature – based on the 7day average high air temperature of the surrounding area.

5.2 Low pavement temperature–based on the 1day low air temperature of the surrounding area.

VI. DESIGN PAVEMENT TEMPERATURE ADJUSTMENTS

Design pavement temperature calculations are based on HMA pavements subjected to fast moving traffic [1] .Specifically, the Dynamic Shear Rheometer (DSR) test is conducted at a rate of 10 radians per second, which corresponds to a traffic speed of about 90 km/hr. (55 mph) Pavements subject to significantly slower (or stopped) traffic such as intersections, toll booth lines and bus stops should contain a stiffer asphalt binder than that which would be used for fast moving traffic. PG asphalt binders are specified in 6^0C increments.Table 5 shows two examples of design high temperature adjustments – often called "binder bumping"

Table 1. Examples of Design Pavement Temperature Adjustments for Slow and Stationary Loads

Original Grade	Grade for Slow Transient Loads (increase 1 grade)	Grade for Stationary Loads (increase 2 grades)	20yr ESALs > 30 million (increase 1 grade)
PG 5822	PG 70-22	PG 70-22	PG 82-22
PG 6422	PG 64-22	PG 76-22	PG 76-22
*the highest possible pavement temperature in North America is about 70°C but two more high temperature grades were			

Penetration grading and old viscosity grading are somewhat limited in the ability to fully characterized asphalt binder for used in HMA pavement. New binder tests and specifications are developed to address HMA pavement performance parameters such as rutting, fatigue, cracking & thermal loading. PG system is related on conditions under which it is used.

PG system uses commonly test penetration and old viscosity but specifies that a particular asphalt binder must pass through following tests at specific conditions as temperature and climate as,

6.1 Rolling thin film oven (RTFO)
6.2 Pressure aging vessel (PAV)
6.3 Rotational viscometer (RV)
6.4 Dynamic shear rheometer (DSR)
6.5 Bending beam rheometer (BBR)
6.6 Direct tension test (DTT)

From above according to our project location and availability we discuss viscometer in details.

VII. PROPOSED WORK IN

Basically, the most important part from Superpave design mix procedure is pumpability during delivery and plant operations.In our study we mainly focus on basic study of Viscometer used for evaluation of temperature at plant mixing, field placement and compaction

7.1 Brookfield viscometer

7.1.1 Grading of asphalt binder

Brookfield viscometer is one of the advanced types of viscometerwhich measures the viscosity of fluid directly and givesthe values in the fundamental units i.e. in mass, length andtime. The method of measurement of viscosity is very simplewe get the viscosity directly in "centipoises". This viscosity isspecified with temperature. The present study involves theuse of Brookfield viscometer for the determination of viscosityof different grades of bitumen.

Figure 1.Brookfield viscometer DV-II version with Thermosel accessory and Temperature controller

Brookfield dial viscometer is a portable one. The complete setof instrument can be separated spare by spare. Very easy tocarry and assemble. As far as the function is concerned, theBrookfield viscometer is divided into three parts such as, <u>*Digital viscometer with stand, Thermosel accessory, Temperature controller.*</u>

7.1.2 Principle of Brookfield viscometer

Table 2: Viscosity of different grade bitumen at different temperatures using Brookfield viscometer.

Test Temperature ^{0}C	Viscosity (poise)		
	30/40	60/70	80/100
60	7060	5260	4560
100	2580	2100	1570
110	720	680	540

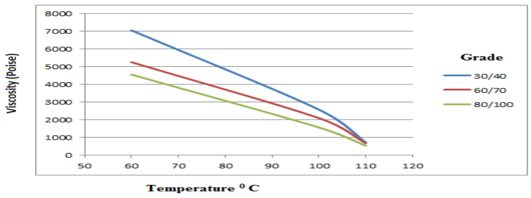

Figure 2. Viscosity-temperature graph

The Brookfield viscometer measures the fluid viscosity at agiven shear rates. Viscosity is a measure of fluids resistance to flow. Theviscometerrotates a sensing element in a fluid and measures the torquenecessary to overcome the viscous resistance, induced onthe sensing element movement. This is accomplished bydriving the immersed elements, which is called as spindle,through a beryllium copper spring. To make the viscosity measurement turn the viscometer switch "ON" which energies the viscometer drive motor. Allow the time to make the indicated reading to stabilize. And note down the viscosity from digital output, when the maximum torque is reached. In the present experiment a spindle number of 1.6 M, samples chamber HT 20 and speed of 2.5rpm is used for measurement of viscosity.

VIII. TEMPERATURE OF ASPHALT BINDER

The Brookfield Rotational Viscometer (RV) is a device commonly used to quantify the viscosity of asphalt binders. A normal RV set-up is shown in figure 1. Typically; the RV test is conducted at 135 ^{0}C at a rate of 20RPM in order to determine the asphalt binder's pumpability. According to Superpave, this result must be less than 3.0 Pa-s to pass PG specifications for fluidity. Viscosity-temperature profiles can be determined through the use of this equipment.The RV device calculates viscosity through the use of a torque transducer for testing conducted under constant rotational speed. The acceptable torque range lies between 2 and 98% for RV machines so spindle changes are acceptable in order to meet the torque criteria.

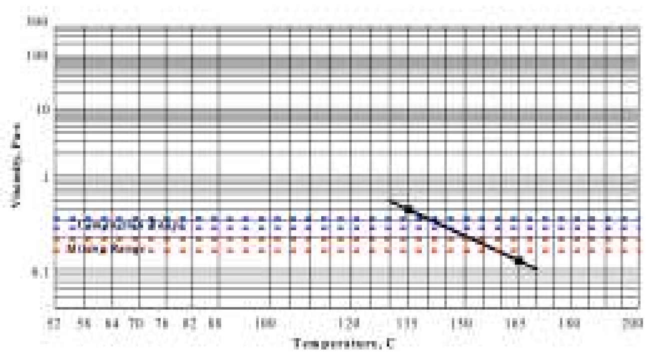

Figure 3.Log scale graph of Viscosity-temperature graph

IX. CONCLUSION

The viscosity of 80/100 Grade bitumen is 4560 poise and 30/40 Grade bitumen is 7060 poise at 60°C. From this we Can conclude that 80/100 Grade bitumen will have lesser Viscosity and 30/40 Grade bitumen will have greater viscosity at a particular temperature.

Brookfield viscometer is used to develop viscosity-temperature graph. By using this graph for the calculation of mixing and compaction temperatures, at least two points should be plotted on the Viscosity-Temperature Chart (Figure 3) with a straight line drawn through the points. In this chart, temperature has a logarithmic scale while viscosity is plotted in log-log scale.

- Mixing temperature ranged from 152°C to 158°C
- Compaction temperature varied from 140° C to 145°C

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