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LABORATORY EVALUATION AND NEURAL NETWORK MODELING FOR ROTATIONAL VISCOSITY OF REACTED AND ACTIVATED RUBBER MODIFIED BINDERS

Mayzan Isied

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LABORATORY EVALUATION AND NEURAL NETWORK MODELING FOR
ROTATIONAL VISCOSITY OF REACTED AND ACTIVATED RUBBER
MODIFIED BINDERS

by

MAYZAN ISIED

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
Departments of Civil Engineering and Construction Management

Mena Souliman, Ph.D., Committee Chair

College of Engineering

The University of Texas at Tyler
May 2019


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This is to certify that the Master's Thesis of

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Dedication

This effort is dedicated to my parents who had believed in me and sacrificed a lot for my wellbeing, Helen and Maher. To my two little brothers, Mayyar and Mehar, for their love, prayers and patience on me.

Without you guys, I would have never done it. I never did it alone, we did it together.

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Abstract

LABORATORY EVALUATION AND NEURAL NETWORK MODELING FOR ROTATIONAL VISCOSITY OF REACTED AND ACTIVATED RUBBER MODIFIED BINDERS

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Crumb rubber surface activation and pretreatment are considered as one of the promising newly introduced methods for asphalt rubber production. Reacted and Activated Rubber (RAR) is an elastomeric asphalt extender produced by the hot blending and activation of crumb rubber with asphalt and Activated Mineral Binder Stabilizer (AMBS). Besides RAR ability in enhancing the performance of asphaltic mixtures, its dry granulate industrial form enabled its addition directly into the mixture utilizing pugmill or the dryer drum with very minimal to no modification required on the plant level.

This study aims to evaluate the rotational viscosity of RAR modified binders and develop an Artificial Neural Network (ANN) viscosity prediction model for extracting a stand-alone viscosity prediction equation. Three different Performance Graded (PG) asphalt binders modified by ten dosages of RAR were tested and evaluated under this study. Sixty-six samples that generated more than three thousand viscosity data points were utilized in binder performance evaluation and ANN modeling.

The study concluded that RAR addition has decreased binder temperature susceptibility in considerable amounts when compared to the virgin binders. Furthermore, it was demonstrated that the testing shearing rate had a significant effect on the measured viscosity values for binders modified with high RAR content.

The developed ANN model as well as the extracted stand-alone viscosity prediction equation had a high value of the coefficient of determination and were statistically valid. Both of them has the ability to predict the RAR modified binder viscosity as a function of binder grade, temperature, testing shearing rates, and RAR content.

Chapter 1

Introduction

Background

Waste materials are obviously considered as serious hazardous threat to the environment due to its accumulations as well as non-biodegradability. Millions of non-biodegradable rubber tires are being stockpiled yearly. Those rubber tires will end up eventually buried under the soil within landfill areas yielding a disturbance to the environment. One of the most common approaches to solve this issue is to recycle the non-biodegradable material into other forms of useful materials. Crumb Rubber (CR) is one of the main products of rubber tire recycling industry that has the ability to be implemented into the Hot Mix Asphalt (HMA) production .

For years, the addition of the crumb rubber modifier was considered as an enhancement to the HMA properties. However, it was never fully implemented in the HMA industry. This lack of implementation was due to the tedious costly production processes of the CR modified binders. The addition of the crumb rubber to the HMA will require specialized plants and equipment; therefore, the production cost of the CR modified HMA was high when compared to conventional HMA mixtures.

Many researchers attempted the modification of crumb rubber to faster achieve its activation and to ease its addition to the HMA. One of the common methods for crumb rubber surface activation is the addition of Activated Mineral Binder Stabilizer (AMBS). Reacted and Activated Rubber (RAR) is considered as newly introduced elastomeric asphalt rubber extender that is mainly produced by the hot blending of AMBS, crumb

rubber, and selected asphalt binder in specific percentages and procedures. The dry granular nature of RAR enabled its addition directly with minimal to no change required on the preexisting HMA plant and equipment.

The reacted and activated rubber, in addition to its great environmental benefits, had highly improved the performance of HMA mixtures and binders. In fact, the RAR modified HMA had better fatigue and rutting performance. Also, RAR modified binders had lower temperature susceptibility.

This study aimed to further investigate and model the effect of RAR addition on the rheological properties of the virgin binders by evaluating and testing virgin binders when modified with wide range of RAR dosages.

Research Scope and Objectives

This study aimed to achieve the following objectives:

- 1) Evaluate the change in the unaged virgin binder rotational viscosity resulted from the addition of Reacted and Activated Rubber (RAR) in different dosages.
- 2) Examine the relationship between the added RAR dose and the introduced enhancement to the unaged virgin binder temperature susceptibility.
- 3) Inspect the effect of utilizing different testing shearing rates (RPMs) during Brookfield rotational viscosity testing for RAR modified binders.
- 4) Develop an Artificial Neural Network (ANN) model that has the ability to predict the binder viscosity as a function of the added RAR dose, temperature, testing shearing rate, and the binder grade.

- 5) Extract a stand-alone binder viscosity prediction equation from the developed ANN model that has the ability to predict the binder viscosity as an effort to generate ASTM A-VTS correlations for RAR modified binders.

Thesis Organization

This thesis was formed from six chapters and four appendixes. Chapter one provides a brief background introduction for the thesis topic as well as a description of the research objectives and scope. Chapter two summarizes the conducted literature review related to binder viscosity, asphalt rubber benefits, production methods, and history, rubber surface activation, reacted and activated rubber production and benefits, and finally artificial neural network modeling and rule extraction approaches. Chapter three provides a detailed description of the utilized materials, experiential design, sample preparation process, and testing procedures. Chapter four discusses the collected testing data and provide a summary for the conducted statistical analysis evaluation. Chapter 5 explains the developed ANN model as well as the utilized rule extraction approach for developing the stan-alone viscosity prediction equation. Appendixes A to D provide the descriptive statistical results, ANOVA results, and ASTM A-VTS correlations for the full datasets resulted from the execution of the full experimental design.

Chapter 2

Literature Review

Under this chapter, a summary of the conducted literature review is presented. The virgin binder viscosity and the importance of ASTM A-VTS are demonstrated. In addition, the rubber modified asphalt historical background, production methods, its benefits and limitation were discussed. Furthermore, Reacted and Activated Rubber (RAR) was studied and evaluated in terms of production technology, its benefits and performance evaluation, and its production process. Finally, the chapter was concluded with an explanation of Artificial Neural Network (ANN) Modeling along with a review of some rule extraction approaches from the developed ANN models.

Binder Viscosity

Asphalt Viscosity The viscosity is generally defined as the resistance of the substance to flow and considered as a very important property of asphaltic materials. This importance is driven by its ability to control the pumpability, the mixability, and the workability of the binder. At a certain value of the viscosity, it would be possible to pump the binder to the mixing chamber, blend it in with the aggregate, and then utilize the mixture for paving effortlessly. One of the common methods that is utilized to measure the dynamic viscosity of asphalt binders is the Rotational Viscometer (RV).

The dominant setup of the Rotational Viscometer is shown in Figure 1. It consists of a device that has the ability to measure the amount of the torque required to rotate a standard size spindle at a constant speed along with a temperature-controlled chamber.

The fluid dynamic viscosity will be calculated proportional to the measured torque value

in Pa.s unit. It is worth mentioning that the Rotational Viscometer is also utilized for viscosity measurements in industries other than asphalt such as chemical and food industries.

There are different methods that maybe utilized for viscosity measurements such as: 1) ford cup, 2) falling ball, and 3) capillary viscometer. However, most of them do not have the ability to add a temperature control device or not applicable for non-Newtonian liquids. Therefore, the RV is utilized for high temperature viscosity measurement for the Superpave PG asphalt binder grading system (1).

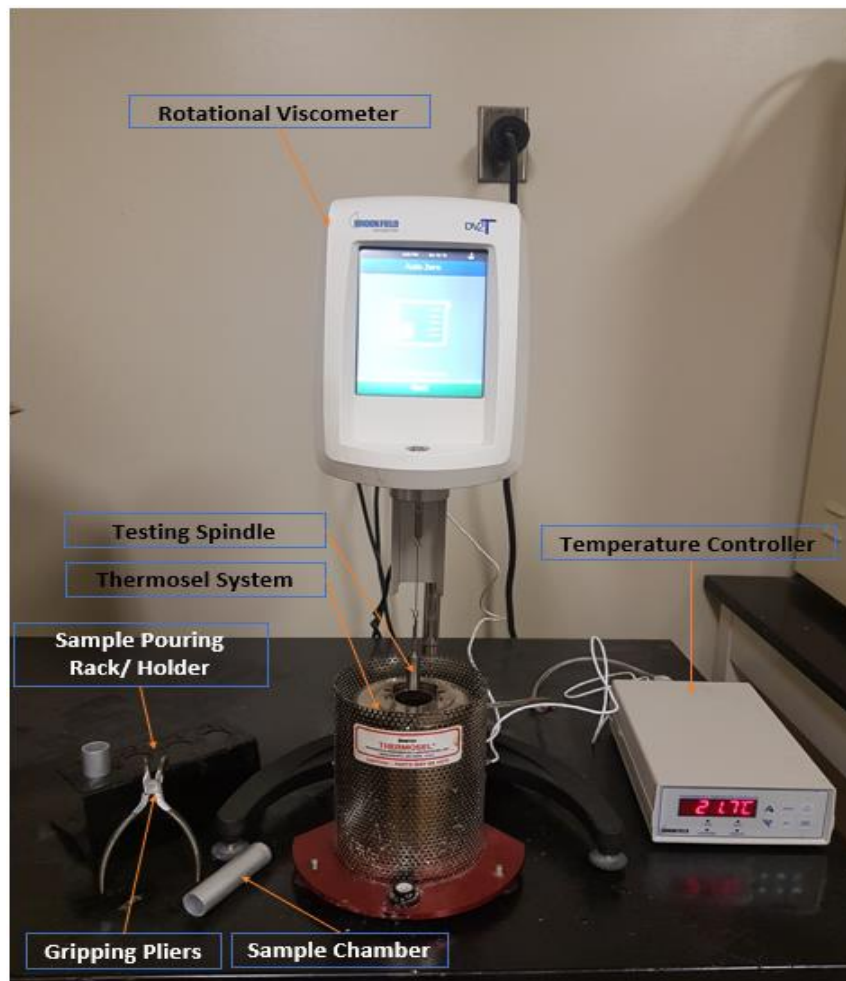


Figure 1. Rotational Viscometer.

ASTM A-VTS The two main general properties that are needed for the characterization of any asphalt binder are physical and rheological. Since asphalt is a byproduct of the petroleum crude oil, the source of crude oil as well as its chemical composition has a high effect on the resulted asphalt binder properties. Different crude oil sources will result in different binder properties. The effect of this difference is seen due to the fact that asphalt is a viscoelastic material, its performance is highly dependent on the temperature and the loading frequency. Considering all the variability resulted from the different chemical composition, loading rate, and temperature, asphalt properties are classified under two main broad categories: physical and rheological (2; 3; 4).

The newly developed Superpave testing protocols have resulted in enhancing the acceptance and utilization of rheological characterization for asphalt binders. Those properties include: 1) temperature susceptibility, 2) shear susceptibility, 3) rate of loading, and 4) stiffness. Dynamic Shear Rheometer (DSR), Bending Beam Rheometer (BBR), and Rotational Viscometer (RV) tests are utilized for binder classification. For example, the RV is utilized as a testing tool to determine the temperature susceptibility of the binder by subjecting it to a wide range of temperature values (5; 6).

Haider et al. (7) evaluated the viscosity temperature susceptibility of asphalt binders by comparing the ASTM A-VTS curves generated utilizing three different test methods. The tests methods utilized in the study were: 1) dynamic shear rheometer, 2) conventional testing that may include but not limited to penetration and softening point, and 3) rotational viscometer. ASTM A-VTS curves were generated for 22 different

binders based on the utilized three different tests. Some of the evaluated binders were polymer modified binders. The study concluded that the A as well as the VTS values calculated based on the tests were significantly different. Furthermore, the study pointed out that this difference in the A-VTS values will have a significant impact on the E* master curves developed for the tested binder as well as the predicted pavement performance, practically, if level three input was utilized in the Mechanistic Empirical Pavement Design Guide (MEPDG). The study recommended to utilize the test that has the nearest temperature to the pavement operational temperature for the generation of ASTM A-VTS curves (7).

Bari and Witzzak (3) have conducted a research study to develop set of prediction models for asphalt binder viscosity as well as complex shear modulus. One of the major goals of this study was to enhance the pre-existing ASTM A-VTS prediction model by including the effect of loading frequency within the model factors. The original ASTM A-VTS equation is shown in Equation 2-1.

$$\log \log(\eta) = A + VTS \log TR \quad (2-1)$$

Where

η = viscosity (cP);

TR = temperature (degree Rankine);

A = regression intercept; and

VTS = regression slope (viscosity temperature susceptibility parameter).

As clearly demonstrated via Equation 1, once the values of A and VTS are known, it is possible to predict the asphalt viscosity values over a wide range of temperatures. However, the calculated viscosity will not account for different loading rates.

The importance of enhancing Equation 1 is due to the fact that all the input levels of the MEPDG are utilizing the binder viscosity as the principle binder input parameter. Consequently, the binder design viscosity is calculated utilizing the ASTM A-VTS model (Equation 1).

The newly developed equation introduced two new factors, c and d, to account for the loading frequency in the original ASTM A-VTS equation as shown in Equation 2.

$$\log \log(\eta)_{f_s, T} = c \times A + d \times VTS \log T_R \quad (2-2)$$

Where

$\eta_{f_s, T}$ = viscosity of asphalt binder as a function of loading frequency (f_s) and temperature (T), (cP);

f_s = loading frequency in dynamic shear mode as used in G^*_b testing;

T_R = temperature (degree Rankine);

A = regression intercept from the ASTM A_i -VTS_i equation (Equation 1);

VTS = slope from the ASTM A_i -VTS_i equation (Equation 1);

c = frequency adjustment factor for A, function of loading frequency (f_s); and

d = frequency adjustment factor for VTS, function of f_s .

Equation 2 was developed and evaluated utilizing 8,940 data points collected from 41 different binders, 9 of which were modified binders. The database included 5 different aging conditions. The developed equation had a high level of accuracy and rationality over the full range of the database. Since the newly developed equation has a similar structure of the old equations utilized in the MEPDG, the paper recommended its implementation in the future versions of the software (3).

Rubber Modified Binders

Historical Background Natural rubber was utilized as an asphalt modifier since the 1840's. However, the concept of adding tire rubber to asphalt was first introduced during the 1950's. In addition, the first application of crumb rubber modified asphalt for pavement construction was in 1964 by Charles McDonald (8).

During the year 1964, and while working for the city of Phoenix at the State of Arizona, Charles McDonald managed to develop a method for adding rubber produced by grounding scrap tires to asphalt cement. In the same year, a "band-aid" patch was hand placed at the Sky Harbor Airport in Phoenix. The hand placed mixture had a satisfactory performance and encouraged the city at that time to continue the evaluation process of this newly introduced binder. The modified mixture had managed successfully to delay the reflective crack appearance. Also, it provided an efficient seal for the existing cracking as well as surface waterproofing sealing for years (8).

The year 1968 witnessed the application of the rubber modified binder as Stress Absorbing Membrane (SAM) by Sahuaro and Asphalt Company. SAM was a method in

which the liquid modified binder will be applied to the pavement surface utilizing asphalt distributor followed by the application of chips. Also, during the same year the first asphalt rubber section was placed utilizing slurry seal machines. The use of such machines has improved the production capacity while reducing the cost. It is noteworthy to say that loose aggregate was one of the biggest problems associated to those types of surface treatments (8).

Rubit, a commercial name for a newly developed asphalt rubber modification technique patented by two Swedish companies, appeared in the late 1960's. The main differences between this new method and the preexisting McDonald's technique were the crumb rubber size (bigger) and the mixing approach. Rubit approach added 3 to 4 percent of crumb rubber by weight of the asphalt when producing HMA surface mixtures as a part of the dry components of the mixture; therefore, technically this method was referred to as the dry application, in which the crumb rubber is added as an aggregate replacement. This technology was patented in the United States under the commercial name of PlusRide in 1978 (8).

McDonald's asphalt rubber was utilized by the State of California in 1978 for improving the durability of HMA. During the following ten years span, more than 20 overlays (dense-graded as well as gap-graded) projects were conducted utilizing asphalt rubber. In fact, the State of California has developed a design guideline in 1992 that had the ability to design a reduced overlay thickness, if asphalt rubber was utilized for specific projects types (8).

Asphalt Rubber Production Methods Asphalt Rubber is defined under ASTM D6114 as a mixture of asphalt cement, crumb rubber modifier, and special additives. In order for the produced mixture to be considered as asphalt rubber, the rubber component in the mixture should be at least 15% of the weight of the total mixture and fully reacted in the hot asphalt to cause the rubber particles swelling (9).

Heitzman (10) developed a concise paper that is discussing utilizing crumb rubber as asphalt modifier in terms of terminology, processes, products, and applications. The study divided the crumb rubber modification process into two main categories, wet and dry processes shown in Figure 2. It was pointed out that during the production of the modified asphalt rubber binder one of the important aspects to look at is the interaction mechanism between the added crumb rubber and the binder. In fact, the reaction itself is not a chemical-based reaction. Upon the blending of the rubber and the binder an interaction reaction will commence. The interaction is dependent on and effected by number of variables, such as, the blending temperature, the blending time while maintaining elevated temperature, the blending energy, and the material properties of crumb rubber as well as asphalt. During this reaction, the absorption of the aromatic component of the binder by the polymer chains of the added rubber will cause the swelling of those chains. The rubber particles swelling will result in having a higher viscosity value at high temperature, that may be 10 times more for a 15% modified binder when compared to a virgin one. However, Bahia and Davies (11) suggested that the viscosity increment for the modified binder cannot be only due to rubber particles

swelling, but also due to the particulate nature of the rubber particles and their high melting points.

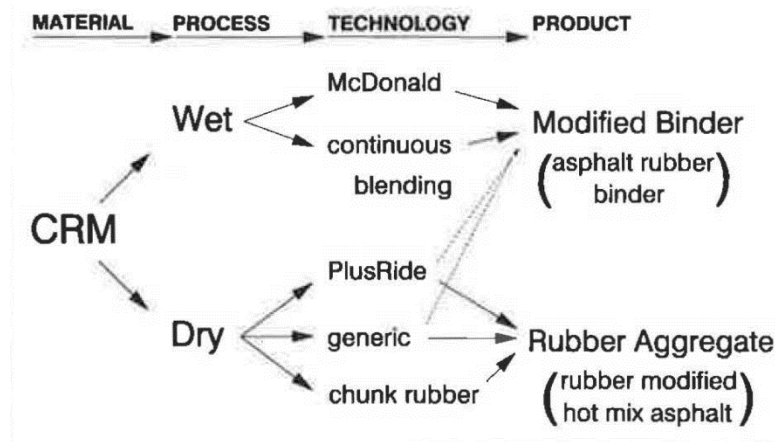


Figure 2. Rubber Modified Binder Production Methods. (After (10))

As shown in Figure 2, the wet process consists of two main processes, McDonald and continuous blending methods. In general, the wet process is based on modifying the binder at elevated temperature with the crumb rubber before being added to the mixture. Under McDonald’s method, a method that was proposed by Charles McDonalds during the 1960s, the modification process is conducted in a blending tank in which the rubber is added and blended with the binder. Then the mixture will be moved into a holding tank equipped with agitates for continuous circulation and agitation of the mixture while allowing sufficient time for the reaction. The reaction time is generally between 45 to 60 minutes. Once the required reaction time elapsed, the reacted mixture of the binder may be utilized for the Hot Mixed Asphalt (HMA) production. On the other hand, and unlike McDonald’s method, in the contentious blending method the reaction between the rubber

and the binder will occur during the mixing and not in the storage tanks; therefore, this method requires special setup with unique agitation units and storage tanks.

Presti (12) pointed out that there is a simpler method to produce the rubber modified binder. Under his research, it was demonstrated that producing the rubber modified binder paving mixture will require drastic changes and modifications on the plant level. Those changes may include the addition of heated blending tanks, heated reaction tanks, rubber feeders, and heated storage tanks for the modified binder. Instead, a standalone trailer-mounted equipment that is equipped with rubber feeding hopper, heated mixing tank, and agitated storage tank may be utilized for the production of the modified binder on the plant site. Such a unit will have the ability to produce the modified binder according to McDonald's method at the plant site to be directly fed into the hot-mix plant for HMA production.

According to Caltrans asphalt rubber usage guide (13), the dry process of rubber modified HMA production is when the rubber modifier is utilized as an aggregate replacement and mixed with the aggregate before the addition of the hot virgin binder. On the other hand, the wet process is when the rubber modifier is added to the virgin binder and mixed thoroughly before being incorporated in the paving mixture. Most of the wet process production techniques require continuous agitation. However, some may be formulated to not require agitation in a continuous manner such as terminal blends. It was pointed out that the temperature is one of the most important factors that is affecting the modified asphalt rubber production, placement, and compaction. During the modified

binder production, binders processed and interacted at lower temperatures will never achieve the same physical properties of those processed at high temperatures.

Modified Asphalt Rubber Benefits and Limitations The physical properties of the rubber modified binder are significantly different from those of unmodified binders particularly at intermediate to high temperature. In fact, the addition of the rubber stiffens the binder as well as increases its elasticity over those temperature ranges; thus, this will decrease the binder temperature susceptibility. Also, the resistance of permanent deformation and fatigue will be improved with a minimal effect on the binder behavior at cold temperatures (13).

Xiao (14) conducted a research study, one of its objectives was the development of fatigue performance prediction models for rubber modified hot mixed asphalt. Under this study, multiple number of samples were prepared and tested utilizing two different binder grades from the same source, one aggregate source, one type of Reclaimed Asphalt Pavement (RAP) and two different types of crumb rubber. The developed models were verified utilizing another aggregate source. A total of 39 different mix designs were developed under this study for fatigue modeling and analysis. It was concluded that the addition of the crumb rubber increases the binder viscosity proportional to the percentage of the added rubber. Also, it was demonstrated that the addition of crumb rubber helps in reducing $G^*\sin\delta$ value during the long-term aging; thus, the addition of the crumb rubber will improve the aging resistance of the mixture.

Shatanawi (15) performed an extensive laboratory evaluation in order to determine the effect of the crumb rubber addition on pavement noise reduction. Also, the

effect of the long-term aging on the noise reduction was assessed. The impedance tube method, that was standardized under the ASTM E1050 by the American Society for Testing and Materials (ASTM) as well as the International Organization for Standardization (ISO 10534-2), was utilized as the main evaluation tool for the noise level during the study. The study concluded that the mixtures with higher rubber content were found statistically less permeable when compared to mixtures without rubber. That was due to the fact that the rubber will clog the pathways between the air voids. It was demonstrated that the crumb rubber did not affect the sound absorption of the pavement as an energy absorbent material. However, the use of rubber will increase the binder content. Consequently, the permeability will be reduced if the aggregate gradation is not changed to maintain the required level of permeability. Thus, the rubber addition will decrease the sound absorption of the pavement by increasing the binder content and not by its physical properties.

Reed (16) under his research study has investigated the aging effect on rubber modified asphalt binders and mixtures. The research was conducted under three phases, viscosity comparison between the modified and unmodified binders were conducted under phase one. The effectiveness of two different aging procedures were evaluated during phase two. Finally, phase three was dedicated towards evaluating the aging effects as seen in the field utilizing field collected samples. The study concluded that rubber modified binder showed a smaller increase in the ratio of unaged to aged viscosity with temperature. Also, it was found that the rubber modified binder has experienced lower aging compared to the virgin binder. The study demonstrated that the lower aging effect

in the rubber modified binders may be due to the asphalt-rubber activation reaction that effect aromatics and maltenes proportions within the binder. The study pointed out that rubber modified binders are more resistance to aging effected compared to the virgin binders.

Souliman and Eifert (17) have evaluated Asphalt Rubber (AR) mixtures in terms of mechanical, mechanistic, and economical value when compared to conventional mixtures. The utilized AR mixtures were gap-graded. The fatigue life of both mixtures, conventional and AR, were predicted utilizing strain-controlled beam fatigue tests according the American Association of State Highway and Transportation Officials (AASHTO) procedures. For the mechanistic analysis, a software that was developed by Western Regional Superpave Center at the University of Nevada , Reno called 3-D move was utilized. In order to conduct the cost to benefit ratio analysis, two different pavement thicknesses (100 and 200 mm) were utilized along with two different traffic speeds (16 and 113 mph). The study concluded that the fatigue life of the AR mixtures was 5.5 times its value for conventional mixtures. In addition, AR mixtures had significantly lower cost of \$25 per 1000 fatigue cycles when compared to the \$108 conventional mixtures cost. Therefore, the study recommended the implementation of the asphalt rubber as a fatigue-resistance layer.

Beside this study, number of studies have demonstrated that utilizing crumb rubber as an asphalt modifier will result in enhancing the fatigue resistance of the pavement sections (18; 19; 20; 21; 22; 23).

Kaloush (24) has developed a comprehensive summary for the findings of some research efforts conducted at Arizona State University to evaluate rubber modified binders and mixtures performance. Also, recommendations on how to implement them in the current pavement design procedures were presented. It was pointed out that the addition of asphalt rubber has improved the binder and mixtures performance and that those improvements, may and should be, reflected and utilized in the current pavement design procedures. Within the paper, it was demonstrated that the addition of rubber had improved the viscosity-temperature susceptibility, due to the fact that, this addition will increase the performance grade for the binder at least by one level. In addition, the rubber modified binders were softer at low temperature conditions when compared to the virgin binders while at high temperature they had a higher viscosity. This is in agreement with the field performance in which the rubber modified mixture had better performance against permanent deformation (rutting) and low-temperature cracking.

According to Caltrans asphalt rubber usage guide (13), one of the issues related to the rubber modified asphalt is production cost since it requires introducing changes on the plant level. In addition, there is the mobilization cost of the production and placement equipment to the project site. For large projects this cost is distributed among big amounts of binder tonnage and the increased unit cost may be justified by the improved service life. However, this is not the case for smaller projects. Since small and large projects will have the same mobilization cost, this will result in very expensive unit cost per tonnage for small projects. This unit cost cannot be justified by the improvement on the service life and maintenance routine.

Reacted and Activated Rubber

Activated Rubber Technology The idea of activating the crumb rubber before utilizing it is not new and have been used in other industries. There is a considerable amount of methods and technologies to modify the crumb rubber before adding it to the binder. In most of those methods, the surface modification for the crumb rubber is the ultimate goal to improve and strengthen its compatibility with the polymer matrix (25; 26). Those technologies include acrylic acid grafting, in which the rubber surface modification is achieved utilizing the bulk polymerization of the acrylic acid with no initiator in order to enhance the compatibility and the reactivity of the rubber particles with the asphalt binders (25). Also, the aromatic aldehyde furfural, that is an organic compound with the formula (C_4H_3OCHO) was utilized in rubber particles activation. Shatanawi et al. (27) have reported that the addition and heating of furfural will initiate a reaction between it and the phenol derivatives, along with the presence of carboxylic acids in the binders, a thermosetting resin will form affecting the rheological properties of the crumb rubber and activating the rubber surface. In addition, Shatanawi et al. (28) have studied the hot water activation for crumb rubber surface. It was discussed that the blending process of the rubber in water while heating for a certain period of time, will help in removing unnecessary oils as well as chemicals from rubber surface so that the surface activation will be achieved. Finally, the activation utilizing Activated Mineral Binder Stabilizer (AMBS), that is the interest of thesis, and in particular the commercially available product “RARXTM”.

Activated Mineral Binder Stabilizer (AMBS), that is produced by activating a unique mined mineral, has helped improve the material performance since 2009. In fact, the rheological properties as well as the ability to resist cracks have been improved in dense and Stone Matrix Asphalt (SMA) mixtures produced utilizing AMBS (29).

The new technology of Reacted and Activated Rubber commercially available under product name “RARX™” (hereinafter referred to as RAR), that is an elastomeric asphalt extender produced by the hot blending and activation of rubber with asphalt and AMBS. The new technology was a result of many experimental trials in which the AMBS was implemented in different mixtures of rubber and asphalt (30).

The main three components in RAR are asphalt, crumb rubber, and AMBS. Generally, RAR blend would contain 62% crumb rubber, 22% soft bitumen, and 16% AMBS. Another 10% of AMBS is usually added for final coating during the mixing after the reaction of the first added 16% as an effort to prevent product re-coagulation (30).

Soft graded asphalt binder is utilized as the asphalt part of the RAR in order to produce the HMA in conventional mixing and laying temperature without sacrificing mixture workability (30).

The crumb rubber is produced by the industrial fine grinding of scrap tires. The produced ground rubber should be free from any impurities such as steel, fabrics, and fibers. Crumb rubber component that may be utilized in RAR production should be finer than 1.0 mm in size (preferably a ASTM No.30 - No.40 sieve particle size) (30).

AMBS is a binder stabilizer that originally was produced as an effort to prevent excessive bitumen drainage during haulage, storage, and laydown of SMA mixtures. The

industrial name of AMBS is “iBind” that is an activated row silica mineral having a maximum particle size of 40 μm . Waste byproducts resulting from phosphate mining industry are a good source of AMBS (30). The ultimate goal of the modification by AMBS is enhancing the viscosity of the binder and the mastic within the mixture by having higher viscosity during rest (reducing the drain down) and lower viscosity during motion (mixture workability) (29).

The working mechanism of RAR in asphalt mixture is demonstrated via Figure 3. Considerable amounts of electrostatically surface charged inorganic particles are present within the crumb rubber. In addition, the AMBS is formed from two main components, organic molecules having a partially electrostatically charged surface and organic hydrophobic chains. It is clear that the presence of AMBS within the binder (utilized in RAR production) will generate an elastomeric network of charged and connected particles. Those particles are from crumb rubber as well as the silica component and hydrophobic chains of the AMBS within the liquid binder environment (30).

The generated networks have a substantial role in enhancing the binder structure along with all the added benefits from the reaction and activation of the added crumb rubber at high temperature. In addition, the special formulations of AMBS existed within the RAR will enhance the RAR and binder connection to the aggregate. This will result in improving the binder aggregate coating that will result in improved moisture resistivity response of the mixture. It is noteworthy to point out that such a network and structure could not be found in regular Asphalt Rubber (AR) modified binders (30).

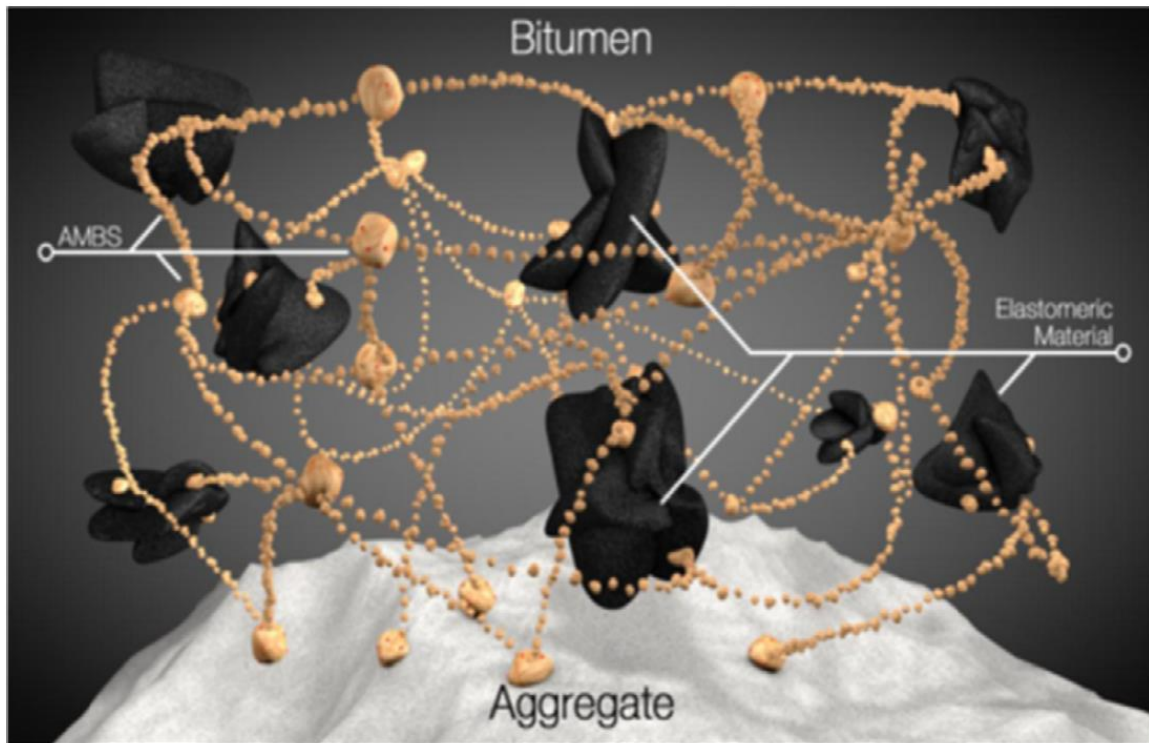


Figure 3. RAR Working Mechanism. (After (30)).

RAR Benefits and Performance Evaluation Having a dry granulate industrial form is one of the important enhancements introduced by the RAR technology to the Asphalt Rubber (AR) binder industry. Unlike regular AR binder, RAR is dry granulated product; therefore, its handling and storage are easier. Furthermore, RAR could be added directly into the mixture utilizing a pugmill or the dryer drum of any asphalt mixing plant as shown in Figure 4. Thus, RAR addition will require no or very minimal modification on the plant level. RAR modifier is added to the asphalt mixture after mixing the aggregates, fillers, and binder at identical HMA mixing temperature (usually 170°C to 180°C). RAR mixing cycle will take around 30s until an even distribution and absorption of RAR within the mixture. The addition of RAR will enhance the binder properties and the higher utilized RAR percent results in better performance. Typically, 15% of the

binder content is considered as the step after which improvements in binder performance are seen (30).

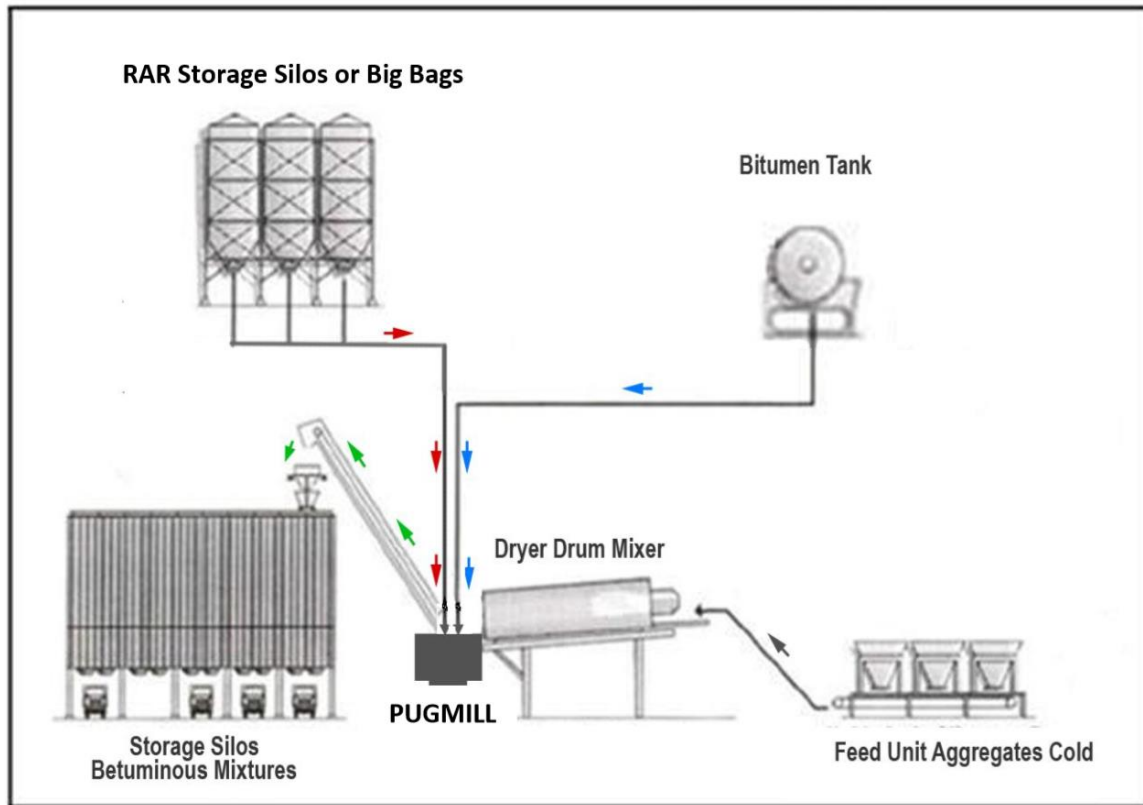


Figure 4. RAR Feeding Mechanism. (After (31))

Since the addition of RAR is replacing part of the virgin binder within the HMA mixture, the modified binder physical as well as rheological properties were studied during the development stages of RAR. Extensive testing was conducted on the RAR modified binder utilizing different RAR percentages to characterize and comment on the behavior of the newly introduced rubber modified binder (32).

Sousa et al. (31) have introduced, explained, and evaluated binder modification process utilizing the newly developed RAR modification technology. Results of testing conducted during the Research and Development (R&D) stage of RAR technology were

introduced and discussed. The testing included binder and mixture performance testing such as viscosity, penetration, ring and ball, resilience, Dynamic Shear Rheometer (DSR), Multi Stress Creep Recovery (MSCR), Marshall stability, draindown test, rutting deformation test, flexural fatigue test, and recovery tests. The utilized HMA mixtures in testing were prepared with different RAR proportions, and included different mixture types such as: dense, open, gap graded and SMA mixtures. The study concluded that RAR produced mixtures outperformed conventional, AR modified, and regular modified mixtures in all aspects. RAR modified binders had a higher positive and lower negative PG grade. In addition, it had better resilient and recovery properties. RAR modified HMA had better stability as well as fatigue and rutting resistance. The study pointed out that RAR modified binders are much easier to produced, handle, store, and transport to project site compared to AR modified binders due to its dry granulated nature. Furthermore, it was discussed that utilizing RAR modified binder will eliminate the need of the complicated wet production process of AR binders as well as the need of continuous agitation and reheating cycles at the plant or project site. Unlike regular AR, RAR is added directly to the pugmill or the dryer drum at the plant requiring no modification on the plant level and resulting in lower production costs. Since RAR is replacing the conventional binder within the HMA mixture, it was discussed that RAR technology may be utilized to produce any AR mixture type given utilizing the correct RAR content. Finally, the study stated that RAR modified mixtures are more cost efficient compared to conventional and AR modified mixtures (31).

Ishai et al. (33) have conducted a research study as a continuation of the R&D stage of RAR modification technology in which three actual field pavement sections were constructed. The RAR modified HMA mixtures were dense and Superpave S graded mixtures. The pavement sections were constructed and monitored within a hot climate region. The test sections were constructed in a way to capture various loading conditions. Three test sections were constructed to include: 1) a residential street, 2) an industrial high traffic area, and 3) an access road to an active quarry. The first section was constructed in October 2012 at the access of an aggregate quarry. That section had a 50 mm HMA RAR modified layer and was subjected to about 500 heavily loaded truck movement within an average temperature of 32°C. In addition, the second section was a two-lane one-way street constructed in September 2014 within a residential area. This section had a 50 mm dense graded RAR modified HMA layer. Finally, the third section was a four lanes two-way street in an industrial area that were constructed in six-night jobs between November and December 2014. This section was formed in three parts as follows: 1) section of 19 mm S graded HMA RAR modified layers for both binder and wearing courses, 2) section of 19 mm S graded HMA RAR modified layer for the binder course and 19 mm dense graded HMA RAR modified layer for the wearing course, and 3) control section with 19 mm S graded conventional HMA layer for the binder course and 19 mm dense graded conventional HMA layer for the wearing course. The study concluded that after more than two years of service for one of the test pavement sections and a couple months for others, the advantages of RAR modified mixtures were clearly shown and strengthen. The study pointed out that RAR modified mixtures are excellent

candidates to be utilized when high performance, heavy-duty, and environmentally friendly HMA mixtures are needed (33).

Kedarisetty et al. (34) have conducted advanced rheological characterization of RAR modified binders. The RAR modified binders were evaluated utilizing three tests, namely: the Brookfield viscometer for binder consistency, DSR and MSCR for advanced rheological and viscoelastic properties characterization. The binders utilized in the study were two viscosity graded binders, VG-30 and VG-40. In addition, one commercially available rubber modified binder CRMB 60 was utilized for performance comparison only. RAR modification was conducted at five different dosages as follows: 5, 10, 15, 20, and 25 percent of the total virgin binder weight. Eleven modified binders and two virgin binders were evaluated under this research study. Viscosity testing was conducted at five different temperatures while DSR testing results were for unaged binders at six different temperatures. The study concluded that the addition of RAR increased the viscosity at higher temperatures and decreased it at lower temperatures. Also, it was noted that increasing the RAR dosage is reducing the temperature susceptibility of the binder. In addition, the study demonstrated that RAR modified binders are more resistant to rutting since that RAR modification is increasing the $G^*/\sin\delta$ values at lower frequencies. Furthermore, the study pointed out the RAR modified binders were highly resilient in nature compared to virgin binders since they exhibited much lower strains due to the viscoelastic effect of the added RAR. Finally, the study recommended utilizing a minimum of 15% RAR of the total weight of the virgin binder to produce RAR modified binders in order to obtain an effective product as well as pronounced

performance enhancement. However, some of the limitation of this study were utilizing only two binder grades and five dosages for modification. Also, the effect of different shearing rate during viscosity testing was not considered (34).

Sousa et al. (35) have designed and evaluated the performance of dense graded HMA mixtures when modified utilizing RAR modifier. The produced RAR modified HMA mixtures were evaluated based on major distresses encountered by pavement sections. Two different RAR dosages were utilized in the modification, namely: 2% and 4% of the total mixture weight. Also, mixtures utilizing unmodified binders as well as market available AR modified binder were included in the performance evaluation and comparison. Rutting resistance, number of cycles to fatigue failure, fracture energy, and moisture damage resistance were studied and analyzed for all the mixtures. The study concluded that RAR modified mixtures with higher dosage performed better in terms of fatigue and rutting. In addition, it was discussed that all the mixtures had almost similar performance in terms of fracture energy as well as resistance to moisture damage. Due to the enhancements introduced by RAR addition to the mixture, the study recommended expanding the evaluation of RAR modification at both levels, laboratory and field, to include all the other aggregate gradations and mixture types (35).

Chen at al. (36) presented an approach for designing the optimum binder content for RAR modified mixtures that included Reclaimed Asphalt Pavement (RAP) utilizing Superpave mix design procedures. In addition, the performance of the produced mixtures was evaluated via a series of laboratory tests. The utilized binder in mixtures preparation was PG 58-28. The selected optimum binder content resulted from both Marshall as well

as Superpave mix design procedures was 11% by total mixture weight, in which the unmodified binder was 6.6% and the RAR modifier was 4.4%. The study concluded that the modified mixtures had a favorable rutting resistance performance and pointed out that these mixtures will be utilized in trail section construction later this year (2019) (36).

Reacted and Activated Rubber Production Process It was believed that a specially designed industrial plant is required for RAR production. Several pilot machinery designs for the proposed production plant were conducted until finally arriving to a functional design. A large- scale industrial plant was designed, manufactured in the United States, and then transferred to its final destination in Israel. The plant as shown in Figure 5 has the ability to produce two batches of one metric ton of RAR per hour in a semi-automatic manner. The feeding and discharge are controlled manually while heating, mixing, and cooling are fully automatic stages (33).

Short term heating and activation process were utilized in RAR production as follows: 1) the fine ground crumb rubber is heated to a target temperature inside the heating mixer and while this is happening, 2) the bitumen is heated to a target temperature at which the AMBS is added to bitumen in the metering container, 3) the AMBS and the bitumen are mixed until arriving to same target temperature before the addition of AMBS, 4) the heated crumb rubber is transferred to the mixing reactor while maintaining the target temperature, 4) the AMBS/ bitumen mixture is pumped to the mixing reactor and mixed with the crumb rubber while heating the mixture to a higher target temperature, 5) the mixture is transferred to a cooling mixer in order to reduce its heat to 50°C, and 6) moving the cooled mixture into a coating mixer and coating it with

additional AMBS and special type of mineral filler. The final product of this process will be dry granulated packaged RAR in industrial size bags for storage or final delivery to project site (33).



Figure 5. RAR Production Plant. (After (33))

Artificial Neural Network Modeling

Background Artificial Neural Networks (herein after referred to as ANN), are highly interconnected structures with strong computational and pattern recognition abilities utilizing simple processing units (artificial neurons) having the ability to perform parallel computations (37; 38).

According to Adeli (39), the first article that included the application of ANN for processing a civil engineering problem was published in 1989. Adeli (39) provided a review for an ample number of researches in which ANN was utilized. The review major focus was on structural and construction management engineering problems. However, the paper included research related to environmental, water resources, traffic, highway, and geotechnical engineering. It was discussed that the majority of civil engineering applications were based on the simple backpropagation algorithm.

Karlaftis and Vlahogianni (40) in their review had compared between statistical methods and artificial intelligence methods in the field of transportation engineering. The paper pointed out that for data analysis in transportation engineering there is two main tools, either statistical or artificial intelligence. The paper drawn conclusions as derived from reviewed literature was that statistical approach is better when: 1) there is an available statistical method that has the ability to solve the problem, 2) the researcher has a background about the functional relationship between the studied experimental factors, and 3) there is a need to quantify the statistical properties of the developed model. On the other hand, ANN was a better approach when: 1) the main concern of the research is obtaining a good prediction, 2) the true function generating the data is unknown or hard

to identify, 3) hard to apply an ideal statistical model to the data, and 4) traditional mathematical methods could not produce a reliable prediction.

The smallest and simplest ANN is formed basically from three layers. Input layer, output layer, and a single hidden layer in between as shown in Figure 6. Each layer of those will include number of neurons. The number of hidden layers as well as neurons will determine the complexity and the ability of the network to deep-learn (14).

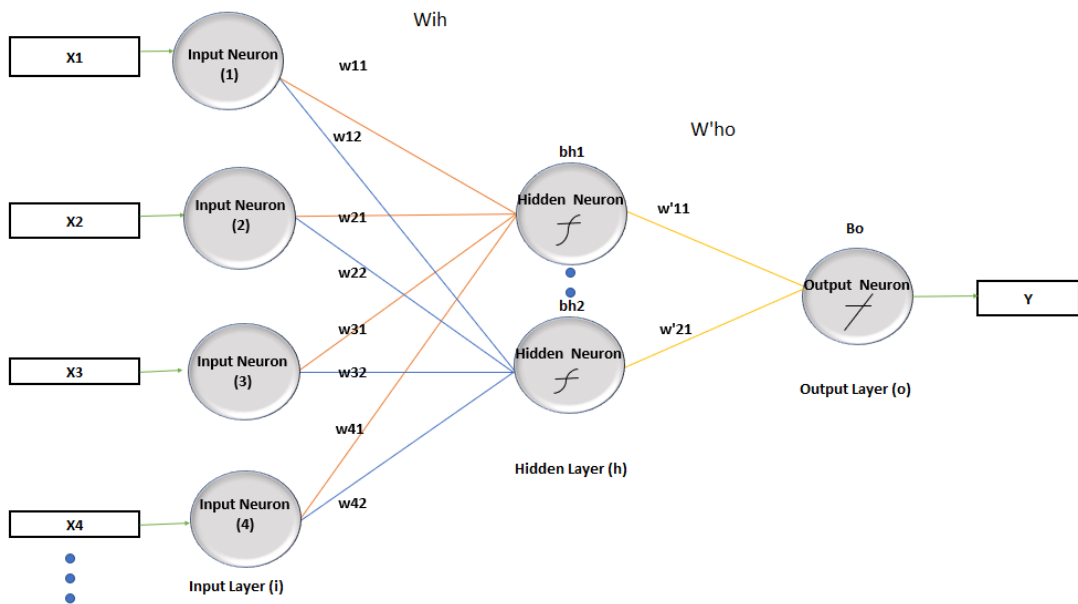


Figure 6. Three-layer Feedforward Neural Network Architecture.

All the input neurons are just connection joints with no processing occurring inside them. However, the neurons within the hidden as well as the output layer are formed from two main parts as shown in Figure 7. The first part is simply a summation (activation) function that will pass a single value resulted from the weighted inputs to the second part, that is a signal (transfer function) that is responsible for the wave signal flow

within the network. Typical transfer function structure maybe expressed as shown in Equation 3.

$$m = f(Wz + b) \tag{2-3}$$

Where,

m = output of the neuron;

W = weight vector;

b = bias;

Z = input vector of the neuron;

and f = transfer function

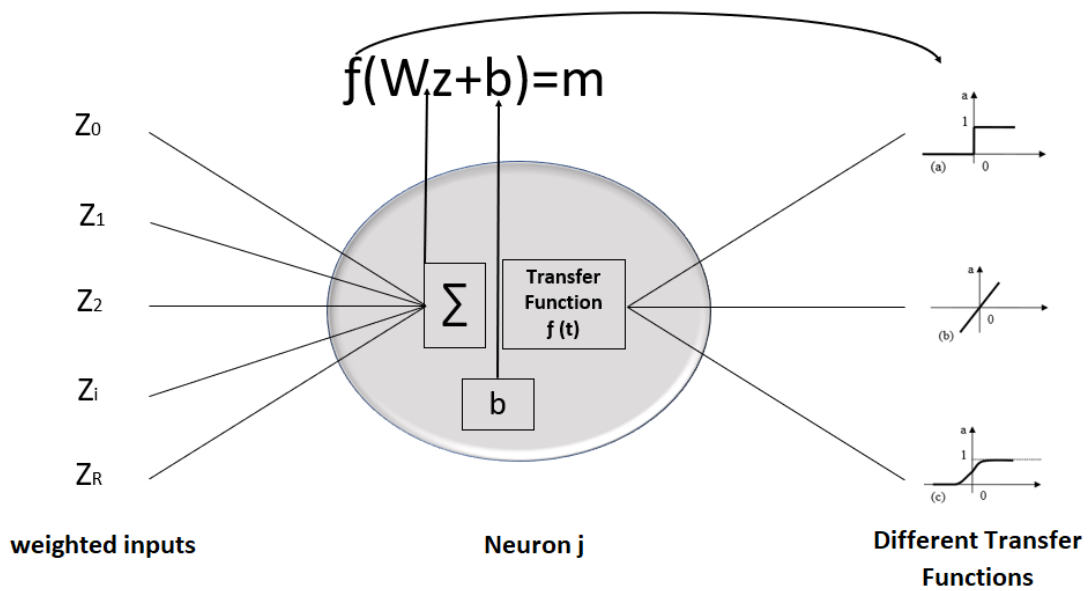


Figure 7. Artificial Neuron Model Architecture.

Backpropagation training technique is one of the commonly adopted training techniques for feedforward networks. This technique, despite its limitations, has systematic and strong mathematical foundations; therefore, its use has expanded ANN application range to include many different engineering problems. The output of a three-layer ANN as shown in Figure 6 may be calculated utilizing Equation 4.

$$N_f = \{B_0 + \sum_{k=1}^n [W_k \cdot f_t(B_{HK} + \sum_{i=1}^m W_{ik}Z_i)]\} \quad (2-4)$$

Where,

B_0 = output layer bias value;

$W_k = (W'_{ho})$ connection weight between neuron k of the hidden layer and the single output layer neuron;

B_{HK} = hidden layer bias value for neuron k;

$W_{ik} = (W_{ih})$ connection weight between input variable i and neuron k in the hidden layer;

Z_i = input value i; and

f_t = the utilized transfer function.

Rule Extraction from Developed Artificial Neural Network Models There is a growing use for ANN modeling techniques in business and engineering related problems involving pattern recognition and regression analysis. The strength of ANN in this regard that it doesn't require a prior knowledge about the relations among modeling data. However, there is a desire to extract this knowledge from the trained networks, in order to provide the user with a better understanding of the results.

Setiono and Thong (41) conducted a research study to develop a rule extraction approach from the trained ANN network. Their research focused only on regression problem solving ANN networks. The developed approach was based on dividing the modeling data into groups. For each group, there will be a linear function that has the ability to approximate the output based on the given inputs. The newly developed extraction approach was explained utilizing two different examples within the paper. The paper discussed that the most important step during the extraction is the local approximation of the activation function within hidden neurons and suggested dividing it into three-piece linear function. The paper concluded that this approach has the ability to replicated with acceptable level of accuracy the nonlinear ANN model into set of linear equation.

Chan and Chan (42) have developed a fully decompositional rule extraction approach from a trained nonlinear regression ANN model. The developed algorithm was called the piece-wise linear artificial neural network (PWL-ANN) algorithm. This algorithm was based on linear approximation of the sigmoid activation function within the artificial neuron as shown in Figure 8. Therefore, it has the ability to replicate ANN model that was built based on sigmoid activation function within the hidden neurons only. The algorithm was validated utilizing 19 different datasets, and it was able to replicate the results of 16 out of the 19 tested datasets to a satisfactory level of accuracy. The paper concluded that there are factors affecting the prediction accuracy of the developed equations other than the approximation of artificial neuron activation function.

In addition, it was pointed out that this algorithm has a strong potential to be applied for engineering problem solutions.

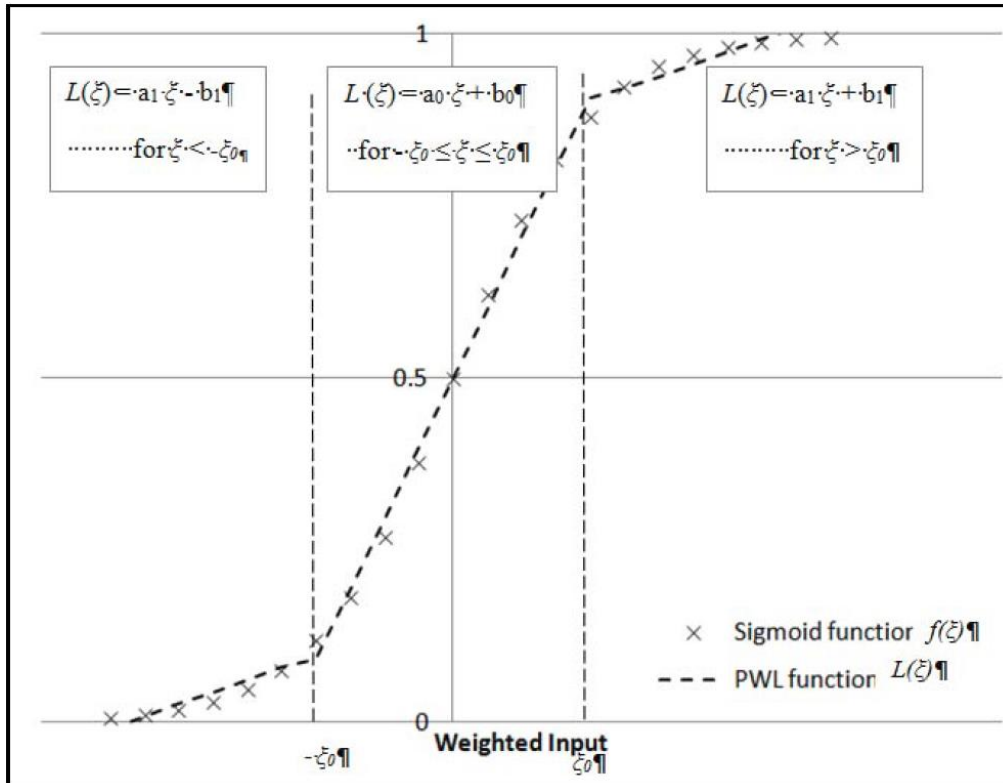


Figure 8. Approximation of the Sigmoid Activation Function Within the Artificial Neuron. (After (42))

As an effort to open ANN “black box” and generate rules from the results of the trained ANN models, the researchers discussed that one of the below listed three main approaches may be utilized in the rule extraction from the trained ANN network (42; 43):

- 1) Decompositional: under this method the network weights, bias and activation function values are utilized to extract the rule while ignoring any possible relationships between input-output data into the network. The main focus here is to approximate the artificial neuron functions.

2) Pedagogical: in this method, the focus is on the relationship between the input and output of the trained ANN network and its relation to the measured data.

Those relations are studied to generate a rule that has the ability to replicate the results of the trained ANN network without the need of the exploration of the ANN network structure or approximating the activation and transfer functions within the artificial neuron.

3) Eclectic: this method is considered as a hybrid method of the two previous methods. in other words, the relationship between the input and output, the weights and bias values for the trained ANN network, and the approximation of the artificial neuron functions are utilized for the rule extraction.

Thesis Research Significance as Drawn from Reviewed Literature

It was agreed in the literature that AR modified binders has a superior performance (13; 14; 15; 16; 17; 18; 19; 20; 21; 22) . However, AR production process is costly, complicated and tedious (10). The importance of crumb rubber surface modification before being added to the virgin binder was demonstrated within the lectures (25; 26; 27; 28) and its ultimate goal was to facilitate the production and utilization of rubber modified binders in HMA production, by reducing the production time as well as the required modification on the plant level. RAR modification technology was excellent in this regard due to the dry granulated final produced HMA modifier. The nature of RAR modifier will enable its haulage, storage and addition to the plant in an easy manner (31; 30; 35; 33).

Considerable research studies commented on the importance of the rheological binder properties for binder classification and PG grading (2; 3; 4; 13; 11; 7). Furthermore, research studies concluded that the higher the dosage of the added RAR modifiers, the higher the introduced enhancements to the binder rheological properties (31; 30; 32). However, there is a need to further evaluate the RAR added doses and relate it to the introduced enhancement in virgin binder properties. In additions, it is important to evaluate the upper limit of RAR modification after which no significant enhancements are introduced as an effort to comment on literature statement, higher the better.

Furthermore, the importance of ASTM A-VTS was demonstrated in the literature, in particular, their role in the determination of the temperature susceptibility of the binder as well as in the pavement performance prediction by the MEPGD (2; 3; 7). Therefore, there is a need to have a viscosity prediction model that has the ability to develop ASTM A-VTS relationships for binders when modified utilizing a wide range of different RAR dosage values.

Chapter 3

Materials, Design of Experiment, and Testing Procedure

This chapter presents the utilized materials in the study and their sources. In addition, this chapter provides a full explanation for the testing program, sample preparation, and sample testing procedures.

Materials

The binders utilized in this study were three different performance graded binders supplied by Valero Asphalt Terminal from Houston, Texas as follows:

- 1) PG 64-22, hereinafter referred to as binder A.
- 2) PG 70-22, hereinafter referred to as binder B.
- 3) PG 76-22, hereinafter referred to as binder C.

The Reacted and Activated Rubber utilized in binder modification was supplied by Consulpav under product name RARX TM, hereinafter referred to as RAR. RAR was added to the virgin binder in ten different dosages, from 5 to 50% by the virgin binder weight in 5% step increments.

Experimental Design

The experiment was designed to evaluate the effect of three factors on the binder viscosity. The evaluated factors were binder grade, RAR content, and testing shearing rate. The full design of experiment as shown in Table 1 yielded a total of 66 samples including one replicate for each sample. The number of collected viscosity data points were 3,168 points.

Table 1. Three Factors Full Factorial Design Executed Under the Study.

Binder Type	RAR Content (%)		0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
	Test Shearing Rate (s-1)	Test Read Temperature (c)											
Binder A (PG 64-22)	1.7	135	Sample 1 48 Viscosity Data Points	Sample 2 48 Viscosity Data Points	Sample 3 48 Viscosity Data Points	Sample 4 48 Viscosity Data Points	Sample 5 48 Viscosity Data Points	Sample 6 48 Viscosity Data Points	Sample 7 48 Viscosity Data Points	Sample 8 48 Viscosity Data Points	Sample 9 48 Viscosity Data Points	Sample 10 48 Viscosity Data Points	Sample 11 48 Viscosity Data Points
		155											
		175											
		195											
	6.8	135											
		155											
		175											
		195											
	17	135											
		155											
		175											
		195											
34	135												
	155												
	175												
	195												
Binder B (PG 70-22)	0.68	135	Sample 12 48 Viscosity Data Points	Sample 13 48 Viscosity Data Points	Sample 14 48 Viscosity Data Points	Sample 15 48 Viscosity Data Points	Sample 16 48 Viscosity Data Points	Sample 17 48 Viscosity Data Points	Sample 18 48 Viscosity Data Points	Sample 19 48 Viscosity Data Points	Sample 20 48 Viscosity Data Points	Sample 21 48 Viscosity Data Points	Sample 22 48 Viscosity Data Points
		155											
		175											
		195											
	1.7	135											
		155											
		175											
		195											
	3.4	135											
		155											
		175											
		195											
6.8	135												
	155												
	175												
	195												
Binder C (PG 76-22)	0.68	135	Sample 23 48 Viscosity Data Points	Sample 24 48 Viscosity Data Points	Sample 25 48 Viscosity Data Points	Sample 26 48 Viscosity Data Points	Sample 27 48 Viscosity Data Points	Sample 28 48 Viscosity Data Points	Sample 29 48 Viscosity Data Points	Sample 30 48 Viscosity Data Points	Sample 31 48 Viscosity Data Points	Sample 32 48 Viscosity Data Points	Sample 33 48 Viscosity Data Points
		155											
		175											
		195											
	1.7	135											
		155											
		175											
		195											
	3.4	135											
		155											
		175											
		195											
6.8	135												
	155												
	175												
	195												

Equipment Setup and Testing Procedure

Under this section, the experiment setup details are discussed in terms of sample preparation and testing.

Sample Preparation The unaged virgin binder was heated for two hours until arriving to a temperature around 170 °C. The binder was then poured into the mixing containers. Those containers were hand-pierced quart metal cans to facilitate heating while mixing as well as sample pouring as shown in Figure 9.

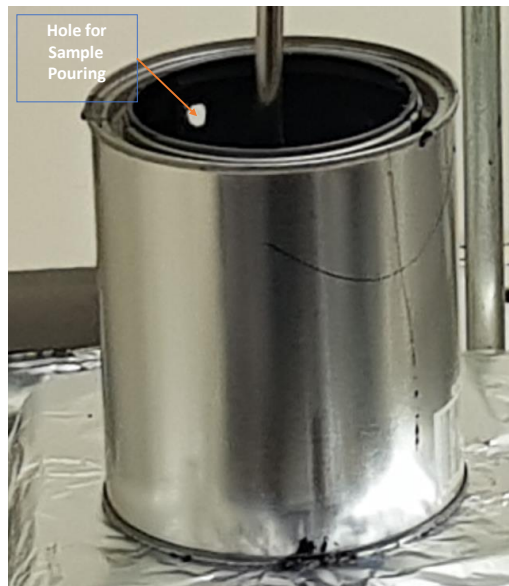


Figure 9. Sample Mixing Containers.

After pouring the heated virgin binder into the containers, the net weight of the binder was recorded and utilized to calculate the required RAR modification by weight as shown in Figure 10. The added RAR was calculated as a percent of the virgin binder weight. For example, to produce a 20% RAR modified mixture, the amount of the required RAR is 0.2 times the net weight of the heated virgin binder recorded earlier.



Figure 10. Determination of the Required RAR Weight for Virgin Binder Modification.

After weighing the required amount of RAR, the mixing process starts. The binder metal can was placed on a hot plate and heated while mixing until arriving to a temperature of 180 °C at which the pre-weighted RAR amount was added to the mixture. The hot plate along with a directly inserted calibrated thermometer were utilized to control a mixing temperature of 180 °C during the entire mixing time. The mixing was conducted for 15 minutes at 1200 RPMs utilizing an electric mixer. The utilized mixing setup is shown in Figure 11. It is noteworthy to mention that all the sample mixing work was conducted inside a fume extraction hood.



Figure 11. Sample Mixing Setup.

After 15 minutes of mixing at 1200 RPMs, the samples were poured into a Brookfield viscosity testing chamber HT-2DB-100 as shown in Figure 12. The utilized spindle in testing was spindle number 27 (SC4-27). As provided by the manufacturer (44), that particular spindle had recommended sample volume of 10.5 ml as shown in Table 2. The specific gravity of the binders as well as the added RAR were utilized to calculate the required sample weight based on a volume of 10.5 ml.

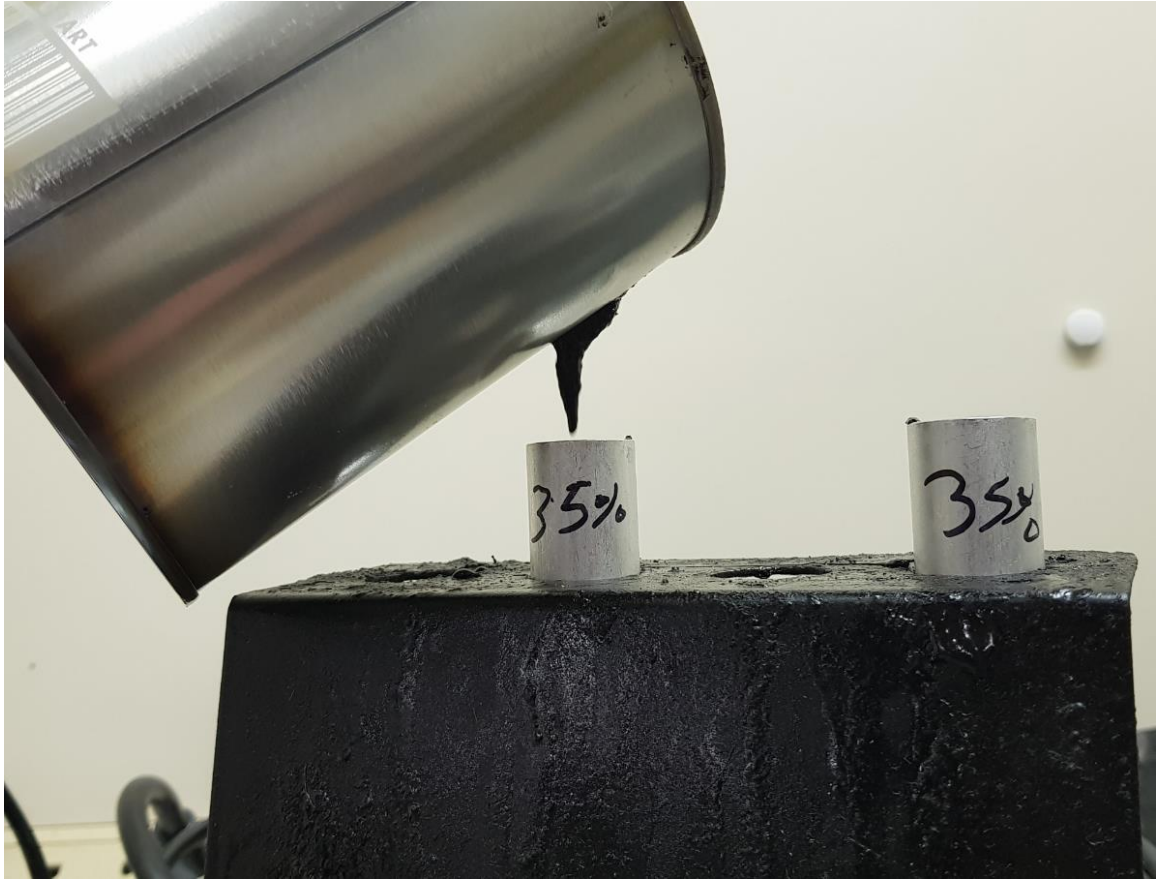


Figure 12. Sample Pouring into the Viscosity Testing Chamber.

Table 2. Thermosel™ Spindles Shear Rate and Sample Volume (44).

Spindle	Shear Rate (s ⁻¹)	Sample Volume (ml)
SC4-18	1.32 N	8.0
SC4-31	0.34 N	10.0
SC4-34	0.28 N	9.5
SC4-21	0.93 N	8.0
SC4-27	0.34 N	10.5
SC4-28	0.28 N	11.5
SC4-29	0.25 N	13.0
HT-DIN-81	1.29 N	7.0

Brookfield Rotational Viscosity Testing This test has the ability to determine the binder viscosity at high temperatures; therefore, it is a tool by which mixing and compaction temperatures of HMA may be determined. Under this test, the binder viscosity is determined by measuring the amount of torque applied to rotate a standard spindle at constant speed while being submerged in a standard testing chamber filled with binder at temperature of interest. For the purpose of this study, the test was conducted according to American Society for Testing and Materials (ASTM) standard D4402 (45) and American Association of State Highway and Transportation Officials (AASHTO) standard T 316-13 (46). Out of the many spindles shown within Table 2, spindle number 27 (SC4-27) that had a shearing rate of 0.34 N and sample volume of 10.5 ml was utilized to conduct the test. The testing setup was as shown in Figure 1. Four different testing shearing rates for each binder were utilized to evaluate the viscosity as shown in Table 1. The testing shearing rates were calculated according to Equation 3-1 (47).

$$\text{TSR} = \text{SR} \times \text{N} \quad (3-1)$$

where,

TSR = Testing Shearing Rate (s^{-1});

SR = Spindle Shearing Rate (s^{-1});

N = Testing Speed in Revolutions per Minute (RPMs).

Chapter 4

Experiment Results and Discussion

Under this chapter, the collected datasets according to the testing program presented under chapter 3 were evaluated. Also, all the statistical analysis tools utilized in drawing the conclusions as well as discussing the collected data were demonstrated.

Statistical Analysis Approach

Descriptive and inferential statistics were the main statistical tools in this study. The descriptive statistic measures were utilized as a tool to describe the main properties of the research variables, summarizing the details, and examine the commonality among the collected data (15). Arithmetic mean, standard deviation, and the standard error of the mean were evaluated for all collected test data at different shearing rate and RAR modification dosages.

Inferential statistics was utilized to draw conclusions related to the full population of the collected data. As demonstrated under chapter 3, this study aimed to evaluate the effect of RAR modifier addition as well as the effect of different testing shearing rates on the virgin binder viscosity. Therefore, Analysis of Variance (ANOVA) was conducted as the main inferential statistics method in this study.

Microsoft Excel software package was utilized in data analysis, data evaluation, and one-way ANOVA execution. ANOVA is considered as a testing tool that has the ability to comment if the means (μ) of several populations (n) are significantly different. Thus, ANOVA was the judging tool to comment on the existence of any significant differences among the means of the collected data from different samples at a confidence

level of 95%. ANOVA tests the null hypotheses (H_0) assuming that the means of all the collected data are equal ($\mu_a = \mu_b = \mu_c \dots = \mu_n$). The ANOVA F-test is the key for accepting or rejecting this null hypotheses (H_0). If the resulted F-test value calculated as shown in Equation 4-1 was bigger the $F_{critical}$ value, then null hypotheses are rejected, else the null hypotheses are accepted. It is noteworthy to point out the value of $F_{critical}$ depends on the degrees of freedom as well as the level of significance (α). Under this study a level of significance of .05 that is equivalent to confidence level of 95% was utilized. In addition, ANOVA was conducted on the full data populations at first to examine the existence of any significant differences between the different samples, and when such difference found, an interval-based ANOVA compering only two samples was carried over to further examine the data and determine the source of mean differences.

$$F - Test = \frac{S^2_B}{S^2_W} \quad (4-1)$$

$$S^2_B = \frac{SSB}{t-1} = \frac{\sum_i n_i (\bar{y}_i - \bar{y}_{all})^2}{t-1} \quad (4-2)$$

$$S^2_W = \frac{SSW}{n_T - t} = \frac{\sum_i n_i (\bar{y}_i - \bar{y}_{all})^2}{n_T - t} \quad (4-3)$$

$$SSW = \sum_{i,j} (\bar{y}_{ij} - \bar{y}_{all})^2 \quad (4-4)$$

$$TSS = \sum_{i=1}^t \sum_{j=1}^{n_i} (\bar{y}_{ij} - \bar{y}_{all})^2 = (n_T - 1)S^2_T \quad (4-5)$$

where,

t = number of different populations;

n_T = number of total observations;

y_{ij} = the j^{th} observation from population i ;

n_i = number of observations in population i ;

y_i = mean of observations from population i ;

y_{all} = mean of all observations from all populations;

SSB = sum of squares between samples;

SSW = sum of squares within samples;

TSS = total sum of squares.

Viscosity Data

Binders data was processed utilizing Microsoft Excel software package for each binder separately. Each binder of the three evaluated binders has around 1056 viscosity values that were collected at different temperature, testing shearing rate, and RAR modification dosage.

The arithmetic Mean (μ), Standard Deviation (SD), and Standard Error (SE) of the collected data were calculated as shown in Equations 4-6 to 4-8. Furthermore, the upper and lower limits of the 95% confidence interval were calculated utilizing Equation 4-9.

$$\mu = \bar{x} = \frac{\sum x}{n} \quad (4-6)$$

$$S_x = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}} \quad (4-7)$$

$$SE = \frac{\sigma}{\sqrt{n}} \quad (4-8)$$

$$CI = \bar{x} \pm (Z_{\alpha/2} \times \frac{\sigma}{\sqrt{n}}) \quad (4-9)$$

where,

x = single observation;

n = number of total observations;

$Z_{\alpha/2}$ = the confidence level (Z-score) at $\alpha = .05$, and that would be a constant value of (1.96).

Table 3, Table 4, and Table 5 are showing the descriptive analysis values for binders A, B, and C respectively. The values shown were at 6.8 (1/s) shearing rate for all the binders. However, the full descriptive analysis tables for the binders at the four evaluated shearing rates are shown in Appendix A.

It is apparent from the tables that the addition of RAR is increasing the binder viscosity for all the studied binders. In addition, within the same binder, the overall viscosity mean is increasing by increasing the RAR modification dosage. Also, at a certain RAR dosage value, binder C had the highest mean value, and that is logical since the virgin binder softness is decreasing from binder A (PG 64-22) to binder C (PG 76-22). For example, at 25% RAR dosage, binder C had a mean value of 2522 cP while binders A and B had values of 1380 and 1835 cP respectively.

Figure 13, Figure 14, and Figure 15 are showing the mean marked with the 95% confidence intervals for binders A, B, and C respectively. The figures compared the mean values for the binders at the studied different shearing rates.

From observing the figures, a difference between the viscosity mean is found at the same RAR dosages under different shearing rates. This difference is pronounced more at higher RAR dosages and it appears in all the studied binders. Further investigation of this difference is needed to determine whether this is a significant difference or not.

Table 3. Arithmetic Mean (μ), Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder A (PG 64-22) at 6.8 Shearing Rate (20 RPMs).

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	239	197	40	318	160.40
5	307	282	58	420	194.39
10	478	420	86	646	309.79
15	585	516	105	792	379.14
20	850	753	154	1151	548.83
25	1380	1226	250	1870	889.35
30	2050	1734	354	2744	1356.24
35	2689	2239	457	3585	1793.44
40	4321	3436	701	5696	2946.42
45	3849	3554	725	5271	2427.26
50	3725	3047	622	4944	2506.01

Table 4. Arithmetic Mean (μ), Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder B (PG 70-22) at 6.8 Shearing Rate (20 RPMs).

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	325	271	55	433	216.51
5	417	378	77	568	265.64
10	582	505	103	785	380.13
15	890	731	149	1182	597.12
20	1149	962	196	1533	763.87
25	1835	1573	321	2464	1205.75
30	2675	2172	443	3544	1806.07
35	3702	3156	644	4964	2438.98
40	4820	3921	800	6389	3251.21
45	4313	2074	489	5271	3354.85
50	6526	3008	709	7916	5136.29

Table 5. Arithmetic Mean (μ), Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder C (PG 76-22) at 6.8 Shearing Rate (20 RPMs).

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	481	414	85	647	315.71
5	616	566	115	843	390.01
10	952	926	189	1323	581.52
15	1247	1134	232	1701	793.03
20	1718	1507	308	2321	1115.38
25	2522	2160	441	3386	1657.32
30	4302	3582	731	5735	2869.39
35	2881	1399	330	3527	2234.48
40	3708	1798	424	4538	2877.43
45	5500	2786	657	6787	4212.21
50	6514	1786	516	7524	5503.32

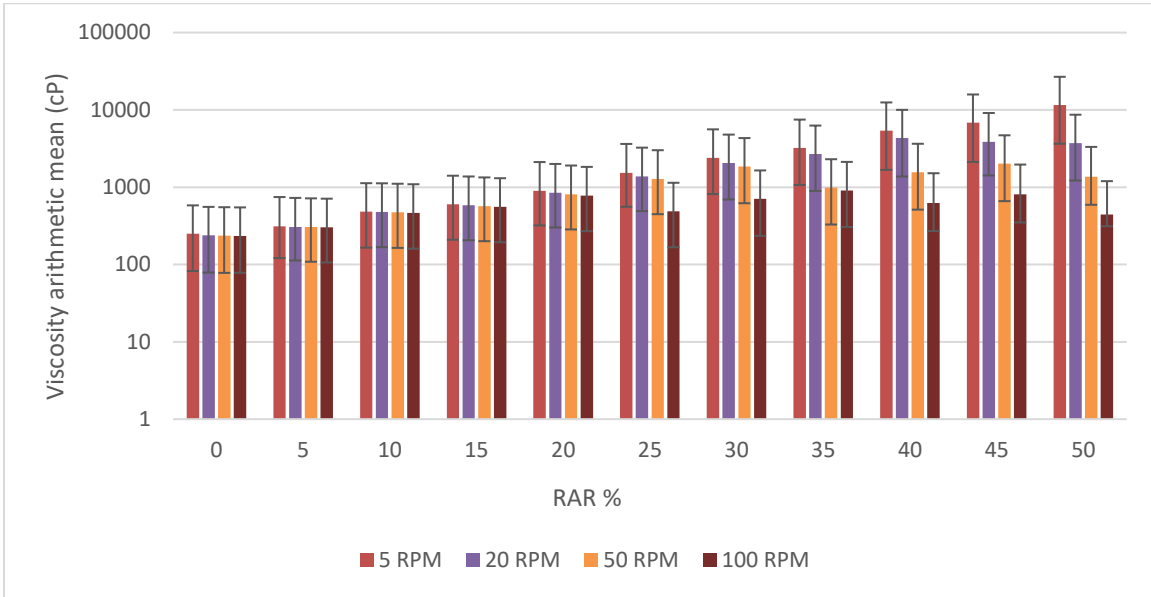


Figure 13. Arithmetic Mean and 95% Confidence Interval Values for Binder A (PG 64-22).

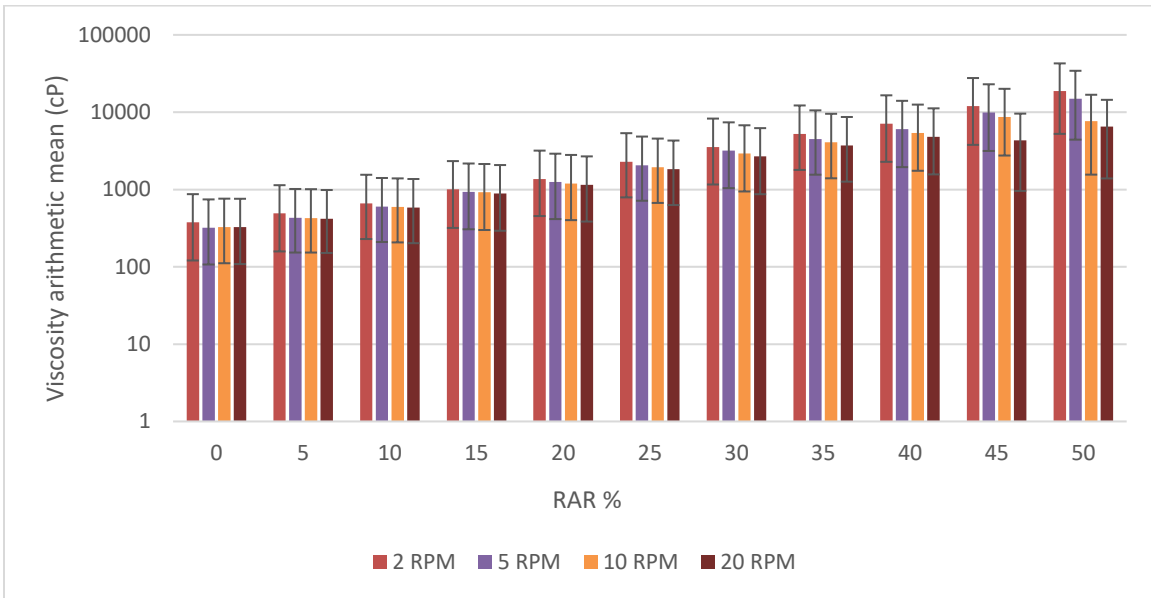


Figure 14. Arithmetic Mean and 95% Confidence Interval Values for Binder B (PG 70-22).

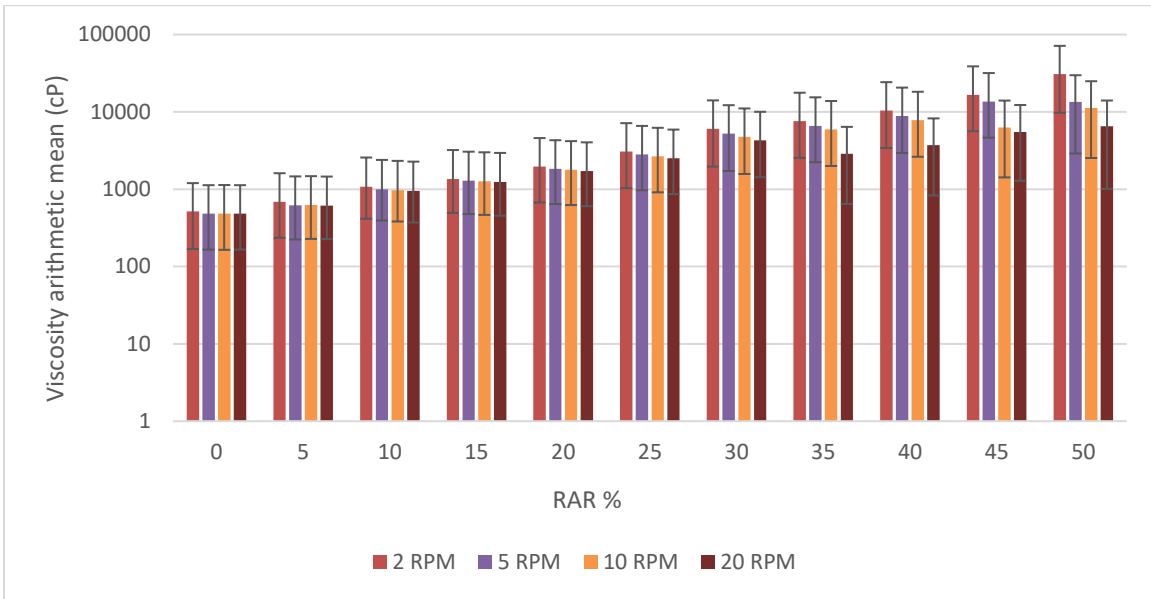


Figure 15. Arithmetic Mean and 95% Confidence Interval Values for Binder C (PG 76-22).

ASTM A-VTS Correlations Development and Discussion

A-VTS correlations for the three tested binders were developed as shown in Figure 16, Figure 17, and Figure 18 based on Equation 4-10.

$$\log \log(\eta) = A + \text{VTS} \log T_R \quad (4-10)$$

Where:

η = viscosity (cP);

T_R = temperature (degree Rankine);

A = regression intercept; and

VTS = regression slope (viscosity temperature susceptibility parameter).

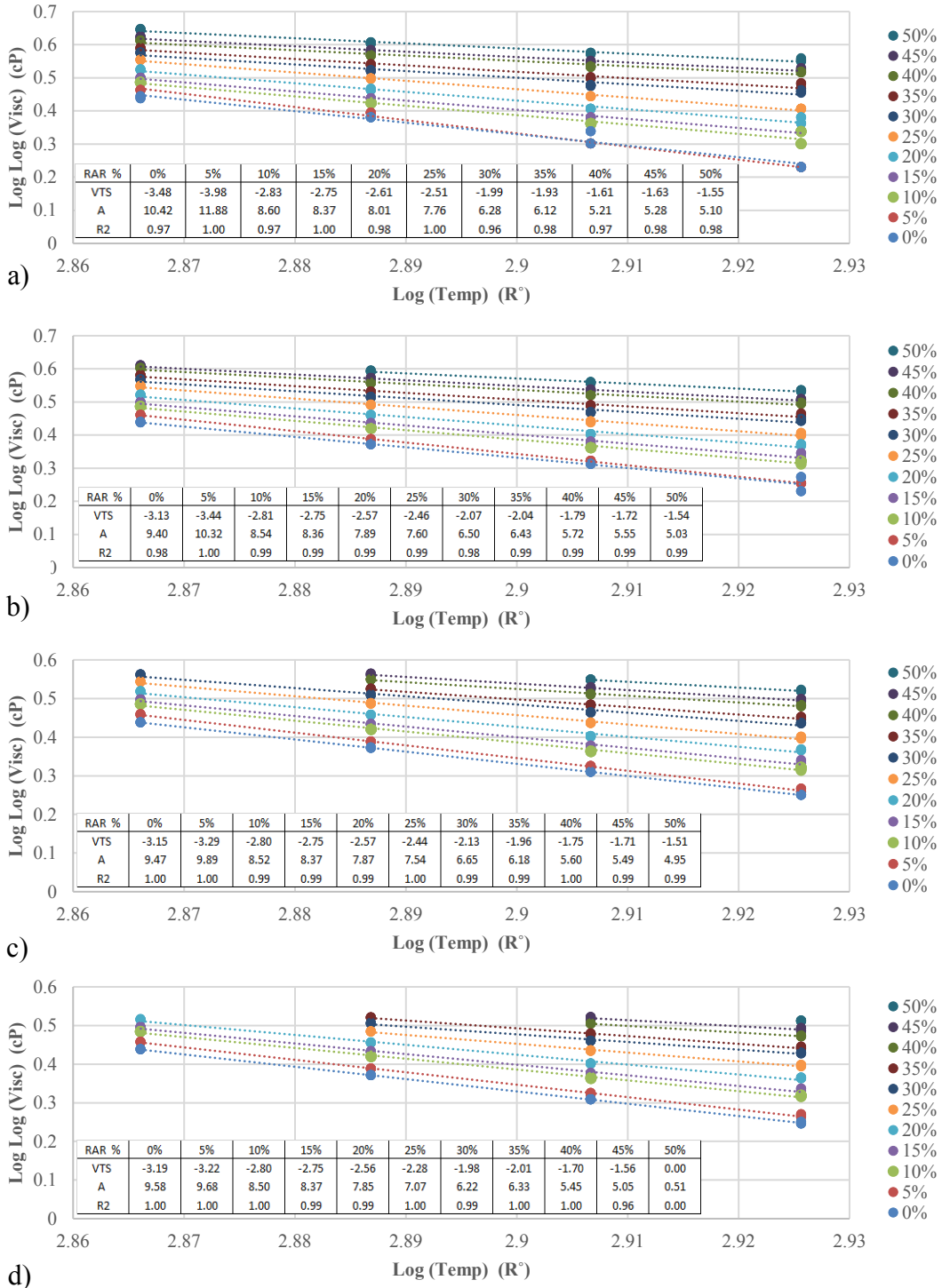
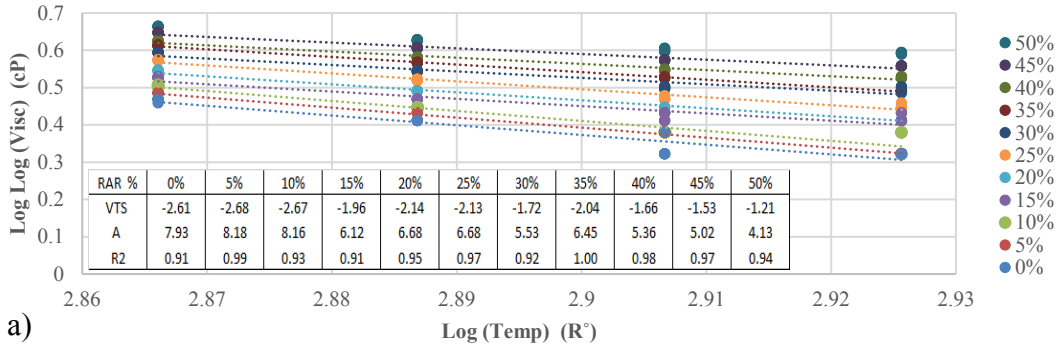
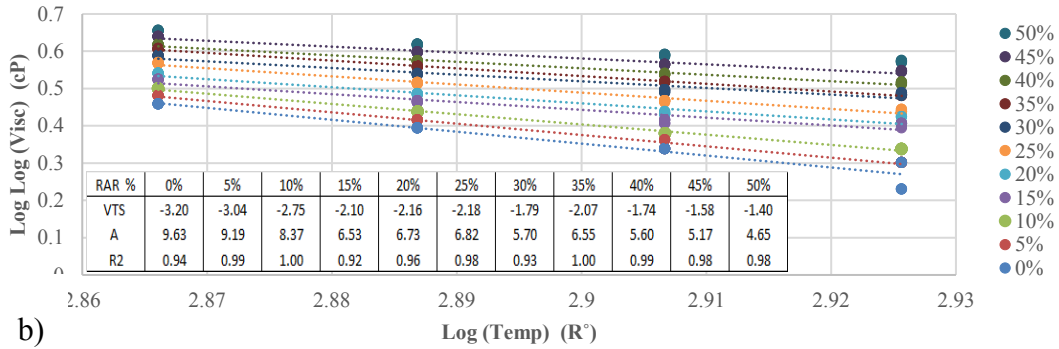


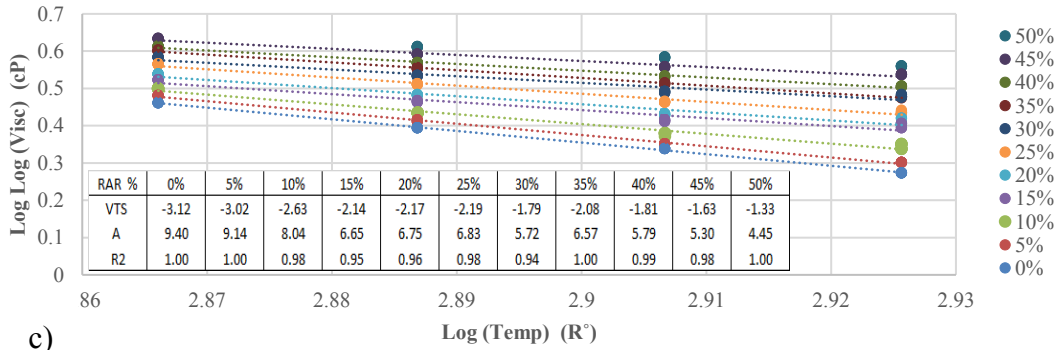
Figure 16. ASTM A-VTS Curves for Binder A at: a) 1.7 shearing rate (5 RPMs), b) 6.8 shearing rate (20 RPMs), c) 17 shearing rate (50 RPMs), and d) 34 shearing rate (100 RPMs).



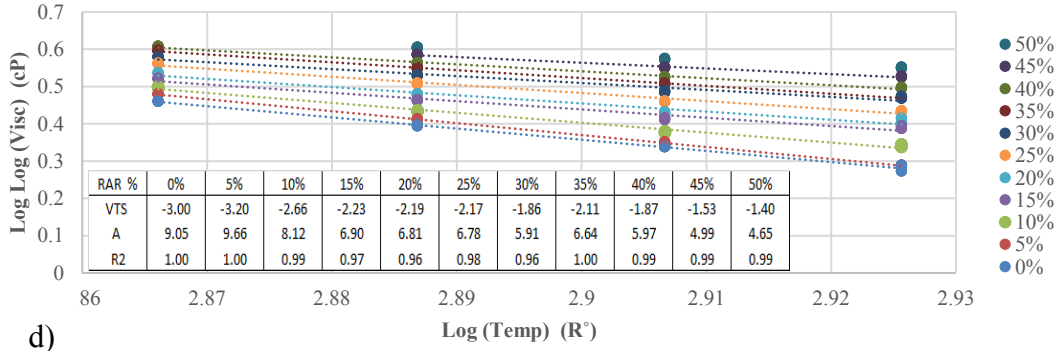
a)



b)

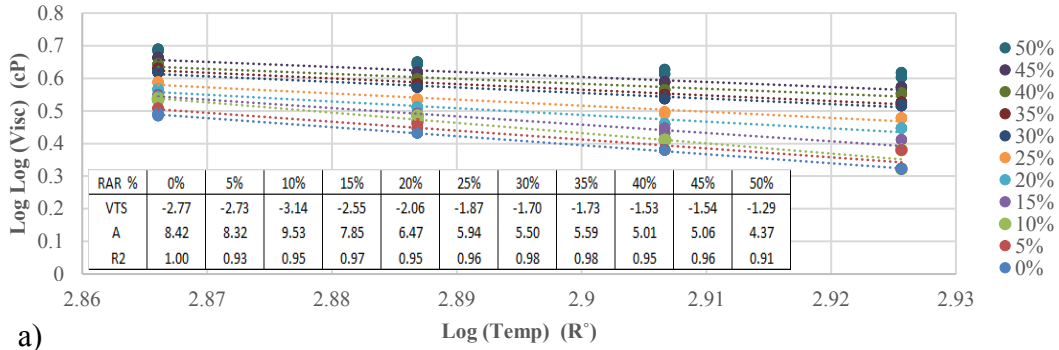


c)

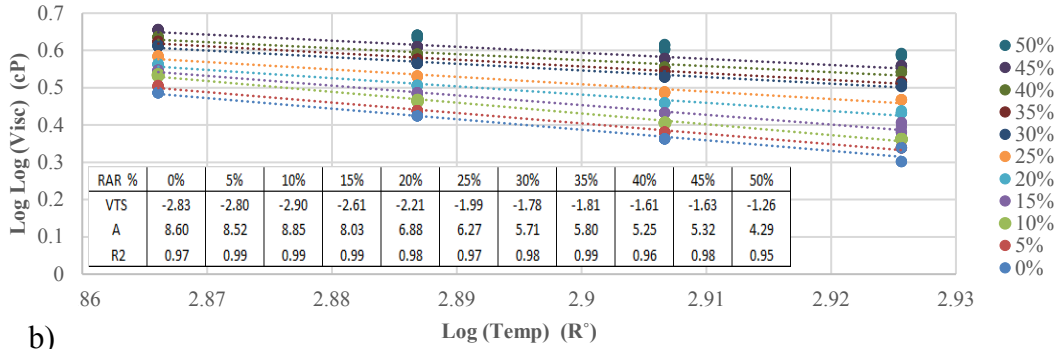


d)

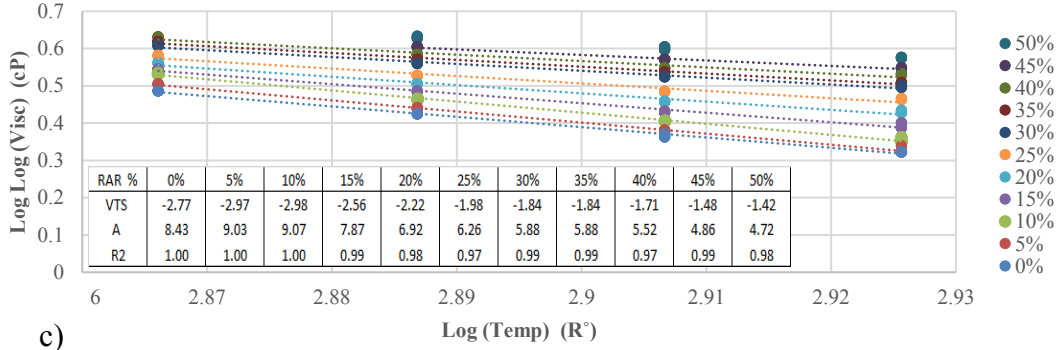
Figure 17. ASTM A-VTS Curves for Binder B at: a) 0.68 shearing rate (2 RPMs), b) 1.7 shearing rate (5 RPMs), c) 3.4 shearing rate (10 RPMs), and d) 6.8 shearing rate (20 RPMs).



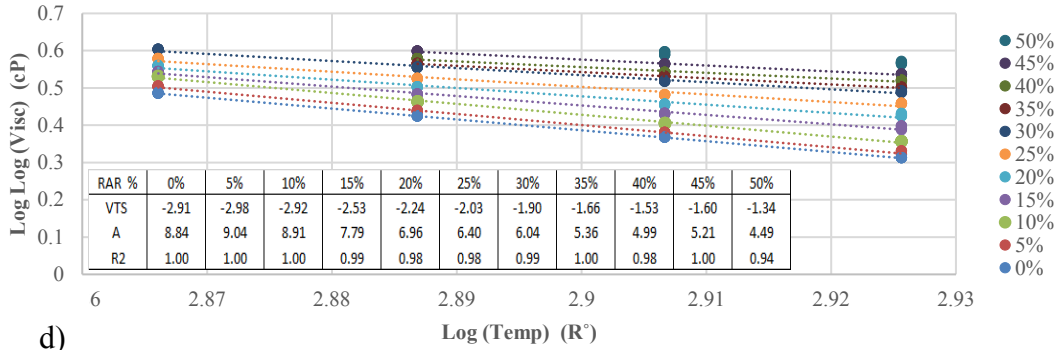
a)



b)



c)



d)

Figure 18. ASTM A-VTS Curves for Binder C at: a) 0.68 shearing rate (2 RPMs), b) 1.7 shearing rate (5 RPMs), c) 3.4 shearing rate (10 RPMs), and d) 6.8 shearing rate (20 RPMs).

The A-VTS correlations were developed for each binder at the 4 evaluated shearing rates. Full A-VTS correlations were developed for each tested sample separately and are presented in Appendix B. The A-VTS correlations as shown in Figure 16, Figure 17, and Figure 18 were developed based on the data collected from both tested samples at a given RAR dose. Therefore, each line within those figures was developed utilizing 24 different viscosity reading at that particular RAR dose and testing shearing rate. Its important to note that in limited occasions when high RAR dose, low temperatures, and high testing shearing rate existed, the rotational viscometer could not measure the viscosity reading; thus, at those occasions no viscosity reading was taken.

It is clearly shown within the figures (Figure 16, Figure 17, and Figure 18) that the addition of RAR is improving the temperature susceptibility of the binders by reducing the slope value of the correlation (VTS). In binder A, the VTS was dropped from -3.48 for a virgin binder to -1.55 for a 50% RAR modified binder at 1.7 (s^{-1}) shearing rate, and that is more than 50% improvement in the binder temperature susceptibility. The enhancement of temperature susceptibility of the binder had a direct relationship with the RAR dose. The higher the dose, the lower the slope, and better the performance. In fact, the RAR addition is improving the binder properties at both high and low temperature and will result in softer binders at lower temperatures. This effect is pronounced in the field performance since its known that AR modified mixtures perform better in terms of permanent deformation (rutting) as well as low temperature cracking (24).

Statistical Analysis Procedures and Results

Overall Analysis of Variance One-way ANOVA was utilized to evaluate the collected binder viscosity data. Table 6, Table 7, and Table 8 are showing the full ANOVA results for binders A, B, and C respectively. The ANOVA procedure was conducted based on Equations 1 to 5 shown earlier within this chapter utilizing Microsoft Excel software package. Under each binder, 22 different samples (2 at each RAR dose) were evaluated at four different shearing rates. In order to evaluate the differences shown in A-VTS figures (Figure 16, Figure 17, and Figure 18), an overall data ANOVA examining the difference between the collected data at given RAR dose and testing shearing rate was carried over. For each binder, 20 tested samples as well as 2 virgin binder samples were compared at each testing shearing rate. The P-values at the four shearing rates were almost zero for the three binders (binder A, binder B, and binder C). Therefore, a significant difference was found between the collected data at all of the evaluated testing shearing rates in the three binders as clearly demonstrated within Table 6, Table 7, and Table 8. Further analysis was conducted to determine the source of the difference between the compared means.

Table 6. ANOVA Results for Binder A at the Four Evaluated Testing Shearing Rates.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Between Groups</u>				
SS	3.07E+09	7.07E+08	1.60E+08	3.69E+07
df	10	10	10	10
MS	3.07E+08	7.07E+07	1.60E+07	3.69E+06
F	23.606	20.073	21.002	18.641
P-value*	4.0E-31	6.8E-27	3.0E-27	1.1E-23
F crit	1.868	1.870	1.873	1.880
<u>Within Groups</u>				
SS	3.29E+09	8.59E+08	1.70E+08	3.82E+07
df	253	244	223	193
MS	1.30E+07	3.52E+06	7.62E+05	1.98E+05
<u>Total</u>				
SS	6.37E+09	1.57E+09	3.30E+08	7.52E+07
df	263	254	233	203

* Highlighted values indicate a significant difference

Table 7. ANOVA Results for Binder B at the Four Evaluated Testing Shearing Rates.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Between Groups</u>				
SS	8.18E+09	5.24E+09	1.99E+09	9.31E+08
df	10	10	10	10
MS	8.18E+08	5.24E+08	1.99E+08	9.31E+07
F	27.436	24.596	22.025	22.016
P-value*	3.9E-35	3.4E-32	3.5E-29	5.6E-29
F crit	1.868	1.868	1.869	1.870
<u>Within Groups</u>				
SS	7.55E+09	5.39E+09	2.24E+09	1.02E+09
df	253	253	247	241
MS	2.98E+07	2.13E+07	9.06E+06	4.23E+06
<u>Total</u>				
SS	1.57E+10	1.06E+10	4.23E+09	1.95E+09
df	263	263	257	251

* Highlighted values indicate a significant difference

Table 8. ANOVA Results for Binder C at the Four Evaluated Testing Shearing Rates.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Between Groups</u>				
SS	2.08E+10	5.49E+09	2.59E+09	7.55E+08
df	10	10	10	10
MS	2.08E+09	5.49E+08	2.59E+08	7.55E+07
F	24.271	21.149	22.039	21.845
P-value*	7.7E-32	3.3E-28	5.3E-29	3.7E-28
F crit	1.868	1.869	1.870	1.873
<u>Within Groups</u>				
SS	2.16E+10	6.41E+09	2.83E+09	7.71E+08
df	253	247	241	223
MS	8.55E+07	2.60E+07	1.18E+07	3.46E+06
<u>Total</u>				
SS	4.24E+10	1.19E+10	5.43E+09	1.53E+09
df	263	257	251	233

* Highlighted values indicate a significant difference

Stepwise Analysis of Variance Step based ANOVA was utilized to further study and evaluate the existed differences within the collected data and to conduct pairwise comparisons. Four different modification incremental steps were utilized, namely: 5%, 10%, 15%, and 20%. For each binder and at each testing shearing rate, pairwise comparisons were executed based on those incremental steps.

The compared pairs were picked as follows:

- 1) For 5% RAR modification step: (0%, 5%), (5%, 10%), (10%, 15%), (15%, 20%), (20%, 25%), (25%, 30%), (30%, 35%), (35%, 40%), (40%, 45%), and (45%, 50%) were compared.
- 2) For 10% RAR modification step: (0%, 10%), (10%, 20%), (20%, 30%), (30%, 40%), and (40%, 50%) were compared.

- 3) For 15% RAR modification step: (0%, 15%), (15%, 30%), and (30%, 45%) were compared.
- 4) For 20% RAR modification step: (0%, 20%), and (20%, 40) were compared.

For each binder, 80 different ANOVA comparison were calculated (20 at each one of the four evaluated testing shearing rates). The P-values for those ANOVA calculations are shown in Table 9 to Table 12 for binder A, Table 13 to Table 16 for binder B, and Table 17 to Table 20 for binder C. In addition, the full ANOVA calculation results are presented within Appendix C.

It is clear by observing Table 9, Table 13, and Table 17 that for the 5% incremental steps no significant difference at 95% confidence level was found between the means, since the P-values are bigger than .05 for most of the cases. Therefore, little improvement to the binder temperature susceptibility is introduced due to increasing the RAR dose by 5% only. For example, no significant difference was spotted between 5% and the 10% RAR modified binders. The same applies for all the binders compared at 5% step.

When the steps are increased to 10%, 15%, and 20% significant differences were found among the data at 95% confidence level, since the P-values were lower than .05 for most of the cases as clearly shown within Table 10, Table 11, Table 12, Table 14, Table 15, Table 16, Table 18, Table 19, and Table 20. Also, it is important to note that the improvement in binder viscosity is directly related to the RAR dose with no upper limits.

In other words, the higher the dose, the lower the slope (VTS), and the better the binder performance in terms of temperature susceptibility.

Table 9. ANOVA P-values for Binder A at 5% Modification Step.

RAR %		P Value at Testing RPM*			
		5 RPM	20 RPM	50 RPM	100 RPM
0	5	4.1E-01	3.4E-01	3.3E-01	3.2E-01
5	10	1.1E-01	1.1E-01	1.0E-01	1.0E-01
10	15	3.9E-01	4.3E-01	4.7E-01	4.9E-01
15	20	1.3E-01	1.6E-01	1.8E-01	1.9E-01
20	25	5.8E-02	7.8E-02	9.0E-02	4.6E-01
25	30	9.6E-02	1.3E-01	1.5E-01	4.5E-02
30	35	2.4E-01	2.7E-01	1.8E-01	1.6E-01
35	40	3.6E-02	5.7E-02	1.2E-02	8.7E-01
40	45	3.0E-01	9.4E-01	1.4E-01	2.7E-02
45	50	3.3E-02	5.6E-01	9.3E-01	3.9E-01

* Highlighted values indicate a significant difference

Table 10. ANOVA P-values for Binder A at 10% Modification Step.

RAR %		P Value at Testing RPM*			
		5 RPM	20 RPM	50 RPM	100 RPM
0	10	1.8E-02	1.5E-02	1.4E-02	1.4E-02
10	20	2.8E-02	4.0E-02	4.9E-02	5.6E-02
20	30	1.7E-03	3.2E-03	4.5E-03	4.0E-01
30	40	2.7E-03	5.8E-03	5.8E-01	6.8E-02
40	50	4.2E-03	5.0E-01	7.4E-02	1.7E-03

* Highlighted values indicate a significant difference

Table 11. ANOVA P-values for Binder A at 15% Modification Step.

RAR %		P Value at Testing RPM*			
		5 RPM	20 RPM	50 RPM	100 RPM
0	15	3.8E-03	3.5E-03	4.0E-03	4.2E-03
15	30	1.3E-04	2.5E-04	3.6E-04	1.4E-02
30	45	3.7E-04	5.4E-03	7.3E-02	5.0E-04

* Highlighted values indicate a significant difference

Table 12. ANOVA P-values for Binder A at 20% Modification Step.

RAR %		P Value at Testing RPM*			
		5 RPM	20 RPM	50 RPM	100 RPM
0	20	3.7E-04	3.7E-04	4.0E-04	4.2E-04
20	40	4.7E-06	1.5E-05	2.7E-05	3.2E-02

* Highlighted values indicate a significant difference

Table 13. ANOVA P-values for Binder B at 5% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	5	2.6E-01	2.4E-01	2.9E-01	3.4E-01
5	10	2.3E-01	2.1E-01	2.2E-01	2.0E-01
10	15	9.2E-02	8.6E-02	8.6E-02	9.7E-02
15	20	2.1E-01	2.4E-01	2.8E-01	3.0E-01
20	25	5.5E-02	6.0E-02	6.8E-02	7.5E-02
25	30	8.3E-02	9.1E-02	1.1E-01	1.3E-01
30	35	1.3E-01	1.7E-01	1.8E-01	2.0E-01
35	40	2.0E-01	2.3E-01	2.5E-01	2.8E-01
40	45	3.8E-02	4.7E-02	5.6E-02	6.2E-01
45	50	4.4E-02	7.5E-02	5.6E-01	1.5E-02

* Highlighted values indicate a significant difference

Table 14. ANOVA P-values for Binder B at 10% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	10	3.5E-02	2.3E-02	3.0E-02	3.3E-02
10	20	9.3E-03	9.0E-03	1.2E-02	1.4E-02
20	30	1.2E-03	1.5E-03	2.0E-03	2.9E-03
30	40	8.9E-03	1.4E-02	1.8E-02	2.3E-02
40	50	2.3E-04	7.3E-04	7.9E-02	1.3E-01

* Highlighted values indicate a significant difference

Table 15. ANOVA P-values for Binder B at 15% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	15	7.2E-04	5.6E-04	6.8E-04	9.1E-04
15	30	1.4E-04	2.0E-04	2.7E-04	4.0E-04
30	45	1.4E-04	2.4E-04	3.4E-04	1.8E-02

* Highlighted values indicate a significant difference

Table 16. ANOVA P-values for Binder B at 20% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	20	1.5E-04	1.0E-04	1.6E-04	2.0E-04
20	40	1.4E-05	2.2E-05	3.5E-05	5.3E-05

* Highlighted values indicate a significant difference

Table 17. ANOVA P-values for Binder B at 5% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	5	2.5E-01	3.3E-01	3.4E-01	3.5E-01
5	10	1.2E-01	1.1E-01	1.3E-01	1.4E-01
10	15	4.0E-01	3.6E-01	3.4E-01	3.3E-01
15	20	1.7E-01	1.9E-01	2.0E-01	2.3E-01
20	25	8.5E-02	1.1E-01	1.3E-01	1.4E-01
25	30	1.1E-02	2.0E-02	2.9E-02	4.3E-02
30	35	3.6E-01	3.5E-01	3.7E-01	1.2E-01
35	40	2.0E-01	2.4E-01	2.7E-01	1.3E-01
40	45	7.2E-02	9.8E-02	3.7E-01	2.8E-02
45	50	1.6E-02	9.7E-01	2.2E-03	2.7E-01

* Highlighted values indicate a significant difference

Table 18. ANOVA P-values for Binder B at 10% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	10	1.8E-02	2.1E-02	2.6E-02	2.8E-02
10	20	3.4E-02	3.6E-02	3.5E-02	3.9E-02
20	30	3.3E-04	6.8E-04	1.2E-03	2.1E-03
30	40	3.6E-02	4.5E-02	5.8E-02	5.2E-01
40	50	3.2E-04	3.8E-02	8.3E-02	2.5E-04

* Highlighted values indicate a significant difference

Table 19. ANOVA P-values for Binder C at 15% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	15	2.7E-03	2.9E-03	3.1E-03	3.2E-03
15	30	3.8E-05	7.7E-05	1.4E-04	2.4E-04
30	45	1.2E-03	1.9E-03	1.8E-01	2.5E-01

* Highlighted values indicate a significant difference

Table 20. ANOVA P-values for Binder C at 20% Modification Step.

RAR %		P Value at Testing RPM*			
		2 RPM	5 RPM	10 RPM	20 RPM
0	20	1.8E-04	2.4E-04	2.8E-04	3.3E-04
20	40	1.9E-05	3.8E-05	7.1E-05	3.6E-04

* Highlighted values indicate a significant difference

Testing Shearing Rate Analysis of Variance The Brookfield viscosity test may be performed utilizing a wide range of shearing rates (RPMs) during sample testing. One of the goals of this study was to evaluate the effect of those rates on the measured viscosity values for RAR modified binders. For binder A, 1.7 s^{-1} (5 RPM), 6.8 s^{-1} (20 RPM), 17 s^{-1} (50 RPM), and 34 s^{-1} (100 RPM) were evaluated. For the other two binders (B and C), a narrower range of the shearing rates were evaluated to examine the changing effected at a lower resolution. Also, this range was picked as an effort to avoid out of device range viscosity readings as possible, especially that binder B and C are harder than binder A. The evaluated shearing rates for binders B and C were as follows: $.68 \text{ s}^{-1}$ (2 RPM), 1.7 s^{-1} (5 RPM), 3.4 s^{-1} (10 RPM), and 6.8 s^{-1} (20 RPM).

Pairwise comparisons were conducted for the evaluated shearing rates. Adjacent pairs were picked for evaluation as follows:

- 1) For binder A: (5 RPM, 20 RPM), (20 RPM, 50 RPM), and (50 RPM, 100 RPM) as shown in Table 21.
- 2) For binder B and C: (2 RPM, 5 RPM), (5 RPM, 10 RPM), and (10 RPM, 20 RPM) as shown in Table 22 and Table 23 respectively.

Table 21, Table 22, and Table 23 are showing the P-values only. However, the full ANOVA results are presented within Appendix D for each sample separately.

Table 21. ANOVA P-values for Binder A at the Four Evaluated Shearing Rates.

RAR %	P Value at Testing RPM*		
	5 RPM & 20 RPM	20 RPM & 50 RPM	50 RPM & 100 RPM
0	8.5E-01	9.7E-01	9.7E-01
5	9.5E-01	9.7E-01	9.8E-01
10	9.8E-01	9.7E-01	9.6E-01
15	9.2E-01	9.1E-01	9.3E-01
20	8.3E-01	8.6E-01	8.8E-01
25	6.8E-01	7.7E-01	2.7E-02
30	5.3E-01	6.8E-01	2.1E-02
35	4.6E-01	1.6E-02	6.4E-01
40	3.3E-01	1.1E-02	1.1E-02
45	7.8E-02	5.6E-02	1.2E-02
50	4.8E-03	4.9E-03	5.8E-03

* Highlighted values indicate a significant difference

Table 22. ANOVA P-values for Binder B at the Four Evaluated Shearing Rates.

RAR %	P Value at Testing RPM*		
	2 RPM & 5 RPM	5 RPM & 10 RPM	10 RPM & 20 RPM
0	5.0E-01	9.4E-01	1.0E+00
5	6.1E-01	9.8E-01	9.2E-01
10	7.0E-01	9.6E-01	9.4E-01
15	7.4E-01	9.5E-01	8.9E-01
20	7.1E-01	8.7E-01	8.6E-01
25	6.9E-01	8.2E-01	8.2E-01
30	6.4E-01	7.2E-01	7.2E-01
35	5.6E-01	6.9E-01	7.0E-01
40	4.8E-01	6.3E-01	6.4E-01
45	4.2E-01	5.6E-01	1.3E-02
50	2.8E-01	9.7E-03	3.1E-01

* Highlighted values indicate a significant difference

Table 23. ANOVA P-values for Binder C at the Four Evaluated Shearing Rates.

RAR %	P Value at Testing RPM*		
	2 RPM & 5 RPM	5 RPM & 10 RPM	10 RPM & 20 RPM
0	7.8E-01	9.8E-01	9.8E-01
5	6.9E-01	9.8E-01	9.6E-01
10	7.9E-01	9.2E-01	9.4E-01
15	8.5E-01	9.5E-01	9.5E-01
20	7.9E-01	9.1E-01	8.9E-01
25	7.3E-01	8.2E-01	8.3E-01
30	5.4E-01	6.8E-01	6.8E-01
35	5.7E-01	6.6E-01	1.6E-02
40	5.0E-01	6.1E-01	1.4E-02
45	4.2E-01	1.3E-02	4.2E-01
50	5.2E-03	2.6E-01	8.2E-03

* Highlighted values indicate a significant difference

As demonstrated within the tables that, in some occasions, there are significant differences between the tested samples at two different shearing rates under same RAR modification dose. This difference is related to the RAR modification dose as well as the testing shearing rate. The significant differences were found at higher RAR dose. In fact, those differences are due to the non-Newtonian behavior of rubber modified binders. Furthermore, the significant differences were found when comparing the high shearing rates. In binder A the majority of differences were between 50 and 100 RPMs while almost no differences between the samples were found at 5 and 20 RPMs. The case is similar for binders B and C, the majority of the differences were between samples tested at 10 and 20 RPMs. It is worth mentioning that the differences started to appear at 25% RAR modified binder A, 45% RAR modified binder B, and 35% RAR modified binder C. It is recommended to test the RAR modified binders at a maximum shearing rate of 3.4 s^{-1} , especially high dosage modified RAR binders (25% and above).

Chapter 5

Artificial Neural Network Modeling

In this chapter the artificial neural modeling approach is discussed in detail. The developed model architecture as well as training methodology are explained. In addition, eclectic rule extraction approach is utilized to generate a rule from the developed trained ANN network. Finally, the extracted equation is tested and evaluated by examine its abilities in predicting the viscosity values and generating ASTM A-VTS correlations for different binder combinations.

Developed Model Architecture

Three-layer feed-forward backpropagation neural network with a sigmoid activation function and one hidden layer is considered as one of the most common network structures utilized for data fitting and regression. Furthermore, single hidden layer has the ability to solve the majority of non-linear problems without network overfitting (42).

Three-layer feed-forward neural network with a backpropagation-error calculation algorithm and two neurons in the hidden layer, was utilized in the model development. The main components of the utilized model architecture are shown in Figure 19, and were as follows:

- 1) Input layer (i): this layer had 4 input neurons. Each one of them was associated to an independent variable.

- 2) Weight factors (W_{ih}): those factors were the linking factors between the input layer (i) and the hidden layer (h). The extracted weight matrix had eight different value, one value form each input to each neuron.
- 3) Hidden layer (h): the layer contained two hidden neurons with tan-sigmoid activation function as well as two biases values (b_{h1} and b_{h2}).
- 4) Weight factors (W'_{ho}): those factors are the links between the hidden layer (h) and the output layer (o). The extracted matrix contained two values, one form each hidden neuron to the output neuron.
- 5) Output layer (o): this layer had a single output neuron with a linear transfer function to the dependent variable and a single bias value (B_o).

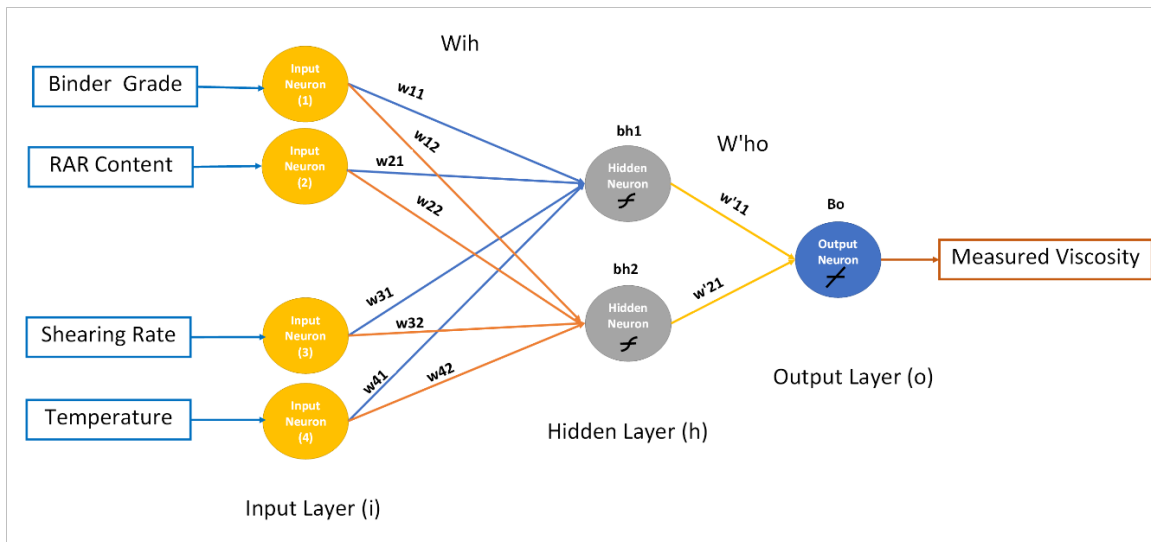


Figure 19. Developed ANN Model Architecture.

Model Development and Training Methodology

Data collected during lab testing conducted according to the experimental design explained under chapter 3 was utilized in the model development. The utilized data included five different factors as follows: 1) Binder grade, 2) Testing shearing rate, 3) RAR content, 4) Temperature, and 5) Binder viscosity. The binder grade was changed from categorical variable to numerical variable by utilizing binder elastic modulus (stiffness) values obtained from the dynamic modulus (E^*) test at 70°F and 10 Hz. Since no dynamic modulus testing was performed under this research study, the Artificial Neural Networks for Asphalt Concrete Dynamic Modulus Prediction (ANNACAP) program (48) recommended by Long-Term Pavement Performance (LTPP) database for E^* prediction was utilized in developing E^* master curve for binder A, B, and C. The model was developed and trained to predict the binder viscosity as a function of the temperature, testing shearing rate, binder grade, and RAR content as shown within Equation 5-1.

$$\text{Viscosity} = f(\text{Temperature}, \text{Testing Shearing Rate}, \text{Binder Grade}, \text{RAR Content}) \quad (5-1)$$

MATLAB (MATLAB R2018a, The Math Works Inc.) was utilized to develop and train the model by feeding the data into the model layers. The total number of datasets utilized in training and developing the model was 3003 datasets. The logarithm of the binder grade (numerical value), testing shearing rate, RAR content, and the logarithm of the degree Rankine temperature were fed in the input layer, while the logarithm of the viscosity logarithm was fed in the output layer.

The model training was conducted utilizing Levenberg-Marquardt backpropagation algorithm in MATLAB. This training algorithm divides the data into three sets. Under this algorithm, seventy percent of the data is utilized as model training data while the other thirty percent is divided equally towards model testing and model validation data. As an effort to keep the network generalization and avoid network overfitting, the model training was stopped when the validation data set error had stopped decreasing for six consecutive iterations (49) as shown in Figure 20.

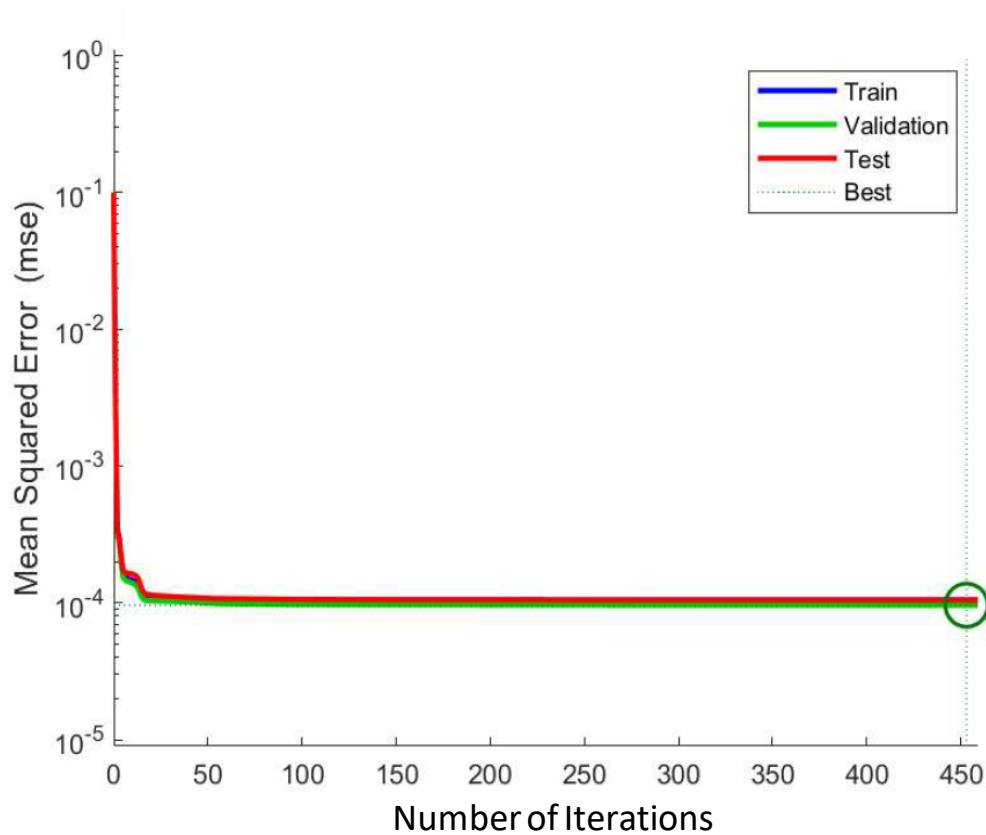


Figure 20. Number of Iterations/ Epochs Required for Model Training (MATLAB R2018a, The Math Works Inc.).

The model performance was validated inside the MATLAB environment as shown in Figure 21. In addition, one-way ANOVA was conducted to evaluate the developed ANN model externally as shown in Table 24. As clearly shown within Figure 21 and Table 14, the model had a high value of the coefficient of determination (R^2) as well as a high P-value at 95% confidence level. The ANN developed model significance as well as statistical validity were demonstrated by having an R^2 value of almost 1 and a P-value of 0.97. Therefore, the model was deemed suitable to be utilized in viscosity prediction as well as rule extraction of a stand-alone viscosity prediction equation.

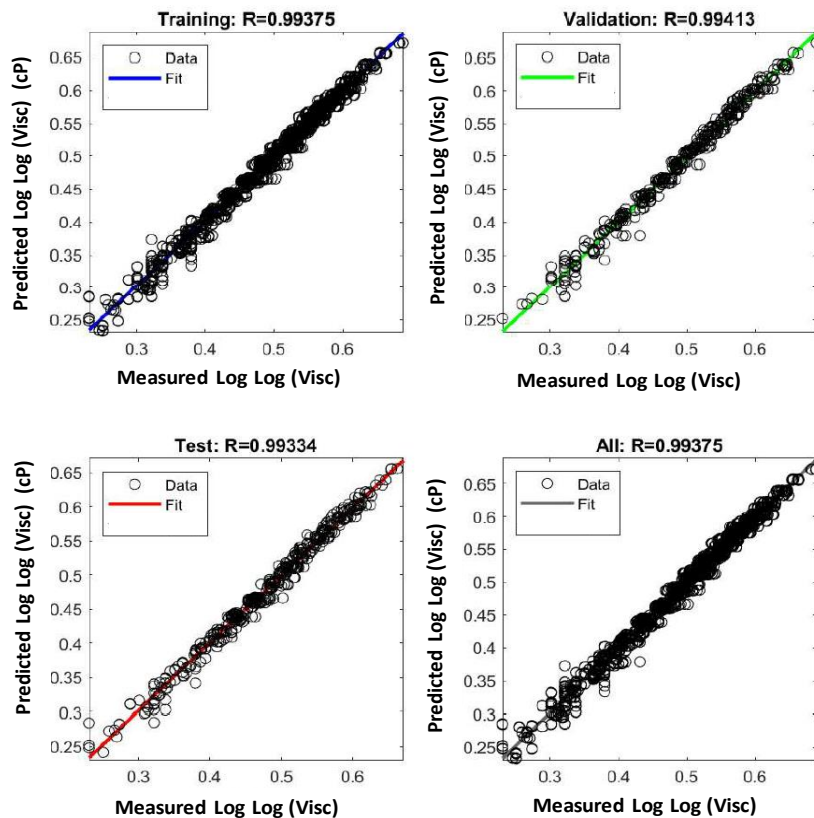


Figure 21. Regression Plots for Training, Validation, Testing, and Overall data (MATLAB R2018a, The Math Works Inc.).

Table 24. Analysis of Variance for the Developed ANN Viscosity Model.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.32E-05	1	1.32E-05	0.002	0.968	3.843
Within Groups	49.779	6004	0.008			
Total	49.779	6005				

Rule Extraction from the Developed Trained ANN Model

As an effort to open the black box and achieve better understanding of the developed ANN models, many researchers attempted to generate rule extraction approaches (41; 42; 43). The three main approaches to extract rules and develop a stand-alone equation from the trained ANN models were discussed in detail under chapter 2. Out of those three approaches, the eclectic approach was utilized for rule extraction under this study. This approach considered as a hybrid approach of decompositional and pedagogical approaches, in which the relationship between the input and output of the trained network as well as its structure inclusive of the weight factors and the biases are needed to generate the rule.

To extract the rule and generate a stand-alone viscosity prediction equation utilizing the developed ANN model architecture as shown in Figure 19, the following values were needed: 1) Weight values from the input to the hidden layer, 2) Bias values in the hidden layer, 3) Weight factors from the hidden layer to the output layer, and 4) Bias values in the output layer. Those values were extracted from MATLAB (MATLAB R2018a, The Math Works Inc.) after concluding the model training and were as shown below.

$$\mathbf{W}_{ih} = \begin{bmatrix} -0.0161 & -0.0191 & -0.140 & -.0035 \\ 0.5171 & 0.0832 & 0.1015 & -0.0883 \end{bmatrix}$$

$$\mathbf{W}_{ho} = \begin{bmatrix} 10.5544 \\ -22.718 \end{bmatrix} \quad \mathbf{b}_{hi} = \begin{bmatrix} -2.6385 \\ -1.345 \end{bmatrix} \quad \mathbf{B}_o = [-9.2695]$$

The developed model structure, the weight values, the bias values, the relationship between the input and output data, and data normalization occurring inside the model environment, all along with statistical and mathematical analysis algorithms, were utilized to extract a stand- alone viscosity prediction equation from the trained and validated ANN model. The extracted equation was a shown in Equation 5-2.

$$\log \log(\eta) = 0.27443(\log PG) - 0.00033(\text{TSR}) - 2.32539(\log T_R) + 0.48089(\text{RAR}) + 6.212 \quad (5-2)$$

Where:

η =viscosity (cP);

PG= binder grade (ksi), binder stiffness values obtained from the dynamic modulus (E^*) test predicted by ANNACAP at 70 F and 10 Hz.

TSR= testing shearing rate (s^{-1}) = testing spindle factor x rotation speed

T_R = temperature (degree Rankine); and

RAR = percent of the added RAR from the virgin binder weight (fraction), for virgin binder only this value is zero.

The extracted stand-alone equation was evaluated utilizing the available 3003 datasets and founded to reliable by having a high value of 0.97 as the coefficient of determination (R^2) as shown in Figure 22. In addition, one-way ANOVA was conducted to further validated the developed equation. As shown in Table 25, the equation was statistically valid by having a P-value of almost 1 and F-value that is much lower than

$F_{critical}$ value at 95% confidence level. Therefore, the developed equation was deemed to be statistically valid and maybe utilized in binder viscosity prediction outside the developed model environment as a stand-alone equation.

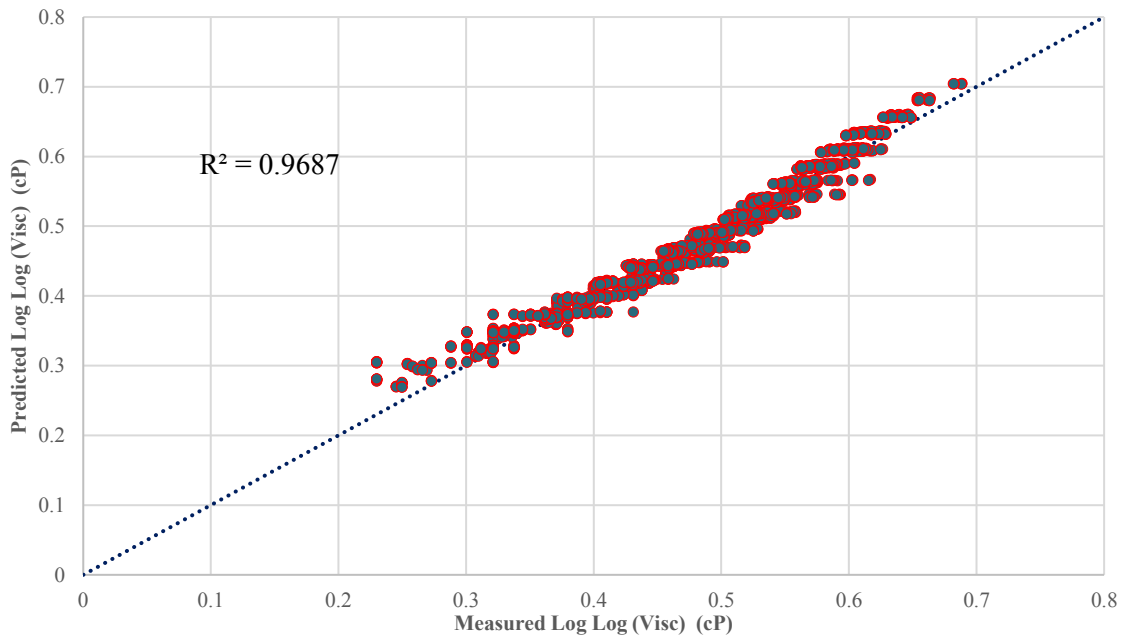


Figure 22. Predicted VS Measured Values of Viscosity for 3003 Datasets Utilizing the Generated Stand-alone Viscosity Prediction Equation.

Table 25. Analysis of Variance for the Predicted VS Measured Values of Viscosity for 3003 Datasets Utilizing the Generated Stand-alone Viscosity Prediction Equation.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.81E-05	1	1.81E-05	0.002	0.963	3.843
Within Groups	49.313	6004	0.008			
Total	49.313	6005				

Viscosity Sensitivity Analysis Utilizing the Developed Stand-alone Equation

The sensitivity of the predicted viscosity utilizing the newly developed equation to the change in binder grade, binder temperature, and RAR content was evaluated in three different ways as follows: 1) ASTM A-VTS corrections for the tested binders were regenerated utilizing the newly developed equation, 2) ASTM A-VTS corrections for a new binder (PG 52-22), that was never part of the lab testing nor the ANN modeling data, were developed and evaluated, and 3) Virgin binder viscosity as predicted by the newly developed equation at different temperatures for the three tested binders as well as the forth newly introduced binder were evaluated and compared. The sensitivity analysis was conducted at four temperatures, ten different RAR content, and one shearing rate of 6.8s^{-1} (20 RPM).

As demonstrated via Figure 23, the newly developed equation had the ability to replicate the ASTM A-VTS corrections developed based on the lab testing presented under chapter 4 herein. Furthermore, the equation was able to produce the ASTM A-VTS correlation for a new binder that was never part of the testing or the modeling data. As shown in Figure 24, the correlation followed the correct trend in which, the addition of RAR would decrease the correlation slope and consequently will decrease the binder temperature susceptibility. Finally, as observed in Figure 25, the equation had the ability to sense the change in the viscosity of the virgin binders at different temperatures. Also, the equation was able to sense the change of the viscosity at the same temperature for different binder grades. For example, PG 76-22 had the highest viscosity while PG 52-22 had the lowest at the same temperature. Therefore, the equation was considered reliable

and has the ability to accurately predict the viscosity values at different temperatures, binder grades, testing shearing rates, and RAR contents.

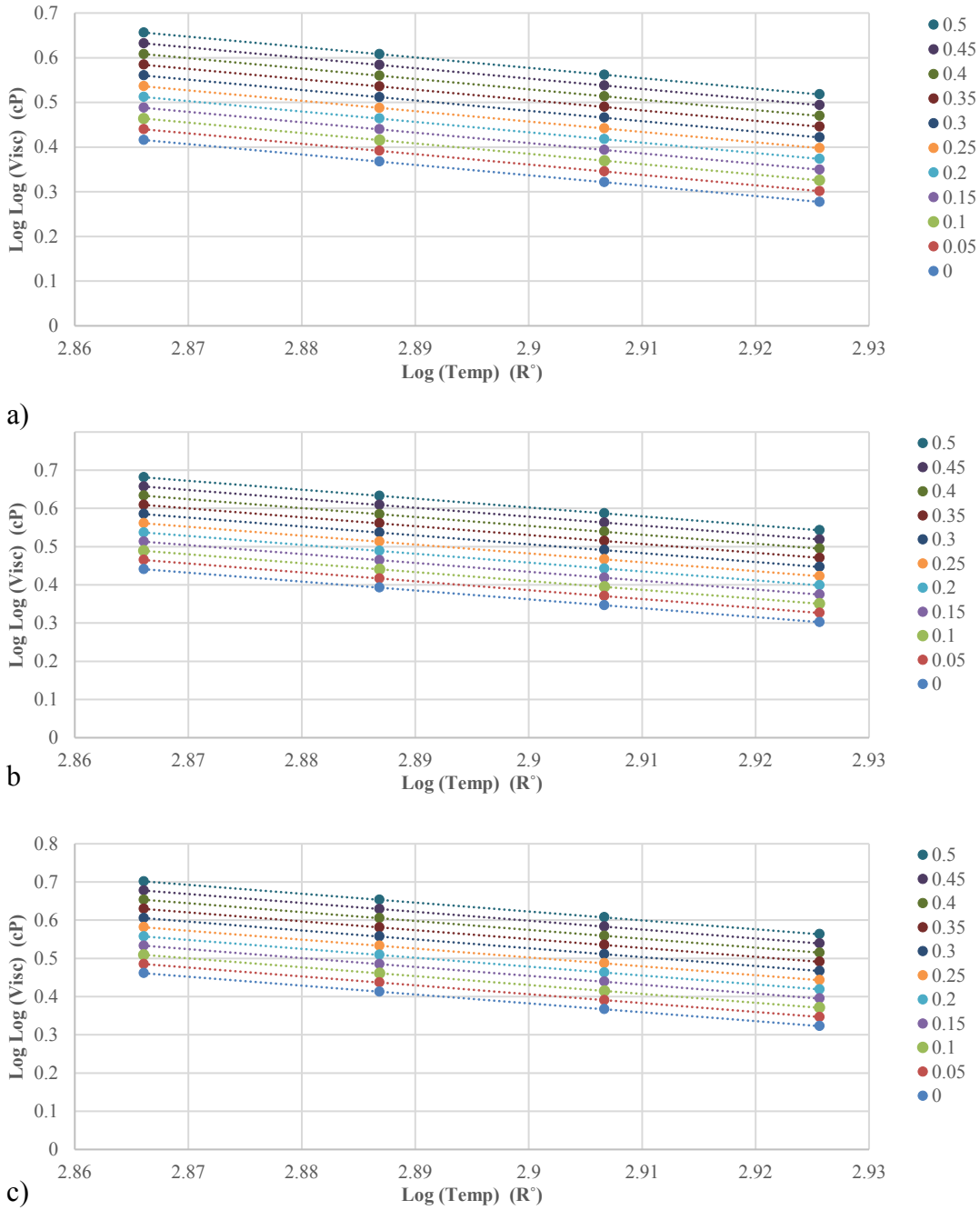


Figure 23. ASTM A-VTS Correlations Generated Utilizing the Newly Developed Prediction Equation for: a) Binder A, b) Binder B, and c) Binder C.

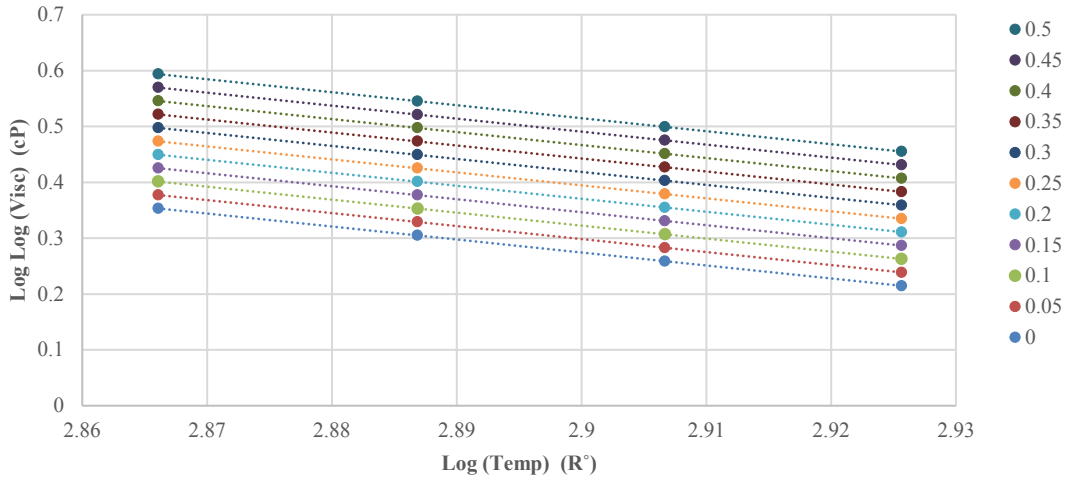


Figure 24. ASTM A-VTS Correlations Generated Utilizing the Newly Developed Prediction Equation for the New Binder PG 52-22.

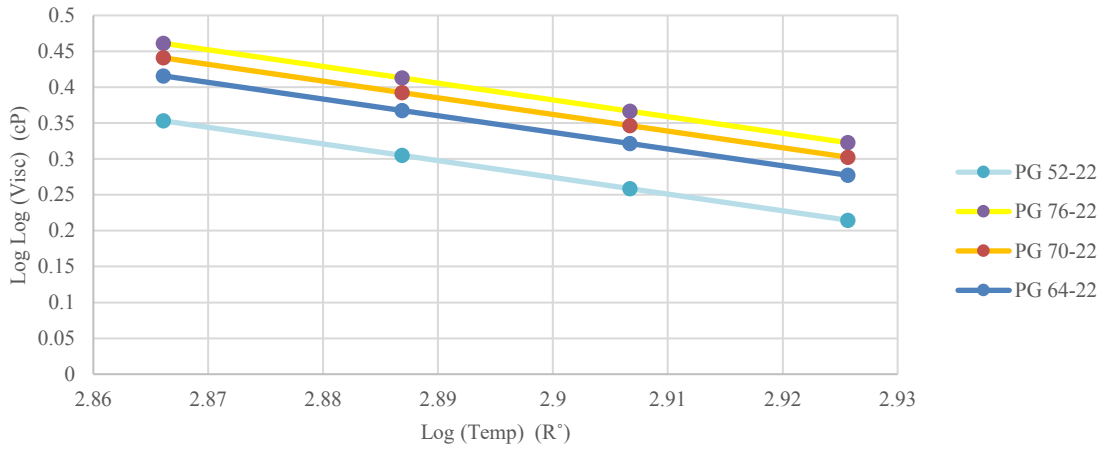


Figure 25. ASTM A-VTS Correlations Generated Utilizing the Newly Developed Prediction Equation for the Four Different Evaluated Virgin Binders.

Chapter 6

Conclusions and Recommendations

Many researchers had attempted to modify the crumb rubber before adding it to the binder. The ultimate goal, in most of the cases, for those modifications is to modify the crumb rubber surface as an effort to improve and strengthen its compatibility with the polymer matrix existed within the binder. Activated Mineral Binder Stabilizer (AMBS) as a binder stabilizer prevents excessive bitumen drainage during haulage, storage, and placement and has helped improving the material performance since 2009. The new technology of Reacted and Activated Rubber (RAR), was a result of many experimental trials in which the AMBS was implemented in different mixtures of rubber and asphalt. The main three components in RAR are asphalt, crumb rubber, and AMBS. Compared to regular AR binder, RAR is dry granulated product; therefore, its handling and storage are easier. RAR dry granulated nature will facilitate its addition to any existing asphalt production plant with minimum or no modification.

The goals of this study were to evaluate the rheological properties of RAR modified unaged binders utilizing Brookfield rotational viscosity testing and examine the effect of varying testing shearing rates on the measured viscosity. Furthermore, the study aimed to develop an ANN viscosity prediction model as an effort to generate a stand-alone viscosity prediction equation. Under the study, three different unaged binders modified by 10 different RAR dosages were evaluated.

Overall, the addition of RAR has improved the binder performance for all the evaluated binders. The introduced enhancement was in terms of reducing the binder's

temperature susceptibility by reducing the slope of the ASTM A-VTS correlations. Direct relationship between the added RAR amounts and improved binder performance was found. The developed ANN model and the extracted stand-alone equation were statistically valid and had the ability to predict the ASTM A-VTS for RAR modified binders. The specific conclusions of this study may be summarized as follows:

- Descriptive analysis results showed that there are differences among measured viscosity values at different testing shearing rates for the same binder grade and RAR content. Those differences were more obvious at higher RAR contents.
- RAR modification improved the temperature susceptibility of the virgin binders by reducing the slope value (VTS) of the ASTM A-VTS correlation for all of the evaluated binders. This reduction had a value of almost 50% when compared to the virgin binder.
- ANOVA results showed that the addition of RAR in 5% incremental steps had no significant enhancement for binder temperature susceptibility for all the evaluated binders at the four utilized testing shearing rates.
- ANOVA results demonstrate a direct relationship between the added RAR amounts and the introduced temperature susceptibility enhancement. Thus, the more RAR, the better the performance. This was found based on the ANOVA results for all the evaluated binders at the four different testing shearing rates.

- ANOVA results for varying the shearing rates at the same binder grade and RAR content showed significant differences at high RAR contents and between high shearing rates. It was believed that the Non-Newtonian behavior of rubber modified binders is the cause of the significant differences between the viscosity values measured at different testing shearing rates.
- The developed ANN model was statistically evaluated and founded to be valid by having a R^2 value of almost one and F value that is much lower the $F_{critical}$ at 95% confidence level. This model had the ability to predict the binder viscosity as a function of the binder grade, temperature, testing shearing rate, and RAR modification percentage.
- The developed ANN model, after being statistically validated, was utilized to extract a stand-alone viscosity prediction equation that may be utilized outside the model environment. The equation statistical validity was demonstrated by having a R^2 value of 0.97 and F value that is much lower the $F_{critical}$ at 95% confidence level. Therefore, the equation deemed reliable for binder viscosity prediction as a function of the binder grade, temperature, testing shearing rate, and RAR content.
- The importance of the newly developed viscosity prediction equation is its ability in developing the predicted full ASTM A-VTS corrections for RAR modified binders from which A and VTS may be calculated.

- Full sensitivity analysis for the newly developed equation was conducted utilizing the study binders as well as a newly introduced binder that was never utilized during the ANN modeling. The equation was sensitive to the change in RAR content, binder grade, and temperature following the trend found by the actual lab testing.
- The newly developed viscosity prediction equation was founded to be sensitive to the change in virgin binder viscosity by changing the binder graded. Therefore, it may be utilized in the viscosity prediction for the virgin unmodified binders.

Based on the drawn conclusion under this study, below are the main recommendations:

- Since the 5% incremental steps had no significant enhancement to the binder temperature susceptibility, it is recommended to limit the RAR modification percentages to 10% incremental steps by the weight of the virgin binder.
- As demonstrated by the ANOVA results of the varying shearing rates, it is highly recommended to test the highly modified RAR binders utilizing a low shearing rate. Also, its it recommended to utilize the ASTM D 2196 titled “Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer” as a replacement for ASTM D4402 and AASHTO T 316-13 since both of them are recommending 20 as a starting testing RPM.

For future research, it is recommended to further validate the developed viscosity prediction equation utilizing real viscosity testing results.

References

1. Pavement Interactive. [Online] February 6, 2019.
<http://www.pavementinteractive.org>.
2. Bari, J., and Witczak, M. (2006). Development of a new revised version of the Witczak E* predictive model for hot mix asphalt mixtures (with discussion). *Journal of the Association of Asphalt Paving Technologists*, 75.
3. Bari, J., and Witczak, M. (2007). New predictive models for viscosity and complex shear modulus of asphalt binders: for use with mechanistic-empirical pavement design guide. *Transportation Research Record: Journal of the Transportation Research Board*, 2.
4. Dongre, R., Myers, L., D'Angelo, J., Paugh, C., and Gudimettla, J. (2005). Field evaluation of Witczak and Hirsch Models for predicting dynamic modulus of hot-mix asphalt. *Journal of Association of Asphalt Paving Technologist*, 74, 381-442.
5. Asphalt Institute. (2001). *Superpave Mix Design, Superpave Series No. 2 (SP-2)*. Asphalt Institute, Lexington, KY.
6. Asphalt Institute. (2003). *Performance Graded Asphalt Binder Specification and Testing, Superpave Series No. 1 (SP-1)*. Asphalt Institute, Lexington, KY.
7. Haider, S. W., Mirza, M. W., Thottempudi, A., Bari, J., and Baladi, G. Y. (2011). Effect of test methods on viscosity temperature susceptibility characterization of asphalt binders for the mechanistic-empirical pavement design guide. In *First Congress of Transportation and Development Institute (TDI) American Society of Civil Engineers*.
8. Brown, R. (1993). *Historical Development: History of use of crumb rubber in asphalt paving materials*. Auburn, AL: National Center for Asphalt Technology.
9. Materials, ASTM D6114/D6114M. s.l.: American Society for Testing and and Binder., 2009. *Standard Specification for Asphalt-Rubber*.
10. Heitzman, M. (1992). Design and construction of asphalt paving materials with crumb rubber modifier. *Transportation Research Record*, 1339.

11. Bahia, H. U., and Davies, R. (1994). Effect of crumb rubber modifiers (CRM) on performance related properties of asphalt binders. *Asphalt paving technology*, 63, 414-414.
12. Presti, D. L. (2013). Recycled tyre rubber modified bitumens for road asphalt mixtures: a literature review. *Construction and Building Materials*, 49, 863-881.
13. The State of California Department of Transportation. *Asphalt Rubber Usage Guide: State of California Department of Transportation, Materials Engineering and Testing Services and 2003*.
14. Xiao, F. (2006). Development of fatigue predictive models of rubberized asphalt concrete (RAC) containing reclaimed asphalt pavement (RAP) mixtures.
15. Shatanawi, K. (2008). The effects of crumb rubber particles on highway noise reduction-A laboratory study.
16. Reed, J. (2010, December). Evaluation of the effects of aging on asphalt rubber pavements. In *Masters Abstracts International* (Vol. 49, No. 03).
17. Souliman, M. I., and Eifert, A. (2016). Mechanistic and Economical Characteristics of Asphalt Rubber Mixtures. *Advances in Civil Engineering*, 2016(Article ID 8647801).
18. Souliman, M. I., Mamlouk, M., and Eifert, A. (2016). Cost-effectiveness of rubber and polymer modified asphalt mixtures as related to sustainable fatigue performance. *Procedia Engineering*, 145, 404-411.
19. Souliman, M. I., and Kaloush, K. E. (2011). Assessment of the extended fatigue life for rubber and polymer modified asphalt mixtures using flexural bending beam fatigue test. *Jordan Journal of Civil Engineering*, 5(2), 210-215.
20. Hamed, F. K. M. (2010). Evaluation of fatigue resistance for modified asphalt concrete mixtures based on dissipated energy concept. *Technische Universität Darmstadt*.
21. Kaloush, K. E., Biligiri, K. P., Zeiada, W., and Rodezno, M. C. (2008). Laboratory evaluation of gap graded asphalt concrete mixtures–Malmo E-06 highway. Sweden, Final Report, Submitted to Swedish Road Administration, Vägverket, 405, 33.

22. Jones, D., Wu, R., Tsai, B. W., Lu, Q., and Harvey, J. T. (2008). Warm-mix asphalt study: test track construction and first-level analysis of phase 1 HVS and laboratory testing (No. UCPRC-SR-2008-11).
23. Soleymani, H., Zhai, H., and Bahia, H. (2004). Role of modified binders in rheology and damage resistance behavior of asphalt mixtures. *Transportation Research Record: Journal of the Transportation Research Board*, (1875), 70-79.
24. Kaloush, K. E. (2014). Asphalt rubber: Performance tests and pavement design issues. *Construction and Building Materials*, 67, 258-264.
25. Kocevski, S., Yagneswaran, S., Xiao, F., Punith, V. S., Smith Jr, D. W., and Amirghanian, S. (2012). Surface modified ground rubber tire by grafting acrylic acid for paving applications. *Construction and Building Materials*, 34, 83-90.
26. Campillo, J. R. M. (2014). Properties of Activated Crumb Rubber Modified Binders. Arizona State University.
27. Shatanawi, K. M., Biro, S., Geiger, A., and Amirghanian, S. N. (2012). Effects of furfural activated crumb rubber on the properties of rubberized asphalt. *Construction and Building Materials*, 28(1), 96-103.
28. Shatanawi, K., Biro, S., Thodesen, C., and Amirghanian, S. (2009). Effects of water activation of crumb rubber on the properties of crumb rubber-modified binders. *International Journal of Pavement Engineering*, 10(4), 289-297.
29. Ishai, I., Sousa, J. B., and Svehinsky, G. (2011). Activated Minerals as Binder Stabilizers in SMA Paving Mixtures. Presented at 90th Annual Meeting of the Transportation Research Board, Washington, D.C., 2011. (No. 11-1213).
30. Sousa, J., Vorobiev, A., Rowe, G., and Ishai, I. (2013). Reacted and activated rubber: elastomeric asphalt extender. *Transportation Research Record: Journal of the Transportation Research Board*, (2371), 32-40.
31. Sousa, J. B., Vorobiev, A., Ishai, I., and Svehinsky, G. (2012, October). Elastomeric Asphalt Extender—A New Frontier on Asphalt Rubber Mixes. In 5th International Asphalt Rubber Conference, Munich, Germany.
32. Sousa, J. B., and Silva, F. (2012). Development Studies Study of RuBind Stage 5—PG Grade Evaluation TA and TA2 RuBind Formulations. RuBind™.

- CONSULPAV–Consultores e Projectistas de Pavimentos, Lda, Casais da Serra, Portugal.
33. Ishai, I., Amit, M., Kesler, T., and Peled, R. (2014). New Advancements in Rubberized Asphalt Using an Elastomeric Asphalt Extender–Three Case Studies. Final Report prepared for Consulpav International.
 34. Kedarisetty, S., Biligiri, K. P., and Sousa, J. B. (2016). Advanced rheological characterization of reacted and activated rubber (RAR) modified asphalt binders. *Construction and Building Materials*, 122, 12-22.
 35. Sousa, J. B., Biligiri, K. P., Saha, G., and Kedarisetty, S. (2018). Reacted and Activated Rubber (RAR)-Modified Dense-Graded Asphalt Mixtures: Design and Performance Evaluation. *Journal of Testing and Evaluation*, 46(6).
 36. Chen, S., Gong, F., You, Z., Sousa, J. B., and Ge, D. (2019). The Development of a New Asphalt Mixture Containing Reacted and Activated Rubber and Reclaimed Asphalt Pavement via Superpave Mix Design and Marshall Mix Design. Presented at 98th Annual Meeting.
 37. McCord, N. M., and Illingworth, W. T. (1990). A practical guide to neural nets. Reading: Addison-Wesley [Material Impreso en biblioteca].
 38. Schalkoff, R. J. (1997). Artificial neural networks (Vol. 1). New York: McGraw-Hill.
 39. Adeli, H. (2001). Neural networks in civil engineering: 1989–2000. *Computer-Aided Civil and Infrastructure Engineering*, 16(2), 126-142.
 40. Karlaftis, M. G., and Vlahogianni, E. I. (2011). Statistical methods versus neural networks in transportation research: Differences, similarities and some insights. *Transportation Research Part C: Emerging Technologies*, 19(3), 387-399.
 41. Setiono, R., and Thong, J. Y. (2004). An approach to generate rules from neural networks for regression problems. *European Journal of Operational Research*, 155(1), 239-250.
 42. Chan, V., and Chan, C. W. (2016). Development and application of an algorithm for extracting multiple linear regression equations from artificial neural networks

- for nonlinear regression problems. In *Cognitive Informatics & Cognitive Computing (ICCI* CC)*, 2.
43. Augasta, M. G., and Kathirvalavakumar, T. (2012). Rule extraction from neural networks—A comparative study. In *Pattern Recognition, Informatics and Medical Engineering (PRIME), 2012 International Conference on* (pp. 404-408). IEEE.
 44. AMETEK Brookfield. [Online] Brookfield Engineering.
<https://www.brookfieldengineering.com/-/media/ametekbrookfield/tech%20sheets/spindles.pdf?la=en>.
 45. Standard, A. S. T. M. (2008). D4402. Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer.
 46. AASHTO T 316-13. (2013). Standard method of test, for viscosity determination of asphalt binder using rotational viscometer.
 47. Brookfield Engineering Laboratories, BROOKFIELD DV2T Viscometer Operating Instructions. Manual No. M13-167-B0614.
 48. Kim, Y. R., Underwood, B., Far, M. S., Jackson, N., Puccinelli, J., and Engineers, N. C. (2011). LTPP computed parameter: dynamic modulus (No. FHWA-HRT-10-035). United States. Federal Highway Administration.
 49. Isied, M. M., and Souliman, M. I. (2018). Integrated predictive artificial neural network fatigue endurance limit model for asphalt concrete pavements. *Canadian Journal of Civil Engineering*, 46(999), 114-123.

Appendix A. Viscosity Descriptive Statistics Results for Binders A, B, and C

Table 1-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder A (PG 64-22) at 5 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	250	206	42	332	167.63
5	313	303	62	434	191.29
10	481	413	84	647	315.89
15	600	523	107	809	390.61
20	898	801	163	1218	577.61
25	1535	1396	285	2094	976.87
30	2394	2041	417	3210	1577.01
35	3215	2674	546	4284	2144.95
40	5410	4186	854	7085	3735.77
45	6854	5308	1083	8978	4730.68
50	11577	9113	1860	15223	7930.98

Table 2-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder A (PG 64-22) at 20 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	239	197	40	318	160.40
5	307	282	58	420	194.39
10	478	420	86	646	309.79
15	585	516	105	792	379.14
20	850	753	154	1151	548.83
25	1380	1226	250	1870	889.35
30	2050	1734	354	2744	1356.24
35	2689	2239	457	3585	1793.44
40	4321	3436	701	5696	2946.42
45	3849	3554	725	5271	2427.26
50	3725	3047	622	4944	2506.01

Table 3-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder A (PG 64-22) at 50 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	237	195	40	315	158.92
5	305	272	55	413	195.86
10	473	410	84	637	308.83
15	570	501	102	770	369.14
20	812	711	145	1097	527.62
25	1282	1120	229	1730	833.55
30	1852	1552	317	2472	1230.90
35	987	823	168	1316	657.50
40	1566	1282	262	2080	1053.35
45	2018	1650	337	2678	1357.41
50	1365	1482	303	1958	771.82

Table 4-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder A (PG 64-22) at 100 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	235	196	40	313	156.76
5	302	266	54	409	195.91
10	467	401	82	627	306.25
15	557	486	99	751	362.28
20	782	676	138	1052	511.19
25	487	418	85	655	320.26
30	707	587	120	942	471.99
35	910	766	156	1217	604.14
40	623	678	138	894	352.15
45	808	875	179	1158	457.47
50	443	783	160	756	129.26

Table 5-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder B (PG 70-22) at 2 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	375	302	62	496	254.29
5	490	395	81	648	331.49
10	661	572	117	890	432.77
15	1005	796	163	1324	686.69
20	1365	1134	231	1818	911.02
25	2281	1976	403	3072	1490.76
30	3552	2902	592	4713	2391.17
35	5214	4475	913	7004	3423.87
40	7121	5699	1163	9401	4840.36
45	11939	9444	1928	15717	8160.53
50	18767	13099	2674	24008	13526.08

Table 6-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder B (PG 70-22) at 5 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	319	268	55	426	211.62
5	431	382	78	584	278.35
10	600	523	107	809	390.61
15	931	764	156	1237	625.54
20	1246	1036	211	1660	831.48
25	2060	1789	365	2776	1344.80
30	3173	2602	531	4214	2131.83
35	4502	3884	793	6056	2948.32
40	6040	4864	993	7986	4093.44
45	9904	7873	1607	13054	6754.48
50	14946	11025	2251	19357	10534.84

Table 7-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder B (PG 70-22) at 10 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	325	278	57	436	213.78
5	428	382	78	581	275.17
10	593	517	106	799	385.92
15	919	748	153	1218	619.45
20	1199	1004	205	1601	797.24
25	1943	1675	342	2613	1272.56
30	2913	2358	481	3856	1969.03
35	4071	3488	712	5467	2675.55
40	5391	4364	891	7137	3645.42
45	8652	6873	1403	11401	5902.30
50	7624	3371	794	9182	6067.33

Table 8-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder B (PG 70-22) at 20 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	325	271	55	433	216.51
5	417	378	77	568	265.64
10	582	505	103	785	380.13
15	890	731	149	1182	597.12
20	1149	962	196	1533	763.87
25	1835	1573	321	2464	1205.75
30	2675	2172	443	3544	1806.07
35	3702	3156	644	4964	2438.98
40	4820	3921	800	6389	3251.21
45	4313	2074	489	5271	3354.85
50	6526	3008	709	7916	5136.29

Table 9-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder C (PG 76-22) at 2 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	516	421	86	684	347.28
5	688	589	120	923	452.01
10	1078	1037	212	1493	663.15
15	1359	1235	252	1854	865.11
20	1958	1682	343	2631	1285.32
25	3063	2574	525	4092	2032.62
30	6069	4908	1002	8032	4104.80
35	7584	6363	1299	10130	5038.63
40	10423	8539	1743	13839	7006.47
45	16606	14058	2870	22230	10981.12
50	30899	24357	4972	40644	21154.24

Table 10-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder C (PG 76-22) at 5 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	481	413	84	647	315.89
5	621	559	114	845	397.15
10	1000	984	201	1394	606.32
15	1292	1193	244	1769	814.23
20	1831	1609	328	2475	1187.54
25	2810	2422	494	3779	1841.43
30	5250	4304	879	6972	3527.85
35	6604	5584	1140	8838	4370.13
40	8844	7355	1501	11787	5900.97
45	13583	11603	2368	18226	8941.16
50	13461	6270	1478	16358	10564.51

Table 11-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder C (PG 76-22) at 10 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	484	411	84	649	319.95
5	624	569	116	852	396.15
10	972	956	195	1354	589.48
15	1270	1164	238	1735	804.27
20	1781	1560	318	2405	1157.31
25	2659	2279	465	3571	1747.44
30	4756	3937	804	6332	3180.99
35	5921	4991	1019	7917	3923.86
40	7800	6572	1341	10429	5170.52
45	6297	3078	726	7719	4874.90
50	11202	5487	1293	13736	8666.84

Table 12-A. Arithmetic Mean, Standard Deviation (SD), Standard Error (SE) and 95% confidence intervals for Binder C (PG 76-22) at 20 RPM.

RAR %	Population Properties			Confidence Intervals	
	Arithmetic Mean (cP)	Standard Deviation (cP)	Standard Error	Upper Limit	Lower Limit
0	481	414	85	647	315.71
5	616	566	115	843	390.01
10	952	926	189	1323	581.52
15	1247	1134	232	1701	793.03
20	1718	1507	308	2321	1115.38
25	2522	2160	441	3386	1657.32
30	4302	3582	731	5735	2869.39
35	2881	1399	330	3527	2234.48
40	3708	1798	424	4538	2877.43
45	5500	2786	657	6787	4212.21
50	6514	1786	516	7524	5503.32

Appendix B. ASTM A-VTS Viscosity Temperature Correlations for Binders A, B, and C

Table 1-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
550	5 RPM	135	2.8661	0.4378	5 RPM	0%	10.561	-3.530	0.995
550	5 RPM	135	2.8661	0.4378					
550	5 RPM	135	2.8661	0.4378					
250	5 RPM	155	2.8869	0.3798					
250	5 RPM	155	2.8869	0.3798					
250	5 RPM	155	2.8869	0.3798					
100	5 RPM	175	2.9067	0.3010					
100	5 RPM	175	2.9067	0.3010					
100	5 RPM	175	2.9067	0.3010					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					

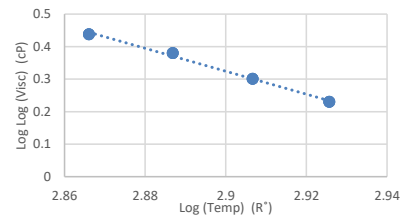


Table 2-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
550	20 RPM	135	2.8661	0.4378	20 RPM	0%	10.278	-3.432	0.993
550	20 RPM	135	2.8661	0.4378					
550	20 RPM	135	2.8661	0.4378					
225	20 RPM	155	2.8869	0.3715					
225	20 RPM	155	2.8869	0.3715					
225	20 RPM	155	2.8869	0.3715					
112.5	20 RPM	175	2.9067	0.3120					
112.5	20 RPM	175	2.9067	0.3120					
112.5	20 RPM	175	2.9067	0.3120					
50	20 RPM	195	2.9257	0.2302					
50	20 RPM	195	2.9257	0.2302					
50	20 RPM	195	2.9257	0.2302					

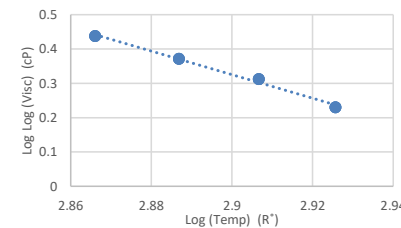


Table 3-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
550	50 RPM	135	2.8661	0.4378	50 RPM	0%	9.462	-3.149	1.000
550	50 RPM	135	2.8661	0.4378					
550	50 RPM	135	2.8661	0.4378					
225	50 RPM	155	2.8869	0.3715					
225	50 RPM	155	2.8869	0.3715					
225	50 RPM	155	2.8869	0.3715					
110	50 RPM	175	2.9067	0.3099					
110	50 RPM	175	2.9067	0.3099					
110	50 RPM	175	2.9067	0.3099					
60	50 RPM	195	2.9257	0.2500					
60	50 RPM	195	2.9257	0.2500					
60	50 RPM	195	2.9257	0.2500					

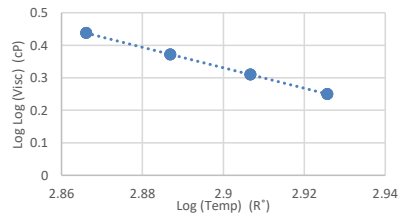


Table 4-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
547.5	100 RPM	135	2.8661	0.4375	100 RPM	0%	9.662	-3.218	1.000
547.5	100 RPM	135	2.8661	0.4375					
547.5	100 RPM	135	2.8661	0.4375					
222.5	100 RPM	155	2.8869	0.3706					
222.5	100 RPM	155	2.8869	0.3706					
222.5	100 RPM	155	2.8869	0.3706					
107.5	100 RPM	175	2.9067	0.3078					
107.5	100 RPM	175	2.9067	0.3078					
107.5	100 RPM	175	2.9067	0.3078					
57.5	100 RPM	195	2.9257	0.2454					
57.5	100 RPM	195	2.9257	0.2454					
57.5	100 RPM	195	2.9257	0.2454					

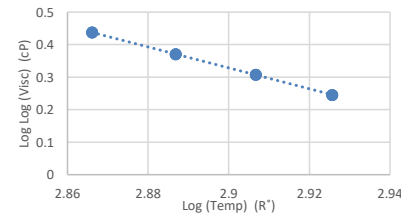


Table 5-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
600	5 RPM	135	2.8661	0.4438	5 RPM	0%	10.278	-3.428	0.959
600	5 RPM	135	2.8661	0.4438					
600	5 RPM	135	2.8661	0.4438					
250	5 RPM	155	2.8869	0.3798					
250	5 RPM	155	2.8869	0.3798					
250	5 RPM	155	2.8869	0.3798					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					

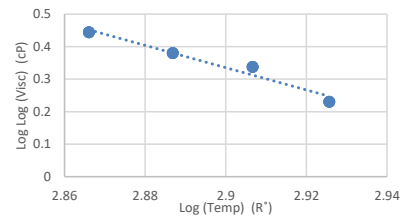


Table 6-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
562.5	20 RPM	135	2.8661	0.4394	20 RPM	0%	8.513	-2.819	0.991
562.5	20 RPM	135	2.8661	0.4394					
562.5	20 RPM	135	2.8661	0.4394					
225	20 RPM	155	2.8869	0.3715					
225	20 RPM	155	2.8869	0.3715					
225	20 RPM	155	2.8869	0.3715					
112.5	20 RPM	175	2.9067	0.3120					
112.5	20 RPM	175	2.9067	0.3120					
112.5	20 RPM	175	2.9067	0.3120					
75	20 RPM	195	2.9257	0.2730					
75	20 RPM	195	2.9257	0.2730					
75	20 RPM	195	2.9257	0.2730					

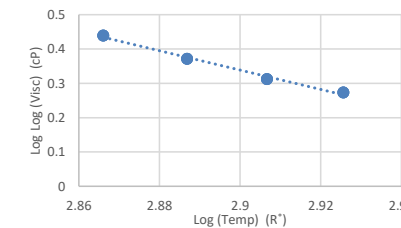


Table 7-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
550	50 RPM	135	2.8661	0.4378	50 RPM	0%	9.487	-3.157	1.000
550	50 RPM	135	2.8661	0.4378					
550	50 RPM	135	2.8661	0.4378					
230	50 RPM	155	2.8869	0.3732					
230	50 RPM	155	2.8869	0.3732					
230	50 RPM	155	2.8869	0.3732					
110	50 RPM	175	2.9067	0.3099					
110	50 RPM	175	2.9067	0.3099					
110	50 RPM	175	2.9067	0.3099					
60	50 RPM	195	2.9257	0.2500					
60	50 RPM	195	2.9257	0.2500					
60	50 RPM	195	2.9257	0.2500					

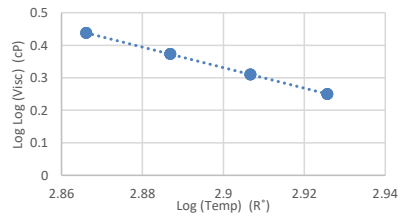


Table 8-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
552.5	100 RPM	135	2.8661	0.4381	100 RPM	0%	9.493	-3.160	1.000
552.5	100 RPM	135	2.8661	0.4381					
552.5	100 RPM	135	2.8661	0.4381					
222.5	100 RPM	155	2.8869	0.3706					
225	100 RPM	155	2.8869	0.3715					
225	100 RPM	155	2.8869	0.3715					
107.5	100 RPM	175	2.9067	0.3078					
107.5	100 RPM	175	2.9067	0.3078					
110	100 RPM	175	2.9067	0.3099					
60	100 RPM	195	2.9257	0.2500					
60	100 RPM	195	2.9257	0.2500					
60	100 RPM	195	2.9257	0.2500					

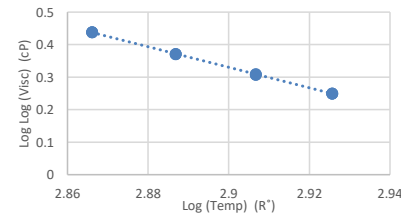


Table 9-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
800	5 RPM	135	2.8661	0.4629	5 RPM	5%	11.880	-3.982	0.996
800	5 RPM	135	2.8661	0.4629					
800	5 RPM	135	2.8661	0.4629					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
100	5 RPM	175	2.9067	0.3010					
100	5 RPM	175	2.9067	0.3010					
100	5 RPM	175	2.9067	0.3010					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					

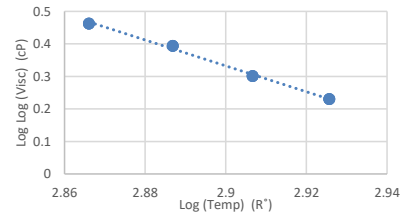


Table 10-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
762.5	20 RPM	135	2.8661	0.4597	20 RPM	5%	10.306	-3.435	1.000
762.5	20 RPM	135	2.8661	0.4597					
762.5	20 RPM	135	2.8661	0.4597					
275	20 RPM	155	2.8869	0.3873					
275	20 RPM	155	2.8869	0.3873					
275	20 RPM	155	2.8869	0.3873					
125	20 RPM	175	2.9067	0.3216					
125	20 RPM	175	2.9067	0.3216					
125	20 RPM	175	2.9067	0.3216					
62.5	20 RPM	195	2.9257	0.2543					
62.5	20 RPM	195	2.9257	0.2543					
62.5	20 RPM	195	2.9257	0.2543					

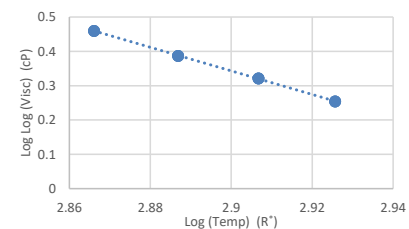


Table 11-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
740	50 RPM	135	2.8661	0.4578	50 RPM	5%	9.675	-3.216	1.000
740	50 RPM	135	2.8661	0.4578					
735	50 RPM	135	2.8661	0.4573					
280	50 RPM	155	2.8869	0.3887					
280	50 RPM	155	2.8869	0.3887					
280	50 RPM	155	2.8869	0.3887					
130	50 RPM	175	2.9067	0.3251					
130	50 RPM	175	2.9067	0.3251					
130	50 RPM	175	2.9067	0.3251					
70	50 RPM	195	2.9257	0.2660					
70	50 RPM	195	2.9257	0.2660					
70	50 RPM	195	2.9257	0.2660					

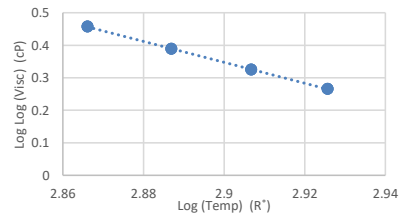


Table 12-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
730	100 RPM	135	2.8661	0.4569	100 RPM	5%	9.545	-3.171	0.999
730	100 RPM	135	2.8661	0.4569					
727.5	100 RPM	135	2.8661	0.4566					
280	100 RPM	155	2.8869	0.3887					
280	100 RPM	155	2.8869	0.3887					
280	100 RPM	155	2.8869	0.3887					
127.5	100 RPM	175	2.9067	0.3234					
130	100 RPM	175	2.9067	0.3251					
130	100 RPM	175	2.9067	0.3251					
70	100 RPM	195	2.9257	0.2660					
72.5	100 RPM	195	2.9257	0.2696					
72.5	100 RPM	195	2.9257	0.2696					

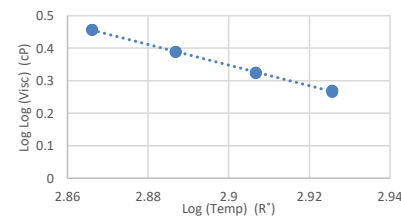


Table 13-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
800	5 RPM	135	2.8661	0.4629	5 RPM	5%	11.880	-3.982	0.996
800	5 RPM	135	2.8661	0.4629					
800	5 RPM	135	2.8661	0.4629					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
100	5 RPM	175	2.9067	0.3010					
100	5 RPM	175	2.9067	0.3010					
100	5 RPM	175	2.9067	0.3010					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					

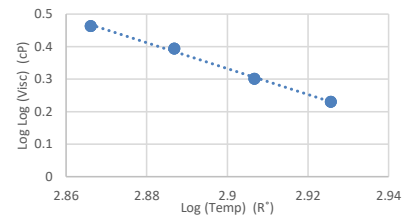


Table 14-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
775	20 RPM	135	2.8661	0.4608	20 RPM	5%	10.337	-3.446	1.000
775	20 RPM	135	2.8661	0.4608					
762.5	20 RPM	135	2.8661	0.4597					
275	20 RPM	155	2.8869	0.3873					
275	20 RPM	155	2.8869	0.3873					
275	20 RPM	155	2.8869	0.3873					
125	20 RPM	175	2.9067	0.3216					
125	20 RPM	175	2.9067	0.3216					
125	20 RPM	175	2.9067	0.3216					
62.5	20 RPM	195	2.9257	0.2543					
62.5	20 RPM	195	2.9257	0.2543					
62.5	20 RPM	195	2.9257	0.2543					

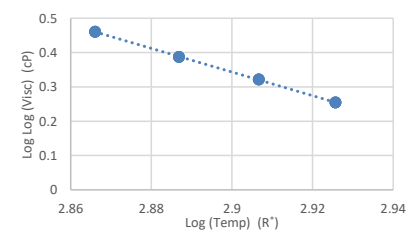


Table 15-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
755	50 RPM	135	2.8661	0.4591	50 RPM	5%	10.095	-3.362	1.000
755	50 RPM	135	2.8661	0.4591					
750	50 RPM	135	2.8661	0.4586					
275	50 RPM	155	2.8869	0.3873					
275	50 RPM	155	2.8869	0.3873					
275	50 RPM	155	2.8869	0.3873					
125	50 RPM	175	2.9067	0.3216					
125	50 RPM	175	2.9067	0.3216					
125	50 RPM	175	2.9067	0.3216					
65	50 RPM	195	2.9257	0.2584					
65	50 RPM	195	2.9257	0.2584					
65	50 RPM	195	2.9257	0.2584					

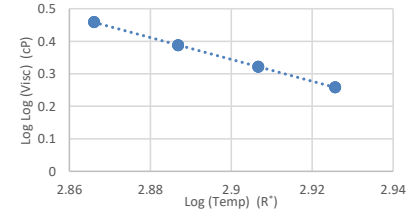


Table 16-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
740	100 RPM	135	2.8661	0.4578	100 RPM	5%	9.822	-3.268	0.999
737.5	100 RPM	135	2.8661	0.4575					
735	100 RPM	135	2.8661	0.4573					
277.5	100 RPM	155	2.8869	0.3880					
277.5	100 RPM	155	2.8869	0.3880					
277.5	100 RPM	155	2.8869	0.3880					
125	100 RPM	175	2.9067	0.3216					
125	100 RPM	175	2.9067	0.3216					
125	100 RPM	175	2.9067	0.3216					
67.5	100 RPM	195	2.9257	0.2623					
67.5	100 RPM	195	2.9257	0.2623					
70	100 RPM	195	2.9257	0.2660					

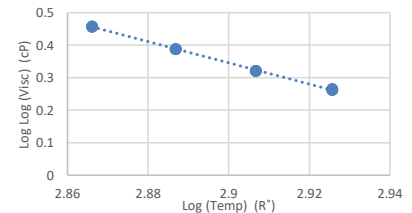


Table 17-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1150	5 RPM	135	2.8661	0.4858	5 RPM	10%	9.380	-3.103	1.000
1150	5 RPM	135	2.8661	0.4858					
1150	5 RPM	135	2.8661	0.4858					
450	5 RPM	155	2.8869	0.4238					
450	5 RPM	155	2.8869	0.4238					
450	5 RPM	155	2.8869	0.4238					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					

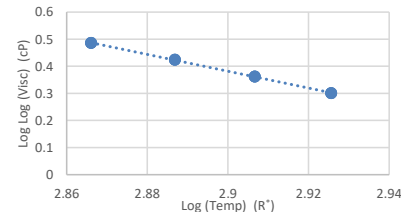


Table 18-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1163	20 RPM	135	2.8661	0.4865	20 RPM	10%	8.610	-2.836	0.993
1163	20 RPM	135	2.8661	0.4865					
1163	20 RPM	135	2.8661	0.4865					
425	20 RPM	155	2.8869	0.4197					
425	20 RPM	155	2.8869	0.4197					
425	20 RPM	155	2.8869	0.4197					
200	20 RPM	175	2.9067	0.3619					
200	20 RPM	175	2.9067	0.3619					
200	20 RPM	175	2.9067	0.3619					
125	20 RPM	195	2.9257	0.3216					
125	20 RPM	195	2.9257	0.3216					
112.5	20 RPM	195	2.9257	0.3120					

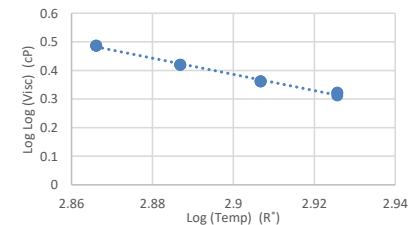


Table 19-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1145	50 RPM	135	2.8661	0.4856	50 RPM	10%	8.628	-2.842	0.996
1135	50 RPM	135	2.8661	0.4850					
1140	50 RPM	135	2.8661	0.4853					
420	50 RPM	155	2.8869	0.4188					
425	50 RPM	155	2.8869	0.4197					
425	50 RPM	155	2.8869	0.4197					
200	50 RPM	175	2.9067	0.3619					
200	50 RPM	175	2.9067	0.3619					
200	50 RPM	175	2.9067	0.3619					
115	50 RPM	195	2.9257	0.3140					
120	50 RPM	195	2.9257	0.3179					
120	50 RPM	195	2.9257	0.3179					

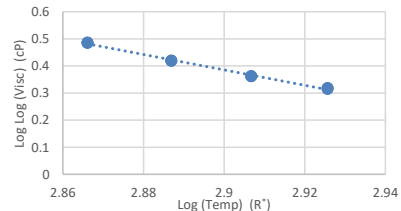


Table 20-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1123	100 RPM	135	2.8661	0.4844	100 RPM	10%	8.560	-2.819	0.997
1115	100 RPM	135	2.8661	0.4839					
1113	100 RPM	135	2.8661	0.4838					
422.5	100 RPM	155	2.8869	0.4193					
422.5	100 RPM	155	2.8869	0.4193					
425	100 RPM	155	2.8869	0.4197					
200	100 RPM	175	2.9067	0.3619					
202.5	100 RPM	175	2.9067	0.3629					
202.5	100 RPM	175	2.9067	0.3629					
117.5	100 RPM	195	2.9257	0.3160					
117.5	100 RPM	195	2.9257	0.3160					
120	100 RPM	195	2.9257	0.3179					

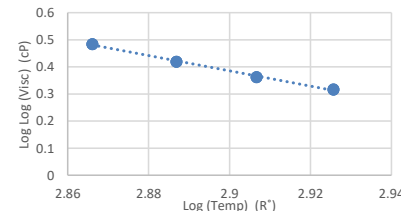


Table 21-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1150	5 RPM	135	2.8661	0.4858	5 RPM	10%	7.810	-2.558	0.974
1150	5 RPM	135	2.8661	0.4858					
1150	5 RPM	135	2.8661	0.4858					
450	5 RPM	155	2.8869	0.4238					
450	5 RPM	155	2.8869	0.4238					
450	5 RPM	155	2.8869	0.4238					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					

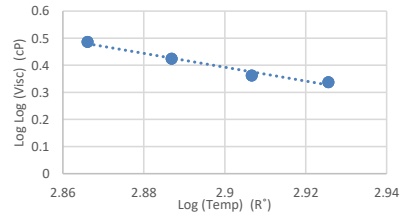


Table 22-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1163	20 RPM	135	2.8661	0.4865	20 RPM	10%	8.473	-2.788	0.992
1163	20 RPM	135	2.8661	0.4865					
1163	20 RPM	135	2.8661	0.4865					
425	20 RPM	155	2.8869	0.4197					
425	20 RPM	155	2.8869	0.4197					
425	20 RPM	155	2.8869	0.4197					
200	20 RPM	175	2.9067	0.3619					
200	20 RPM	175	2.9067	0.3619					
200	20 RPM	175	2.9067	0.3619					
125	20 RPM	195	2.9257	0.3216					
125	20 RPM	195	2.9257	0.3216					
125	20 RPM	195	2.9257	0.3216					

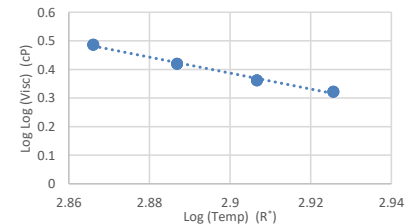


Table 23-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1145	50 RPM	135	2.8661	0.4856	50 RPM	10%	8.404	-2.764	0.995
1140	50 RPM	135	2.8661	0.4853					
1140	50 RPM	135	2.8661	0.4853					
430	50 RPM	155	2.8869	0.4205					
430	50 RPM	155	2.8869	0.4205					
430	50 RPM	155	2.8869	0.4205					
205	50 RPM	175	2.9067	0.3639					
205	50 RPM	175	2.9067	0.3639					
205	50 RPM	175	2.9067	0.3639					
125	50 RPM	195	2.9257	0.3216					
125	50 RPM	195	2.9257	0.3216					
125	50 RPM	195	2.9257	0.3216					

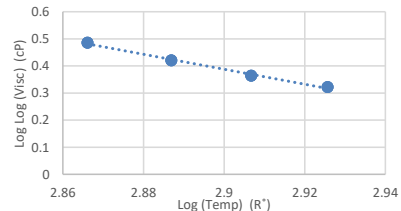


Table 24-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1125	100 RPM	135	2.8661	0.4845	100 RPM	10%	8.445	-2.779	0.997
1118	100 RPM	135	2.8661	0.4841					
1113	100 RPM	135	2.8661	0.4838					
425	100 RPM	155	2.8869	0.4197					
427.5	100 RPM	155	2.8869	0.4201					
427.5	100 RPM	155	2.8869	0.4201					
202.5	100 RPM	175	2.9067	0.3629					
205	100 RPM	175	2.9067	0.3639					
207.5	100 RPM	175	2.9067	0.3649					
120	100 RPM	195	2.9257	0.3179					
122.5	100 RPM	195	2.9257	0.3198					
122.5	100 RPM	195	2.9257	0.3198					

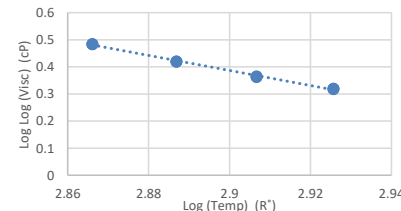


Table 25-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1450	5 RPM	135	2.8661	0.4999	5 RPM	15%	8.369	-2.746	0.996
1450	5 RPM	135	2.8661	0.4999					
1450	5 RPM	135	2.8661	0.4999					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
250	5 RPM	175	2.9067	0.3798					
250	5 RPM	175	2.9067	0.3798					
250	5 RPM	175	2.9067	0.3798					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					

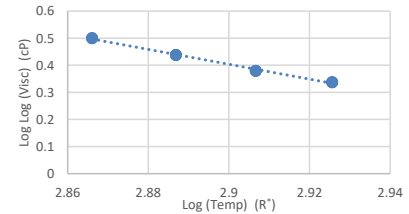


Table 26-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1438	20 RPM	135	2.8661	0.4994	20 RPM	15%	8.005	-2.621	0.989
1425	20 RPM	135	2.8661	0.4988					
1425	20 RPM	135	2.8661	0.4988					
537.5	20 RPM	155	2.8869	0.4362					
537.5	20 RPM	155	2.8869	0.4362					
525	20 RPM	155	2.8869	0.4346					
250	20 RPM	175	2.9067	0.3798					
250	20 RPM	175	2.9067	0.3798					
250	20 RPM	175	2.9067	0.3798					
162.5	20 RPM	195	2.9257	0.3446					
162.5	20 RPM	195	2.9257	0.3446					
162.5	20 RPM	195	2.9257	0.3446					

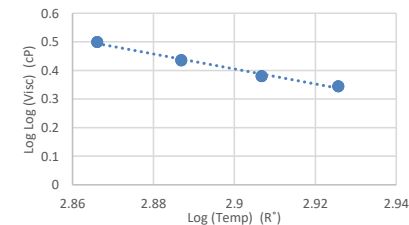


Table 27-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1390	50 RPM	135	2.8661	0.4973	50 RPM	15%	8.184	-2.684	0.992
1380	50 RPM	135	2.8661	0.4969					
1380	50 RPM	135	2.8661	0.4969					
520	50 RPM	155	2.8869	0.4339					
515	50 RPM	155	2.8869	0.4333					
520	50 RPM	155	2.8869	0.4339					
240	50 RPM	175	2.9067	0.3766					
240	50 RPM	175	2.9067	0.3766					
245	50 RPM	175	2.9067	0.3782					
155	50 RPM	195	2.9257	0.3405					
150	50 RPM	195	2.9257	0.3377					
150	50 RPM	195	2.9257	0.3377					

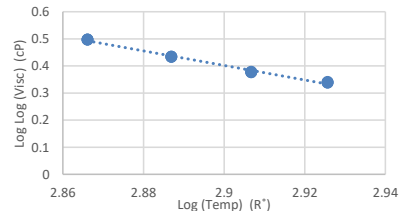


Table 28-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1358	100 RPM	135	2.8661	0.4959	100 RPM	15%	8.218	-2.696	0.994
1350	100 RPM	135	2.8661	0.4956					
1343	100 RPM	135	2.8661	0.4953					
512.5	100 RPM	155	2.8869	0.4329					
510	100 RPM	155	2.8869	0.4326					
512.5	100 RPM	155	2.8869	0.4329					
237.5	100 RPM	175	2.9067	0.3758					
240	100 RPM	175	2.9067	0.3766					
242.5	100 RPM	175	2.9067	0.3774					
147.5	100 RPM	195	2.9257	0.3362					
147.5	100 RPM	195	2.9257	0.3362					
147.5	100 RPM	195	2.9257	0.3362					

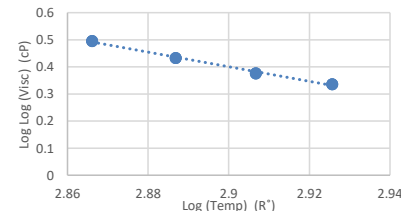


Table 29-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)											
					RPM	RAR	A	VTS	R2							
1450	5 RPM	135	2.8661	0.4999		<table border="1"> <thead> <tr> <th>RPM</th> <th>RAR</th> <th>A</th> <th>VTS</th> <th>R2</th> </tr> </thead> <tbody> <tr> <td>5 RPM</td> <td>15%</td> <td>8.369</td> <td>-2.746</td> <td>0.996</td> </tr> </tbody> </table>	RPM	RAR	A	VTS	R2	5 RPM	15%	8.369	-2.746	0.996
RPM	RAR	A	VTS	R2												
5 RPM	15%	8.369	-2.746	0.996												
1450	5 RPM	135	2.8661	0.4999												
1450	5 RPM	135	2.8661	0.4999												
550	5 RPM	155	2.8869	0.4378												
550	5 RPM	155	2.8869	0.4378												
550	5 RPM	155	2.8869	0.4378												
250	5 RPM	175	2.9067	0.3798												
250	5 RPM	175	2.9067	0.3798												
250	5 RPM	175	2.9067	0.3798												
150	5 RPM	195	2.9257	0.3377												
150	5 RPM	195	2.9257	0.3377												
150	5 RPM	195	2.9257	0.3377												

Table 30-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)											
					RPM	RAR	A	VTS	R2							
1425	20 RPM	135	2.8661	0.4988		<table border="1"> <thead> <tr> <th>RPM</th> <th>RAR</th> <th>A</th> <th>VTS</th> <th>R2</th> </tr> </thead> <tbody> <tr> <td>20 RPM</td> <td>15%</td> <td>8.720</td> <td>-2.870</td> <td>0.994</td> </tr> </tbody> </table>	RPM	RAR	A	VTS	R2	20 RPM	15%	8.720	-2.870	0.994
RPM	RAR	A	VTS	R2												
20 RPM	15%	8.720	-2.870	0.994												
1425	20 RPM	135	2.8661	0.4988												
1413	20 RPM	135	2.8661	0.4983												
525	20 RPM	155	2.8869	0.4346												
525	20 RPM	155	2.8869	0.4346												
525	20 RPM	155	2.8869	0.4346												
225	20 RPM	175	2.9067	0.3715												
225	20 RPM	175	2.9067	0.3715												
225	20 RPM	175	2.9067	0.3715												
137.5	20 RPM	195	2.9257	0.3301												
137.5	20 RPM	195	2.9257	0.3301												
137.5	20 RPM	195	2.9257	0.3301												

Table 31-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1395	50 RPM	135	2.8661	0.4976	50 RPM	15%	8.558	-2.814	0.993
1385	50 RPM	135	2.8661	0.4971					
1385	50 RPM	135	2.8661	0.4971					
510	50 RPM	155	2.8869	0.4326					
510	50 RPM	155	2.8869	0.4326					
505	50 RPM	155	2.8869	0.4319					
225	50 RPM	175	2.9067	0.3715					
225	50 RPM	175	2.9067	0.3715					
225	50 RPM	175	2.9067	0.3715					
140	50 RPM	195	2.9257	0.3317					
140	50 RPM	195	2.9257	0.3317					
140	50 RPM	195	2.9257	0.3317					

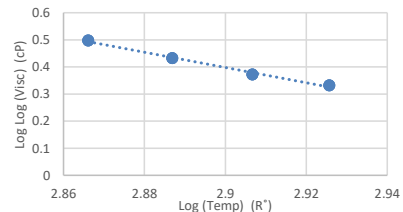


Table 32-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1350	100 RPM	135	2.8661	0.4956	100 RPM	15%	8.530	-2.804	0.995
1343	100 RPM	135	2.8661	0.4953					
1340	100 RPM	135	2.8661	0.4951					
497.5	100 RPM	155	2.8869	0.4308					
495	100 RPM	155	2.8869	0.4305					
495	100 RPM	155	2.8869	0.4305					
225	100 RPM	175	2.9067	0.3715					
227.5	100 RPM	175	2.9067	0.3724					
227.5	100 RPM	175	2.9067	0.3724					
137.5	100 RPM	195	2.9257	0.3301					
137.5	100 RPM	195	2.9257	0.3301					
135	100 RPM	195	2.9257	0.3284					

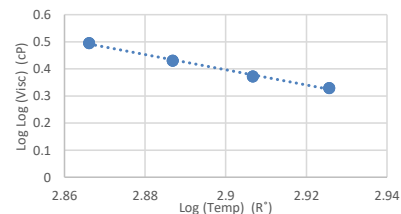


Table 33-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
2200	5 RPM	135	2.8661	0.5241	5 RPM	20%	8.361	-2.735	0.997
2200	5 RPM	135	2.8661	0.5241					
2150	5 RPM	135	2.8661	0.5228					
800	5 RPM	155	2.8869	0.4629					
800	5 RPM	155	2.8869	0.4629					
800	5 RPM	155	2.8869	0.4629					
350	5 RPM	175	2.9067	0.4055					
350	5 RPM	175	2.9067	0.4055					
350	5 RPM	175	2.9067	0.4055					
200	5 RPM	195	2.9257	0.3619					
200	5 RPM	195	2.9257	0.3619					
200	5 RPM	195	2.9257	0.3619					

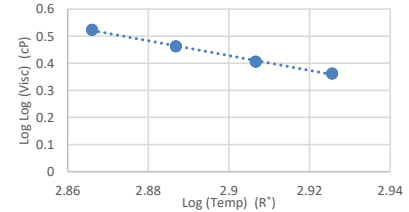


Table 34-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
2063	20 RPM	135	2.8661	0.5204	20 RPM	20%	7.915	-2.582	0.990
2050	20 RPM	135	2.8661	0.5201					
2037	20 RPM	135	2.8661	0.5197					
762.5	20 RPM	155	2.8869	0.4597					
762.5	20 RPM	155	2.8869	0.4597					
750	20 RPM	155	2.8869	0.4586					
337.5	20 RPM	175	2.9067	0.4028					
337.5	20 RPM	175	2.9067	0.4028					
337.5	20 RPM	175	2.9067	0.4028					
212.5	20 RPM	195	2.9257	0.3669					
225	20 RPM	195	2.9257	0.3715					
212.5	20 RPM	195	2.9257	0.3669					

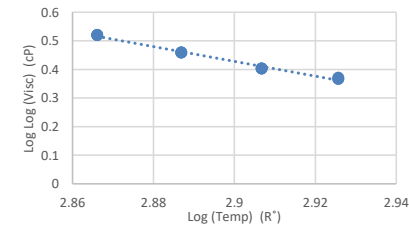


Table 35-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1965	50 RPM	135	2.8661	0.5176	50 RPM	20%	7.891	-2.574	0.991
1940	50 RPM	135	2.8661	0.5169					
1940	50 RPM	135	2.8661	0.5169					
740	50 RPM	155	2.8869	0.4578					
730	50 RPM	155	2.8869	0.4569					
730	50 RPM	155	2.8869	0.4569					
325	50 RPM	175	2.9067	0.4000					
330	50 RPM	175	2.9067	0.4011					
330	50 RPM	175	2.9067	0.4011					
210	50 RPM	195	2.9257	0.3659					
210	50 RPM	195	2.9257	0.3659					
210	50 RPM	195	2.9257	0.3659					

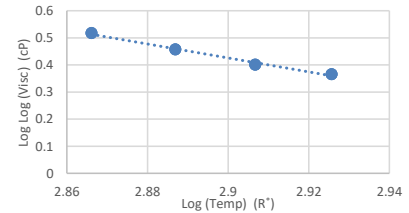


Table 36-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1885	100 RPM	135	2.8661	0.5153	100 RPM	20%	7.883	-2.572	0.993
1865	100 RPM	135	2.8661	0.5146					
1858	100 RPM	135	2.8661	0.5144					
707.5	100 RPM	155	2.8869	0.4548					
707.5	100 RPM	155	2.8869	0.4548					
705	100 RPM	155	2.8869	0.4546					
325	100 RPM	175	2.9067	0.4000					
325	100 RPM	175	2.9067	0.4000					
330	100 RPM	175	2.9067	0.4011					
202.5	100 RPM	195	2.9257	0.3629					
202.5	100 RPM	195	2.9257	0.3629					
202.5	100 RPM	195	2.9257	0.3629					

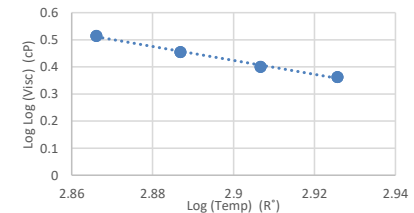


Table 37-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
2200	5 RPM	135	2.8661	0.5241	5 RPM	20%	7.668	-2.494	0.978
2250	5 RPM	135	2.8661	0.5253					
2200	5 RPM	135	2.8661	0.5241					
800	5 RPM	155	2.8869	0.4629					
850	5 RPM	155	2.8869	0.4668					
850	5 RPM	155	2.8869	0.4668					
350	5 RPM	175	2.9067	0.4055					
350	5 RPM	175	2.9067	0.4055					
350	5 RPM	175	2.9067	0.4055					
250	5 RPM	195	2.9257	0.3798					
250	5 RPM	195	2.9257	0.3798					
250	5 RPM	195	2.9257	0.3798					

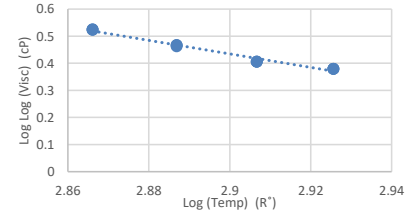


Table 38-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
2113	20 RPM	135	2.8661	0.5218	20 RPM	20%	7.865	-2.564	0.986
2113	20 RPM	135	2.8661	0.5218					
2088	20 RPM	135	2.8661	0.5211					
775	20 RPM	155	2.8869	0.4608					
775	20 RPM	155	2.8869	0.4608					
762.5	20 RPM	155	2.8869	0.4597					
337.5	20 RPM	175	2.9067	0.4028					
337.5	20 RPM	175	2.9067	0.4028					
337.5	20 RPM	175	2.9067	0.4028					
225	20 RPM	195	2.9257	0.3715					
225	20 RPM	195	2.9257	0.3715					
225	20 RPM	195	2.9257	0.3715					

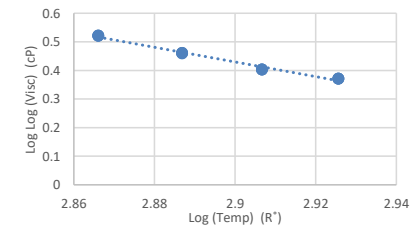


Table 39-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
2010	50 RPM	135	2.8661	0.5189	50 RPM	20%	7.846	-2.558	0.990
1990	50 RPM	135	2.8661	0.5184					
1975	50 RPM	135	2.8661	0.5179					
735	50 RPM	155	2.8869	0.4573					
730	50 RPM	155	2.8869	0.4569					
740	50 RPM	155	2.8869	0.4578					
335	50 RPM	175	2.9067	0.4023					
335	50 RPM	175	2.9067	0.4023					
335	50 RPM	175	2.9067	0.4023					
215	50 RPM	195	2.9257	0.3678					
215	50 RPM	195	2.9257	0.3678					
215	50 RPM	195	2.9257	0.3678					

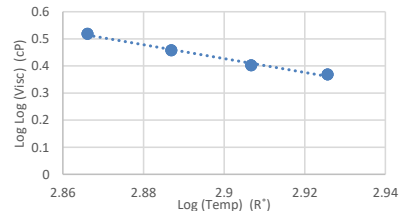


Table 40-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
1915	100 RPM	135	2.8661	0.5162	100 RPM	20%	7.825	-2.552	0.993
1883	100 RPM	135	2.8661	0.5152					
1880	100 RPM	135	2.8661	0.5151					
717.5	100 RPM	155	2.8869	0.4557					
715	100 RPM	155	2.8869	0.4555					
715	100 RPM	155	2.8869	0.4555					
330	100 RPM	175	2.9067	0.4011					
332.5	100 RPM	175	2.9067	0.4017					
332.5	100 RPM	175	2.9067	0.4017					
207.5	100 RPM	195	2.9257	0.3649					
207.5	100 RPM	195	2.9257	0.3649					
207.5	100 RPM	195	2.9257	0.3649					

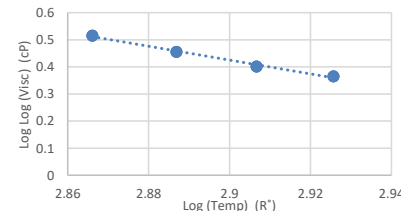


Table 41-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
3850	5 RPM	135	2.8661	0.5545	5 RPM	25%	7.785	-2.524	0.996
3850	5 RPM	135	2.8661	0.5545					
3800	5 RPM	135	2.8661	0.5539					
1400	5 RPM	155	2.8869	0.4978					
1400	5 RPM	155	2.8869	0.4978					
1400	5 RPM	155	2.8869	0.4978					
600	5 RPM	175	2.9067	0.4438					
600	5 RPM	175	2.9067	0.4438					
600	5 RPM	175	2.9067	0.4438					
350	5 RPM	195	2.9257	0.4055					
350	5 RPM	195	2.9257	0.4055					
350	5 RPM	195	2.9257	0.4055					

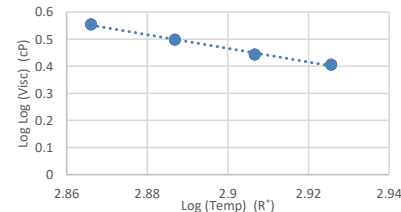


Table 42-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
3438	20 RPM	135	2.8661	0.5485	20 RPM	25%	7.498	-2.426	0.994
3425	20 RPM	135	2.8661	0.5483					
3375	20 RPM	135	2.8661	0.5476					
1250	20 RPM	155	2.8869	0.4909					
1263	20 RPM	155	2.8869	0.4916					
1250	20 RPM	155	2.8869	0.4909					
575	20 RPM	175	2.9067	0.4409					
575	20 RPM	175	2.9067	0.4409					
575	20 RPM	175	2.9067	0.4409					
337.5	20 RPM	195	2.9257	0.4028					
350	20 RPM	195	2.9257	0.4055					
350	20 RPM	195	2.9257	0.4055					

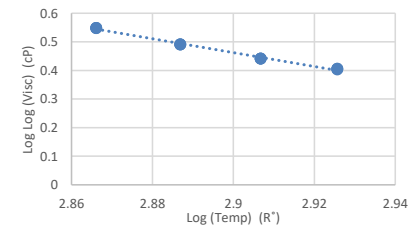


Table 43-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
3145	50 RPM	135	2.8661	0.5438	50 RPM	25%	7.463	-2.415	0.995
3125	50 RPM	135	2.8661	0.5434					
3080	50 RPM	135	2.8661	0.5426					
1175	50 RPM	155	2.8869	0.4871					
1180	50 RPM	155	2.8869	0.4874					
1180	50 RPM	155	2.8869	0.4874					
540	50 RPM	175	2.9067	0.4365					
545	50 RPM	175	2.9067	0.4372					
550	50 RPM	175	2.9067	0.4378					
325	50 RPM	195	2.9257	0.4000					
325	50 RPM	195	2.9257	0.4000					
330	50 RPM	195	2.9257	0.4011					

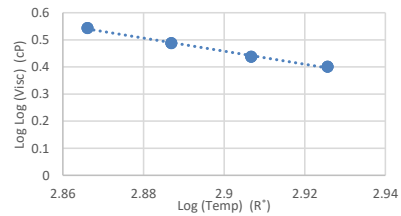


Table 44-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	25%	6.962	-2.244	0.996
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
1130	100 RPM	155	2.8869	0.4847					
1123	100 RPM	155	2.8869	0.4844					
1120	100 RPM	155	2.8869	0.4842					
525	100 RPM	175	2.9067	0.4346					
530	100 RPM	175	2.9067	0.4353					
532.5	100 RPM	175	2.9067	0.4356					
312.5	100 RPM	195	2.9257	0.3970					
317.5	100 RPM	195	2.9257	0.3982					
312.5	100 RPM	195	2.9257	0.3970					

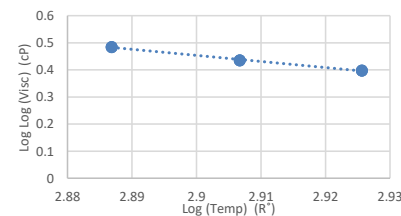


Table 45-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
3800	5 RPM	135	2.8661	0.5539	5 RPM	25%	7.733	-2.506	0.995
3800	5 RPM	135	2.8661	0.5539					
3750	5 RPM	135	2.8661	0.5532					
1350	5 RPM	155	2.8869	0.4956					
1400	5 RPM	155	2.8869	0.4978					
1350	5 RPM	155	2.8869	0.4956					
600	5 RPM	175	2.9067	0.4438					
600	5 RPM	175	2.9067	0.4438					
600	5 RPM	175	2.9067	0.4438					
350	5 RPM	195	2.9257	0.4055					
350	5 RPM	195	2.9257	0.4055					
350	5 RPM	195	2.9257	0.4055					

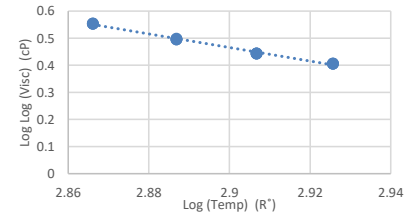


Table 46-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
3338	20 RPM	135	2.8661	0.5470	20 RPM	25%	7.712	-2.501	0.996
3338	20 RPM	135	2.8661	0.5470					
3338	20 RPM	135	2.8661	0.5470					
1238	20 RPM	155	2.8869	0.4903					
1238	20 RPM	155	2.8869	0.4903					
1238	20 RPM	155	2.8869	0.4903					
550	20 RPM	175	2.9067	0.4378					
562.5	20 RPM	175	2.9067	0.4394					
550	20 RPM	175	2.9067	0.4378					
312.5	20 RPM	195	2.9257	0.3970					
325	20 RPM	195	2.9257	0.4000					
325	20 RPM	195	2.9257	0.4000					

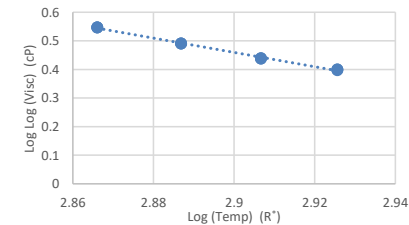


Table 47-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
3115	50 RPM	135	2.8661	0.5433	50 RPM	25%	7.615	-2.469	0.996
3070	50 RPM	135	2.8661	0.5425					
3080	50 RPM	135	2.8661	0.5426					
1160	50 RPM	155	2.8869	0.4864					
1155	50 RPM	155	2.8869	0.4861					
1150	50 RPM	155	2.8869	0.4858					
530	50 RPM	175	2.9067	0.4353					
535	50 RPM	175	2.9067	0.4359					
535	50 RPM	175	2.9067	0.4359					
305	50 RPM	195	2.9257	0.3952					
315	50 RPM	195	2.9257	0.3976					
310	50 RPM	195	2.9257	0.3964					

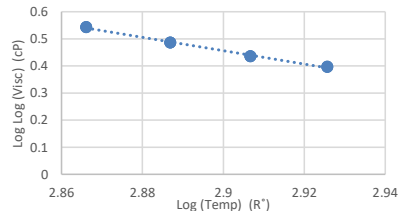


Table 48-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	25%	7.170	-2.317	0.997
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
1108	100 RPM	155	2.8869	0.4835					
1115	100 RPM	155	2.8869	0.4839					
1113	100 RPM	155	2.8869	0.4838					
522.5	100 RPM	175	2.9067	0.4343					
520	100 RPM	175	2.9067	0.4339					
517.5	100 RPM	175	2.9067	0.4336					
300	100 RPM	195	2.9257	0.3939					
302.5	100 RPM	195	2.9257	0.3946					
297.5	100 RPM	195	2.9257	0.3933					

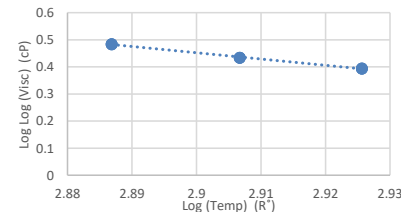


Table 49-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
5700	5 RPM	135	2.8661	0.5747	5 RPM	30%	6.310	-2.004	0.966
5700	5 RPM	135	2.8661	0.5747					
5650	5 RPM	135	2.8661	0.5743					
2100	5 RPM	155	2.8869	0.5214					
2050	5 RPM	155	2.8869	0.5201					
2000	5 RPM	155	2.8869	0.5186					
1000	5 RPM	175	2.9067	0.4771					
1000	5 RPM	175	2.9067	0.4771					
950	5 RPM	175	2.9067	0.4739					
700	5 RPM	195	2.9257	0.4541					
750	5 RPM	195	2.9257	0.4586					
750	5 RPM	195	2.9257	0.4586					

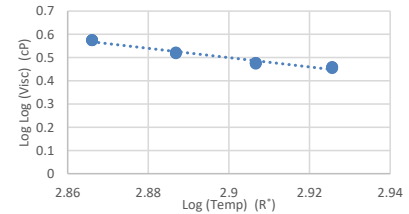


Table 50-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
4900	20 RPM	135	2.8661	0.5670	20 RPM	30%	6.576	-2.099	0.982
4850	20 RPM	135	2.8661	0.5665					
4725	20 RPM	135	2.8661	0.5652					
1813	20 RPM	155	2.8869	0.5130					
1800	20 RPM	155	2.8869	0.5126					
1813	20 RPM	155	2.8869	0.5130					
862.5	20 RPM	175	2.9067	0.4677					
862.5	20 RPM	175	2.9067	0.4677					
862.5	20 RPM	175	2.9067	0.4677					
600	20 RPM	195	2.9257	0.4438					
587.5	20 RPM	195	2.9257	0.4423					
587.5	20 RPM	195	2.9257	0.4423					

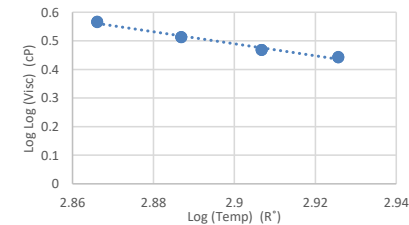


Table 51-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
4330	50 RPM	135	2.8661	0.5607	50 RPM	30%	6.633	-2.120	0.988
4325	50 RPM	135	2.8661	0.5606					
4275	50 RPM	135	2.8661	0.5600					
1655	50 RPM	155	2.8869	0.5077					
1665	50 RPM	155	2.8869	0.5080					
1670	50 RPM	155	2.8869	0.5082					
810	50 RPM	175	2.9067	0.4637					
815	50 RPM	175	2.9067	0.4641					
800	50 RPM	175	2.9067	0.4629					
535	50 RPM	195	2.9257	0.4359					
530	50 RPM	195	2.9257	0.4353					
525	50 RPM	195	2.9257	0.4346					

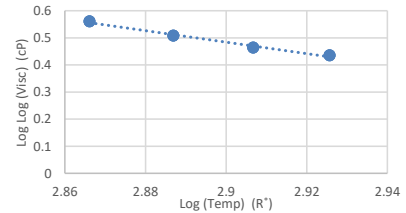


Table 52-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	30%	6.182	-1.967	0.993
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
1555	100 RPM	155	2.8869	0.5040					
1570	100 RPM	155	2.8869	0.5046					
1553	100 RPM	155	2.8869	0.5040					
762.5	100 RPM	175	2.9067	0.4597					
762.5	100 RPM	175	2.9067	0.4597					
765	100 RPM	175	2.9067	0.4599					
480	100 RPM	195	2.9257	0.4283					
482.5	100 RPM	195	2.9257	0.4287					
470	100 RPM	195	2.9257	0.4269					

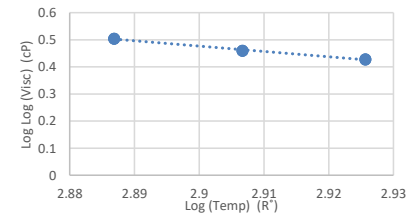


Table 53-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
5800	5 RPM	135	2.8661	0.5756	5 RPM	30%	6.246	-1.981	0.964
5800	5 RPM	135	2.8661	0.5756					
5800	5 RPM	135	2.8661	0.5756					
2100	5 RPM	155	2.8869	0.5214					
2150	5 RPM	155	2.8869	0.5228					
2150	5 RPM	155	2.8869	0.5228					
1000	5 RPM	175	2.9067	0.4771					
1000	5 RPM	175	2.9067	0.4771					
1000	5 RPM	175	2.9067	0.4771					
750	5 RPM	195	2.9257	0.4586					
800	5 RPM	195	2.9257	0.4629					
750	5 RPM	195	2.9257	0.4586					

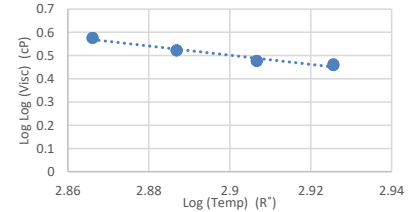


Table 54-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
4975	20 RPM	135	2.8661	0.5678	20 RPM	30%	6.430	-2.047	0.973
4925	20 RPM	135	2.8661	0.5673					
4913	20 RPM	135	2.8661	0.5672					
1875	20 RPM	155	2.8869	0.5149					
1863	20 RPM	155	2.8869	0.5146					
1863	20 RPM	155	2.8869	0.5146					
850	20 RPM	175	2.9067	0.4668					
887.5	20 RPM	175	2.9067	0.4696					
875	20 RPM	175	2.9067	0.4686					
650	20 RPM	195	2.9257	0.4492					
625	20 RPM	195	2.9257	0.4465					
637.5	20 RPM	195	2.9257	0.4479					

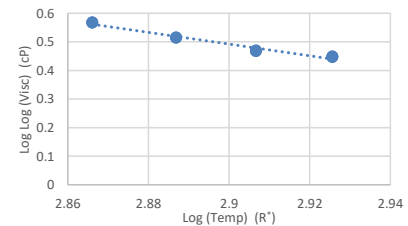


Table 55-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
4455	50 RPM	135	2.8661	0.5622	50 RPM	30%	6.661	-2.130	0.986
4455	50 RPM	135	2.8661	0.5622					
4420	50 RPM	135	2.8661	0.5617					
1715	50 RPM	155	2.8869	0.5098					
1695	50 RPM	155	2.8869	0.5091					
1715	50 RPM	155	2.8869	0.5098					
810	50 RPM	175	2.9067	0.4637					
805	50 RPM	175	2.9067	0.4633					
810	50 RPM	175	2.9067	0.4637					
545	50 RPM	195	2.9257	0.4372					
540	50 RPM	195	2.9257	0.4365					
540	50 RPM	195	2.9257	0.4365					

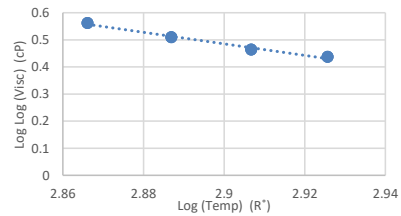


Table 56-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	30%	6.251	-1.991	0.991
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
1608	100 RPM	155	2.8869	0.5060					
1608	100 RPM	155	2.8869	0.5060					
1603	100 RPM	155	2.8869	0.5058					
765	100 RPM	175	2.9067	0.4599					
767.5	100 RPM	175	2.9067	0.4602					
765	100 RPM	175	2.9067	0.4599					
487.5	100 RPM	195	2.9257	0.4294					
485	100 RPM	195	2.9257	0.4291					
477.5	100 RPM	195	2.9257	0.4280					

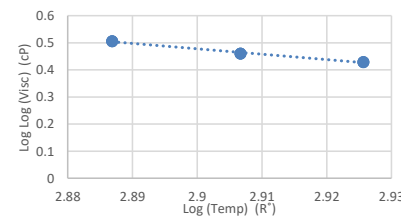


Table 57-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
7750	5 RPM	135	2.8661	0.5899	5 RPM	35%	5.839	-1.834	0.970
7800	5 RPM	135	2.8661	0.5902					
7700	5 RPM	135	2.8661	0.5896					
2950	5 RPM	155	2.8869	0.5403					
2950	5 RPM	155	2.8869	0.5403					
2900	5 RPM	155	2.8869	0.5394					
1450	5 RPM	175	2.9067	0.4999					
1500	5 RPM	175	2.9067	0.5019					
1450	5 RPM	175	2.9067	0.4999					
1100	5 RPM	195	2.9257	0.4831					
1050	5 RPM	195	2.9257	0.4802					
1100	5 RPM	195	2.9257	0.4831					

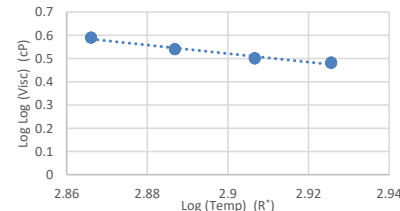


Table 58-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
6450	20 RPM	135	2.8661	0.5809	20 RPM	35%	6.263	-1.984	0.988
6438	20 RPM	135	2.8661	0.5808					
6413	20 RPM	135	2.8661	0.5806					
2475	20 RPM	155	2.8869	0.5307					
2488	20 RPM	155	2.8869	0.5309					
2463	20 RPM	155	2.8869	0.5304					
1238	20 RPM	175	2.9067	0.4903					
1238	20 RPM	175	2.9067	0.4903					
1238	20 RPM	175	2.9067	0.4903					
825	20 RPM	195	2.9257	0.4649					
787.5	20 RPM	195	2.9257	0.4618					
800	20 RPM	195	2.9257	0.4629					

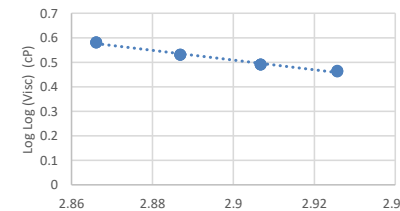


Table 59-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	35%	5.984	-1.891	0.997
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
2225	50 RPM	155	2.8869	0.5247					
2240	50 RPM	155	2.8869	0.5251					
2245	50 RPM	155	2.8869	0.5252					
1110	50 RPM	175	2.9067	0.4836					
1115	50 RPM	175	2.9067	0.4839					
1120	50 RPM	175	2.9067	0.4842					
680	50 RPM	195	2.9257	0.4522					
670	50 RPM	195	2.9257	0.4512					
675	50 RPM	195	2.9257	0.4517					

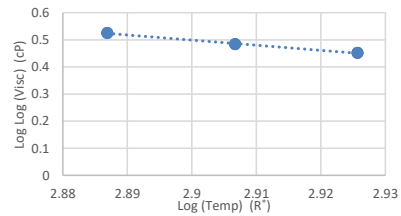


Table 60-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	35%	6.221	-1.975	0.998
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
2078	100 RPM	155	2.8869	0.5208					
2080	100 RPM	155	2.8869	0.5209					
2060	100 RPM	155	2.8869	0.5203					
1025	100 RPM	175	2.9067	0.4787					
1020	100 RPM	175	2.9067	0.4784					
1030	100 RPM	175	2.9067	0.4790					
595	100 RPM	195	2.9257	0.4432					
605	100 RPM	195	2.9257	0.4443					
610	100 RPM	195	2.9257	0.4449					

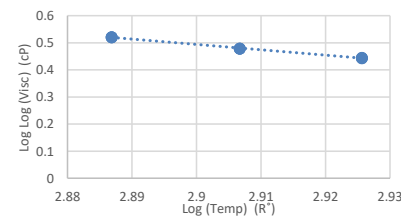


Table 61-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
7400	5 RPM	135	2.8661	0.5876	5 RPM	35%	6.410	-2.033	0.993
7350	5 RPM	135	2.8661	0.5873					
7450	5 RPM	135	2.8661	0.5880					
2850	5 RPM	155	2.8869	0.5384					
2850	5 RPM	155	2.8869	0.5384					
2800	5 RPM	155	2.8869	0.5375					
1400	5 RPM	175	2.9067	0.4978					
1400	5 RPM	175	2.9067	0.4978					
1400	5 RPM	175	2.9067	0.4978					
850	5 RPM	195	2.9257	0.4668					
850	5 RPM	195	2.9257	0.4668					
850	5 RPM	195	2.9257	0.4668					

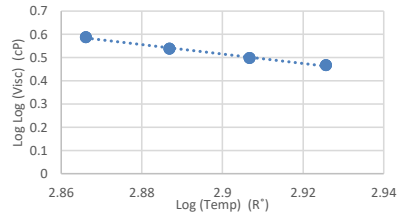


Table 62-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
6250	20 RPM	135	2.8661	0.5793	20 RPM	35%	6.596	-2.100	0.996
6238	20 RPM	135	2.8661	0.5792					
6175	20 RPM	135	2.8661	0.5787					
2425	20 RPM	155	2.8869	0.5295					
2463	20 RPM	155	2.8869	0.5304					
2438	20 RPM	155	2.8869	0.5298					
1200	20 RPM	175	2.9067	0.4884					
1200	20 RPM	175	2.9067	0.4884					
1200	20 RPM	175	2.9067	0.4884					
712.5	20 RPM	195	2.9257	0.4553					
700	20 RPM	195	2.9257	0.4541					
687.5	20 RPM	195	2.9257	0.4529					

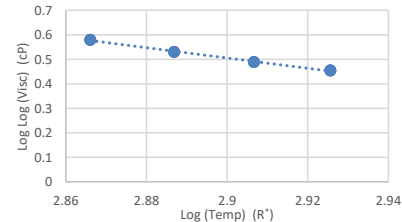


Table 63-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	35%	6.366	-2.024	0.999
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
2180	50 RPM	155	2.8869	0.5235					
2175	50 RPM	155	2.8869	0.5234					
2185	50 RPM	155	2.8869	0.5237					
1090	50 RPM	175	2.9067	0.4825					
1070	50 RPM	175	2.9067	0.4814					
1070	50 RPM	175	2.9067	0.4814					
610	50 RPM	195	2.9257	0.4449					
610	50 RPM	195	2.9257	0.4449					
615	50 RPM	195	2.9257	0.4454					

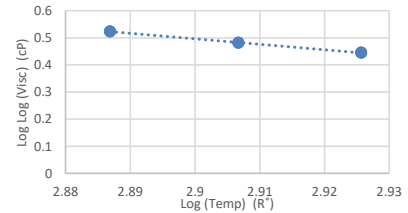


Table 64-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	35%	6.449	-2.054	0.998
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
2042	100 RPM	155	2.8869	0.5198					
2028	100 RPM	155	2.8869	0.5194					
2020	100 RPM	155	2.8869	0.5192					
985	100 RPM	175	2.9067	0.4762					
995	100 RPM	175	2.9067	0.4768					
977.5	100 RPM	175	2.9067	0.4757					
570	100 RPM	195	2.9257	0.4403					
562.5	100 RPM	195	2.9257	0.4394					
567.5	100 RPM	195	2.9257	0.4400					

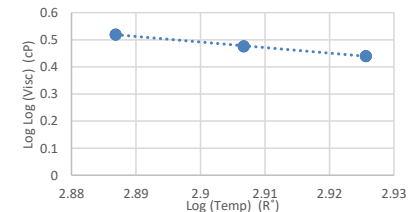


Table 65-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
11900	5 RPM	135	2.8661	0.6102	5 RPM	40%	5.188	-1.599	0.970
12050	5 RPM	135	2.8661	0.6108					
12350	5 RPM	135	2.8661	0.6119					
4900	5 RPM	155	2.8869	0.5670					
4900	5 RPM	155	2.8869	0.5670					
4850	5 RPM	155	2.8869	0.5665					
2650	5 RPM	175	2.9067	0.5344					
2550	5 RPM	175	2.9067	0.5323					
2600	5 RPM	175	2.9067	0.5334					
2000	5 RPM	195	2.9257	0.5186					
1900	5 RPM	195	2.9257	0.5157					
1900	5 RPM	195	2.9257	0.5157					

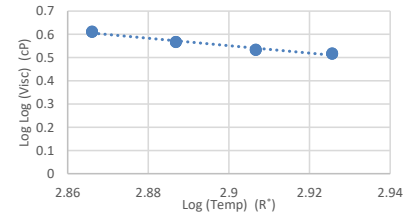


Table 66-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
9975	20 RPM	135	2.8661	0.6019	20 RPM	40%	5.686	-1.776	0.988
9800	20 RPM	135	2.8661	0.6011					
9750	20 RPM	135	2.8661	0.6009					
4025	20 RPM	155	2.8869	0.5569					
3975	20 RPM	155	2.8869	0.5562					
3988	20 RPM	155	2.8869	0.5564					
2075	20 RPM	175	2.9067	0.5207					
2050	20 RPM	175	2.9067	0.5201					
2050	20 RPM	175	2.9067	0.5201					
1388	20 RPM	195	2.9257	0.4973					
1375	20 RPM	195	2.9257	0.4967					
1325	20 RPM	195	2.9257	0.4945					

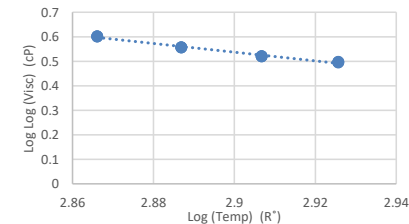


Table 67-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	40%	5.524	-1.724	0.996
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
3480	50 RPM	155	2.8869	0.5492					
3460	50 RPM	155	2.8869	0.5489					
3450	50 RPM	155	2.8869	0.5487					
1790	50 RPM	175	2.9067	0.5123					
1760	50 RPM	175	2.9067	0.5113					
1740	50 RPM	175	2.9067	0.5106					
1090	50 RPM	195	2.9257	0.4825					
1075	50 RPM	195	2.9257	0.4816					
1085	50 RPM	195	2.9257	0.4822					

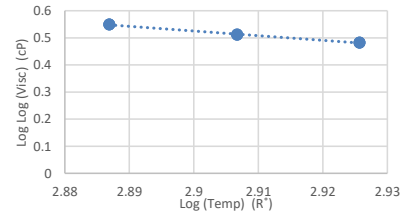


Table 68-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	40%	#N/A	#N/A	#N/A
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
1573	100 RPM	175	2.9067	0.5047					
1570	100 RPM	175	2.9067	0.5046					
1578	100 RPM	175	2.9067	0.5049					
942.5	100 RPM	195	2.9257	0.4734					
935	100 RPM	195	2.9257	0.4729					
927.5	100 RPM	195	2.9257	0.4724					

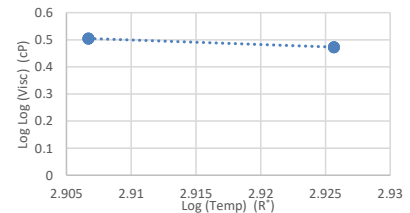


Table 69-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
12250	5 RPM	135	2.8661	0.6115	5 RPM	40%	5.238	-1.616	0.967
12500	5 RPM	135	2.8661	0.6125					
12450	5 RPM	135	2.8661	0.6123					
4800	5 RPM	155	2.8869	0.5660					
4900	5 RPM	155	2.8869	0.5670					
4850	5 RPM	155	2.8869	0.5665					
2550	5 RPM	175	2.9067	0.5323					
2550	5 RPM	175	2.9067	0.5323					
2650	5 RPM	175	2.9067	0.5344					
1950	5 RPM	195	2.9257	0.5172					
1900	5 RPM	195	2.9257	0.5157					
1950	5 RPM	195	2.9257	0.5172					

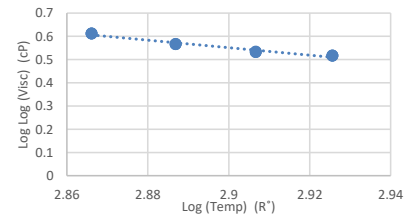


Table 70-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
10050	20 RPM	135	2.8661	0.6023	20 RPM	40%	5.750	-1.798	0.986
9950	20 RPM	135	2.8661	0.6018					
9875	20 RPM	135	2.8661	0.6015					
3963	20 RPM	155	2.8869	0.5561					
4038	20 RPM	155	2.8869	0.5570					
3950	20 RPM	155	2.8869	0.5559					
2013	20 RPM	175	2.9067	0.5190					
2013	20 RPM	175	2.9067	0.5190					
2025	20 RPM	175	2.9067	0.5194					
1388	20 RPM	195	2.9257	0.4973					
1363	20 RPM	195	2.9257	0.4962					
1300	20 RPM	195	2.9257	0.4933					

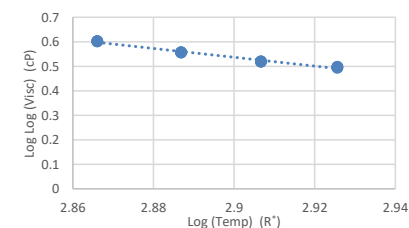


Table 71-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	40%	5.678	-1.777	0.997
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
3440	50 RPM	155	2.8869	0.5486					
3480	50 RPM	155	2.8869	0.5492					
3415	50 RPM	155	2.8869	0.5482					
1740	50 RPM	175	2.9067	0.5106					
1715	50 RPM	175	2.9067	0.5098					
1745	50 RPM	175	2.9067	0.5108					
1060	50 RPM	195	2.9257	0.4808					
1025	50 RPM	195	2.9257	0.4787					
1045	50 RPM	195	2.9257	0.4799					

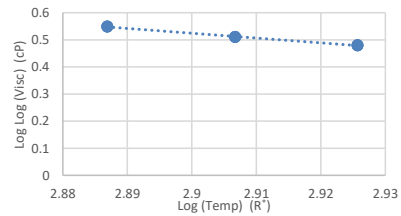


Table 72-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	40%	#N/A	#N/A	#N/A
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
1575	100 RPM	175	2.9067	0.5048					
1560	100 RPM	175	2.9067	0.5042					
1550	100 RPM	175	2.9067	0.5038					
917.5	100 RPM	195	2.9257	0.4717					
910	100 RPM	195	2.9257	0.4712					
920	100 RPM	195	2.9257	0.4718					

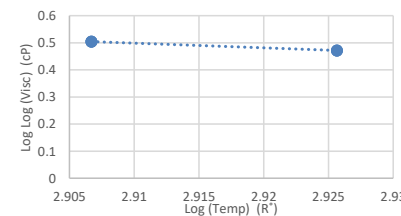


Table 73-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
14600	5 RPM	135	2.8661	0.6195	5 RPM	45%	5.287	-1.630	0.984
14850	5 RPM	135	2.8661	0.6203					
14900	5 RPM	135	2.8661	0.6205					
5950	5 RPM	155	2.8869	0.5769					
5900	5 RPM	155	2.8869	0.5764					
5850	5 RPM	155	2.8869	0.5760					
3300	5 RPM	175	2.9067	0.5464					
3250	5 RPM	175	2.9067	0.5455					
3250	5 RPM	175	2.9067	0.5455					
2100	5 RPM	195	2.9257	0.5214					
2250	5 RPM	195	2.9257	0.5253					
2100	5 RPM	195	2.9257	0.5214					

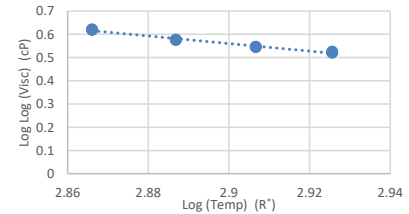


Table 74-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
11950	20 RPM	135	2.8661	0.6104	20 RPM	45%	5.699	-1.776	0.993
11950	20 RPM	135	2.8661	0.6104					
11950	20 RPM	135	2.8661	0.6104					
4925	20 RPM	155	2.8869	0.5673					
4850	20 RPM	155	2.8869	0.5665					
4888	20 RPM	155	2.8869	0.5669					
2525	20 RPM	175	2.9067	0.5318					
2513	20 RPM	175	2.9067	0.5315					
2525	20 RPM	175	2.9067	0.5318					
1625	20 RPM	195	2.9257	0.5066					
1563	20 RPM	195	2.9257	0.5043					
1538	20 RPM	195	2.9257	0.5034					

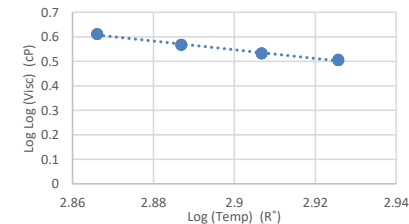


Table 75-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	45%	5.523	-1.719	0.999
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
4230	50 RPM	155	2.8869	0.5595					
4245	50 RPM	155	2.8869	0.5597					
4245	50 RPM	155	2.8869	0.5597					
2150	50 RPM	175	2.9067	0.5228					
2225	50 RPM	175	2.9067	0.5247					
2205	50 RPM	175	2.9067	0.5242					
1285	50 RPM	195	2.9257	0.4926					
1290	50 RPM	195	2.9257	0.4928					
1300	50 RPM	195	2.9257	0.4933					

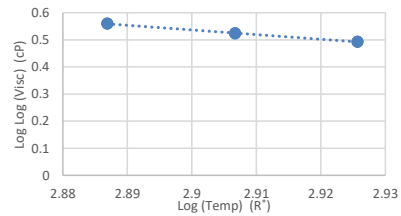


Table 76-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	45%	#N/A	#N/A	#N/A
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
1923	100 RPM	175	2.9067	0.5164					
1930	100 RPM	175	2.9067	0.5166					
1905	100 RPM	175	2.9067	0.5159					
1158	100 RPM	195	2.9257	0.4862					
1150	100 RPM	195	2.9257	0.4858					
1150	100 RPM	195	2.9257	0.4858					

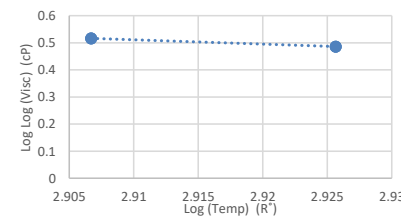


Table 77-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)					
					RPM	RAR	A	VTS	R2	
15900	5 RPM	135	2.8661	0.6234		5 RPM	45%	5.276	-1.624	0.987
16350	5 RPM	135	2.8661	0.6246						
16100	5 RPM	135	2.8661	0.6240						
6650	5 RPM	155	2.8869	0.5824						
6800	5 RPM	155	2.8869	0.5835						
6750	5 RPM	155	2.8869	0.5831						
3450	5 RPM	175	2.9067	0.5487						
3600	5 RPM	175	2.9067	0.5510						
3550	5 RPM	175	2.9067	0.5503						
2400	5 RPM	195	2.9257	0.5289						
2400	5 RPM	195	2.9257	0.5289						
2250	5 RPM	195	2.9257	0.5253						

Table 78-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)					
					RPM	RAR	A	VTS	R2	
#N/A	20 RPM	135	#N/A	#N/A		20 RPM	45%	5.350	-1.655	0.998
#N/A	20 RPM	135	#N/A	#N/A						
#N/A	20 RPM	135	#N/A	#N/A						
5438	20 RPM	155	2.8869	0.5723						
5438	20 RPM	155	2.8869	0.5723						
5375	20 RPM	155	2.8869	0.5718						
2738	20 RPM	175	2.9067	0.5362						
2800	20 RPM	175	2.9067	0.5375						
2800	20 RPM	175	2.9067	0.5375						
1688	20 RPM	195	2.9257	0.5088						
1638	20 RPM	195	2.9257	0.5071						
1663	20 RPM	195	2.9257	0.5080						

Table 79-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	45%	5.457	-1.695	0.999
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
4670	50 RPM	155	2.8869	0.5646					
4595	50 RPM	155	2.8869	0.5638					
4570	50 RPM	155	2.8869	0.5635					
2405	50 RPM	175	2.9067	0.5291					
2375	50 RPM	175	2.9067	0.5284					
2405	50 RPM	175	2.9067	0.5291					
1395	50 RPM	195	2.9257	0.4976					
1410	50 RPM	195	2.9257	0.4982					
1425	50 RPM	195	2.9257	0.4988					

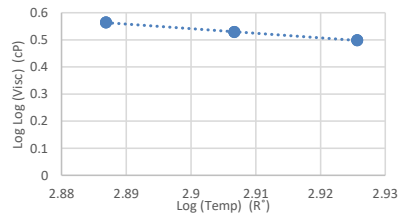


Table 80-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	45%	#N/A	#N/A	#N/A
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
2113	100 RPM	175	2.9067	0.5218					
2105	100 RPM	175	2.9067	0.5216					
2088	100 RPM	175	2.9067	0.5211					
1283	100 RPM	195	2.9257	0.4925					
1290	100 RPM	195	2.9257	0.4928					
1285	100 RPM	195	2.9257	0.4926					

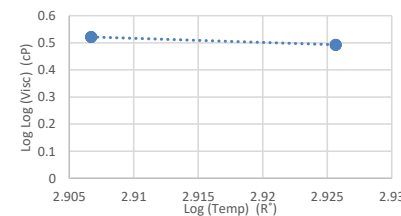


Table 81-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
25550	5 RPM	135	2.8661	0.6442	5 RPM	50%	5.163	-1.578	0.984
26000	5 RPM	135	2.8661	0.6449					
25750	5 RPM	135	2.8661	0.6445					
10050	5 RPM	155	2.8869	0.6023					
10400	5 RPM	155	2.8869	0.6039					
10150	5 RPM	155	2.8869	0.6028					
5500	5 RPM	175	2.9067	0.5729					
5300	5 RPM	175	2.9067	0.5710					
5400	5 RPM	175	2.9067	0.5720					
3700	5 RPM	195	2.9257	0.5524					
3600	5 RPM	195	2.9257	0.5510					
3450	5 RPM	195	2.9257	0.5487					

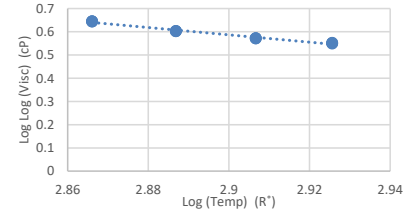


Table 82-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	50%	5.049	-1.545	0.992
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
8038	20 RPM	155	2.8869	0.5916					
8013	20 RPM	155	2.8869	0.5915					
7963	20 RPM	155	2.8869	0.5912					
4050	20 RPM	175	2.9067	0.5572					
3975	20 RPM	175	2.9067	0.5562					
3925	20 RPM	175	2.9067	0.5556					
2513	20 RPM	195	2.9257	0.5315					
2513	20 RPM	195	2.9257	0.5315					
2525	20 RPM	195	2.9257	0.5318					

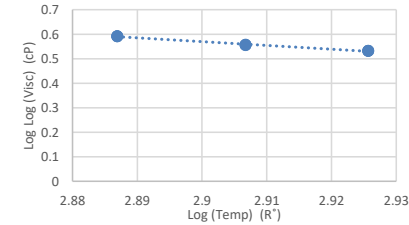


Table 83-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	50%	#N/A	#N/A	#N/A
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	155	#N/A	#N/A					
#N/A	50 RPM	155	#N/A	#N/A					
#N/A	50 RPM	155	#N/A	#N/A					
3435	50 RPM	175	2.9067	0.5485					
3350	50 RPM	175	2.9067	0.5472					
3355	50 RPM	175	2.9067	0.5472					
2050	50 RPM	195	2.9257	0.5201					
1980	50 RPM	195	2.9257	0.5181					
2005	50 RPM	195	2.9257	0.5188					

Table 84-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	50%	#N/A	#N/A	#N/A
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	175	#N/A	#N/A					
#N/A	100 RPM	175	#N/A	#N/A					
#N/A	100 RPM	175	#N/A	#N/A					
1740	100 RPM	195	2.9257	0.5106					
1740	100 RPM	195	2.9257	0.5106					
1765	100 RPM	195	2.9257	0.5114					

Table 85-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 5 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
26800	5 RPM	135	2.8661	0.6462	5 RPM	50%	5.028	-1.530	0.979
27200	5 RPM	135	2.8661	0.6469					
27050	5 RPM	135	2.8661	0.6466					
10850	5 RPM	155	2.8869	0.6059					
11150	5 RPM	155	2.8869	0.6072					
11000	5 RPM	155	2.8869	0.6065					
5600	5 RPM	175	2.9067	0.5738					
5700	5 RPM	175	2.9067	0.5747					
5700	5 RPM	175	2.9067	0.5747					
4150	5 RPM	195	2.9257	0.5585					
3950	5 RPM	195	2.9257	0.5559					
3850	5 RPM	195	2.9257	0.5545					

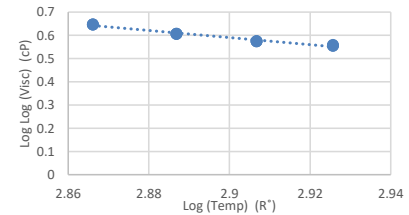


Table 86-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 20 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	50%	5.005	-1.528	0.990
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
8463	20 RPM	155	2.8869	0.5941					
8550	20 RPM	155	2.8869	0.5946					
8313	20 RPM	155	2.8869	0.5933					
4313	20 RPM	175	2.9067	0.5605					
4163	20 RPM	175	2.9067	0.5586					
4088	20 RPM	175	2.9067	0.5577					
2613	20 RPM	195	2.9257	0.5337					
2713	20 RPM	195	2.9257	0.5357					
2675	20 RPM	195	2.9257	0.5350					

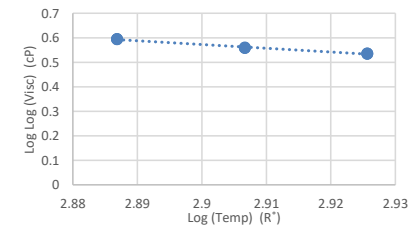


Table 87-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 50 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	50 RPM	135	#N/A	#N/A	50 RPM	50%	#N/A	#N/A	#N/A
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	135	#N/A	#N/A					
#N/A	50 RPM	155	#N/A	#N/A					
#N/A	50 RPM	155	#N/A	#N/A					
#N/A	50 RPM	155	#N/A	#N/A					
3470	50 RPM	175	2.9067	0.5490					
3470	50 RPM	175	2.9067	0.5490					
3465	50 RPM	175	2.9067	0.5490					
2120	50 RPM	195	2.9257	0.5220					
2060	50 RPM	195	2.9257	0.5203					
1995	50 RPM	195	2.9257	0.5185					

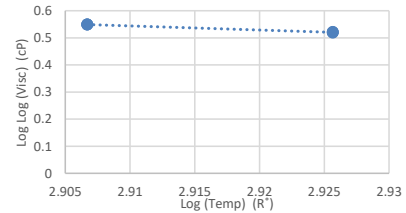


Table 88-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder A (PG 64-22) at 100 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder A (PG 64-22)				
					RPM	RAR	A	VTS	R2
#N/A	100 RPM	135	#N/A	#N/A	100 RPM	50%	#N/A	#N/A	#N/A
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	135	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	155	#N/A	#N/A					
#N/A	100 RPM	175	#N/A	#N/A					
#N/A	100 RPM	175	#N/A	#N/A					
#N/A	100 RPM	175	#N/A	#N/A					
1803	100 RPM	195	2.9257	0.5127					
1792	100 RPM	195	2.9257	0.5123					
1783	100 RPM	195	2.9257	0.5120					

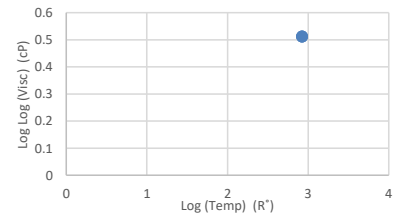


Table 89-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
750	2 RPM	135	2.8661	0.4586	2 RPM	0%	8.002	-2.632	0.906
875	2 RPM	135	2.8661	0.4686					
875	2 RPM	135	2.8661	0.4686					
375	2 RPM	155	2.8869	0.4106					
375	2 RPM	155	2.8869	0.4106					
375	2 RPM	155	2.8869	0.4106					
125	2 RPM	175	2.9067	0.3216					
125	2 RPM	175	2.9067	0.3216					
125	2 RPM	175	2.9067	0.3216					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					

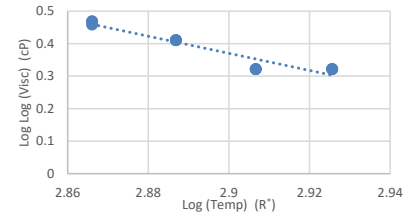


Table 90-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
750	5 RPM	135	2.8661	0.4586	5 RPM	0%	11.143	-3.725	0.972
750	5 RPM	135	2.8661	0.4586					
750	5 RPM	135	2.8661	0.4586					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					
50	5 RPM	195	2.9257	0.2302					

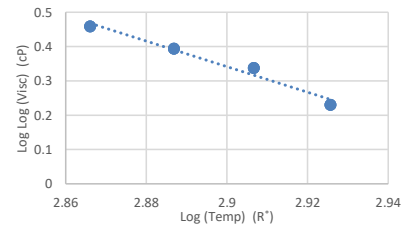


Table 91-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
775	10 RPM	135	2.8661	0.4608	10 RPM	0%	9.404	-3.120	0.999
775	10 RPM	135	2.8661	0.4608					
775	10 RPM	135	2.8661	0.4608					
300	10 RPM	155	2.8869	0.3939					
300	10 RPM	155	2.8869	0.3939					
300	10 RPM	155	2.8869	0.3939					
150	10 RPM	175	2.9067	0.3377					
150	10 RPM	175	2.9067	0.3377					
150	10 RPM	175	2.9067	0.3377					
75	10 RPM	195	2.9257	0.2730					
75	10 RPM	195	2.9257	0.2730					
75	10 RPM	195	2.9257	0.2730					

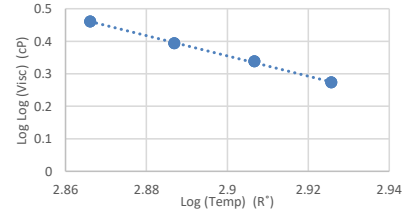


Table 92-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
762.5	20 RPM	135	2.8661	0.4597	20 RPM	0%	9.400	-3.119	0.999
762.5	20 RPM	135	2.8661	0.4597					
762.5	20 RPM	135	2.8661	0.4597					
312.5	20 RPM	155	2.8869	0.3970					
312.5	20 RPM	155	2.8869	0.3970					
312.5	20 RPM	155	2.8869	0.3970					
150	20 RPM	175	2.9067	0.3377					
150	20 RPM	175	2.9067	0.3377					
150	20 RPM	175	2.9067	0.3377					
75	20 RPM	195	2.9257	0.2730					
75	20 RPM	195	2.9257	0.2730					
75	20 RPM	195	2.9257	0.2730					

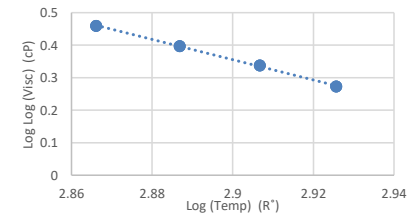


Table 93-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
875	2 RPM	135	2.8661	0.4686	2 RPM	0%	7.860	-2.581	0.914
875	2 RPM	135	2.8661	0.4686					
875	2 RPM	135	2.8661	0.4686					
375	2 RPM	155	2.8869	0.4106					
375	2 RPM	155	2.8869	0.4106					
375	2 RPM	155	2.8869	0.4106					
125	2 RPM	175	2.9067	0.3216					
125	2 RPM	175	2.9067	0.3216					
250	2 RPM	175	2.9067	0.3798					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					

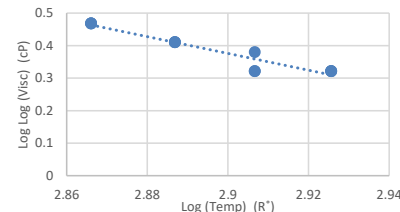


Table 94-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
750	5 RPM	135	2.8661	0.4586	5 RPM	0%	8.108	-2.671	0.990
750	5 RPM	135	2.8661	0.4586					
750	5 RPM	135	2.8661	0.4586					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
300	5 RPM	155	2.8869	0.3939					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					

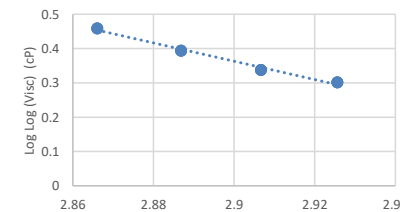


Table 95-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
775	10 RPM	135	2.8661	0.4608	10 RPM	0%	9.404	-3.120	0.999
775	10 RPM	135	2.8661	0.4608					
775	10 RPM	135	2.8661	0.4608					
300	10 RPM	155	2.8869	0.3939					
300	10 RPM	155	2.8869	0.3939					
300	10 RPM	155	2.8869	0.3939					
150	10 RPM	175	2.9067	0.3377					
150	10 RPM	175	2.9067	0.3377					
150	10 RPM	175	2.9067	0.3377					
75	10 RPM	195	2.9257	0.2730					
75	10 RPM	195	2.9257	0.2730					
75	10 RPM	195	2.9257	0.2730					

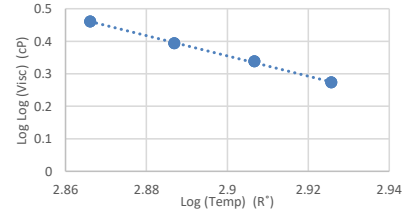


Table 96-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
762.5	20 RPM	135	2.8661	0.4597	20 RPM	0%	8.704	-2.877	0.998
762.5	20 RPM	135	2.8661	0.4597					
762.5	20 RPM	135	2.8661	0.4597					
300	20 RPM	155	2.8869	0.3939					
300	20 RPM	155	2.8869	0.3939					
300	20 RPM	155	2.8869	0.3939					
150	20 RPM	175	2.9067	0.3377					
150	20 RPM	175	2.9067	0.3377					
150	20 RPM	175	2.9067	0.3377					
87.5	20 RPM	195	2.9257	0.2883					
87.5	20 RPM	195	2.9257	0.2883					
87.5	20 RPM	195	2.9257	0.2883					

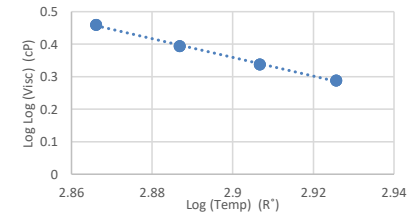


Table 97-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1125	2 RPM	135	2.8661	0.4845	2 RPM	5%	8.276	-2.718	0.998
1125	2 RPM	135	2.8661	0.4845					
1125	2 RPM	135	2.8661	0.4845					
500	2 RPM	155	2.8869	0.4312					
500	2 RPM	155	2.8869	0.4312					
500	2 RPM	155	2.8869	0.4312					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					

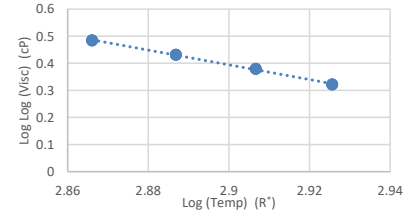


Table 98-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1050	5 RPM	135	2.8661	0.4802	5 RPM	5%	9.372	-3.103	0.986
1050	5 RPM	135	2.8661	0.4802					
1050	5 RPM	135	2.8661	0.4802					
400	5 RPM	155	2.8869	0.4153					
400	5 RPM	155	2.8869	0.4153					
400	5 RPM	155	2.8869	0.4153					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
150	5 RPM	175	2.9067	0.3377					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					

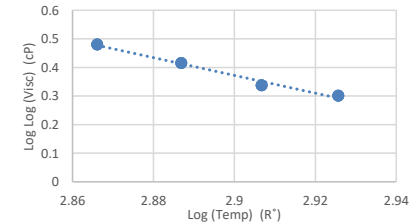


Table 99-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1050	10 RPM	135	2.8661	0.4802	10 RPM	5%	9.108	-3.012	0.997
1050	10 RPM	135	2.8661	0.4802					
1050	10 RPM	135	2.8661	0.4802					
375	10 RPM	155	2.8869	0.4106					
375	10 RPM	155	2.8869	0.4106					
375	10 RPM	155	2.8869	0.4106					
175	10 RPM	175	2.9067	0.3508					
175	10 RPM	175	2.9067	0.3508					
175	10 RPM	175	2.9067	0.3508					
100	10 RPM	195	2.9257	0.3010					
100	10 RPM	195	2.9257	0.3010					
100	10 RPM	195	2.9257	0.3010					

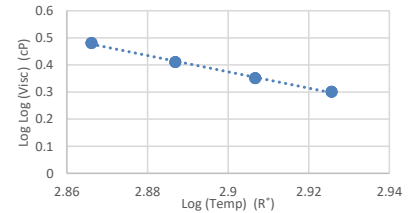


Table 100-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1025	20 RPM	135	2.8661	0.4787	20 RPM	5%	9.682	-3.212	0.999
1025	20 RPM	135	2.8661	0.4787					
1025	20 RPM	135	2.8661	0.4787					
375	20 RPM	155	2.8869	0.4106					
375	20 RPM	155	2.8869	0.4106					
375	20 RPM	155	2.8869	0.4106					
162.5	20 RPM	175	2.9067	0.3446					
162.5	20 RPM	175	2.9067	0.3446					
162.5	20 RPM	175	2.9067	0.3446					
87.5	20 RPM	195	2.9257	0.2883					
87.5	20 RPM	195	2.9257	0.2883					
87.5	20 RPM	195	2.9257	0.2883					

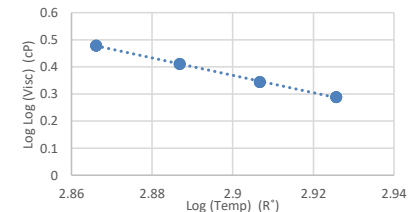


Table 101-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1125	2 RPM	135	2.8661	0.4845	2 RPM	5%	8.082	-2.652	0.984
1125	2 RPM	135	2.8661	0.4845					
1125	2 RPM	135	2.8661	0.4845					
375	2 RPM	155	2.8869	0.4106					
500	2 RPM	155	2.8869	0.4312					
375	2 RPM	155	2.8869	0.4106					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					

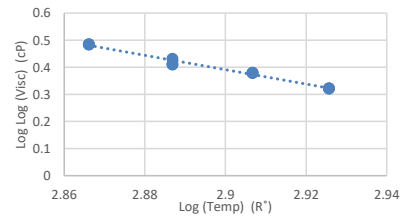


Table 102-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1050	5 RPM	135	2.8661	0.4802	5 RPM	5%	9.009	-2.976	0.999
1050	5 RPM	135	2.8661	0.4802					
1050	5 RPM	135	2.8661	0.4802					
400	5 RPM	155	2.8869	0.4153					
400	5 RPM	155	2.8869	0.4153					
400	5 RPM	155	2.8869	0.4153					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					

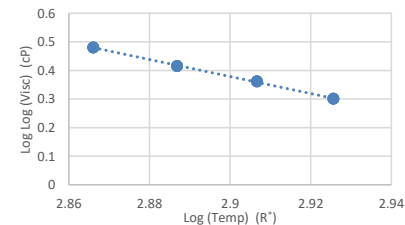


Table 103-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1050	10 RPM	135	2.8661	0.4802	10 RPM	5%	9.175	-3.034	0.998
1050	10 RPM	135	2.8661	0.4802					
1050	10 RPM	135	2.8661	0.4802					
400	10 RPM	155	2.8869	0.4153					
400	10 RPM	155	2.8869	0.4153					
400	10 RPM	155	2.8869	0.4153					
175	10 RPM	175	2.9067	0.3508					
175	10 RPM	175	2.9067	0.3508					
175	10 RPM	175	2.9067	0.3508					
100	10 RPM	195	2.9257	0.3010					
100	10 RPM	195	2.9257	0.3010					
100	10 RPM	195	2.9257	0.3010					

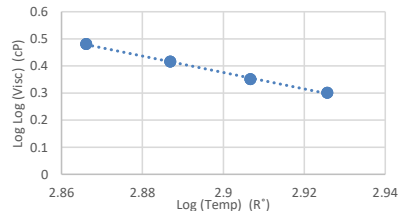


Table 104-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1025	20 RPM	135	2.8661	0.4787	20 RPM	5%	9.646	-3.198	1.000
1038	20 RPM	135	2.8661	0.4795					
1038	20 RPM	135	2.8661	0.4795					
387.5	20 RPM	155	2.8869	0.4130					
387.5	20 RPM	155	2.8869	0.4130					
387.5	20 RPM	155	2.8869	0.4130					
175	20 RPM	175	2.9067	0.3508					
175	20 RPM	175	2.9067	0.3508					
175	20 RPM	175	2.9067	0.3508					
87.5	20 RPM	195	2.9257	0.2883					
87.5	20 RPM	195	2.9257	0.2883					
87.5	20 RPM	195	2.9257	0.2883					

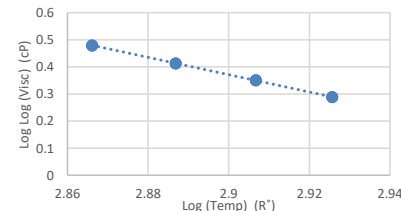


Table 105-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1625	2 RPM	135	2.8661	0.5066	2 RPM	10%	6.987	-2.264	0.906
1625	2 RPM	135	2.8661	0.5066					
1625	2 RPM	135	2.8661	0.5066					
625	2 RPM	155	2.8869	0.4465					
625	2 RPM	155	2.8869	0.4465					
625	2 RPM	155	2.8869	0.4465					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	195	2.9257	0.3798					
250	2 RPM	195	2.9257	0.3798					
250	2 RPM	195	2.9257	0.3798					

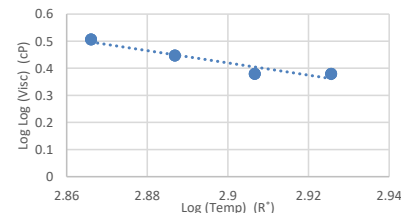


Table 106-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1450	5 RPM	135	2.8661	0.4999	5 RPM	10%	8.369	-2.746	0.996
1450	5 RPM	135	2.8661	0.4999					
1450	5 RPM	135	2.8661	0.4999					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
250	5 RPM	175	2.9067	0.3798					
250	5 RPM	175	2.9067	0.3798					
250	5 RPM	175	2.9067	0.3798					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					

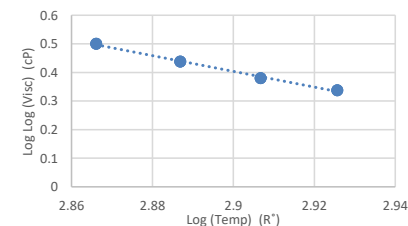


Table 107-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)						
					RPM	RAR	A	VTS	R2		
1450	10 RPM	135	2.8661	0.4999		<table border="1"> <tr> <td>10 RPM</td> <td>10%</td> <td>7.744</td> <td>-2.530</td> <td>0.980</td> </tr> </table>	10 RPM	10%	7.744	-2.530	0.980
10 RPM	10%	7.744	-2.530	0.980							
1425	10 RPM	135	2.8661	0.4988							
1450	10 RPM	135	2.8661	0.4999							
525	10 RPM	155	2.8869	0.4346							
525	10 RPM	155	2.8869	0.4346							
525	10 RPM	155	2.8869	0.4346							
250	10 RPM	175	2.9067	0.3798							
250	10 RPM	175	2.9067	0.3798							
250	10 RPM	175	2.9067	0.3798							
175	10 RPM	195	2.9257	0.3508							
175	10 RPM	195	2.9257	0.3508							
175	10 RPM	195	2.9257	0.3508							

Table 108-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)						
					RPM	RAR	A	VTS	R2		
1425	20 RPM	135	2.8661	0.4988		<table border="1"> <tr> <td>20 RPM</td> <td>10%</td> <td>7.982</td> <td>-2.613</td> <td>0.989</td> </tr> </table>	20 RPM	10%	7.982	-2.613	0.989
20 RPM	10%	7.982	-2.613	0.989							
1413	20 RPM	135	2.8661	0.4983							
1425	20 RPM	135	2.8661	0.4988							
525	20 RPM	155	2.8869	0.4346							
537.5	20 RPM	155	2.8869	0.4362							
525	20 RPM	155	2.8869	0.4346							
250	20 RPM	175	2.9067	0.3798							
250	20 RPM	175	2.9067	0.3798							
250	20 RPM	175	2.9067	0.3798							
162.5	20 RPM	195	2.9257	0.3446							
162.5	20 RPM	195	2.9257	0.3446							
162.5	20 RPM	195	2.9257	0.3446							

Table 109-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
1500	2 RPM	135	2.8661	0.5019		2 RPM	10%	9.342	-3.083	0.998
1625	2 RPM	135	2.8661	0.5066						
1500	2 RPM	135	2.8661	0.5019						
625	2 RPM	155	2.8869	0.4465						
625	2 RPM	155	2.8869	0.4465						
625	2 RPM	155	2.8869	0.4465						
250	2 RPM	175	2.9067	0.3798						
250	2 RPM	175	2.9067	0.3798						
250	2 RPM	175	2.9067	0.3798						
125	2 RPM	195	2.9257	0.3216						
125	2 RPM	195	2.9257	0.3216						
125	2 RPM	195	2.9257	0.3216						

Table 110-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
1450	5 RPM	135	2.8661	0.4999		5 RPM	10%	8.369	-2.746	0.996
1450	5 RPM	135	2.8661	0.4999						
1450	5 RPM	135	2.8661	0.4999						
550	5 RPM	155	2.8869	0.4378						
550	5 RPM	155	2.8869	0.4378						
550	5 RPM	155	2.8869	0.4378						
250	5 RPM	175	2.9067	0.3798						
250	5 RPM	175	2.9067	0.3798						
250	5 RPM	175	2.9067	0.3798						
150	5 RPM	195	2.9257	0.3377						
150	5 RPM	195	2.9257	0.3377						
150	5 RPM	195	2.9257	0.3377						

Table 111-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1450	10 RPM	135	2.8661	0.4999	10 RPM	10%	8.334	-2.735	0.992
1425	10 RPM	135	2.8661	0.4988					
1425	10 RPM	135	2.8661	0.4988					
525	10 RPM	155	2.8869	0.4346					
525	10 RPM	155	2.8869	0.4346					
525	10 RPM	155	2.8869	0.4346					
225	10 RPM	175	2.9067	0.3715					
250	10 RPM	175	2.9067	0.3798					
250	10 RPM	175	2.9067	0.3798					
150	10 RPM	195	2.9257	0.3377					
150	10 RPM	195	2.9257	0.3377					
150	10 RPM	195	2.9257	0.3377					

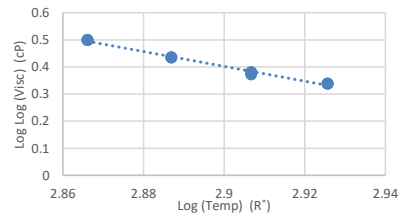


Table 112-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
1388	20 RPM	135	2.8661	0.4973	20 RPM	10%	8.259	-2.710	0.992
1388	20 RPM	135	2.8661	0.4973					
1400	20 RPM	135	2.8661	0.4978					
512.5	20 RPM	155	2.8869	0.4329					
525	20 RPM	155	2.8869	0.4346					
512.5	20 RPM	155	2.8869	0.4329					
237.5	20 RPM	175	2.9067	0.3758					
237.5	20 RPM	175	2.9067	0.3758					
237.5	20 RPM	175	2.9067	0.3758					
150	20 RPM	195	2.9257	0.3377					
150	20 RPM	195	2.9257	0.3377					
150	20 RPM	195	2.9257	0.3377					

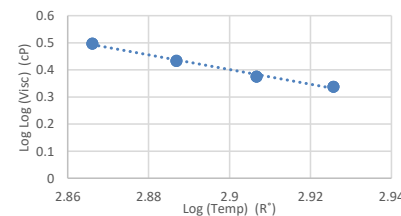


Table 113-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
2375	2 RPM	135	2.8661	0.5284		2 RPM	15%	5.889	-1.874	0.927
2375	2 RPM	135	2.8661	0.5284						
2375	2 RPM	135	2.8661	0.5284						
875	2 RPM	155	2.8869	0.4686						
875	2 RPM	155	2.8869	0.4686						
875	2 RPM	155	2.8869	0.4686						
500	2 RPM	175	2.9067	0.4312						
500	2 RPM	175	2.9067	0.4312						
500	2 RPM	175	2.9067	0.4312						
375	2 RPM	195	2.9257	0.4106						
375	2 RPM	195	2.9257	0.4106						
500	2 RPM	195	2.9257	0.4312						

Table 114-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
2150	5 RPM	135	2.8661	0.5228		5 RPM	15%	6.450	-2.071	0.926
2200	5 RPM	135	2.8661	0.5241						
2200	5 RPM	135	2.8661	0.5241						
850	5 RPM	155	2.8869	0.4668						
850	5 RPM	155	2.8869	0.4668						
850	5 RPM	155	2.8869	0.4668						
350	5 RPM	175	2.9067	0.4055						
400	5 RPM	175	2.9067	0.4153						
400	5 RPM	175	2.9067	0.4153						
350	5 RPM	195	2.9257	0.4055						
350	5 RPM	195	2.9257	0.4055						
350	5 RPM	195	2.9257	0.4055						

Table 115-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2150	10 RPM	135	2.8661	0.5228	10 RPM	15%	6.432	-2.065	0.945
2150	10 RPM	135	2.8661	0.5228					
2150	10 RPM	135	2.8661	0.5228					
850	10 RPM	155	2.8869	0.4668					
850	10 RPM	155	2.8869	0.4668					
825	10 RPM	155	2.8869	0.4649					
400	10 RPM	175	2.9067	0.4153					
400	10 RPM	175	2.9067	0.4153					
400	10 RPM	175	2.9067	0.4153					
350	10 RPM	195	2.9257	0.4055					
350	10 RPM	195	2.9257	0.4055					
325	10 RPM	195	2.9257	0.4000					

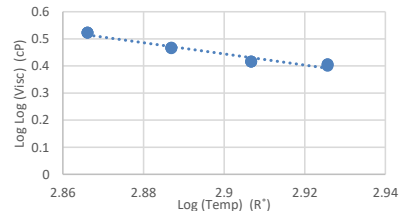


Table 116-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2113	20 RPM	135	2.8661	0.5218	20 RPM	15%	6.758	-2.179	0.971
2100	20 RPM	135	2.8661	0.5214					
2100	20 RPM	135	2.8661	0.5214					
812.5	20 RPM	155	2.8869	0.4639					
800	20 RPM	155	2.8869	0.4629					
812.5	20 RPM	155	2.8869	0.4639					
400	20 RPM	175	2.9067	0.4153					
400	20 RPM	175	2.9067	0.4153					
400	20 RPM	175	2.9067	0.4153					
300	20 RPM	195	2.9257	0.3939					
300	20 RPM	195	2.9257	0.3939					
300	20 RPM	195	2.9257	0.3939					

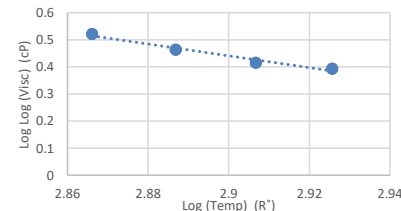


Table 117-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2250	2 RPM	135	2.8661	0.5253	2 RPM	15%	6.356	-2.038	0.903
2250	2 RPM	135	2.8661	0.5253					
2250	2 RPM	135	2.8661	0.5253					
875	2 RPM	155	2.8869	0.4686					
875	2 RPM	155	2.8869	0.4686					
875	2 RPM	155	2.8869	0.4686					
375	2 RPM	175	2.9067	0.4106					
375	2 RPM	175	2.9067	0.4106					
375	2 RPM	175	2.9067	0.4106					
375	2 RPM	195	2.9257	0.4106					
375	2 RPM	195	2.9257	0.4106					
375	2 RPM	195	2.9257	0.4106					

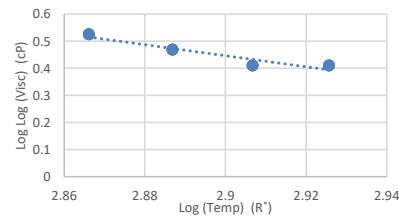


Table 118-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2200	5 RPM	135	2.8661	0.5241	5 RPM	15%	6.609	-2.127	0.922
2150	5 RPM	135	2.8661	0.5228					
2200	5 RPM	135	2.8661	0.5241					
800	5 RPM	155	2.8869	0.4629					
800	5 RPM	155	2.8869	0.4629					
800	5 RPM	155	2.8869	0.4629					
350	5 RPM	175	2.9067	0.4055					
350	5 RPM	175	2.9067	0.4055					
400	5 RPM	175	2.9067	0.4153					
300	5 RPM	195	2.9257	0.3939					
350	5 RPM	195	2.9257	0.4055					
350	5 RPM	195	2.9257	0.4055					

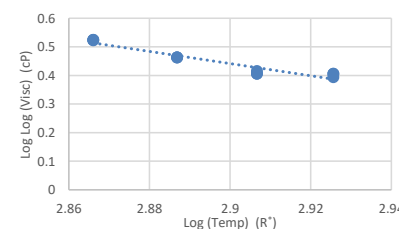


Table 119-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2150	10 RPM	135	2.8661	0.5228	10 RPM	15%	6.863	-2.215	0.959
2125	10 RPM	135	2.8661	0.5221					
2125	10 RPM	135	2.8661	0.5221					
825	10 RPM	155	2.8869	0.4649					
800	10 RPM	155	2.8869	0.4629					
800	10 RPM	155	2.8869	0.4629					
375	10 RPM	175	2.9067	0.4106					
375	10 RPM	175	2.9067	0.4106					
375	10 RPM	175	2.9067	0.4106					
300	10 RPM	195	2.9257	0.3939					
300	10 RPM	195	2.9257	0.3939					
300	10 RPM	195	2.9257	0.3939					

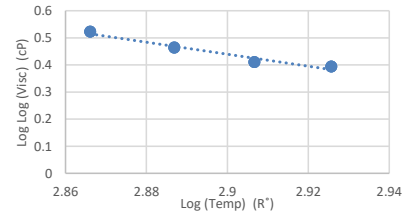


Table 120-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2075	20 RPM	135	2.8661	0.5207	20 RPM	15%	7.045	-2.279	0.975
2063	20 RPM	135	2.8661	0.5204					
2050	20 RPM	135	2.8661	0.5201					
787.5	20 RPM	155	2.8869	0.4618					
787.5	20 RPM	155	2.8869	0.4618					
800	20 RPM	155	2.8869	0.4629					
375	20 RPM	175	2.9067	0.4106					
375	20 RPM	175	2.9067	0.4106					
375	20 RPM	175	2.9067	0.4106					
275	20 RPM	195	2.9257	0.3873					
275	20 RPM	195	2.9257	0.3873					
275	20 RPM	195	2.9257	0.3873					

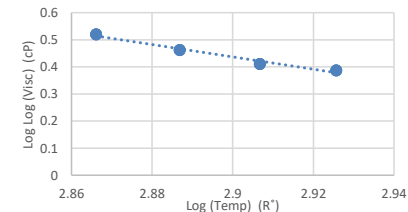


Table 121-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
3250	2 RPM	135	2.8661	0.5455		2 RPM	20%	6.155	-1.960	0.957
3250	2 RPM	135	2.8661	0.5455						
3250	2 RPM	135	2.8661	0.5455						
1250	2 RPM	155	2.8869	0.4909						
1250	2 RPM	155	2.8869	0.4909						
1250	2 RPM	155	2.8869	0.4909						
625	2 RPM	175	2.9067	0.4465						
625	2 RPM	175	2.9067	0.4465						
625	2 RPM	175	2.9067	0.4465						
500	2 RPM	195	2.9257	0.4312						
500	2 RPM	195	2.9257	0.4312						
500	2 RPM	195	2.9257	0.4312						

Table 122-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
2900	5 RPM	135	2.8661	0.5394		5 RPM	20%	6.316	-2.018	0.948
2950	5 RPM	135	2.8661	0.5403						
2950	5 RPM	135	2.8661	0.5403						
1150	5 RPM	155	2.8869	0.4858						
1150	5 RPM	155	2.8869	0.4858						
1150	5 RPM	155	2.8869	0.4858						
550	5 RPM	175	2.9067	0.4378						
550	5 RPM	175	2.9067	0.4378						
500	5 RPM	175	2.9067	0.4312						
450	5 RPM	195	2.9257	0.4238						
450	5 RPM	195	2.9257	0.4238						
450	5 RPM	195	2.9257	0.4238						

Table 123-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)											
					RPM	RAR	A	VTS	R2							
2850	10 RPM	135	2.8661	0.5384		<table border="1"> <tr> <th>RPM</th> <th>RAR</th> <th>A</th> <th>VTS</th> <th>R2</th> </tr> <tr> <td>10 RPM</td> <td>20%</td> <td>6.435</td> <td>-2.060</td> <td>0.946</td> </tr> </table>	RPM	RAR	A	VTS	R2	10 RPM	20%	6.435	-2.060	0.946
RPM	RAR	A	VTS	R2												
10 RPM	20%	6.435	-2.060	0.946												
2850	10 RPM	135	2.8661	0.5384												
2825	10 RPM	135	2.8661	0.5379												
1100	10 RPM	155	2.8869	0.4831												
1100	10 RPM	155	2.8869	0.4831												
1075	10 RPM	155	2.8869	0.4816												
500	10 RPM	175	2.9067	0.4312												
500	10 RPM	175	2.9067	0.4312												
500	10 RPM	175	2.9067	0.4312												
425	10 RPM	195	2.9257	0.4197												
425	10 RPM	195	2.9257	0.4197												
425	10 RPM	195	2.9257	0.4197												

Table 124-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)											
					RPM	RAR	A	VTS	R2							
2713	20 RPM	135	2.8661	0.5357		<table border="1"> <tr> <th>RPM</th> <th>RAR</th> <th>A</th> <th>VTS</th> <th>R2</th> </tr> <tr> <td>20 RPM</td> <td>20%</td> <td>6.502</td> <td>-2.084</td> <td>0.959</td> </tr> </table>	RPM	RAR	A	VTS	R2	20 RPM	20%	6.502	-2.084	0.959
RPM	RAR	A	VTS	R2												
20 RPM	20%	6.502	-2.084	0.959												
2713	20 RPM	135	2.8661	0.5357												
2713	20 RPM	135	2.8661	0.5357												
1038	20 RPM	155	2.8869	0.4795												
1025	20 RPM	155	2.8869	0.4787												
1038	20 RPM	155	2.8869	0.4795												
487.5	20 RPM	175	2.9067	0.4294												
500	20 RPM	175	2.9067	0.4312												
500	20 RPM	175	2.9067	0.4312												
400	20 RPM	195	2.9257	0.4153												
387.5	20 RPM	195	2.9257	0.4130												
400	20 RPM	195	2.9257	0.4153												

Table 125-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
3250	2 RPM	135	2.8661	0.5455		2 RPM	20%	7.203	-2.325	0.972
3125	2 RPM	135	2.8661	0.5434						
3125	2 RPM	135	2.8661	0.5434						
1250	2 RPM	155	2.8869	0.4909						
1250	2 RPM	155	2.8869	0.4909						
1250	2 RPM	155	2.8869	0.4909						
500	2 RPM	175	2.9067	0.4312						
500	2 RPM	175	2.9067	0.4312						
500	2 RPM	175	2.9067	0.4312						
375	2 RPM	195	2.9257	0.4106						
375	2 RPM	195	2.9257	0.4106						
375	2 RPM	195	2.9257	0.4106						

Table 126-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)					
					RPM	RAR	A	VTS	R2	
2950	5 RPM	135	2.8661	0.5403		5 RPM	20%	7.138	-2.304	0.981
2950	5 RPM	135	2.8661	0.5403						
2900	5 RPM	135	2.8661	0.5394						
1100	5 RPM	155	2.8869	0.4831						
1150	5 RPM	155	2.8869	0.4858						
1100	5 RPM	155	2.8869	0.4831						
500	5 RPM	175	2.9067	0.4312						
500	5 RPM	175	2.9067	0.4312						
500	5 RPM	175	2.9067	0.4312						
350	5 RPM	195	2.9257	0.4055						
350	5 RPM	195	2.9257	0.4055						
350	5 RPM	195	2.9257	0.4055						

Table 127-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2825	10 RPM	135	2.8661	0.5379		20%	7.074	-2.283	0.974
2850	10 RPM	135	2.8661	0.5384					
2825	10 RPM	135	2.8661	0.5379					
1075	10 RPM	155	2.8869	0.4816					
1075	10 RPM	155	2.8869	0.4816					
1075	10 RPM	155	2.8869	0.4816					
475	10 RPM	175	2.9067	0.4276					
475	10 RPM	175	2.9067	0.4276					
475	10 RPM	175	2.9067	0.4276					
350	10 RPM	195	2.9257	0.4055					
350	10 RPM	195	2.9257	0.4055					
350	10 RPM	195	2.9257	0.4055					

Table 128-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
2725	20 RPM	135	2.8661	0.5360		20%	7.125	-2.301	0.977
2725	20 RPM	135	2.8661	0.5360					
2725	20 RPM	135	2.8661	0.5360					
1038	20 RPM	155	2.8869	0.4795					
1025	20 RPM	155	2.8869	0.4787					
1025	20 RPM	155	2.8869	0.4787					
462.5	20 RPM	175	2.9067	0.4257					
462.5	20 RPM	175	2.9067	0.4257					
462.5	20 RPM	175	2.9067	0.4257					
337.5	20 RPM	195	2.9257	0.4028					
325	20 RPM	195	2.9257	0.4000					
337.5	20 RPM	195	2.9257	0.4028					

Table 129-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
5625	2 RPM	135	2.8661	0.5740	2 RPM	25%	6.864	-2.196	0.978
5625	2 RPM	135	2.8661	0.5740					
5500	2 RPM	135	2.8661	0.5729					
2125	2 RPM	155	2.8869	0.5221					
2125	2 RPM	155	2.8869	0.5221					
2125	2 RPM	155	2.8869	0.5221					
875	2 RPM	175	2.9067	0.4686					
875	2 RPM	175	2.9067	0.4686					
875	2 RPM	175	2.9067	0.4686					
625	2 RPM	195	2.9257	0.4465					
625	2 RPM	195	2.9257	0.4465					
625	2 RPM	195	2.9257	0.4465					

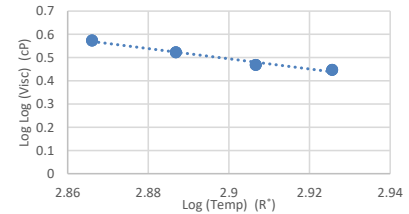


Table 130-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
5100	5 RPM	135	2.8661	0.5691	5 RPM	25%	6.956	-2.230	0.989
5050	5 RPM	135	2.8661	0.5686					
5050	5 RPM	135	2.8661	0.5686					
1900	5 RPM	155	2.8869	0.5157					
1900	5 RPM	155	2.8869	0.5157					
1900	5 RPM	155	2.8869	0.5157					
850	5 RPM	175	2.9067	0.4668					
850	5 RPM	175	2.9067	0.4668					
850	5 RPM	175	2.9067	0.4668					
550	5 RPM	195	2.9257	0.4378					
550	5 RPM	195	2.9257	0.4378					
550	5 RPM	195	2.9257	0.4378					

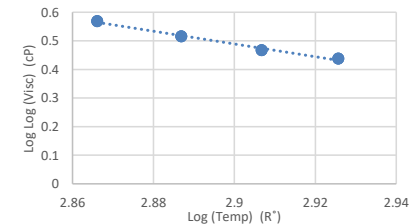


Table 131-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
4775	10 RPM	135	2.8661	0.5657	10 RPM	25%	6.943	-2.227	0.988
4700	10 RPM	135	2.8661	0.5649					
4750	10 RPM	135	2.8661	0.5655					
1775	10 RPM	155	2.8869	0.5118					
1800	10 RPM	155	2.8869	0.5126					
1800	10 RPM	155	2.8869	0.5126					
800	10 RPM	175	2.9067	0.4629					
825	10 RPM	175	2.9067	0.4649					
800	10 RPM	175	2.9067	0.4629					
525	10 RPM	195	2.9257	0.4346					
525	10 RPM	195	2.9257	0.4346					
525	10 RPM	195	2.9257	0.4346					

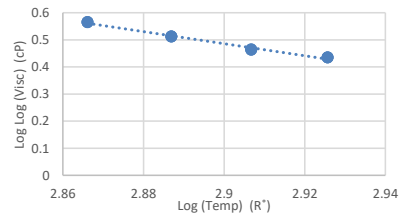


Table 132-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
4488	20 RPM	135	2.8661	0.5625	20 RPM	25%	6.824	-2.187	0.984
4463	20 RPM	135	2.8661	0.5622					
4438	20 RPM	135	2.8661	0.5620					
1700	20 RPM	155	2.8869	0.5093					
1688	20 RPM	155	2.8869	0.5088					
1675	20 RPM	155	2.8869	0.5084					
775	20 RPM	175	2.9067	0.4608					
775	20 RPM	175	2.9067	0.4608					
762.5	20 RPM	175	2.9067	0.4597					
512.5	20 RPM	195	2.9257	0.4329					
525	20 RPM	195	2.9257	0.4346					
525	20 RPM	195	2.9257	0.4346					

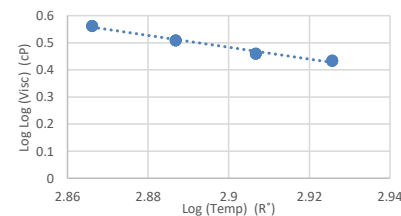


Table 133-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
5500	2 RPM	135	2.8661	0.5729	2 RPM	25%	6.490	-2.067	0.974
5375	2 RPM	135	2.8661	0.5718					
5375	2 RPM	135	2.8661	0.5718					
2000	2 RPM	155	2.8869	0.5186					
2000	2 RPM	155	2.8869	0.5186					
2000	2 RPM	155	2.8869	0.5186					
875	2 RPM	175	2.9067	0.4686					
1000	2 RPM	175	2.9067	0.4771					
1000	2 RPM	175	2.9067	0.4771					
625	2 RPM	195	2.9257	0.4465					
750	2 RPM	195	2.9257	0.4586					
625	2 RPM	195	2.9257	0.4465					

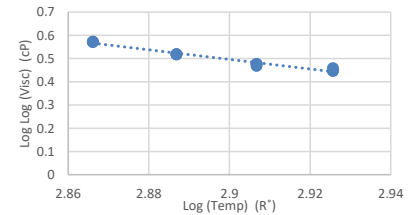


Table 134-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
4850	5 RPM	135	2.8661	0.5665	5 RPM	25%	6.685	-2.136	0.978
4900	5 RPM	135	2.8661	0.5670					
4900	5 RPM	135	2.8661	0.5670					
1850	5 RPM	155	2.8869	0.5142					
1800	5 RPM	155	2.8869	0.5126					
1800	5 RPM	155	2.8869	0.5126					
850	5 RPM	175	2.9067	0.4668					
800	5 RPM	175	2.9067	0.4629					
850	5 RPM	175	2.9067	0.4668					
550	5 RPM	195	2.9257	0.4378					
600	5 RPM	195	2.9257	0.4438					
600	5 RPM	195	2.9257	0.4438					

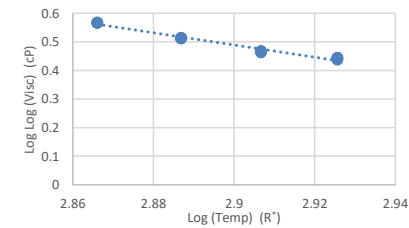


Table 135-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
4650	10 RPM	135	2.8661	0.5644	10 RPM	25%	6.717	-2.149	0.981
4575	10 RPM	135	2.8661	0.5635					
4575	10 RPM	135	2.8661	0.5635					
1725	10 RPM	155	2.8869	0.5101					
1725	10 RPM	155	2.8869	0.5101					
1725	10 RPM	155	2.8869	0.5101					
800	10 RPM	175	2.9067	0.4629					
800	10 RPM	175	2.9067	0.4629					
800	10 RPM	175	2.9067	0.4629					
550	10 RPM	195	2.9257	0.4378					
525	10 RPM	195	2.9257	0.4346					
575	10 RPM	195	2.9257	0.4409					

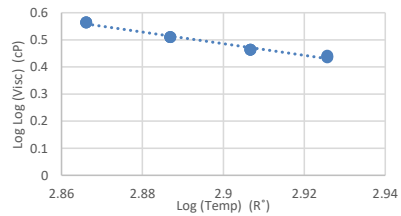


Table 136-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
4338	20 RPM	135	2.8661	0.5608	20 RPM	25%	6.730	-2.154	0.980
4350	20 RPM	135	2.8661	0.5609					
4313	20 RPM	135	2.8661	0.5605					
1625	20 RPM	155	2.8869	0.5066					
1625	20 RPM	155	2.8869	0.5066					
1638	20 RPM	155	2.8869	0.5071					
750	20 RPM	175	2.9067	0.4586					
750	20 RPM	175	2.9067	0.4586					
750	20 RPM	175	2.9067	0.4586					
525	20 RPM	195	2.9257	0.4346					
525	20 RPM	195	2.9257	0.4346					
525	20 RPM	195	2.9257	0.4346					

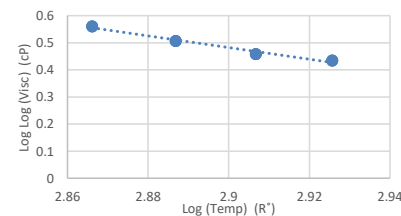


Table 137-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
8375	2 RPM	135	2.8661	0.5936	2 RPM	30%	5.795	-1.818	0.935
8250	2 RPM	135	2.8661	0.5929					
8250	2 RPM	135	2.8661	0.5929					
3125	2 RPM	155	2.8869	0.5434					
3125	2 RPM	155	2.8869	0.5434					
3000	2 RPM	155	2.8869	0.5412					
1375	2 RPM	175	2.9067	0.4967					
1375	2 RPM	175	2.9067	0.4967					
1375	2 RPM	175	2.9067	0.4967					
1125	2 RPM	195	2.9257	0.4845					
1250	2 RPM	195	2.9257	0.4909					
1250	2 RPM	195	2.9257	0.4909					

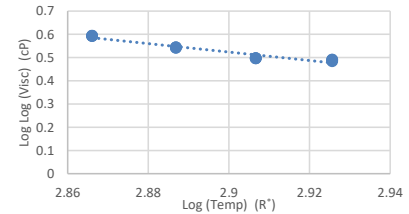


Table 138-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
7350	5 RPM	135	2.8661	0.5873	5 RPM	30%	5.835	-1.834	0.937
7300	5 RPM	135	2.8661	0.5870					
7400	5 RPM	135	2.8661	0.5876					
2750	5 RPM	155	2.8869	0.5365					
2800	5 RPM	155	2.8869	0.5375					
2750	5 RPM	155	2.8869	0.5365					
1250	5 RPM	175	2.9067	0.4909					
1200	5 RPM	175	2.9067	0.4884					
1250	5 RPM	175	2.9067	0.4909					
1050	5 RPM	195	2.9257	0.4802					
1100	5 RPM	195	2.9257	0.4831					
1100	5 RPM	195	2.9257	0.4831					

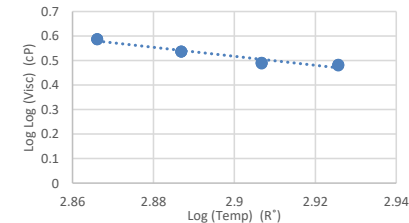


Table 139-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
6700	10 RPM	135	2.8661	0.5828	10 RPM	30%	5.831	-1.834	0.949
6700	10 RPM	135	2.8661	0.5828					
6650	10 RPM	135	2.8661	0.5824					
2550	10 RPM	155	2.8869	0.5323					
2525	10 RPM	155	2.8869	0.5318					
2575	10 RPM	155	2.8869	0.5329					
1200	10 RPM	175	2.9067	0.4884					
1200	10 RPM	175	2.9067	0.4884					
1175	10 RPM	175	2.9067	0.4871					
1000	10 RPM	195	2.9257	0.4771					
1000	10 RPM	195	2.9257	0.4771					
975	10 RPM	195	2.9257	0.4755					

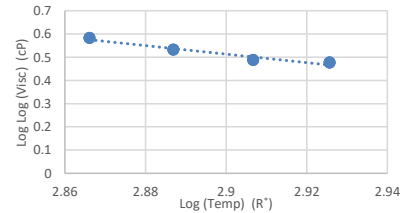


Table 140-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
6113	20 RPM	135	2.8661	0.5782	20 RPM	30%	5.983	-1.888	0.962
6150	20 RPM	135	2.8661	0.5785					
6138	20 RPM	135	2.8661	0.5784					
2350	20 RPM	155	2.8869	0.5278					
2375	20 RPM	155	2.8869	0.5284					
2375	20 RPM	155	2.8869	0.5284					
1100	20 RPM	175	2.9067	0.4831					
1125	20 RPM	175	2.9067	0.4845					
1125	20 RPM	175	2.9067	0.4845					
887.5	20 RPM	195	2.9257	0.4696					
875	20 RPM	195	2.9257	0.4686					
862.5	20 RPM	195	2.9257	0.4677					

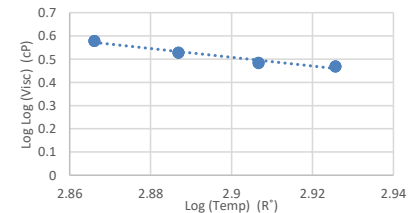


Table 141-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
8500	2 RPM	135	2.8661	0.5943	2 RPM	30%	5.260	-1.632	0.904
8250	2 RPM	135	2.8661	0.5929					
8250	2 RPM	135	2.8661	0.5929					
3250	2 RPM	155	2.8869	0.5455					
3125	2 RPM	155	2.8869	0.5434					
3125	2 RPM	155	2.8869	0.5434					
1500	2 RPM	175	2.9067	0.5019					
1500	2 RPM	175	2.9067	0.5019					
1500	2 RPM	175	2.9067	0.5019					
1375	2 RPM	195	2.9257	0.4967					
1500	2 RPM	195	2.9257	0.5019					
1500	2 RPM	195	2.9257	0.5019					

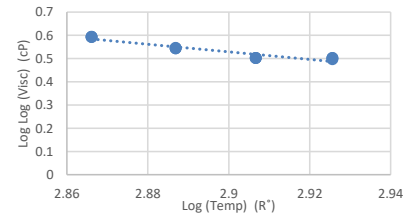


Table 142-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
7500	5 RPM	135	2.8661	0.5883	5 RPM	30%	5.563	-1.738	0.933
7550	5 RPM	135	2.8661	0.5886					
7500	5 RPM	135	2.8661	0.5883					
2900	5 RPM	155	2.8869	0.5394					
2900	5 RPM	155	2.8869	0.5394					
2850	5 RPM	155	2.8869	0.5384					
1350	5 RPM	175	2.9067	0.4956					
1350	5 RPM	175	2.9067	0.4956					
1350	5 RPM	175	2.9067	0.4956					
1200	5 RPM	195	2.9257	0.4884					
1200	5 RPM	195	2.9257	0.4884					
1200	5 RPM	195	2.9257	0.4884					

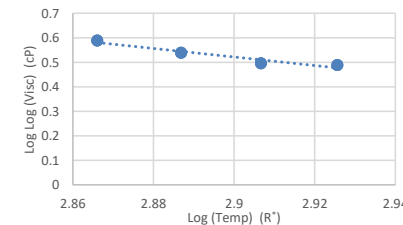


Table 143-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
6875	10 RPM	135	2.8661	0.5840	10 RPM	30%	5.601	-1.753	0.943
6850	10 RPM	135	2.8661	0.5838					
6850	10 RPM	135	2.8661	0.5838					
2675	10 RPM	155	2.8869	0.5350					
2650	10 RPM	155	2.8869	0.5344					
2650	10 RPM	155	2.8869	0.5344					
1275	10 RPM	175	2.9067	0.4921					
1275	10 RPM	175	2.9067	0.4921					
1275	10 RPM	175	2.9067	0.4921					
1100	10 RPM	195	2.9257	0.4831					
1100	10 RPM	195	2.9257	0.4831					
1075	10 RPM	195	2.9257	0.4816					

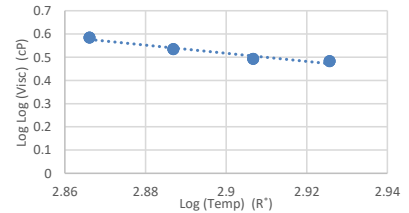


Table 144-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
6350	20 RPM	135	2.8661	0.5801	20 RPM	30%	5.831	-1.834	0.964
6325	20 RPM	135	2.8661	0.5799					
6250	20 RPM	135	2.8661	0.5793					
2463	20 RPM	155	2.8869	0.5304					
2450	20 RPM	155	2.8869	0.5301					
2475	20 RPM	155	2.8869	0.5307					
1200	20 RPM	175	2.9067	0.4884					
1213	20 RPM	175	2.9067	0.4891					
1200	20 RPM	175	2.9067	0.4884					
950	20 RPM	195	2.9257	0.4739					
937.5	20 RPM	195	2.9257	0.4730					
912.5	20 RPM	195	2.9257	0.4713					

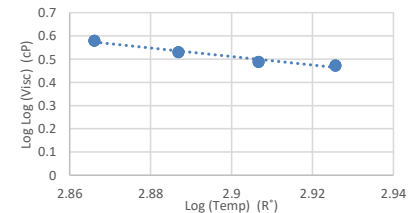


Table 145-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
12880	2 RPM	135	2.8661	0.6138	2 RPM	35%	6.514	-2.059	0.999
12880	2 RPM	135	2.8661	0.6138					
12750	2 RPM	135	2.8661	0.6134					
5000	2 RPM	155	2.8869	0.5681					
5000	2 RPM	155	2.8869	0.5681					
4875	2 RPM	155	2.8869	0.5668					
2250	2 RPM	175	2.9067	0.5253					
2375	2 RPM	175	2.9067	0.5284					
2375	2 RPM	175	2.9067	0.5284					
1250	2 RPM	195	2.9257	0.4909					
1250	2 RPM	195	2.9257	0.4909					
1250	2 RPM	195	2.9257	0.4909					

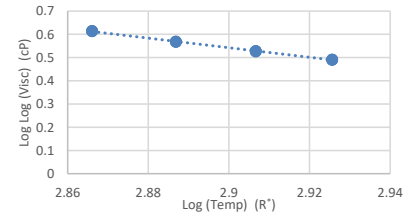


Table 146-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
11150	5 RPM	135	2.8661	0.6072	5 RPM	35%	6.580	-2.085	0.998
11100	5 RPM	135	2.8661	0.6070					
11150	5 RPM	135	2.8661	0.6072					
4300	5 RPM	155	2.8869	0.5603					
4250	5 RPM	155	2.8869	0.5597					
4300	5 RPM	155	2.8869	0.5603					
2000	5 RPM	175	2.9067	0.5186					
2000	5 RPM	175	2.9067	0.5186					
2000	5 RPM	175	2.9067	0.5186					
1100	5 RPM	195	2.9257	0.4831					
1100	5 RPM	195	2.9257	0.4831					
1100	5 RPM	195	2.9257	0.4831					

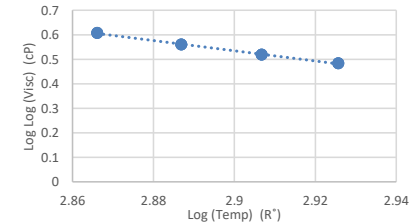


Table 147-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
10030	10 RPM	135	2.8661	0.6022	10 RPM	35%	6.601	-2.094	0.999
10000	10 RPM	135	2.8661	0.6021					
9950	10 RPM	135	2.8661	0.6018					
3875	10 RPM	155	2.8869	0.5549					
3900	10 RPM	155	2.8869	0.5552					
3825	10 RPM	155	2.8869	0.5542					
1850	10 RPM	175	2.9067	0.5142					
1850	10 RPM	175	2.9067	0.5142					
1850	10 RPM	175	2.9067	0.5142					
1000	10 RPM	195	2.9257	0.4771					
1000	10 RPM	195	2.9257	0.4771					
1000	10 RPM	195	2.9257	0.4771					

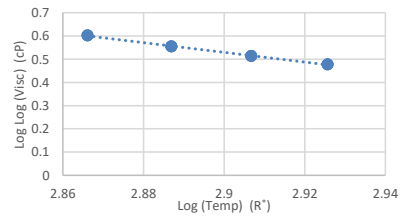


Table 148-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
9075	20 RPM	135	2.8661	0.5975	20 RPM	35%	6.633	-2.107	0.999
9000	20 RPM	135	2.8661	0.5971					
8950	20 RPM	135	2.8661	0.5968					
3563	20 RPM	155	2.8869	0.5505					
3500	20 RPM	155	2.8869	0.5495					
3563	20 RPM	155	2.8869	0.5505					
1688	20 RPM	175	2.9067	0.5088					
1700	20 RPM	175	2.9067	0.5093					
1663	20 RPM	175	2.9067	0.5080					
925	20 RPM	195	2.9257	0.4722					
912.5	20 RPM	195	2.9257	0.4713					
912.5	20 RPM	195	2.9257	0.4713					

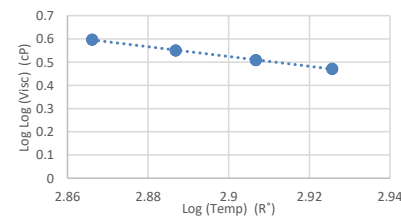


Table 149-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
12000	2 RPM	135	2.8661	0.6106	2 RPM	35%	6.389	-2.016	0.998
12130	2 RPM	135	2.8661	0.6111					
12000	2 RPM	135	2.8661	0.6106					
4750	2 RPM	155	2.8869	0.5655					
4750	2 RPM	155	2.8869	0.5655					
4875	2 RPM	155	2.8869	0.5668					
2250	2 RPM	175	2.9067	0.5253					
2250	2 RPM	175	2.9067	0.5253					
2250	2 RPM	175	2.9067	0.5253					
1250	2 RPM	195	2.9257	0.4909					
1250	2 RPM	195	2.9257	0.4909					
1250	2 RPM	195	2.9257	0.4909					

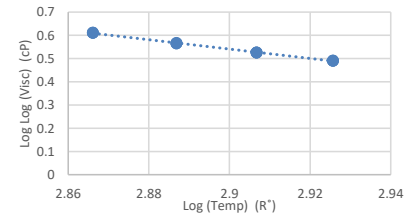


Table 150-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
10400	5 RPM	135	2.8661	0.6039	5 RPM	35%	6.518	-2.064	0.998
10400	5 RPM	135	2.8661	0.6039					
10500	5 RPM	135	2.8661	0.6044					
4100	5 RPM	155	2.8869	0.5578					
4050	5 RPM	155	2.8869	0.5572					
4050	5 RPM	155	2.8869	0.5572					
1900	5 RPM	175	2.9067	0.5157					
1950	5 RPM	175	2.9067	0.5172					
1950	5 RPM	175	2.9067	0.5172					
1050	5 RPM	195	2.9257	0.4802					
1100	5 RPM	195	2.9257	0.4831					
1050	5 RPM	195	2.9257	0.4802					

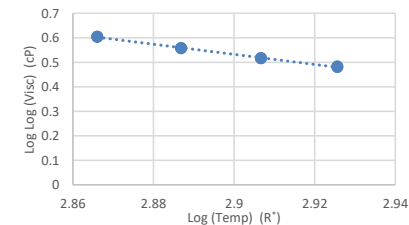


Table 151-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
9525	10 RPM	135	2.8661	0.5998	10 RPM	35%	6.533	-2.071	0.998
9375	10 RPM	135	2.8661	0.5990					
9400	10 RPM	135	2.8661	0.5991					
3675	10 RPM	155	2.8869	0.5521					
3675	10 RPM	155	2.8869	0.5521					
3700	10 RPM	155	2.8869	0.5524					
1775	10 RPM	175	2.9067	0.5118					
1750	10 RPM	175	2.9067	0.5110					
1750	10 RPM	175	2.9067	0.5110					
950	10 RPM	195	2.9257	0.4739					
1000	10 RPM	195	2.9257	0.4771					
1000	10 RPM	195	2.9257	0.4771					

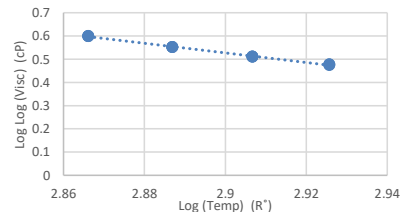


Table 152-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
8625	20 RPM	135	2.8661	0.5950	20 RPM	35%	6.649	-2.113	0.999
8625	20 RPM	135	2.8661	0.5950					
8525	20 RPM	135	2.8661	0.5945					
3375	20 RPM	155	2.8869	0.5476					
3388	20 RPM	155	2.8869	0.5478					
3375	20 RPM	155	2.8869	0.5476					
1625	20 RPM	175	2.9067	0.5066					
1600	20 RPM	175	2.9067	0.5057					
1613	20 RPM	175	2.9067	0.5062					
875	20 RPM	195	2.9257	0.4686					
875	20 RPM	195	2.9257	0.4686					
887.5	20 RPM	195	2.9257	0.4696					

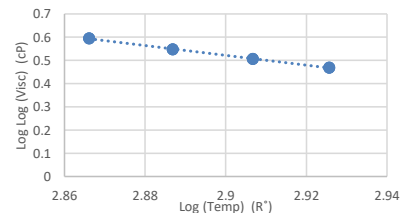


Table 153-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
16130	2 RPM	135	2.8661	0.6240	2 RPM	40%	5.410	-1.672	0.980
16250	2 RPM	135	2.8661	0.6244					
16130	2 RPM	135	2.8661	0.6240					
6250	2 RPM	155	2.8869	0.5793					
6375	2 RPM	155	2.8869	0.5803					
6375	2 RPM	155	2.8869	0.5803					
3250	2 RPM	175	2.9067	0.5455					
3250	2 RPM	175	2.9067	0.5455					
3250	2 RPM	175	2.9067	0.5455					
2250	2 RPM	195	2.9257	0.5253					
2250	2 RPM	195	2.9257	0.5253					
2250	2 RPM	195	2.9257	0.5253					

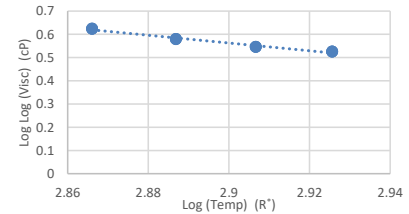


Table 154-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
13850	5 RPM	135	2.8661	0.6172	5 RPM	40%	5.661	-1.761	0.988
13750	5 RPM	135	2.8661	0.6168					
13750	5 RPM	135	2.8661	0.6168					
5350	5 RPM	155	2.8869	0.5715					
5550	5 RPM	155	2.8869	0.5734					
5500	5 RPM	155	2.8869	0.5729					
2750	5 RPM	175	2.9067	0.5365					
2750	5 RPM	175	2.9067	0.5365					
2800	5 RPM	175	2.9067	0.5375					
1850	5 RPM	195	2.9257	0.5142					
1800	5 RPM	195	2.9257	0.5126					
1750	5 RPM	195	2.9257	0.5110					

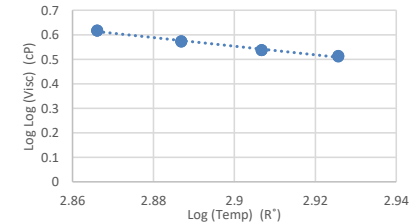


Table 155-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
12330	10 RPM	135	2.8661	0.6118	10 RPM	40%	5.809	-1.815	0.991
12380	10 RPM	135	2.8661	0.6120					
12300	10 RPM	135	2.8661	0.6117					
4975	10 RPM	155	2.8869	0.5678					
4925	10 RPM	155	2.8869	0.5673					
4975	10 RPM	155	2.8869	0.5678					
2475	10 RPM	175	2.9067	0.5307					
2500	10 RPM	175	2.9067	0.5312					
2400	10 RPM	175	2.9067	0.5289					
1600	10 RPM	195	2.9257	0.5057					
1550	10 RPM	195	2.9257	0.5038					
1550	10 RPM	195	2.9257	0.5038					

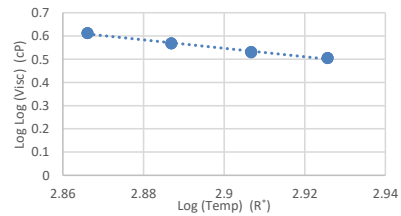


Table 156-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
11110	20 RPM	135	2.8661	0.6070	20 RPM	40%	6.017	-1.888	0.995
11090	20 RPM	135	2.8661	0.6069					
11060	20 RPM	135	2.8661	0.6068					
4488	20 RPM	155	2.8869	0.5625					
4488	20 RPM	155	2.8869	0.5625					
4513	20 RPM	155	2.8869	0.5628					
2225	20 RPM	175	2.9067	0.5247					
2188	20 RPM	175	2.9067	0.5238					
2225	20 RPM	175	2.9067	0.5247					
1350	20 RPM	195	2.9257	0.4956					
1338	20 RPM	195	2.9257	0.4951					
1313	20 RPM	195	2.9257	0.4939					

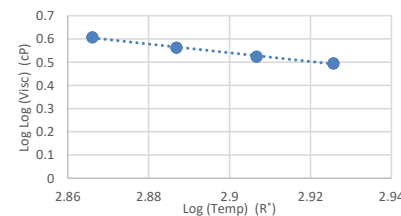


Table 157-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
16750	2 RPM	135	2.8661	0.6257	2 RPM	40%	5.319	-1.640	0.979
16630	2 RPM	135	2.8661	0.6254					
16630	2 RPM	135	2.8661	0.6254					
6500	2 RPM	155	2.8869	0.5813					
6500	2 RPM	155	2.8869	0.5813					
6500	2 RPM	155	2.8869	0.5813					
3375	2 RPM	175	2.9067	0.5476					
3500	2 RPM	175	2.9067	0.5495					
3375	2 RPM	175	2.9067	0.5476					
2375	2 RPM	195	2.9257	0.5284					
2375	2 RPM	195	2.9257	0.5284					
2375	2 RPM	195	2.9257	0.5284					

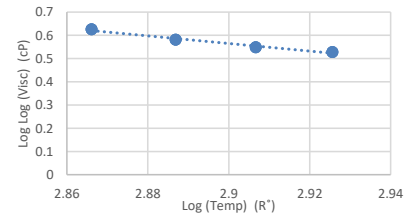


Table 158-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
14100	5 RPM	135	2.8661	0.6180	5 RPM	40%	5.535	-1.717	0.985
14150	5 RPM	135	2.8661	0.6181					
14100	5 RPM	135	2.8661	0.6180					
5500	5 RPM	155	2.8869	0.5729					
5650	5 RPM	155	2.8869	0.5743					
5600	5 RPM	155	2.8869	0.5738					
2950	5 RPM	175	2.9067	0.5403					
2850	5 RPM	175	2.9067	0.5384					
2850	5 RPM	175	2.9067	0.5384					
1900	5 RPM	195	2.9257	0.5157					
1900	5 RPM	195	2.9257	0.5157					
1950	5 RPM	195	2.9257	0.5172					

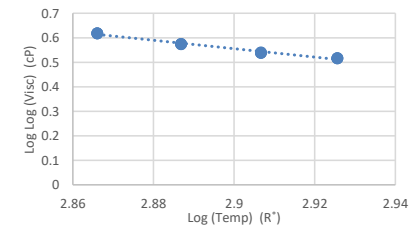


Table 159-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
12580	10 RPM	135	2.8661	0.6128	10 RPM	40%	5.765	-1.799	0.992
12550	10 RPM	135	2.8661	0.6126					
12650	10 RPM	135	2.8661	0.6130					
5075	10 RPM	155	2.8869	0.5688					
5025	10 RPM	155	2.8869	0.5683					
5050	10 RPM	155	2.8869	0.5686					
2575	10 RPM	175	2.9067	0.5329					
2575	10 RPM	175	2.9067	0.5329					
2525	10 RPM	175	2.9067	0.5318					
1600	10 RPM	195	2.9257	0.5057					
1600	10 RPM	195	2.9257	0.5057					
1625	10 RPM	195	2.9257	0.5066					

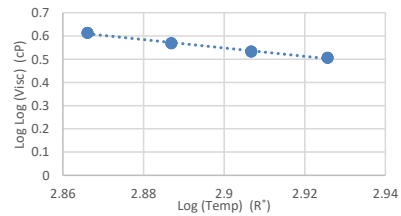


Table 160-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
11230	20 RPM	135	2.8661	0.6075	20 RPM	40%	5.931	-1.858	0.994
11280	20 RPM	135	2.8661	0.6077					
11190	20 RPM	135	2.8661	0.6073					
4600	20 RPM	155	2.8869	0.5638					
4525	20 RPM	155	2.8869	0.5630					
4513	20 RPM	155	2.8869	0.5628					
2250	20 RPM	175	2.9067	0.5253					
2275	20 RPM	175	2.9067	0.5259					
2263	20 RPM	175	2.9067	0.5257					
1400	20 RPM	195	2.9257	0.4978					
1388	20 RPM	195	2.9257	0.4973					
1375	20 RPM	195	2.9257	0.4967					

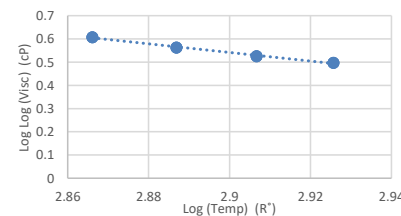


Table 161-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
27630	2 RPM	135	2.8661	0.6475	2 RPM	45%	5.025	-1.529	0.973
27630	2 RPM	135	2.8661	0.6475					
27500	2 RPM	135	2.8661	0.6473					
11000	2 RPM	155	2.8869	0.6065					
10880	2 RPM	155	2.8869	0.6060					
11250	2 RPM	155	2.8869	0.6076					
5625	2 RPM	175	2.9067	0.5740					
5500	2 RPM	175	2.9067	0.5729					
5625	2 RPM	175	2.9067	0.5740					
4000	2 RPM	195	2.9257	0.5566					
4125	2 RPM	195	2.9257	0.5582					
4125	2 RPM	195	2.9257	0.5582					

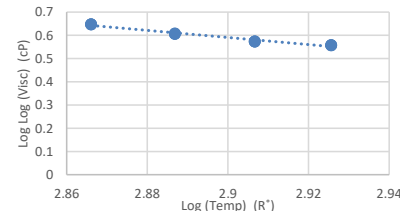


Table 162-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
22900	5 RPM	135	2.8661	0.6395	5 RPM	45%	5.141	-1.572	0.975
23050	5 RPM	135	2.8661	0.6398					
23000	5 RPM	135	2.8661	0.6397					
9200	5 RPM	155	2.8869	0.5981					
9100	5 RPM	155	2.8869	0.5976					
9200	5 RPM	155	2.8869	0.5981					
4600	5 RPM	175	2.9067	0.5638					
4650	5 RPM	175	2.9067	0.5644					
4650	5 RPM	175	2.9067	0.5644					
3300	5 RPM	195	2.9257	0.5464					
3350	5 RPM	195	2.9257	0.5472					
3400	5 RPM	195	2.9257	0.5480					

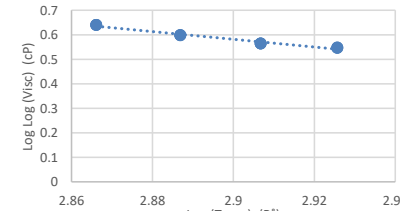


Table 163-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
19930	10 RPM	135	2.8661	0.6334	10 RPM	45%	5.314	-1.635	0.983
20050	10 RPM	135	2.8661	0.6337					
20130	10 RPM	135	2.8661	0.6339					
8025	10 RPM	155	2.8869	0.5916					
8050	10 RPM	155	2.8869	0.5917					
8025	10 RPM	155	2.8869	0.5916					
4125	10 RPM	175	2.9067	0.5582					
4075	10 RPM	175	2.9067	0.5575					
4025	10 RPM	175	2.9067	0.5569					
2775	10 RPM	195	2.9257	0.5370					
2825	10 RPM	195	2.9257	0.5379					
2750	10 RPM	195	2.9257	0.5365					

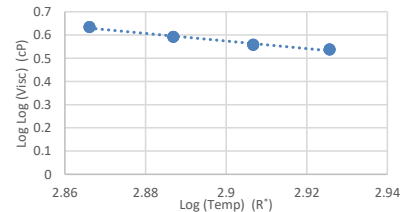


Table 164-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	45%	4.993	-1.527	0.994
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
7175	20 RPM	155	2.8869	0.5861					
7113	20 RPM	155	2.8869	0.5857					
7113	20 RPM	155	2.8869	0.5857					
3625	20 RPM	175	2.9067	0.5514					
3663	20 RPM	175	2.9067	0.5519					
3638	20 RPM	175	2.9067	0.5516					
2325	20 RPM	195	2.9257	0.5272					
2325	20 RPM	195	2.9257	0.5272					
2263	20 RPM	195	2.9257	0.5257					

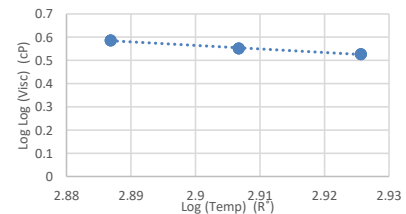


Table 165-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
27000	2 RPM	135	2.8661	0.6465	2 RPM	45%	5.013	-1.525	0.969
27130	2 RPM	135	2.8661	0.6467					
27130	2 RPM	135	2.8661	0.6467					
10880	2 RPM	155	2.8869	0.6060					
10630	2 RPM	155	2.8869	0.6049					
10500	2 RPM	155	2.8869	0.6044					
5375	2 RPM	175	2.9067	0.5718					
5375	2 RPM	175	2.9067	0.5718					
5500	2 RPM	175	2.9067	0.5729					
4000	2 RPM	195	2.9257	0.5566					
4125	2 RPM	195	2.9257	0.5582					
4000	2 RPM	195	2.9257	0.5566					

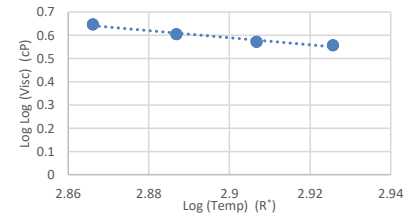


Table 166-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
22300	5 RPM	135	2.8661	0.6383	5 RPM	45%	5.192	-1.590	0.978
22550	5 RPM	135	2.8661	0.6388					
22600	5 RPM	135	2.8661	0.6389					
8800	5 RPM	155	2.8869	0.5960					
8900	5 RPM	155	2.8869	0.5965					
8850	5 RPM	155	2.8869	0.5963					
4500	5 RPM	175	2.9067	0.5627					
4600	5 RPM	175	2.9067	0.5638					
4600	5 RPM	175	2.9067	0.5638					
3150	5 RPM	195	2.9257	0.5439					
3200	5 RPM	195	2.9257	0.5447					
3250	5 RPM	195	2.9257	0.5455					

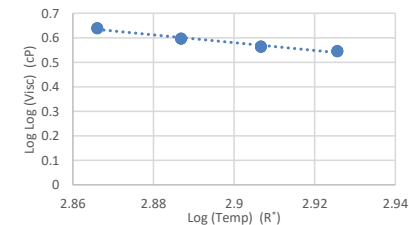


Table 167-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
19600	10 RPM	135	2.8661	0.6327	10 RPM	45%	5.293	-1.628	0.983
19580	10 RPM	135	2.8661	0.6326					
19630	10 RPM	135	2.8661	0.6328					
7925	10 RPM	155	2.8869	0.5910	10 RPM	45%	5.293	-1.628	0.983
7875	10 RPM	155	2.8869	0.5906					
7925	10 RPM	155	2.8869	0.5910					
4100	10 RPM	175	2.9067	0.5578	10 RPM	45%	5.293	-1.628	0.983
3925	10 RPM	175	2.9067	0.5556					
4025	10 RPM	175	2.9067	0.5569					
2800	10 RPM	195	2.9257	0.5375	10 RPM	45%	5.293	-1.628	0.983
2725	10 RPM	195	2.9257	0.5360					
2750	10 RPM	195	2.9257	0.5365					

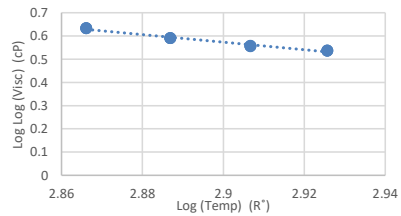


Table 168-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	45%	4.991	-1.527	0.992
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
6950	20 RPM	155	2.8869	0.5846	20 RPM	45%	4.991	-1.527	0.992
7013	20 RPM	155	2.8869	0.5850					
6988	20 RPM	155	2.8869	0.5848					
3538	20 RPM	175	2.9067	0.5501	20 RPM	45%	4.991	-1.527	0.992
3550	20 RPM	175	2.9067	0.5503					
3563	20 RPM	175	2.9067	0.5505					
2325	20 RPM	195	2.9257	0.5272	20 RPM	45%	4.991	-1.527	0.992
2263	20 RPM	195	2.9257	0.5257					
2200	20 RPM	195	2.9257	0.5241					

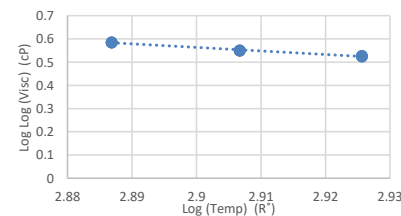


Table 169-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
39880	2 RPM	135	2.8661	0.6628	2 RPM	50%	4.098	-1.201	0.915
39250	2 RPM	135	2.8661	0.6622					
40000	2 RPM	135	2.8661	0.6630					
17250	2 RPM	155	2.8869	0.6270					
16380	2 RPM	155	2.8869	0.6247					
16130	2 RPM	155	2.8869	0.6240					
9125	2 RPM	175	2.9067	0.5977					
8750	2 RPM	175	2.9067	0.5957					
9000	2 RPM	175	2.9067	0.5971					
8250	2 RPM	195	2.9257	0.5929					
8375	2 RPM	195	2.9257	0.5936					
8250	2 RPM	195	2.9257	0.5929					

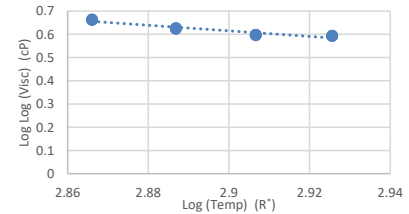


Table 170-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
32450	5 RPM	135	2.8661	0.6543	5 RPM	50%	4.714	-1.418	0.976
32100	5 RPM	135	2.8661	0.6538					
32900	5 RPM	135	2.8661	0.6549					
13050	5 RPM	155	2.8869	0.6144					
13600	5 RPM	155	2.8869	0.6163					
14100	5 RPM	155	2.8869	0.6180					
7400	5 RPM	175	2.9067	0.5876					
7050	5 RPM	175	2.9067	0.5853					
7450	5 RPM	175	2.9067	0.5880					
5350	5 RPM	195	2.9257	0.5715					
5100	5 RPM	195	2.9257	0.5691					
5300	5 RPM	195	2.9257	0.5710					

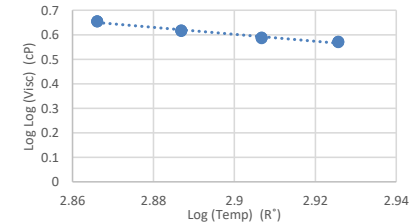


Table 171-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
#N/A	10 RPM	135	#N/A	#N/A	10 RPM	50%	4.333	-1.290	0.995
#N/A	10 RPM	135	#N/A	#N/A					
#N/A	10 RPM	135	#N/A	#N/A					
11830	10 RPM	155	2.8869	0.6099					
11880	10 RPM	155	2.8869	0.6101					
11700	10 RPM	155	2.8869	0.6094					
6500	10 RPM	175	2.9067	0.5813					
6550	10 RPM	175	2.9067	0.5816					
6425	10 RPM	175	2.9067	0.5807					
4250	10 RPM	195	2.9257	0.5597					
4200	10 RPM	195	2.9257	0.5591					
4325	10 RPM	195	2.9257	0.5606					

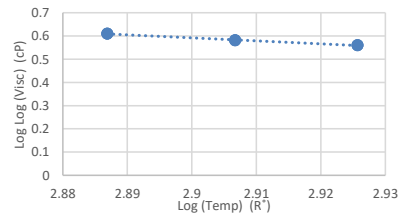


Table 172-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	50%	4.547	-1.366	0.989
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
10360	20 RPM	155	2.8869	0.6037					
10550	20 RPM	155	2.8869	0.6046					
10430	20 RPM	155	2.8869	0.6040					
5463	20 RPM	175	2.9067	0.5726					
5400	20 RPM	175	2.9067	0.5720					
5425	20 RPM	175	2.9067	0.5722					
3663	20 RPM	195	2.9257	0.5519					
3638	20 RPM	195	2.9257	0.5516					
3538	20 RPM	195	2.9257	0.5501					

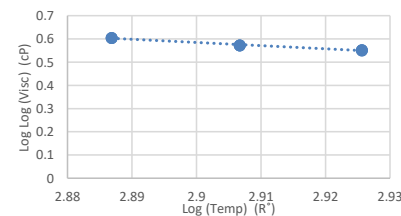


Table 173-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 2 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
40500	2 RPM	135	2.8661	0.6635	2 RPM	50%	4.167	-1.224	0.967
41130	2 RPM	135	2.8661	0.6641					
40250	2 RPM	135	2.8661	0.6632					
17500	2 RPM	155	2.8869	0.6277					
17880	2 RPM	155	2.8869	0.6286					
17250	2 RPM	155	2.8869	0.6270					
10630	2 RPM	175	2.9067	0.6049					
10500	2 RPM	175	2.9067	0.6044					
10500	2 RPM	175	2.9067	0.6044					
7625	2 RPM	195	2.9257	0.5891					
8125	2 RPM	195	2.9257	0.5922					
7875	2 RPM	195	2.9257	0.5906					

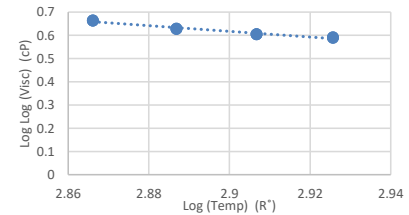


Table 174-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 5 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
32500	5 RPM	135	2.8661	0.6544	5 RPM	50%	4.588	-1.374	0.980
33400	5 RPM	135	2.8661	0.6555					
33600	5 RPM	135	2.8661	0.6557					
14400	5 RPM	155	2.8869	0.6189					
14400	5 RPM	155	2.8869	0.6189					
14050	5 RPM	155	2.8869	0.6178					
8000	5 RPM	175	2.9067	0.5914					
7850	5 RPM	175	2.9067	0.5905					
7850	5 RPM	175	2.9067	0.5905					
5500	5 RPM	195	2.9257	0.5729					
5550	5 RPM	195	2.9257	0.5734					
5750	5 RPM	195	2.9257	0.5751					

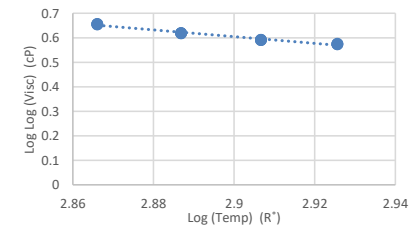


Table 175-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 10 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
#N/A	10 RPM	135	#N/A	#N/A	10 RPM	50%	4.564	-1.369	0.999
#N/A	10 RPM	135	#N/A	#N/A					
#N/A	10 RPM	135	#N/A	#N/A					
12150	10 RPM	155	2.8869	0.6111					
12250	10 RPM	155	2.8869	0.6115					
12380	10 RPM	155	2.8869	0.6120					
6650	10 RPM	175	2.9067	0.5824					
6825	10 RPM	175	2.9067	0.5837					
6875	10 RPM	175	2.9067	0.5840					
4075	10 RPM	195	2.9257	0.5575					
4200	10 RPM	195	2.9257	0.5591					
4175	10 RPM	195	2.9257	0.5588					

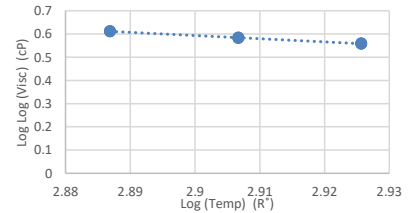


Table 176-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder B (PG 70-22) at 20 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder B (PG 70-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	50%	4.746	-1.435	0.998
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
10350	20 RPM	155	2.8869	0.6037					
10610	20 RPM	155	2.8869	0.6048					
10640	20 RPM	155	2.8869	0.6050					
5625	20 RPM	175	2.9067	0.5740					
5763	20 RPM	175	2.9067	0.5753					
5638	20 RPM	175	2.9067	0.5742					
3500	20 RPM	195	2.9257	0.5495					
3463	20 RPM	195	2.9257	0.5489					
3413	20 RPM	195	2.9257	0.5482					

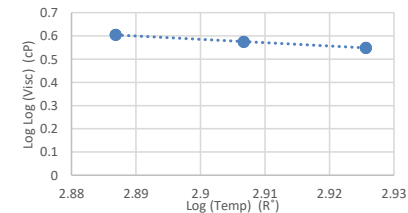


Table 177-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1125	2 RPM	135	2.8661	0.4845	2 RPM	0%	8.276	-2.718	0.998
1125	2 RPM	135	2.8661	0.4845					
1125	2 RPM	135	2.8661	0.4845					
500	2 RPM	155	2.8869	0.4312					
500	2 RPM	155	2.8869	0.4312					
500	2 RPM	155	2.8869	0.4312					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					

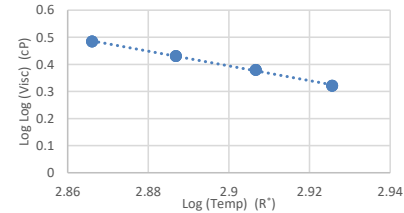


Table 178-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1150	5 RPM	135	2.8661	0.4858	5 RPM	0%	9.380	-3.103	1.000
1150	5 RPM	135	2.8661	0.4858					
1150	5 RPM	135	2.8661	0.4858					
450	5 RPM	155	2.8869	0.4238					
450	5 RPM	155	2.8869	0.4238					
450	5 RPM	155	2.8869	0.4238					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
200	5 RPM	175	2.9067	0.3619					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					
100	5 RPM	195	2.9257	0.3010					

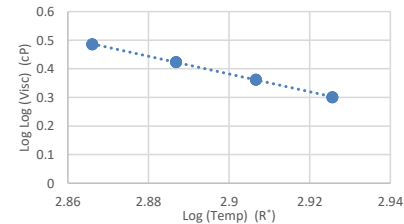


Table 179-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1150	10 RPM	135	2.8661	0.4858	10 RPM	0%	8.500	-2.797	0.994
1150	10 RPM	135	2.8661	0.4858					
1150	10 RPM	135	2.8661	0.4858					
450	10 RPM	155	2.8869	0.4238					
450	10 RPM	155	2.8869	0.4238					
450	10 RPM	155	2.8869	0.4238					
200	10 RPM	175	2.9067	0.3619					
200	10 RPM	175	2.9067	0.3619					
200	10 RPM	175	2.9067	0.3619					
125	10 RPM	195	2.9257	0.3216					
125	10 RPM	195	2.9257	0.3216					
125	10 RPM	195	2.9257	0.3216					

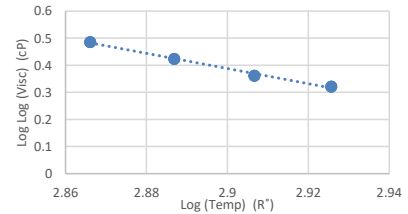


Table 180-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1138	20 RPM	135	2.8661	0.4852	20 RPM	0%	8.808	-2.904	1.000
1138	20 RPM	135	2.8661	0.4852					
1138	20 RPM	135	2.8661	0.4852					
450	20 RPM	155	2.8869	0.4238					
450	20 RPM	155	2.8869	0.4238					
450	20 RPM	155	2.8869	0.4238					
212.5	20 RPM	175	2.9067	0.3669					
212.5	20 RPM	175	2.9067	0.3669					
212.5	20 RPM	175	2.9067	0.3669					
112.5	20 RPM	195	2.9257	0.3120					
112.5	20 RPM	195	2.9257	0.3120					
112.5	20 RPM	195	2.9257	0.3120					

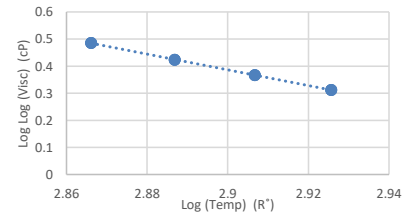


Table 181-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
1250	2 RPM	135	2.8661	0.4909		2 RPM	0%	8.565	-2.817	0.999
1250	2 RPM	135	2.8661	0.4909						
1250	2 RPM	135	2.8661	0.4909						
500	2 RPM	155	2.8869	0.4312						
500	2 RPM	155	2.8869	0.4312						
500	2 RPM	155	2.8869	0.4312						
250	2 RPM	175	2.9067	0.3798						
250	2 RPM	175	2.9067	0.3798						
250	2 RPM	175	2.9067	0.3798						
125	2 RPM	195	2.9257	0.3216						
125	2 RPM	195	2.9257	0.3216						
125	2 RPM	195	2.9257	0.3216						

Table 182-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
1150	5 RPM	135	2.8661	0.4858		5 RPM	0%	7.810	-2.558	0.974
1150	5 RPM	135	2.8661	0.4858						
1150	5 RPM	135	2.8661	0.4858						
450	5 RPM	155	2.8869	0.4238						
450	5 RPM	155	2.8869	0.4238						
450	5 RPM	155	2.8869	0.4238						
200	5 RPM	175	2.9067	0.3619						
200	5 RPM	175	2.9067	0.3619						
200	5 RPM	175	2.9067	0.3619						
150	5 RPM	195	2.9257	0.3377						
150	5 RPM	195	2.9257	0.3377						
150	5 RPM	195	2.9257	0.3377						

Table 183-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1150	10 RPM	135	2.8661	0.4858	10 RPM	0%	8.357	-2.747	0.999
1150	10 RPM	135	2.8661	0.4858					
1150	10 RPM	135	2.8661	0.4858					
450	10 RPM	155	2.8869	0.4238					
450	10 RPM	155	2.8869	0.4238					
450	10 RPM	155	2.8869	0.4238					
225	10 RPM	175	2.9067	0.3715					
225	10 RPM	175	2.9067	0.3715					
225	10 RPM	175	2.9067	0.3715					
125	10 RPM	195	2.9257	0.3216					
125	10 RPM	195	2.9257	0.3216					
125	10 RPM	195	2.9257	0.3216					

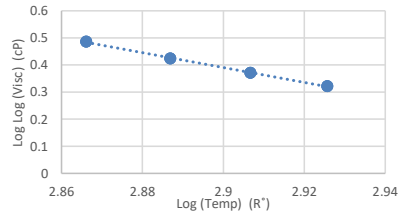


Table 184-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 0% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1163	20 RPM	135	2.8661	0.4865	20 RPM	0%	8.867	-2.924	1.000
1163	20 RPM	135	2.8661	0.4865					
1163	20 RPM	135	2.8661	0.4865					
450	20 RPM	155	2.8869	0.4238					
450	20 RPM	155	2.8869	0.4238					
450	20 RPM	155	2.8869	0.4238					
212.5	20 RPM	175	2.9067	0.3669					
212.5	20 RPM	175	2.9067	0.3669					
212.5	20 RPM	175	2.9067	0.3669					
112.5	20 RPM	195	2.9257	0.3120					
112.5	20 RPM	195	2.9257	0.3120					
112.5	20 RPM	195	2.9257	0.3120					

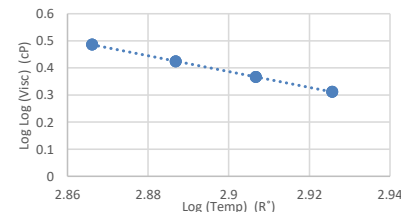


Table 185-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1625	2 RPM	135	2.8661	0.5066	2 RPM	5%	6.987	-2.264	0.906
1625	2 RPM	135	2.8661	0.5066					
1625	2 RPM	135	2.8661	0.5066					
625	2 RPM	155	2.8869	0.4465					
625	2 RPM	155	2.8869	0.4465					
625	2 RPM	155	2.8869	0.4465					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	195	2.9257	0.3798					
250	2 RPM	195	2.9257	0.3798					
250	2 RPM	195	2.9257	0.3798					

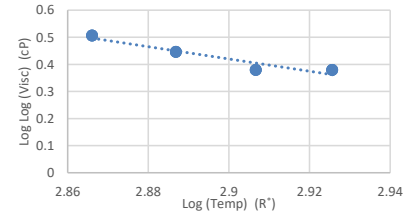


Table 186-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1550	5 RPM	135	2.8661	0.5038	5 RPM	5%	8.573	-2.817	0.994
1550	5 RPM	135	2.8661	0.5038					
1600	5 RPM	135	2.8661	0.5057					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
250	5 RPM	175	2.9067	0.3798					
250	5 RPM	175	2.9067	0.3798					
250	5 RPM	175	2.9067	0.3798					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					

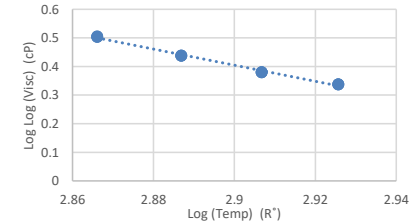


Table 187-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1575	10 RPM	135	2.8661	0.5048	10 RPM	5%	8.861	-2.916	0.994
1575	10 RPM	135	2.8661	0.5048					
1575	10 RPM	135	2.8661	0.5048					
575	10 RPM	155	2.8869	0.4409					
575	10 RPM	155	2.8869	0.4409					
575	10 RPM	155	2.8869	0.4409					
250	10 RPM	175	2.9067	0.3798					
250	10 RPM	175	2.9067	0.3798					
250	10 RPM	175	2.9067	0.3798					
150	10 RPM	195	2.9257	0.3377					
150	10 RPM	195	2.9257	0.3377					
125	10 RPM	195	2.9257	0.3216					

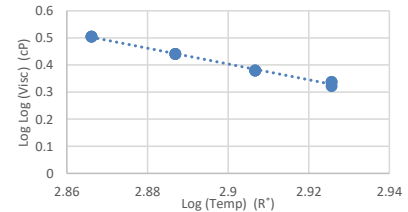


Table 188-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1563	20 RPM	135	2.8661	0.5043	20 RPM	5%	8.908	-2.933	0.998
1563	20 RPM	135	2.8661	0.5043					
1563	20 RPM	135	2.8661	0.5043					
562.5	20 RPM	155	2.8869	0.4394					
550	20 RPM	155	2.8869	0.4378					
562.5	20 RPM	155	2.8869	0.4394					
250	20 RPM	175	2.9067	0.3798					
250	20 RPM	175	2.9067	0.3798					
250	20 RPM	175	2.9067	0.3798					
137.5	20 RPM	195	2.9257	0.3301					
137.5	20 RPM	195	2.9257	0.3301					
137.5	20 RPM	195	2.9257	0.3301					

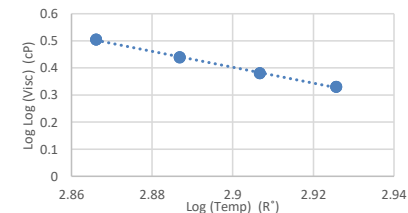


Table 189-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1625	2 RPM	135	2.8661	0.5066	2 RPM	5%	9.654	-3.189	0.990
1625	2 RPM	135	2.8661	0.5066					
1625	2 RPM	135	2.8661	0.5066					
750	2 RPM	155	2.8869	0.4586					
750	2 RPM	155	2.8869	0.4586					
750	2 RPM	155	2.8869	0.4586					
250	2 RPM	175	2.9067	0.3798	2 RPM	5%	9.654	-3.189	0.990
250	2 RPM	175	2.9067	0.3798					
250	2 RPM	175	2.9067	0.3798					
125	2 RPM	195	2.9257	0.3216	2 RPM	5%	9.654	-3.189	0.990
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					

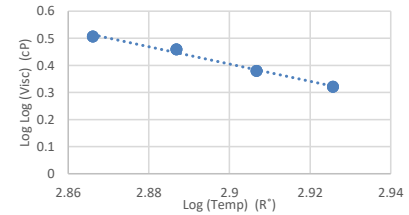


Table 190-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1500	5 RPM	135	2.8661	0.5019	5 RPM	5%	8.459	-2.777	0.995
1500	5 RPM	135	2.8661	0.5019					
1500	5 RPM	135	2.8661	0.5019					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
550	5 RPM	155	2.8869	0.4378					
250	5 RPM	175	2.9067	0.3798	5 RPM	5%	8.459	-2.777	0.995
250	5 RPM	175	2.9067	0.3798					
250	5 RPM	175	2.9067	0.3798					
150	5 RPM	195	2.9257	0.3377	5 RPM	5%	8.459	-2.777	0.995
150	5 RPM	195	2.9257	0.3377					
150	5 RPM	195	2.9257	0.3377					

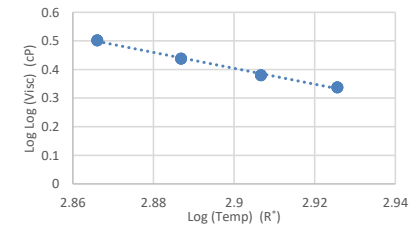


Table 191-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1525	10 RPM	135	2.8661	0.5029	10 RPM	5%	9.192	-3.032	1.000
1525	10 RPM	135	2.8661	0.5029					
1525	10 RPM	135	2.8661	0.5029					
550	10 RPM	155	2.8869	0.4378					
550	10 RPM	155	2.8869	0.4378					
550	10 RPM	155	2.8869	0.4378					
250	10 RPM	175	2.9067	0.3798					
250	10 RPM	175	2.9067	0.3798					
250	10 RPM	175	2.9067	0.3798					
125	10 RPM	195	2.9257	0.3216					
125	10 RPM	195	2.9257	0.3216					
125	10 RPM	195	2.9257	0.3216					

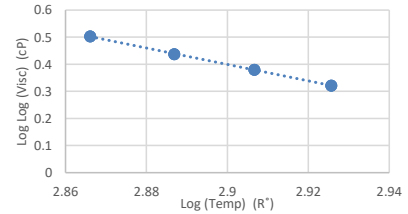


Table 192-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 5% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
1513	20 RPM	135	2.8661	0.5024	20 RPM	5%	9.169	-3.024	0.999
1513	20 RPM	135	2.8661	0.5024					
1513	20 RPM	135	2.8661	0.5024					
537.5	20 RPM	155	2.8869	0.4362					
537.5	20 RPM	155	2.8869	0.4362					
537.5	20 RPM	155	2.8869	0.4362					
237.5	20 RPM	175	2.9067	0.3758					
250	20 RPM	175	2.9067	0.3798					
250	20 RPM	175	2.9067	0.3798					
125	20 RPM	195	2.9257	0.3216					
125	20 RPM	195	2.9257	0.3216					
125	20 RPM	195	2.9257	0.3216					

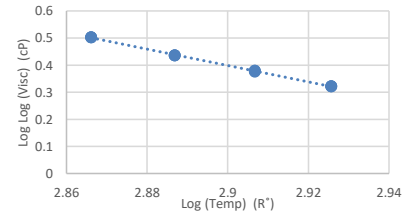


Table 193-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
2875	2 RPM	135	2.8661	0.5389	2 RPM	10%	11.001	-3.647	0.984
2875	2 RPM	135	2.8661	0.5389					
2875	2 RPM	135	2.8661	0.5389					
1125	2 RPM	155	2.8869	0.4845					
1125	2 RPM	155	2.8869	0.4845					
1125	2 RPM	155	2.8869	0.4845					
375	2 RPM	175	2.9067	0.4106					
375	2 RPM	175	2.9067	0.4106					
375	2 RPM	175	2.9067	0.4106					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					
125	2 RPM	195	2.9257	0.3216					

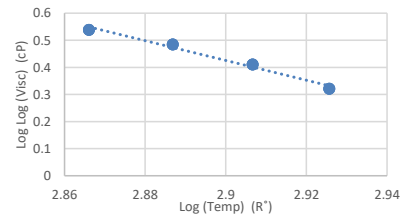


Table 194-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
2700	5 RPM	135	2.8661	0.5355	5 RPM	10%	8.945	-2.936	0.994
2700	5 RPM	135	2.8661	0.5355					
2700	5 RPM	135	2.8661	0.5355					
850	5 RPM	155	2.8869	0.4668					
850	5 RPM	155	2.8869	0.4668					
850	5 RPM	155	2.8869	0.4668					
350	5 RPM	175	2.9067	0.4055					
350	5 RPM	175	2.9067	0.4055					
350	5 RPM	175	2.9067	0.4055					
200	5 RPM	195	2.9257	0.3619					
200	5 RPM	195	2.9257	0.3619					
200	5 RPM	195	2.9257	0.3619					

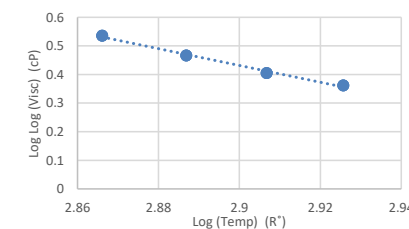


Table 195-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
2600	10 RPM	135	2.8661	0.5334	10 RPM	10%	8.983	-2.949	0.995
2600	10 RPM	135	2.8661	0.5334					
2600	10 RPM	135	2.8661	0.5334					
825	10 RPM	155	2.8869	0.4649					
825	10 RPM	155	2.8869	0.4649					
825	10 RPM	155	2.8869	0.4649					
350	10 RPM	175	2.9067	0.4055					
350	10 RPM	175	2.9067	0.4055					
350	10 RPM	175	2.9067	0.4055					
175	10 RPM	195	2.9257	0.3508					
200	10 RPM	195	2.9257	0.3619					
200	10 RPM	195	2.9257	0.3619					

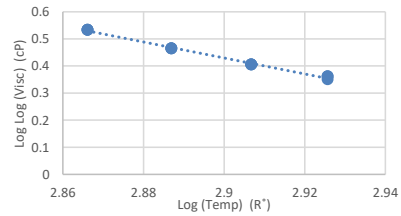


Table 196-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
2525	20 RPM	135	2.8661	0.5318	20 RPM	10%	8.966	-2.944	0.997
2525	20 RPM	135	2.8661	0.5318					
2525	20 RPM	135	2.8661	0.5318					
812.5	20 RPM	155	2.8869	0.4639					
812.5	20 RPM	155	2.8869	0.4639					
812.5	20 RPM	155	2.8869	0.4639					
350	20 RPM	175	2.9067	0.4055					
350	20 RPM	175	2.9067	0.4055					
350	20 RPM	175	2.9067	0.4055					
187.5	20 RPM	195	2.9257	0.3566					
187.5	20 RPM	195	2.9257	0.3566					
187.5	20 RPM	195	2.9257	0.3566					

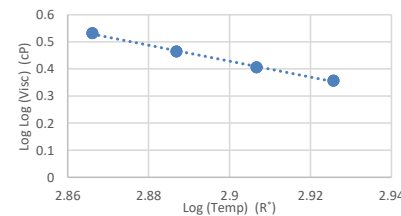


Table 197-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
2625	2 RPM	135	2.8661	0.5339		2 RPM	10%	8.058	-2.627	0.983
2625	2 RPM	135	2.8661	0.5339						
2625	2 RPM	135	2.8661	0.5339						
875	2 RPM	155	2.8869	0.4686						
875	2 RPM	155	2.8869	0.4686						
875	2 RPM	155	2.8869	0.4686						
375	2 RPM	175	2.9067	0.4106						
375	2 RPM	175	2.9067	0.4106						
375	2 RPM	175	2.9067	0.4106						
250	2 RPM	195	2.9257	0.3798						
250	2 RPM	195	2.9257	0.3798						
250	2 RPM	195	2.9257	0.3798						

Table 198-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
2550	5 RPM	135	2.8661	0.5323		5 RPM	10%	8.751	-2.869	0.994
2550	5 RPM	135	2.8661	0.5323						
2500	5 RPM	135	2.8661	0.5312						
850	5 RPM	155	2.8869	0.4668						
800	5 RPM	155	2.8869	0.4629						
800	5 RPM	155	2.8869	0.4629						
350	5 RPM	175	2.9067	0.4055						
350	5 RPM	175	2.9067	0.4055						
350	5 RPM	175	2.9067	0.4055						
200	5 RPM	195	2.9257	0.3619						
200	5 RPM	195	2.9257	0.3619						
200	5 RPM	195	2.9257	0.3619						

Table 199-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
2475	10 RPM	135	2.8661	0.5307	10 RPM	10%	9.158	-3.011	0.999
2500	10 RPM	135	2.8661	0.5312					
2475	10 RPM	135	2.8661	0.5307					
800	10 RPM	155	2.8869	0.4629					
800	10 RPM	155	2.8869	0.4629					
800	10 RPM	155	2.8869	0.4629					
350	10 RPM	175	2.9067	0.4055					
350	10 RPM	175	2.9067	0.4055					
350	10 RPM	175	2.9067	0.4055					
175	10 RPM	195	2.9257	0.3508					
175	10 RPM	195	2.9257	0.3508					
175	10 RPM	195	2.9257	0.3508					

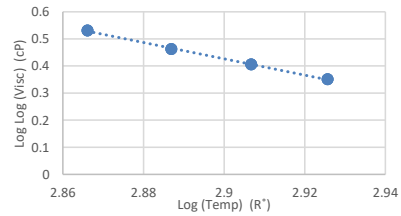


Table 200-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 10% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
2425	20 RPM	135	2.8661	0.5295	20 RPM	10%	8.847	-2.903	0.997
2425	20 RPM	135	2.8661	0.5295					
2413	20 RPM	135	2.8661	0.5292					
787.5	20 RPM	155	2.8869	0.4618					
787.5	20 RPM	155	2.8869	0.4618					
787.5	20 RPM	155	2.8869	0.4618					
337.5	20 RPM	175	2.9067	0.4028					
350	20 RPM	175	2.9067	0.4055					
350	20 RPM	175	2.9067	0.4055					
187.5	20 RPM	195	2.9257	0.3566					
187.5	20 RPM	195	2.9257	0.3566					
187.5	20 RPM	195	2.9257	0.3566					

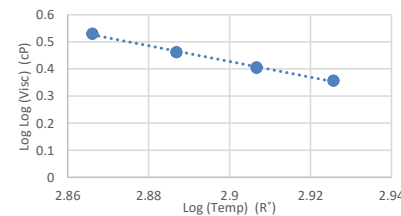


Table 201-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3500	2 RPM	135	2.8661	0.5495	2 RPM	15%	7.214	-2.327	0.992
3500	2 RPM	135	2.8661	0.5495					
3500	2 RPM	135	2.8661	0.5495					
1250	2 RPM	155	2.8869	0.4909					
1250	2 RPM	155	2.8869	0.4909					
1250	2 RPM	155	2.8869	0.4909					
625	2 RPM	175	2.9067	0.4465					
625	2 RPM	175	2.9067	0.4465					
625	2 RPM	175	2.9067	0.4465					
375	2 RPM	195	2.9257	0.4106					
375	2 RPM	195	2.9257	0.4106					
375	2 RPM	195	2.9257	0.4106					

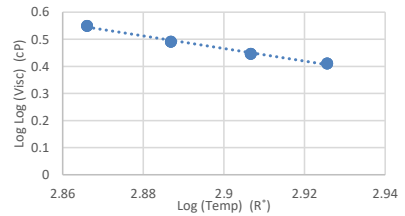


Table 202-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3300	5 RPM	135	2.8661	0.5464	5 RPM	15%	7.601	-2.464	0.982
3250	5 RPM	135	2.8661	0.5455					
3300	5 RPM	135	2.8661	0.5464					
1150	5 RPM	155	2.8869	0.4858					
1150	5 RPM	155	2.8869	0.4858					
1150	5 RPM	155	2.8869	0.4858					
500	5 RPM	175	2.9067	0.4312					
500	5 RPM	175	2.9067	0.4312					
500	5 RPM	175	2.9067	0.4312					
300	5 RPM	195	2.9257	0.3939					
350	5 RPM	195	2.9257	0.4055					
350	5 RPM	195	2.9257	0.4055					

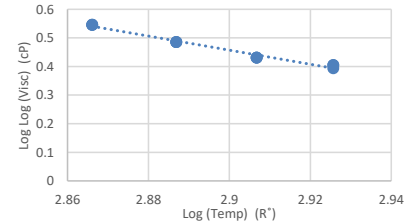


Table 203-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3200	10 RPM	135	2.8661	0.5447	10 RPM	15%	7.573	-2.454	0.986
3175	10 RPM	135	2.8661	0.5443					
3175	10 RPM	135	2.8661	0.5443					
1125	10 RPM	155	2.8869	0.4845					
1125	10 RPM	155	2.8869	0.4845					
1100	10 RPM	155	2.8869	0.4831					
500	10 RPM	175	2.9067	0.4312					
500	10 RPM	175	2.9067	0.4312					
500	10 RPM	175	2.9067	0.4312					
325	10 RPM	195	2.9257	0.4000					
325	10 RPM	195	2.9257	0.4000					
325	10 RPM	195	2.9257	0.4000					

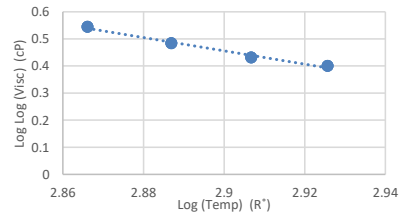


Table 204-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3100	20 RPM	135	2.8661	0.5430	20 RPM	15%	7.613	-2.468	0.990
3100	20 RPM	135	2.8661	0.5430					
3100	20 RPM	135	2.8661	0.5430					
1075	20 RPM	155	2.8869	0.4816					
1088	20 RPM	155	2.8869	0.4824					
1100	20 RPM	155	2.8869	0.4831					
500	20 RPM	175	2.9067	0.4312					
500	20 RPM	175	2.9067	0.4312					
500	20 RPM	175	2.9067	0.4312					
312.5	20 RPM	195	2.9257	0.3970					
312.5	20 RPM	195	2.9257	0.3970					
312.5	20 RPM	195	2.9257	0.3970					

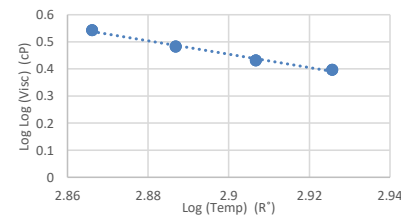


Table 205-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3250	2 RPM	135	2.8661	0.5455	2 RPM	15%	8.493	-2.773	1.000
3250	2 RPM	135	2.8661	0.5455					
3250	2 RPM	135	2.8661	0.5455					
1125	2 RPM	155	2.8869	0.4845					
1125	2 RPM	155	2.8869	0.4845					
1125	2 RPM	155	2.8869	0.4845					
500	2 RPM	175	2.9067	0.4312	2 RPM	15%	8.493	-2.773	1.000
500	2 RPM	175	2.9067	0.4312					
500	2 RPM	175	2.9067	0.4312					
250	2 RPM	195	2.9257	0.3798					
250	2 RPM	195	2.9257	0.3798					
250	2 RPM	195	2.9257	0.3798					

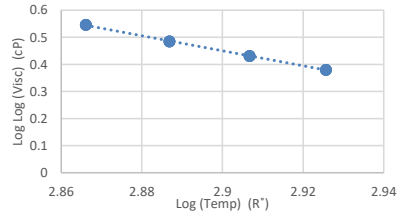


Table 206-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3200	5 RPM	135	2.8661	0.5447	5 RPM	15%	8.449	-2.758	0.999
3200	5 RPM	135	2.8661	0.5447					
3200	5 RPM	135	2.8661	0.5447					
1100	5 RPM	155	2.8869	0.4831					
1100	5 RPM	155	2.8869	0.4831					
1150	5 RPM	155	2.8869	0.4858					
500	5 RPM	175	2.9067	0.4312	5 RPM	15%	8.449	-2.758	0.999
500	5 RPM	175	2.9067	0.4312					
500	5 RPM	175	2.9067	0.4312					
250	5 RPM	195	2.9257	0.3798					
250	5 RPM	195	2.9257	0.3798					
250	5 RPM	195	2.9257	0.3798					

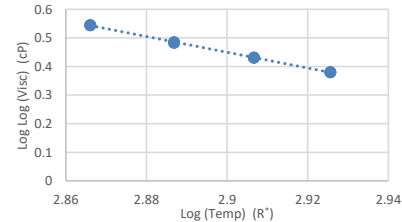


Table 207-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3175	10 RPM	135	2.8661	0.5443	10 RPM	15%	8.160	-2.658	0.996
3150	10 RPM	135	2.8661	0.5439					
3150	10 RPM	135	2.8661	0.5439					
1125	10 RPM	155	2.8869	0.4845					
1125	10 RPM	155	2.8869	0.4845					
1125	10 RPM	155	2.8869	0.4845					
475	10 RPM	175	2.9067	0.4276					
475	10 RPM	175	2.9067	0.4276					
475	10 RPM	175	2.9067	0.4276					
275	10 RPM	195	2.9257	0.3873					
275	10 RPM	195	2.9257	0.3873					
275	10 RPM	195	2.9257	0.3873					

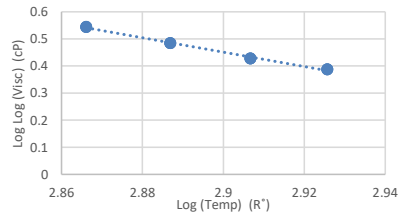


Table 208-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 15% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
3113	20 RPM	135	2.8661	0.5432	20 RPM	15%	7.973	-2.594	0.995
3100	20 RPM	135	2.8661	0.5430					
3100	20 RPM	135	2.8661	0.5430					
1100	20 RPM	155	2.8869	0.4831					
1100	20 RPM	155	2.8869	0.4831					
1100	20 RPM	155	2.8869	0.4831					
487.5	20 RPM	175	2.9067	0.4294					
487.5	20 RPM	175	2.9067	0.4294					
487.5	20 RPM	175	2.9067	0.4294					
275	20 RPM	195	2.9257	0.3873					
287.5	20 RPM	195	2.9257	0.3907					
287.5	20 RPM	195	2.9257	0.3907					

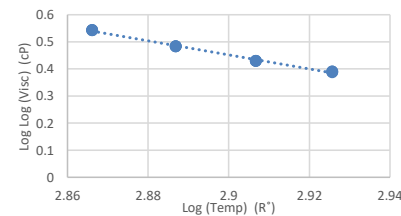


Table 209-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
4750	2 RPM	135	2.8661	0.5655		2 RPM	20%	6.449	-2.056	0.951
4625	2 RPM	135	2.8661	0.5641						
4625	2 RPM	135	2.8661	0.5641						
1750	2 RPM	155	2.8869	0.5110						
1750	2 RPM	155	2.8869	0.5110						
1750	2 RPM	155	2.8869	0.5110						
750	2 RPM	175	2.9067	0.4586						
750	2 RPM	175	2.9067	0.4586						
750	2 RPM	175	2.9067	0.4586						
625	2 RPM	195	2.9257	0.4465						
625	2 RPM	195	2.9257	0.4465						
625	2 RPM	195	2.9257	0.4465						

Table 210-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
4400	5 RPM	135	2.8661	0.5615		5 RPM	20%	6.896	-2.212	0.984
4400	5 RPM	135	2.8661	0.5615						
4400	5 RPM	135	2.8661	0.5615						
1600	5 RPM	155	2.8869	0.5057						
1600	5 RPM	155	2.8869	0.5057						
1600	5 RPM	155	2.8869	0.5057						
750	5 RPM	175	2.9067	0.4586						
750	5 RPM	175	2.9067	0.4586						
750	5 RPM	175	2.9067	0.4586						
500	5 RPM	195	2.9257	0.4312						
500	5 RPM	195	2.9257	0.4312						
500	5 RPM	195	2.9257	0.4312						

Table 211-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
4300	10 RPM	135	2.8661	0.5603	10 RPM	20%	6.999	-2.248	0.986
4275	10 RPM	135	2.8661	0.5600					
4300	10 RPM	135	2.8661	0.5603					
1550	10 RPM	155	2.8869	0.5038					
1550	10 RPM	155	2.8869	0.5038					
1550	10 RPM	155	2.8869	0.5038					
725	10 RPM	175	2.9067	0.4564					
725	10 RPM	175	2.9067	0.4564					
725	10 RPM	175	2.9067	0.4564					
475	10 RPM	195	2.9257	0.4276					
475	10 RPM	195	2.9257	0.4276					
475	10 RPM	195	2.9257	0.4276					

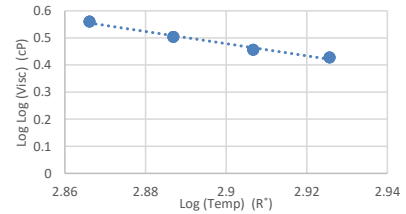


Table 212-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
4163	20 RPM	135	2.8661	0.5586	20 RPM	20%	7.080	-2.277	0.986
4163	20 RPM	135	2.8661	0.5586					
4175	20 RPM	135	2.8661	0.5588					
1513	20 RPM	155	2.8869	0.5024					
1500	20 RPM	155	2.8869	0.5019					
1488	20 RPM	155	2.8869	0.5014					
700	20 RPM	175	2.9067	0.4541					
687.5	20 RPM	175	2.9067	0.4529					
700	20 RPM	175	2.9067	0.4541					
450	20 RPM	195	2.9257	0.4238					
462.5	20 RPM	195	2.9257	0.4257					
450	20 RPM	195	2.9257	0.4238					

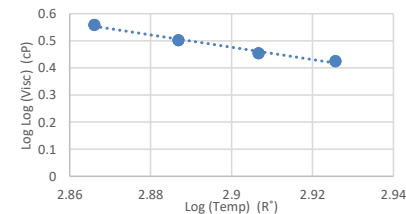


Table 213-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
4750	2 RPM	135	2.8661	0.5655		2 RPM	20%	6.490	-2.070	0.950
4750	2 RPM	135	2.8661	0.5655						
4750	2 RPM	135	2.8661	0.5655						
1750	2 RPM	155	2.8869	0.5110						
1750	2 RPM	155	2.8869	0.5110						
1750	2 RPM	155	2.8869	0.5110						
750	2 RPM	175	2.9067	0.4586						
750	2 RPM	175	2.9067	0.4586						
750	2 RPM	175	2.9067	0.4586						
625	2 RPM	195	2.9257	0.4465						
625	2 RPM	195	2.9257	0.4465						
625	2 RPM	195	2.9257	0.4465						

Table 214-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
4550	5 RPM	135	2.8661	0.5632		5 RPM	20%	6.870	-2.203	0.978
4550	5 RPM	135	2.8661	0.5632						
4500	5 RPM	135	2.8661	0.5627						
1600	5 RPM	155	2.8869	0.5057						
1600	5 RPM	155	2.8869	0.5057						
1600	5 RPM	155	2.8869	0.5057						
750	5 RPM	175	2.9067	0.4586						
750	5 RPM	175	2.9067	0.4586						
750	5 RPM	175	2.9067	0.4586						
500	5 RPM	195	2.9257	0.4312						
500	5 RPM	195	2.9257	0.4312						
550	5 RPM	195	2.9257	0.4378						

Table 215-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
4400	10 RPM	135	2.8661	0.5615	10 RPM	20%	6.836	-2.191	0.980
4375	10 RPM	135	2.8661	0.5612					
4350	10 RPM	135	2.8661	0.5609					
1575	10 RPM	155	2.8869	0.5048					
1600	10 RPM	155	2.8869	0.5057					
1575	10 RPM	155	2.8869	0.5048					
750	10 RPM	175	2.9067	0.4586					
750	10 RPM	175	2.9067	0.4586					
725	10 RPM	175	2.9067	0.4564					
500	10 RPM	195	2.9257	0.4312					
500	10 RPM	195	2.9257	0.4312					
525	10 RPM	195	2.9257	0.4346					

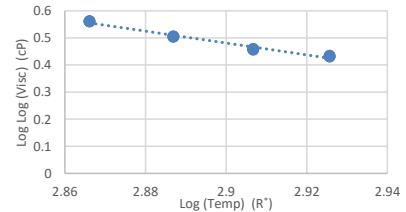


Table 216-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 20% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
4213	20 RPM	135	2.8661	0.5593	20 RPM	20%	6.841	-2.194	0.980
4213	20 RPM	135	2.8661	0.5593					
4188	20 RPM	135	2.8661	0.5589					
1513	20 RPM	155	2.8869	0.5024					
1513	20 RPM	155	2.8869	0.5024					
1525	20 RPM	155	2.8869	0.5029					
712.5	20 RPM	175	2.9067	0.4553					
725	20 RPM	175	2.9067	0.4564					
712.5	20 RPM	175	2.9067	0.4553					
487.5	20 RPM	195	2.9257	0.4294					
500	20 RPM	195	2.9257	0.4312					
487.5	20 RPM	195	2.9257	0.4294					

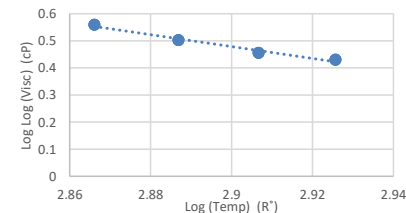


Table 217-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
7125	2 RPM	135	2.8661	0.5858	2 RPM	25%	5.854	-1.840	0.969
7125	2 RPM	135	2.8661	0.5858					
7250	2 RPM	135	2.8661	0.5866					
2625	2 RPM	155	2.8869	0.5339					
2625	2 RPM	155	2.8869	0.5339					
2625	2 RPM	155	2.8869	0.5339					
1375	2 RPM	175	2.9067	0.4967					
1375	2 RPM	175	2.9067	0.4967					
1375	2 RPM	175	2.9067	0.4967					
1000	2 RPM	195	2.9257	0.4771					
1000	2 RPM	195	2.9257	0.4771					
1000	2 RPM	195	2.9257	0.4771					

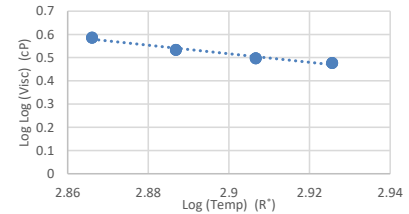


Table 218-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
6700	5 RPM	135	2.8661	0.5828	5 RPM	25%	6.210	-1.966	0.973
6650	5 RPM	135	2.8661	0.5824					
6600	5 RPM	135	2.8661	0.5820					
2450	5 RPM	155	2.8869	0.5301					
2450	5 RPM	155	2.8869	0.5301					
2400	5 RPM	155	2.8869	0.5289					
1200	5 RPM	175	2.9067	0.4884					
1200	5 RPM	175	2.9067	0.4884					
1150	5 RPM	175	2.9067	0.4858					
850	5 RPM	195	2.9257	0.4668					
850	5 RPM	195	2.9257	0.4668					
850	5 RPM	195	2.9257	0.4668					

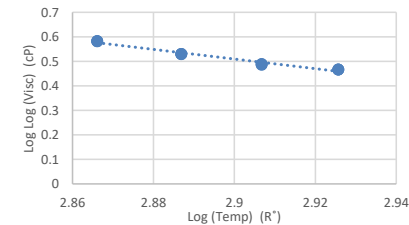


Table 219-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
6300	10 RPM	135	2.8661	0.5797	10 RPM	25%	6.253	-1.982	0.970
6300	10 RPM	135	2.8661	0.5797					
6325	10 RPM	135	2.8661	0.5799					
2325	10 RPM	155	2.8869	0.5272					
2275	10 RPM	155	2.8869	0.5259					
2275	10 RPM	155	2.8869	0.5259					
1100	10 RPM	175	2.9067	0.4831					
1100	10 RPM	175	2.9067	0.4831					
1100	10 RPM	175	2.9067	0.4831					
800	10 RPM	195	2.9257	0.4629					
800	10 RPM	195	2.9257	0.4629					
825	10 RPM	195	2.9257	0.4649					

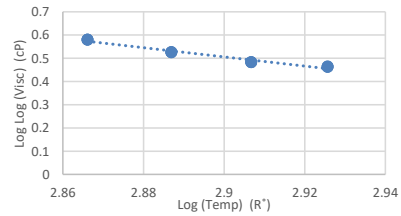


Table 220-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
5988	20 RPM	135	2.8661	0.5772	20 RPM	25%	6.378	-2.026	0.977
5975	20 RPM	135	2.8661	0.5771					
6000	20 RPM	135	2.8661	0.5773					
2188	20 RPM	155	2.8869	0.5238					
2200	20 RPM	155	2.8869	0.5241					
2188	20 RPM	155	2.8869	0.5238					
1063	20 RPM	175	2.9067	0.4809					
1063	20 RPM	175	2.9067	0.4809					
1050	20 RPM	175	2.9067	0.4802					
750	20 RPM	195	2.9257	0.4586					
750	20 RPM	195	2.9257	0.4586					
725	20 RPM	195	2.9257	0.4564					

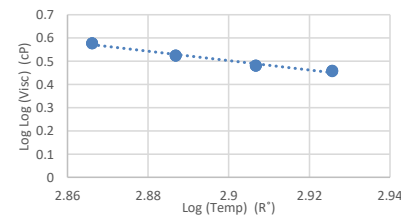


Table 221-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
7500	2 RPM	135	2.8661	0.5883	2 RPM	25%	6.027	-1.901	0.954
7375	2 RPM	135	2.8661	0.5875					
7375	2 RPM	135	2.8661	0.5875					
2750	2 RPM	155	2.8869	0.5365					
2625	2 RPM	155	2.8869	0.5339					
2625	2 RPM	155	2.8869	0.5339					
1250	2 RPM	175	2.9067	0.4909					
1250	2 RPM	175	2.9067	0.4909					
1250	2 RPM	175	2.9067	0.4909					
1000	2 RPM	195	2.9257	0.4771					
1000	2 RPM	195	2.9257	0.4771					
1000	2 RPM	195	2.9257	0.4771					

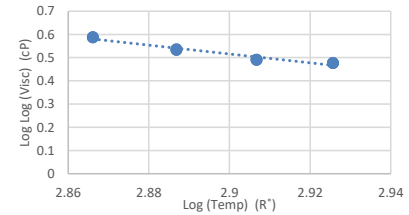


Table 222-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
6950	5 RPM	135	2.8661	0.5846	5 RPM	25%	6.328	-2.006	0.968
6900	5 RPM	135	2.8661	0.5842					
6900	5 RPM	135	2.8661	0.5842					
2400	5 RPM	155	2.8869	0.5289					
2500	5 RPM	155	2.8869	0.5312					
2450	5 RPM	155	2.8869	0.5301					
1150	5 RPM	175	2.9067	0.4858					
1150	5 RPM	175	2.9067	0.4858					
1150	5 RPM	175	2.9067	0.4858					
850	5 RPM	195	2.9257	0.4668					
850	5 RPM	195	2.9257	0.4668					
850	5 RPM	195	2.9257	0.4668					

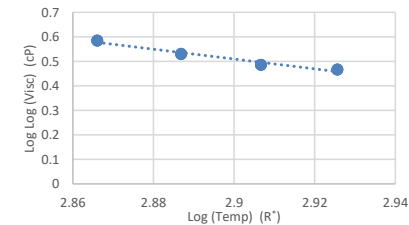


Table 223-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
6500	10 RPM	135	2.8661	0.5813	10 RPM	25%	6.272	-1.988	0.972
6500	10 RPM	135	2.8661	0.5813					
6475	10 RPM	135	2.8661	0.5811					
2350	10 RPM	155	2.8869	0.5278					
2300	10 RPM	155	2.8869	0.5266					
2325	10 RPM	155	2.8869	0.5272					
1125	10 RPM	175	2.9067	0.4845					
1150	10 RPM	175	2.9067	0.4858					
1125	10 RPM	175	2.9067	0.4845					
800	10 RPM	195	2.9257	0.4629					
825	10 RPM	195	2.9257	0.4649					
825	10 RPM	195	2.9257	0.4649					

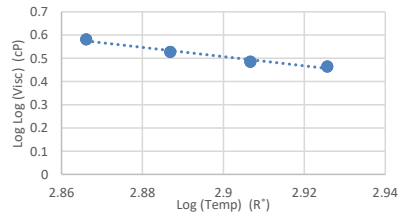


Table 224-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 25% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
6125	20 RPM	135	2.8661	0.5783	20 RPM	25%	6.418	-2.039	0.979
6150	20 RPM	135	2.8661	0.5785					
6113	20 RPM	135	2.8661	0.5782					
2238	20 RPM	155	2.8869	0.5250					
2238	20 RPM	155	2.8869	0.5250					
2250	20 RPM	155	2.8869	0.5253					
1075	20 RPM	175	2.9067	0.4816					
1075	20 RPM	175	2.9067	0.4816					
1075	20 RPM	175	2.9067	0.4816					
737.5	20 RPM	195	2.9257	0.4575					
750	20 RPM	195	2.9257	0.4586					
750	20 RPM	195	2.9257	0.4586					

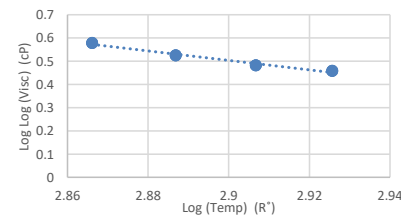


Table 225-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
13750	2 RPM	135	2.8661	0.6168	2 RPM	30%	5.554	-1.724	0.982
13880	2 RPM	135	2.8661	0.6173					
13750	2 RPM	135	2.8661	0.6168					
5375	2 RPM	155	2.8869	0.5718					
5375	2 RPM	155	2.8869	0.5718					
5375	2 RPM	155	2.8869	0.5718					
2750	2 RPM	175	2.9067	0.5365					
2750	2 RPM	175	2.9067	0.5365					
2750	2 RPM	175	2.9067	0.5365					
1875	2 RPM	195	2.9257	0.5149					
1875	2 RPM	195	2.9257	0.5149					
1875	2 RPM	195	2.9257	0.5149					

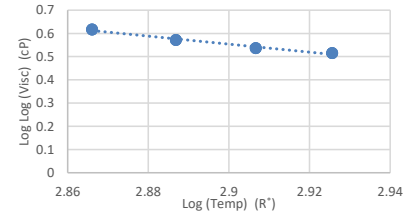


Table 226-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
12000	5 RPM	135	2.8661	0.6106	5 RPM	30%	5.798	-1.811	0.987
12050	5 RPM	135	2.8661	0.6108					
12000	5 RPM	135	2.8661	0.6106					
4650	5 RPM	155	2.8869	0.5644					
4650	5 RPM	155	2.8869	0.5644					
4600	5 RPM	155	2.8869	0.5638					
2350	5 RPM	175	2.9067	0.5278					
2350	5 RPM	175	2.9067	0.5278					
2350	5 RPM	175	2.9067	0.5278					
1550	5 RPM	195	2.9257	0.5038					
1550	5 RPM	195	2.9257	0.5038					
1500	5 RPM	195	2.9257	0.5019					

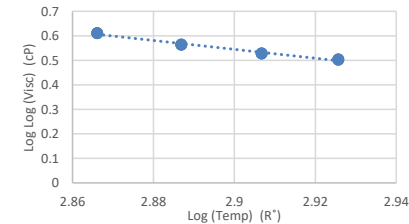


Table 227-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
11030	10 RPM	135	2.8661	0.6067	10 RPM	30%	5.928	-1.858	0.990
11000	10 RPM	135	2.8661	0.6065					
10930	10 RPM	135	2.8661	0.6062					
4225	10 RPM	155	2.8869	0.5594					
4175	10 RPM	155	2.8869	0.5588					
4150	10 RPM	155	2.8869	0.5585					
2175	10 RPM	175	2.9067	0.5234					
2200	10 RPM	175	2.9067	0.5241					
2150	10 RPM	175	2.9067	0.5228					
1350	10 RPM	195	2.9257	0.4956					
1375	10 RPM	195	2.9257	0.4967					
1325	10 RPM	195	2.9257	0.4945					

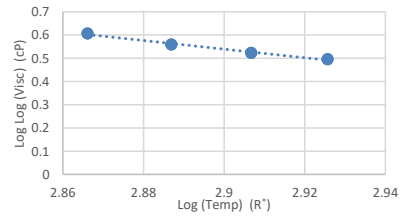


Table 228-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
10060	20 RPM	135	2.8661	0.6023	20 RPM	30%	6.082	-1.913	0.992
10000	20 RPM	135	2.8661	0.6021					
10000	20 RPM	135	2.8661	0.6021					
3850	20 RPM	155	2.8869	0.5545					
3850	20 RPM	155	2.8869	0.5545					
3813	20 RPM	155	2.8869	0.5540					
1950	20 RPM	175	2.9067	0.5172					
1925	20 RPM	175	2.9067	0.5165					
1963	20 RPM	175	2.9067	0.5176					
1225	20 RPM	195	2.9257	0.4897					
1188	20 RPM	195	2.9257	0.4878					
1175	20 RPM	195	2.9257	0.4871					

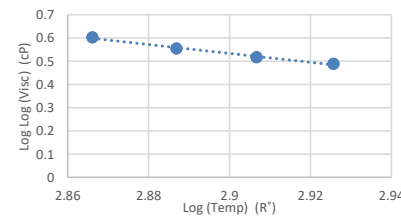


Table 229-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
14380	2 RPM	135	2.8661	0.6189		2 RPM	30%	5.443	-1.685	0.978
14380	2 RPM	135	2.8661	0.6189						
14380	2 RPM	135	2.8661	0.6189						
5500	2 RPM	155	2.8869	0.5729						
5500	2 RPM	155	2.8869	0.5729						
5375	2 RPM	155	2.8869	0.5718						
3000	2 RPM	175	2.9067	0.5412						
2875	2 RPM	175	2.9067	0.5389						
2875	2 RPM	175	2.9067	0.5389						
2000	2 RPM	195	2.9257	0.5186						
2000	2 RPM	195	2.9257	0.5186						
2000	2 RPM	195	2.9257	0.5186						

Table 230-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)					
					RPM	RAR	A	VTS	R2	
12500	5 RPM	135	2.8661	0.6125		5 RPM	30%	5.624	-1.750	0.981
12550	5 RPM	135	2.8661	0.6126						
12550	5 RPM	135	2.8661	0.6126						
4800	5 RPM	155	2.8869	0.5660						
4750	5 RPM	155	2.8869	0.5655						
4750	5 RPM	155	2.8869	0.5655						
2500	5 RPM	175	2.9067	0.5312						
2450	5 RPM	175	2.9067	0.5301						
2500	5 RPM	175	2.9067	0.5312						
1700	5 RPM	195	2.9257	0.5093						
1650	5 RPM	195	2.9257	0.5075						
1700	5 RPM	195	2.9257	0.5093						

Table 231-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
11330	10 RPM	135	2.8661	0.6079	10 RPM	30%	5.830	-1.824	0.986
11380	10 RPM	135	2.8661	0.6081					
11430	10 RPM	135	2.8661	0.6083					
4325	10 RPM	155	2.8869	0.5606					
4250	10 RPM	155	2.8869	0.5597					
4325	10 RPM	155	2.8869	0.5606					
2275	10 RPM	175	2.9067	0.5259					
2225	10 RPM	175	2.9067	0.5247					
2200	10 RPM	175	2.9067	0.5241					
1450	10 RPM	195	2.9257	0.4999					
1450	10 RPM	195	2.9257	0.4999					
1425	10 RPM	195	2.9257	0.4988					

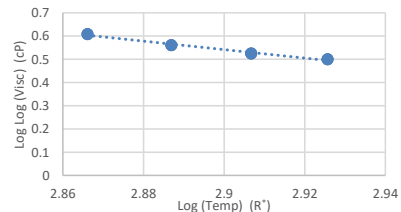


Table 232-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 30% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
10280	20 RPM	135	2.8661	0.6034	20 RPM	30%	5.996	-1.883	0.990
10260	20 RPM	135	2.8661	0.6033					
10240	20 RPM	135	2.8661	0.6032					
3913	20 RPM	155	2.8869	0.5554					
3913	20 RPM	155	2.8869	0.5554					
3888	20 RPM	155	2.8869	0.5551					
2000	20 RPM	175	2.9067	0.5186					
2013	20 RPM	175	2.9067	0.5190					
1988	20 RPM	175	2.9067	0.5183					
1275	20 RPM	195	2.9257	0.4921					
1250	20 RPM	195	2.9257	0.4909					
1238	20 RPM	195	2.9257	0.4903					

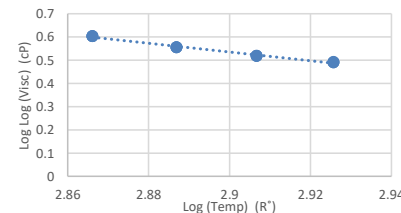


Table 233-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
17880	2 RPM	135	2.8661	0.6286	2 RPM	35%	5.587	-1.732	0.983
18000	2 RPM	135	2.8661	0.6289					
18130	2 RPM	135	2.8661	0.6292					
6500	2 RPM	155	2.8869	0.5813					
6625	2 RPM	155	2.8869	0.5822					
6500	2 RPM	155	2.8869	0.5813					
3500	2 RPM	175	2.9067	0.5495					
3500	2 RPM	175	2.9067	0.5495					
3500	2 RPM	175	2.9067	0.5495					
2250	2 RPM	195	2.9257	0.5253					
2250	2 RPM	195	2.9257	0.5253					
2250	2 RPM	195	2.9257	0.5253					

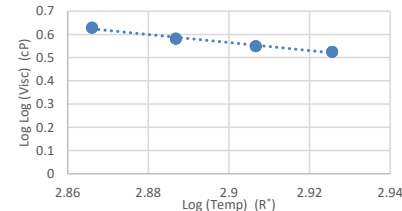


Table 234-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
15600	5 RPM	135	2.8661	0.6225	5 RPM	35%	5.795	-1.806	0.990
15650	5 RPM	135	2.8661	0.6227					
15550	5 RPM	135	2.8661	0.6224					
5750	5 RPM	155	2.8869	0.5751					
5750	5 RPM	155	2.8869	0.5751					
5750	5 RPM	155	2.8869	0.5751					
3100	5 RPM	175	2.9067	0.5430					
3050	5 RPM	175	2.9067	0.5421					
3050	5 RPM	175	2.9067	0.5421					
1850	5 RPM	195	2.9257	0.5142					
1850	5 RPM	195	2.9257	0.5142					
1850	5 RPM	195	2.9257	0.5142					

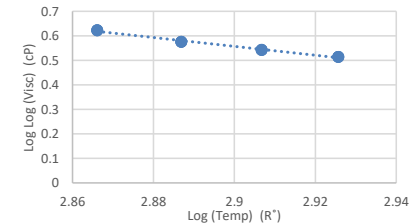


Table 235-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
14080	10 RPM	135	2.8661	0.6179	10 RPM	35%	5.876	-1.836	0.990
14050	10 RPM	135	2.8661	0.6178					
13930	10 RPM	135	2.8661	0.6174					
5200	10 RPM	155	2.8869	0.5701					
5225	10 RPM	155	2.8869	0.5703					
5175	10 RPM	155	2.8869	0.5698					
2700	10 RPM	175	2.9067	0.5355					
2725	10 RPM	175	2.9067	0.5360					
2750	10 RPM	175	2.9067	0.5365					
1650	10 RPM	195	2.9257	0.5075					
1650	10 RPM	195	2.9257	0.5075					
1675	10 RPM	195	2.9257	0.5084					

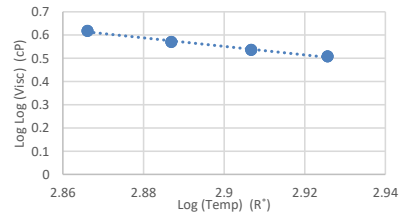


Table 236-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	35%	5.409	-1.678	0.999
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
4725	20 RPM	155	2.8869	0.5652					
4688	20 RPM	155	2.8869	0.5648					
4700	20 RPM	155	2.8869	0.5649					
2438	20 RPM	175	2.9067	0.5298					
2475	20 RPM	175	2.9067	0.5307					
2450	20 RPM	175	2.9067	0.5301					
1463	20 RPM	195	2.9257	0.5004					
1450	20 RPM	195	2.9257	0.4999					
1438	20 RPM	195	2.9257	0.4994					

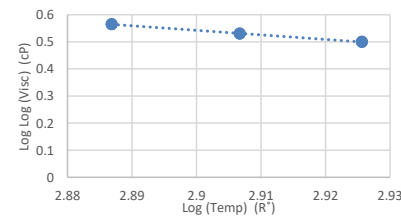


Table 237-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
18130	2 RPM	135	2.8661	0.6292	2 RPM	35%	5.596	-1.735	0.983
18130	2 RPM	135	2.8661	0.6292					
17880	2 RPM	135	2.8661	0.6286					
6625	2 RPM	155	2.8869	0.5822					
6625	2 RPM	155	2.8869	0.5822					
6500	2 RPM	155	2.8869	0.5813					
3500	2 RPM	175	2.9067	0.5495					
3500	2 RPM	175	2.9067	0.5495					
3500	2 RPM	175	2.9067	0.5495					
2250	2 RPM	195	2.9257	0.5253					
2250	2 RPM	195	2.9257	0.5253					
2250	2 RPM	195	2.9257	0.5253					

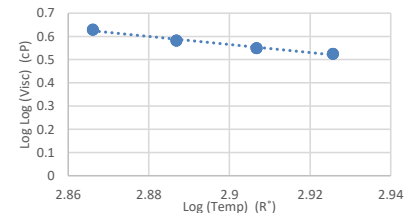


Table 238-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
15850	5 RPM	135	2.8661	0.6233	5 RPM	35%	5.805	-1.809	0.986
15900	5 RPM	135	2.8661	0.6234					
15950	5 RPM	135	2.8661	0.6235					
5800	5 RPM	155	2.8869	0.5756					
5800	5 RPM	155	2.8869	0.5756					
5700	5 RPM	155	2.8869	0.5747					
3050	5 RPM	175	2.9067	0.5421					
3000	5 RPM	175	2.9067	0.5412					
3000	5 RPM	175	2.9067	0.5412					
1900	5 RPM	195	2.9257	0.5157					
1850	5 RPM	195	2.9257	0.5142					
1900	5 RPM	195	2.9257	0.5157					

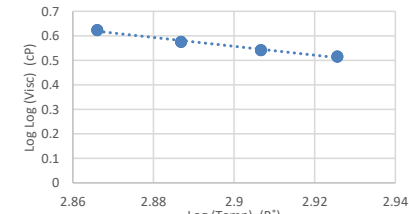


Table 239-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
14230	10 RPM	135	2.8661	0.6184	10 RPM	35%	5.875	-1.836	0.989
14150	10 RPM	135	2.8661	0.6181					
14080	10 RPM	135	2.8661	0.6179					
5200	10 RPM	155	2.8869	0.5701					
5150	10 RPM	155	2.8869	0.5696					
5225	10 RPM	155	2.8869	0.5703					
2800	10 RPM	175	2.9067	0.5375					
2750	10 RPM	175	2.9067	0.5365					
2700	10 RPM	175	2.9067	0.5355					
1700	10 RPM	195	2.9257	0.5093					
1650	10 RPM	195	2.9257	0.5075					
1650	10 RPM	195	2.9257	0.5075					

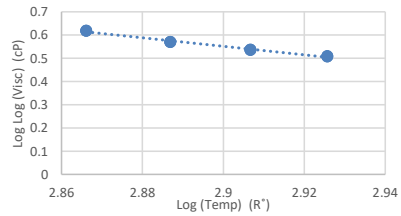


Table 240-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 35% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	35%	5.318	-1.647	0.998
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
4713	20 RPM	155	2.8869	0.5651					
4713	20 RPM	155	2.8869	0.5651					
4763	20 RPM	155	2.8869	0.5656					
2450	20 RPM	175	2.9067	0.5301					
2488	20 RPM	175	2.9067	0.5309					
2438	20 RPM	175	2.9067	0.5298					
1513	20 RPM	195	2.9257	0.5024					
1475	20 RPM	195	2.9257	0.5009					
1475	20 RPM	195	2.9257	0.5009					

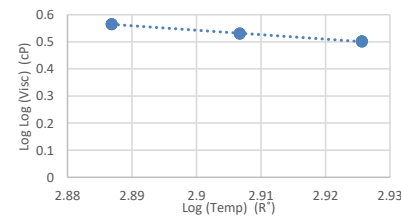


Table 241-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
24880	2 RPM	135	2.8661	0.6430	2 RPM	40%	4.966	-1.511	0.943
24380	2 RPM	135	2.8661	0.6422					
24250	2 RPM	135	2.8661	0.6419					
8750	2 RPM	155	2.8869	0.5957					
9000	2 RPM	155	2.8869	0.5971					
9000	2 RPM	155	2.8869	0.5971					
4625	2 RPM	175	2.9067	0.5641					
4625	2 RPM	175	2.9067	0.5641					
4625	2 RPM	175	2.9067	0.5641					
3750	2 RPM	195	2.9257	0.5532					
3750	2 RPM	195	2.9257	0.5532					
3875	2 RPM	195	2.9257	0.5549					

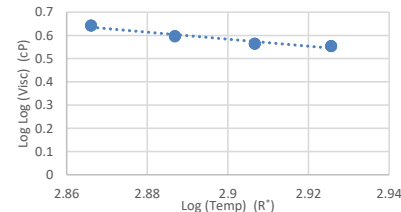


Table 242-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
21200	5 RPM	135	2.8661	0.6361	5 RPM	40%	5.244	-1.610	0.956
20850	5 RPM	135	2.8661	0.6354					
21050	5 RPM	135	2.8661	0.6358					
7700	5 RPM	155	2.8869	0.5896					
7650	5 RPM	155	2.8869	0.5892					
7550	5 RPM	155	2.8869	0.5886					
3850	5 RPM	175	2.9067	0.5545					
3850	5 RPM	175	2.9067	0.5545					
3850	5 RPM	175	2.9067	0.5545					
3050	5 RPM	195	2.9257	0.5421					
2950	5 RPM	195	2.9257	0.5403					
3000	5 RPM	195	2.9257	0.5412					

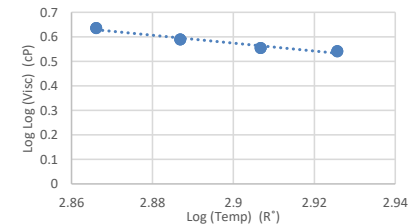


Table 243-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
18680	10 RPM	135	2.8661	0.6306	10 RPM	40%	5.457	-1.686	0.966
18600	10 RPM	135	2.8661	0.6304					
18580	10 RPM	135	2.8661	0.6303					
6800	10 RPM	155	2.8869	0.5835					
6775	10 RPM	155	2.8869	0.5833					
6750	10 RPM	155	2.8869	0.5831					
3375	10 RPM	175	2.9067	0.5476					
3325	10 RPM	175	2.9067	0.5468					
3400	10 RPM	175	2.9067	0.5480					
2525	10 RPM	195	2.9257	0.5318					
2525	10 RPM	195	2.9257	0.5318					
2450	10 RPM	195	2.9257	0.5301					

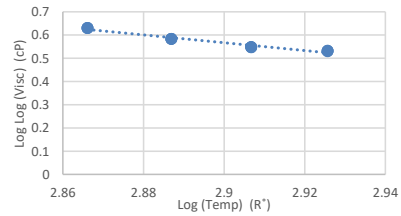


Table 244-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	40%	4.934	-1.510	0.981
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
6138	20 RPM	155	2.8869	0.5784					
6150	20 RPM	155	2.8869	0.5785					
6075	20 RPM	155	2.8869	0.5779					
2988	20 RPM	175	2.9067	0.5410					
3038	20 RPM	175	2.9067	0.5419					
3013	20 RPM	175	2.9067	0.5415					
2075	20 RPM	195	2.9257	0.5207					
2037	20 RPM	195	2.9257	0.5197					
2013	20 RPM	195	2.9257	0.5190					

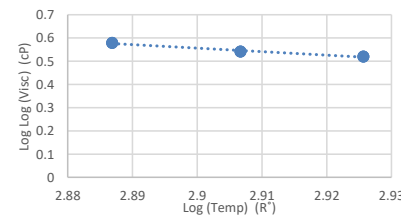


Table 245-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
24380	2 RPM	135	2.8661	0.6422	2 RPM	40%	5.058	-1.543	0.951
24750	2 RPM	135	2.8661	0.6428					
24380	2 RPM	135	2.8661	0.6422					
8875	2 RPM	155	2.8869	0.5964					
8750	2 RPM	155	2.8869	0.5957					
8750	2 RPM	155	2.8869	0.5957					
4625	2 RPM	175	2.9067	0.5641					
4625	2 RPM	175	2.9067	0.5641					
4625	2 RPM	175	2.9067	0.5641					
3625	2 RPM	195	2.9257	0.5514					
3625	2 RPM	195	2.9257	0.5514					
3625	2 RPM	195	2.9257	0.5514					

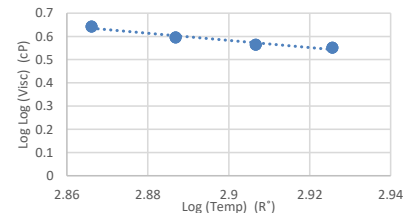


Table 246-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
20950	5 RPM	135	2.8661	0.6356	5 RPM	40%	5.252	-1.613	0.955
20800	5 RPM	135	2.8661	0.6353					
20800	5 RPM	135	2.8661	0.6353					
7600	5 RPM	155	2.8869	0.5889					
7600	5 RPM	155	2.8869	0.5889					
7650	5 RPM	155	2.8869	0.5892					
3750	5 RPM	175	2.9067	0.5532					
3800	5 RPM	175	2.9067	0.5539					
3800	5 RPM	175	2.9067	0.5539					
2900	5 RPM	195	2.9257	0.5394					
3050	5 RPM	195	2.9257	0.5421					
3000	5 RPM	195	2.9257	0.5412					

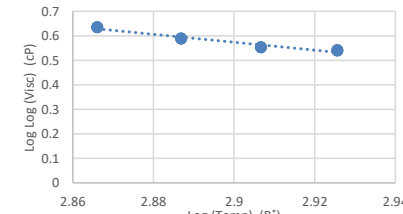


Table 247-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
18650	10 RPM	135	2.8661	0.6305	10 RPM	40%	5.573	-1.727	0.975
18530	10 RPM	135	2.8661	0.6302					
18430	10 RPM	135	2.8661	0.6300					
6850	10 RPM	155	2.8869	0.5838					
6850	10 RPM	155	2.8869	0.5838					
6875	10 RPM	155	2.8869	0.5840					
3375	10 RPM	175	2.9067	0.5476					
3325	10 RPM	175	2.9067	0.5468					
3375	10 RPM	175	2.9067	0.5476					
2425	10 RPM	195	2.9257	0.5295					
2375	10 RPM	195	2.9257	0.5284					
2350	10 RPM	195	2.9257	0.5278					

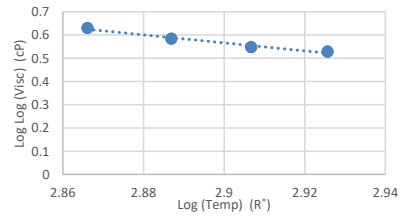


Table 248-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 40% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	40%	5.053	-1.551	0.985
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
6075	20 RPM	155	2.8869	0.5779					
6088	20 RPM	155	2.8869	0.5780					
6138	20 RPM	155	2.8869	0.5784					
3000	20 RPM	175	2.9067	0.5412					
3013	20 RPM	175	2.9067	0.5415					
2963	20 RPM	175	2.9067	0.5405					
2037	20 RPM	195	2.9257	0.5197					
1963	20 RPM	195	2.9257	0.5176					
1938	20 RPM	195	2.9257	0.5168					

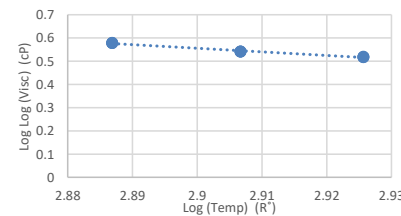


Table 249-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
39500	2 RPM	135	2.8661	0.6624	2 RPM	45%	4.965	-1.504	0.960
39130	2 RPM	135	2.8661	0.6621					
38630	2 RPM	135	2.8661	0.6615					
13880	2 RPM	155	2.8869	0.6173					
13630	2 RPM	155	2.8869	0.6164					
13750	2 RPM	155	2.8869	0.6168					
7625	2 RPM	175	2.9067	0.5891					
7375	2 RPM	175	2.9067	0.5875					
7375	2 RPM	175	2.9067	0.5875					
5375	2 RPM	195	2.9257	0.5718					
5500	2 RPM	195	2.9257	0.5729					
5500	2 RPM	195	2.9257	0.5729					

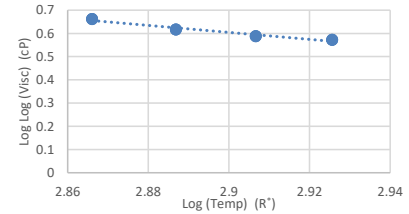


Table 250-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
32050	5 RPM	135	2.8661	0.6538	5 RPM	45%	5.281	-1.616	0.973
32300	5 RPM	135	2.8661	0.6541					
32450	5 RPM	135	2.8661	0.6543					
11350	5 RPM	155	2.8869	0.6080					
11550	5 RPM	155	2.8869	0.6088					
11650	5 RPM	155	2.8869	0.6092					
6000	5 RPM	175	2.9067	0.5773					
5900	5 RPM	175	2.9067	0.5764					
5950	5 RPM	175	2.9067	0.5769					
4150	5 RPM	195	2.9257	0.5585					
4100	5 RPM	195	2.9257	0.5578					
4100	5 RPM	195	2.9257	0.5578					

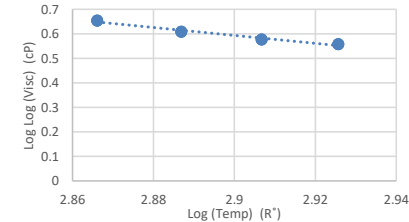


Table 251-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	10 RPM	135	#N/A	#N/A	10 RPM	45%	4.764	-1.442	0.989
#N/A	10 RPM	135	#N/A	#N/A					
#N/A	10 RPM	135	#N/A	#N/A					
10230	10 RPM	155	2.8869	0.6031					
10300	10 RPM	155	2.8869	0.6035					
10330	10 RPM	155	2.8869	0.6036					
5225	10 RPM	175	2.9067	0.5703					
5150	10 RPM	175	2.9067	0.5696					
5225	10 RPM	175	2.9067	0.5703					
3500	10 RPM	195	2.9257	0.5495					
3325	10 RPM	195	2.9257	0.5468					
3300	10 RPM	195	2.9257	0.5464					

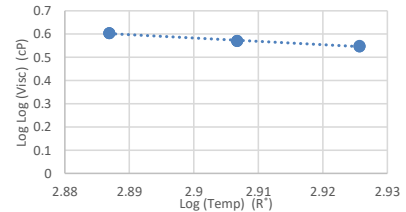


Table 252-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	45%	5.176	-1.586	0.998
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
9150	20 RPM	155	2.8869	0.5979					
9138	20 RPM	155	2.8869	0.5978					
9175	20 RPM	155	2.8869	0.5980					
4600	20 RPM	175	2.9067	0.5638					
4638	20 RPM	175	2.9067	0.5642					
4600	20 RPM	175	2.9067	0.5638					
2788	20 RPM	195	2.9257	0.5372					
2725	20 RPM	195	2.9257	0.5360					
2725	20 RPM	195	2.9257	0.5360					

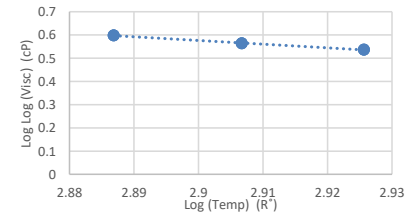


Table 253-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
40380	2 RPM	135	2.8661	0.6633	2 RPM	45%	5.158	-1.570	0.967
40500	2 RPM	135	2.8661	0.6635					
40630	2 RPM	135	2.8661	0.6636					
13880	2 RPM	155	2.8869	0.6173					
14000	2 RPM	155	2.8869	0.6176					
14250	2 RPM	155	2.8869	0.6184					
7375	2 RPM	175	2.9067	0.5875					
7375	2 RPM	175	2.9067	0.5875					
7250	2 RPM	175	2.9067	0.5866					
5125	2 RPM	195	2.9257	0.5693					
5125	2 RPM	195	2.9257	0.5693					
5375	2 RPM	195	2.9257	0.5718					

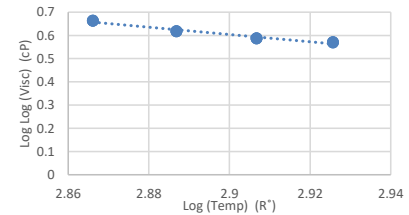


Table 254-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
32700	5 RPM	135	2.8661	0.6546	5 RPM	45%	5.368	-1.646	0.977
33150	5 RPM	135	2.8661	0.6552					
33300	5 RPM	135	2.8661	0.6554					
11700	5 RPM	155	2.8869	0.6094					
11750	5 RPM	155	2.8869	0.6096					
11700	5 RPM	155	2.8869	0.6094					
6000	5 RPM	175	2.9067	0.5773					
5950	5 RPM	175	2.9067	0.5769					
6050	5 RPM	175	2.9067	0.5777					
4050	5 RPM	195	2.9257	0.5572					
4000	5 RPM	195	2.9257	0.5566					
4100	5 RPM	195	2.9257	0.5578					

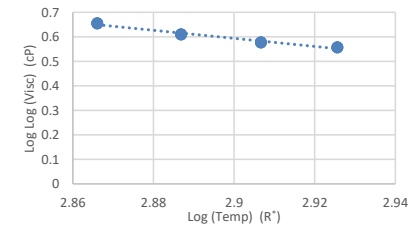


Table 255-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	10 RPM	135	#N/A	#N/A	10 RPM	45%	4.961	-1.510	0.991
#N/A	10 RPM	135	#N/A	#N/A					
#N/A	10 RPM	135	#N/A	#N/A					
10500	10 RPM	155	2.8869	0.6044					
10580	10 RPM	155	2.8869	0.6047					
10380	10 RPM	155	2.8869	0.6038					
5175	10 RPM	175	2.9067	0.5698					
5175	10 RPM	175	2.9067	0.5698					
5150	10 RPM	175	2.9067	0.5696					
3300	10 RPM	195	2.9257	0.5464					
3300	10 RPM	195	2.9257	0.5464					
3200	10 RPM	195	2.9257	0.5447					

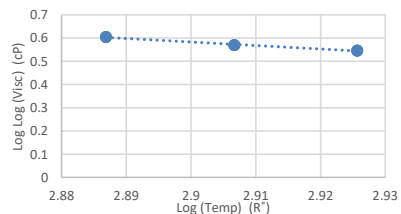


Table 256-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 45% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	45%	5.235	-1.607	0.997
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
9175	20 RPM	155	2.8869	0.5980					
9263	20 RPM	155	2.8869	0.5984					
9150	20 RPM	155	2.8869	0.5979					
4563	20 RPM	175	2.9067	0.5634					
4575	20 RPM	175	2.9067	0.5635					
4575	20 RPM	175	2.9067	0.5635					
2738	20 RPM	195	2.9257	0.5362					
2713	20 RPM	195	2.9257	0.5357					
2700	20 RPM	195	2.9257	0.5355					

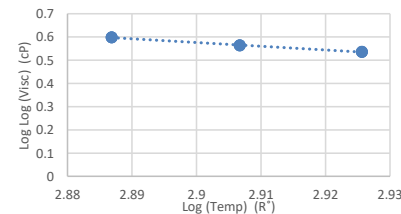


Table 257-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
76750	2 RPM	135	2.8661	0.6889	2 RPM	50%	4.171	-1.217	0.937
76380	2 RPM	135	2.8661	0.6887					
75880	2 RPM	135	2.8661	0.6884					
28630	2 RPM	155	2.8869	0.6490					
28750	2 RPM	155	2.8869	0.6492					
28380	2 RPM	155	2.8869	0.6487					
16630	2 RPM	175	2.9067	0.6254					
17130	2 RPM	175	2.9067	0.6267					
16500	2 RPM	175	2.9067	0.6251					
13880	2 RPM	195	2.9257	0.6173					
13500	2 RPM	195	2.9257	0.6160					
13380	2 RPM	195	2.9257	0.6156					

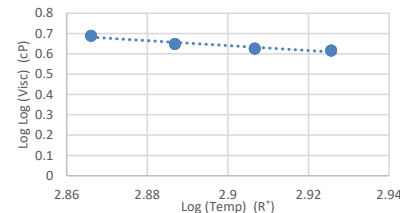


Table 258-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	5 RPM	135	#N/A	#N/A	5 RPM	50%	4.408	-1.305	0.997
#N/A	5 RPM	135	#N/A	#N/A					
#N/A	5 RPM	135	#N/A	#N/A					
23150	5 RPM	155	2.8869	0.6399					
23350	5 RPM	155	2.8869	0.6403					
23300	5 RPM	155	2.8869	0.6402					
12750	5 RPM	175	2.9067	0.6134					
12550	5 RPM	175	2.9067	0.6126					
13250	5 RPM	175	2.9067	0.6151					
8000	5 RPM	195	2.9257	0.5914					
7650	5 RPM	195	2.9257	0.5892					
7450	5 RPM	195	2.9257	0.5880					

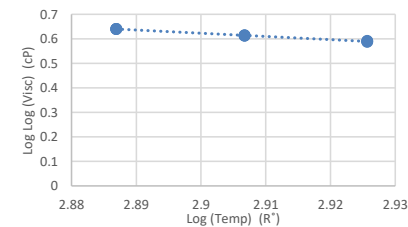


Table 259-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	10 RPM	135	#N/A	#N/A	10 RPM	50%	4.875	-1.470	0.999
#N/A	10 RPM	135	#N/A	#N/A					
#N/A	10 RPM	135	#N/A	#N/A					
19180	10 RPM	155	2.8869	0.6317					
19430	10 RPM	155	2.8869	0.6323					
19500	10 RPM	155	2.8869	0.6325					
10550	10 RPM	175	2.9067	0.6046					
10350	10 RPM	175	2.9067	0.6037					
10430	10 RPM	175	2.9067	0.6040					
5800	10 RPM	195	2.9257	0.5756					
5625	10 RPM	195	2.9257	0.5740					
5825	10 RPM	195	2.9257	0.5758					

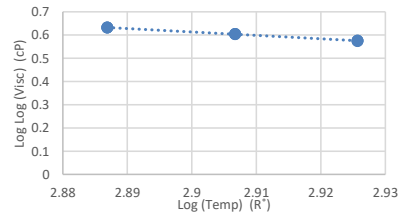


Table 260-B. Sample A Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample A for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	50%	#N/A	#N/A	#N/A
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	155	#N/A	#N/A					
#N/A	20 RPM	155	#N/A	#N/A					
#N/A	20 RPM	155	#N/A	#N/A					
8650	20 RPM	175	2.9067	0.5952					
8863	20 RPM	175	2.9067	0.5963					
8875	20 RPM	175	2.9067	0.5964					
4550	20 RPM	195	2.9257	0.5632					
5000	20 RPM	195	2.9257	0.5681					
5238	20 RPM	195	2.9257	0.5704					

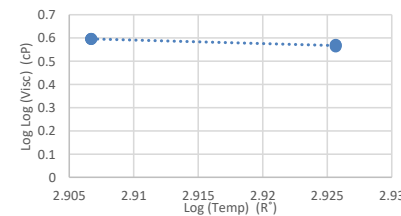


Table 261-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 2 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
64380	2 RPM	135	2.8661	0.6820	2 RPM	50%	4.563	-1.356	0.946
65880	2 RPM	135	2.8661	0.6829					
64880	2 RPM	135	2.8661	0.6823					
24130	2 RPM	155	2.8869	0.6417					
24000	2 RPM	155	2.8869	0.6415					
24380	2 RPM	155	2.8869	0.6422					
12630	2 RPM	175	2.9067	0.6129					
12750	2 RPM	175	2.9067	0.6134					
12250	2 RPM	175	2.9067	0.6115					
10130	2 RPM	195	2.9257	0.6027					
10250	2 RPM	195	2.9257	0.6032					
10130	2 RPM	195	2.9257	0.6027					

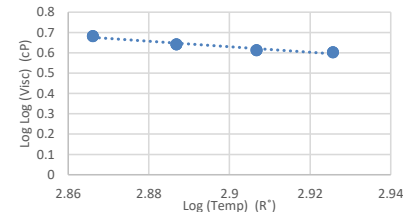


Table 262-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 5 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	5 RPM	135	#N/A	#N/A	5 RPM	50%	4.166	-1.224	0.969
#N/A	5 RPM	135	#N/A	#N/A					
#N/A	5 RPM	135	#N/A	#N/A					
19600	5 RPM	155	2.8869	0.6327					
19650	5 RPM	155	2.8869	0.6328					
20250	5 RPM	155	2.8869	0.6341					
9700	5 RPM	175	2.9067	0.6006					
10050	5 RPM	175	2.9067	0.6023					
10200	5 RPM	175	2.9067	0.6030					
7350	5 RPM	195	2.9257	0.5873					
6850	5 RPM	195	2.9257	0.5838					
7200	5 RPM	195	2.9257	0.5863					

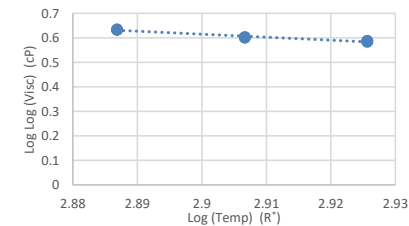


Table 263-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 10 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	10 RPM	135	#N/A	#N/A	10 RPM	50%	4.574	-1.368	0.992
#N/A	10 RPM	135	#N/A	#N/A					
#N/A	10 RPM	135	#N/A	#N/A					
17330	10 RPM	155	2.8869	0.6272					
17130	10 RPM	155	2.8869	0.6267					
17280	10 RPM	155	2.8869	0.6271					
8725	10 RPM	175	2.9067	0.5956					
8725	10 RPM	175	2.9067	0.5956					
8875	10 RPM	175	2.9067	0.5964					
5725	10 RPM	195	2.9257	0.5749					
5650	10 RPM	195	2.9257	0.5743					
5500	10 RPM	195	2.9257	0.5729					

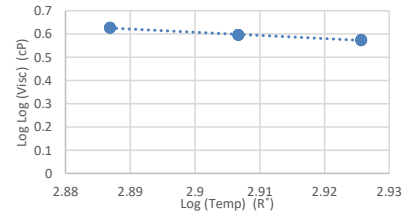
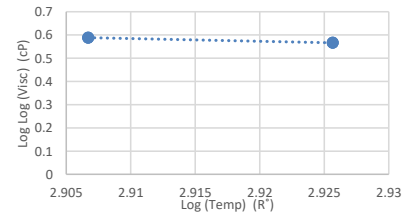


Table 264-B. Sample B Viscosity Data and ASTM A-VTS Correlations for Binder C (PG 76-22) at 20 RPM and 50% RAR Content.

Viscosity (cP)	Speed (RPM)	Temperature (°C)	Log Temp (R)	Log Log Visc (cP)	Sample B for Binder C (PG 76-22)				
					RPM	RAR	A	VTS	R2
#N/A	20 RPM	135	#N/A	#N/A	20 RPM	50%	#N/A	#N/A	#N/A
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	135	#N/A	#N/A					
#N/A	20 RPM	155	#N/A	#N/A					
#N/A	20 RPM	155	#N/A	#N/A					
#N/A	20 RPM	155	#N/A	#N/A					
7413	20 RPM	175	2.9067	0.5877					
7538	20 RPM	175	2.9067	0.5885					
7588	20 RPM	175	2.9067	0.5888					
4863	20 RPM	195	2.9257	0.5667					
4763	20 RPM	195	2.9257	0.5656					
4825	20 RPM	195	2.9257	0.5663					



Appendix C. Analysis of Variance Results for Binders A, B, and C

Table 1-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 5%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	6000	5737.5	5685	5640
Average	250	239.0625	236.875	235
<u>Summary for 5 % Group</u>				
Count	24	24	24	24
Sum	7500	7375	7310	7255
Average	312.5	307.29167	304.58333	302.29167
<u>Between Groups</u>				
SS	4.69E+04	5.59E+04	5.50E+04	5.43E+04
df	1	1	1	1
MS	4.69E+04	5.59E+04	5.50E+04	5.43E+04
F	0.699	0.944	0.984	0.998
P-value*	4.1E-01	3.4E-01	3.3E-01	3.2E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	3.09E+06	2.72E+06	2.57E+06	2.51E+06
df	46	46	46	46
MS	6.71E+04	5.91E+04	5.59E+04	5.45E+04
<u>Total</u>				
SS	3.13E+06	2.78E+06	2.63E+06	2.56E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 2-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 5% and 10%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 5 % Group</u>				
Count	24	24	24	24
Sum	7500	7375	7310	7255
Average	312.5	307.29167	304.58333	302.29167
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	11550	11465.5	11350	11197
Average	481.25	477.72917	472.91667	466.54167
<u>Between Groups</u>				
SS	3.42E+05	3.49E+05	3.40E+05	3.24E+05
df	1	1	1	1
MS	3.42E+05	3.49E+05	3.40E+05	3.24E+05
F	2.602	2.725	2.810	2.800
P-value*	1.1E-01	1.1E-01	1.0E-01	1.0E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	6.04E+06	5.88E+06	5.57E+06	5.32E+06
df	46	46	46	46
MS	1.31E+05	1.28E+05	1.21E+05	1.16E+05
<u>Total</u>				
SS	6.38E+06	6.23E+06	5.91E+06	5.64E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 3-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 10% and 15%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	11550	11465.5	11350	11197
Average	481.25	477.72917	472.91667	466.54167
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	14400	14051	13670	13359
Average	600	585.45833	569.58333	556.625
<u>Between Groups</u>				
SS	1.69E+05	1.39E+05	1.12E+05	9.74E+04
df	1	1	1	1
MS	1.69E+05	1.39E+05	1.12E+05	9.74E+04
F	0.761	0.630	0.535	0.491
P-value*	3.9E-01	4.3E-01	4.7E-01	4.9E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.02E+07	1.02E+07	9.64E+06	9.12E+06
df	46	46	46	46
MS	2.22E+05	2.21E+05	2.10E+05	1.98E+05
<u>Total</u>				
SS	1.04E+07	1.03E+07	9.75E+06	9.22E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 4-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 15% and 20%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	14400	14051	13670	13359
Average	600	585.45833	569.58333	556.625
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	21550	20401.5	19490	18758.5
Average	897.91667	850.0625	812.08333	781.60417
<u>Between Groups</u>				
SS	1.07E+06	8.40E+05	7.06E+05	6.07E+05
df	1	1	1	1
MS	1.07E+06	8.40E+05	7.06E+05	6.07E+05
F	2.328	2.018	1.866	1.753
P-value*	1.3E-01	1.6E-01	1.8E-01	1.9E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	2.10E+07	1.92E+07	1.74E+07	1.59E+07
df	46	46	46	46
MS	4.57E+05	4.16E+05	3.78E+05	3.46E+05
<u>Total</u>				
SS	2.21E+07	2.00E+07	1.81E+07	1.65E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 5-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 25%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	21550	20401.5	19490	18758.5
Average	897.91667	850.0625	812.08333	781.60417
<u>Summary for 25 % Group</u>				
Count	24	24	24	18
Sum	36850	33116.5	30760	11699
Average	1535.4167	1379.8542	1281.6667	649.94444
<u>Between Groups</u>				
SS	4.88E+06	3.37E+06	2.65E+06	1.78E+05
df	1	1	1	1
MS	4.88E+06	3.37E+06	2.65E+06	1.78E+05
F	3.766	3.254	3.007	0.565
P-value*	5.8E-02	7.8E-02	9.0E-02	4.6E-01
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	5.96E+07	4.76E+07	4.05E+07	1.26E+07
df	46	46	46	40
MS	1.29E+06	1.03E+06	8.80E+05	3.16E+05
<u>Total</u>				
SS	6.44E+07	5.10E+07	4.31E+07	1.28E+07
df	47	47	47	41

* Highlighted values indicate a significant difference

Table 6-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 25% and 30%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 25 % Group</u>				
Count	24	24	24	18
Sum	36850	33116.5	30760	11699
Average	1535.4167	1379.8542	1281.6667	649.94444
<u>Summary for 30 % Group</u>				
Count	24	24	24	18
Sum	57450	49202.5	44440	16967
Average	2393.75	2050.1042	1851.6667	942.61111
<u>Between Groups</u>				
SS	8.84E+06	5.39E+06	3.90E+06	7.71E+05
df	1	1	1	1
MS	8.84E+06	5.39E+06	3.90E+06	7.71E+05
F	2.891	2.390	2.129	4.332
P-value*	9.6E-02	1.3E-01	1.5E-01	4.5E-02
F crit	4.052	4.052	4.052	4.130
<u>Within Groups</u>				
SS	1.41E+08	1.04E+08	8.42E+07	6.05E+06
df	46	46	46	34
MS	3.06E+06	2.26E+06	1.83E+06	1.78E+05
<u>Total</u>				
SS	1.50E+08	1.09E+08	8.81E+07	6.82E+06
df	47	47	47	35

* Highlighted values indicate a significant difference

Table 7-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 35%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	18
Sum	57450	49202.5	44440	16967
Average	2393.75	2050.1042	1851.6667	942.61111
<u>Summary for 35 % Group</u>				
Count	24	24	18	18
Sum	77150	64542.5	23685	21850.5
Average	3214.5833	2689.2708	1315.8333	1213.9167
<u>Between Groups</u>				
SS	8.09E+06	4.90E+06	2.95E+06	6.62E+05
df	1	1	1	1
MS	8.09E+06	4.90E+06	2.95E+06	6.62E+05
F	1.429	1.222	1.870	2.089
P-value*	2.4E-01	2.7E-01	1.8E-01	1.6E-01
F crit	4.052	4.052	4.085	4.130
<u>Within Groups</u>				
SS	2.60E+08	1.84E+08	6.32E+07	1.08E+07
df	46	46	40	34
MS	5.66E+06	4.01E+06	1.58E+06	3.17E+05
<u>Total</u>				
SS	2.68E+08	1.89E+08	6.61E+07	1.14E+07
df	47	47	41	35

* Highlighted values indicate a significant difference

Table 8-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 35% and 40%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 35 % Group</u>				
Count	24	24	18	18
Sum	77150	64542.5	23685	21850.5
Average	3214.5833	2689.2708	1315.8333	1213.9167
<u>Summary for 40 % Group</u>				
Count	24	24	18	12
Sum	129850	103704	37595	14958.5
Average	5410.4167	4321	2088.6111	1246.5417
<u>Between Groups</u>				
SS	5.79E+07	3.20E+07	5.37E+06	7.66E+03
df	1	1	1	1
MS	5.79E+07	3.20E+07	5.37E+06	7.66E+03
F	4.691	3.800	7.029	0.027
P-value*	3.6E-02	5.7E-02	1.2E-02	8.7E-01
F crit	4.052	4.052	4.130	4.196
<u>Within Groups</u>				
SS	5.67E+08	3.87E+08	2.60E+07	8.09E+06
df	46	46	34	28
MS	1.23E+07	8.41E+06	7.65E+05	2.89E+05
<u>Total</u>				
SS	6.25E+08	4.19E+08	3.14E+07	8.10E+06
df	47	47	35	29

* Highlighted values indicate a significant difference

Table 9-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 40% and 45%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 40 % Group</u>				
Count	24	24	18	12
Sum	129850	103704	37595	14958.5
Average	5410.4167	4321	2088.6111	1246.5417
<u>Summary for 45 % Group</u>				
Count	24	21	18	12
Sum	164500	92380	48425	19380
Average	6854.1667	4399.0476	2690.2778	1615
<u>Between Groups</u>				
SS	2.50E+07	6.82E+04	3.26E+06	8.15E+05
df	1	1	1	1
MS	2.50E+07	6.82E+04	3.26E+06	8.15E+05
F	1.095	0.006	2.294	5.609
P-value*	3.0E-01	9.4E-01	1.4E-01	2.7E-02
F crit	4.052	4.067	4.130	4.301
<u>Within Groups</u>				
SS	1.05E+09	5.11E+08	4.83E+07	3.19E+06
df	46	43	34	22
MS	2.28E+07	1.19E+07	1.42E+06	1.45E+05
<u>Total</u>				
SS	1.08E+09	5.11E+08	5.15E+07	4.01E+06
df	47	44	35	23

* Highlighted values indicate a significant difference

Table 10-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 45% and 50%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 45 % Group</u>				
Count	24	21	18	12
Sum	164500	92380	48425	19380
Average	6854.1667	4399.0476	2690.2778	1615
<u>Summary for 50 % Group</u>				
Count	24	18	12	6
Sum	277850	89406	32755	10623
Average	11577.083	4967	2729.5833	1770.5
<u>Between Groups</u>				
SS	2.68E+08	0.00E+00	1.11E+04	9.67E+04
df	1	0	1	1
MS	2.68E+08	0.00E+00	1.11E+04	9.67E+04
F	4.813	0.000	0.009	0.790
P-value*	3.3E-02	0.0E+00	9.3E-01	3.9E-01
F crit	4.052	0.000	4.196	4.494
<u>Within Groups</u>				
SS	2.56E+09	0.00E+00	3.59E+07	1.96E+06
df	46	0	28	16
MS	5.56E+07	0.00E+00	1.28E+06	1.22E+05
<u>Total</u>				
SS	2.83E+09	0.00E+00	3.59E+07	2.06E+06
df	47	0	29	17

* Highlighted values indicate a significant difference

Table 11-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 10%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	6000	5737.5	5685	5640
Average	250	239.0625	236.875	235
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	11550	11465.5	11350	11197
Average	481.25	477.72917	472.91667	466.54167
<u>Between Groups</u>				
SS	6.42E+05	6.84E+05	6.69E+05	6.43E+05
df	1	1	1	1
MS	6.42E+05	6.84E+05	6.69E+05	6.43E+05
F	6.019	6.363	6.486	6.474
P-value*	1.8E-02	1.5E-02	1.4E-02	1.4E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	4.90E+06	4.94E+06	4.74E+06	4.57E+06
df	46	46	46	46
MS	1.07E+05	1.07E+05	1.03E+05	9.94E+04
<u>Total</u>				
SS	5.55E+06	5.63E+06	5.41E+06	5.21E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 12-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 10% and 20%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	11550	11465.5	11350	11197
Average	481.25	477.72917	472.91667	466.54167
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	21550	20401.5	19490	18758.5
Average	897.91667	850.0625	812.08333	781.60417
<u>Between Groups</u>				
SS	2.08E+06	1.66E+06	1.38E+06	1.19E+06
df	1	1	1	1
MS	2.08E+06	1.66E+06	1.38E+06	1.19E+06
F	5.133	4.477	4.098	3.859
P-value*	2.8E-02	4.0E-02	4.9E-02	5.6E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.87E+07	1.71E+07	1.55E+07	1.42E+07
df	46	46	46	46
MS	4.06E+05	3.72E+05	3.37E+05	3.09E+05
<u>Total</u>				
SS	2.08E+07	1.88E+07	1.69E+07	1.54E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 13-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 30%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	21550	20401.5	19490	18758.5
Average	897.91667	850.0625	812.08333	781.60417
<u>Summary for 30 % Group</u>				
Count	24	24	24	18
Sum	57450	49202.5	44440	16967
Average	2393.75	2050.1042	1851.6667	942.61111
<u>Between Groups</u>				
SS	2.69E+07	1.73E+07	1.30E+07	2.67E+05
df	1	1	1	1
MS	2.69E+07	1.73E+07	1.30E+07	2.67E+05
F	11.168	9.669	8.904	0.739
P-value*	1.7E-03	3.2E-03	4.5E-03	4.0E-01
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	1.11E+08	8.22E+07	6.70E+07	1.44E+07
df	46	46	46	40
MS	2.40E+06	1.79E+06	1.46E+06	3.61E+05
<u>Total</u>				
SS	1.37E+08	9.95E+07	8.00E+07	1.47E+07
df	47	47	47	41

* Highlighted values indicate a significant difference

Table 14-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 40%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	18
Sum	57450	49202.5	44440	16967
Average	2393.75	2050.1042	1851.6667	942.61111
<u>Summary for 40 % Group</u>				
Count	24	24	18	12
Sum	129850	103704	37595	14958.5
Average	5410.4167	4321	2088.6111	1246.5417
<u>Between Groups</u>				
SS	1.09E+08	6.19E+07	5.77E+05	6.65E+05
df	1	1	1	1
MS	1.09E+08	6.19E+07	5.77E+05	6.65E+05
F	10.070	8.356	0.314	3.599
P-value*	2.7E-03	5.8E-03	5.8E-01	6.8E-02
F crit	4.052	4.052	4.085	4.196
<u>Within Groups</u>				
SS	4.99E+08	3.41E+08	7.36E+07	5.17E+06
df	46	46	40	28
MS	1.08E+07	7.41E+06	1.84E+06	1.85E+05
<u>Total</u>				
SS	6.08E+08	4.03E+08	7.41E+07	5.84E+06
df	47	47	41	29

* Highlighted values indicate a significant difference

Table 15-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 40% and 50%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 40 % Group</u>				
Count	24	24	18	12
Sum	129850	103704	37595	14958.5
Average	5410.4167	4321	2088.6111	1246.5417
<u>Summary for 50 % Group</u>				
Count	24	18	12	6
Sum	277850	89406	32755	10623
Average	11577.083	4967	2729.5833	1770.5
<u>Between Groups</u>				
SS	4.56E+08	4.29E+06	2.96E+06	1.10E+06
df	1	1	1	1
MS	4.56E+08	4.29E+06	2.96E+06	1.10E+06
F	9.075	0.459	3.448	14.143
P-value*	4.2E-03	5.0E-01	7.4E-02	1.7E-03
F crit	4.052	4.085	4.196	4.494
<u>Within Groups</u>				
SS	2.31E+09	3.74E+08	2.40E+07	1.24E+06
df	46	40	28	16
MS	5.03E+07	9.35E+06	8.58E+05	7.76E+04
<u>Total</u>				
SS	2.77E+09	3.78E+08	2.70E+07	2.34E+06
df	47	41	29	17

* Highlighted values indicate a significant difference

Table 16-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 15%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	6000	5737.5	5685	5640
Average	250	239.0625	236.875	235
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	14400	14051	13670	13359
Average	600	585.45833	569.58333	556.625
<u>Between Groups</u>				
SS	1.47E+06	1.44E+06	1.33E+06	1.24E+06
df	1	1	1	1
MS	1.47E+06	1.44E+06	1.33E+06	1.24E+06
F	9.295	9.455	9.193	9.054
P-value*	3.8E-03	3.5E-03	4.0E-03	4.2E-03
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	7.28E+06	7.01E+06	6.65E+06	6.31E+06
df	46	46	46	46
MS	1.58E+05	1.52E+05	1.44E+05	1.37E+05
<u>Total</u>				
SS	8.75E+06	8.45E+06	7.97E+06	7.55E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 17-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 15% and 30%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	14400	14051	13670	13359
Average	600	585.45833	569.58333	556.625
<u>Summary for 30 % Group</u>				
Count	24	24	24	18
Sum	57450	49202.5	44440	16967
Average	2393.75	2050.1042	1851.6667	942.61111
<u>Between Groups</u>				
SS	3.86E+07	2.57E+07	1.97E+07	1.53E+06
df	1	1	1	1
MS	3.86E+07	2.57E+07	1.97E+07	1.53E+06
F	17.387	15.726	14.839	6.547
P-value*	1.3E-04	2.5E-04	3.6E-04	1.4E-02
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	1.02E+08	7.53E+07	6.11E+07	9.36E+06
df	46	46	46	40
MS	2.22E+06	1.64E+06	1.33E+06	2.34E+05
<u>Total</u>				
SS	1.41E+08	1.01E+08	8.09E+07	1.09E+07
df	47	47	47	41

* Highlighted values indicate a significant difference

Table 18-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 45%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	18
Sum	57450	49202.5	44440	16967
Average	2393.75	2050.1042	1851.6667	942.61111
<u>Summary for 45 % Group</u>				
Count	24	21	18	12
Sum	164500	92380	48425	19380
Average	6854.1667	4399.0476	2690.2778	1615
<u>Between Groups</u>				
SS	2.39E+08	6.18E+07	7.23E+06	3.26E+06
df	1	1	1	1
MS	2.39E+08	6.18E+07	7.23E+06	3.26E+06
F	14.765	8.602	3.386	15.472
P-value*	3.7E-04	5.4E-03	7.3E-02	5.0E-04
F crit	4.052	4.067	4.085	4.196
<u>Within Groups</u>				
SS	7.44E+08	3.09E+08	8.54E+07	5.89E+06
df	46	43	40	28
MS	1.62E+07	7.18E+06	2.14E+06	2.10E+05
<u>Total</u>				
SS	9.83E+08	3.71E+08	9.27E+07	9.15E+06
df	47	44	41	29

* Highlighted values indicate a significant difference

Table 19-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 20%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	6000	5737.5	5685	5640
Average	250	239.0625	236.875	235
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	21550	20401.5	19490	18758.5
Average	897.91667	850.0625	812.08333	781.60417
<u>Between Groups</u>				
SS	5.04E+06	4.48E+06	3.97E+06	3.59E+06
df	1	1	1	1
MS	5.04E+06	4.48E+06	3.97E+06	3.59E+06
F	14.743	14.796	14.611	14.484
P-value*	3.7E-04	3.7E-04	4.0E-04	4.2E-04
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.57E+07	1.39E+07	1.25E+07	1.14E+07
df	46	46	46	46
MS	3.42E+05	3.03E+05	2.72E+05	2.48E+05
<u>Total</u>				
SS	2.08E+07	1.84E+07	1.65E+07	1.50E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 20-C. ANOVA Results for Binder A (PG 64-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 40%.

Source of Variation	Testing RPM			
	5 RPM	20 RPM	50 RPM	100 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	21550	20401.5	19490	18758.5
Average	897.91667	850.0625	812.08333	781.60417
<u>Summary for 40 % Group</u>				
Count	24	24	18	12
Sum	129850	103704	37595	14958.5
Average	5410.4167	4321	2088.6111	1246.5417
<u>Between Groups</u>				
SS	2.44E+08	1.45E+08	1.68E+07	1.73E+06
df	1	1	1	1
MS	2.44E+08	1.45E+08	1.68E+07	1.73E+06
F	26.909	23.372	22.478	5.006
P-value*	4.7E-06	1.5E-05	2.7E-05	3.2E-02
F crit	4.052	4.052	4.085	4.130
<u>Within Groups</u>				
SS	4.18E+08	2.85E+08	2.98E+07	1.17E+07
df	46	46	40	34
MS	9.08E+06	6.19E+06	7.46E+05	3.45E+05
<u>Total</u>				
SS	6.62E+08	4.29E+08	4.66E+07	1.35E+07
df	47	47	41	35

* Highlighted values indicate a significant difference

Table 21-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 5%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	9000	7650	7800	7800
Average	375	318.75	325	325
<u>Summary for 5 % Group</u>				
Count	24	24	24	24
Sum	11750	10350	10275	10001
Average	489.58333	431.25	428.125	416.70833
<u>Between Groups</u>				
SS	1.58E+05	1.52E+05	1.28E+05	1.01E+05
df	1	1	1	1
MS	1.58E+05	1.52E+05	1.28E+05	1.01E+05
F	1.275	1.395	1.142	0.934
P-value*	2.6E-01	2.4E-01	2.9E-01	3.4E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	5.68E+06	5.01E+06	5.14E+06	4.97E+06
df	46	46	46	46
MS	1.24E+05	1.09E+05	1.12E+05	1.08E+05
<u>Total</u>				
SS	5.84E+06	5.16E+06	5.27E+06	5.07E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 22-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 5% and 10%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 5 % Group</u>				
Count	24	24	24	24
Sum	11750	10350	10275	10001
Average	489.58333	431.25	428.125	416.70833
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	15875	14400	14225	13976.5
Average	661.45833	600	592.70833	582.35417
<u>Between Groups</u>				
SS	3.54E+05	3.42E+05	3.25E+05	3.29E+05
df	1	1	1	1
MS	3.54E+05	3.42E+05	3.25E+05	3.29E+05
F	1.468	1.627	1.573	1.654
P-value*	2.3E-01	2.1E-01	2.2E-01	2.0E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.11E+07	9.66E+06	9.51E+06	9.16E+06
df	46	46	46	46
MS	2.41E+05	2.10E+05	2.07E+05	1.99E+05
<u>Total</u>				
SS	1.15E+07	1.00E+07	9.83E+06	9.48E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 23-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 10% and 15%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	15875	14400	14225	13976.5
Average	661.45833	600	592.70833	582.35417
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	24125	22350	22050	21351
Average	1005.2083	931.25	918.75	889.625
<u>Between Groups</u>				
SS	1.42E+06	1.32E+06	1.28E+06	1.13E+06
df	1	1	1	1
MS	1.42E+06	1.32E+06	1.28E+06	1.13E+06
F	2.952	3.070	3.086	2.868
P-value*	9.2E-02	8.6E-02	8.6E-02	9.7E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	2.21E+07	1.97E+07	1.90E+07	1.82E+07
df	46	46	46	46
MS	4.80E+05	4.29E+05	4.13E+05	3.95E+05
<u>Total</u>				
SS	2.35E+07	2.10E+07	2.03E+07	1.93E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 24-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 15% and 20%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	24125	22350	22050	21351
Average	1005.2083	931.25	918.75	889.625
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	32750	29900	28775	27565.5
Average	1364.5833	1245.8333	1198.9583	1148.5625
<u>Between Groups</u>				
SS	1.55E+06	1.19E+06	9.42E+05	8.05E+05
df	1	1	1	1
MS	1.55E+06	1.19E+06	9.42E+05	8.05E+05
F	1.615	1.434	1.202	1.103
P-value*	2.1E-01	2.4E-01	2.8E-01	3.0E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	4.41E+07	3.81E+07	3.61E+07	3.36E+07
df	46	46	46	46
MS	9.60E+05	8.28E+05	7.84E+05	7.30E+05
<u>Total</u>				
SS	4.57E+07	3.93E+07	3.70E+07	3.44E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 25-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 25%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	32750	29900	28775	27565.5
Average	1364.5833	1245.8333	1198.9583	1148.5625
<u>Summary for 25 % Group</u>				
Count	24	24	24	24
Sum	54750	49450	46625	44041
Average	2281.25	2060.4167	1942.7083	1835.0417
<u>Between Groups</u>				
SS	1.01E+07	7.96E+06	6.64E+06	5.66E+06
df	1	1	1	1
MS	1.01E+07	7.96E+06	6.64E+06	5.66E+06
F	3.886	3.728	3.481	3.328
P-value*	5.5E-02	6.0E-02	6.8E-02	7.5E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.19E+08	9.83E+07	8.77E+07	7.82E+07
df	46	46	46	46
MS	2.59E+06	2.14E+06	1.91E+06	1.70E+06
<u>Total</u>				
SS	1.29E+08	1.06E+08	9.44E+07	8.38E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 26-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 25% and 30%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 25 % Group</u>				
Count	24	24	24	24
Sum	54750	49450	46625	44041
Average	2281.25	2060.4167	1942.7083	1835.0417
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	85250	76150	69900	64202
Average	3552.0833	3172.9167	2912.5	2675.0833
<u>Between Groups</u>				
SS	1.94E+07	1.49E+07	1.13E+07	8.47E+06
df	1	1	1	1
MS	1.94E+07	1.49E+07	1.13E+07	8.47E+06
F	3.145	2.979	2.698	2.355
P-value*	8.3E-02	9.1E-02	1.1E-01	1.3E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	2.83E+08	2.29E+08	1.92E+08	1.65E+08
df	46	46	46	46
MS	6.16E+06	4.99E+06	4.18E+06	3.60E+06
<u>Total</u>				
SS	3.03E+08	2.44E+08	2.04E+08	1.74E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 27-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 35%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	85250	76150	69900	64202
Average	3552.0833	3172.9167	2912.5	2675.0833
<u>Summary for 35 % Group</u>				
Count	24	24	24	24
Sum	125140	108050	97705	88840.5
Average	5214.1667	4502.0833	4071.0417	3701.6875
<u>Between Groups</u>				
SS	3.32E+07	2.12E+07	1.61E+07	1.26E+07
df	1	1	1	1
MS	3.32E+07	2.12E+07	1.61E+07	1.26E+07
F	2.331	1.940	1.817	1.723
P-value*	1.3E-01	1.7E-01	1.8E-01	2.0E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	6.54E+08	5.03E+08	4.08E+08	3.38E+08
df	46	46	46	46
MS	1.42E+07	1.09E+07	8.86E+06	7.34E+06
<u>Total</u>				
SS	6.87E+08	5.24E+08	4.24E+08	3.50E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 28-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 35% and 40%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 35 % Group</u>				
Count	24	24	24	24
Sum	125140	108050	97705	88840.5
Average	5214.1667	4502.0833	4071.0417	3701.6875
<u>Summary for 40 % Group</u>				
Count	24	24	24	24
Sum	170895	144950	129390	115677
Average	7120.625	6039.5833	5391.25	4819.875
<u>Between Groups</u>				
SS	4.36E+07	2.84E+07	2.09E+07	1.50E+07
df	1	1	1	1
MS	4.36E+07	2.84E+07	2.09E+07	1.50E+07
F	1.661	1.464	1.340	1.185
P-value*	2.0E-01	2.3E-01	2.5E-01	2.8E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.21E+09	8.91E+08	7.18E+08	5.83E+08
df	46	46	46	46
MS	2.63E+07	1.94E+07	1.56E+07	1.27E+07
<u>Total</u>				
SS	1.25E+09	9.19E+08	7.39E+08	5.98E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 29-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 40% and 45%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 40 % Group</u>				
Count	24	24	24	24
Sum	170895	144950	129390	115677
Average	7120.625	6039.5833	5391.25	4819.875
<u>Summary for 45 % Group</u>				
Count	24	24	24	18
Sum	286535	237700	207645	77630
Average	11938.958	9904.1667	8651.875	4312.7778
<u>Between Groups</u>				
SS	2.79E+08	1.79E+08	1.28E+08	2.64E+06
df	1	1	1	1
MS	2.79E+08	1.79E+08	1.28E+08	2.64E+06
F	4.579	4.185	3.850	0.248
P-value*	3.8E-02	4.7E-02	5.6E-02	6.2E-01
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	2.80E+09	1.97E+09	1.52E+09	4.27E+08
df	46	46	46	40
MS	6.08E+07	4.28E+07	3.31E+07	1.07E+07
<u>Total</u>				
SS	3.08E+09	2.15E+09	1.65E+09	4.29E+08
df	47	47	47	41

* Highlighted values indicate a significant difference

Table 30-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 45% and 50%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 45 % Group</u>				
Count	24	24	24	18
Sum	286535	237700	207645	77630
Average	11938.958	9904.1667	8651.875	4312.7778
<u>Summary for 50 % Group</u>				
Count	24	24	18	18
Sum	450405	358700	137240	117469
Average	18766.875	14945.833	7624.4444	6526.0556
<u>Between Groups</u>				
SS	5.59E+08	3.05E+08	1.09E+07	4.41E+07
df	1	1	1	1
MS	5.59E+08	3.05E+08	1.09E+07	4.41E+07
F	4.291	3.324	0.339	6.605
P-value*	4.4E-02	7.5E-02	5.6E-01	1.5E-02
F crit	4.052	4.052	4.085	4.130
<u>Within Groups</u>				
SS	6.00E+09	4.22E+09	1.28E+09	2.27E+08
df	46	46	40	34
MS	1.30E+08	9.18E+07	3.20E+07	6.67E+06
<u>Total</u>				
SS	6.56E+09	4.53E+09	1.29E+09	2.71E+08
df	47	47	41	35

* Highlighted values indicate a significant difference

Table 31-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 10%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	9000	7650	7800	7800
Average	375	318.75	325	325
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	15875	14400	14225	13976.5
Average	661.45833	600	592.70833	582.35417
<u>Between Groups</u>				
SS	9.85E+05	9.49E+05	8.60E+05	7.95E+05
df	1	1	1	1
MS	9.85E+05	9.49E+05	8.60E+05	7.95E+05
F	4.714	5.493	4.994	4.831
P-value*	3.5E-02	2.3E-02	3.0E-02	3.3E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	9.61E+06	7.95E+06	7.92E+06	7.57E+06
df	46	46	46	46
MS	2.09E+05	1.73E+05	1.72E+05	1.65E+05
<u>Total</u>				
SS	1.06E+07	8.90E+06	8.78E+06	8.36E+06
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 32-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 10% and 20%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	15875	14400	14225	13976.5
Average	661.45833	600	592.70833	582.35417
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	32750	29900	28775	27565.5
Average	1364.5833	1245.8333	1198.9583	1148.5625
<u>Between Groups</u>				
SS	5.93E+06	5.01E+06	4.41E+06	3.85E+06
df	1	1	1	1
MS	5.93E+06	5.01E+06	4.41E+06	3.85E+06
F	7.361	7.434	6.917	6.520
P-value*	9.3E-03	9.0E-03	1.2E-02	1.4E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	3.71E+07	3.10E+07	2.93E+07	2.71E+07
df	46	46	46	46
MS	8.06E+05	6.73E+05	6.38E+05	5.90E+05
<u>Total</u>				
SS	4.30E+07	3.60E+07	3.37E+07	3.10E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 33-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 30%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	32750	29900	28775	27565.5
Average	1364.5833	1245.8333	1198.9583	1148.5625
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	85250	76150	69900	64202
Average	3552.0833	3172.9167	2912.5	2675.0833
<u>Between Groups</u>				
SS	5.74E+07	4.46E+07	3.52E+07	2.80E+07
df	1	1	1	1
MS	5.74E+07	4.46E+07	3.52E+07	2.80E+07
F	11.834	11.363	10.727	9.912
P-value*	1.2E-03	1.5E-03	2.0E-03	2.9E-03
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	2.23E+08	1.80E+08	1.51E+08	1.30E+08
df	46	46	46	46
MS	4.85E+06	3.92E+06	3.28E+06	2.82E+06
<u>Total</u>				
SS	2.81E+08	2.25E+08	1.86E+08	1.58E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 34-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 40%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	85250	76150	69900	64202
Average	3552.0833	3172.9167	2912.5	2675.0833
<u>Summary for 40 % Group</u>				
Count	24	24	24	24
Sum	170895	144950	129390	115677
Average	7120.625	6039.5833	5391.25	4819.875
<u>Between Groups</u>				
SS	1.53E+08	9.86E+07	7.37E+07	5.52E+07
df	1	1	1	1
MS	1.53E+08	9.86E+07	7.37E+07	5.52E+07
F	7.472	6.481	5.994	5.495
P-value*	8.9E-03	1.4E-02	1.8E-02	2.3E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	9.41E+08	7.00E+08	5.66E+08	4.62E+08
df	46	46	46	46
MS	2.05E+07	1.52E+07	1.23E+07	1.00E+07
<u>Total</u>				
SS	1.09E+09	7.99E+08	6.40E+08	5.17E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 35-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 40% and 50%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 40 % Group</u>				
Count	24	24	24	24
Sum	170895	144950	129390	115677
Average	7120.625	6039.5833	5391.25	4819.875
<u>Summary for 50 % Group</u>				
Count	24	24	18	18
Sum	450405	358700	137240	117469
Average	18766.875	14945.833	7624.4444	6526.0556
<u>Between Groups</u>				
SS	1.63E+09	9.52E+08	5.13E+07	2.99E+07
df	1	1	1	1
MS	1.63E+09	9.52E+08	5.13E+07	2.99E+07
F	15.951	13.109	3.251	2.360
P-value*	2.3E-04	7.3E-04	7.9E-02	1.3E-01
F crit	4.052	4.052	4.085	4.085
<u>Within Groups</u>				
SS	4.69E+09	3.34E+09	6.31E+08	5.07E+08
df	46	46	40	40
MS	1.02E+08	7.26E+07	1.58E+07	1.27E+07
<u>Total</u>				
SS	6.32E+09	4.29E+09	6.82E+08	5.37E+08
df	47	47	41	41

* Highlighted values indicate a significant difference

Table 36-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 15%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	9000	7650	7800	7800
Average	375	318.75	325	325
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	24125	22350	22050	21351
Average	1005.2083	931.25	918.75	889.625
<u>Between Groups</u>				
SS	4.77E+06	4.50E+06	4.23E+06	3.83E+06
df	1	1	1	1
MS	4.77E+06	4.50E+06	4.23E+06	3.83E+06
F	13.150	13.734	13.284	12.583
P-value*	7.2E-04	5.6E-04	6.8E-04	9.1E-04
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.67E+07	1.51E+07	1.46E+07	1.40E+07
df	46	46	46	46
MS	3.62E+05	3.28E+05	3.18E+05	3.04E+05
<u>Total</u>				
SS	2.14E+07	1.96E+07	1.89E+07	1.78E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 37-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 15% and 30%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	24125	22350	22050	21351
Average	1005.2083	931.25	918.75	889.625
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	85250	76150	69900	64202
Average	3552.0833	3172.9167	2912.5	2675.0833
<u>Between Groups</u>				
SS	7.78E+07	6.03E+07	4.77E+07	3.83E+07
df	1	1	1	1
MS	7.78E+07	6.03E+07	4.77E+07	3.83E+07
F	17.195	16.397	15.587	14.566
P-value*	1.4E-04	2.0E-04	2.7E-04	4.0E-04
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	2.08E+08	1.69E+08	1.41E+08	1.21E+08
df	46	46	46	46
MS	4.53E+06	3.68E+06	3.06E+06	2.63E+06
<u>Total</u>				
SS	2.86E+08	2.29E+08	1.88E+08	1.59E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 38-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 45%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	85250	76150	69900	64202
Average	3552.0833	3172.9167	2912.5	2675.0833
<u>Summary for 45 % Group</u>				
Count	24	24	24	18
Sum	286535	237700	207645	77630
Average	11938.958	9904.1667	8651.875	4312.7778
<u>Between Groups</u>				
SS	8.44E+08	5.44E+08	3.95E+08	2.76E+07
df	1	1	1	1
MS	8.44E+08	5.44E+08	3.95E+08	2.76E+07
F	17.295	15.818	14.975	6.076
P-value*	1.4E-04	2.4E-04	3.4E-04	1.8E-02
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	2.25E+09	1.58E+09	1.21E+09	1.82E+08
df	46	46	46	40
MS	4.88E+07	3.44E+07	2.64E+07	4.54E+06
<u>Total</u>				
SS	3.09E+09	2.12E+09	1.61E+09	2.09E+08
df	47	47	47	41

* Highlighted values indicate a significant difference

Table 39-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 20%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	9000	7650	7800	7800
Average	375	318.75	325	325
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	32750	29900	28775	27565.5
Average	1364.5833	1245.8333	1198.9583	1148.5625
<u>Between Groups</u>				
SS	1.18E+07	1.03E+07	9.17E+06	8.14E+06
df	1	1	1	1
MS	1.18E+07	1.03E+07	9.17E+06	8.14E+06
F	17.077	18.027	16.888	16.310
P-value*	1.5E-04	1.0E-04	1.6E-04	2.0E-04
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	3.17E+07	2.63E+07	2.50E+07	2.30E+07
df	46	46	46	46
MS	6.88E+05	5.72E+05	5.43E+05	4.99E+05
<u>Total</u>				
SS	4.34E+07	3.66E+07	3.41E+07	3.11E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 40-C. ANOVA Results for Binder B (PG 70-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 40%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	32750	29900	28775	27565.5
Average	1364.5833	1245.8333	1198.9583	1148.5625
<u>Summary for 40 % Group</u>				
Count	24	24	24	24
Sum	170895	144950	129390	115677
Average	7120.625	6039.5833	5391.25	4819.875
<u>Between Groups</u>				
SS	3.98E+08	2.76E+08	2.11E+08	1.62E+08
df	1	1	1	1
MS	3.98E+08	2.76E+08	2.11E+08	1.62E+08
F	23.547	22.298	21.038	19.849
P-value*	1.4E-05	2.2E-05	3.5E-05	5.3E-05
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	7.77E+08	5.69E+08	4.61E+08	3.75E+08
df	46	46	46	46
MS	1.69E+07	1.24E+07	1.00E+07	8.15E+06
<u>Total</u>				
SS	1.17E+09	8.45E+08	6.72E+08	5.37E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 41-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 5%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	12375	11550	11625	11553
Average	515.625	481.25	484.375	481.375
<u>Summary for 5 % Group</u>				
Count	24	24	24	24
Sum	16500	14900	14975	14790.5
Average	687.5	620.83333	623.95833	616.27083
<u>Between Groups</u>				
SS	3.54E+05	2.34E+05	2.34E+05	2.18E+05
df	1	1	1	1
MS	3.54E+05	2.34E+05	2.34E+05	2.18E+05
F	1.354	0.967	0.948	0.889
P-value*	2.5E-01	3.3E-01	3.4E-01	3.5E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.20E+07	1.11E+07	1.13E+07	1.13E+07
df	46	46	46	46
MS	2.62E+05	2.42E+05	2.47E+05	2.46E+05
<u>Total</u>				
SS	1.24E+07	1.14E+07	1.16E+07	1.15E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 42-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 5% and 10%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 5 % Group</u>				
Count	24	24	24	24
Sum	16500	14900	14975	14790.5
Average	687.5	620.83333	623.95833	616.27083
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	25875	24000	23325	22850.5
Average	1078.125	1000	971.875	952.10417
<u>Between Groups</u>				
SS	1.83E+06	1.73E+06	1.45E+06	1.35E+06
df	1	1	1	1
MS	1.83E+06	1.73E+06	1.45E+06	1.35E+06
F	2.575	2.694	2.347	2.298
P-value*	1.2E-01	1.1E-01	1.3E-01	1.4E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	3.27E+07	2.95E+07	2.85E+07	2.71E+07
df	46	46	46	46
MS	7.11E+05	6.40E+05	6.19E+05	5.89E+05
<u>Total</u>				
SS	3.45E+07	3.12E+07	2.99E+07	2.84E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 43-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 10% and 15%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	25875	24000	23325	22850.5
Average	1078.125	1000	971.875	952.10417
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	32625	31000	30475	29926
Average	1359.375	1291.6667	1269.7917	1246.9167
<u>Between Groups</u>				
SS	9.49E+05	1.02E+06	1.07E+06	1.04E+06
df	1	1	1	1
MS	9.49E+05	1.02E+06	1.07E+06	1.04E+06
F	0.730	0.853	0.939	0.972
P-value*	4.0E-01	3.6E-01	3.4E-01	3.3E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	5.98E+07	5.50E+07	5.22E+07	4.93E+07
df	46	46	46	46
MS	1.30E+06	1.20E+06	1.13E+06	1.07E+06
<u>Total</u>				
SS	6.08E+07	5.60E+07	5.32E+07	5.04E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 44-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 15% and 20%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	32625	31000	30475	29926
Average	1359.375	1291.6667	1269.7917	1246.9167
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	47000	43950	42750	41242
Average	1958.3333	1831.25	1781.25	1718.4167
<u>Between Groups</u>				
SS	4.31E+06	3.49E+06	3.14E+06	2.67E+06
df	1	1	1	1
MS	4.31E+06	3.49E+06	3.14E+06	2.67E+06
F	1.977	1.741	1.658	1.499
P-value*	1.7E-01	1.9E-01	2.0E-01	2.3E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	1.00E+08	9.23E+07	8.71E+07	8.19E+07
df	46	46	46	46
MS	2.18E+06	2.01E+06	1.89E+06	1.78E+06
<u>Total</u>				
SS	1.04E+08	9.58E+07	9.02E+07	8.45E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 45-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 25%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	47000	43950	42750	41242
Average	1958.3333	1831.25	1781.25	1718.4167
<u>Summary for 25 % Group</u>				
Count	24	24	24	24
Sum	73500	67450	63825	60516.5
Average	3062.5	2810.4167	2659.375	2521.5208
<u>Between Groups</u>				
SS	1.46E+07	1.15E+07	9.25E+06	7.74E+06
df	1	1	1	1
MS	1.46E+07	1.15E+07	9.25E+06	7.74E+06
F	3.094	2.722	2.426	2.231
P-value*	8.5E-02	1.1E-01	1.3E-01	1.4E-01
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	2.17E+08	1.94E+08	1.75E+08	1.60E+08
df	46	46	46	46
MS	4.73E+06	4.23E+06	3.81E+06	3.47E+06
<u>Total</u>				
SS	2.32E+08	2.06E+08	1.85E+08	1.67E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 46-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 25% and 30%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 25 % Group</u>				
Count	24	24	24	24
Sum	73500	67450	63825	60516.5
Average	3062.5	2810.4167	2659.375	2521.5208
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	145645	126000	114150	103257
Average	6068.5417	5250	4756.25	4302.375
<u>Between Groups</u>				
SS	1.08E+08	7.14E+07	5.28E+07	3.81E+07
df	1	1	1	1
MS	1.08E+08	7.14E+07	5.28E+07	3.81E+07
F	7.060	5.855	5.098	4.351
P-value*	1.1E-02	2.0E-02	2.9E-02	4.3E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	7.07E+08	5.61E+08	4.76E+08	4.02E+08
df	46	46	46	46
MS	1.54E+07	1.22E+07	1.03E+07	8.75E+06
<u>Total</u>				
SS	8.15E+08	6.32E+08	5.29E+08	4.40E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 47-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 35%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	145645	126000	114150	103257
Average	6068.5417	5250	4756.25	4302.375
<u>Summary for 35 % Group</u>				
Count	24	24	24	18
Sum	182025	158500	142095	51855
Average	7584.375	6604.1667	5920.625	2880.8333
<u>Between Groups</u>				
SS	2.76E+07	2.20E+07	1.63E+07	2.08E+07
df	1	1	1	1
MS	2.76E+07	2.20E+07	1.63E+07	2.08E+07
F	0.854	0.885	0.805	2.532
P-value*	3.6E-01	3.5E-01	3.7E-01	1.2E-01
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	1.49E+09	1.14E+09	9.29E+08	3.28E+08
df	46	46	46	40
MS	3.23E+07	2.49E+07	2.02E+07	8.21E+06
<u>Total</u>				
SS	1.51E+09	1.17E+09	9.46E+08	3.49E+08
df	47	47	47	41

* Highlighted values indicate a significant difference

Table 48-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 35% and 40%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 35 % Group</u>				
Count	24	24	24	18
Sum	182025	158500	142095	51855
Average	7584.375	6604.1667	5920.625	2880.8333
<u>Summary for 40 % Group</u>				
Count	24	24	24	18
Sum	250145	212250	187195	66742
Average	10422.708	8843.75	7799.7917	3707.8889
<u>Between Groups</u>				
SS	9.67E+07	6.02E+07	4.24E+07	6.16E+06
df	1	1	1	1
MS	9.67E+07	6.02E+07	4.24E+07	6.16E+06
F	1.705	1.412	1.245	2.373
P-value*	2.0E-01	2.4E-01	2.7E-01	1.3E-01
F crit	4.052	4.052	4.052	4.130
<u>Within Groups</u>				
SS	2.61E+09	1.96E+09	1.57E+09	8.82E+07
df	46	46	46	34
MS	5.67E+07	4.26E+07	3.40E+07	2.59E+06
<u>Total</u>				
SS	2.70E+09	2.02E+09	1.61E+09	9.44E+07
df	47	47	47	35

* Highlighted values indicate a significant difference

Table 49-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 40% and 45%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 40 % Group</u>				
Count	24	24	24	18
Sum	250145	212250	187195	66742
Average	10422.708	8843.75	7799.7917	3707.8889
<u>Summary for 45 % Group</u>				
Count	24	24	18	18
Sum	398535	326000	113345	98991
Average	16605.625	13583.333	6296.9444	5499.5
<u>Between Groups</u>				
SS	4.59E+08	2.70E+08	2.32E+07	2.89E+07
df	1	1	1	1
MS	4.59E+08	2.70E+08	2.32E+07	2.89E+07
F	3.391	2.857	0.805	5.254
P-value*	7.2E-02	9.8E-02	3.7E-01	2.8E-02
F crit	4.052	4.052	4.085	4.130
<u>Within Groups</u>				
SS	6.22E+09	4.34E+09	1.15E+09	1.87E+08
df	46	46	40	34
MS	1.35E+08	9.44E+07	2.89E+07	5.50E+06
<u>Total</u>				
SS	6.68E+09	4.61E+09	1.18E+09	2.16E+08
df	47	47	41	35

* Highlighted values indicate a significant difference

Table 50-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 45% and 50%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 45 % Group</u>				
Count	24	24	18	18
Sum	398535	326000	113345	98991
Average	16605.625	13583.333	6296.9444	5499.5
<u>Summary for 50 % Group</u>				
Count	24	18	18	12
Sum	741580	242300	201630	78166
Average	30899.167	13461.111	11201.667	6513.8333
<u>Between Groups</u>				
SS	2.45E+09	1.54E+05	2.17E+08	7.41E+06
df	1	1	1	1
MS	2.45E+09	1.54E+05	2.17E+08	7.41E+06
F	6.200	0.002	10.940	1.241
P-value*	1.6E-02	9.7E-01	2.2E-03	2.7E-01
F crit	4.052	4.085	4.130	4.196
<u>Within Groups</u>				
SS	1.82E+10	3.76E+09	6.73E+08	1.67E+08
df	46	40	34	28
MS	3.95E+08	9.41E+07	1.98E+07	5.97E+06
<u>Total</u>				
SS	2.06E+10	3.76E+09	8.89E+08	1.74E+08
df	47	41	35	29

* Highlighted values indicate a significant difference

Table 51-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 10%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	12375	11550	11625	11553
Average	515.625	481.25	484.375	481.375
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	25875	24000	23325	22850.5
Average	1078.125	1000	971.875	952.10417
<u>Between Groups</u>				
SS	3.80E+06	3.23E+06	2.85E+06	2.66E+06
df	1	1	1	1
MS	3.80E+06	3.23E+06	2.85E+06	2.66E+06
F	6.061	5.670	5.269	5.166
P-value*	1.8E-02	2.1E-02	2.6E-02	2.8E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	2.88E+07	2.62E+07	2.49E+07	2.37E+07
df	46	46	46	46
MS	6.26E+05	5.70E+05	5.41E+05	5.15E+05
<u>Total</u>				
SS	3.26E+07	2.94E+07	2.77E+07	2.63E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 52-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 10% and 20%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 10 % Group</u>				
Count	24	24	24	24
Sum	25875	24000	23325	22850.5
Average	1078.125	1000	971.875	952.10417
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	47000	43950	42750	41242
Average	1958.3333	1831.25	1781.25	1718.4167
<u>Between Groups</u>				
SS	9.30E+06	8.29E+06	7.86E+06	7.05E+06
df	1	1	1	1
MS	9.30E+06	8.29E+06	7.86E+06	7.05E+06
F	4.761	4.662	4.699	4.503
P-value*	3.4E-02	3.6E-02	3.5E-02	3.9E-02
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	8.98E+07	8.18E+07	7.70E+07	7.20E+07
df	46	46	46	46
MS	1.95E+06	1.78E+06	1.67E+06	1.56E+06
<u>Total</u>				
SS	9.91E+07	9.01E+07	8.48E+07	7.90E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 53-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 30%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	47000	43950	42750	41242
Average	1958.3333	1831.25	1781.25	1718.4167
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	145645	126000	114150	103257
Average	6068.5417	5250	4756.25	4302.375
<u>Between Groups</u>				
SS	2.03E+08	1.40E+08	1.06E+08	8.01E+07
df	1	1	1	1
MS	2.03E+08	1.40E+08	1.06E+08	8.01E+07
F	15.061	13.283	11.844	10.612
P-value*	3.3E-04	6.8E-04	1.2E-03	2.1E-03
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	6.19E+08	4.86E+08	4.12E+08	3.47E+08
df	46	46	46	46
MS	1.35E+07	1.06E+07	8.97E+06	7.55E+06
<u>Total</u>				
SS	8.22E+08	6.26E+08	5.19E+08	4.27E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 54-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 40%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	145645	126000	114150	103257
Average	6068.5417	5250	4756.25	4302.375
<u>Summary for 40 % Group</u>				
Count	24	24	24	18
Sum	250145	212250	187195	66742
Average	10422.708	8843.75	7799.7917	3707.8889
<u>Between Groups</u>				
SS	2.28E+08	1.55E+08	1.11E+08	3.64E+06
df	1	1	1	1
MS	2.28E+08	1.55E+08	1.11E+08	3.64E+06
F	4.691	4.268	3.788	0.415
P-value*	3.6E-02	4.5E-02	5.8E-02	5.2E-01
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	2.23E+09	1.67E+09	1.35E+09	3.50E+08
df	46	46	46	40
MS	4.85E+07	3.63E+07	2.93E+07	8.75E+06
<u>Total</u>				
SS	2.46E+09	1.83E+09	1.46E+09	3.54E+08
df	47	47	47	41

* Highlighted values indicate a significant difference

Table 55-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 40% and 50%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 40 % Group</u>				
Count	24	24	24	18
Sum	250145	212250	187195	66742
Average	10422.708	8843.75	7799.7917	3707.8889
<u>Summary for 50 % Group</u>				
Count	24	18	18	12
Sum	741580	242300	201630	78166
Average	30899.167	13461.111	11201.667	6513.8333
<u>Between Groups</u>				
SS	5.03E+09	2.19E+08	1.19E+08	5.67E+07
df	1	1	1	1
MS	5.03E+09	2.19E+08	1.19E+08	5.67E+07
F	15.105	4.586	3.163	17.632
P-value*	3.2E-04	3.8E-02	8.3E-02	2.5E-04
F crit	4.052	4.085	4.085	4.196
<u>Within Groups</u>				
SS	1.53E+10	1.91E+09	1.51E+09	9.00E+07
df	46	40	40	28
MS	3.33E+08	4.78E+07	3.76E+07	3.22E+06
<u>Total</u>				
SS	2.04E+10	2.13E+09	1.62E+09	1.47E+08
df	47	41	41	29

* Highlighted values indicate a significant difference

Table 56-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 15%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	12375	11550	11625	11553
Average	515.625	481.25	484.375	481.375
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	32625	31000	30475	29926
Average	1359.375	1291.6667	1269.7917	1246.9167
<u>Between Groups</u>				
SS	8.54E+06	7.88E+06	7.40E+06	7.03E+06
df	1	1	1	1
MS	8.54E+06	7.88E+06	7.40E+06	7.03E+06
F	10.031	9.883	9.723	9.644
P-value*	2.7E-03	2.9E-03	3.1E-03	3.2E-03
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	3.92E+07	3.67E+07	3.50E+07	3.35E+07
df	46	46	46	46
MS	8.52E+05	7.97E+05	7.61E+05	7.29E+05
<u>Total</u>				
SS	4.77E+07	4.46E+07	4.24E+07	4.06E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 57-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 15% and 30%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 15 % Group</u>				
Count	24	24	24	24
Sum	32625	31000	30475	29926
Average	1359.375	1291.6667	1269.7917	1246.9167
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	145645	126000	114150	103257
Average	6068.5417	5250	4756.25	4302.375
<u>Between Groups</u>				
SS	2.66E+08	1.88E+08	1.46E+08	1.12E+08
df	1	1	1	1
MS	2.66E+08	1.88E+08	1.46E+08	1.12E+08
F	20.776	18.847	17.307	15.873
P-value*	3.8E-05	7.7E-05	1.4E-04	2.4E-04
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	5.89E+08	4.59E+08	3.88E+08	3.25E+08
df	46	46	46	46
MS	1.28E+07	9.98E+06	8.43E+06	7.06E+06
<u>Total</u>				
SS	8.55E+08	6.47E+08	5.34E+08	4.37E+08
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 58-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 30% and 45%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 30 % Group</u>				
Count	24	24	24	24
Sum	145645	126000	114150	103257
Average	6068.5417	5250	4756.25	4302.375
<u>Summary for 45 % Group</u>				
Count	24	24	18	18
Sum	398535	326000	113345	98991
Average	16605.625	13583.333	6296.9444	5499.5
<u>Between Groups</u>				
SS	1.33E+09	8.33E+08	2.44E+07	1.47E+07
df	1	1	1	1
MS	1.33E+09	8.33E+08	2.44E+07	1.47E+07
F	12.018	10.882	1.887	1.381
P-value*	1.2E-03	1.9E-03	1.8E-01	2.5E-01
F crit	4.052	4.052	4.085	4.085
<u>Within Groups</u>				
SS	5.10E+09	3.52E+09	5.18E+08	4.27E+08
df	46	46	40	40
MS	1.11E+08	7.66E+07	1.29E+07	1.07E+07
<u>Total</u>				
SS	6.43E+09	4.36E+09	5.42E+08	4.42E+08
df	47	47	41	41

* Highlighted values indicate a significant difference

Table 59-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 0% and 20%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 0 % Group</u>				
Count	24	24	24	24
Sum	12375	11550	11625	11553
Average	515.625	481.25	484.375	481.375
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	47000	43950	42750	41242
Average	1958.3333	1831.25	1781.25	1718.4167
<u>Between Groups</u>				
SS	2.50E+07	2.19E+07	2.02E+07	1.84E+07
df	1	1	1	1
MS	2.50E+07	2.19E+07	2.02E+07	1.84E+07
F	16.614	15.851	15.519	15.031
P-value*	1.8E-04	2.4E-04	2.8E-04	3.3E-04
F crit	4.052	4.052	4.052	4.052
<u>Within Groups</u>				
SS	6.92E+07	6.35E+07	5.98E+07	5.62E+07
df	46	46	46	46
MS	1.50E+06	1.38E+06	1.30E+06	1.22E+06
<u>Total</u>				
SS	9.41E+07	8.53E+07	8.00E+07	7.46E+07
df	47	47	47	47

* Highlighted values indicate a significant difference

Table 60-C. ANOVA Results for Binder C (PG 76-22) at the Four Evaluated Testing Shearing Rates Between RAR Contents 20% and 40%.

Source of Variation	Testing RPM			
	2 RPM	5 RPM	10 RPM	20 RPM
<u>Summary for 20 % Group</u>				
Count	24	24	24	24
Sum	47000	43950	42750	41242
Average	1958.3333	1831.25	1781.25	1718.4167
<u>Summary for 40 % Group</u>				
Count	24	24	24	18
Sum	250145	212250	187195	66742
Average	10422.708	8843.75	7799.7917	3707.8889
<u>Between Groups</u>				
SS	8.60E+08	5.90E+08	4.35E+08	4.07E+07
df	1	1	1	1
MS	8.60E+08	5.90E+08	4.35E+08	4.07E+07
F	22.702	20.818	19.056	15.192
P-value*	1.9E-05	3.8E-05	7.1E-05	3.6E-04
F crit	4.052	4.052	4.052	4.085
<u>Within Groups</u>				
SS	1.74E+09	1.30E+09	1.05E+09	1.07E+08
df	46	46	46	40
MS	3.79E+07	2.83E+07	2.28E+07	2.68E+06
<u>Total</u>				
SS	2.60E+09	1.89E+09	1.48E+09	1.48E+08
df	47	47	47	41

* Highlighted values indicate a significant difference

Appendix D. Testing Shearing Rate Analysis of Variance Results for Binders A, B, and C

Table 1-D. ANOVA Results for Binder A (PG 64-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 5 RPM and 20 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 5 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	24
Sum	6000	7500	11550	14400	21550	36850	57450	77150	129850	164500	277850
Average	250	312.5	481.25	600	897.91667	1535.4167	2393.75	3214.5833	5410.4167	6854.1667	11577.083
<u>Summary for 20 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	21	18
Sum	5737.5	7375	11465.5	14051	20401.5	33116.5	49202.5	64542.5	103704	92380	89406
Average	239.0625	307.29167	477.72917	585.45833	850.0625	1379.8542	2050.1042	2689.2708	4321	4399.0476	4967
<u>Between Groups</u>											
SS	1.44E+03	3.26E+02	1.49E+02	2.54E+03	2.75E+04	2.90E+05	1.42E+06	3.31E+06	1.42E+07	6.75E+07	4.49E+08
df	1.00E+00	1	1	1	1	1	1	1	1	1	1
MS	1.44E+03	3.26E+02	1.49E+02	2.54E+03	2.75E+04	2.90E+05	1.42E+06	3.31E+06	1.42E+07	6.75E+07	4.49E+08
F	0.035	0.004	0.001	0.009	0.046	0.168	0.395	0.545	0.971	3.270	8.931
P-value*	8.5E-01	9.5E-01	9.8E-01	9.2E-01	8.3E-01	6.8E-01	5.3E-01	4.6E-01	3.3E-01	7.8E-02	4.8E-03
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.067	4.085
<u>Within Groups</u>											
SS	1.86E+06	3.94E+06	7.98E+06	1.24E+07	2.78E+07	7.94E+07	1.65E+08	2.80E+08	6.74E+08	8.88E+08	2.01E+09
df	4.60E+01	46	46	46	46	46	46	46	46	43	40
MS	4.05E+04	8.57E+04	1.74E+05	2.70E+05	6.04E+05	1.73E+06	3.59E+06	6.08E+06	1.47E+07	2.06E+07	5.03E+07
<u>Total</u>											
SS	1.87E+06	3.94E+06	7.98E+06	1.24E+07	2.78E+07	7.97E+07	1.66E+08	2.83E+08	6.89E+08	9.55E+08	2.46E+09
df	4.70E+01	47	47	47	47	47	47	47	47	44	41

* Highlighted values indicate a significant difference

Table 2-D. ANOVA Results for Binder A (PG 64-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 20 RPM and 50 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 20 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	21	18
Sum	5737.5	7375	11465.5	14051	20401.5	33116.5	49202.5	64542.5	103704	92380	89406
Average	239.0625	307.29167	477.72917	585.45833	850.0625	1379.8542	2050.1042	2689.2708	4321	4399.0476	4967
<u>Summary for 50 RPM Group</u>											
Count	24	24	24	24	24	24	24	18	18	18	12
Sum	5685	7310	11350	13670	19490	30760	44440	23685	37595	48425	32755
Average	236.875	304.58333	472.91667	569.58333	812.08333	1281.6667	1851.6667	1315.8333	2088.6111	2690.2778	2729.5833
<u>Between Groups</u>											
SS	5.74E+01	8.80E+01	2.78E+02	3.02E+03	1.73E+04	1.16E+05	4.73E+05	1.94E+07	5.13E+07	2.83E+07	3.60E+07
df	1	1	1	1	1	1	1	1	1	1	1
MS	5.74E+01	8.80E+01	2.78E+02	3.02E+03	1.73E+04	1.16E+05	4.73E+05	1.94E+07	5.13E+07	2.83E+07	3.60E+07
F	0.001	0.001	0.002	0.012	0.032	0.084	0.175	6.304	7.078	3.881	9.310
P-value*	9.7E-01	9.7E-01	9.7E-01	9.1E-01	8.6E-01	7.7E-01	6.8E-01	1.6E-02	1.1E-02	5.6E-02	4.9E-03
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.085	4.085	4.105	4.196
<u>Within Groups</u>											
SS	1.76E+06	3.53E+06	7.92E+06	1.19E+07	2.47E+07	6.34E+07	1.25E+08	1.23E+08	2.90E+08	2.70E+08	1.08E+08
df	46	46	46	46	46	46	46	40	40	37	28
MS	3.83E+04	7.67E+04	1.72E+05	2.58E+05	5.36E+05	1.38E+06	2.71E+06	3.08E+06	7.24E+06	7.29E+06	3.87E+06
<u>Total</u>											
SS	1.76E+06	3.53E+06	7.92E+06	1.19E+07	2.47E+07	6.35E+07	1.25E+08	1.43E+08	3.41E+08	2.98E+08	1.44E+08
df	47	47	47	47	47	47	47	41	41	38	29

* Highlighted values indicate a significant difference

Table 3-D. ANOVA Results for Binder A (PG 64-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 50 RPM and 100 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 50 RPM Group</u>											
Count	24	24	24	24	24	24	24	18	18	18	12
Sum	5685	7310	11350	13670	19490	30760	44440	23685	37595	48425	32755
Average	236.875	304.58333	472.91667	569.58333	812.08333	1281.6667	1851.6667	1315.8333	2088.6111	2690.2778	2729.5833
<u>Summary for 100 RPM Group</u>											
Count	24	24	24	24	24	18	18	18	12	12	6
Sum	5640	7255	11197	13359	18758.5	11699	16967	21850.5	14958.5	19380	10623
Average	235	302.29167	466.54167	556.625	781.60417	649.94444	942.61111	1213.9167	1246.5417	1615	1770.5
<u>Between Groups</u>											
SS	4.22E+01	6.30E+01	4.88E+02	2.02E+03	1.11E+04	4.10E+06	8.50E+06	9.35E+04	5.11E+06	8.32E+06	3.68E+06
df	1	1	1	1	1	1	1	1	1	1	1
MS	4.22E+01	6.30E+01	4.88E+02	2.02E+03	1.11E+04	4.10E+06	8.50E+06	9.35E+04	5.11E+06	8.32E+06	3.68E+06
F	0.001	0.001	0.003	0.008	0.023	5.302	5.733	0.217	7.354	7.276	10.110
P-value*	9.7E-01	9.8E-01	9.6E-01	9.3E-01	8.8E-01	2.7E-02	2.1E-02	6.4E-01	1.1E-02	1.2E-02	5.8E-03
F crit	4.052	4.052	4.052	4.052	4.052	4.085	4.085	4.130	4.196	4.196	4.494
<u>Within Groups</u>											
SS	1.75E+06	3.32E+06	7.56E+06	1.12E+07	2.21E+07	3.10E+07	5.93E+07	1.46E+07	1.94E+07	3.20E+07	5.82E+06
df	46	46	46	46	46	40	40	34	28	28	16
MS	3.81E+04	7.23E+04	1.64E+05	2.43E+05	4.81E+05	7.74E+05	1.48E+06	4.31E+05	6.94E+05	1.14E+06	3.64E+05
<u>Total</u>											
SS	1.75E+06	3.32E+06	7.56E+06	1.12E+07	2.21E+07	3.51E+07	6.78E+07	1.47E+07	2.45E+07	4.04E+07	9.50E+06
df	47	47	47	47	47	41	41	35	29	29	17

* Highlighted values indicate a significant difference

Table 4-D. ANOVA Results for Binder B (PG 64-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 2 RPM and 5 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 2 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	24
Sum	9000	11750	15875	24125	32750	54750	85250	125140	170895	286535	450405
Average	375	489.58333	661.45833	1005.2083	1364.5833	2281.25	3552.0833	5214.1667	7120.625	11938.958	18766.875
<u>Summary for 5 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	24
Sum	7650	10350	14400	22350	29900	49450	76150	108050	144950	237700	358700
Average	318.75	431.25	600	931.25	1245.8333	2060.4167	3172.9167	4502.0833	6039.5833	9904.1667	14945.833
<u>Between Groups</u>											
SS	3.80E+04	4.08E+04	4.53E+04	6.56E+04	1.69E+05	5.85E+05	1.73E+06	6.08E+06	1.40E+07	4.97E+07	1.75E+08
df	1.00E+00	1	1	1	1	1	1	1	1	1	1
MS	3.80E+04	4.08E+04	4.53E+04	6.56E+04	1.69E+05	5.85E+05	1.73E+06	6.08E+06	1.40E+07	4.97E+07	1.75E+08
F	0.467	0.270	0.151	0.108	0.144	0.165	0.227	0.347	0.500	0.657	1.195
P-value*	5.0E-01	6.1E-01	7.0E-01	7.4E-01	7.1E-01	6.9E-01	6.4E-01	5.6E-01	4.8E-01	4.2E-01	2.8E-01
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052
<u>Within Groups</u>											
SS	3.74E+06	6.95E+06	1.38E+07	2.80E+07	5.42E+07	1.63E+08	3.49E+08	8.07E+08	1.29E+09	3.48E+09	6.74E+09
df	4.60E+01	46	46	46	46	46	46	46	46	46	46
MS	8.14E+04	1.51E+05	3.00E+05	6.09E+05	1.18E+06	3.55E+06	7.60E+06	1.76E+07	2.81E+07	7.56E+07	1.47E+08
<u>Total</u>											
SS	3.78E+06	6.99E+06	1.39E+07	2.81E+07	5.44E+07	1.64E+08	3.51E+08	8.14E+08	1.31E+09	3.53E+09	6.92E+09
df	4.70E+01	47	47	47	47	47	47	47	47	47	47

* Highlighted values indicate a significant difference

Table 5-D. ANOVA Results for Binder B (PG 64-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 5 RPM and 10 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 5 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	24
Sum	7650	10350	14400	22350	29900	49450	76150	108050	144950	237700	358700
Average	318.75	431.25	600	931.25	1245.8333	2060.4167	3172.9167	4502.0833	6039.5833	9904.1667	14945.833
<u>Summary for 10 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	18
Sum	7800	10275	14225	22050	28775	46625	69900	97705	129390	207645	137240
Average	325	428.125	592.70833	918.75	1198.9583	1942.7083	2912.5	4071.0417	5391.25	8651.875	7624.4444
<u>Between Groups</u>											
SS	4.69E+02	1.17E+02	6.38E+02	1.88E+03	2.64E+04	1.66E+05	8.14E+05	2.23E+06	5.04E+06	1.88E+07	5.51E+08
df	1	1	1	1	1	1	1	1	1	1	1
MS	4.69E+02	1.17E+02	6.38E+02	1.88E+03	2.64E+04	1.66E+05	8.14E+05	2.23E+06	5.04E+06	1.88E+07	5.51E+08
F	0.006	0.001	0.002	0.003	0.025	0.055	0.132	0.164	0.236	0.345	7.379
P-value*	9.4E-01	9.8E-01	9.6E-01	9.5E-01	8.7E-01	8.2E-01	7.2E-01	6.9E-01	6.3E-01	5.6E-01	9.7E-03
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.085
<u>Within Groups</u>											
SS	3.43E+06	6.72E+06	1.24E+07	2.63E+07	4.79E+07	1.38E+08	2.84E+08	6.27E+08	9.82E+08	2.51E+09	2.99E+09
df	46	46	46	46	46	46	46	46	46	46	40
MS	7.45E+04	1.46E+05	2.71E+05	5.72E+05	1.04E+06	3.00E+06	6.17E+06	1.36E+07	2.14E+07	5.46E+07	7.47E+07
<u>Total</u>											
SS	3.43E+06	6.72E+06	1.24E+07	2.63E+07	4.79E+07	1.38E+08	2.84E+08	6.29E+08	9.87E+08	2.53E+09	3.54E+09
df	47	47	47	47	47	47	47	47	47	47	41

* Highlighted values indicate a significant difference

Table 6-D. ANOVA Results for Binder B (PG 64-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 10 RPM and 20 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 10 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	18
Sum	7800	10275	14225	22050	28775	46625	69900	97705	129390	207645	137240
Average	325	428.125	592.70833	918.75	1198.9583	1942.7083	2912.5	4071.0417	5391.25	8651.875	7624.4444
<u>Summary for 20 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	18	18
Sum	7800	10001	13976.5	21351	27565.5	44041	64202	88840.5	115677	77630	117469
Average	325	416.70833	582.35417	889.625	1148.5625	1835.0417	2675.0833	3701.6875	4819.875	4312.7778	6526.0556
<u>Between Groups</u>											
SS	0.00E+00	1.56E+03	1.29E+03	1.02E+04	3.05E+04	1.39E+05	6.76E+05	1.64E+06	3.92E+06	1.94E+08	1.09E+07
df	1	1	1	1	1	1	1	1	1	1	1
MS	0.00E+00	1.56E+03	1.29E+03	1.02E+04	3.05E+04	1.39E+05	6.76E+05	1.64E+06	3.92E+06	1.94E+08	1.09E+07
F	0.000	0.011	0.005	0.019	0.032	0.053	0.132	0.148	0.228	6.681	1.064
P-value*	1.0E+00	9.2E-01	9.4E-01	8.9E-01	8.6E-01	8.2E-01	7.2E-01	7.0E-01	6.4E-01	1.3E-02	3.1E-01
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.085	4.130
<u>Within Groups</u>											
SS	3.47E+06	6.64E+06	1.20E+07	2.52E+07	4.45E+07	1.21E+08	2.36E+08	5.09E+08	7.92E+08	1.16E+09	3.47E+08
df	46	46	46	46	46	46	46	46	46	40	34
MS	7.54E+04	1.44E+05	2.61E+05	5.47E+05	9.66E+05	2.64E+06	5.14E+06	1.11E+07	1.72E+07	2.90E+07	1.02E+07
<u>Total</u>											
SS	3.47E+06	6.64E+06	1.20E+07	2.52E+07	4.45E+07	1.22E+08	2.37E+08	5.11E+08	7.95E+08	1.35E+09	3.58E+08
df	47	47	47	47	47	47	47	47	47	41	35

* Highlighted values indicate a significant difference

Table 7-D. ANOVA Results for Binder C (PG 76-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 2 RPM and 5 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 5 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	24
Sum	12375	16500	25875	32625	47000	73500	145645	182025	250145	398535	741580
Average	515.625	687.5	1078.125	1359.375	1958.3333	3062.5	6068.5417	7584.375	10422.708	16605.625	30899.167
<u>Summary for 20 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	18
Sum	11550	14900	24000	31000	43950	67450	126000	158500	212250	326000	242300
Average	481.25	620.83333	1000	1291.6667	1831.25	2810.4167	5250	6604.1667	8843.75	13583.333	13461.111
<u>Between Groups</u>											
SS	1.42E+04	5.33E+04	7.32E+04	5.50E+04	1.94E+05	7.63E+05	8.04E+06	1.15E+07	2.99E+07	1.10E+08	3.13E+09
df	1.00E+00	1	1	1	1	1	1	1	1	1	1
MS	1.42E+04	5.33E+04	7.32E+04	5.50E+04	1.94E+05	7.63E+05	8.04E+06	1.15E+07	2.99E+07	1.10E+08	3.13E+09
F	0.082	0.162	0.072	0.037	0.072	0.122	0.377	0.322	0.471	0.660	8.741
P-value*	7.8E-01	6.9E-01	7.9E-01	8.5E-01	7.9E-01	7.3E-01	5.4E-01	5.7E-01	5.0E-01	4.2E-01	5.2E-03
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.085
<u>Within Groups</u>											
SS	8.00E+06	1.52E+07	4.70E+07	6.79E+07	1.25E+08	2.87E+08	9.80E+08	1.65E+09	2.92E+09	7.64E+09	1.43E+10
df	4.60E+01	46	46	46	46	46	46	46	46	46	40
MS	1.74E+05	3.30E+05	1.02E+06	1.48E+06	2.71E+06	6.25E+06	2.13E+07	3.58E+07	6.35E+07	1.66E+08	3.58E+08
<u>Total</u>											
SS	8.02E+06	1.52E+07	4.71E+07	6.79E+07	1.25E+08	2.88E+08	9.88E+08	1.66E+09	2.95E+09	7.75E+09	1.74E+10
df	4.70E+01	47	47	47	47	47	47	47	47	47	41

* Highlighted values indicate a significant difference

Table 8-D. ANOVA Results for Binder C (PG 76-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 5 RPM and 10 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 20 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	24	18
Sum	11550	14900	24000	31000	43950	67450	126000	158500	212250	326000	242300
Average	481.25	620.83333	1000	1291.6667	1831.25	2810.4167	5250	6604.1667	8843.75	13583.333	13461.111
<u>Summary for 50 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	18	18
Sum	11625	14975	23325	30475	42750	63825	114150	142095	187195	113345	201630
Average	484.375	623.95833	971.875	1269.7917	1781.25	2659.375	4756.25	5920.625	7799.7917	6296.9444	11201.667
<u>Between Groups</u>											
SS	1.17E+02	1.17E+02	9.49E+03	5.74E+03	3.00E+04	2.74E+05	2.93E+06	5.61E+06	1.31E+07	5.46E+08	4.59E+07
df	1	1	1	1	1	1	1	1	1	1	1
MS	1.17E+02	1.17E+02	9.49E+03	5.74E+03	3.00E+04	2.74E+05	2.93E+06	5.61E+06	1.31E+07	5.46E+08	4.59E+07
F	0.001	0.000	0.010	0.004	0.012	0.049	0.172	0.200	0.269	6.705	1.324
P-value*	9.8E-01	9.8E-01	9.2E-01	9.5E-01	9.1E-01	8.2E-01	6.8E-01	6.6E-01	6.1E-01	1.3E-02	2.6E-01
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.085	4.130
<u>Within Groups</u>											
SS	7.81E+06	1.46E+07	4.33E+07	6.39E+07	1.15E+08	2.54E+08	7.83E+08	1.29E+09	2.24E+09	3.26E+09	1.18E+09
df	46	46	46	46	46	46	46	46	46	40	34
MS	1.70E+05	3.18E+05	9.41E+05	1.39E+06	2.51E+06	5.53E+06	1.70E+07	2.80E+07	4.86E+07	8.14E+07	3.47E+07
<u>Total</u>											
SS	7.81E+06	1.46E+07	4.33E+07	6.39E+07	1.16E+08	2.55E+08	7.86E+08	1.30E+09	2.25E+09	3.80E+09	1.23E+09
df	47	47	47	47	47	47	47	47	47	41	35

* Highlighted values indicate a significant difference

Table 9-D. ANOVA Results for Binder C (PG 76-22) for all of the Evaluated RAR Contents Between Testing Shearing Rates of 10 RPM and 20 RPM.

Source of Variation	RAR Content										
	0 %	5 %	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %
<u>Summary for 50 RPM Group</u>											
Count	24	24	24	24	24	24	24	24	24	18	18
Sum	11625	14975	23325	30475	42750	63825	114150	142095	187195	113345	201630
Average	484.375	623.95833	971.875	1269.7917	1781.25	2659.375	4756.25	5920.625	7799.7917	6296.9444	11201.667
<u>Summary for 100 RPM Group</u>											
Count	24	24	24	24	24	24	24	18	18	18	12
Sum	11553	14790.5	22850.5	29926	41242	60516.5	103257	51855	66742	98991	78166
Average	481.375	616.27083	952.10417	1246.9167	1718.4167	2521.5208	4302.375	2880.8333	3707.8889	5499.5	6513.8333
<u>Between Groups</u>											
SS	1.08E+02	7.09E+02	4.69E+03	6.28E+03	4.74E+04	2.28E+05	2.47E+06	9.50E+07	1.72E+08	5.72E+06	1.58E+08
df	1	1	1	1	1	1	1	1	1	1	1
MS	1.08E+02	7.09E+02	4.69E+03	6.28E+03	4.74E+04	2.28E+05	2.47E+06	9.50E+07	1.72E+08	5.72E+06	1.58E+08
F	0.001	0.002	0.005	0.005	0.020	0.046	0.175	6.272	6.572	0.664	8.101
P-value*	9.8E-01	9.6E-01	9.4E-01	9.5E-01	8.9E-01	8.3E-01	6.8E-01	1.6E-02	1.4E-02	4.2E-01	8.2E-03
F crit	4.052	4.052	4.052	4.052	4.052	4.052	4.052	4.085	4.085	4.130	4.196
<u>Within Groups</u>											
SS	7.83E+06	1.48E+07	4.07E+07	6.07E+07	1.08E+08	2.27E+08	6.52E+08	6.06E+08	1.05E+09	2.93E+08	5.47E+08
df	46	46	46	46	46	46	46	40	40	34	28
MS	1.70E+05	3.22E+05	8.86E+05	1.32E+06	2.35E+06	4.93E+06	1.42E+07	1.52E+07	2.62E+07	8.62E+06	1.95E+07
<u>Total</u>											
SS	7.83E+06	1.48E+07	4.07E+07	6.07E+07	1.08E+08	2.27E+08	6.54E+08	7.01E+08	1.22E+09	2.99E+08	7.05E+08
df	47	47	47	47	47	47	47	41	41	35	29

* Highlighted values indicate a significant difference