2006

ASPHALT PAVEMENT PRESSURE DISTRIBUTIONS USING TEKSCAN MEASUREMENT SYSTEM

Justin Anderson
University of Kentucky, jsande1@engr.uky.edu

ABSTRACT OF MSCE THESIS

ASPHALT PAVEMENT PRESSURE DISTRIBUTIONS USING TEKSCAN MEASUREMENT SYSTEM

As a nation that depends so heavily on its infrastructure, the United States continually seeks to better maintain the investment that it has made in its roadways. Asphalt pavements make up the majority of the paved roadways in the United States and ultimately contribute to the bulk of the expense of highway maintenance. The goal of this research was to develop a means for taking a simple measurement of pressure at various interfaces on and within an asphalt pavement structure in an effort to directly assess the damaging effects of different wheel loadings. It is well known that ever increasing wheel loads and other unusual wheel loading conditions are detrimental to the effort of maintaining the roadways. The results of the data can be compared to the classic empiricalistic and mechanistic approaches to asphalt pavement design and analysis, as well as the more modern finite-element computer modeling programs. The Tekscan measurement system, which utilizes a very thin matrix based pressure sensitive sensor, has been deemed applicable for measuring pavement pressures. Various types of wheel loadings have been considered throughout this study. It was determined that the type of tire, tire inflation pressure, applied load, and the asphalt itself all have an effect on the resultant pressures on the surface of and within an asphalt pavement structure. This research may contribute to the understanding of pressure distributions at the tire/asphalt interface depending on the type of tire, adjustments in tire inflation pressure, and varying the wheel load. The results may lead to a better understanding of pressure distributions at varying depths within an asphalt pavement structure. The ability to quantify these variables could assist designers when analyzing and designing asphalt pavements.

KEYWORDS: Asphalt, Pressure, Pavement, Tekscan, Sensor

Justin Anderson

12/14/2006

ASPHALT PAVEMENT PRESSURE DISTRIBUTIONS USING TEKSCAN MEASUREMENT SYSTEM

By

Justin Seth Anderson

______Dr. Jerry G. Rose____________
Director of Thesis

______Dr. Kamyar C. Mahboub______
Director of Graduate Studies

____________12/14/2006__________

RULES FOR THE USE OF THESES

Unpublished theses submitted for the Master's degree and deposited in the University of Kentucky Library are as a rule open for inspection, but are to be used only with due regard to the rights of the authors. Bibliographical references may be noted, but quotations or summaries of parts may be published only with the permission of the author, and with the usual scholarly acknowledgments.

Extensive copying or publication of the thesis in whole or in part also requires the consent of the Dean of the Graduate School of the University of Kentucky.

A library that borrows this thesis for use by its patrons is expected to secure the signature of each user.

<u>Name</u> <u>Date</u>

THESIS

Justin Seth Anderson

The Graduate School

University of Kentucky

2006

ASPHALT PAVEMENT PRESSURE DISTRIBUTIONS USING TEKSCAN MEASUREMENT SYSTEM

THESIS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering in the College of Engineering at the University of Kentucky

By

Justin Anderson

Lexington, Kentucky

Director: Dr. Jerry G. Rose, Professor of Civil Engineering

Lexington, Kentucky

2006

ACKNOWLEDGEMENTS

The following thesis benefited from the insights, direction and assistance of several people. First, I wish to thank my Thesis Chair, Dr. Jerry G. Rose, for his dedicated guidance during the thesis process. His commitment to every stage of this thesis process allowed me to produce a quality product on schedule. I would also like to thank the other members of my Thesis Committee, Dr. Michael Kalinski and Dr. Sebastian Bryson for their time, insight, and instructive comments. I would also like to thank Mr. Gerald L. Nichols. The funding that he provided for this project made much of the research contained in this thesis possible. I would also like to thank the National Center for Asphalt Technology (NCAT), Gregg Laboratories, and KYDOT for their contributions. Without their input the creation of the laboratory pavement specimen would not have been possible.

In addition to the assistance above, I also received equally important assistance from my family. My mother and father, Steve and Jane Anderson, provided support through encouragement to pursue my Master's Degree. The assistance provided by each of these individuals has been of great value.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Files

File Name: JAThesis.pdf (9.3 Mb)

Chapter 1

Introduction and Scope of Research

1.1 Background

A well-developed infrastructure is one of the most valuable assets to any nation. Developing and maintaining an adequate transportation infrastructure is critical to achieving and sustaining an acceptable standard of living and economic development for a country. Maintaining a high level of performance from pavements is a key to maximizing the investment that both state and federal transportation agencies have made in infrastructure. Therefore, the ability to better analyze the factors that decrease the service life of paved surfaces is of significant importance. Since the bulk of American roadways are asphalt, the ability to study pressures and stress distributions on top of and within asphalt pavements in particular is most desirable and is thus the focus of this thesis.

1.2 Pressure Cell Studies

Previous research analyzing the strength enhancement of hot mix asphalt (HMA) in railway/highway crossings has been completed in recent years at the University of Kentucky (Walker, 2002). This research documented the optimum installation practices for rehabilitating railroad/highway crossings with an asphalt layer (termed asphalt underlayment) and determined how asphalt layers are able to impart enhanced strength and stability to crossings. Walker's research utilized the Geokon Model 3500 Earth Pressure Cell measurement instrument. This cell consists of two stainless steel plates welded together around their perimeter and separated by a thin cavity filled with hydraulic fluid. External pressures squeeze the two plates together creating an equal pressure in the internal fluid. A length of stainless steel tubing connects the fluid filled cavity to a pressure transducer (strain gauge) that converts the fluid pressure into an electrical signal transmitted to the readout location. Figure 1.1 is a picture of a typical pressure cell.

Figure 1.1 Typical Pressure Cell (Geokon, 2006)

The measurements were obtained beneath railroad crossings at the ballast/asphalt interface in an effort to differentiate between the pressure exerted on the HMA underlayment by both the rail traffic and the highway traffic along the crossing. The instrument was able to provide a single average value of pressure at the interface. Figure 1.2 shows a typical application of the pressure cell in a railroad trackbed.

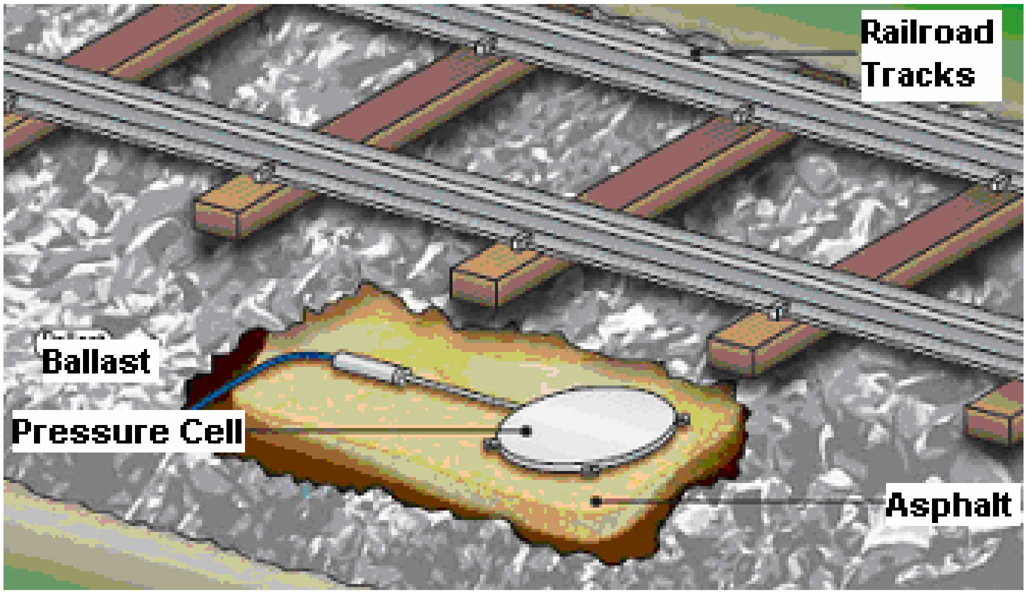


Figure 1.2 Typical Application of Pressure Cell (Geokon, 2006).

A substantial amount of research has been conducted in recent years evaluating railroad crossings with asphalt underlayment, which serves as a substitute for granular subballast (Rose & Tucker, 2002, Walker, 2002).

1.3 Tekscan Pressure Measurement System

Another pressure measurement system that has been determined applicable for pressure measurements in a railroad track is the Tekscan pressure measurement system (Stith, 2005). Stith first used the Tekscan system at the University of Kentucky to develop a pressure measurement technique within a railroad track. This research showed that measurements taken at the rail base/tie plate interface were found to be very repeatable.

Christian (2005) also did research with the Tekscan Pressure Measurement system. She developed a procedure for pressure measurements with the Tekscan measurement system at the tire/pavement interface. Christian's work served as a precursor for the development of the core procedure for this work, which will be discussed in detail in Chapters Five and Six.

1.4 Objectives and Scope

It is the technology that Stith (2005) and Christian (2005) developed and used, not necessarily the results of their research, that is of particular importance to this thesis. The Tekscan pressure measurement system proved to be a very useful tool for measuring the pressures within a track structure, but to limit the technology strictly to that application could be a mistake. On that same note, research performed by Walker (2002) further evaluated how asphalt layers are able to provide enhanced support and stability to crossings, but did not provide a complete understanding, as she noted in her recommendations for future research. Walker's research was limited to pressure measurements in highway pavements at the base/subgrade level.

By combining the ideas from Stith (2005) and Walker (2002), it may be possible to gain a more in-depth understanding of how pressures are distributed throughout an asphalt pavement structure. Specifically, it is the focus of this thesis to optimize a direct pressure measurement method within an asphalt structure, with initial tests in the laboratory and subsequent tests on highway pavements. Therefore, by combining the Tekscan technology utilized by Stith (2005) and Christian (2005) with the pressure cell experimentation used in Walker's (2002) highway/rail crossing research, it should be possible to develop a direct pressure measurement technique within an asphalt structure using the Tekscan system. From this measurement technique the current pavement design techniques, which include mechanistic, empirical and computer modeling, can be verified for accuracy.

The benefits to the pavement design area of the civil engineering profession would be significant should an optimized direct measurement technique be successfully developed. Therefore, it is the focus of this thesis to describe the advances made towards the development of a direct pressure measurement technique on the surface and within the structure of an asphalt pavement.

The specific goal of the research was to determine pressures on top of and within an asphalt pavement structure using the Tekscan Pressure Measurement System. This goal was achieved by adhering to the following objectives and tasks:

- Develop an application for the new Tekscan USB system.
- Optimize a procedure to install the Tekscan sensor for asphalt pavement measurements in laboratory and highway pavements.
- Develop a technique for data collection and analysis.
- Evaluate various wheel loadings on a pavement using the Tekscan system.

Chapter 2

Literature Review of Related Work

2.1 Introduction

This chapter discusses previous research related to pressure tests within asphalt pavements as well as research related to studies using a pressure sensitive film. This thesis combines the two technologies.

2.2 Existing Pavement Analysis Methods

Research related to determining the strength or stability of asphalt mix designs is abundant. Most of these tests are laboratory-based and can have results much different than those in an actual pavement. A laboratory setting provides an optimal testing environment. For example, in a laboratory test, the asphalt specimen can be placed in a gyratory compactor and compacted to optimum density at specified temperatures. However, the conditions in a pavement are typically much harsher than in the laboratory and ultimately yield different results. This is possibly due to weather related causes or abnormal loading conditions. Ruth (2006) states that:

> "Mix designs, quality control and quality assurance (QC/QA), and construction requirements are not currently directly related to quality, but should focus on shear strength, tensile strength and other behavior-related test methods to define an in-service behavior of asphalt paving mixtures."

2.2.1 Boussinesq Theory. The theory presented by Boussinesq, is used to describe a pavement system as a homogeneous, isotropic, linear elastic half-space and provides a procedure for determining the stresses, strains and deflections (Hildebrand, 2002). Boussinesq's theory assumes a concentrated load applied on an elastic half-space. The notation for Boussinesq's equation for vertical stress due to a point load is shown in Figure 2.1.

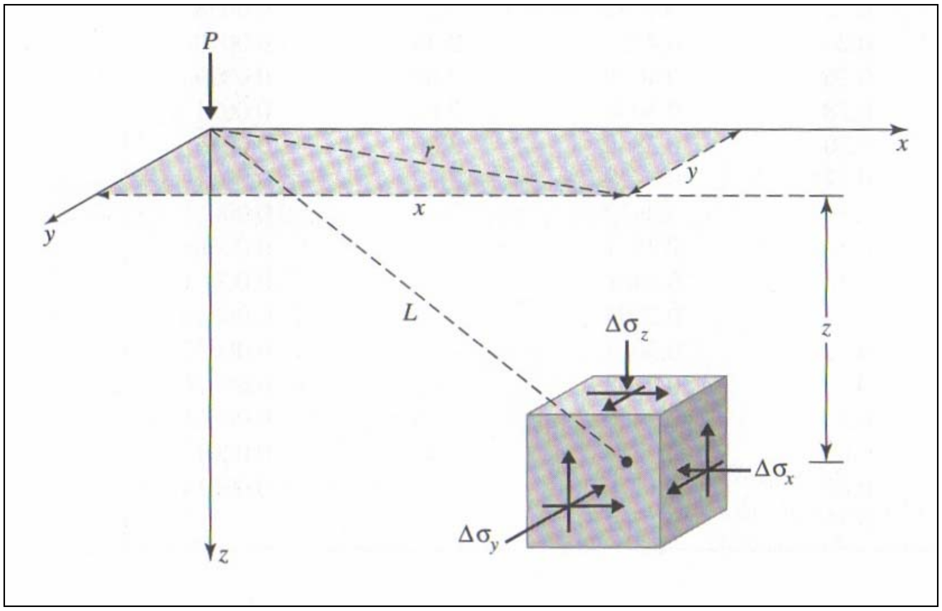


Figure 2.1 Stresses in an Elastic Medium Caused by a Point Load (Das, 2002)

Boussinesq's equation for vertical stress due to a point load is (Das, 2002):

$$\Delta\sigma_Z = \frac{3P}{2\pi}\frac{z^3}{(r \quad + z^2)^{5/2}}$$

2.2.2 Burmister's Layered Elastic Theory. Burmister expanded Boussinesq's one-layer system to a two and three-layer system (Huang, 2004). This was a major advance in pavement analysis. Burmister's model assumed homogeneous properties, finite thickness, isotropic properties, complete interlayer friction, no shear stress on surface and a linear-elastic behavior of materials. Figure 2.2 shows Burmister's multi-layered system subjected to a circular loading, where 'a' represents the radius of the circular loading, 'q' represents the load, and 'h' represents the thickness of the layer.

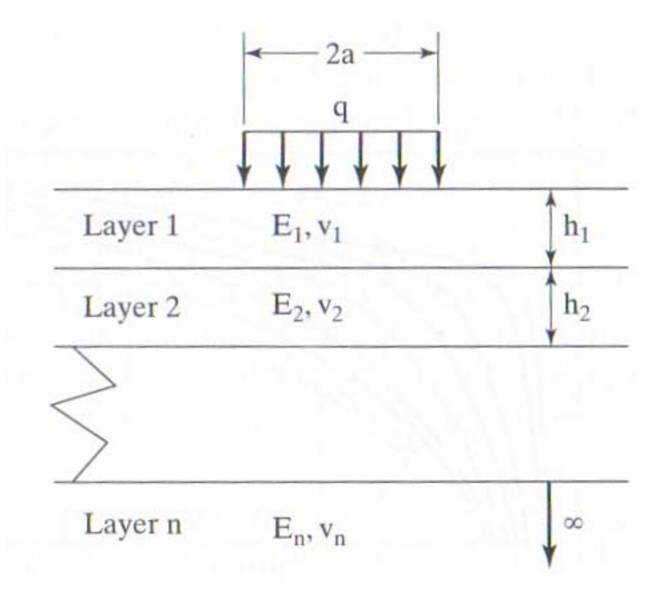


Figure 2.2 An n-layer System Subjected to a Circular Loading (Huang, 2004)

Figure 2.3 is a graphical illustration of the vertical stress distribution with depth under the center of a circular loaded area.

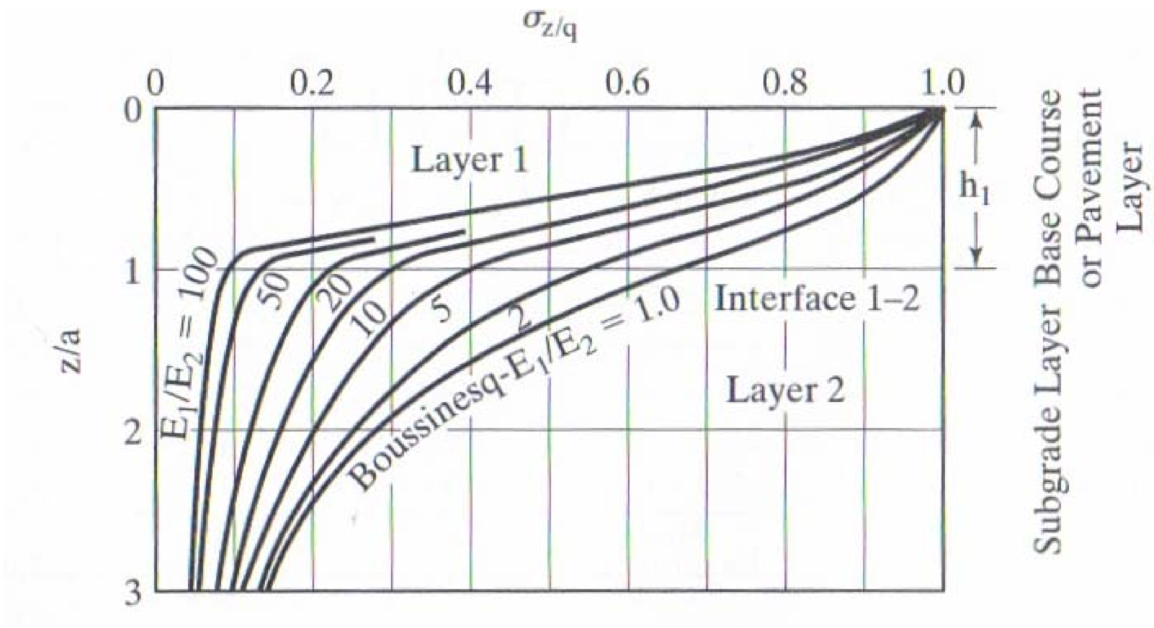


Figure 2.3 Vertical Stress Distributin in a Two-Layerd System (Huang, 2004)

2.2.3 Solutions by Charts. Foster and Ahlvin presented charts for determining the vertical stress under a circular applied load with radius 'a' and a force 'q'. Their work assumed the half-space to be incompressible with a Poisson's ratio υ of 0.5. Figure 2.4 is a vertical stress distribution due to a circular loading by Foster and Ahlvin (Huang, 2004).

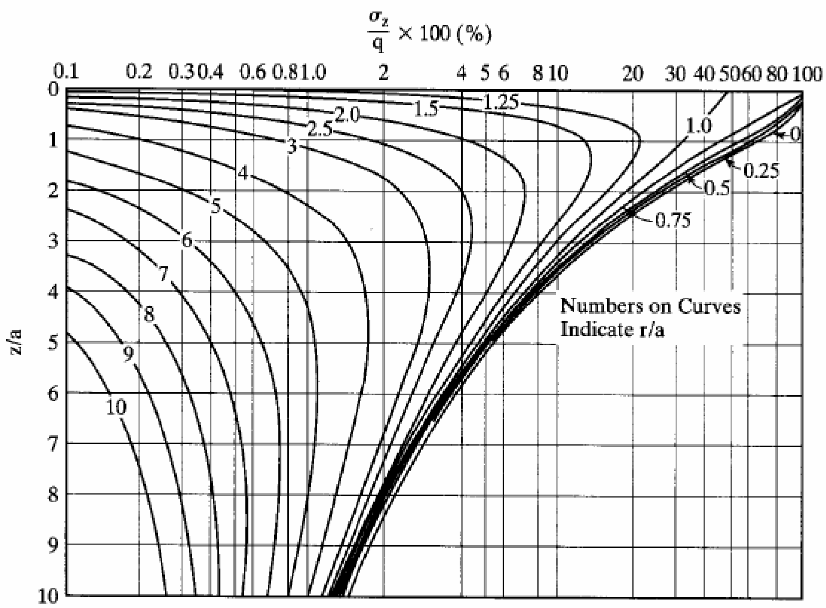


Figure 2.4 Foster and Ahlvin Vertical Stress Distribution (Huang, 2004)

2.2.4 Computer Based n-layer Analysis. Huang applied Burmister's theory to a multilayer system with any number of layers using a computer (Huang, 2004). Huang developed the KENLAYER computer program, which solves elastic multilayer system's under a circular loaded area and applies only to flexible pavements with no joints or rigid layers. KENLAYER can be applied under many different wheel loadings, with each layer behaving differently, either linear elastic, nonlinear elastic, or viscoelastic. More information on this program can be found in (Huang, 2004). The point of interest with respect to this thesis is the program's ability to estimate stresses between the asphalt layers.

2.2.5 Mechanistic-Empirical Study of Effects of Truck Tire Pressure on Pavement. The study, conducted by Wang and Machemehi (Wang et al., 2006), was closely related to the subject of this thesis. In their study, contact stresses at the tire/pavement interface were input into a finite element program to assess immediate pavement response for three tire configurations: single tires, dual tires, and dual-tire tandem axles (Wang et al., 2006). The critical pavement responses determined by the finite element program were input into pavement distress transfer functions to further analyze the effects of tire inflation pressure on pavement performance (Wang et al., 2006). The finite element program, using the measured tire/pavement contact stress data, computed the pavement responses at selected locations in the pavement structures. These were compared with the results predicted by a multilayer program using the traditional uniform contact stress method, which assumes a uniform circular contact area (Wang et al., 2006).

The results of the Wang and Machemhl (Wang et al., 2006) study showed that the computation results tend to overestimate the horizontal tensile strains at the bottom of the asphalt concrete and underestimate the vertical compressive strains at the top of the subgrade (Wang et al., 2006). Prediction of the effects of tire pressure on pavement performance showed that increased tire pressure resulted in increased pavement distress due to both cracking and rutting and that tire inflation pressure is also related to the shape of pavement ruts (Wang et al., 2006).

2.3 Piezoelectric Film

By definition, piezoelectric materials when mechanically deformed, generate an electric charge. Piezoelectric sensors measure the electrical potential caused by applying mechanical force to a piezoelectric material. The Tekscan pressure measurement system (discussed in

Chapter 3) is merely a piezoelectric film, known as semi-conductive pressure-sensitive ink, which has been incorporated into a computer system.

2.3.1 Measurement of the Dynamic Normal Pressure between Tire and Ground Using PVDF Piezoelectric Films. Marsili (2000) used polyvinylidene fluoride films (PVDF) to measure the contact pressure between a car tire and an asphalt pavement. Unfortunately, the size of the sensor was not clearly defined. The calibration procedure was performed in 'real conditions', which also is not clearly defined. The results of this work indicated a typical uncertainty below 3 percent (Marsili, 2000).

2.3.2 Experimental Determination of Pressure Distribution of Truck Tire Pavement Contact. Marshek et al. (1986) performed research in which a pressure sensitive film was used to show the pressure distribution beneath a statically loaded truck tire. Both bald and treaded bias ply truck tires were loaded with a hydraulic ram. The pressure sensitive film allowed the entire pressure to be captured and stored.

The experimental results showed that the tread patterns on a tire have a significant effect on the size of contact area and shape of pressure profiles (Marshek et al., 1986). Treaded tires tended to have a smaller contact area due to the presence of tread gaps that reduced the number of contact points in the tire footprints. High pressures were consistently found at tread-gap interfaces and at the tire shoulder. The results also showed that tire inflation pressure determined the location of regions of high pressure in the contact patch (Marshek et al., 1986). High inflation pressure produced a significant reduction in contact area and a shifting of high pressures toward the center region of the contact path. Finally, it was determined that the axle load affected the contact area and pressure distribution (Marshek et al., 1986).

Chapter 3

Tekscan Pressure Distribution System

3.1 Introduction to Tekscan

Tekscan is a non-intrusive/non-invasive method of measuring the pressures at various interfaces. The Tekscan Industrial Sensing System (I-Scan) allows pressure distribution measurements to be obtained using an ordinary PC. The system can sample pressure data in real-time and present it as a color-coded or other type of display. Additionally, the system has the capability to record data as a 'movie' for later analysis. Furthermore, the data can be exported into other data processing programs like Microsoft Excel for additional data analyses.

3.2 Data Acquisition Hardware

Tekscan has a variety of data acquisition interfaces ranging from the simple serial to more complex parallel, USB, and PCI interface boards. Each sensor uses sophisticated microprocessor-based circuitry to control scanning, adjust sensitivity and optimize the performance. Previously cited Tekscan research utilized the PCI interface boards. This research utilizes the new and much improved USB system.

3.2.1 Sensors. The model 5260 sensor was used in initial research and the model 5250 sensor was used in this research. Essential to every Tekscan pressure measurement system is the extremely thin and very flexible sensor. Sensors come in both grid-based and single load cell configurations, and are available in a wide range of shapes, sizes and spatial resolutions (sensor spacing). These sensors are capable of measuring pressures ranging from as low as 0-2.175 psi

(0-15 kPa) to as high as 0-2175 psi (0-175 MPa). Each application requires an optimal match between the dimensional characteristics of the object(s) to be tested and the spatial resolution and pressure range provided by Tekscan's sensor technology.

The Tekscan sensor is very thin (approx. 0.1 mm thick) and is made up of two polyester sheets with semi-conductive ink printed in rows on one sheet and in columns on the other. Figure 3.1 contains a diagram of the typical sensor components. The sensing region of the model 5260 sensor is 19.0 inches wide and 8.1 inches long and the sensing region of the model 5250 sensor is 9.7 inches wide and 9.7 inches long. The pressure sensitive rows on the 5260 sensor are spaced 0.18 inches apart and the columns are spaced 0.36 inches apart, totaling 2288 cells per sensor (15 sensel per sq-in). The pressure sensitive rows on the 5250 sensor are spaced 0.22 inches apart and the columns are also spaced 0.22 inches apart, totaling 1936 cells per sensor (20.7 sensel per sq-in). The 5250 model sensor, which has a capacity of 1200 psi (8.3 MPa), was primarily used due to its higher sensel density. Figure 3.2 shows the 5250 and 5260 sensors. Appendix A contains the manufacturer's specifications for the sensors used in this research.

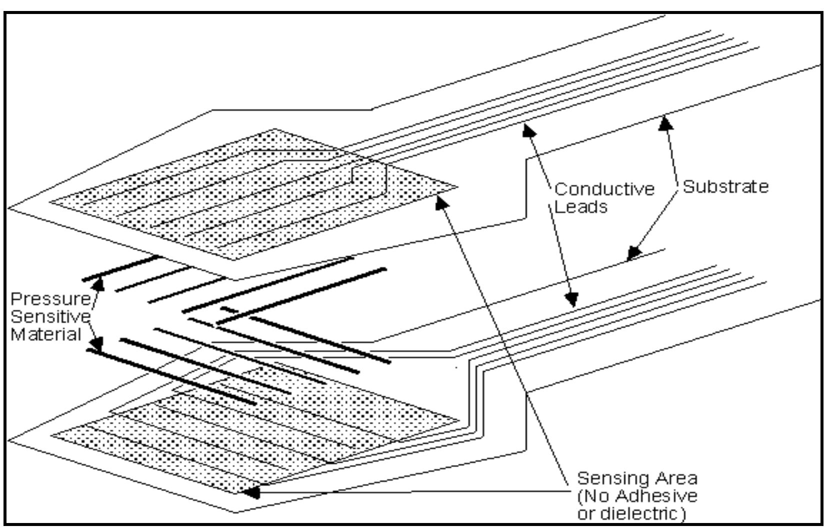


Figure 3.1 Basic Sensor Components (Stith, 2005).

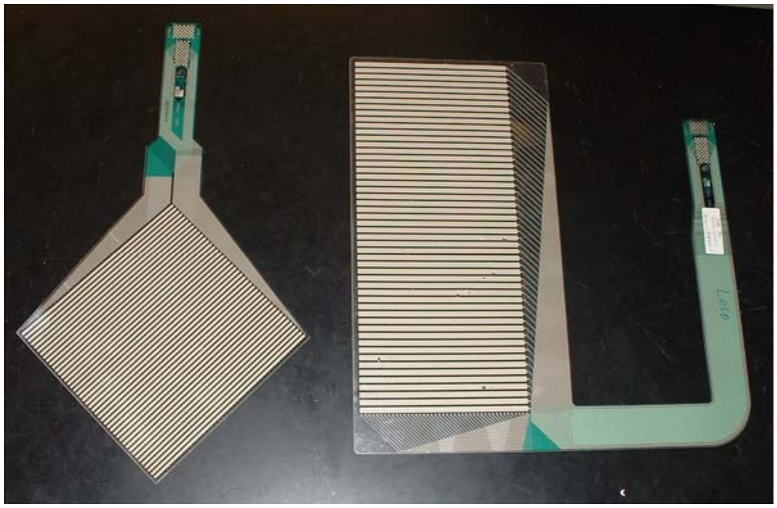


Figure 3.2 Model 5250 Sensor (left) and Model 5260 Sensor (right).

The previously mentioned 'ink' rows are pressure sensitive and their conductivity varies with applied force. Specifically, the application of a pressure to an active sensor results in a change in the resistance of the sensing element in inverse proportion to the pressure applied. Figure 3.3 shows the relationship of resistivity versus applied pressure. The I-Scan software uses this relationship to translate resistivity into a raw reading of pressure. After a simple calibration is performed, this raw force can be displayed in the measurement units of choice.

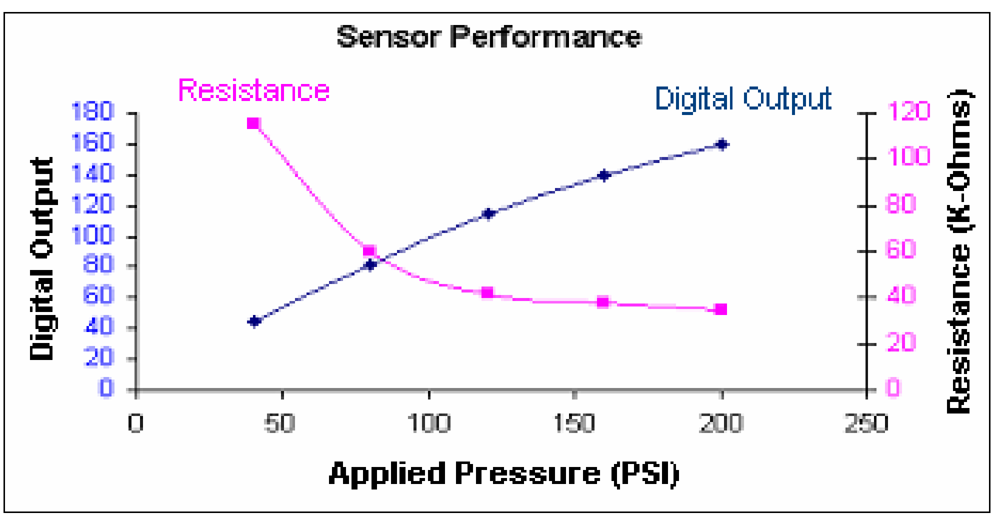


Figure 3.3 The Tekscan Sensor's Force vs. Resistivity Relationship (Stith, 2005).

The Tekscan pressure measurement system engages only one row and one column on the sensor at a particular time so that a reading can be taken at the intersection. These intersections make up a sort of matrix, as the simplified electronic schematic in Figure 3.4 shows. The previously mentioned 'engaging' process occurs several hundred thousand times a second, which allows to system to produce very reasonable raw data.

It is of significance that the basic principal upon which a strain gage records data is basically that the electrical resistance of a length of wire varies in direct proportion to the change in any strain applied to it. From this principal, it is reasonable to view the Tekscan sensor as a pressure mat made up of numerous strain gages.

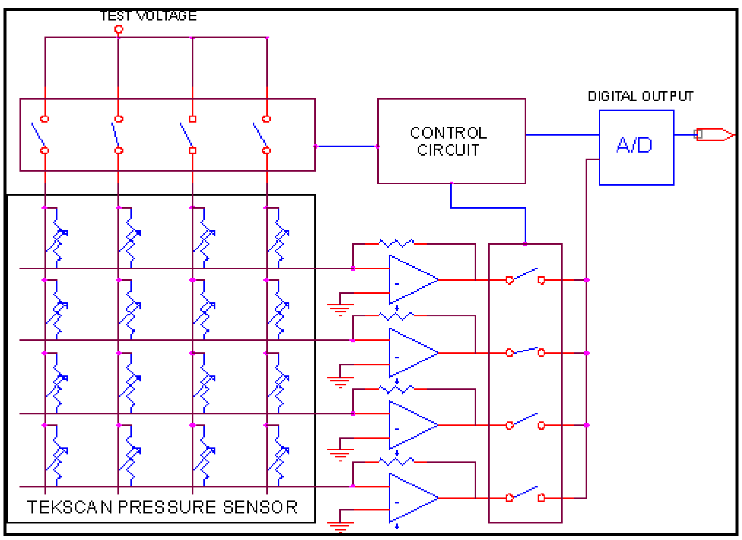


Figure 3.4 Simplified Electronic Schematic (Stith, 2005).

3.2.2 Acquisition Handle. The acquisition handle serves as the link between the computer and the sensor. The handle contains pogo pins that clamp over the lead of the sensor. These pogo pins make individual contact with each of the silver lead ends that connect to the columns and rows of pressure sensitive ink. Figures 3.5 and 3.6 show the Tekscan Pressure Measurement system setup.

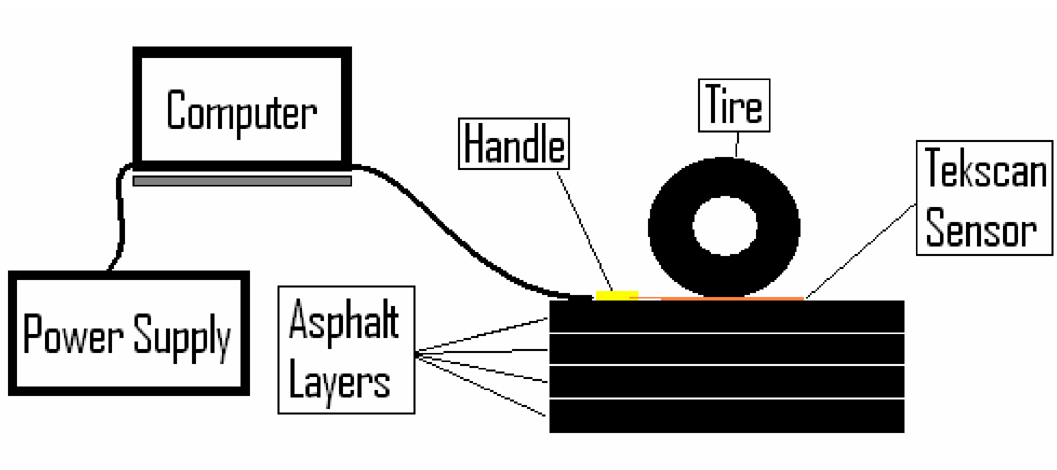


Figure 3.5 Schematic Diagram of USB Tekscan Measurement System at Tire/Asphalt Interface.

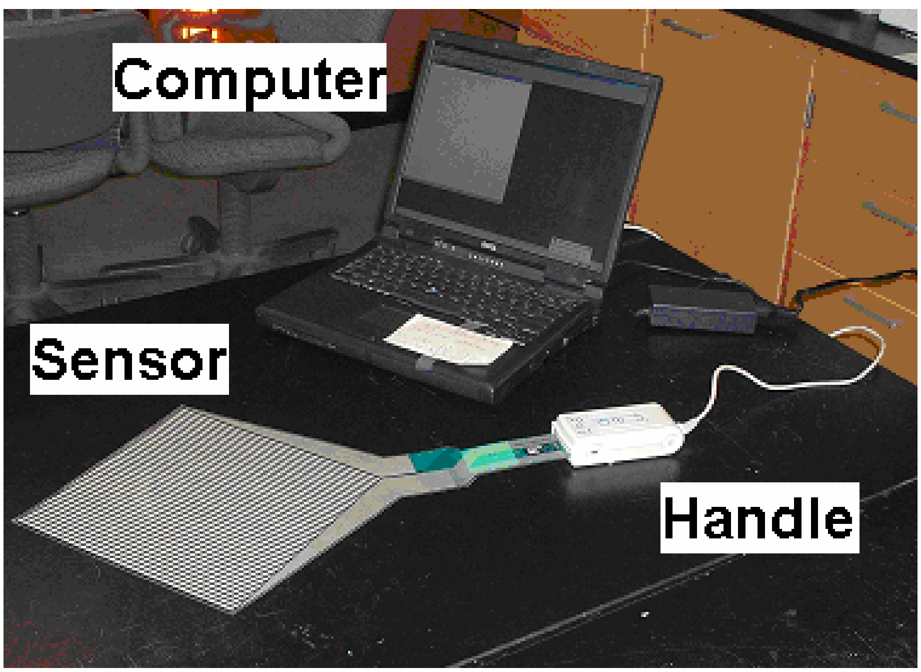


Figure 3.6 Picture of Tekscan Setup Using USB System.

3.2.3 Computer and I-Scan Software. The computer should ideally be a laptop to allow for increased mobility. The laptop's minimum requirements are listed in Appendix A. I-Scan is the computer program, developed by Tekscan, that enables the user to record and analyze data.

3.2.4 Power Source. The power source is not as important of an issue as it was in previous work which required a magma box. The magma box housed a cardbus-to-PCI expansion system for attaching the handle. This box was necessary to transform the output from the handle to a form that the computer could input. The magma box was powered by a separate 110V power source. If the power source was interrupted, a loss of data would occur. The entire USB system can run off of the computer's power source, making it much more versatile.

3.3 Analyzing and Editing Data

I-Scan allows the user to record data in real-time tests for later analysis. Stith (2005) thoroughly discusses the process of analyzing and editing data and therefore will only be briefly summarized here. In general, data can be edited to repair/replace any missing rows or columns that may have been omitted during testing. This is accomplished by averaging data from neighboring cells and adding the value to the total raw sum. Missing data often occurs as a result of an impure power source (current is interrupted or weak) or damage to the sensor. Two pure power sources must be used to minimize the effects of this when the PCI system is used (one for the magma box and one for the computer).

3.4 System Limitations

The sensor does have limitations. The Tekscan system is only an 8-bit system. This only allows for a raw sum output ranging from 0-255 in each cell. Values exceeding their maximum capacity of 255 raw sum are considered 'saturated'. Saturation refers to a cell that has reached its maximum capacity, which means that the actual value could be infinitely higher than 255. The factory saturation pressure, referred to here, is a recommended usage pressure at which the sensors will read 200 raw units. The actual saturation pressure should be slightly higher.

In addition, due to the spacing of the rows and the threshold of the 5260 model sensor used in previous research, the pressure distribution was only accurate under relatively heavy loading. The pressure was not very accurate at low readings because the true area was not accounted for, since Tekscan only reads the area in contact with the sensor, neglecting space between treads, surface voids, and those cells that are not within the pressure threshold of the system.

3.5 Major Advantages of New System

This section will discuss the advantages of the more conventional USB Tekscan system over the older PCI Bus System.

3.5.1 Compatibility and Mobility. The system used for this research allows for accurate pressure readings at lighter loadings, which is very desirable when testing within a pavement structure. Also, the system is much more versatile with the USB system since the handle is compatible with almost any computer, whereas before a PCI card (Figure 3.7) had to be installed.

The Peripheral Component Interconnect (PCI) provides direct access to system memory for connected devices, but uses a bridge to connect to the frontside bus and therefore to the CPU. (The frontside bus is a physical connection that actually connects the processor to most of the other components in the computer, including main memory (RAM), hard drives and the PCI slots). The PCI card uses 47 pins, as shown in Figure 3.7, to connect to the bus (Tyson, 2006).

Figure 3.7 A Typical PCI Card (Brian, 2006).

Almost all modern computers come with one or more Universal Serial Bus connectors on the back (See Figure 3.8). These USB connectors permit attaching everything from a mouse to a printer to a computer quickly and easily. The operating system supports USB as well, so the installation of the device drivers is also quick and easy. Compared to other means of connecting devices to a computer (including parallel ports, serial ports and special cards that are installed inside the computer's case), USB devices are incredibly simple. In a USB system the computer acts as the host and up to 127 devices can connect to the host either directly or by way of USB hubs (Brian, 2006). With USB 2, the bus has a maximum data rate of 480 megabits per second, which is much faster than the PCI card (Brian, 2006).

Figure 3.8 Typical USB Slot on the Back of a PC (Brian, 2006).

3.5.2 Adjustable vs. Fixed Gain. Due to the USB system's greater compatibility with the Microsoft Windows Operating System, and Tekscan's newly developed USB system, adjustable gain has been made possible. Adjustable Gain refers to the user's ability to adjust the sensitivity via the I-Scan software. Alternatively, under the old PCI Tekscan system, which used fixed gain, in order to take a pressure reading over a low-pressure range, a special sensor corresponding to that pressure range had to be obtained. Similarly, for higher-pressure readings, a higher capacity sensor had to be obtained. For example, there are versions of the 5250 model sensor that can read up to 1200 psi, but not very accurate at low pressures. Likewise, there are 10-psi versions of the 5250-model sensor that are very accurate at low pressures, but become saturated at higher pressures. Therefore, the USB system has eliminated the need for optimizing the pressure range of a sensor, by allowing a higher range sensor to be used over the entire range of pressure readings.

3.5.3 Averaging and Default Views. Under the new USB system, the pressure distribution image displayed on the screen, within the I-Scan program, can be viewed in two different ways. The first way is the <u>default view</u>, which appears as a very pixilated image. The default view displays each pressure 'node' as an individual pixel on the screen. Therefore, only the pressure nodes that are under load are displayed on the screen. This results in a somewhat discontinuous image at times. Figure 3.9 is an example screenshot of the default view.

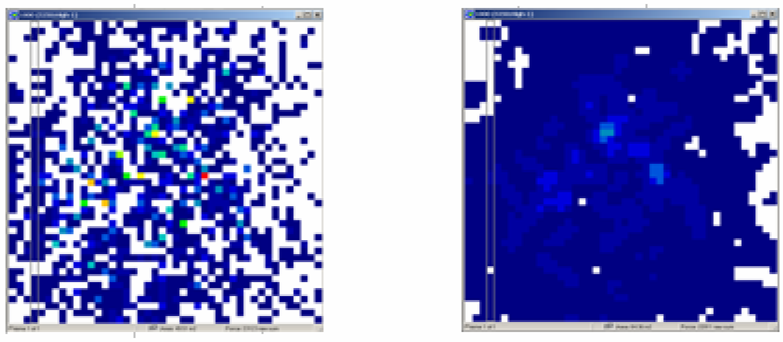
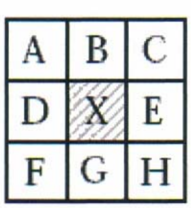


Figure 3.9 Default View (Left) and Averaging View (Right).

The <u>averaging view</u> displays the image with each cell's pressure value modified to reflect the value of its neighbors. Figure 3.9 shows a typical screenshot of the averaging view. The purpose of using the averaging view is discussed in greater detail in Chapter 7. The averaging view includes neighboring cells that have zero load. The result is a smoother image, with an increase in total loading area since certain cells with a previous zero value now have a value. As an example, in the group of nine cells shown in Figure 3.10, the averaged pressure value of X is calculated as follows (Tekscan Users Manual, 2006):



$$Xavg := \frac{\frac{A+C+F+H}{2} + B + D + E + G + X}{7}$$

Figure 3.10 Equation Tekscan Uses to Calculate Values in 'Averaging View' (Tekscan, 2006).

The analysis and editing of data should be carried out in the default view. This view allows the user to edit an individual cell quickly and easily because the true value of force applied to a particular cell is displayed. The averaging view changes the original data such that it is almost impossible to determine which cells are missing, saturated, etc. All editing for this research was performed in the default view.

Chapter 4

Initial Investigations

4.1 Initial Tests with PCI Tekscan System

This section briefly discusses the activities that led up to the selection of the optimum test setup and procedures used in this research. Each test contributed to the eventual acceptance of the optimum laboratory test method described in Chapter 5 and the pavement test method described in Chapter 6. The results are discussed in generalities and specific data is omitted.

4.1.1 Tire Section in Loading Machine. Initial Tekscan tests with the asphalt/tire interface utilized a small representative section of a typical tire. In fact, much of Christian's (2005) research, discussed in Section 1.3, is based on this loading arrangement. Figure 4.1 shows the initial test arrangement.

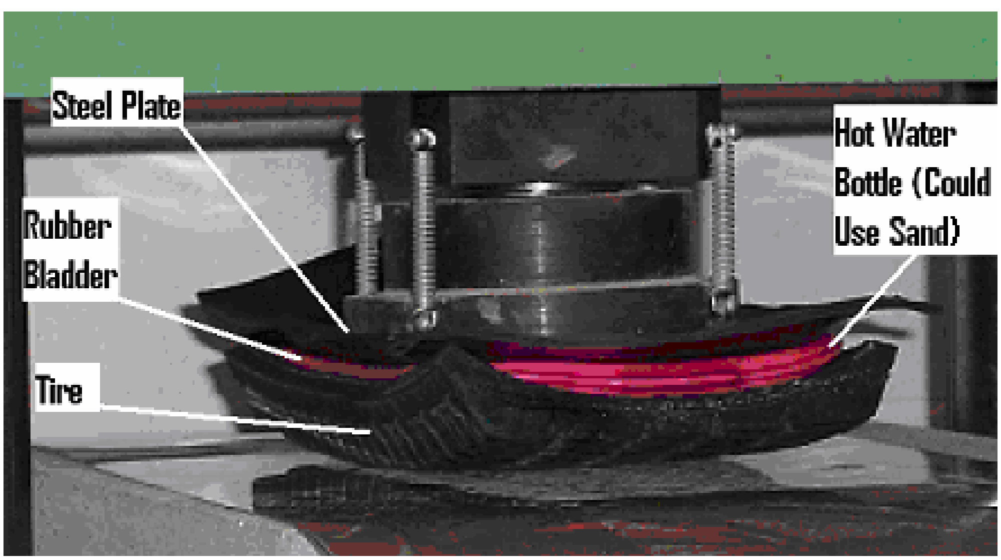


Figure 4.1 Initial Test Arrangement with a Tire Section and Rubber Bladder.

This section of tire was about 1 foot in length and had a steel plate and rubber bladder (filled with hydraulic fluid) placed in the center to try to simulate the air pressure distribution within a tire. Alternatively, a bag of sand was used in place of the rubber bladder in an effort to simulate the air pressure within an actual tire. A metal plate approximately 8 inches in length and 5 inches in width was also placed on top of the bag of sand to distribute the load. This loading arrangement did not provide consistent load distribution. However, these initial tests did indicate that the Tekscan system was applicable for measuring pressure distribution between tires and pavement surfaces. In order to represent an asphalt pavement, a section of asphalt was fabricated in the laboratory (used recycled asphalt from old core samples) and compacted using a Satec Axial Loading Machine.

This was also the first attempt to calibrate the sensor for pressure measurements at the tire/asphalt interface. Initial work was done at the tire/concrete pavement interface as is pictured in Figure 4.1. To calibrate the sensor, known loads were applied to the Tekscan sensor, positioned between the tire and the asphalt, using the Satec Loading Machine. When a desired loading interval was reached, a snapshot was taken using Tekscan's I-Scan software. The Tekscan reading of force was in Raw Sum units. A calibration factor could then be used to convert Raw Sum readings, taken in a test into a known unit (pounds-force).

4.1.2 Passenger Car on Asphalt Parking Lot. Numerous tests were performed using a wheel of a typical passenger car to load the Tekscan Sensor in several different parking lots. These tests were performed on various asphalt pavements of unknown thickness. At the time, asphalt thickness was not considered significant because only the tire/asphalt interface was of interest. The procedure for this test was as follows: the Tekscan Sensor Model 5260 and Model 5250 were placed on top of the asphalt and a single wheel of a car was carefully driven across them. The car was equipped with radial tires. Readings were taken and converted to lbf units using the calibration factor obtained from the calibration tests described in Section 4.1.1. For a check of accuracy, the car was weighed on the scales at the local asphalt plant. The total weight of the car and weights on individual tires were measured. The results of the Tekscan force readings, taken from the tests, were compared to the loads measured at the asphalt plant. The pressure readings taken from the tests were compared to the tire pressure.

4.1.3 Boom Truck, Coal Truck & Drill Rig on an Asphalt Pavement. Other tests were conducted which utilized a boom truck, coal truck and a drill rig to apply a much heavier wheel loading to the asphalt pavement. The test arrangement was very similar to that described in Section 4.1.2. The major difference was the type of tire on the boom truck, coal truck and drill rig. Each of these vehicles was equipped with bias ply tires. The structure of the bias ply tire is much different than the radial tire. In as much, the pressure data was much different between radial and bias ply tires. Section 4.1.3.1 provides a detailed discussion of radial vs. bias ply tires.

The calibration factor and the associated pressure data differed depending on which type of tire was being investigated. As a result it was desirable to investigate the difference between bias ply and radial tires in future research.

4.1.3.1 Comparison of Bias Ply & Radial Tires. The construction of bias ply (refer Figure 4.2) and radial tires are significantly different. The plies on a radial tire run from bead to bead directly across the tire radially. The cords are perpendicular to the bead. Successive plies are then layered over the existing ones with all cords being parallel. The plies on a bias ply tire run at an angle to the bead, therefore in a biased direction (Luiz, 2005).

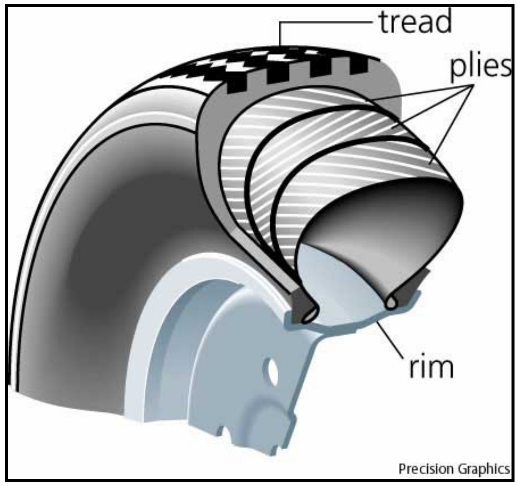


Figure 4.2 Schematic of the Construction of a Bias-Ply Tire (Luiz, 2005).

Different layers have opposing angles, criss-crossing across the tire. On an unbelted tire, like most bias ply designs, the tread rubber is molded right on top of the plies. For a belted tire, like a radial, a flat layer of material, usually a steel mesh is placed between the body and tread (Luiz, 2005). The *belt* is just a weave of metal fibers that overlap in a pattern very similar to the criss-crossing bias ply material. Each belt adds an additional layer in the tread area but leaves the sidewall area untouched. Figure 4.3 contains an illustration of this description.

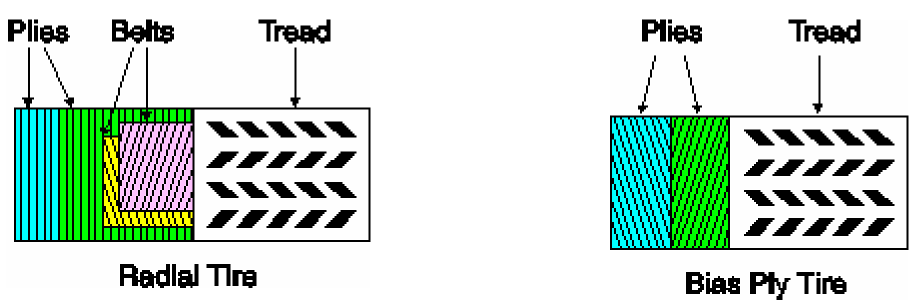


Figure 4.3 Schematic of Radial and Bias Ply Cross-Section (Luiz, 2005).

The mechanics of each type of tire also had to be understood to investigate the tire/asphalt interface. Image a tire without plies or tread rubber, but simply rubber mounted on a rim. As air is added, the tire would behave like a balloon as it expanded and the pressure could not build up very high because the rubber could not provide enough tension. The plies on a tire, though, prevent this over expansion and allow pressure to build up. The tread is much thicker than the sidewalls as it adds stiffness and flattens out the tread producing the shape of a tire.

Inside the tire, air under pressure presses equally in all directions, allowing the tire to act as a spring resisting the weight of the vehicle. The sidewall must deform allowing the tire to flatten. The contact area between the road and tire multiplied by the air pressure in the tire should equal the load on the tire. However, this is not precisely the case and is the key to many of the differences between radial and bias ply tires. As mentioned previously, the cords that make up the plies can be considered as a thread. They are easy to bend but resist being stretched (tension).

Remember that the plies criss-cross across a bias ply tire. One layer is strong in the weak direction of another. As the tire is compressed and flattened, some of the cords are put under tension, i.e. stretched, but they resist. Hence, the body of the tire aids in supporting the load. Bias ply bodies are usually made of nylon cord, which is very strong. Bias ply tires are rounded in the tread area because there is nothing beyond the tread rubber to flatten them out. As the tire rolls, the center section must deflect more than the edges, leading to higher contact pressure in the middle. The tread blocks also tip inward. All of this results in a contact area that is smaller than expected.

A radial tire has the cords running perpendicular to the bead and to the ground (Luiz, 2005). Hence, as the tire flattens out, the sidewall plies just bend, adding very little resistance. This produces the distinctive radial bulge. The bodies usually consist of polyester, which is less stiff than nylon. The combination of radial pattern, polyester material, and belt results in the load being distributed equally across the contact area. Since the body adds very little stiffness, the load is almost entirely carried by the air, resulting in a contact area very close to expected.

Bias ply bodies are usually made of nylon, which is extremely strong but not very pliable. Radial bodies are usually made of polyester, which is not quite as strong as nylon, but is more flexible. Bias ply tires use more layers of the stronger nylon material while radials have fewer layers of polyester. The bias ply pattern allows one layer to strengthen the others. The radial piles are placed such that all cords are parallel, preventing them from reinforcing each other. This construction makes bias plies very durable, resistant to bursting, and tolerant to twisting and bending. Since the sidewall is as strong as the rest of the body, the sidewalls can accommodate high lateral loads, twisting, and bending which would cause a radial to split (Luiz, 2005).

Another important factor is that a belt can be added to a bias ply tire. The belt is usually steel or fiberglass and is placed between the tread and body, similar to the radial. The belt resists the rounding of the tread area, giving a flatter tread and distributing the load through the side walls and into the tread, rather than distributing the load entirely over the tire's air pressure (Luiz, 2005). Otherwise, the tire is the same as a bias ply. This could be critical in testing should one tire on a given vehicle be bias-ply and another be belted bias-ply because the results could be very different.

An example that illustrates the difference between bias-ply and radial tires is evaluating cornering performance. Figure 4.4 shows the bias-ply tire (on the left) losing contact with the road as both tread and sidewalls distort under a cornering load. The radial tire (on the right) flexes mostly in the sidewall area keeping the tread flat on the road. This scenario demonstrates the contrast in the materials used in the sidewall and how differently they carry a load.

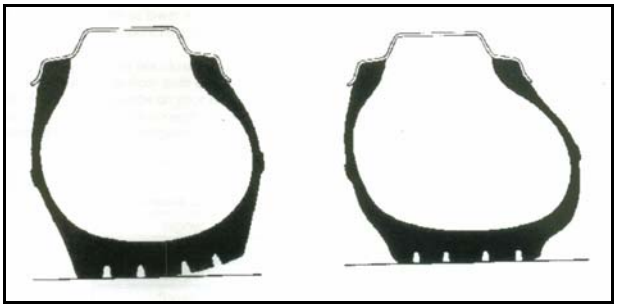


Figure 4.4 Schematic of How Bias-Ply Tire (left) and Radial (right) Grip the Road (Luiz, 2005).

4.1.4 Sensor Calibrated in Place with Portable Hydraulic Scales. The calibration factor was observed to change at different testing locations and over relatively short time periods. Therefore, it was desirable to calibrate the sensor under actual loading conditions and very close to the time of testing. Consequently, portable hydraulic scales were obtained from the Kentucky Department of Vehicle Enforcement in Frankfort, KY for use in measuring wheel load outside of a laboratory setting. Vehicle enforcement officers frequently use portable hydraulic scales to measure wheel loads of trucks to see if their wheel loads exceed the legal weight limit. This is particularly important in areas like Eastern Kentucky where overloaded coal trucks are prevalent.

The scales were first loaded on the Satec machine, which was described in Section 4.1.1, to ensure that they were reading accurately. The scales were then used to measure wheel loads. These readings were then compared to Tekscan readings. The Tekscan raw sum reading was divided by the load obtained from the portable scale to obtain a calibration factor. Figure 4.5 is a picture of a tandem axle wheel loading being measured on the portable scales.

Figure 4.5 Portable scales used to measure wheel load for calibration.

Initial attempts were made to measure pressures within an asphalt pavement using the portable scales to calibrate the Tekscan sensor. The car described in Section 4.1.2 was used to apply the load to both the sensor and the portable scale. In order to ensure that the wheels were loading equally while moving over the scales (i.e. one wheel was not carrying more load as a result of the car tilting) a ramp was constructed. The car moving over the ramp and the sensor placed between two layers of asphalt are shown in Figure 4.6.

Figure 4.6 Car on Ramps Leading up to Portable Scales (left) and Tekscan Sensor Install Between Asphalt Layers (right).

The portable scales read in load increments of 100 lb and were ultimately not accurate enough for calibration, but did serve as a check on Tekscan's applicability. The ability to measure pressures between layers of asphalt, though, was of interest. It was evident that if pressures could be accurately measured at the asphalt/asphalt interface, then it may be applicable for measuring pressure within an asphalt pavement structure.

4.1.5 Car in Back Yard. This test used the same car as described in Section 4.1.2. Since it was desirable, in this test, to measure the pressure within the asphalt pavement (as opposed to only on the top layer), several asphalt layers were fabricated and compacted similar to the process described in Section 4.1.1. The following experiment was derived in an effort to test pressures within these layers. The idea was to create an asphalt structure using subgrade, a DGA layer, and several asphalt layers that could be tested in place using Tekscan. The theory was that if a point load (like that of a wheel load) was applied to the surface layer, then the pressure would spread out in a cone-like shape as it was distributed down through the asphalt layers. Also, the pressure would be expected to drop to near zero as it was distributed deeper into the pavement.

The procedure for creating the test structure was as follows. First, 2 ft x 1 ft x 2 in. thick sections of asphalt pavements were created in the laboratory from existing asphalt cores. The cores were heated in an oven, and then placed in a 2 ft x 1 ft x 1.75 – 2 in. mold. Four asphalt layers having a total asphalt thickness of 7.5 inches were fabricated. The Satec machine was utilized to statically compact the specimens. The layers were then allowed to cure for several days before being tested. Next, DGA samples were obtained and adjusted to an optimum moisture content of six percent, as advised by the KDOT Division of Materials. A hole was then dug approximately 1 ft x 2 ft x 1 ft deep to accommodate the 3 in. of DGA and 7.5 in. of asphalt thicknesses. The profile of the test is depicted in Figure 4.7. Similarly, Figure 4.8 is a picture of the setup.

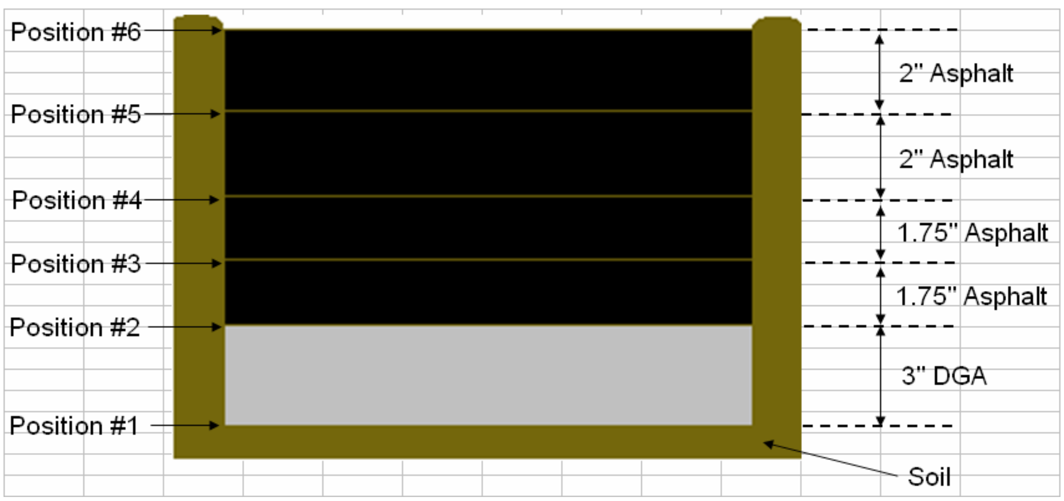


Figure 4.7 Schematic of Test Setup in Back yard.

Figure 4.8 Tekscan Sensor Installed in the Test Hole.

The sensor was placed between the asphalt and DGA layers (referred to as positions numbers 1-6) in an effort to test the pressure distribution between each layer of asphalt. This was the end of the process, though, when a fundamental error was discovered. When testing deeper and deeper into the layers, the force should remain the same while the loading area increases causing a constantly decreasing gross pressure. The promise in this method was that the pressure behaved as expected (decreased with depth) down to a certain point in the asphalt layers. The limitations of the system did not allow for accurate testing deep within the asphalt structure, due to the Tekscan PCI system's inability to accurately read low pressures. As a result, a newer, more sensitive system was required.

4.2 Initial Tests with New USB System

The new and improved USB Tekscan pressure measurement system described in Chapter 3 was used in all of the tests discussed in this section.

4.2.1 Load Tire Section with Jack. This series of tests utilized the tire section, rubber bladder, and steel plate shown in Figure 4.1. The tire section was positioned on top of the asphalt layers, DGA layer, and clay subgrade described in section 5.2 & 5.3. A fast-action hydraulic jack was used to apply the load to the tire section. Data was recorded, using Tekscan's I-Scan software, at jack pressure gauge readings at 100-psi intervals (i.e. 100 psi, 200 psi, 300 psi…). The jack was previously calibrated on the Satec Testing Machine. To calibrate the jack, the loading machine was used as a loading frame, and as the jack applied pressure, the Satec machine provided a reading for the compression force. These values were noted and used in the research as the 'known applied load'. Using this 'known applied' load the Tekscan sensor was calibrated. Figure 4.9 is a schematic of the test setup and Figure 4.10 is a picture of the test setup.

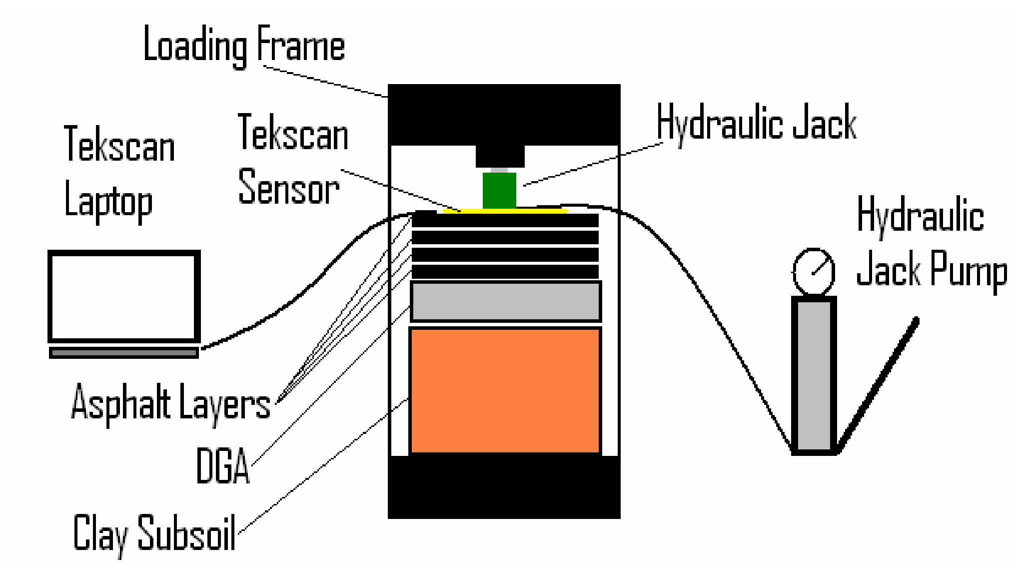


Figure 4.9 Schematic of Applying Load with Jack

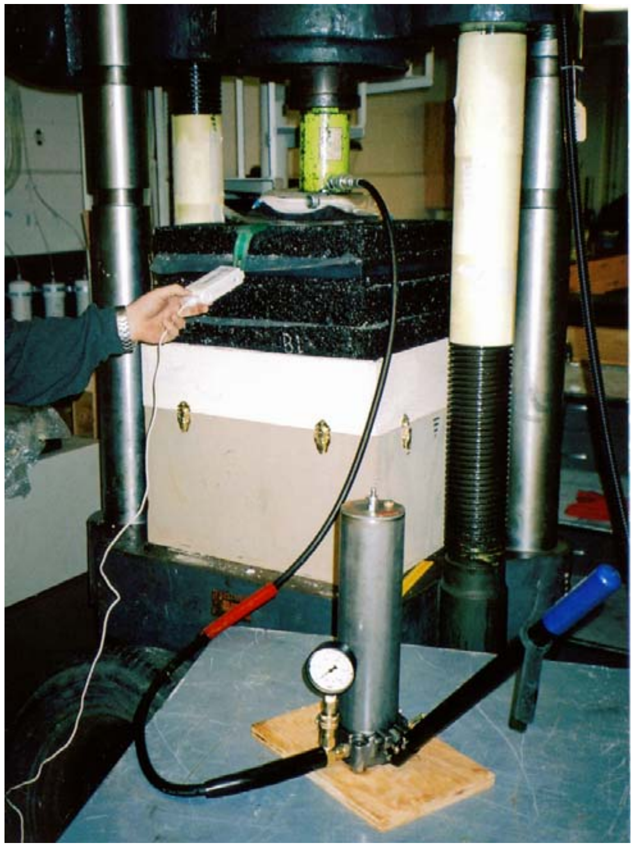


Figure 4.10 Picture of Hydraulic Jack Setup.

The Tekscan sensor was placed between the layers with protective Teflon & Mylar as described in Section 5.3.1.1. This setup proved to be valid in terms of its repeatability.

4.2.2 Directly Loading a Tire on a Rim. In an effort to find a more realistic loading scenario for the laboratory tests, an actual tire on a rim was used. This test aided in defining the differences between the loading patterns of the section of tire and an actual tire. Figure 4.11 is a schematic and picture of the test setup.

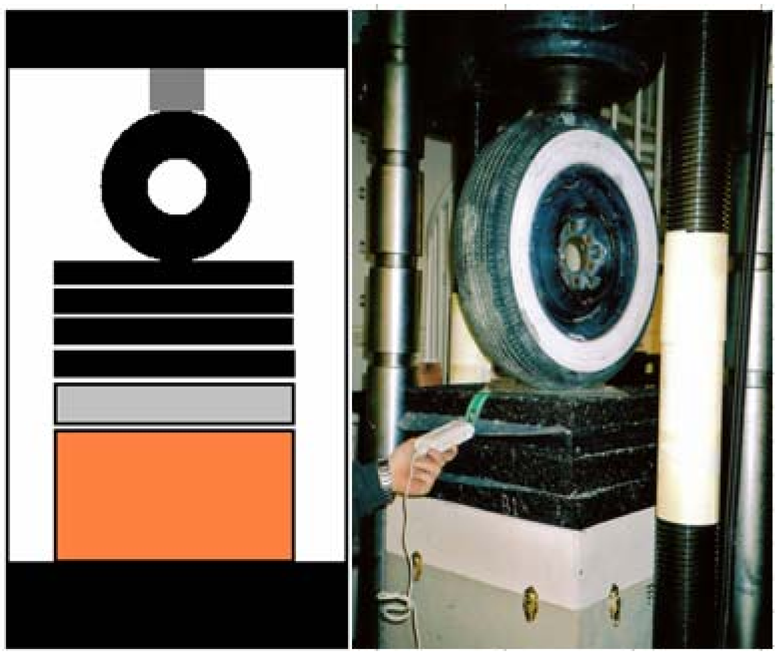


Figure 4.11 Schematic (left) and Picture (right) of Test Setup for Tire Loaded Directly From the Top

This test proved to be fairly realistic. The fault with this test was that the tire was not loaded through the center of the wheel, like a car's axle would load it. Therefore, a simple loading frame was developed to apply a more realistic load to the tire. The optimum laboratory test setup and procedure, which includes a loading frame, is described in Chapter 5.

Chapter 5

Laboratory Pressure Tests Within the Asphalt Pavement Structure

5.1 Introduction

This chapter focuses on Tekscan pressure measurements made at the surface of and within a typical asphalt pavement structure. The laboratory tests are intended to simulate test conditions on an actual pavement structure. Figures 5.1 and 5.2 are views of the test setup described in this section.

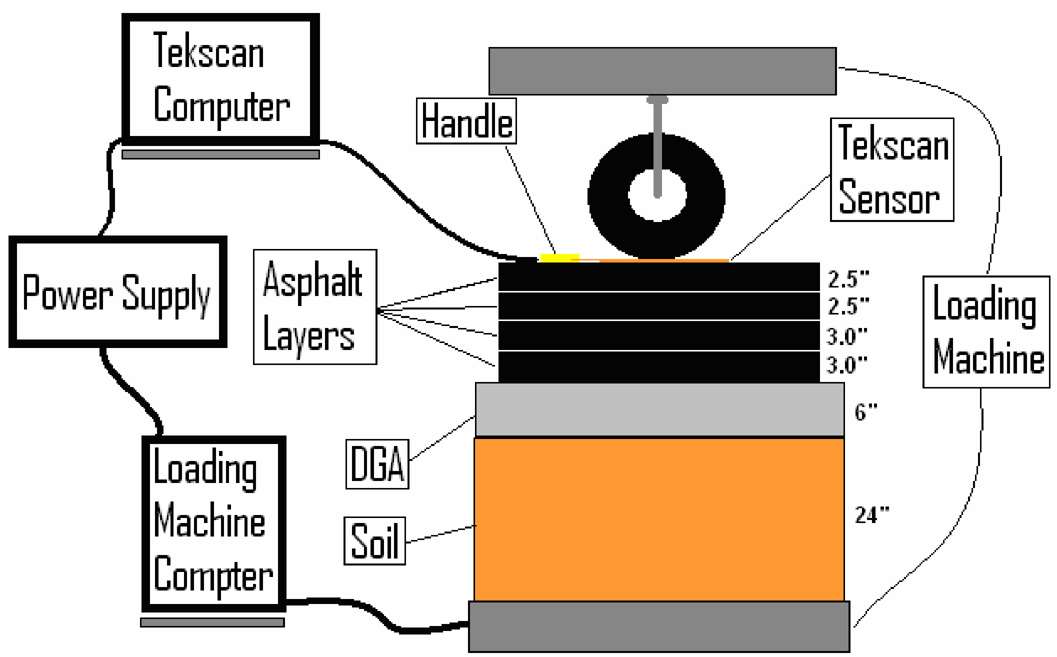


Figure 5.1 Schematic of Test Setup

Figure 5.2 The Selected Laboratory Test Setup.

5.2 Laboratory Pavement Specimen

Materials were obtained and fabricated into a laboratory prototype of a typical asphalt pavement. The pavement section was comprised of a subgrade layer, dense graded aggregate (DGA) layer, and four asphalt layers.

5.2.1 Soil Subgrade. A very typical soil subgrade was desirable for the laboratory test pavement section. The soil used in this research had to be validated as such. Gregg Laboratories, Inc., a local Geotechnical Engineering Firm, was contacted in an effort to locate an acceptable sample. Gregg was involved in a current roadway project for which it had just completed performing compaction (ASTM D 698-91) and bearing ratio (ASTM D 1883-99) tests. The soil chosen was classified as a light olive brown, lean clay, with light gray mottling and a few shaley limestone fragments. It had a California Bearing Ratio (CBR) at 95% of maximum density equal to 0.9, a plasticity index of 18, a liquid limit of 39, and an optimum moisture content of 16.4%. Based on these, the soil would be classified as a very poor quality soil, but typical for many soils in the area. See Appendix B for the complete laboratory test results.

The sample was taken at the same roadway location of the soil that was tested by Gregg. The soil was excavated to a depth of 6 inches to 1 foot beneath the top of the compacted subgrade surface. A sample was obtained to produce approximately 5.5 ft^3 of compacted soil. Figures 5.3 and 5.4 show the excavation process. The soil was then sealed to prevent loss of moisture.

Figure 5.3 Soil Excavation Process.

Figure 5.4 Soil Excavated Approximately 6 inches – 1 foot Deep.

The soil was compacted in the laboratory at optimum moisture content in 2 in. lifts into a 20 in. x 20 in. x 2 ft deep plywood (3/4 in. thickness) box that served as the frame for the subgrade specimen. An iron digger was used to compact each lift. See Figure 5.5 for the process of compacting the soil with an iron digger in the plywood box.

Figure 5.5 Compacting Clay with Iron Digger.

5.2.2 Dense Graded Aggregate (DGA) Base. The typical granular base consisted of a 6 in. thick layer of DGA that was placed above the 2-ft layer of compacted clay. The KDOT's Division of Materials provided the DGA specimen. The sample was returned to the laboratory where the moisture content was increased to about 6% as recommended by the Division of Materials to achieve a typical DGA moisture content. The DGA sample at optimum moisture content was placed in a plywood frame in 2 in. lifts, very similar to the clay sample, and compacted with the iron digger.

5.2.3 Asphalt Specimens. Perhaps the most critical and important portion of the pavement section is the asphalt layers. It was desirable for the asphalt layers to represent very typical dense-graded Superpave mixes compacted such that no further compaction would occur during the tests. This property of optimum compaction is also desirable on the roadway so that wheel loadings will not further compact the asphalt and create rutting.

Initial attempts were made in the laboratories at the University of Kentucky to create the desired specimens. Facilities were not available to adequately compact the large size specimens. Therefore, the National Center for Asphalt Technology (NCAT) at Auburn University was contacted to fabricate very typical asphalt specimens. The selected size of the specimen was 20 in. by 20 in. and around 2 to 4 in. thick. Four layers were produced: two base layers at 3.0 in. thickness and two surface layers at 2.5 in. thickness.

The specimens were compacted in a steel mold during the compaction process at NCAT. Thin steel plates were placed on top of the asphalt specimen. Figure 5.6 is a picture of the mold and the thin steel plates. The specimen was then placed in a compaction machine that utilized a large roller that ran back and forth across the tops of the thin steel plates to create a sort of kneading action while compacting the asphalt. Figure 5.7 is a picture of the compaction machine.

Figure 5.6 Asphalt Compaction Mold.

Figure 5.7 Asphalt Compaction Machine.

The surface course slab mix design included an air content of 4.8 percent, specific gravity of 2.556, and a PG grade 64-22 asphalt binder. The base course slab mix design included an air content of 4.4 percent, a specific gravity of 2.597, and a 64-22 performance graded binder. The detailed mix design data can be found in Appendix C.

During the shifting of the slabs while placing the sensors, the asphalt loses its frictional bond between layers. That is to say, the asphalt slabs adhere when they are allowed to rest upon one another for an extended period of time. Moving the slabs breaks any frictional bond that had developed. Since Tekscan is intended to be a non-intrusive measurement technique, some steps have to be taken into account for this phenomenon.

A simple three-step process was developed to help regain some of the interlayer frictional bonding between the asphalt slabs immediately upon shifting. First, 1 in. loading straps were placed along the edges of the asphalt and cranked to a 'snug' tension. This 'snug' tension is based on feel, so it is just tight enough to hold the edges of the asphalt together, but not tight enough to further compact or destroy the slabs. Next a load was applied (usually by the tire) to the center of the slab and unloaded several times to further "seat" the asphalt layers at the interface. The straps were removed and if the asphalt slabs showed no rebound movement or curling, the section was ready for testing.

5.3 Baldwin Loading Machine

Once the roadway cross-section (combination subgrade, DGA base and asphalt layers) was prepared, it was placed in a Universal Baldwin Loading Machine. The loading machine is a universal Baldwin hydraulic testing machine with a 300,000 lbf capacity. The recording system is a Satec loading systems brand software package entitled 'NuVision - II'. The loading machine proved to be ideal, considering the size of roadway cross-section, both in the vertical and horizontal planes, and its loading capacity.

Following is the procedure for preparing the loading machine for a test (Satec Systems Manual, 1997):

1. Check to be sure that the proper rating of main power for the machine frame and the computer system is supplied to the system and all electrical cords are plugged in.
2. Turn on power to all peripheral equipment that interfaces with the PC. This includes the monitor, printer, controller, any digital calipers, etc.
3. Turn on power to the PC's CPU. Once the PC is on, select the program "NuVision II".
4. Turn on power to the machine frame. Make sure the NuVision software is running.
5. Move the adjustable middle (electrically powered) crosshead up or down to allow ample room to install any grips or fixtures into the test space. After positioning the middle crosshead, turn the power off to the frame to insure against personal injury or equipment damage.

The Baldwin/Satec loading machine has a wide range of capabilities. The loading machine is rated at 300,000 lbf capacity, but only 2,000 lbf was required for this research. Similarly, only a few of the Satec software features were used.

The Satec software is fairly simple to use, although it is a fairly old system. The following steps outline the procedure for conducting a test (Satec Systems Manual, 1997).

1. Set up the machine frame for a test by adjusting the middle platen with the electrical loading system.

2. From the NuVision II Main Menu, select the "Applications" menu and use the arrow keys to highlight the desired test application. Type in the name of the desired test procedure and press <ENTER>. If unsure of the name, just press the enter key and a list containing all of the procedures sorted alphabetically will appear. Highlight the desired procedure and press <ENTER>. The procedure name is "Tekscan" for this test.

3. After selecting the procedure, a series of displays appears as a reminder of a) test requirements, b) procedure description (if any), and c) cautionary comments. Press any key (except <ESC>) to continue. The Pre Test screen will appear.

4. Toggle through the different boxes of the Pre Test screen by using the <TAB> key. Enter the "Before Test Dimensions" in the appropriate box and fill in any required "Custom Questions" in the appropriate box. NuVision II will not permit the test to start until the fields in the "Before Test Dimensions" box are complete.

5. As a safety or precautionary measure, all channels should be zeroed before conducting a test. Go to "Channels" on the menu bar and highlight "Zero all Channels" and press <ENTER>.

6. Now, the machine should be ready to conduct a test. Go to "Start" on the menu bar and highlight "Run Test Procedure" and press <ENTER> (the <F11> key may be pressed as a 'short cut' instead). Once the test is running, the "During Test Menu Screen" will be displayed. Figure 5.8 is a screenshot of an example Test Menu Screen.

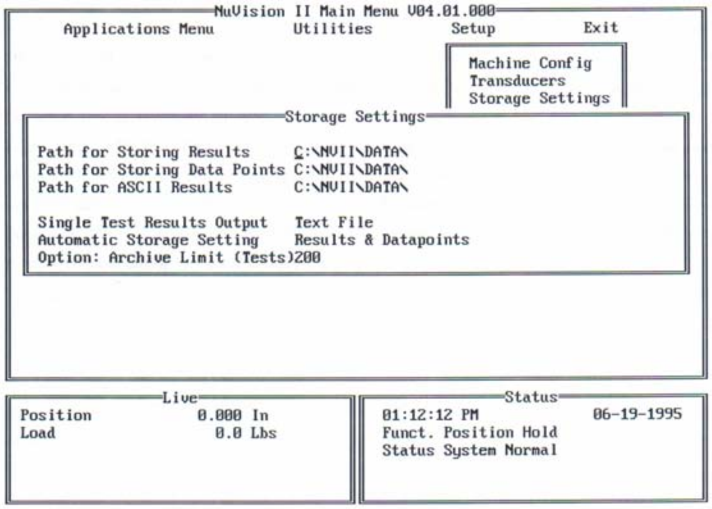


Figure 5.8 Typical Screenshot of NuVision II User Interface (Satec Systems Manual, 1997).

7. If it is desirable to manually override a test, then rather than "running the procedure" as stated in step 6, simply use the hydraulic load and unload buttons found on the loading machine. *(All of the data taken in this body of work was taken using the manually overridden test procedure).* Monitor the "Live Section" of the Test Menu Screen (as shown in Figure 5.8). Figure 5.9 is a schematic of the machine control station box used to manually override the machine.

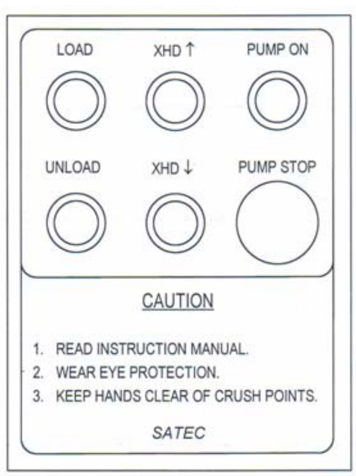


Figure 5.9 Schematic of Control Box (Satec Systems Manual, 1997).

8. When the test is finished, remove the specimen and prepare the system for another test (if applicable).

5.4 Tires & Loading Frame

After mixed results with the tire section described in section 4.1.1, a more realistic loading application was desirable. It was desirable to simulate the actual loading on a pavement between an automotive tire and an asphalt pavement by loading a full-size tire in a realistic manner.

5.4.1 Tires. Three different types of tires were used and loaded using a customized loading frame.

5.4.1.1 Radial Tire. The first tire used was a radial tire. This tire is very typical of most late model passenger cars, trucks, and SUV's. Figure 5.10 contains a picture of the radial tire used in the laboratory tests.

5.4.1.2 Bias Ply Tire. Many older model cars were equipped with bias ply tires. Most heavy trucks use bias ply tires, but the prototype size of the laboratory setup did not provide sufficient space for a large tire. Therefore, a typical bias ply heavy-duty trailer tire was obtained. Figure 5.10 contains a picture of the bias ply tire used in the tests.

5.4.1.3 Small Trailer Tire. There was real concern that the large contact area of the full-size automotive tires used in these tests would create unrealistic boundary conditions at the edges of the asphalt specimens. Therefore, a much smaller, bias-ply utility trailer tire was obtained. Figure 5.10 is a picture of this small utility trailer tire.

Figure 5.10 Radial Tire (Left), Bias Ply Tire (Middle), Small Utility Trailer Tire (Right).

5.4.2 Tire Loading Frame. Initial tests with the tires involved simply applying a compressive load directly to the top of the tire, as opposed to the center of the tire as an axle on a vehicle would apply the load to the tire. This method was deemed too unrealistic. A loading frame, pictured in Figure 5.11, was constructed from two 16 in. long by ¾ in. diameter steel pipe, connected by 90 degree elbows to a 12 in. by ½ in. diameter solid steel conduit. This ½ in. steel conduit runs through a cam in the center of the tire. At the ends of the two 16 in. steel pipes, two round fastening plates serve to transfer the load from the loading machine to the wheel loading frame.

Figure 5.11 Radial Tire with Loading Frame

5.5 Setting up Tekscan

The Tekscan setup with the USB system is fairly simple. The procedure is as follows:

- Plug the Handle into the USB Port located in the back of the Computer
  - It is not essential to plug the USB port in first because most later model operating systems can recognized a USB component that has been added post-boot-sequence.
- Power up the Computer
- Open the Tekscan Software, I-Scan, on the Computer
  - I-Scan will open at this point, but some of the functions will not be accessible without the handle being recognized. Be sure that the handle is plugged into the USB port.
- Once in I-Scan

- Click File
- Click New Session
- Choose the Handle (i.e. 5250 – software map will be used for the 5250 Sensor)
- Click OK
- A 'Sensor Misalignment' error should pop up. This will be remedied when the handle and the sensor are properly connected.

- Plug Handle into Tekscan Sensor
    - This must be done carefully to ensure that the handle's pogo pins make proper contact with all of the lead wires on the sensor. If this is done incorrectly, the result will be a loss of data.
- The Handle Misaligned error box should disappear from the screen if the handle is connected properly to the sensor.
- Check to be sure the computer is recognizing all of the rows in the sensor by running a finger across the rows. The computer may not be recognizing some of the rows.
- Go to Options, click on settings, then click on sensitivity, and choose the desired level.
    - An important note is that the sensor must be calibrated at the same sensitivity setting for which it will be used to measure.
- Begin the test.

5.5.1 Tekscan Sensors. Tekscan Model 5250 sensors were used in this series of tests. Layers of Teflon and Mylar were placed on either side of the sensor to prevent shear damage during the loading cycles. Furthermore, the Teflon and Mylar were taped in place using Scotch tape to prevent them from sliding and/or shifting when maneuvering them in and out of position between the layers. The sensors were then alternately placed on top of the surface layer and between the asphalt layers as desired.

Two sensor arrangements were used. The first arrangement consisted of four 10 in. x 10 in. sensors taped together such that they covered the entire 20 in. x 20 in. asphalt slab. Figure 5.12 depicts the first sensor arrangement.

Figure 5.12 Four Sensor Arrangement.

The second configuration was a single sensor placed in the center of the slab. The sensors were inserted between a layer of Teflon and layer of Mylar on either side to protect against shearing forces that can affect the validity of compression loadings and damage the sensor (see Figure 5.13).

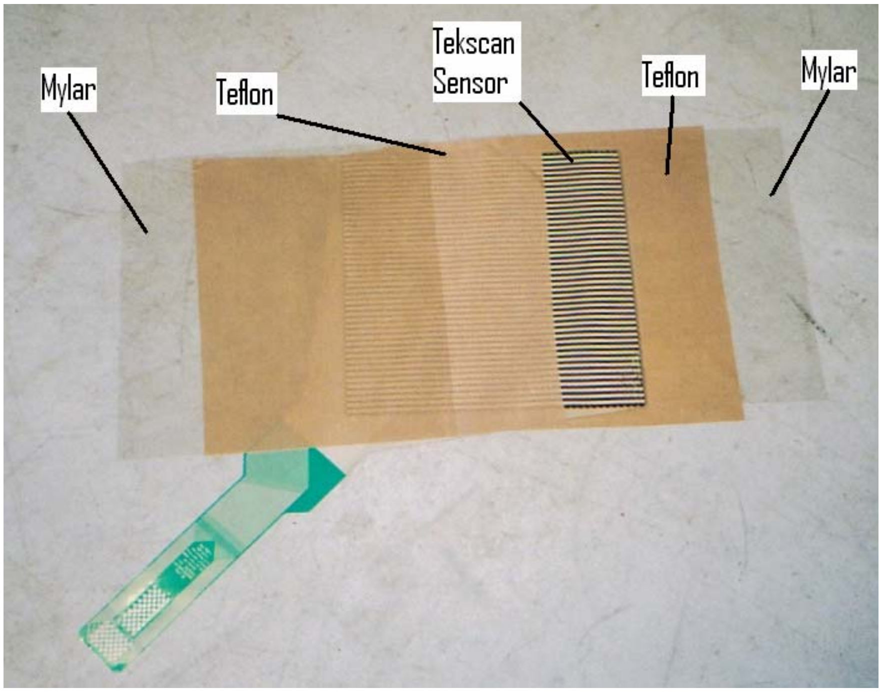


Figure 5.13 Arrangement of Mylar, Teflon and Tekscan Sensor.

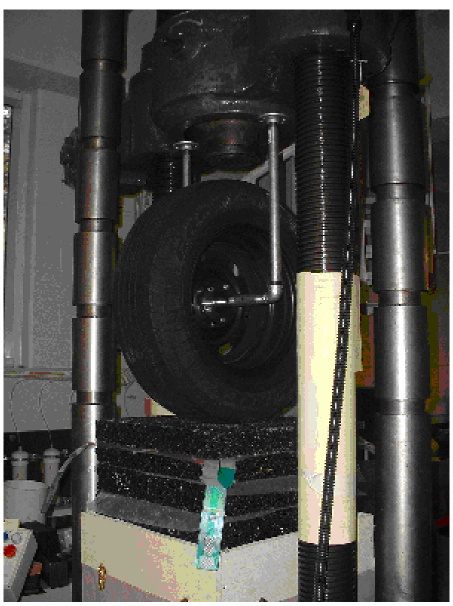
5.6 Recording Data

The data recording sequence requires at least two people. One person manually controls the loading. The other person controls the I-Scan software and notes the loading levels. The Tekscan readings filenames are saved such that they reflect information pertaining to the test (i.e. a reading at 1223 lbf on the loading machine would be saved as a filename “1223” under a folder specific to the test date and the sensor used). The person operating the loading machine manually applies the load and prompts the other person to read the data at the desired loading level. The person monitoring the I-Scan software clicks on the ‘snapshot’ function to record the data at that point in time. The ‘snapshot’ function freezes and positions the image for later analysis and/or editing. This is a very useful feature since the software is constantly taking real-time readings.

5.7 Laboratory Test Procedures

Several testing procedures were developed during this investigation. Two different sensor arrangements and three different types of tires were used. Similarly, pavement tests were performed to verify the laboratory findings. This section will outline the laboratory testing procedures.

5.7.1 Lab Test Procedure No.1. In Test Procedure No. 1, four 5250 model sensors were placed together so that they covered the entire 20 in. x 20 in. area of the asphalt slab. This arrangement was intended to encompass the entire load applied over the surface of the asphalt slabs and to measure the pressure at each asphalt layer interface. Figure 5.14 is a picture and schematic of the setup with this four-sensor configuration between the first and second layers of asphalt.



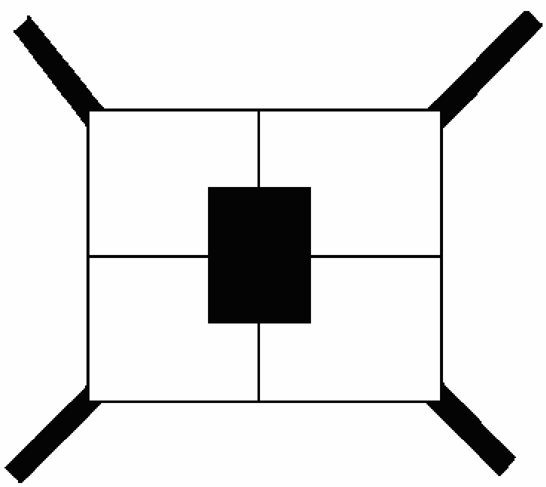


Figure 5.14 Test Procedure No. 1 Typical Setup (sensors between layers 1 & 2)

The tire was then placed directly in the center of the four sensors. The remainder of the test procedure followed the setup described in Sections 5.1 through 5.6.

5.7.2 Laboratory Test Procedure No.2. The configuration for Test Procedure No. 2 was a single sensor placed directly in the center of each asphalt slab. Figure 5.15 is a picture and schematic of the test.

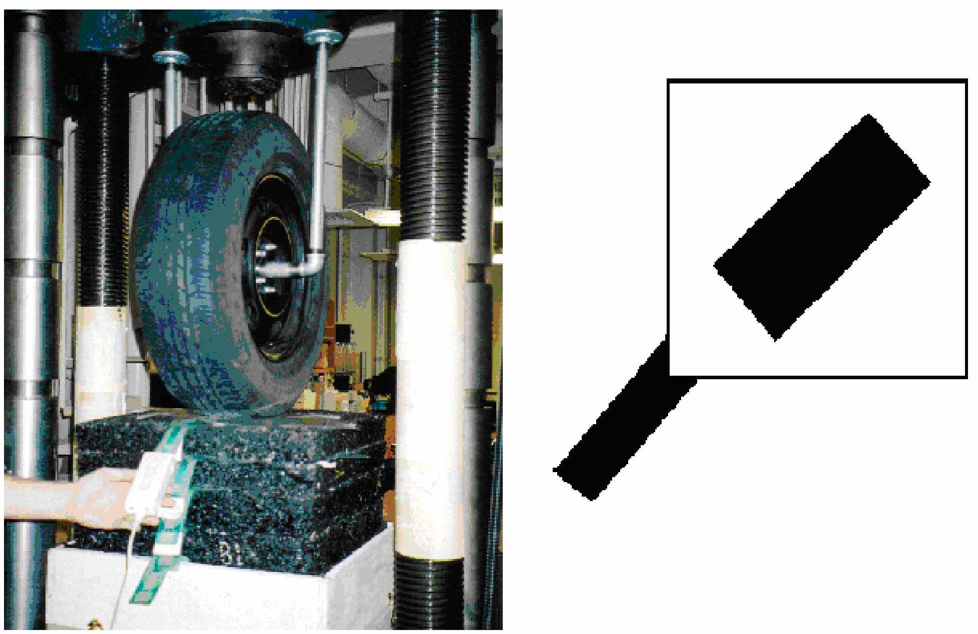


Figure 5.15 Test Procedure No. 2 Typical Setup.

A single 10 in. x 10 in. 5250 model sensor was placed on top of the asphalt and in between each layer of asphalt directly in the center of the slab. The test followed the procedures outlined in sections 5.1 through 5.6.

5.7.3 Laboratory Test Procedure No. 3. This procedure used the sensor configuration described in Test Procedure No. 2. Figure 5.15 shows the tire's orientation over the sensor.

This procedure involved adjusting the tire inflation pressure within the tire to 20 psi, 34 psi, and 50 psi. The tire inflation pressure was then checked using three different tire gages to insure accuracy. The remainder of the test sequence followed the procedures outlined in Sections 5.1 through 5.6.

Chapter 6

Pressure Tests on an Asphalt Pavement

6.1 Introduction

This chapter focuses on the Tekscan pressure measurements made on a typical asphalt pavement. The test site was a new highway development in the Hamburg area of Lexington, KY. Two roads in this newly developed area, Vendor Way and a private road leading to the AAA office, served as test locations. Figure 6.1 is a map of the test location.

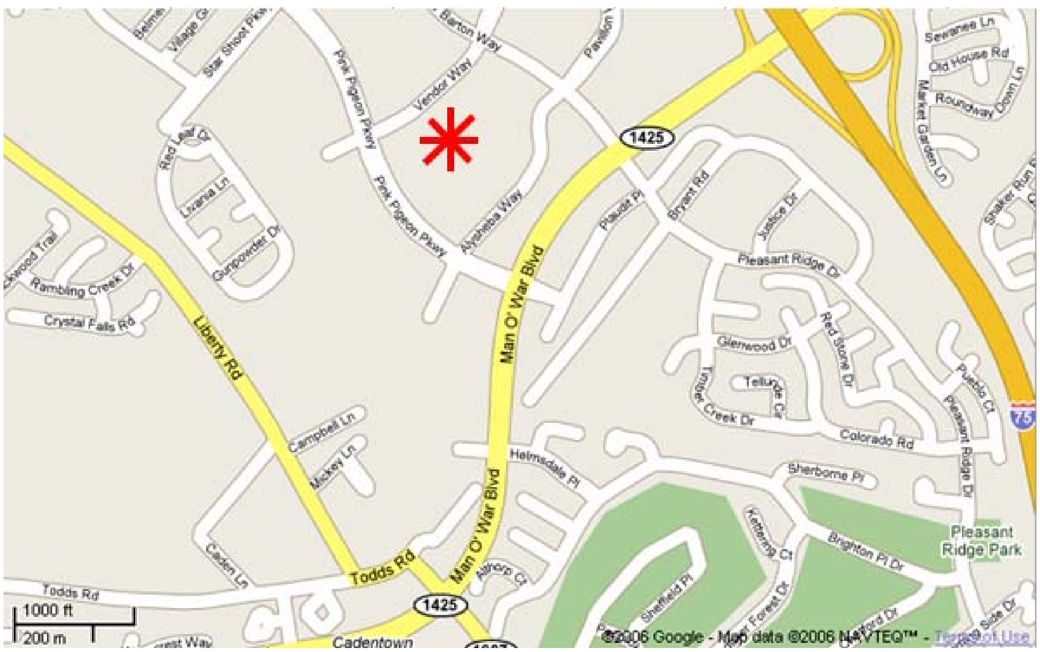


Figure 6.1 Map to Test Site (www.google.com/maps)

6.2 Description of Pavement

The pavement selected for these tests was at the same location where the subgrade samples were obtained for the laboratory prototype tests and studies. The pavement section on Vendor Way consisted of 11 in. of DGA, 3 in. of asphalt base, and 1 in. of surface asphalt (the surface was not complete). Similarly, the section for the pavement at the private road to AAA test location consisted of 8 in. of DGA, 3 in. of asphalt base, and 1 in. of surface asphalt.

6.3 Vehicle Used to Apply the Load

The automobile used to apply the load to the pavement was a 2004 model Mercury Sable station wagon with radial tires. The wheel load was measured on the scales at a local asphalt plant. The total weight of the car was 3720 lb. The right front wheel weighed 1040 lb. It was used for these measurements.

6.4 Adjusting the Tire Inflation Pressure

A portable compressed air tank was used to adjust the tire inflation pressure to 45 psi, 36 psi, and 20 psi levels. The tire was driven over the sensor to evaluate the effect of tire inflation pressures on the contact pressures at the tire/asphalt interface. The results from this procedure can be compared to the changes in tire inflation pressure described in Laboratory Test Procedure No. 3, which is discussed in Section 5.7.3.

6.5 Setting up the Tekscan System

Setting up the Tekscan System for the pavement tests was very similar to the laboratory tests described in Section 5.5. The only difference between setting the system up in the laboratory and in the pavement test was to position the computer in a safe location such that moisture, dust and other environmental hazards would not affect its operation. Also the Tekscan handle (described in Section 3.3.2) was kept free of dust, rocks, and moisture.

6.6 Installing the Tekscan Sensor

The Tekscan model 5250 sensor was used in the pavement tests. Sheets of Teflon and Mylar were placed on both sides of the sensor, as described in Section 5.5.1, to protect it from shearing forces. The sensor was then placed directly on top of the asphalt surface in the wheel path of the car. The sensor was positioned such that when the wheel would pass over the center of the sensor so the imprint would fit entirely on the sensor. Figure 6.2 is a picture of the test setup and the positioning of the sensor prior to the test.

Figure 6.2 Picture of Pavement Test Setup.

6.7 Recording Data

Recording data in the pavement tests was different from that in the laboratory. Since the load application (wheel load) is constant and the only variable is the position of the wheel, the I-Scan software's movie recording capabilities were used. A movie is a series of single frame 'snapshots' that can be played forward and backward, stopped and paused, like a movie.

The following steps were taken to record the movie:

- Click the 'File' tab at the top of the screen. In the drop down box, select new session and confirm that the sensor type is correct.
- Click on options and a drop down box entitled 'Acquisition Parameters' will appear. Set the scan rate to maximum.
- When the test is ready to begin, select the record button at the top of the screen. Figure 6.3 is a picture of the buttons used to operate the movie function.

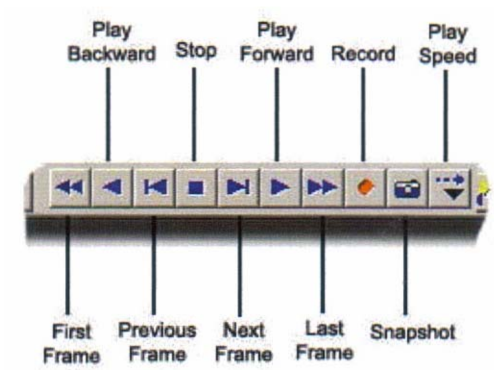


Figure 6.3 Buttons Used to Operate I-Scan software's 'Movie' function (Tekscan, 2006).

- When the test has concluded, select the 'stop' button at the top of the screen.
- Save the movie.

A snapshot was not suitable for this test since it would be difficult to take a snapshot at the exact instant the wheel was entirely on the sensor. After each test was complete, the movie was saved for later analysis. A representative single frame, when the wheel was entirely on the sensor, was selected from the movie for the analysis of pressures on the pavement.

Chapter 7

Data Analysis

7.1 Introduction

This chapter analyzes the test data obtained for various tests. Each test was intended to study the pressure distribution on the surface of and within an asphalt pavement. The main variables investigated were 1) the type of tire, 2) the pressure distribution within an asphalt pavement, 3) the wheel load, 4) the effect of change in tire pressure, and 5) boundary conditions. Table 7.1 is a comparison of the various tests conducted. The table is arranged by test number and indicates the type of tire used in the particular tests, whether or not straps were used to hold the layers together, the position of the sensor, the arrangement (number) of sensors used, the tire inflation pressure, and whether the test was conducted in the laboratory or on the pavement.

Since the area under the tire is so critical to understanding the pressure at each layer interface, two methods of area analysis were implemented based upon Tekscan's capabilities. First, the default view, which appears as a very pixilated image, was used to evaluate the area. Second, the averaging view, which appears as a fairly smooth image, was used to evaluate the area. Refer to Section 3.5.3 for more information on the default and averaging views. This technique permits evaluating the area between the treads on a tire when calculating the contact pressure (i.e. to compare a pressure that includes the area between the treads into the calculation of the contact area, to one that excludes it). Pressures obtained for the various tests, which can be found in Appendixes E, F and G, are reported as based on both the default view and the averaging view. Pressures based on the default view are referred to as the pressure based on net area, and pressures based on the averaging view are referred to as the pressure based on gross area.

	Tire Type			Straps?		Position					Number of Sensors				Tire
	Radial	Bias Ply	Small Utility	Yes	No	Top	Btwn 1&2	Btwn 2&3	Btwn 3&4	Btwn 4&DGA	1	4	Lab	Field	Pressure
Test 1	X				X	X					X		X		36 psi
Test 2	X				X	X						X	X		36 psi
Test 3	X				X		X					X	X		36 psi
Test 4	X				X				X			X	X		36 psi
Test 5	X				X	X					X		X		36 psi
Test 6	X				X	X						X	X		36 psi
Test 7	X			X			X					X	X		36 psi
Test 8	X				X		X					X	X		36 psi
Test 9		X			X	X					X		X		36 psi
Test 10		X			X	X						X	X		36 psi
Test 11		X		X			X					X	X		36 psi
Test 12		X			X		X					X	X		36 psi
Test 13	X										X		X		36 psi
Test 14a	X			X		X					X		X		36 psi
Test 14b	X			X			X				X		X		36 psi
Test 14c	X			X				X			X		X		36 psi
Test 14d	X			X					X		X		X		36 psi
Test 14e	X			X						X	X		X		36 psi
Test 15a		X		X		X					X		X		36 psi
Test 15b		X		X			X				X		X		36 psi
Test 15c		X		X				X			X		X		36 psi
Test 15d		X		X					X		X		X		36 psi
Test 15e		X		X						X	X		X		36 psi
Test 16a			X	X		X					X		X		36 psi
Test 16b			X	X			X				X		X		36 psi
Test 16c			X	X				X			X		X		36 psi
Test 16d			X	X					X		X		X		36 psi
Test 16e			X	X						X	X		X		36 psi
Test 17	X				X	X					X		X		34 psi
Test 18a	X				X	X					X		X		34 psi
Test 18b	X				X		X				X		X		34 psi
Test 18c	X				X			X			X		X		34 psi
Test 18d	X				X				X		X		X		34 psi
Test 18e	X				X					X	X		X		34 psi
Test 19a	X				X	X					X		X		34 psi
Test 19b	X				X	X					X		X		50 psi
Test 19c	X				X	X					X		X		20 psi
Test 20a	X				X	X					X			X	34 psi
Test 20b	X				X	X					X			X	50 psi
Test 20c	X				X	X					X			X	20 psi
Test 21	X				X	X					X			X	34 psi
Test 22a	X				X	X					X			X	34 psi
Test 22b	X				X	X					X			X	50 psi
Test 22c	X				X	X					X			X	20 psi
Test 23	X				X	X					X			X	36 psi
Test 24	X				X	X					X			X	36 psi
Test 25	X				X	X					X			X	36 psi
Test 26	X				X	X					X			X	36 psi

Note: Tests 14a - 16e used straps to attempt to reestablish interlayer friction (released straps before test began)

Table 7.1 Test Comparison

The data pertaining to each of the tests discussed in this chapter can be found in Appendixes E, F, and G. The original test data reported in Appendix E has been normalized to intervals of 400 lbf ranging from 0 – 2000 lbf and reported in Appendix F. Similarly, the original test data from the pavement tests is reported in Appendix G. Most of the laboratory data used in this section will come from the normalized data.

7.2 Calibration of Sensors

This section discusses calibration of a sensor for use in a pressure measurement as well as typical results obtained from various tests. Referring to Table 7.1, any test on the top layer of the asphalt could be considered as a calibration since the known load is directly applied to the particular interface. The reasoning behind this is that by placing the tire completely on the sensor, the entire load applied to the asphalt would be applied to a single sensor. Therefore, the total raw sum output by Tekscan can then be directly compared to the known applied machine load to yield a calibration factor.

The Tekscan system measures pressure in a raw unit form. In order to convert the raw readings into a SI, U.S. or other unit, a calibration of the sensor must be conducted. The calibration process is fairly simple. First, a known load (force) is applied to the Tekscan sensor using some common unit of measurement (pounds-force in this research). Next, the I-Scan software is used to record a measurement of this known load. Finally, the raw sum given by Tekscan is divided by the known applied load to achieve a calibration factor. This process is typically carried out over a range of loads and the average is used. The calibration factor is used in subsequent tests to convert raw units into known units.

Example

Load applied to sensor by testing machine = 480.1 lbf

Measured Tekscan reading = 11493 Raw Sum

Tekscan Raw Sum / Known Applied Load = Calibration Factor

11493 Raw Sum / 480.1 lbf = 23.94 Raw Sum / lbf

Loads less than 400 lbf were omitted from this analysis. Values at the low applied loads were fairly inaccurate for the I-Scan sensitivity setting that was used for these tests. Using a more sensitive setting would have caused the sensor to become too saturated at the higher load levels. As a result an optimum Tekscan sensitivity setting for the loading interval of interest (400 lbf – 2000 lbf) was chosen and used throughout the research. The setting was sensitive enough to read accurately at wheel loadings of 400 lbf and did not become saturated at the 2000 lbf interval. This rational was justified because actual wheel loadings are typically greater than 400 lbf. Values for applied loads of 400 lbf are denoted in Appendixes E, F, and G with gray boxes through the data.

7.2.1 Drift. Six different model 5250 sensors were used in this research. The sensors were labeled 5250-5, 5250-6, 5250-7, 5250-8, 5250-9, and 5250-10. Before a test, each sensor was calibrated. Typically, calibration was performed on the same day as the test to prevent drift due to time. According to the Tekscan User Manual:

> "Drift is the change in sensor (and system) output when a constant force is applied over a period of time. Among other things, the sensor design, sensitivity, interface material, applied load, and environmental conditions may influence the drift. It is important to take drift into account when calibrating the sensor, so that its effects can be minimized. The simplest way to accomplish this is to perform the sensor calibration in a time frame similar to that which will be used" (Tekscan, 2006).

To show the importance of calibrating a sensor immediately before its use, particularly when it is new, the change in the calibration factor with time for each of the previously mentioned sensor numbers is shown in Table 7.2. Each calibration was performed using a radial tire in the laboratory and followed Test Procedure No. 2, which was described in Section 5.7.2, using a single sensor. The complete sets of data used to calculate the average calibration factor can be found in Appendixes E and G. Specifically, the test performed on 9/4/2006 is referred to as Test No. 1 and can be found in Appendix E. The test performed on 9/19/2006 is referred to as Test No. 5 and can also be found in Appendix E. The test performed on 10/5/2006 is referred to as Test No. 13 and can be found in Appendix E. The test performed on 10/25/2006 is referred to as Test No. 17 and can be found in Appendix G.

	Average Calibration Factor (Raw Sum/lbf)											
	5250-5		5250-6		5250-7		5250-8		5250-9		5250-10	
Date	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross
9/4/2006	24.31	24.18	28.15	28.01	27.75	27.61	31.28	31.39	-	-	-	-
9/19/2006	29.67	29.55	28.92	28.82	29.18	29.12	31.23	31.11	-	-	-	-
10/5/2006	-	-	-	-	-	-	-	-	27.74	27.64	11.90	11.78
10/25/2006	23.20	23.09	28.55	28.43	-	-	30.97	31.48	30.36	28.34	13.34	13.22

Table 7.2 Calibration Factor Changes (Drift) with Time

Sensors 5250-9 and 5250-10 were initially used on 10/5/2006. The other four sensors had seen considerable use previous to 9/4/2006, which is the earliest data that is recorded in this research. Since sensors 5250-9 and 5250-10 were new, their calibration factors showed more fluctuation with time. Sensor 5250-7 shows this same change as the new sensors, but it had a considerable number of damaged or missing rows, which made it unreliable, and was ultimately replaced. According to the Tekscan User's Manual:

> "Sensors must be 'exercised' by loading them three to five times before they are used (which is called 'conditioning' the sensor). Conditioning helps to lessen the effects of drift, and is required for new sensors, and for sensors that have not been used for a length of time" (Tekscan, 2006).

The calibration factors, listed in Table 7.2, for Sensors 5250-9 and 5250-10 reflect the typical behavior of a new sensor.

7.2.2 Measurement Interface. The calibration factor is also heavily affected by the interface at which it is being measured. This is due to the fact that the composition (compliance) of the materials that comprise the interface, at which the measurements are being taken, is very critical. According to the Tekscan User's Manual:

> "A compliant material is one that cushions high points of contact and fills in low points of contact. Placing a compliant material, like rubber, between two hard surfaces will lower the peak pressure areas, increase pressure in low pressure areas, and increase contact area" (Tekscan, 2006).

There were noticeable differences between the calibration factors taken in the laboratory and the calibration factors taken on the pavement. Compliance is a likely cause. For example, the calibration factor for the 5250-9 sensor for a radial tire loaded over the laboratory asphalt specimen is much different than the calibration factor taken on the pavement. Table 7.3 contains summarized data take from tests 17, 18a, 19a, 21, and 25, which can be found in their entirety in Appendix F. Table 7.3 compares calibration factors for the 5250-9 sensor, taken at the tire/asphalt interface in the laboratory to those taken on the pavement. All of the tests listed in Table 7.3 were performed on the same day (10/25/2006) so drift due to time is not a likely factor.

Average Calibration Factors (Raw Sum/lbf)			
Test No.	**Net**	**Gross**	**Location**
17	30.36	28.34	Laboratory
18a	31.37	31.29	Laboratory
19a	33.46	33.37	Laboratory
AVG	**31.73**	**31.00**	
21	26.14	26.05	Vendor Street
25	21.92	21.84	Private Road to AAA

Table 7.3 Comparison of Calibration Factors from Tests Taken at Different Tire/Asphalt Interfaces.

Two major factors could have contributed to this fluctuation in the calibration factor with location. First, the tire used in the laboratory was a Goodyear Integrity P215/70R15 97S radial tire and it had a much different configuration than the one used on the pavement, which was a Continental Touring Contact AS P215/60R16 94T radial tire. Second, the prototype laboratory pavement surface and the in-place pavement surfaces were much different. These factors likely contributed to the difference in results. To emphasize this point, results from Tests 23, 24, and 26 (Appendix G) can be directly compared to evaluate the importance of the calibrating a sensor for a particular location. Test 23 was evaluated using the laboratory calibration factor. Test No. 24 was evaluated using the calibration factor from Test No. 21 which was performed about 1/8 of a mile away from Test No. 24. Test No. 26 is simply the data from Test No. 24 evaluated using a calibration factor unique to the test location. The results from Tests 23, 24, and 26 yielded very different results as Table 7.4 shows. The complete data for Tests 23, 24, and 26 are in Appendix G.

Data Taken at AAA Test Site Evaluated Using Different Calibration Factors			
Test No.	Pressure (psi) Based on Net Area	Pressure (psi) Based on Gross Area	Calibration Factor Based On
23	32.58	23.26	Laboratory Calibration
24	37.78	23.40	Private Road
26	45.06	30.36	Unique to this Site
Note: Tire Pressure was 36 psi			

Table 7.4 Data Taken at AAA Test Site Evaluated Using Different Calibration Factors.

The only difference between Tests 23, 24, and 26 is the calibration factor used to determine pressure. The same tire and loading were used in each of the three tests. Identical values of raw sum and area were used, which were taken directly from test data, for each test. The values of pressure from these three tests vary significantly with changes in the calibration factor. Therefore, some emphasis must be placed on the effect of the pavement interface compliance on the calibration factor.

7.3 Effect of the Type of Tire on the Pressures at the Tire/Asphalt Interface

Tekscan was used as a measurement technique for evaluating the pressure between the tire and the top of the asphalt. It was desirable to develop a technique for measuring (with reasonable accuracy) the pressure, or stress, that the asphalt experiences as it is loaded. Similarly, the effect that the type of tire has on the stress was of interest. As described in Section 5.4, three different tires were used to accomplish this goal: radial, bias ply, and a small utility trailer tire.

The first tire used in this research was a radial tire. Radial tires are the most common on passenger vehicles. Several laboratory tests, 1, 2, 5, 6, and 14a, were conducted using the radial tire at the tire/asphalt interface. Each of these tests followed the test setup as described in Sections 5.1 through 5.6. Test numbers 2 and 6 followed Test Procedure No. 1, which was described in Section 5.7.1, and used four sensors. Test numbers 1, 5, and 14a followed Test Procedure No. 2, which was described in Section 5.7.2, and used a single sensor centered over the asphalt layer. The two sensor configurations used in Test Procedures No. 1 & 2 should yield the same pressure readings. The four-sensor configuration would then serve as four independent tests, while also illustrating the pressure distribution over the entire 20 in. by 20 in. layer of asphalt. Both configurations could then be used to compare one to the other.

The second tire was a bias ply tire. Bias ply tires are very common on heavier trucks, older model cars, and heavy-duty trailers. Several tests were conducted using a bias ply tire.

Test numbers 9, 10, and 15a were conducted on the top layer using a bias ply tire. Test numbers 9 and 15a followed Test Procedure No. 2, while Test No. 10 followed Test Procedure No. 1.

The third tire used in this research was a small bias ply utility trailer tire. Test No. 16a was conducted using the small utility trailer tire, and followed Test Procedure No. 2.

Table 7.5 compiles normalized data from tests that involved measuring the contact pressure at the tire/asphalt interface. The table is assembled by test number, and includes both the net pressure and the gross pressure over a range of 400 – 2000 lbf for the three tire types. The tire pressure within the radial tire was 35 psi at the time of each test. Similarly, the pressure in the bias ply tire was 45 psi and the small trailer tire was 41 psi at the time of the test. These were the tire manufacturer's recommendations for the individual tires.

Figures 7.1 and 7.2 are graphical representations of the measured pressures on the top layer of asphalt. Figure 7.1 is based on net area and Figure 7.2 is based on gross area. The graphs correspond to the laboratory test data recorded in Table 7.5. Each figure shows that each tire demonstrates a different pressure pattern although each were loaded on the same asphalt surface at the same applied load.

Tire Pressure Ranges (psi) Loads from (400 lbf - 2000 lbf)								
RADIAL			*BIAS PLY*			*SMALL UTILITY TIRE*		
Test No.	**Net Pressure**	**Gross Pressure**	**Test No.**	**Net Pressure**	**Gross Pressure**	**Test No.**	**Net Pressure**	**Gross Pressure**
1	28.31 - 40.45	19.58 - 33.74	9	26.11 - 45.42	22.13 - 39.46	16a	39.10 - 66.94	27.09 - 50.02
2	21.38 - 49.34	16.24 - 40.25	10	22.34 - 43.79	19.71 - 39.57			
5	23.79 - 39.87	17.27 - 33.88	15a	34.34 - 48.19	24.84 - 38.12			
6	12.23 - 43.34	8.87 - 34.68						
14a	31.17 - 43.71	18.79 - 32.67						
Average	**23.38 - 43.34**	**16.15 - 35.044**	**Average**	**27.60 - 45.8**	**22.23 - 39.05**	**Average**	**39.10 - 66.94**	**27.09 - 50.02**
Note: Values taken from Normalized Data Tables								

Table 7.5 Pressure Ranges for Three Tires at Tire/Asphalt Interface (Top of Asphalt)

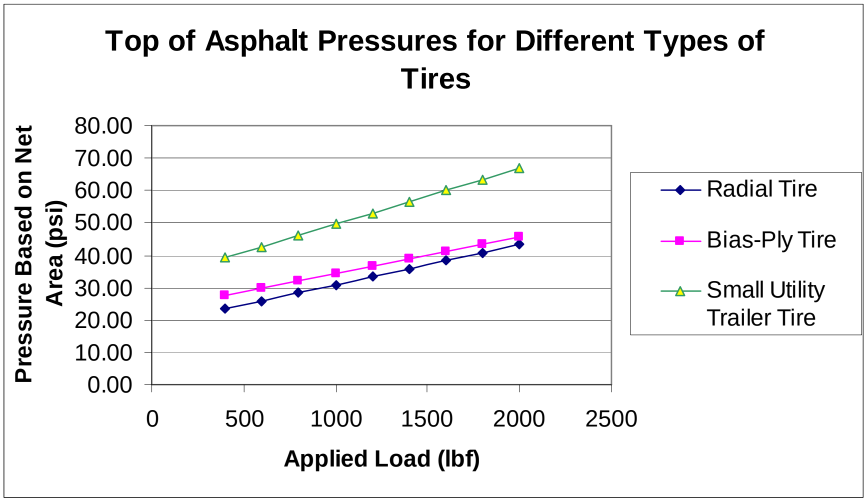


Figure 7.1 Top of Asphalt Pressures Under Different Types of Tire Loadings Based on Net Area.

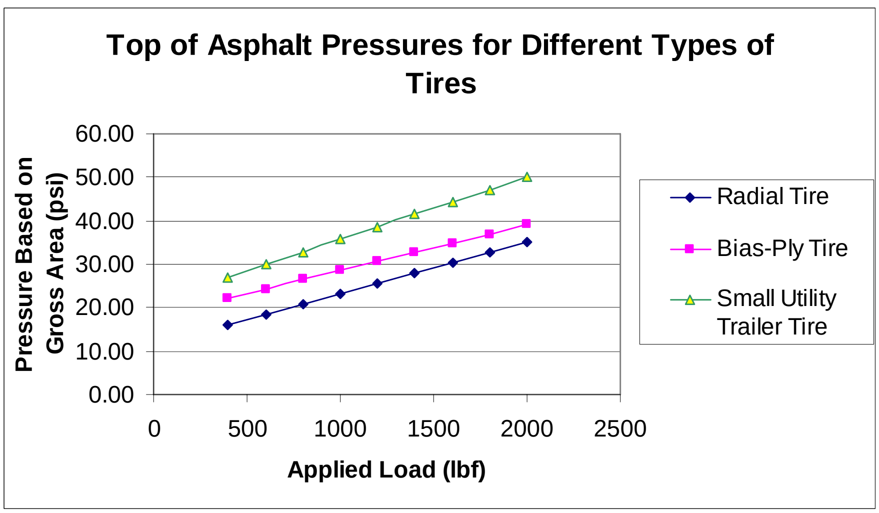


Figure 7.2 Top of Asphalt Pressures Under Different Types of Tire Loadings Based on Gross Area.

The average range for the contact pressure based on net area (Net Pressure) for the radial tire was 23.38 psi when a 400 lbf load was applied, increasing linearly to 43.34 psi when a 2000 lbf load was applied. Similarly, the average range for the contact pressure based on gross area (Gross Pressure) was 16.15 psi when a 400 lbf load was applied, increasing linearly to 35.04 psi when a 2000 lbf load was applied. Multiple charts attesting to this linear relationship can be found in Appendix E. The pressure based on the net area reveals a much higher contact pressure than the tire inflation pressure at higher loads.

Furthermore, in pavement design, the area under the tire is considered to be circular. This geometry allows empirical calculations and computer modeling programs like KENLAYER to assume axisymmetric loading conditions. Figure 7.3 shows that the typical tire imprints are certainly not circular, but even vary depending on type of tire.

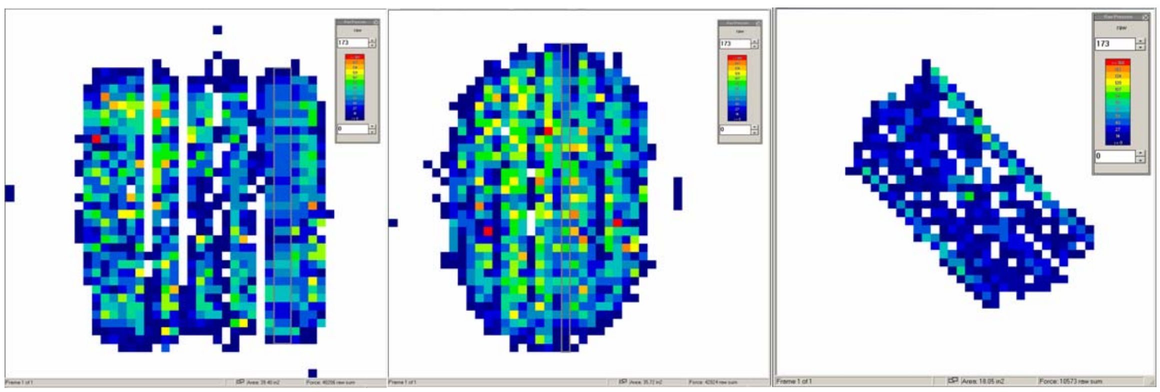


Figure 7.3 Screenshots of Typical Radial Tire (Left), Bias Ply Tire (Middle), and a Small Utility Tire (Right) Imprints.

This contact area that a tire exerts onto the asphalt pavement can be viewed as its unique 'thumbprint' and may be very different depending on the type of tire. This is important to note because just as the asphalt surface seemed to have an effect on tests results, the unique surface of a tire might have a similar effect. Obviously, as data from Table 6.4 shows, the smaller the tire imprint, the higher the contact pressure. Also, it is typical for a more rigid tire to have a smaller tire imprint, due to the stiffer sidewalls resisting deformation.

7.4 Effect of Varying Tire Inflation Pressure

It is common in pavement structural design to use the recommended tire inflation pressure as a parameter for design. In fact, the computer modeling program specifically designed for analysis of flexible pavements, 'KENLAYER', uses tire inflation pressure as one of its input parameters. The reason for using the tire pressure is that the load is assumed to be uniformly distributed over the contact area, and the size of the contact area depends on the contact pressure. It is assumed that the contact pressure is greater than the tire pressure for tires with lower inflation pressures. This is because the walls of the tires are in compression and the sum of vertical forces due to wall and tire pressure must be equal to the force due to contact pressure (Huang, 2004). It is also assume that the contact pressure is smaller than the tire pressure for high pressure tires, because the wall of the tire is in tension (Huang, 2004). However, in pavement design, the contact pressure is generally assumed to be equal to the tire pressure (Huang, 2004). The assumption is that the heavier axle loads have higher tire pressures and consequently have more destructive effects on pavements. The use of tire pressure as the contact pressure represents a margin of safety (Huang, 2004).

Test numbers 19, 20, and 22, data for which can be found in Appendix G, were designed to evaluate the effect of different tire pressures on the pavement pressure using the Tekscan pressure measurement system. Test No. 19 followed Test Procedure No. 3, and is discussed in Section 5.7.3. Tests 20 and 22 followed the setup described in Chapter 6. Table 7.6 contains average pressures based on net area and average pressures based on gross area from tests 19, 20 and 22. It is important to note that the laboratory pressures are based on a 1200 lb applied load and the pavement pressures are based on a wheel load of 1040 lb. This wheel was weighed on a recently calibrated scale at an asphalt plant. The table refers to a 'Pavement Calibration Factor'.

This is simply a calibration performed on the pavement, under the actual loading conditions, using the known wheel load of 1040 lb.

Tire Inflation Pressure (psi)	Laboratory (Using Laboratory Calibration Factor)		Pavement (Using Laboratory Calibration Factor)		Pavement (Using Pavement Calibration Factor)	
	Net (psi)	Gross (psi)	Net (psi)	Gross (psi)	Net (psi)	Gross (psi)
50	43.93	31.17	38.95	30.19	48.98	32.85
35	36.65	26.20	35.11	26.90	40.77	29.27
20	29.84	20.82	26.10	18.87	32.82	20.52

Table 7.6 Change in Tire/Pavement Contact Pressure with Tire Inflation Pressure.

Figures 7.4 and 7.5 are graphical representations of the relationship between tire inflation pressure and measured pressures at different tire/asphalt interfaces. Figure 7.4 is based on the net area and Figure 7.5 is based on the gross area. The graphs correspond to the data listed in Table 7.6. The graphs show that the asphalt surface has a clear effect on the measured pavement pressure.

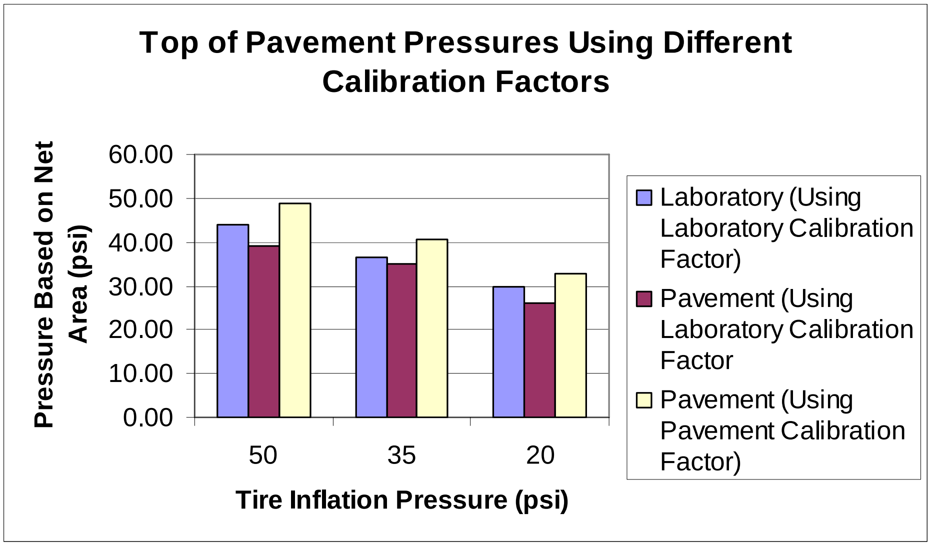


Figure 7.4 Top of Pavement Contact Pressure Based on Net Area.

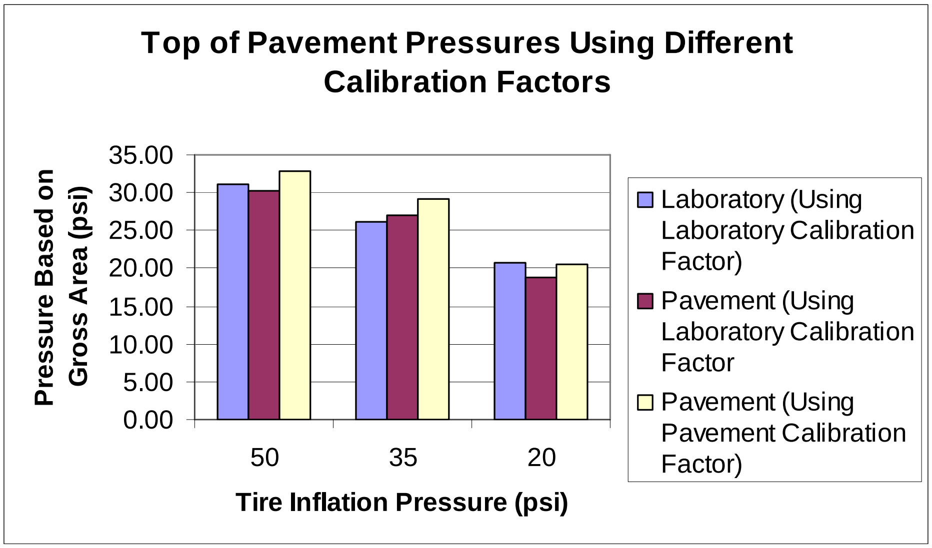


Figure 7.5 Top of Pavement Contact Pressure Based on Gross Area.

When the tire inflation pressure was equal to 50 psi, the net pressure was much closer to the tire inflation pressure than the gross pressure, but still lower. Alternatively, the gross pressure was not close to the tire inflation pressure. When the tire inflation pressure was equal to 35 psi in the laboratory tests, the net pressure was very close to the tire inflation pressure. Again, the gross pressure was not close to the tire inflation pressure. When the tire inflation pressure was equal to 35 psi on the pavement, the net pressure was close to the tire inflation pressure regardless of whether the laboratory or pavement calibration factor was used. The gross pressure was not close to the tire inflation pressure. When the tire inflation pressure was equal to 20 psi, both the laboratory readings and the pavement readings reflected a tire/pavement contact pressure higher than 20 psi for the net pressure. Alternatively, the gross pressure was very close to the tire inflation pressure.

Figure 7.6 is a compilation of I-Scan screenshots from both the laboratory and pavement tests at 20 psi, 35 psi, and 50 psi tire inflation pressures. The screenshots show both the default and the averaging views of the tire imprint. The images represent the effect a change in tire pressure has on the contact area at the tire/asphalt interface. Also note, as discussed in Section 7.3, the tires have much different material compositions. Obviously, from Figure 7.6, the laboratory tire imprint is much larger than the tire imprint from in the pavement tests. When an equal load is applied in the laboratory and on the pavement, different pressures result due to this variation in contact area.

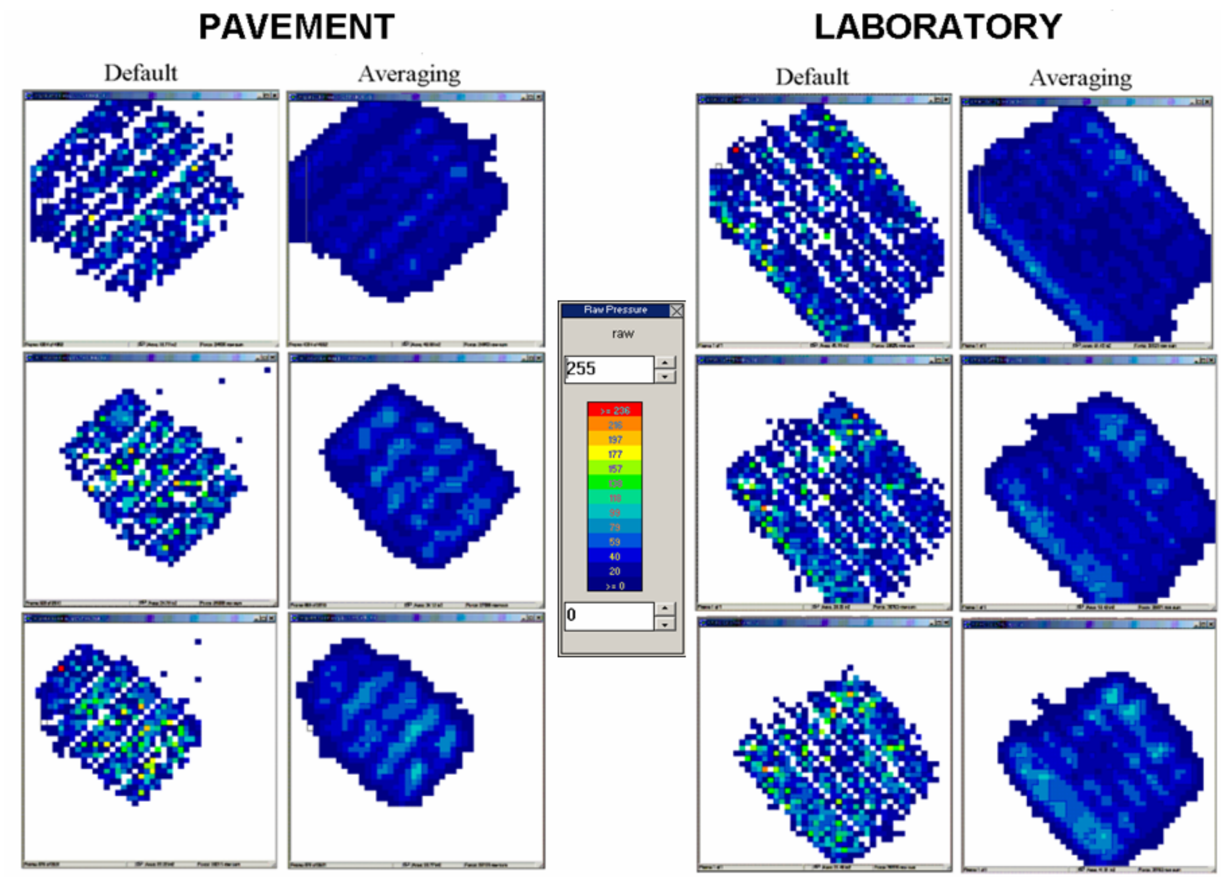


Figure 7.6 Example I-Scan Screenshots from Laboratory and Pavement Tests with Radial Tires.

7.5 Pressures within an Asphalt Pavement Structure

While the pressure at the tire/asphalt interface is of interest, an asphalt pavement is a layered structure and must be analyzed as such. A section of asphalt pavement consists of a number of layers including a subgrade, subbase, base, and surface. Each layer experiences stresses in a different manner based on a number of factors. Two of the most important factors affecting the stress distribution within an asphalt pavement are the material composition and depth.

Theoretically, the pressure should decrease with depth as research by Boussinesq, Burmister, and Ahlvin & Ulery showed, which was discussed in greater detail in Chapter 3. While previous researchers theorized how pressures behave within a media, they could not accurately measure it. Therefore, it was desirable to evaluate the applicability of the Tekscan pressure measurement system for analyzing the pressures within an asphalt pavement structure. The results could be used to either verify or contradict these accepted theories and to add to the understanding of pressure distributions with depth in a pavement structure.

Several laboratory tests were conducted to obtain interlayer measurements between each of the five layers of the pavement structure (four-asphalt layers & one-DGA layer). The setup and procedure for using Tekscan to measure within the structure is discussed in Chapter 5. Laboratory Tests 14, 15, and 16 were designed to test the pressure within the pavement structure with increasing depth using three different types of tires. Specifically, Test No. 14 used a radial tire, Test No. 15 used a bias ply tire, and Test No. 16 used a small utility trailer tire. These three tests provide a comparison of both the distribution of stresses through a pavement and the effect of the tire on that distribution.

Table 7.7 is a compilation of the pressures based on the net area at an applied load of 1200 lbf. A single load was chosen to make the illustration simple. Figures 7.7 and 7.8 are graphical representations of the net and gross pressures, taken from tests 14, 15, and 16, at a load of 1200 lbf. The points in these graphs correspond to the data in Table 7.7. Figures 7.7 & 7.8

show an obvious change from very high pressures at the surface of the asphalt, to a fairly constant pressure (around 18 psi for net and 10 psi for gross) just 2.5 inches deep into asphalt pavement.

		Pressure (psi)					
		Based on Net Area			Based on Gross Area		
		Test Number			Test Number		
	Depth (in)	14	15	16	14	15	16
Top Layer	0	37.44	41.26	53.02	25.73	31.48	38.56
Btwn 1 & 2	2.5	17.22	17.11	18.83	10.94	10.71	11.33
Btwn 2 & 3	5	14.40	16.14	16.58	8.60	9.76	10.34
Btwn 3 & 4	8	16.04	15.18	16.45	8.84	8.85	10.09
Btwn 4 & DGA	11	18.04	17.78	17.96	11.30	10.18	11.53
Note: Pressures at 1200lbf applied load							

Table 7.7 Pressures with Depth at 1200 lb Load (from Tests 14, 15, and 16).

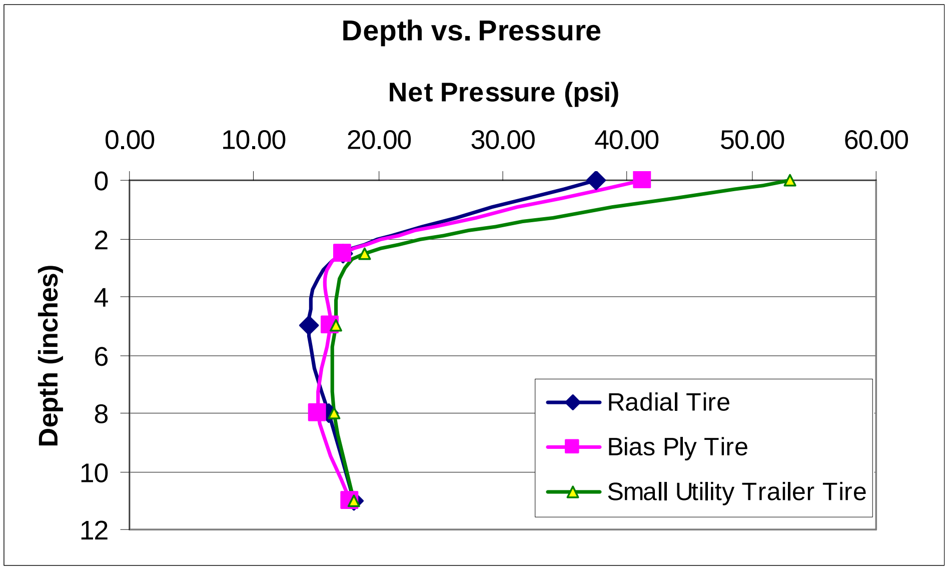


Figure 7.7 Graphical Illustration of Net Pressure with Varying Depth. (Based on data from tests 14, 15, and 16 which can be found in Appendix E & F)

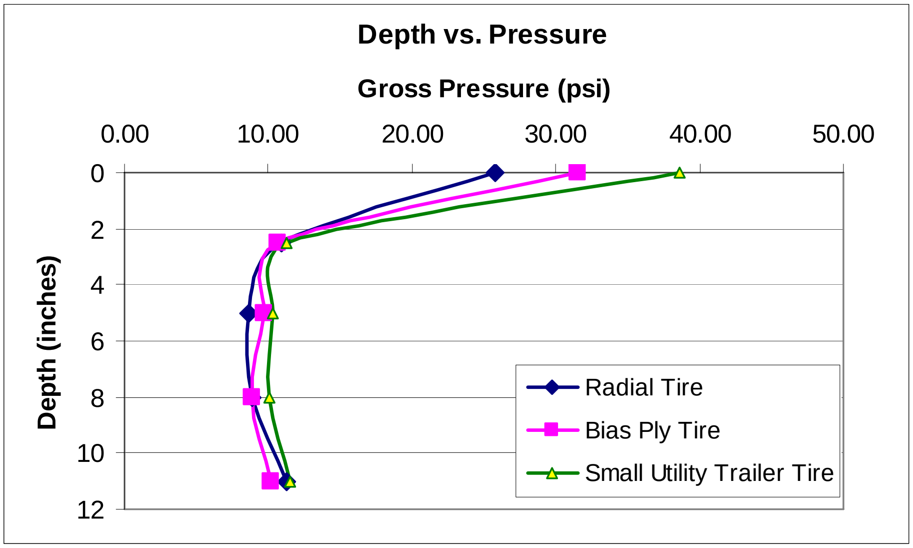


Figure 7.8 Graphical Illustration of Gross Pressure with Varying Depth. (Based on data from tests 14, 15, and 16 which can be found in Appendix E & F)

7.6 Boundary Conditions

The concern with using a full size tire was that the 20 in. x 20 in. asphalt specimen would be too small to accommodate all of the loading application. The concern was that the load would spread out such that it would reach the edges of the pavement and affect the measurements. An existing pavement would be more like an infinite area than the finite area used in this setup. Therefore, to determine whether an unrealistic loading condition was being created at the boundaries of the asphalt, the small utility trailer tire was used to compare to the full size radial and full size bias ply tires. It was believed that since the loading area of the small utility trailer tire was so small, the boundary conditions would have a lesser effect. If boundary conditions exist, then the data would reflect a sharp difference in the pressure distribution with depth when using the small utility trailer tire to apply the load than when using the full sized tires to apply the load.

Figures 7.7 & 7.8 show the same pattern, with respect to the pressure distribution with depth, for the small utility trailer tire and the full size radial and bias ply tires. The small utility trailer tire exerts a surface contact pressure of 53.02 psi, which dissipates to 18.83 psi over a 2.5 in. pavement thickness. This behavior is very similar to the decrease from a surface contact pressure of 41.26 psi and 37.44 psi to 17.11 psi and 17.22 psi for the bias ply and radial tires, respectively, over a 2.5 in. thickness.

Chapter 8

Findings and Conclusions

The purpose of this study was to develop and evaluate the applicability of the Tekscan USB system for measuring pressures at the surface of and within an asphalt pavement structure. This is a reasonably simple and direct procedure. The study was conducted in a laboratory setting and on highway pavements. The tests determined that the Tekscan Measurement System is applicable. Greater success was achieved with the tire/pavement interface measurement procedure. Advances were made toward developing procedures for correctly installing the sensor within an asphalt pavement structure and obtaining direct measurements. Experimental data has been collected for verifying previous empirical and mechanistic predictions.

Major Accomplishments

Advantages of the Tekscan USB System over the PCI System

- The USB system has fewer "handle misalignment" errors.
- The USB system incorporates "adjustable gain" which eliminates the need for using multiple sensors with varying sensitivity and capacity ranges.
- The Magma box is eliminated; therefore, only a single power source is required, which can be the computer battery.
- The USB system is much more portable, which is especially useful in non-laboratory tests.

Calibration of Sensors

- The sensor must be calibrated very close to the time of the test to avoid drift due to time.
- Care should be taken when positioning the sensor.
- A sheet of Teflon and Mylar should be placed on both sides of the sensor to minimize shear stresses and protect against mechanical damage.
- The sensor surface should be free of rocks and dust before calibrating to avoid damaging the sensor and/or reporting false high intensity points.
- The sensor should be loaded and unloaded as rapidly as possible to avoid drift.
- Each sensor has a unique calibration factor, so a single calibration factor cannot be used for multiple sensors.
- Calibration is very repeatable on similar interfaces and under similar loading levels.
- A calibrated laboratory force testing machine or a known tire load are applicable for calibrating the sensors.
- The sensors must be calibrated at the Tekscan sensitivity setting at which it will be used to take measurements.
- The sensors should be conditioned by loading them two to three times at the approximate force level at which they will be used. This is particularly important when a sensor is new or when it has not been used for a long period of time.

Laboratory Pavement Specimen

- Very realistic materials should be used to fabricate the laboratory pavement specimen.
- Soil should be compacted at near optimum moisture content.
- Soil layer should be thick enough to minimize the effects of the much harder surface of the steel bottom frame of the loading machine.
- Asphalt slabs must be "seated" or allowed to regain good contact after being shifted.
- The pavement specimen must be thoroughly compacted to avoid further compaction during testing.
- Thin rubber, or other equally compliant material, can be used between rough interfaces as long as the sensor is calibrated accordingly.
- The largest decrease in pressure is from the top of the asphalt to the interface between the 1^{st} and 2^{nd} layers of asphalt. This represents a 2.5 in. distance from the top of asphalt to the 1^{st} and 2^{nd} layer interface.
- Loading straps can be used to expedite the process of seating the asphalt. Straps can also be used to restrain the asphalt slabs from edge curling.

Effect of the Type of Tire and its Inflation Pressure on Contact Pressure

- Each type of tire affects the pressure distribution through the pavement in a similar manner.
- The contact area varies depending on the type of tire.
- The sensor must be calibrated for each type of tire.

- The more rigid the tire, the more concentrated its contact area.
- Contact areas are not circular.
- The tire must be loaded in a realistic manner using a loading frame and a cam assembly.
- The tire inflation pressure and the corresponding pressure exerted onto the pavement are not necessarily equal for varying pressures.

Applied Loads

- The load applied in the laboratory should be reasonably close to the actual wheel loads exerted on typical highway pavements. Consequently, the typical load range is 400 lbf to 2000 lbf.
- The sensors are not accurate at applied loads lower than 400 lbf at the I-Scan Sensitivity setting used in this research ('High-1').
- The load should be applied over a range (in the laboratory) to assess the effect of applied load versus pressure.
- The relationship between applied load and pavement pressure is linear.
- The load should be applied in the center of the pavement specimen.
- The load should be applied manually so the loads can be applied and released very rapidly.
- The load should be applied and released rapidly to avoid drift of the sensor.

Net Pressures vs. Gross Pressures

- The net pressure appears as a very pixilated image and the gross pressure appears as a very smooth image on the computer screen.
- The net pressure reveals missing rows and saturated cells and the gross pressure averages out any anomalies.
- The gross pressure calculation includes the area between the treads; the net pressure does not.
- The gross pressure calculation is based on a larger contact area than the net pressure calculations.
- The gross pressure is always lower than the net pressure.
- The pressure calculation based on net area is closer to the measured tire inflation pressure.
- Editing should be done on the net area, which is the Tekscan default view.

Remaining Concerns

Interlayer Bonding

- The individual asphalt layers comprising the laboratory specimen used in this research were not bonded.
- Interlayer bonding/strength may effect the pressure distribution throughout an asphalt pavement structure.
- Interlayer bonding should not have an effect on pressures measured on the surface of the asphalt.

Boundary Conditions

- The pressure is much lower between the 1st and 2nd layers of the pavement than on the top surface of the asphalt.
- The pressure remains fairly constant at interfaces throughout the depth of the pavement (i.e. between 2nd and 3rd, 3rd and 4th, etc.).
- The Tekscan pressure image is much different at the top of the asphalt than between the interfaces, but appears very similar at all of the interfaces, except for the interface between the 4th layer of asphalt and DGA.

Based on the findings from this research, the USB Tekscan Pressure Measurement System is applicable for pavement studies. Test results are very repeatable when measuring similar interfaces. The Tekscan system is a simple, direct procedure for measuring the pressures on the surface of and within asphalt pavements.

This study has explored various techniques for implementing the Tekscan measurement system into the design and analysis of asphalt pavements. An applicable technique was developed for placing the sensor in an asphalt pavement. Significant experimental data has been obtained to assess the effects of five different variables: 1) type of tire, 2) pressure distribution within an asphalt pavement, 3) load, 4) effect of change in tire pressure, and 5) boundary conditions.

Chapter 9

Summary and Recommendations for Future Research

Using a pressure sensitive material, like the Tekscan sensor, for measuring pressures on the surface and within an asphalt pavement is an intriguing concept. The goal of this research was to develop a means for taking a simple measurement of pressure at various interfaces on and within an asphalt pavement structure in an effort to directly assess the damaging effects of different wheel loadings. The results of the data can be compared to the classic empiricalistic and mechanistic approaches to asphalt pavement design and analysis, as well as the more modern finite-element computer modeling programs.

Various types of wheel loadings have been considered throughout this study. It has been determined that the type of tire, tire inflation pressure, applied load, and the asphalt pavement all have an effect on the pressures on the surface of and within an asphalt pavement structure. This was accomplished by incorporating a higher technology into the much older science of asphalt pavement design. The technical aspects of the Tekscan Pressure measurement system is constantly being improved and researchers are finding new and beneficial uses for it. However, the applications for the Tekscan system within asphalt pavement studies have yet to be exhausted.

While the current USB system is not currently equipped to handle multiple sensors simultaneously, it could be easily upgraded to do so. This would allow for a sensor to be placed between each layer while the computer reads them simultaneously under a single applied load. This would eliminate another variable in the process of assessing pressures within an asphalt pavement structure.

The size of the asphalt pavement specimen could be adjusted, likely increased in area, such that the effects of boundary conditions on the distribution of pressure throughout the pavement can be further studied. The current laboratory pavement specimen is somewhat small with respect to the full-sized tires used to apply the load. If the asphalt layers were larger in area than the current laboratory pavement specimen, then the pressure distribution measurements within the pavement structure might be different.

Since interlayer bonding is an issue, the layers could be tacked together with the Tekscan sensors in between the layers. This would provide the interlayer interface bond strength that is lacking in the current pavement specimen. It is possible that interlayer bonding could affect the distribution of pressures within an asphalt pavement structure.

Since the type of tire has been a major variable in this study, identical tires should be used for measurements in the laboratory and on pavements to eliminate this as a variable. As a result, the load, type of tire, and tire inflation pressure would be eliminated as variables. The surface of the asphalt could then be evaluated individually.

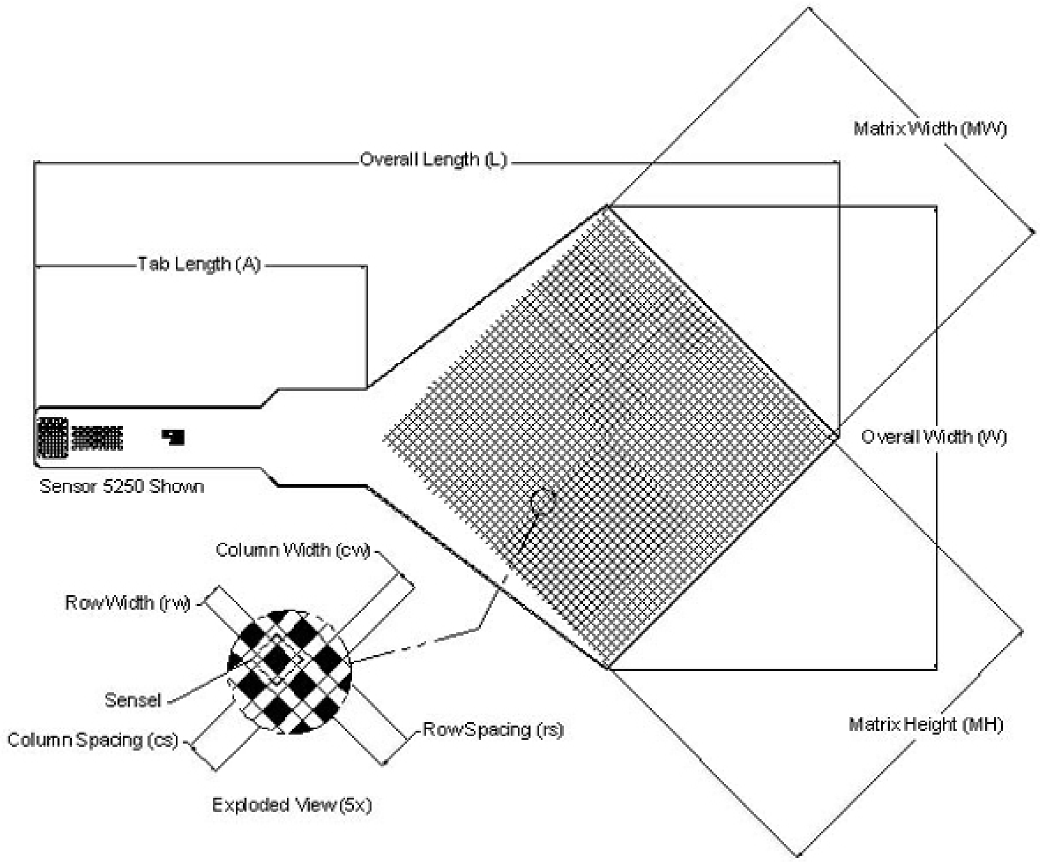
The new USB system is very portable and is compatible with most any computer. The most damaging types of wheel loadings that highways in the United States experience are from overweight trucks. Vehicle enforcement officers could consider this technology for weighing overweight trucks with increased certainty. The process would be simple and much faster than the currently used portable hydraulic scales.

This new application for this technology has increased the understanding of stresses within an asphalt pavement structure. The technology is proven to be very accurate and repeatable. The results may benefit asphalt pavement designers by assisting them to better understand the forces that are destroying the nation's highways and assist them in designing stronger/longer-lasting pavements to adequately support the ever-increasing wheel loads.

Appendix A - Manufacturer's Specifications for Tekscan Sensors & USB Evolution Hardware Specifications

Sensor Map #5250

MAP AND SENSOR MODEL NUMBER: 5250
SENSOR NAME: CMP

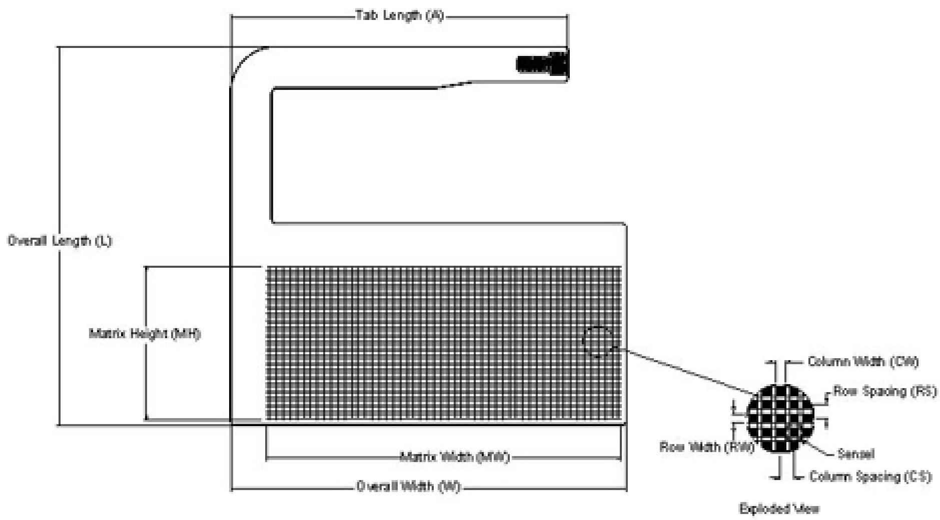


	General Dimensions			Sensing Region Dimensions								Summary	
Model Number	Overall Length *L*	Overall Width *W*	Tab Length *A*	Matrix Width *MW*	Matrix Height *MH*	Columns *CW*	Columns *CS*	Columns *Qty.*	Rows *RW*	Rows *RS*	Rows *Qty.*	No. of Sensels	Sensel Density
US	(in)	(in)	(in)	(in)	(in)	(in)	(in)		(in)	(in)			(sensel per sq-in)
5250	24.5	14.1	10	9.68	9.68	0.13	0.22	44	0.13	0.22	44	1936	20.7
Metric	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)		(mm)	(mm)			(sensel per sq-cm)
5250	622	358	254	246	246	3.3	5.59	44	3.3	5.59	44	1936	3.2

Tekscan, Inc.
307 West First Street. South Boston, MA. 02127-1309. USA
tel: 800.248.3669 / 617.464.4500 fax: 617.464.4266
marketing@tekscan.com

Sensor Map #5260

MAP AND SENSOR MODEL NUMBER: 5260
SENSOR NAME: CATALYST



	General Dimensions			Sensing Region Dimensions								Summary	
Type	Overall Length *L*	Overall Width *W*	Tab Length *A*	Matrix Width *MW*	Matrix Height *MH*	Columns *CW*	Columns *CS*	Columns *Qty.*	Rows *RW*	Rows *RS*	Rows *Qty.*	No. of Sensels	Sensel Density
US	(in)	(in)	(in)	(in)	(in)	(in)	(in)		(in)	(in)			(sensel per sq-in)
5260	20	21.1	18	18.98	8.14	0.265	0.365	52	0.120	0.185	44	2288	15
Metric	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)		(mm)	(mm)			(sensel per sq-cm)
5260	508	537	457	482	207	6.73	9.27	52	3.05	4.70	44	2288	2

Tekscan, Inc.
307 West First Street. South Boston, MA. 02127-1309. USA
tel: 800.248.3669 / 617.464.4500 fax: 617.464.4266
marketing@tekscan.com

Evolution Hardware Installation

The Tekscan Evolution handle does not require an additional interface card or parallel box in order to be connected to your computer. Most computers now come equipped with at least 2 USB connectors. These handles can be connected directly to your computer via the handle's USB cable. When inserted into your computer, the computer's operating system will automatically detect and configure the hardware for use.

USB SYSTEM

The following section provides information on the USB System hardware, and procedures for installation and setup.

USB System Requirements

The ***I-Scan*** system can be added to most IBM-compatible personal computers. To function properly, your system must have the following minimum requirements:

<table>
<tr><td colspan="2"></td></tr>
<tr><td>Suggested Requirements
• Pentium 300 MHz
• 64 MB RAM
• 1 GB hard drive
• CD ROM drive
• One USB port (12 MB/Sec. minimum)
• Windows operating systems (2000/XP)
Note: The USB interface is not supported for other versions of Windows.</td><td>Requirements for Video add-on
• Tekscan Video add-on software
• Pentium 600MHz
• 128 MB RAM
• 10 GB Hard drive
• CD ROM drive
• One USB port (12 MB/Sec. minimum)
• Firewire (iLink or IEEE1394) port
• ATA-33, 7200 RPM Hard drive
• DV (digital video) Format Camcorder with Firewire (iLink or IEEE1394) port
• Windows operating systems (2000/XP)
Note: The USB interface is not supported for other versions of Windows.</td></tr>
</table>

Known Incompatibilities:

- Windows 95/98/ME/NT – The USB interface is not supported for Windows 95/98/ME/NT.
- Digital Video Cameras – Currently, DV format is the only video format supported for capturing video directly using Tekscan software. Cameras that use other formats than the standard DV format are not compatible for video capture. With video cameras using other non-DV formats, a third party software must be used to transfer video from the camera to the computer.

USB Component Identification

The following table provides a view of all the components that ship with your USB System:

USB Handle with attached USB cable

Installation CD

User Manual

Also Included:

Tekscan I-Scan "family" Sensor(s) -- Depends upon application.

Sensor Carrying Case *(Part ZCAS-4850)*

Type CF equipment

F-type applied part which provides a higher degree of protection of electric shock than that provided by type BF applied parts.

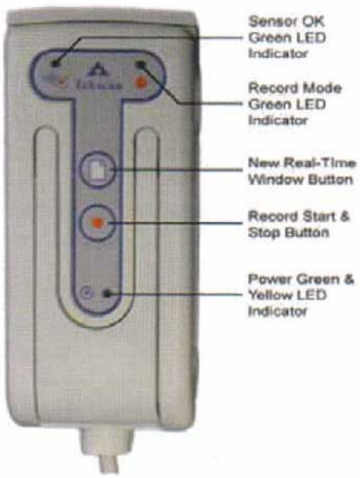
USB Handle

The USB Sensor handle gathers the data from the sensor and processes it so that it can be sent easily to the computer. The buttons on the sensor handle may also be used to start or stop a recording. This function is referred to as '**Remote Recording**'.

The handle has a latch on its topside. In the 'Up' position, the latch retracts the contact pins inside the handle to allow insertion of the sensor tab. The sensor tab is placed into the sensor handle. The handle's attached USB cable is then connected directly to your computer via the USB port.

Note: the handle is shipped with the latch in the "open" position. It is advised that you keep the handle latch in the "open" position when the handle is not in use.

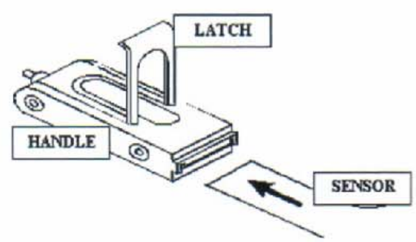
The following displays the buttons and their functionality for the USB Handle:



The following label is printed on all USB handles displaying the compliancy, model number, warnings and parameters:

- **Sensor OK Green LED Indicator:** A green light here indicates that the sensor is correctly inserted into the handle and a Real-Time window can be opened.
- **Record Mode Green LED Indicator:** A green light here indicates that the sensor is recording pressure data and transferring that data to your computer.
- **New Real-Time Window Button:** This will open a new Real-Time window in the software, so that you can begin recording pressure data.
- **Record Start & Stop Button:** Use this button to start a recording or stop a recording that is in progress.
- **Power Green & Yellow LED Indicator:** When yellow, this light indicates that the handle is receiving power, but is not yet initialized. When Green, this light indicates that the handle is receiving power and has been initialized by the computer (i.e.: the device shows up under the Windows device manager).

Inserting a Sensor into the USB Handle



2. Lift the latch on the handle.
3. Slide the sensor tab with the **This Side UP** legend facing the raised handle latch. Slide the tab in until it reaches its mechanical stop. *Do not force the tab into the handle.*
4. Close the latch.

Once the sensor is inserted into the handle, connect the attached USB cable to the computer's USB port. Your computer should automatically detect the new hardware and configure it for your system. If the driver is not found, insert the Tekscan software CD that came with your system and have the computer locate the driver on your CD. Then follow the on-screen instructions.

After following this procedure and starting the ***I-Scan*** software, the message below the real-time window for the sensor should be '**Sensor OK**'. If the message is '**MISALIGNED**', re-insert the sensor using the above procedure. If the '**Sensor OK**' message still does not appear, consult the '**Troubleshooting**' section.

Caution! Do not allow the handle to hang from the sensor. The handle may become damaged, resulting in a misaligned sensor.

USB Handle Maintenance and Care

- The handle cannot be autoclaved.
- Do not let any liquid drip onto the electronics inside the handle. If this occurs, the handle will stop working and must be allowed to dry for 24 hours. You can use your air syringe, however, to significantly reduce this drying time. Do not attempt to dry out the handle using any other method, or you may destroy the delicate electronics.
- To properly clean the device, be sure to wipe down the handle with a 70% Isopropyl Alcohol solution. To do this, slightly dampen a cloth with the alcohol solution, careful not to soak or saturate the cloth. Then wipe the handle after each use.

USB Handle Specifications

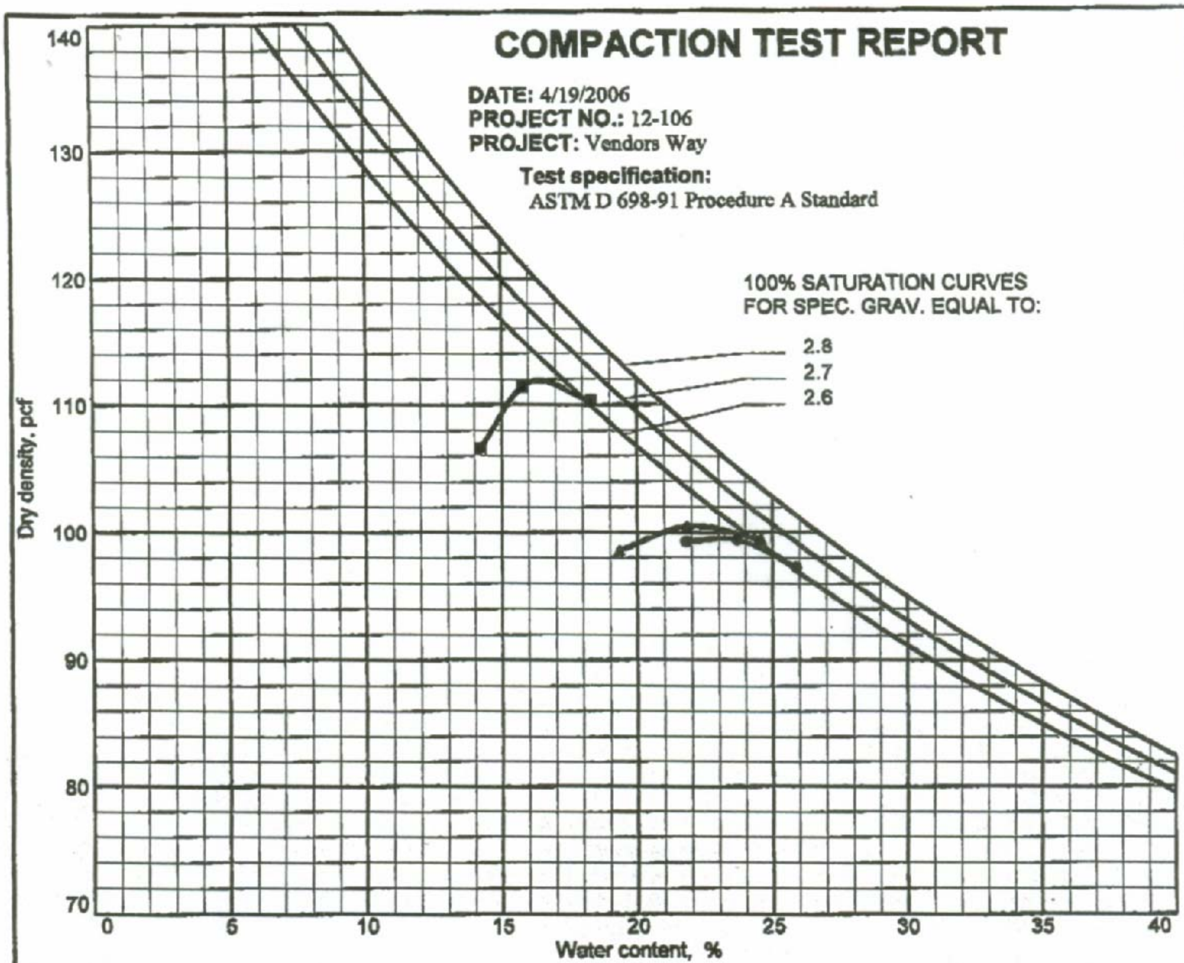
COMMUNICATION/DATA ACQUISITION:	
COMMUNICATION PROTOCOL TO HOST COMPUTER	USB 1.1 or 2.0 Compatible, 12 Mbps
SCAN SPEED	Up to 9.84 Hz.
DIGITAL PRESSURE RESOLUTION	8 BIT
ELECTRICAL:	
POWER SOURCE:	Host Computer's USB BUS
POWER CONSUMPTION:	200mA MAX at 5V
MECHANICAL:	
USB CABLE:	
LENGTH in (mm)	180 (4572) - Standard
WEIGHT lbs (kgs)	0.40 (0.18)
HANDLE ENCLOSURE:	
SIZE LxWxH in (mm)	5.42x2.25x1.88 (137.7x57.2x47.6)
OPEN LEVER HEIGHT in (mm)	4.30 (109.2)
WEIGHT lbs (kgs)	0.40 (0.18)
AMBIENT OPERATING CONDITIONS:	
TEMPERATURE: °F (°C)	14 to 131 (-10 to 55) Prolonged use at high Temperatures should be avoided
HUMIDITY: %	0 to 90 (non condensing)
PRESSURE: psi (kPa)	1.7 to 14.7 (11.6 to 101.3) (sea level to 50,000 ft)
STORAGE AND TRANSPORT CONDITIONS:	
TEMPERATURE: °F (°C)	-4 to 131 (-20 to 55) Short-Term 41 to 104 (5 to 40) Long-Term
HUMIDITY: %	0 to 90 (non condensing)
PRESSURE: psi (kPa)	1.7 to 14.7 (11.6 to 101.3) (sea level to 50,000 ft)

USB Hardware Installation

The Tekscan USB handle does not require an additional interface card or parallel box in order to be connected to your computer. Most computers now come equipped with at least 2 USB connectors. These handles can be connected directly to your computer via the handle's USB cable. When inserted into your computer, the computer's operating system will automatically detect and configure the hardware for use.

Appendix B – Soil Test Data

Figure A.1 Soil Excavation and Transport.



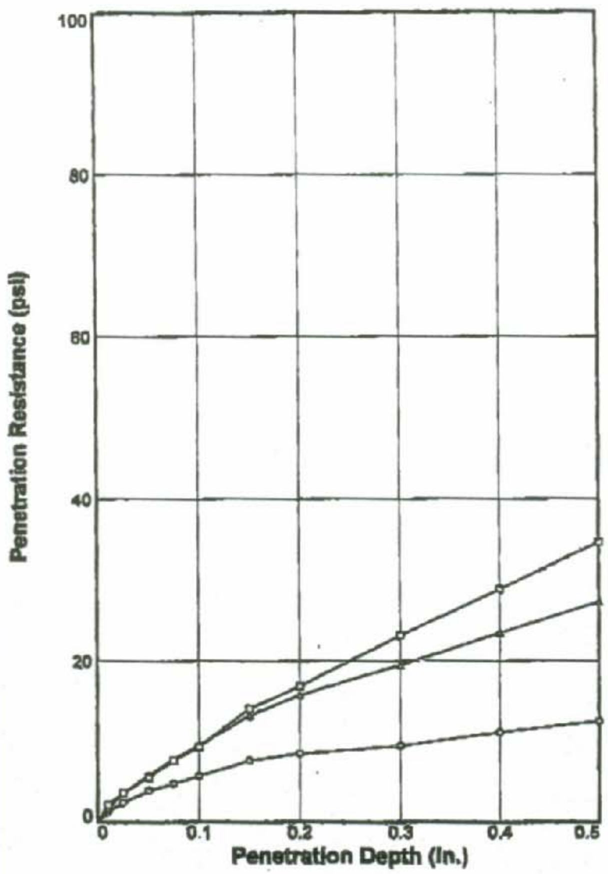
	No.	LOCATION AND DESCRIPTION	REMARKS
●	16375	**Location:** Vendors Way Extension STA 22+00; 10' Lt of CL Yellowish-brown, light brown fat clay.	CBR (ASTM D 1883) @ 95% MAX. DENSITY= 2.6
■	16376	**Location:** Vendors Way Extension STA 16+00; @ CL Light olive brown w/ light gray mottling, lean clay. (w/ a few shaley Limestone	CBR (ASTM D 1883) @ 95% MAX. DENSITY= 0.9
▲	16377	**Location:** Vendors Way Extension STA 26+00; 10' RT of CL Light brown, light olive brown fat clay.	CBR (ASTM D 1883) @ 95% MAX. DENSITY= 1.1

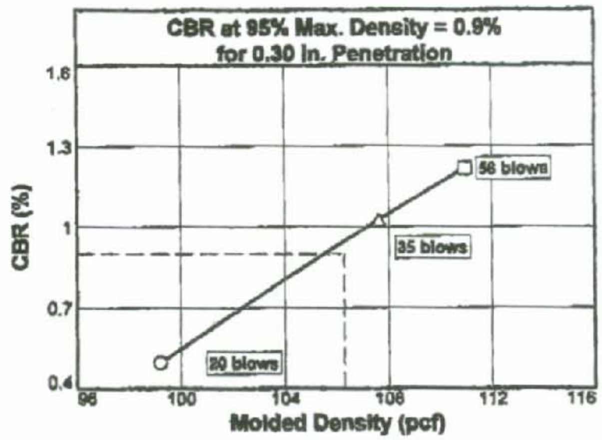
	No.	USCS	LL	PI	NAT. MOIST.	OVERSIZE	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●	16375	CH	74	45		%>No.4=0.0	97.8 %	99.5 pcf	23.2 %
■	16376	CL	39	18		%>No.4=3.2	87.8 %	111.9 pcf	16.4 %
▲	16377	CH	59	35		%>No.4=1.4	93.8 %	100.5 pcf	22.1 %

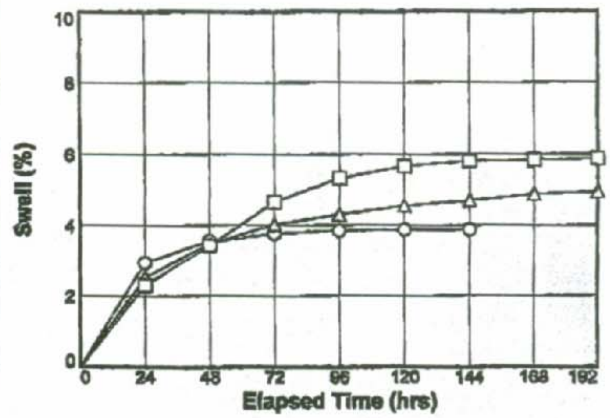
Figure

GREGG LABORATORIES, INC.

BEARING RATIO TEST REPORT
ASTM D 1883-99







	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.30 in.			
1 ○	99.2	88.7	16.8	95.5	85.3	25.3	0.6	0.5	0.000	12.64	3.9
2 △	107.6	96.2	16.4	102.6	91.7	23.0	1.0	1.0	0.000	12.63	4.9
3 □	111.0	99.2	16.8	104.8	93.7	22.0	0.9	1.2	0.000	12.67	5.9

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Light olive brown w/ light gray mottling, lean clay. (w/ a few shaley Limestone fragments)	CL	111.9	16.4	39	18

Project No: 12-106

Project: Vendors Way

Location: Vendors Way Extension STA 16+00; @ CL

Sample Number: 16376 **Depth:** subgrade

Date:

Test Description/Remarks:

BEARING RATIO TEST REPORT

GREGG LABORATORIES, INC.

Figure ______

Appendix C - Asphalt Mix Design

12.5 mm Surface Coarse Slab Design

$$C = \frac{m}{V}$$

m = 33,000g Aggregate + 1591 Binder = 34,591g
v = (20 in. x 20 in. x 2 in.) = 50.8 cm x 50.8 cm x 5.08 cm = 13,109.7 cm^3

$$C_{mb}estimated = \frac{m}{v} = \frac{34{,}591g}{13{,}109.7cm^3} 2.638$$

After making design slab and sawing it into 4 pieces, each section was bulked

$$C_{mb}acutal = \frac{(2.309 + 2.300 + 2.323 + 2.305)}{4} = 2.309$$

$$CorrectionFactor = \frac{C_{mb}act}{C_{mb}est} = \frac{2.309}{2.638} = 0.875$$

Mass Calc. for 4% VTM @ 96% of C_{mm}

$$m = \frac{(0.96)(C_{mm})(V)}{CF} = \frac{(0.96)(2.556)(13{,}109.7)}{0.875} = 36763.5g$$

using 36,800g Total Mix
Binder (wt) = (0.048)(36,800g)=1766.4 of 67-22 Binder @ 4.8% AC
Aggregate (wt) = 36,800 – 1766.4 = <u>35033.6g</u>

NATIONAL CENTER FOR ASPHALT TECHNOLOGY

Maximum Specific Gravity of Bituminous Paving Mixtures
(AASHTO T209)

Project: UK | Date: 2/12/2006

Tested By: JH | Calculated By: JH

Sample Identification: 12.5mm SLAB RICE

Sample Number:	1	2		
Bowl Number:	1	2		
Weight of Bowl in Air, gm (A)	2208.0	2310.0		
Weight of Bowl in Water, gm (B)	1392.5	1456.5		
Weight of Bowl & Sample in Air, gm (C)	4396.0	4276.4		
Weight of Sample, gm (D) = C - A	2188.0	1966.4		
Dry Back wt, gm (D') (if needed only)				
Weight of Bowl & Sample in Water, gm (E)	2724.4	2653.7		
Maximum Specific Gravity of Mix, G_{mm} (F) = D / (D + B - E)	2.556	2.556		
Asphalt Content of Mix, % (G)				
Speicfic Gravity of Asphalt, G_b (H)				
Effective Specific Gravity of Aggregate, G_{se} (100-G) / [(100/F) - G/H)]				
G_{mm} Values at specified % AC's $\frac{100}{\frac{AC}{G_b} + \frac{100-AC}{G_{se}}}$				

NCAT Lab Form 302 July 28, 1999

NATIONAL CENTER FOR ASPHALT TECHNOLOGY

Bulk Specific Gravity and Percent Air Voids of Compacted Bituminous Mixtures
(AASHTO T166 & T269)

Project: UK　　Date: 2/14/2006

Tested By: B. BURMESTER　　Calculated By: JH

Sample Identification: 12.5mm Design Slab

Sample Number	Dry Weight grams (A)	Submerged Weight, gm (B)	SSD Weight, gm (C)	Bulk Specific Gravity, G_{mb} (D)=A/(C-B)	Theor. Max Spec. Gravity, G_{mm} (E)	Percent Air Voids, VTM 100(1-D/E)
1	8357.6	4815.9	8435.0	2.309	2.556	9.7
2	8406.2	4823.8	8467.8	2.307	2.556	9.7
3	8525.7	4901.8	8517.2	2.358	2.556	7.7
4	8461.6	4860.5	8531.7	2.305	2.556	9.8

Technician: ____________　　Project Manager: ____________

NCAT Lab Form 301　　July 21, 1999

Proect	**University of Kentuckey**			
Mix identification; 12.5mm 424 Surface Coarse				
Aggregate **Labstock LMS**				Need 2
Total Needed				
Desired Batch weight		35,033		
Sieve Sizes		% Passing	Blend Weights	Accumulative Blend Weights
25.00mm	1	100	0	0
19.00mm	3/4	100	0	0
12.5mm	1/2	98	700.66	700.66
9.5mm	3/8	84	4904.62	5605.28
4.75mm	4	42	14713.86	20319.14
2.36mm	8	28	4904.62	25223.76
1.18mm	16	20	2802.64	28026.4
0.600mm	30	14	2101.98	30128.38
0.300mm	50	10	1401.32	31529.7
0.15mm	100	6	1401.32	32931.02
0.075mm	200	3.5	875.825	33806.845
pan	-200	0	1226.155	35033

AC= 4.8 %
Lab Stock Binder 67-22
VMA 14.1
Gmm=2.556
ALDOT Division 7, 99 303 203 012 901

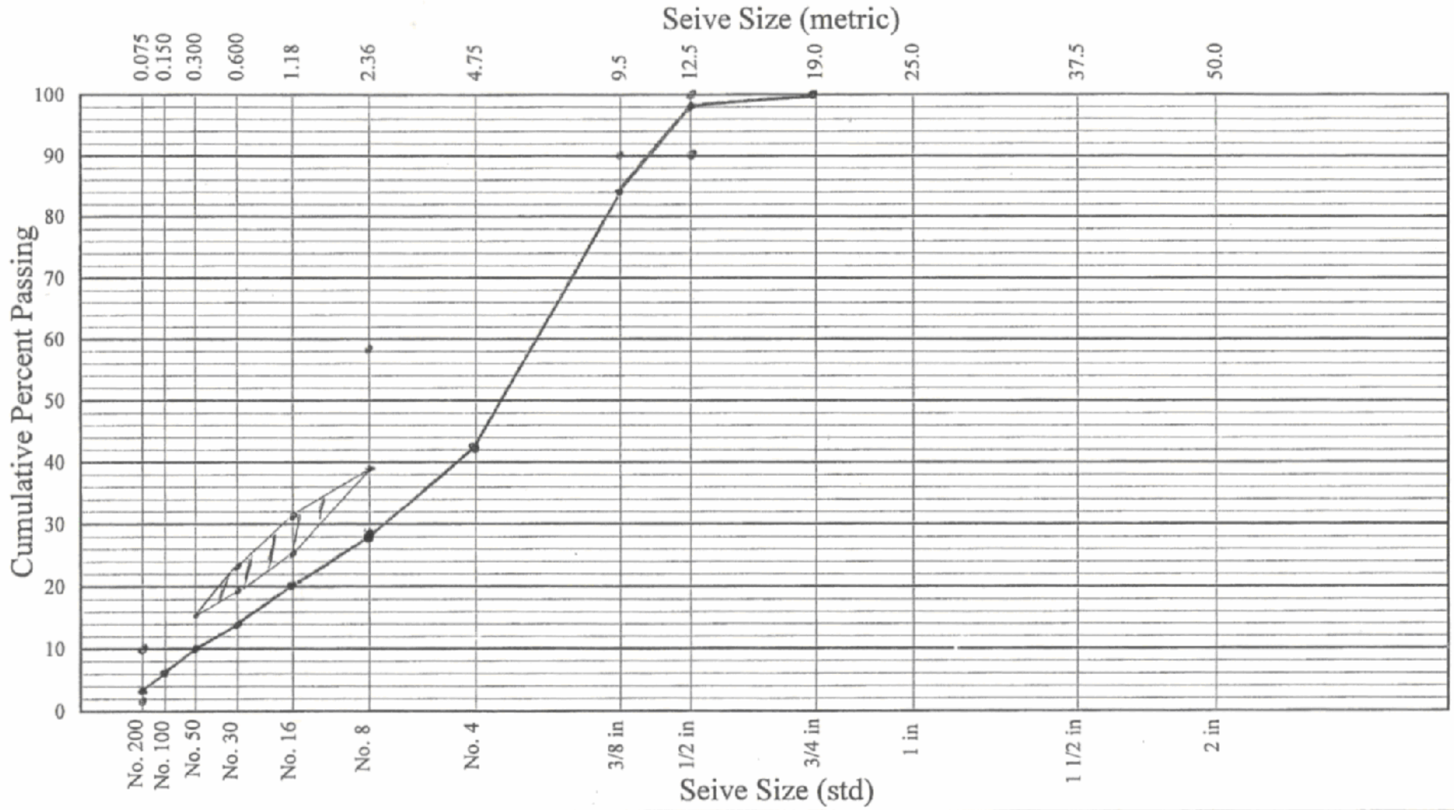
Binder wt (g) = 1766.4 g

NATIONAL CENTER FOR ASPHALT TECHNOLOGY

Sieve Analysis for Fine and Coarse Aggregate (Washed or Dry)
(AASHTO T11 and T27)

Project: University of Kentucky   Date: 2/8/06

Sample Identification: 12.5mm surface coarse mix B.R2   °Control Points
- Restricted Zone



NCAT Lab Form   July 30, 1999

19 mm Base Coarse Slab Design

$$C = \frac{m}{V}$$

m = 46,000g Aggregate + 2100g Binder = 48,100g
v = (20 in. x 20 in. x 3 in.) = 50.8 cm x 50.8 cm x 7.62 cm = 19,664 cm^3

$$C_{mb} estimated = \frac{m}{v} = \frac{48{,}100g}{19{,}664cm^3} = 2.446$$

After making design slab and sawing it into 4 pieces, each section was bulked

$$C_{mb} acutal = \frac{(2.399 + 2.441 + 2.401 + 2.395)}{4} = 2.409$$

$$CorrectionFactor = \frac{C_{mb} act}{C_{mb} est} = \frac{2.409}{2.446} = 0.985$$

Mass Calc. for 4% VTM @ 96% of C_{mm}

$$m = \frac{(0.96)(C_{mm})(V)}{CF} = \frac{(0.96)(2.597)(19{,}664)}{0.985} = 49{,}771.3g$$

using 49,800g as Mass @ 4.0% VTM
AC = 4.4%
Binder (wt) = (0.044)(49,800g)=2191.2g
Aggregate (wt) = 47,609g Agg

NATIONAL CENTER FOR ASPHALT TECHNOLOGY

Maximum Specific Gravity of Bituminous Paving Mixtures
(AASHTO T209)

Project: UK Date: 2/15/2006

Tested By: MINGUS Calculated By: MINGUS

Sample Identification: 19mm Slab design

Sample Number:	1	2		
Bowl Number:	1	2		
Weight of Bowl in Air, gm (A)	2208.0	2310.0		
Weight of Bowl in Water, gm (B)	1392.5	1456.5		
Weight of Bowl & Sample in Air, gm (C)	4718.3	5077.9		
Weight of Sample, gm (D) = C - A	2510.3	2767.9		
Dry Back wt, gm (D') (if needed only)				
Weight of Bowl & Sample in Water, gm (E)	2936.5	3157.9		
Maximum Specific Gravity of Mix, G_{mm} (F) = D / (D + B - E)	2.598	2.595		
Asphalt Content of Mix, % (G)				
Speicfic Gravity of Asphalt, G_b (H)				
Effective Specific Gravity of Aggregate, G_{se} (100-G) / [(100/F) - G/H)]				
G_{mm} Values at specified % AC's $\frac{100}{\frac{AC}{G_b} + \frac{100-AC}{G_{se}}}$				

NCAT Lab Form 302 July 28, 1999

NATIONAL CENTER FOR ASPHALT TECHNOLOGY

Bulk Specific Gravity and Percent Air Voids of Compacted Bituminous Mixtures (AASHTO T166 & T269)

Project: UK Date: 2/15/2006

Tested By: JH Calculated By: JH

Sample Identification: 19mm Design Slab

Sample Number	Dry Weight grams (A)	Submerged Weight, gm (B)	SSD Weight, gm (C)	Bulk Specific Gravity, G_{mb} (D)=A/(C-B)	Theor. Max Spec. Gravity, G_{mm} (E)	Percent Air Voids, VTM 100(1-D/E)
1	11546.9	6848.5	11661.0	2.399	2.597	7.6
2	11707.2	6883.9	1168.0	-2.048	2.597	178.9
3	11840.0	7023.0	11955.0	2.401	2.597	7.6
4	11835.0	7018.0	11960.0	2.395	2.597	7.8

Technician: Project Manager:

NCAT Lab Form 301 July 21, 1999

Proect	University of Kentuckey			
Mix identification; 19mm				
Aggregate Labstock LMS				Need 2
Total Needed				
Desired Batch weight		47,600		
Sieve Sizes		% Passing	Blend Weights	Accumulative Blend Weights
25.00mm	1	100	0	0
19.00mm	3/4	95	2380	2380
12.5mm	1/2	76	9044	11424
9.5mm	3/8	64	5712	17136
4.75mm	4	37	12852	29988
2.36mm	8	25	5712	35700
1.18mm	16	19	2856	38556
0.600mm	30	14	2380	40936
0.300mm	50	10	1904	42840
0.15mm	100	7	1428	44268
0.075mm	200	5	952	45220
pan	-200	0	2380	47600

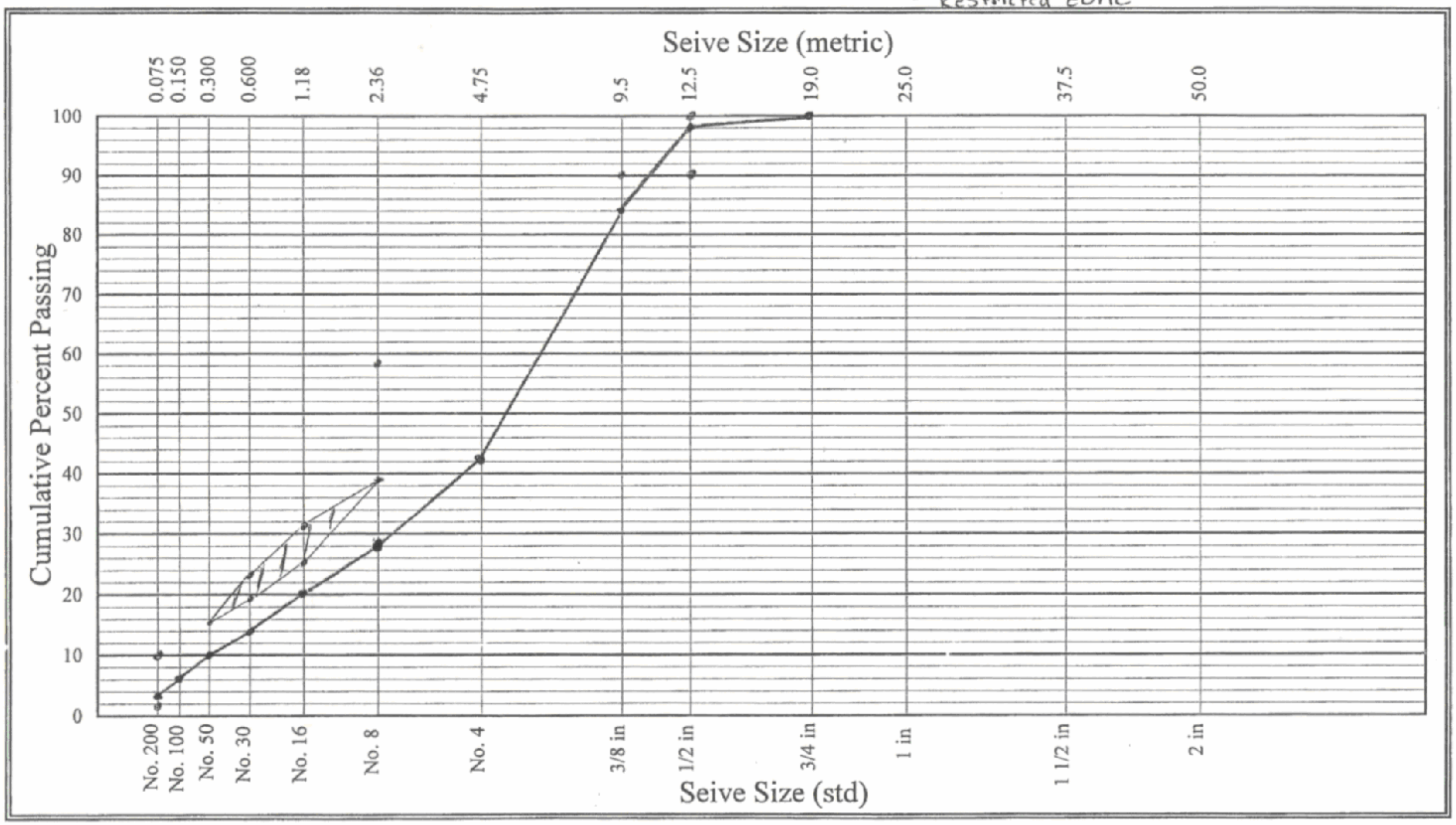
Labstock Biner 67-22
19mm Base Mix
AC=4.4
Binder wt= 2190.8
Gmm=2.597

NATIONAL CENTER FOR ASPHALT TECHNOLOGY

Sieve Analysis for Fine and Coarse Aggregate (Washed or Dry)
(AASHTO T11 and T27)

Project: University of Kentucky Date: 2/8/06

Sample Identification: 12.5mm Surface coarse mix B.R2 °Control Points
- Restricted Zone



NCAT Lab Form July 30, 1999

Appendix D - Baldwin Loading System

This Appendix contains information reproduced from the Satec User's Manual (Satec, 1997). The original copy was in very poor condition. Pertinent information is included herein.

GENERAL

The Baldwin-Tate-Emery universal testing machine, functionally speaking, contains three basic elements: the loading system, the weighing system, and the indicating system. This instruction will be concerned mainly with the loading system, the other two elements being covered in separate leaflets.

DESCRIPTION

Efficient operation of this equipment demands that the operator have some knowledge of its construction. The loading system consists of a loading frame which applies the load to the specimen, a sensitive frame which transmits this load to the weighing system, and a pumping unit. (See Fig. D.1) The loading frame is supported by the base, which is rigidly anchored to the foundation. Integral with this base is the hydraulic cylinder which contains the loading ram. The work table attached to this ram carries two compression columns on which the tension crosshead is mounted.

The screws which are part of the sensitive frame are supported by the cylinder through preload springs. The adjustable crosshead is mounted on the screws and is located between the top cross- head and table of the loading frame. The lower ends of the screws are tied together by the bottom crosshead to complete the sensitive frame. The weighing capsule is located between bottom crosshead and the underside of the hydraulic cylinder. The preload springs besides supporting the weight of this sensitive frame are also used to apply an initial load to the weighing capsule. This frame is stabilized horizontally by the stayplates and the weighing capsule.

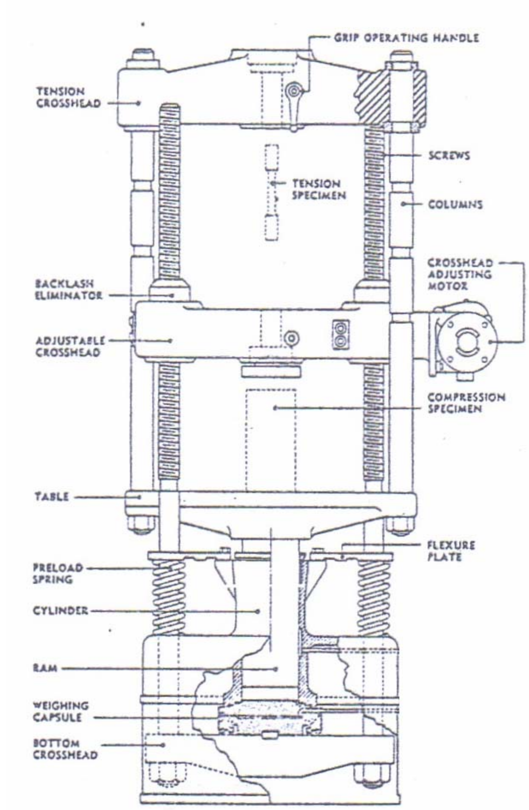


Figure D.1 Schematic of Baldwin Loading Machine Components.

When hydraulic fluid is applied to the cylinder, a specimen placed between the table and the adjustable crosshead will be compressed by upward motion- of the table and a specimen gripped between the tension crosshead and sensitive crosshead will be put in tension by the upward travel of the tension crosshead. In either case, the force on the sensitive crosshead will always be exerted in the upward direction. This force is transmitted by the screws to the bottom crosshead to compress the weighing capsule.

The adjustable crosshead is infinitely adjustable to any position between the table and the top cross- head. Gear nuts retained in the ends of this cross- head ride on the screws and are rotated by worms driven by a gear motor. These nuts are split and spring loaded to eliminate backlash in the threads between the nut and the screw.

The tension crosshead is adjustable in fixed steps to provide convenient heights for tension testing. This crosshead is attached to the columns by split collars and can be raised or lowered by using the adjustable crosshead as an elevator.

The pumping unit which is located in the lower half of the control console supplies the hydraulic fluid required for load application. It contains a variable volume radial piston pump driven by an electric motor. The discharge of the pump is controlled by a differential device, which is, essentially, a two-chamber unit separated by a flexible diaphragm. One chamber is connected to the pump side of the control valve and the other to the cylinder side. Any change in pressure in the cylinder or in the pump will result in movement of the diaphragm. Since the diaphragm is connected to the pump plunger, this movement will change the stroke of the pump and thus its displacement, thereby tending to equalize the forces against the diaphragm. In other words, the speed of the ram is automatically maintained constant regardless of variations in resistance against the ram or internal leakage in the pump. The pump discharge after passing through the control valve enters the cylinder to drive the ram upward. A second valve of similar construction as the control valve is used to drain the cylinder allowing the rain to return by gravity. The pumping unit is protected by a spring-loaded relief valve which is set slightly above the pressure required to produce the capacity load of the machine. The control and release valves are actually two valves in one. (See Fig. 3.) The large handwheel on each valve controls a large spindle to produce the fast testing speeds and a micrometer knob within this handwheel controls a small spindle to produce the slower testing speeds.

OPERATION

Positioning the tension crosshead—

1. Remove the upper retaining rings and split collars.
2. Raise the adjustable crosshead (using the pushbutton crosshead motor) to make contact with the tension crosshead. After smooth contact, continue to raise the adjustable crosshead to move the tension crosshead clear of the lower split collars.
3. Remove the lower split collars.
4. Move the tension crosshead to the desired position leaving room for insertion of the lower split collars.
5. Insert lower split collars and lower tension cross-head until it rests on the lower split collars.
6. Insert upper split collars and replace the retaining rings.

STANDARD COMPRESSION TEST

1. Insert the compression plate in the adjustable crosshead.
2. Move the adjustable crosshead, to provide a compression space about ½ inches greater than the specimen to be tested.
3. Place compression specimen on table making certain that it is centrally located in relation to the compression plate.
4. Open release valve and close the 1ondng valve.

5. Start pump.
6. Close release valve and open loading valve Just as soon as the specimen makes contact with the compression plate, close the coarse control and open the fine (micrometer control so that the load is applied at the desired rate.
7. When the test is completed, close the flat loading control and open the coarse release valve.

Figure D.2 is a picture of the laboratory setup including the computer system that controls the operation of the Baldwin Loading Machine. The Satec Software, used to control the machine, is described in section 5.3.

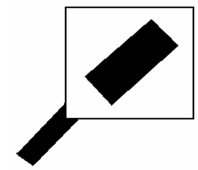
Figure D.2 Computer System that Controls Baldwin Loading Machine.

Appendix E - Original Laboratory Data

Tekscan Pressure Test in Asphalt Structure

TEST 1

CALIBRATIONS



Date: 9/4/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

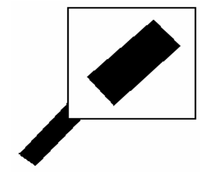
Position: Completely on the Sensor
Sensor: 5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Calibration Factor (Based on Net Area) (Raw/lb)	Averagng Tekscan Raw Sum (Gross Area)	Calibration Factor (Based on Gross Area) (Raw/lb)	Default Net Area (in2)	Averaging Gross Area (in2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
1205	1254.1	30958	24.69	30867	24.61	35.96	46.17	34.87	27.16
1191	1240.1	31110	25.09	31025	25.02	36.15	46.32	34.30	26.77
1180	1229.1	30150	24.53	30060	24.46	35.72	45.83	34.41	26.82
1024	1073.1	26402	24.60	26301	24.51	32.04	41.67	33.49	25.75
817	866.1	20881	24.11	20762	23.97	27.01	35.57	32.07	24.35
807	856.1	20879	24.39	20751	24.24	26.96	35.62	31.75	24.03
802	851.1	20736	24.36	20613	24.22	26.86	35.04	31.69	24.29
590	639.1	15525	24.29	15413	24.12	21.44	28.85	29.81	22.15
431	480.1	11493	23.94	11403	23.75	16.26	23.23	29.53	20.67
410	459.1	11204	24.40	11122	24.23	15.39	22.07	29.83	20.80
399	448.1	10305	23.00	10222	22.81	15.25	21.73	29.38	20.62
238	287.1	6438	22.42	6364	22.17	10.84	16.31	26.49	17.60
61	110.1	3215	29.20	3177	28.86	5.47	8.95	20.13	12.30
46	95.1	2738	28.79	2705	28.44	5.28	8.42	18.01	11.29
45	94.1	3052	32.43	3008	31.97	5.23	7.70	17.99	12.22
			24.31		**24.18**				

Position: Completely on the Sensor
Sensor: 5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Calibration Factor (Based on Net Area) (Raw/lb)	Averagng Tekscan Raw Sum (Gross Area)	Calibration Factor (Based on Gross Area) (Raw/lb)	Default Net Area (in2)	Averaging Gross Area (in2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
1280	1329.1	37313	28.07	37166	27.96	38.38	49.76	34.63	26.71
1232	1281.1	36282	28.32	36148	28.22	37.70	48.93	33.98	26.18
1228	1277.1	35945	28.15	35809	28.04	37.80	48.69	33.79	26.23
1030	1079.1	30165	27.95	30019	27.82	32.96	43.71	32.74	24.69
844	893.1	24627	27.57	24510	27.44	27.98	37.80	31.92	23.63
810	859.1	24158	28.12	24014	27.95	27.73	37.12	30.98	23.14
788	837.1	23403	27.96	23268	27.80	26.62	36.11	31.45	23.18
595	644.1	17999	27.94	17920	27.82	21.20	29.72	30.38	21.67
400	449.1	12930	28.79	12851	28.62	15.05	22.55	29.84	19.92
391	440.1	12488	28.38	12424	28.23	14.52	22.07	30.31	19.94
388	437.1	12424	28.42	12339	28.23	14.91	22.07	29.32	19.81
238	287.1	7664	26.69	7604	26.49	9.73	16.12	29.51	17.81
42	91.1	2791	30.64	2749	30.18	4.50	8.62	20.24	10.57
35	84.1	2845	33.83	2787	33.14	4.69	8.32	17.93	10.11
19	68.1	2159	31.70	2113	31.03	4.02	8.42	16.94	8.09
			28.15		**28.01**				

TEST 1



Position: Completely on the Sensor

Sensor: 5250-7

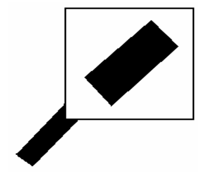
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1207	1256.1	33652	26.79	33556	26.71	35.96	46.13	34.93	27.23
1202	1251.1	35313	28.23	35136	28.08	36.11	46.61	34.65	26.84
1062	1111.1	30734	27.66	30615	27.55	32.86	43.46	33.81	25.57
816	865.1	24431	28.24	24317	28.11	28.31	37.85	30.56	22.86
808	857.1	24087	28.10	23972	27.97	27.44	36.88	31.24	23.24
806	855.1	22519	26.33	22393	26.19	25.89	35.96	33.03	23.78
606	655.1	18377	28.05	18290	27.92	21.83	30.93	30.01	21.18
406	455.1	13343	29.32	13272	29.16	16.55	25.26	27.50	18.02
402	451.1	11777	26.11	11695	25.93	15.54	22.99	29.03	19.62
395	444.1	12731	28.67	12649	28.48	16.12	23.81	27.55	18.65
194	243.1	7199	29.61	7154	29.43	10.21	16.36	23.81	14.86
35	84.1	2677	31.83	2625	31.21	5.08	8.62	16.56	9.76
5	54.1	1700	31.42	1622	29.98	4.45	9.44	12.16	5.73
0	49.1	1483	30.20	1427	29.06	4.45	8.47	11.03	5.80
			27.75		**27.61**				

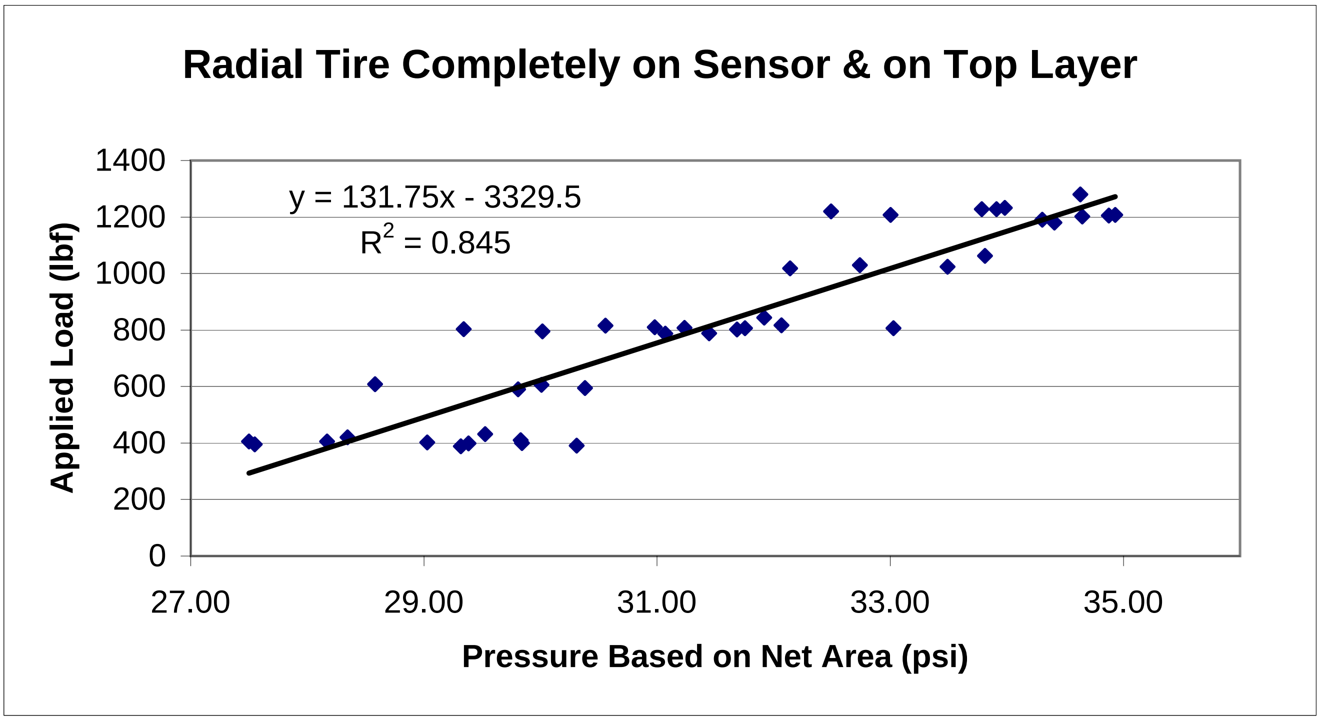
Position: Completely on the Sensor

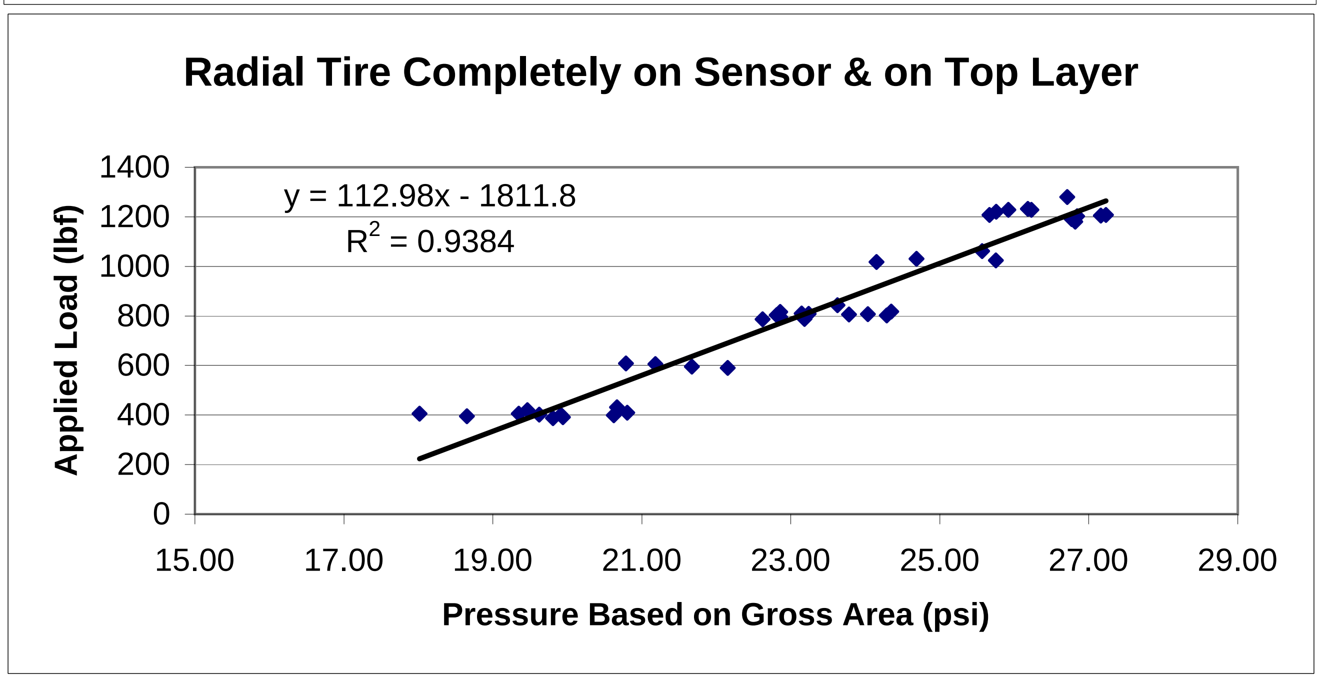
Sensor: 5250-8

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1228	1277.1	38309	30.00	38454	30.11	37.66	49.27	33.91	25.92
1220	1269.1	38703	30.50	38845	30.61	39.06	49.27	32.49	25.76
1208	1257.1	37874	30.13	38010	30.24	38.09	48.98	33.00	25.67
1018	1067.1	33253	31.16	33381	31.28	33.20	44.19	32.14	24.15
803	852.1	27167	31.88	27297	32.03	29.04	37.36	29.34	22.81
795	844.1	26856	31.82	26972	31.95	28.12	36.93	30.02	22.86
787	836.1	26506	31.70	26611	31.83	26.91	36.96	31.07	22.62
608	657.1	21042	32.02	21177	32.23	22.99	31.61	28.58	20.79
430	479.1	14988	31.28	15078	31.47	19.02	25.89	25.19	18.51
420	469.1	15004	31.98	15004	31.98	16.55	24.10	28.34	19.46
405	454.1	14346	31.59	14346	31.59	16.12	23.47	28.17	19.35
215	264.1	8805	33.34	8805	33.34	9.29	15.39	28.43	17.16
43	92.1	3686	40.02	3686	40.02	4.40	8.08	20.93	11.40
38	87.1	3428	39.36	2428	27.88	4.21	7.50	20.69	11.61
28	77.1	3034	39.35	3034	39.35	4.11	7.07	18.76	10.91
			31.28		**31.39**				

TEST 1

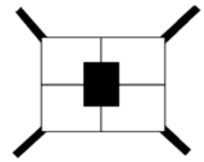



Radial Tire Completely on Sensor & on Top Layer
y = 131.75x - 3329.5
R2 = 0.845
Applied Load (lbf)
Pressure Based on Net Area (psi)
0
200
400
600
800
1000
1200
1400
27.00
29.00
31.00
33.00
35.00


Radial Tire Completely on Sensor & on Top Layer
y = 112.98x - 1811.8
R2 = 0.9384
Applied Load (lbf)
Pressure Based on Gross Area (psi)
0
200
400
600
800
1000
1200
1400
15.00
17.00
19.00
21.00
23.00
25.00
27.00
29.00

Tekscan Pressure Test in Asphalt Structure

TEST 2



Date: 9/4/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Position: Top Layer

5250-5

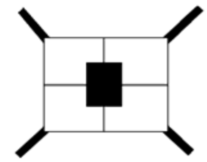
A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1240	1289.1	6640	273.14	6573	271.84	8.23	9.58	33.19	28.38
1218	1267.1	6369	261.99	6302	260.63	8.03	9.39	32.63	27.76
1202	1251.1	6445	265.12	6391	264.31	8.13	9.39	32.61	28.15
966	1015.1	5234	215.30	5169	213.77	6.63	8.18	32.47	26.13
817	866.1	4465	183.67	4419	182.75	5.86	7.21	31.34	25.35
812	861.1	4384	180.34	4345	179.69	5.90	7.31	30.57	24.58
795	844.1	4309	177.25	4270	176.59	5.61	6.97	31.60	25.34
604	653.1	3070	126.29	3037	125.60	4.36	5.42	28.96	23.17
441	490.1	2011	82.72	1989	82.26	3.00	3.97	27.57	20.72
422	471.1	1973	81.16	1950	80.65	3.10	3.82	26.18	21.11
395	444.1	1781	73.26	1767	73.08	2.66	3.53	27.54	20.70
190	239.1	516	21.23	508	21.01	0.92	1.50	23.07	14.01
55	104.1	22	0.90	16	0.66	0.19	0.24	4.76	2.76
29	78.1	0	0.00	0	0.00	0.00	0.00	0.00	0.00
14	63.1	0	0.00	0	0.00	0.00	0.00	0.00	0.00

Position: Top Layer

5250-6

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1220	1269.1	8326	295.77	8395	299.71	8.86	11.66	33.38	25.70
1215	1264.1	8360	296.98	8421	300.64	8.86	11.81	33.52	25.46
1049	1098.1	7472	265.44	7541	269.23	8.18	10.99	32.45	24.50
818	867.1	6003	213.25	6067	216.60	7.36	9.63	28.97	22.49
816	865.1	5998	213.07	6042	215.71	7.31	9.58	29.15	22.52
806	855.1	5932	210.73	5993	213.96	7.36	9.53	28.63	22.45
648	697.1	4742	168.45	4780	170.65	6.2	8.18	27.17	20.86
413	462.1	3208	113.96	3233	115.42	5.32	6.63	21.42	17.41
384	433.1	3011	106.96	3035	108.35	5.13	6.24	20.85	17.36
379	428.1	2881	102.34	2901	103.57	5.23	6.29	19.57	16.47
206	255.1	1807	64.19	1814	64.76	3.87	4.74	16.59	13.66
64	113.1	860	30.55	852	30.42	2.27	3.05	13.46	9.97
54	103.1	780	27.71	771	27.53	2.18	2.90	12.71	9.49
53	102.1	784	27.85	783	27.95	2.23	3.05	12.49	9.17

TEST 2



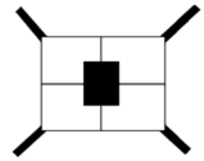
Position: Top Layer
5250-7

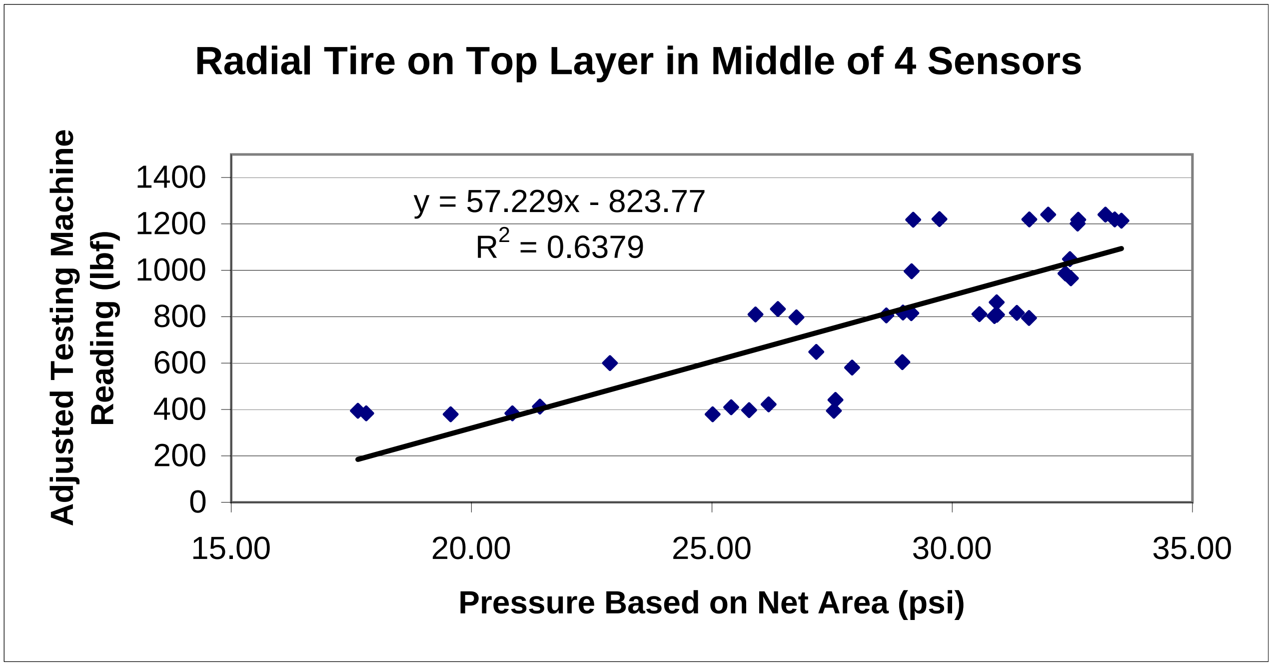
A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1221	1270.1	5512	198.63	5463	197.86	6.68	7.79	29.74	25.40
1219	1268.1	5411	194.99	5366	194.35	6.68	7.84	29.19	24.79
997	1046.1	4232	152.50	4196	151.97	5.23	6.39	29.16	23.78
834	883.1	3220	116.04	3194	115.68	4.40	5.28	26.37	21.91
810	859.1	3099	111.68	3079	111.52	4.31	5.13	25.91	21.74
798	847.1	3126	112.65	3095	112.10	4.21	5.08	26.76	22.07
600	649.1	2000	72.07	1976	71.57	3.15	3.92	22.88	18.26
394	443.1	969	34.92	949	34.37	1.98	2.57	17.64	13.37
383	432.1	934	33.66	915	33.14	1.89	2.52	17.81	13.15
381	430.1	899	32.40	876	31.73	0.63	2.47	51.42	12.85
194	243.1	181	6.52	160	5.80	0.50	0.92	13.05	6.30
53	102.1	4	0.14	0	0.00	0.50	0.00	0.29	0.00
43	92.1	0	0.00	0	0.00	0.00	0.00	0.00	0.00
20	69.1	26	0.94	21	0.76	0.00	0.39	0.00	1.95

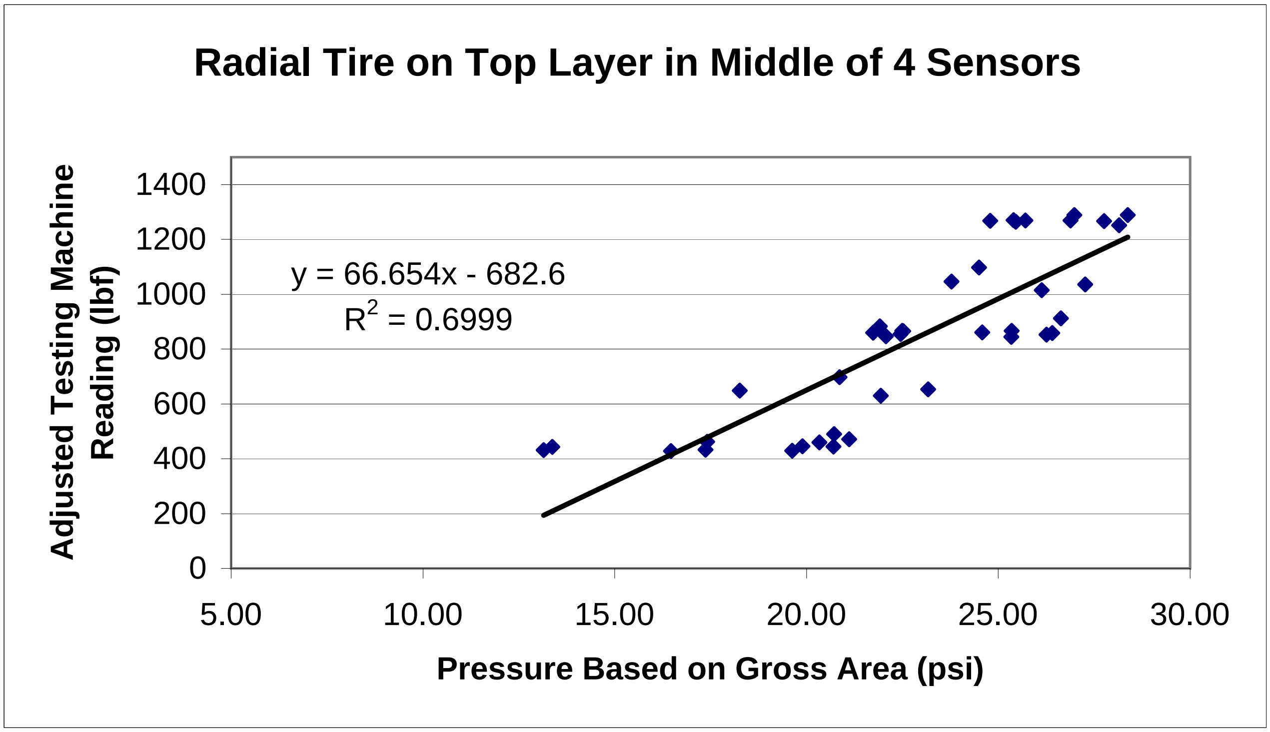
Position: Top Layer
5250-8

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1240	1289.1	12931	413.40	12830	408.73	12.92	15.15	32.00	26.98
1220	1269.1	12873	411.54	12783	407.23	13.02	15.15	31.61	26.88
987	1036.1	11508	367.90	11433	364.22	11.37	13.36	32.36	27.26
863	912.1	10439	333.73	10358	329.98	10.79	12.39	30.93	26.63
809	858.1	10073	322.03	9989	318.22	10.41	12.05	30.93	26.41
803	852.1	9813	313.71	9735	310.13	10.16	11.81	30.88	26.26
581	630.1	6934	221.68	6864	218.67	7.94	9.97	27.92	21.93
410	459.1	5539	177.08	5471	174.29	6.97	8.57	25.41	20.34
397	446.1	5346	170.91	5288	168.46	6.63	8.47	25.78	19.89
380	429.1	5266	168.35	5219	166.26	6.73	8.47	25.01	19.63
216	265.1	3878	123.98	3829	121.98	5.95	7.11	20.84	17.16
53	102.1	2252	71.99	2218	70.66	4.40	5.52	16.36	12.80
47	96.1	2228	71.23	2196	69.96	4.21	5.42	16.92	12.91
9	58.1	1589	50.80	1572	50.08	3.34	4.65	15.21	10.77

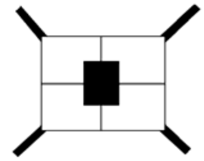
TEST 2




Radial Tire on Top Layer in Middle of 4 Sensors
y = 57.229x - 823.77
R2 = 0.6379
Adjusted Testing Machine Reading (lbf)
0
200
400
600
800
1000
1200
1400
15.00
20.00
25.00
30.00
35.00
Pressure Based on Net Area (psi)


Radial Tire on Top Layer in Middle of 4 Sensors
y = 66.654x - 682.6
R2 = 0.6999
Adjusted Testing Machine Reading (lbf)
0
200
400
600
800
1000
1200
1400
5.00
10.00
15.00
20.00
25.00
30.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure ***TEST 3***



Date: 9/4/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)
Asphalt directly over sensor
(total 20 in. x 20 in. = 78.8 lb with 10 in. x 10 in. over sensor ≈ 25% total mass) ≈ 19.7 lb

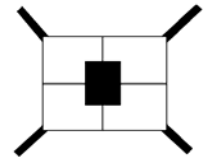
Position: Between 1 & 2 layer
5250-5

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1202	317.7	3125	128.55	2907	120.22	9.97	16.50	12.89	7.29
1200	317.2	2975	122.38	2774	114.72	9.15	15.54	13.37	7.38
1013	270.45	2568	105.64	2370	98.01	8.76	15.34	12.06	6.39
807	218.95	2227	91.61	2032	84.04	8.32	14.42	11.01	5.83
800	217.2	2120	87.21	1912	79.07	8.32	14.13	10.48	5.60
772	210.2	2142	88.11	1934	79.98	8.13	13.94	10.84	5.74
581	162.45	1767	72.69	1549	64.06	7.74	13.07	9.39	4.90
419	121.95	1567	64.46	1358	56.16	7.31	12.78	8.82	4.39
394	115.7	1490	61.29	1307	54.05	7.07	12.25	8.67	4.41
380	112.2	1429	58.78	1209	50.00	6.92	11.66	8.49	4.29
232	75.2	1175	48.33	943	39.00	6.20	10.36	7.80	3.76
40	27.2	859	35.34	614	25.39	5.28	8.62	6.69	2.95
34	25.7	759	31.22	533	22.04	4.60	7.84	6.79	2.81
29	24.45	752	30.93	515	21.30	4.79	7.79	6.46	2.73

Position: Between 1 & 2 layer
5250-6

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1204	318.2	9201	326.86	9042	322.81	15.15	23.28	21.57	13.87
1191	314.95	9260	328.95	9049	323.06	15.58	23.33	21.11	13.85
1040	277.2	8517	302.56	8314	296.82	15.49	23.67	19.53	12.54
821	222.45	6959	247.21	6800	242.77	13.79	22.70	17.93	10.69
820	222.2	7328	260.32	7114	253.98	15.10	22.84	17.24	11.12
816	221.2	7126	253.14	6977	249.09	13.99	22.99	18.09	10.83
586	163.7	5938	210.94	5737	204.82	14.33	22.12	14.72	9.26
403	117.95	4344	154.32	4164	148.66	12.83	20.57	12.03	7.23
392	115.2	4155	147.60	3973	141.84	12.58	20.52	11.73	6.91
382	112.7	4189	148.81	3977	141.99	12.87	20.47	11.56	6.94
205	68.45	2752	97.76	2544	90.82	11.08	18.15	8.82	5.00
28	24.2	1114	39.57	949	33.88	6.44	10.84	6.14	3.13
15	20.95	939	33.36	769	27.45	6.10	9.83	5.47	2.79
8	19.2	950	33.75	794	28.35	6.10	9.78	5.53	2.90

TEST 3



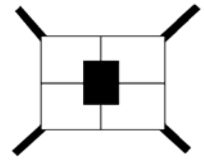
Position: Between 1 & 2 layer
5250-7

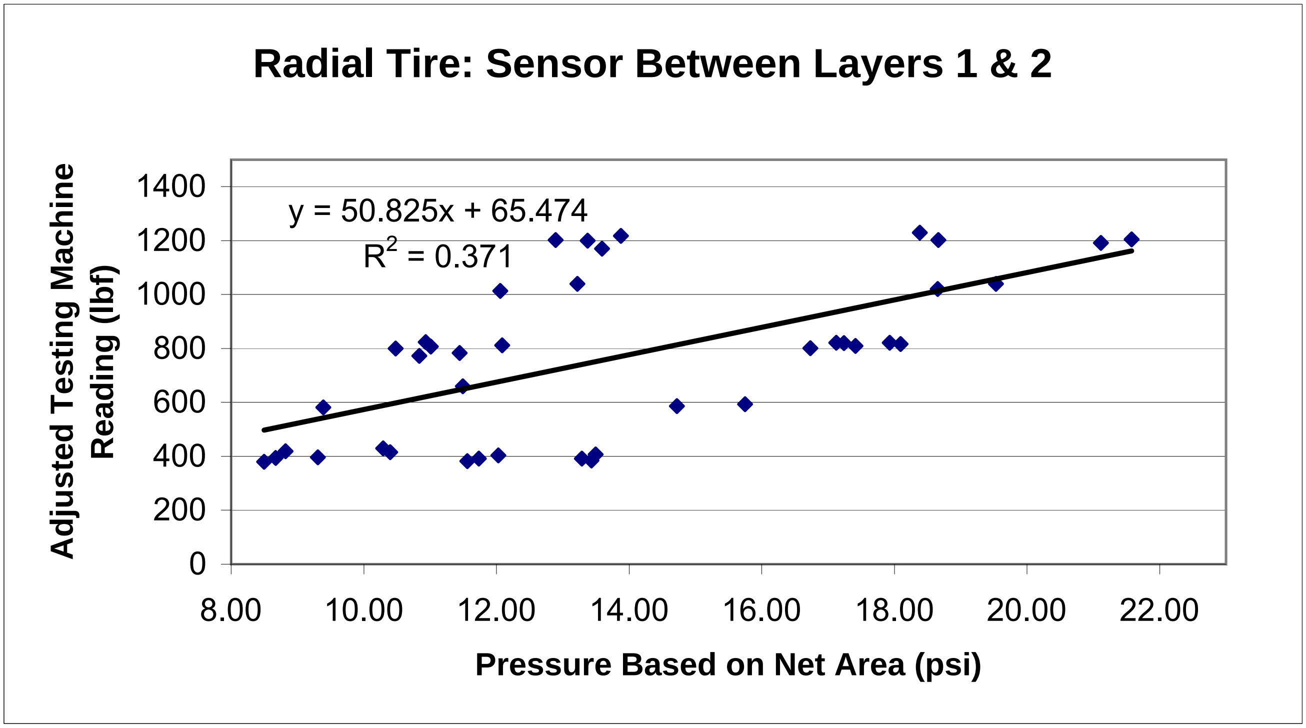
A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1218	321.7	2553	92.00	2477	89.71	6.63	10.70	13.88	8.38
1170	309.7	2557	92.14	2473	89.57	6.78	11.71	13.59	7.65
1040	277.2	2238	80.65	2154	78.02	6.10	9.24	13.22	8.44
824	223.2	2057	74.13	1950	70.63	6.78	10.26	10.93	6.88
812	220.2	1979	71.32	1885	68.27	5.90	9.39	12.09	7.27
783	212.95	1982	71.42	1906	69.03	6.24	8.76	11.45	7.88
660	182.2	1684	60.68	1621	58.71	5.28	8.18	11.49	7.18
429	124.45	1411	50.85	1318	47.74	4.94	7.89	10.29	6.05
415	120.95	1353	48.76	1291	46.76	4.69	7.16	10.40	6.53
396	116.2	1462	52.68	1340	48.53	5.66	8.62	9.31	5.63
209	69.45	1113	40.11	1039	37.63	4.45	6.73	9.01	5.59
26	23.7	824	29.69	762	27.60	3.39	5.61	8.76	4.92
17	21.45	552	19.89	469	16.99	3.44	5.71	5.78	2.97
5	18.45	543	19.57	488	17.67	3.68	6.24	5.32	2.83

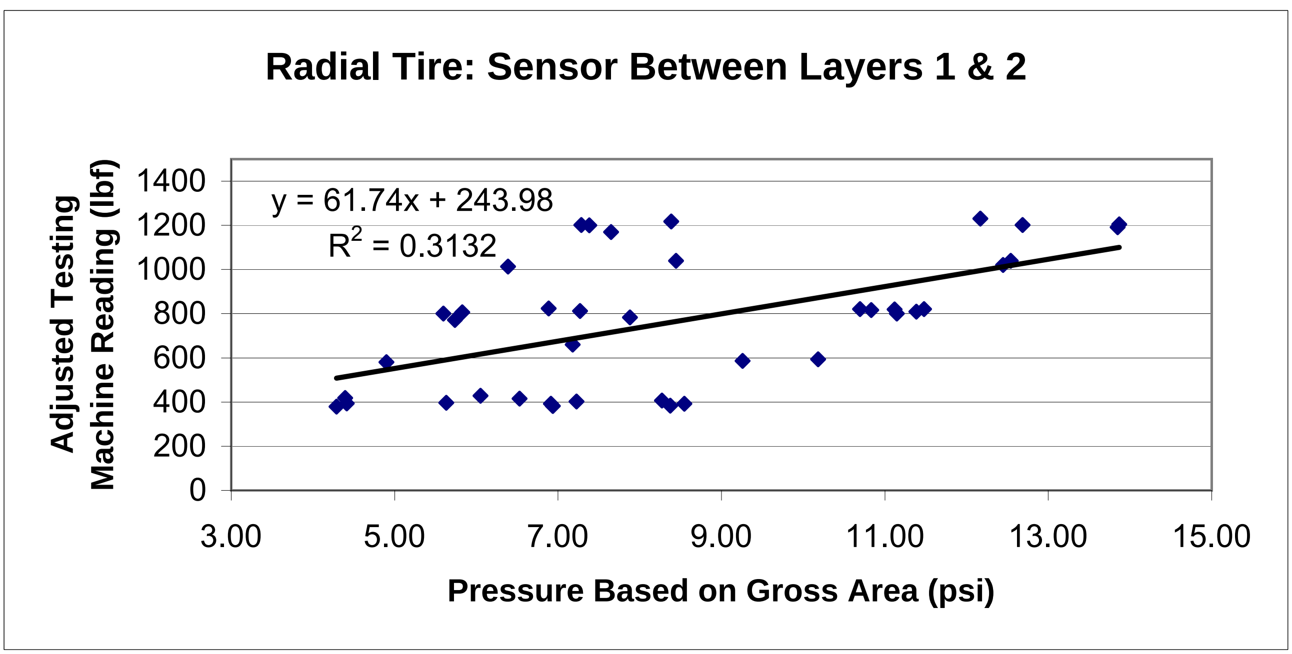
Position: Between 1 & 2 layer
5250-8

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1230	324.7	10299	329.25	10019	319.18	17.91	26.23	18.38	12.17
1202	317.7	10367	331.43	10119	322.36	17.76	25.41	18.66	12.69
1021	272.45	9626	307.74	9382	298.88	16.50	24.01	18.65	12.45
821	222.45	8737	279.32	8475	269.99	16.31	23.52	17.13	11.48
809	219.45	8623	275.67	8389	267.25	15.83	23.47	17.41	11.39
801	217.45	8589	274.58	8298	264.35	16.41	23.72	16.73	11.14
593	165.45	7557	241.59	7287	232.14	15.34	22.80	15.75	10.18
407	118.95	6209	198.50	5957	189.77	14.71	22.94	13.49	8.27
392	115.2	6338	202.62	6104	194.46	15.25	22.75	13.29	8.55
384	113.2	6163	197.03	5927	188.82	14.67	22.55	13.43	8.37
220	72.2	4338	138.68	4127	131.47	12.39	21.30	11.19	6.17
31	24.95	1860	59.46	1667	53.11	8.62	14.62	6.90	3.63
15	20.95	1576	50.38	1367	43.55	7.79	13.65	6.47	3.19
5	18.45	1262	40.35	1045	33.29	7.11	11.66	5.67	2.86

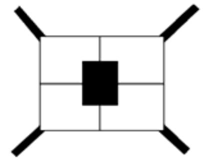
TEST 3




Radial Tire: Sensor Between Layers 1 & 2
y = 50.825x + 65.474
R2 = 0.371
Adjusted Testing Machine Reading (lbf)
Pressure Based on Net Area (psi)
0
200
400
600
800
1000
1200
1400
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00


Radial Tire: Sensor Between Layers 1 & 2
y = 61.74x + 243.98
R2 = 0.3132
Adjusted Testing Machine Reading (lbf)
Pressure Based on Gross Area (psi)
0
200
400
600
800
1000
1200
1400
3.00
5.00
7.00
9.00
11.00
13.00
15.00

Tekscan Pressure Test in Asphalt Structure — *TEST 4*



Date: 9/4/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)
Asphalt directly over sensor
(total 20 in. x 20 in. x 2 in.= 78.8 lb with 10 in. x 10 in. over sensor ≈ 25% total mass) ≈ 19.7 lb
(total 20 in. x 20 in. x 2 in. = 78.8 lb with 10 in. x 10 in. over sensor ≈ 25% total mass) ≈ 19.7 lb
(total 20 in. x 20 in.x 3 in.)= 105.7 lb with 10 in. x 10 in. over sensor ≈ 25% total mass) ≈ 26.4 lb

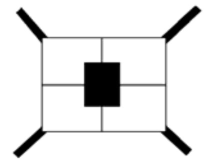
Position: Between 3 & 4 layer
5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1244	339.725	6939	285.44	6648	274.94	20.23	37.41	14.11	7.35
1212	331.725	6962	286.38	6679	276.22	20.38	37.12	14.05	7.44
1010	281.225	6326	260.22	6037	249.67	19.17	36.54	13.57	6.83
829	235.975	5666	233.07	5366	221.92	19.07	35.91	12.22	6.18
824	234.725	5778	237.68	5500	227.46	19.26	36.15	12.34	6.29
801	228.975	5675	233.44	5374	222.25	18.83	35.62	12.40	6.24
637	187.975	5017	206.38	4719	195.16	17.62	34.17	11.71	5.71
426	135.225	4079	167.79	3788	156.66	16.70	32.23	10.05	4.86
377	122.975	4062	167.09	3748	155.00	16.94	31.8	9.86	4.87
367	120.475	3834	157.71	3530	145.99	15.68	30.54	10.06	4.78
219	83.475	3125	128.55	2829	117.00	13.99	28.17	9.19	4.15
52	41.725	2389	98.27	2087	86.31	12.68	25.12	7.75	3.44
45	39.975	2328	95.76	2017	83.42	13.16	24.68	7.28	3.38
29	35.975	2278	93.71	1971	81.51	12.87	23.62	7.28	3.45

Position: Between 3 & 4 layer
5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1221	333.975	11013	391.23	10798	385.51	22.17	40.22	17.65	9.58
1184	324.725	10425	370.34	10159	362.69	21.83	39.06	16.96	9.29
1036	287.725	9736	345.86	9460	337.74	21.34	38.48	16.21	8.78
860	243.725	9303	330.48	8993	321.06	21.10	38.09	15.66	8.43
825	234.975	8977	318.90	8673	309.64	21.01	37.27	15.18	8.31
787	225.475	8139	289.13	7814	278.97	18.15	35.19	15.93	7.93
569	170.975	6948	246.82	6639	237.02	17.23	33.69	14.33	7.04
430	136.225	6301	223.84	5986	213.71	17.96	33.2	12.46	6.44
427	135.475	6359	225.90	6016	214.78	18.05	32.28	12.52	6.65
392	126.725	5988	212.72	5665	202.25	15.83	31.02	13.44	6.52
202	79.225	4616	163.98	4335	154.77	15.49	28.65	10.59	5.40
54	42.225	3339	118.61	3049	108.85	13.41	24.2	8.85	4.50
47	40.475	3354	119.15	3071	109.64	13.36	23.38	8.92	4.69
33	36.975	3348	118.93	3083	110.07	13.41	23.43	8.87	4.70

TEST 4



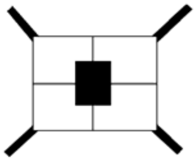
Position: Between 3 & 4 layer
5250-7

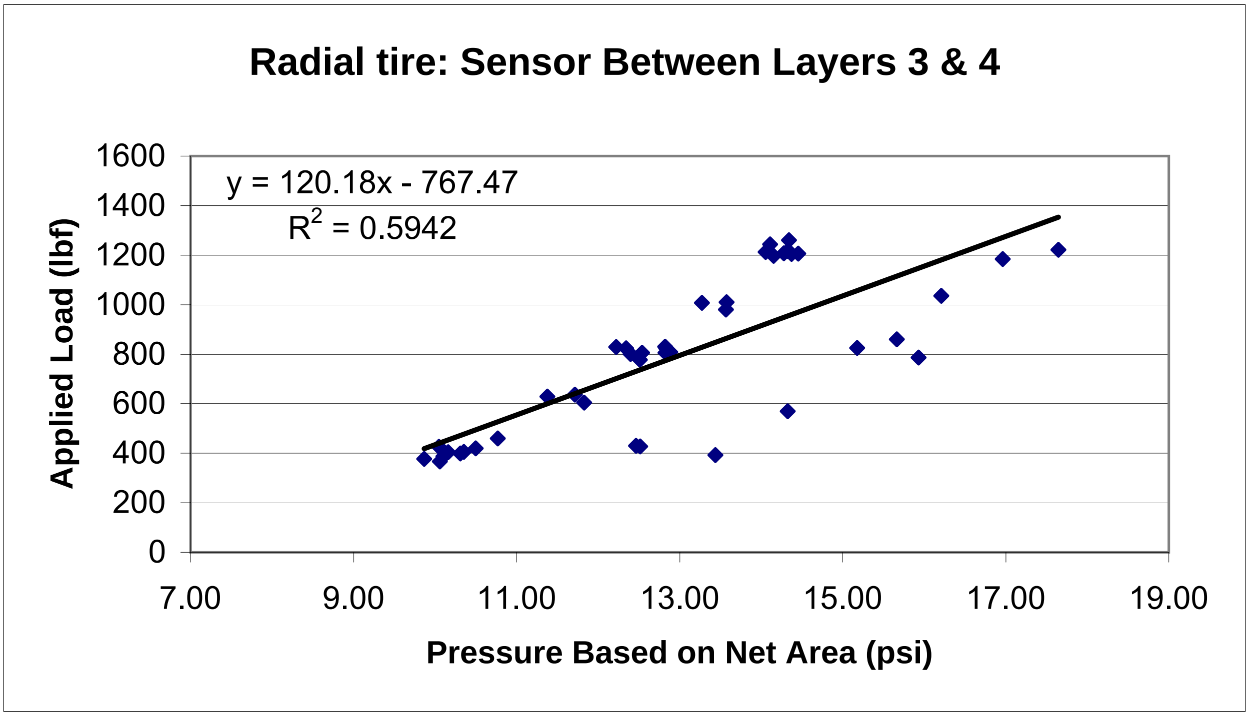
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
1217	332.975	4520	162.88	4273	154.76	11.37	27.30	14.33	5.67
1208	330.725	4869	175.46	4645	168.24	12.29	28.80	14.28	5.84
1206	330.225	5106	184.00	4847	175.55	12.73	29.43	14.45	5.97
1007	280.475	3956	142.56	3703	134.12	10.74	25.75	13.27	5.21
824	234.725	3775	136.04	3547	128.47	10.6	25.85	12.83	4.97
806	230.225	3434	123.75	3210	116.26	9.87	24.15	12.54	4.81
778	223.225	4000	144.14	3760	136.18	11.52	27.68	12.51	4.92
629	185.975	2949	106.27	2696	97.65	9.34	22.02	11.38	4.43
404	129.725	2346	84.54	2080	75.34	8.32	19.21	10.16	3.92
399	128.475	2838	102.27	2529	91.60	9.92	22.36	10.31	4.10
388	125.725	2565	92.43	2292	83.01	9.15	21.10	10.10	3.93
208	80.725	1886	67.96	1605	58.13	7.45	15.88	9.12	3.66
84	49.725	1777	64.04	1456	52.73	7.99	14.67	8.01	3.59
77	47.975	1446	52.11	1186	42.96	6.39	12.78	8.15	3.36
59	43.475	1495	53.87	1224	44.33	6.82	13.41	7.90	3.31

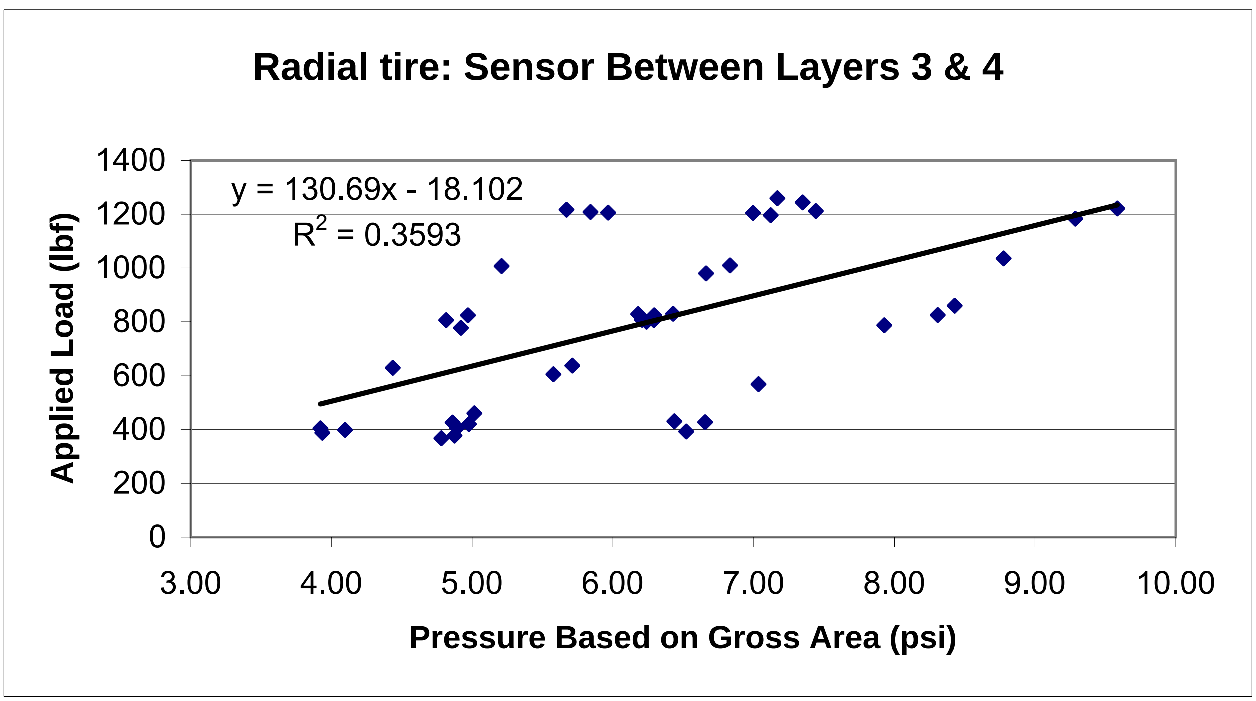
Position: Between 3 & 4 layer
5250-8

Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
1260	343.725	11528	368.54	11130	354.57	25.70	49.46	14.34	7.17
1205	329.975	10964	350.51	10564	336.54	24.39	48.11	14.37	7.00
1197	327.975	11183	357.51	10766	342.98	25.26	48.16	14.15	7.12
980	273.725	10105	323.05	9697	308.92	23.81	46.37	13.57	6.66
830	236.225	9530	304.67	9082	289.33	23.76	45.01	12.82	6.43
808	230.725	9148	292.46	8759	279.04	22.70	44.96	12.88	6.21
806	230.225	9340	298.59	8928	284.42	23.28	45.21	12.83	6.29
605	179.975	7824	250.13	7440	237.02	21.15	42.50	11.83	5.58
460	143.725	6683	213.65	6301	200.73	19.84	40.03	10.77	5.01
420	133.725	6705	214.35	6320	201.34	20.42	40.46	10.50	4.98
406	130.225	6489	207.45	6072	193.44	20.04	39.54	10.35	4.89
182	74.225	4641	148.37	4239	135.04	17.04	33.44	8.71	4.04
52	41.725	3510	112.21	3097	98.66	14.62	27.73	7.68	3.56
43	39.475	3575	114.29	3125	99.55	15.44	27.10	7.40	3.67
25	34.975	3275	104.70	2875	91.59	14.08	25.94	7.44	3.53

TEST 4

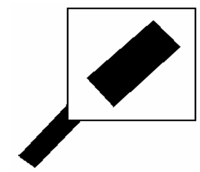



Radial tire: Sensor Between Layers 3 & 4
y = 120.18x - 767.47
R2 = 0.5942
Applied Load (lbf)
1600
1400
1200
1000
800
600
400
200
0
7.00
9.00
11.00
13.00
15.00
17.00
19.00
Pressure Based on Net Area (psi)


Radial tire: Sensor Between Layers 3 & 4
y = 130.69x - 18.102
R2 = 0.3593
Applied Load (lbf)
1400
1200
1000
800
600
400
200
0
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure ***TEST 5***

CALIBRATIONS -- Radial Tire



Date: 9/19/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

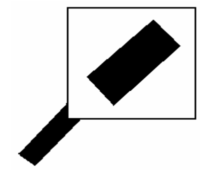
Position: Completely on the Sensor
Sensor: 5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1995	2044.1	53463	26.15	53335	26.09	47.82	57.64	42.75	35.46
1977	2026.1	52923	26.12	52792	26.06	47.63	57.45	42.54	35.27
1627	1676.1	47807	28.52	47686	28.45	44.43	54.06	37.72	31.00
1612	1661.1	47311	28.48	47176	28.40	44.38	53.87	37.43	30.84
1247	1296.1	39862	30.76	39753	30.67	39.16	48.59	33.10	26.67
1217	1266.1	38770	30.62	38645	30.52	38.91	47.92	32.54	26.42
801	850.1	27113	31.89	27017	31.78	30.73	39.11	27.66	21.74
786	835.1	26218	31.40	26118	31.28	30.30	28.77	27.56	29.03
418	467.1	14747	31.57	14631	31.32	19.46	26.77	24.00	17.45
410	459.1	14295	31.14	14191	30.91	18.39	26.18	24.96	17.54
47	96.1	3875	40.32	3826	39.81	5.90	9.10	16.29	10.56
22	71.1	3050	42.90	2996	42.14	4.74	7.31	15.00	9.73
			29.67		**29.55**				

Position: Completely on the Sensor
Sensor: 5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1975	2024.1	55976	27.65	55842	27.59	49.17	59.39	41.17	34.08
1957	2006.1	56228	28.03	56098	27.96	49.51	59.53	40.52	33.70
1633	1682.1	48145	28.62	48008	28.54	45.11	55.13	37.29	30.51
1608	1657.1	48328	29.16	48181	29.08	45.30	54.84	36.58	30.22
1249	1298.1	38545	29.69	38422	29.60	40.32	49.03	32.19	26.48
1182	1231.1	35627	28.94	35504	28.84	38.19	46.95	32.24	26.22
867	916.1	26988	29.46	26873	29.33	32.62	40.90	28.08	22.40
825	874.1	25110	28.73	25016	28.62	30.44	39.06	28.72	22.38
405	454.1	13220	29.11	13128	28.91	17.57	24.44	25.85	18.58
396	445.1	13275	29.82	13219	29.70	17.81	25.36	24.99	17.55
44	93.1	3096	33.25	3020	32.44	6.44	10.84	14.46	8.59
4	53.1	1904	35.86	1842	34.69	4.84	8.08	10.97	6.57
			28.92		**28.82**				

TEST 5



Position: Completely on the Sensor

Sensor: 5250-7

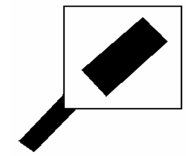
A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Calibration Factor (Based on Net Area) (Raw/lb)	E Averagng Tekscan Raw Sum (Gross Area)	F Calibration Factor (Based on Gross Area) (Raw/lb)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2072	2121.1	60327	28.44	61503	29.00	53.63	63.84	39.55	33.23
2000	2049.1	59354	28.97	59270	28.92	53.39	65.44	38.38	31.31
1658	1707.1	50257	29.44	50114	29.36	47.82	59.53	35.70	28.68
1625	1674.1	49978	29.85	49827	29.76	47.43	59.24	35.30	28.26
1264	1313.1	38926	29.64	38786	29.54	40.12	50.63	32.73	25.94
1218	1267.1	37949	29.95	37816	29.84	39.69	49.90	31.92	25.39
841	890.1	26166	29.40	26034	29.25	30.73	39.93	28.97	22.29
816	865.1	25775	29.79	25636	29.63	30.35	38.87	28.50	22.26
433	482.1	13457	27.91	13355	27.70	18.44	25.75	26.14	18.72
401	450.1	12777	28.39	12679	28.17	17.33	24.64	25.97	18.27
42	91.1	2642	29.00	2597	28.51	5.28	9.05	17.25	10.07
29	78.1	2276	29.14	2217	28.39	4.60	7.70	16.98	10.14
			29.18		**29.12**				

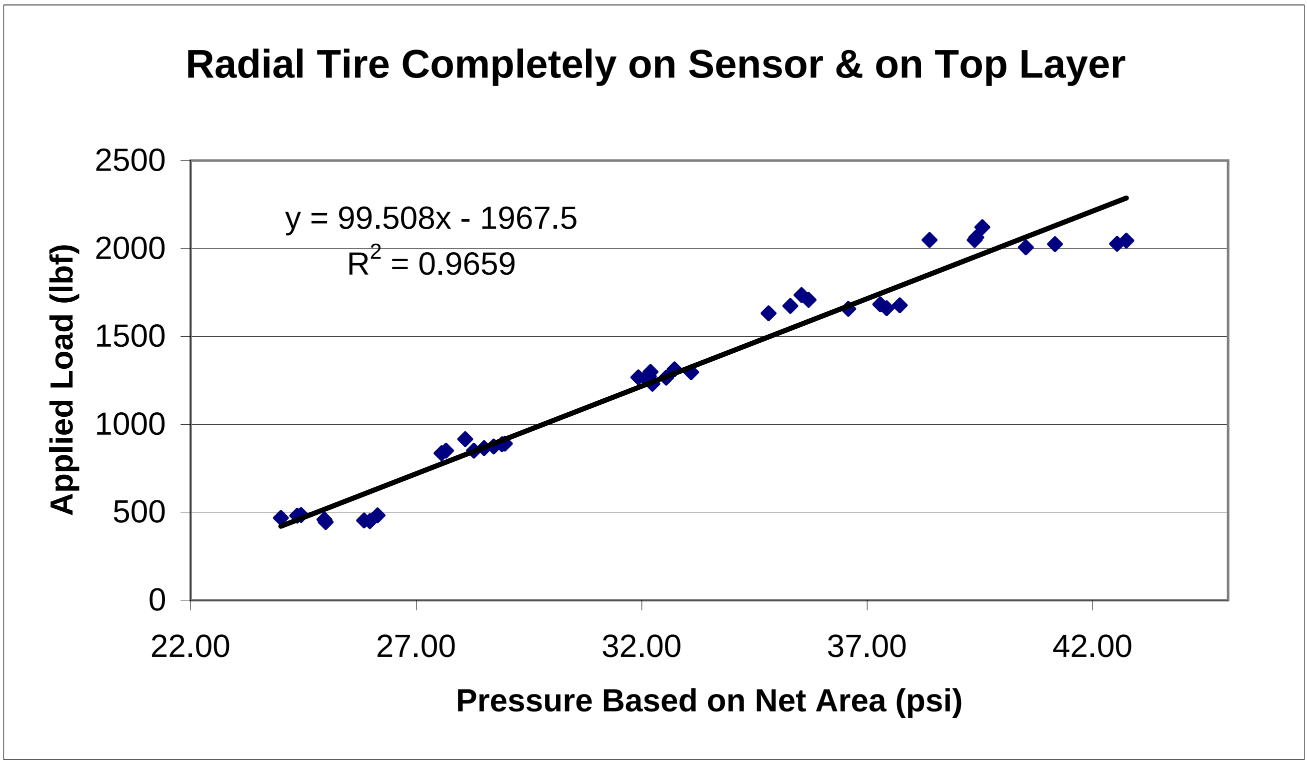
Position: Completely on the Sensor

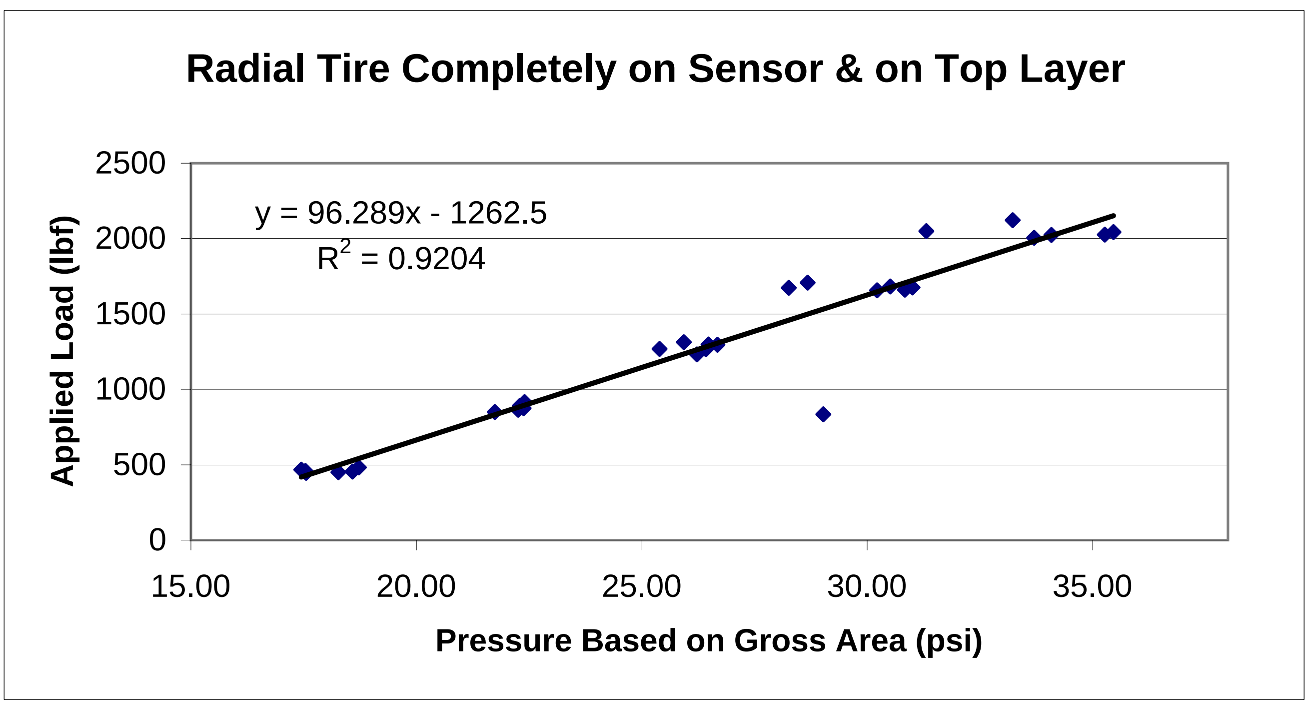
Sensor: 5250-8

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Calibration Factor (Based on Net Area) (Raw/lb)	E Averagng Tekscan Raw Sum (Gross Area)	F Calibration Factor (Based on Gross Area) (Raw/lb)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2013	2062.1	61666	29.90	61503	29.83	52.32	63.84	39.41	32.30
2000	2049.1	60842	29.69	60682	29.61	52.03	63.60	39.38	32.22
1687	1736.1	54008	31.11	53859	31.02	48.84	60.02	35.55	28.93
1582	1631.1	50667	31.06	50542	30.99	46.85	58.52	34.82	27.87
1224	1273.1	40607	31.90	40468	31.79	39.59	49.71	32.16	25.61
1215	1264.1	40206	31.81	40080	31.71	39.40	49.61	32.08	25.48
838	887.1	28318	31.92	28202	31.79	30.69	39.88	28.91	22.24
801	850.1	27381	32.21	27260	32.07	30.06	38.53	28.28	22.06
435	484.1	15189	31.38	15095	31.18	19.80	27.25	24.45	17.77
432	481.1	15073	31.33	14987	31.15	19.75	27.06	24.36	17.78
58	107.1	3597	33.59	3535	33.01	6.78	11.57	15.80	9.26
57	106.1	3652	34.42	3588	33.82	6.68	11.52	15.88	9.21
			31.23		**31.11**				

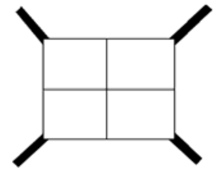
TEST 5




Radial Tire Completely on Sensor & on Top Layer
y = 99.508x - 1967.5
R2 = 0.9659
Applied Load (lbf)
2500
2000
1500
1000
500
0
22.00
27.00
32.00
37.00
42.00
Pressure Based on Net Area (psi)


Radial Tire Completely on Sensor & on Top Layer
y = 96.289x - 1262.5
R2 = 0.9204
Applied Load (lbf)
2500
2000
1500
1000
500
0
15.00
20.00
25.00
30.00
35.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure ***TEST 6***



Date: 9/19/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

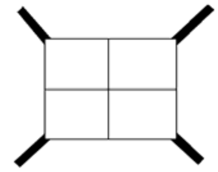
Position: Top Layer
5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2031	2080.1	11030	371.76	11131	376.68	10.89	13.60	34.59	27.33
1674	1723.1	8526	287.36	8604	291.17	9.29	12.05	31.34	23.85
1220	1269.1	5312	179.04	5360	181.39	7.02	9.05	25.84	19.78
821	870.1	2449	82.54	2483	84.03	4.26	6.05	19.72	13.64
429	478.1	297	10.01	292	9.88	0.92	1.69	10.74	5.92
30	79.1	0	0.00	0	0.00	0	0.00	0.00	0.00

Position: Top Layer
5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1980	2029.1	10493	362.83	10559	366.38	9.15	11.81	40.04	30.72
1630	1679.1	9025	312.07	9084	315.20	8.08	10.50	39.01	29.72
1183	1232.1	7172	247.99	7199	249.79	6.73	8.66	37.12	28.64
867	916.1	5512	190.59	5546	192.44	5.81	7.55	33.12	25.24
388	437.1	3365	116.36	3382	117.35	3.97	5.47	29.56	21.27
26	75.1	636	21.99	630	21.86	1.65	2.61	13.25	8.43

TEST 6



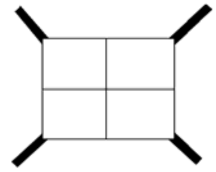
Position: Top Layer
5250-7

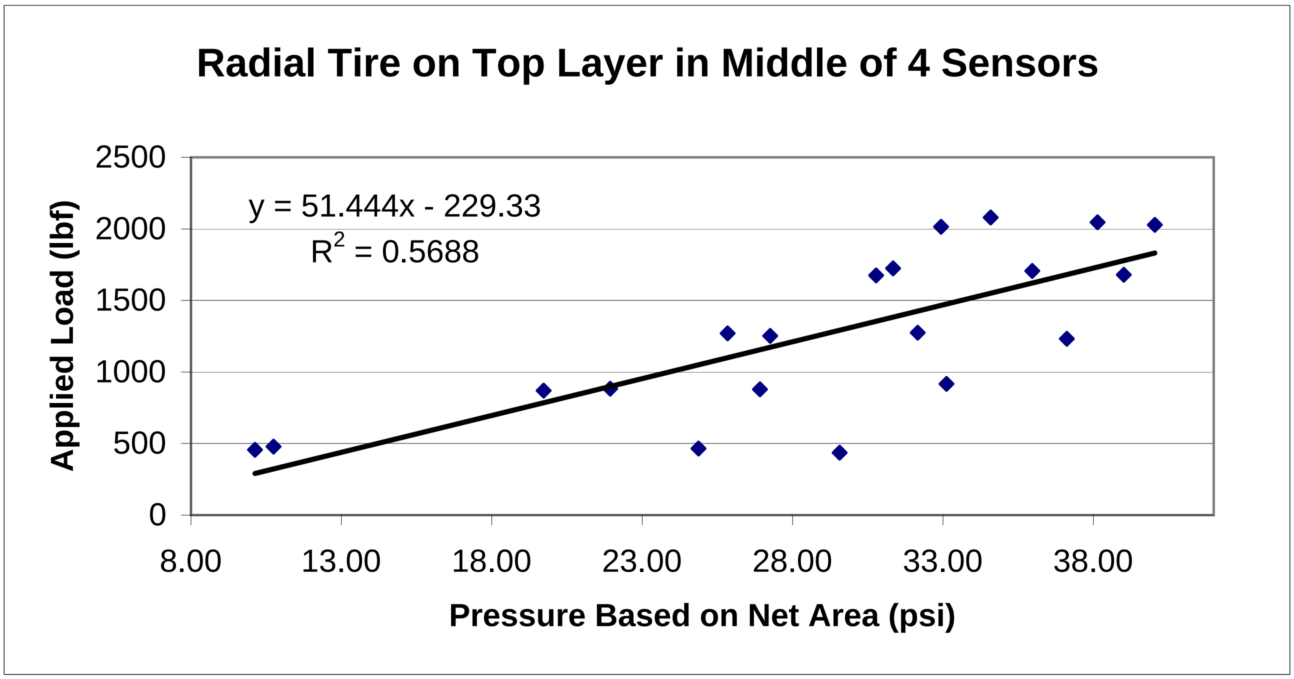
Loading Machine (lb)	Weight on Sensor (lb)	Unaveraged Tekscan (Raw)	Unaveraged Load (lb)	Averaged Tekscan (Raw)	Averaged Load (lb)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Averaged (Gross) Pressure (psi)	Unaveraged (Net) Pressure (psi)
1965	2014.1	8213	281.46	8219	282.25	8.57	9.97	32.93	28.23
1625	1674.1	6537	224.02	6552	225.00	7.31	8.66	30.78	25.87
1204	1253.1	4449	152.47	4453	152.92	5.61	6.53	27.26	23.35
834	883.1	2334	79.99	2319	79.64	3.63	4.5	21.94	17.77
406	455.1	256	8.77	227	7.80	0.77	1.26	10.12	6.96
13	62.1	7	0.24	2	0.07	0.05	0.05	1.37	4.80

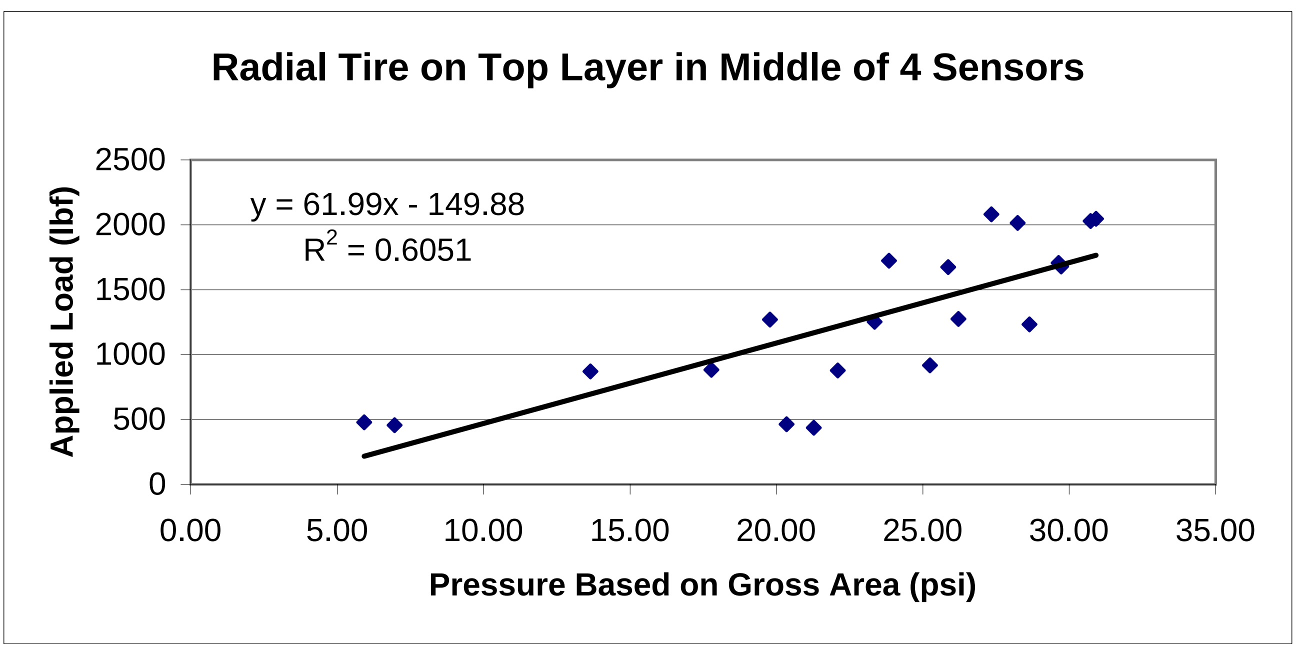
Position: Top Layer
5250-8

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1998	2047.1	17144	548.96	17049	548.02	14.37	17.76	38.14	30.91
1656	1705.1	14558	466.15	14459	464.77	12.92	15.73	35.97	29.63
1226	1275.1	11091	355.14	10996	353.46	10.99	13.55	32.16	26.21
829	878.1	7547	241.66	7462	239.86	8.91	10.94	26.92	22.09
415	464.1	4613	147.71	4534	145.74	5.86	7.26	24.87	20.35
43	92.1	1130	36.18	1079	34.68	2.32	3.15	14.95	11.49

TEST 6



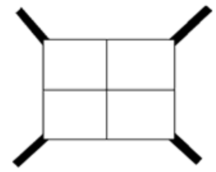

Radial Tire on Top Layer in Middle of 4 Sensors
y = 51.444x - 229.33
R2 = 0.5688
Applied Load (lbf)
0
500
1000
1500
2000
2500
8.00
13.00
18.00
23.00
28.00
33.00
38.00
Pressure Based on Net Area (psi)


Radial Tire on Top Layer in Middle of 4 Sensors
y = 61.99x - 149.88
R2 = 0.6051
Applied Load (lbf)
0
500
1000
1500
2000
2500
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure

WITH STRAPS

<u>TEST 7</u>



Date: 9/19/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

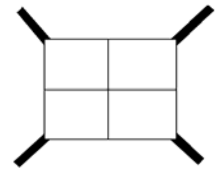
Position: Between 1&2 Layer
5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1987		12078	407.08	11680	395.26	28.22	40.61	14.01	10.02
1639		9792	330.03	9400	318.10	25.22	37.85	12.61	8.72
1247		7157	241.22	6788	229.71	21.25	33.73	10.81	7.15
833		4898	165.08	4506	152.49	16.31	27.39	9.35	6.03
452		2936	98.96	2603	88.09	12.00	19.60	7.34	5.05
38		1616	54.47	1403	47.48	8.03	12.05	5.91	4.52

Position: Between 1&2 Layer
5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2006		20487	708.40	20036	695.21	31.46	42.06	22.10	16.84
1650		18200	629.32	17763	616.34	31.07	40.80	19.84	15.42
1246		14973	517.74	14569	505.52	29.57	38.62	17.10	13.41
844		11073	382.88	10685	370.75	27.15	35.82	13.66	10.69
445		6775	234.27	6443	223.56	23.38	31.41	9.56	7.46
57		2506	86.65	2256	78.28	13.46	21.83	5.82	3.97

TEST 7



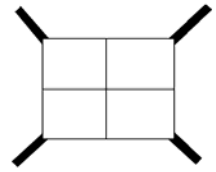
Position: Between 1&2 Layer
5250-7

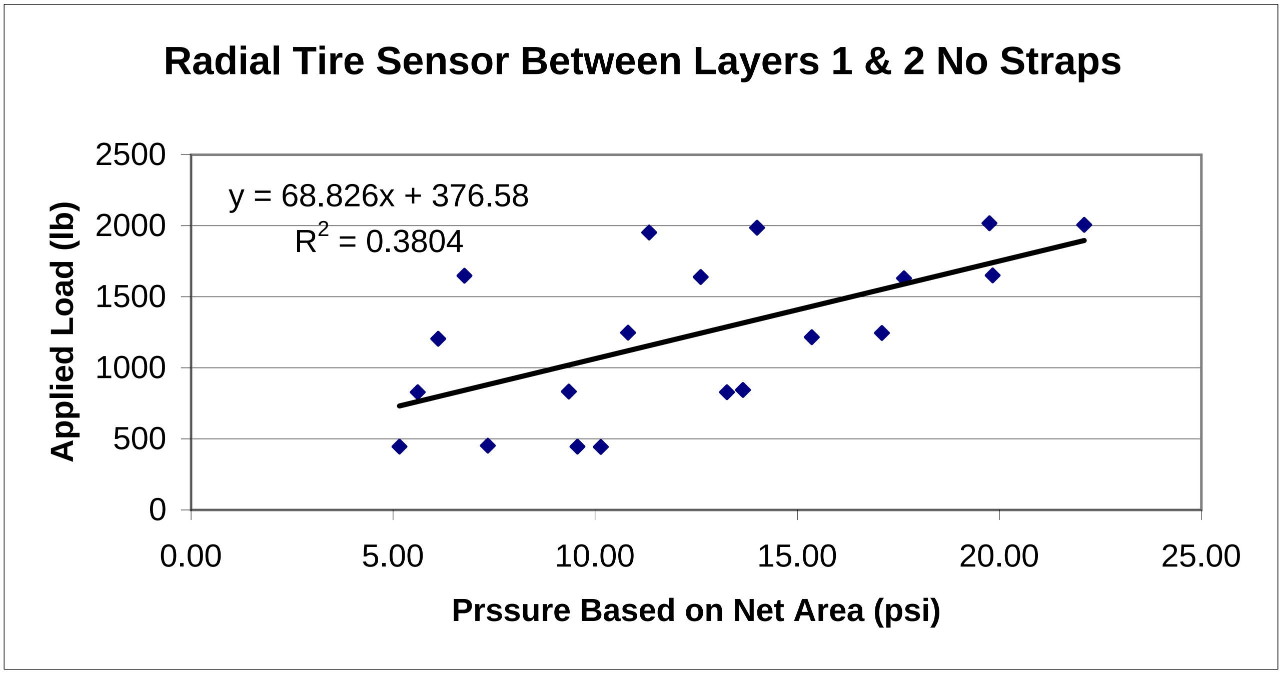
A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in2)	H Averaging Gross Area (in2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1953		8694	297.94	8215	282.11	24.88	38.43	11.34	7.75
1648		6886	235.98	6395	219.61	32.48	32.48	6.76	7.27
1205		4528	155.17	4074	139.90	22.89	22.89	6.11	6.78
829		3264	111.86	2886	99.11	17.67	17.67	5.61	6.33
446		2440	83.62	2182	74.93	14.52	14.52	5.16	5.76
48		1745	59.80	1603	55.05	10.02	10.02	5.49	5.97

Position: Between 1&2 Layer
5250-8

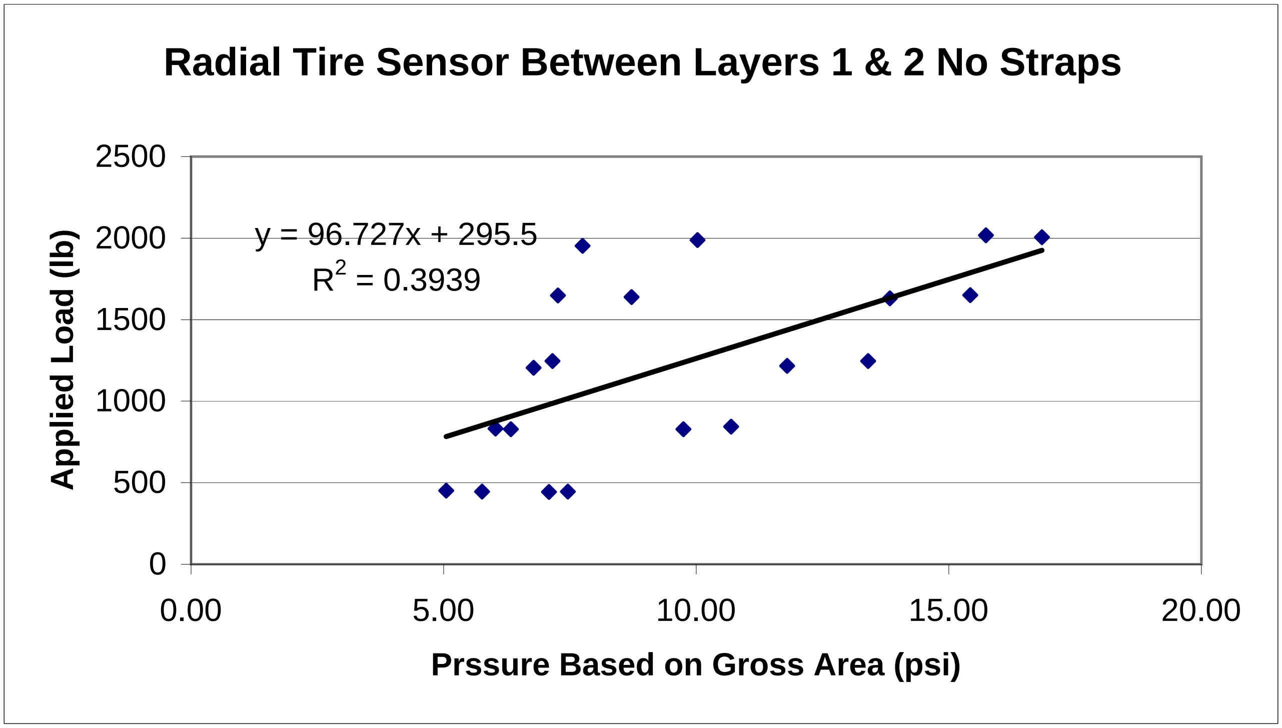
A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in2)	H Averaging Gross Area (in2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2017		22216	711.37	21894	703.76	35.62	45.21	19.76	15.73
1631		19345	619.44	18998	610.67	34.61	44.77	17.64	13.84
1217		16179	518.06	15824	508.65	33.11	43.90	15.36	11.80
829		12963	415.08	12659	406.91	30.69	42.59	13.26	9.75
443		9276	297.02	9024	290.07	28.60	41.91	10.14	7.09
9		2933	93.92	2653	85.28	14.81	23.91	5.76	3.93

TEST 7





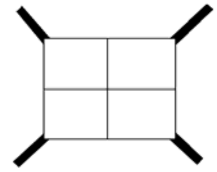
Radial Tire Sensor Between Layers 1 & 2 No Straps
y = 68.826x + 376.58
R2 = 0.3804
Applied Load (lb)
Prssure Based on Net Area (psi)
0
500
1000
1500
2000
2500
0.00
5.00
10.00
15.00
20.00
25.00



Radial Tire Sensor Between Layers 1 & 2 No Straps
y = 96.727x + 295.5
R2 = 0.3939
Applied Load (lb)
Prssure Based on Gross Area (psi)
0
500
1000
1500
2000
2500
0.00
5.00
10.00
15.00
20.00

Tekscan Pressure Test in Asphalt Structure — ***TEST 8***

NO STRAPS



Date: 9/19/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

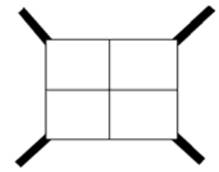
Position: Between 1&2 Layer
5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2036		11417	384.80	11032	373.33	23.57	30.69	15.84	12.54
1661		8819	297.24	8442	285.69	20.65	28.41	13.83	10.46
1210		6060	204.25	5732	193.98	16.65	25.56	11.65	7.99
818		3815	128.58	3484	117.90	12.34	20.42	9.55	6.30
433		2010	67.75	1630	55.16	8.28	12.34	6.66	5.49
46		859	28.95	599	20.27	5.61	7.74	3.61	3.74

Position: Between 1&2 Layer
5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1962		11534	398.82	11298	392.02	19.51	24.83	20.09	16.06
1635		9542	329.94	9332	323.80	17.67	23.33	18.33	14.14
1224		9428	326.00	9132	316.86	17.33	21.1	18.28	15.45
822		7060	244.12	6778	235.18	15.92	18.73	14.77	13.03
392		3276	113.28	3082	106.94	11.91	14.18	8.98	7.99
39		1170	40.46	976	33.87	7.79	11.04	4.35	3.66

TEST 8



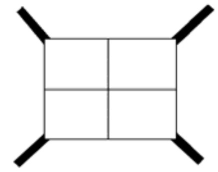
Position: Between 1&2 Layer
5250-7

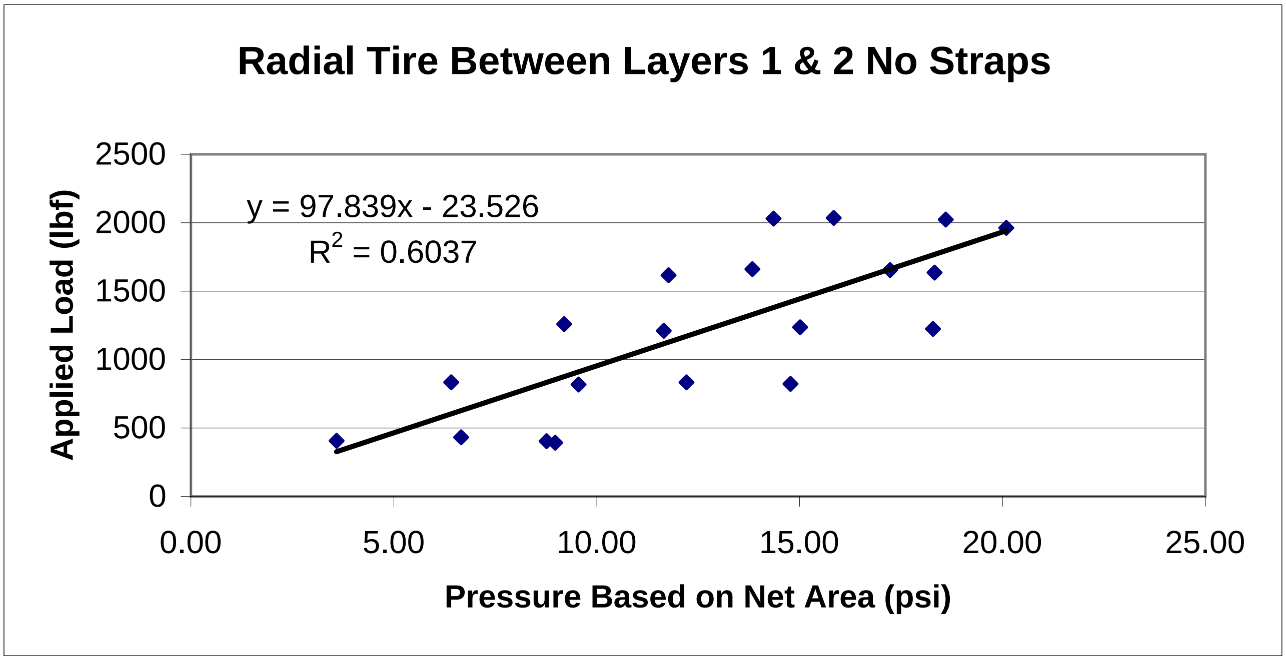
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in2)	Averaging Gross Area (in2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2031		7892	270.46	7490	257.21	17.91	26.23	14.36	10.31
1617		5602	191.98	5177	177.78	15.1	20.96	11.77	9.16
1259		3630	124.40	3254	111.74	12.15	16.31	9.20	7.63
834		1883	64.53	1528	52.47	8.18	10.5	6.41	6.15
406		843	28.89	552	18.96	5.28	5.52	3.59	5.23
26		260	8.91	122	4.18	2.13	2.42	1.96	3.68

Position: Between 1&2 Layer
5250-8

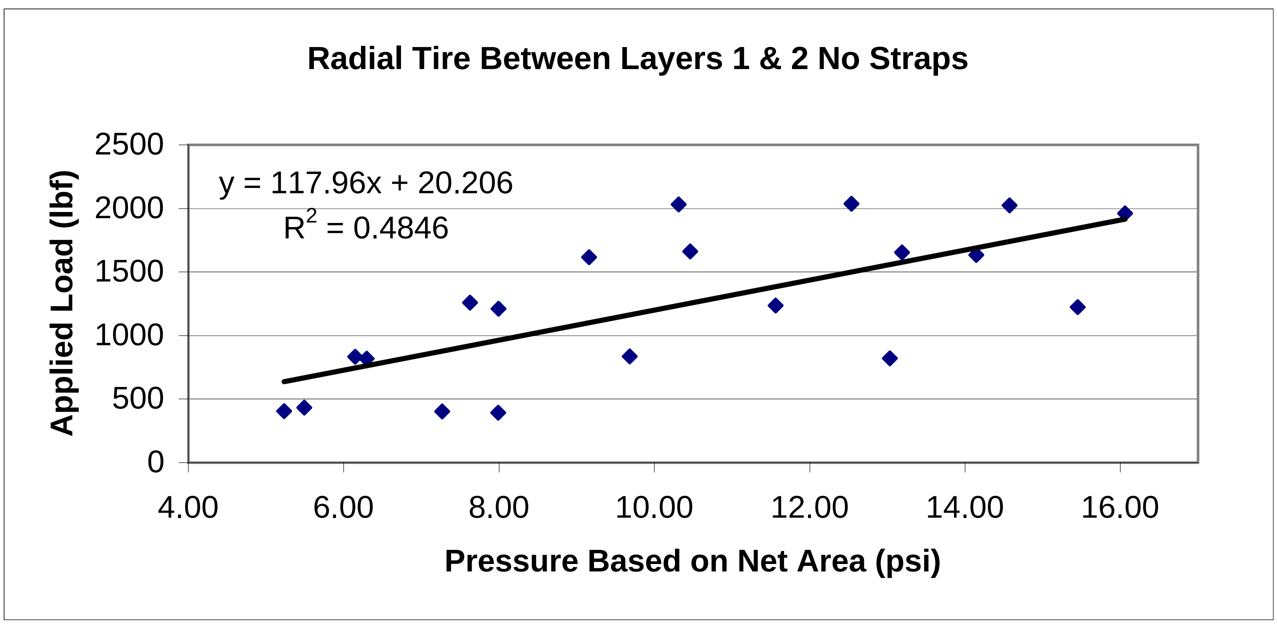
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in2)	Averaging Gross Area (in2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2023		15085	483.03	14731	473.51	25.46	33.15	18.60	14.57
1654		12698	406.60	12347	396.88	23.04	30.83	17.23	13.19
1237		9927	317.87	9607	308.81	20.57	27.49	15.01	11.56
835		6983	223.60	6676	214.59	17.57	23.09	12.21	9.68
404		4220	135.13	3946	126.84	14.47	18.59	8.77	7.27
27		1479	47.36	1224	39.34	8.95	13.6	4.40	3.48

TEST 8





Radial Tire Between Layers 1 & 2 No Straps
y = 97.839x - 23.526
R2 = 0.6037
Applied Load (lbf)
2500
2000
1500
1000
500
0
0.00
5.00
10.00
15.00
20.00
25.00
Pressure Based on Net Area (psi)

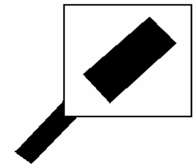


Radial Tire Between Layers 1 & 2 No Straps
y = 117.96x + 20.206
R2 = 0.4846
Applied Load (lbf)
2500
2000
1500
1000
500
0
4.00
6.00
8.00
10.00
12.00
14.00
16.00
Pressure Based on Net Area (psi)

Tekscan Pressure Test in Asphalt Structure

TEST 9

CALIBRATIONS -- Bias Ply Tire



Date: 9/22/2006
Room: 16
Setup: Tire with Loading Apparatus (49.5 lb according to 077 scales)

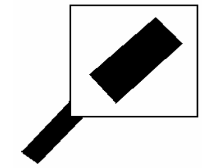
Position: Completely on the Sensor
Sensor: 5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1518	1567.5	45836	29.24	45720	29.17	38.48	47.43	40.74	33.05
1514	1563.5	46125	29.50	46013	29.43	38.67	46.03	40.43	33.97
1230	1279.5	38822	30.34	38731	30.27	34.90	41.14	36.66	31.10
1221	1270.5	38105	29.99	37990	29.90	34.75	39.69	36.56	32.01
839	888.5	27166	30.58	27060	30.46	28.31	33.44	31.38	26.57
815	864.5	27097	31.34	26992	31.22	28.12	31.85	30.74	27.14
433	482.5	15037	31.16	14945	30.97	17.71	21.10	27.24	22.87
413	462.5	14208	30.72	14117	30.52	16.84	20.13	27.46	22.98
78	127.5	4525	35.49	4471	35.07	6.63	8.86	19.23	14.39
39	88.5	3310	37.40	3252	36.75	5.47	6.49	16.18	13.64
			30.36		**30.24**				

Position: Completely on the Sensor
Sensor: 5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1719	1768.5	48891	27.65	48743	27.56	40.95	47.43	43.19	37.29
1606	1655.5	47268	28.55	47128	28.47	40.27	46.03	41.11	35.97
1242	1291.5	38736	29.99	38611	29.90	35.57	41.14	36.31	31.39
1165	1214.5	36683	30.20	36560	30.10	34.94	39.69	34.76	30.60
833	882.5	26706	30.26	26598	30.14	28.31	33.44	31.17	26.39
786	835.5	25787	30.86	25670	30.72	27.01	31.85	30.93	26.23
415	464.5	13774	29.65	13683	29.46	17.67	21.10	26.29	22.01
397	446.5	13927	31.19	13836	30.99	16.75	20.13	26.66	22.18
66	115.5	3909	33.84	3860	33.42	6.10	8.86	18.93	13.04
14	63.5	2491	39.23	2447	38.54	4.40	6.49	14.43	9.78
			32.13		**30.93**				

TEST 9



Position: **Completely on the Sensor**
Sensor: 5250-7

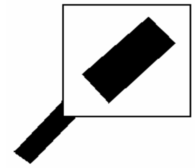
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**

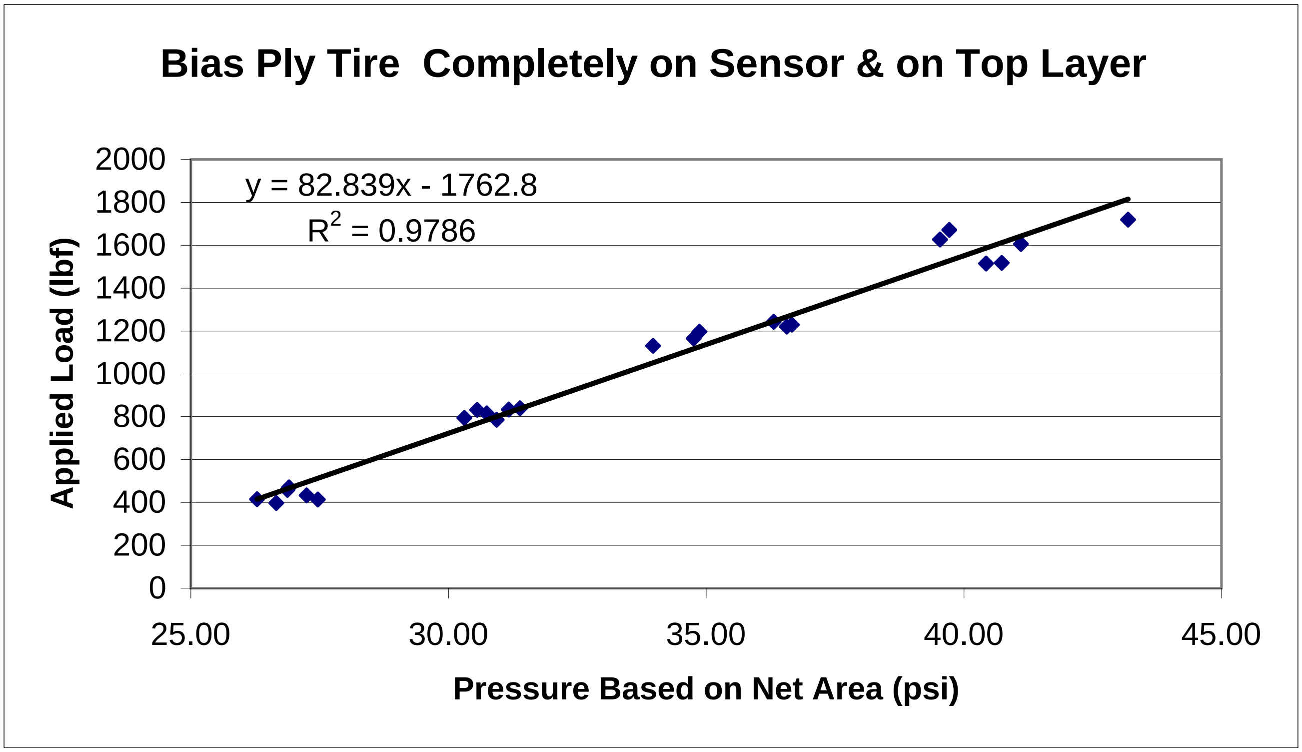
SENSOR DAMAGED

Position: **Completely on the Sensor**
Sensor: 5250-8

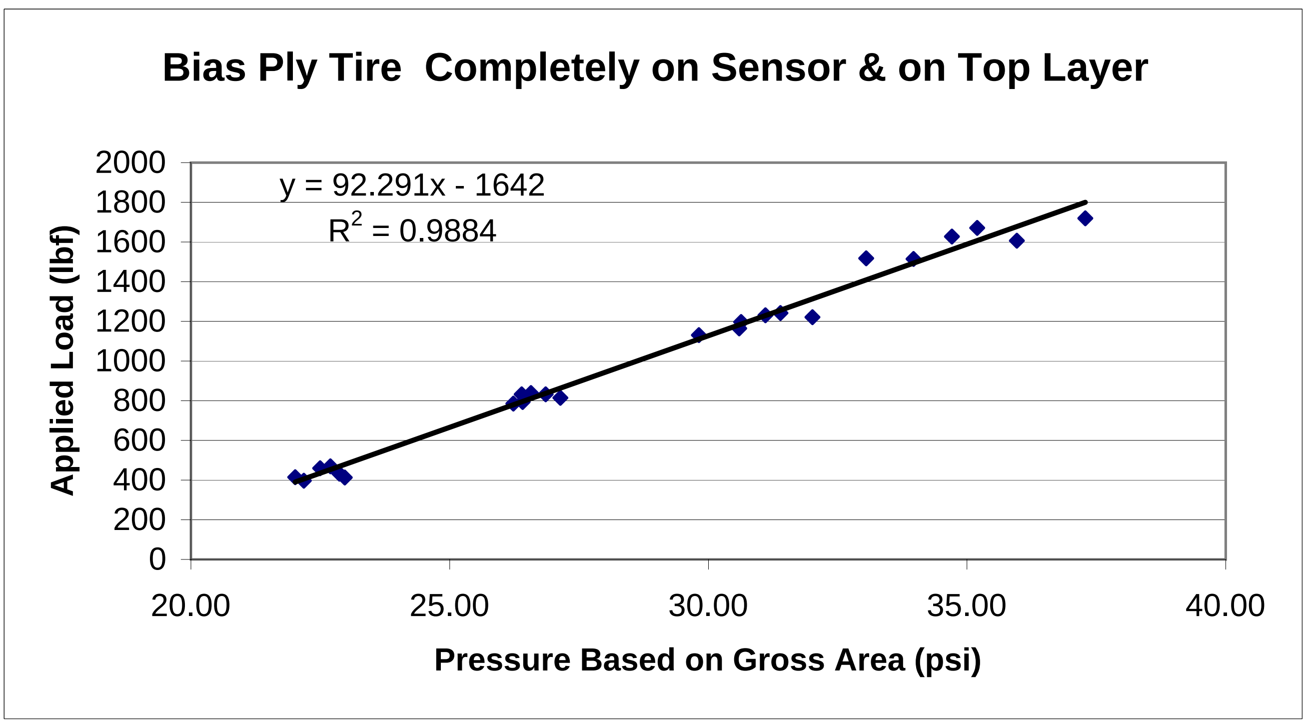
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1671	1720.5	55801	32.43	55667	32.36	43.32	48.88	39.72	35.20
1627	1676.5	54126	32.29	53996	32.21	42.40	48.30	39.54	34.71
1196	1245.5	42024	33.74	41882	33.63	35.72	40.66	34.87	30.63
1131	1180.5	40190	34.04	40047	33.92	34.75	39.59	33.97	29.82
832	881.5	30830	34.97	30698	34.82	28.85	32.82	30.55	26.86
794	843.5	29331	34.77	29198	34.62	27.83	31.94	30.31	26.41
470	519.5	18723	36.04	18601	35.81	19.31	22.89	26.90	22.70
459	508.5	18650	36.68	18540	36.46	18.92	22.60	26.88	22.50
45	94.5	4088	43.26	4027	42.61	6.92	8.95	13.66	10.56
43	92.5	4107	44.40	4047	43.75	6.15	8.81	15.04	10.50
			36.26		**36.02**				

TEST 9



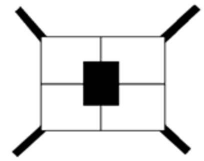


Bias Ply Tire Completely on Sensor & on Top Layer
y = 82.839x - 1762.8
R2 = 0.9786
Applied Load (lbf)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
25.00
30.00
35.00
40.00
45.00
Pressure Based on Net Area (psi)



Bias Ply Tire Completely on Sensor & on Top Layer
y = 92.291x - 1642
R2 = 0.9884
Applied Load (lbf)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
20.00
25.00
30.00
35.00
40.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure ***TEST 10***



Date: 9/22/2006
Room: 16
Setup: Tire with Loading Apparatus (49.5 lb according to 077 scales)

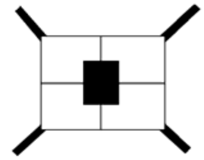
Position: Top Layer
5250-5

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2007		16254	514.69	16171	515.33	14.71	15.97	35.03	32.23
1945		15777	499.59	15679	499.65	14.62	15.68	34.18	31.86
1640		13358	422.99	13278	423.14	12.73	13.94	33.24	30.34
1617		13129	415.74	13054	416.00	12.63	14.13	32.94	29.42
1227		9928	314.38	9850	313.89	10.02	11.28	31.33	27.87
1212		9859	312.19	9792	312.05	9.97	11.18	31.30	27.92
831		6865	217.38	6812	217.08	7.55	8.42	28.75	25.82
779		6385	202.18	6327	201.63	7.11	7.74	28.36	26.12
387		2987	94.59	2954	94.14	4.36	5.03	21.59	18.80
377		2958	93.67	2923	93.15	4.36	4.99	21.36	18.77
21		12	0.38	0	0.00	0.15	0.00	0.00	0.00
14		0	0.00	0	0.00	0	0.00	0.00	0.00

Position: Top Layer
5250-6

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2006		14871	477.55	14786	478.05	10.31	11.37	46.37	42.00
1947		14880	477.84	14771	477.56	10.41	11.28	45.88	42.36
1630		12116	389.08	12024	388.75	9.00	10.07	43.19	38.64
1605		11826	379.77	11740	379.57	8.95	9.97	42.41	38.09
1229		9171	294.51	9075	293.40	7.45	8.42	39.38	34.98
1203		8810	282.92	8713	281.70	7.50	8.23	37.56	34.38
785		5549	178.20	5466	176.72	5.71	6.34	30.95	28.11
771		5383	172.86	5288	170.97	5.32	6.05	32.14	28.57
409		2501	80.31	2435	78.73	2.81	3.48	28.02	23.08
390		2432	78.10	2357	76.20	2.71	3.48	28.12	22.44
19		136	4.37	116	3.75	0.29	0.73	12.93	5.98
7		87	2.79	70	2.26	0.29	0.68	7.80	4.11

TEST 10



Position: 5250-7 Top Layer

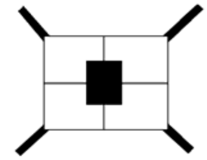
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**

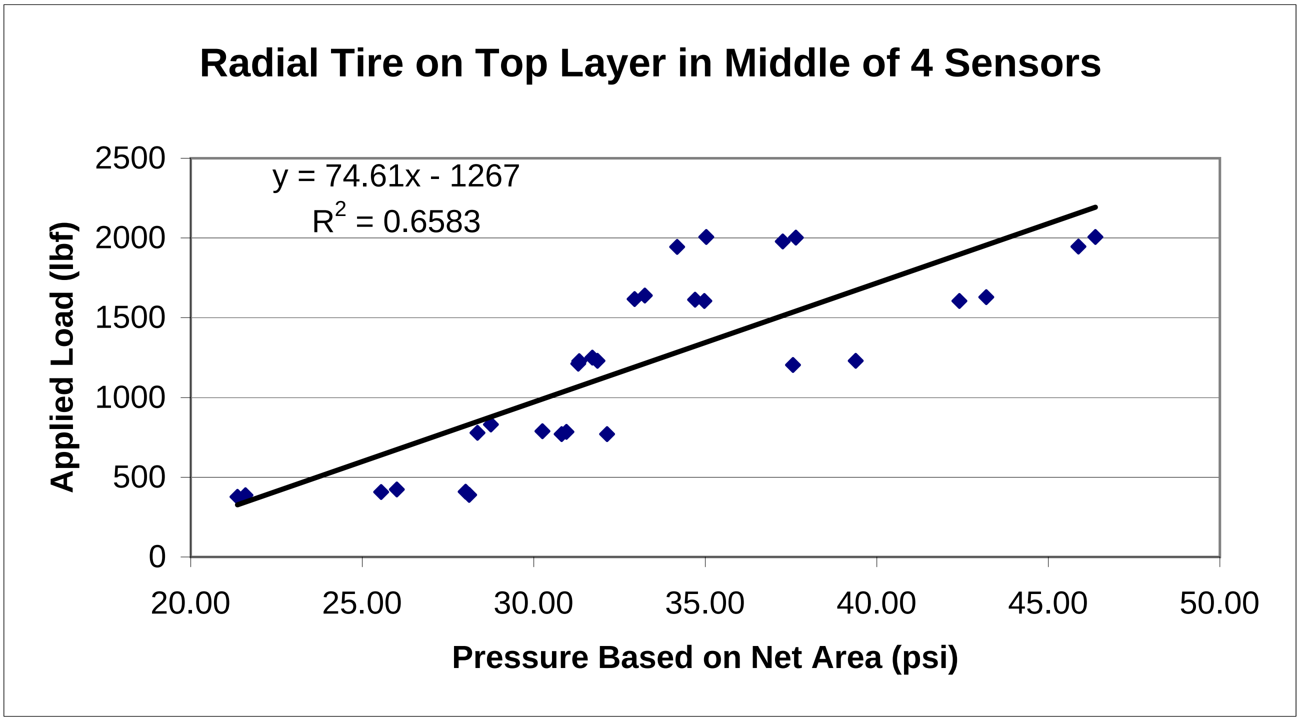
SENSOR DAMAGED

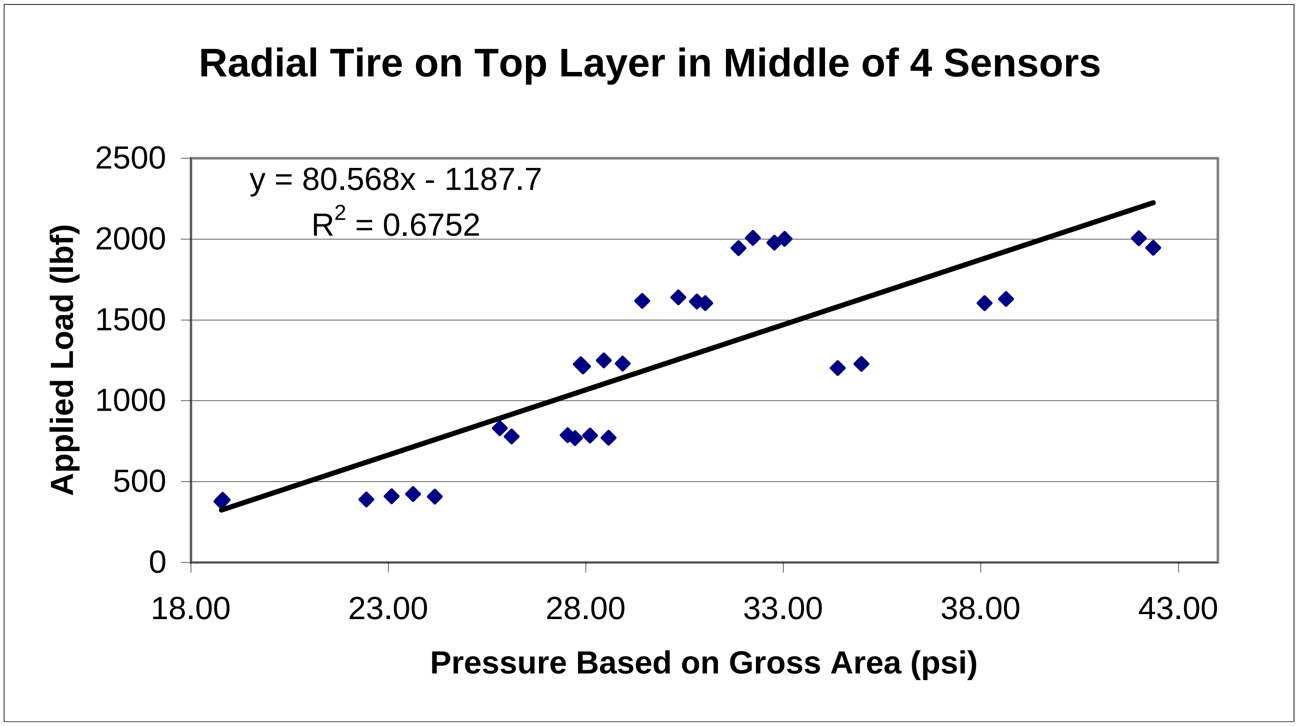
Position: 5250-8 Top Layer

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2002		22087	609.13	21975	610.08	16.21	18.44	37.64	33.03
1978		21912	604.30	21822	605.83	16.26	18.44	37.26	32.77
1613		18926	521.95	18810	522.21	15.05	16.94	34.70	30.81
1605		18783	518.01	18654	517.88	14.81	16.7	34.97	31.02
1250		15876	437.84	15751	437.28	13.79	15.39	31.71	28.45
1230		15587	429.87	15447	428.85	13.46	14.86	31.86	28.93
788		12032	331.83	11922	330.98	10.94	12.05	30.25	27.54
770		11772	324.66	11652	323.49	10.5	11.71	30.81	27.72
424		8291	228.65	8158	226.49	8.71	9.68	26.00	23.62
408		8100	223.39	7971	221.29	8.66	9.24	25.55	24.18
24		3035	83.70	2985	82.87	4.16	4.99	19.92	16.77
14		2799	77.19	2750	76.35	4.07	4.84	18.76	15.95

TEST 10



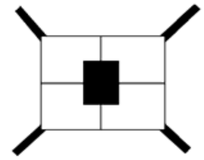

Radial Tire on Top Layer in Middle of 4 Sensors
y = 74.61x - 1267
R^2 = 0.6583
Applied Load (lbf)
2500
2000
1500
1000
500
0
20.00
25.00
30.00
35.00
40.00
45.00
50.00
Pressure Based on Net Area (psi)


Radial Tire on Top Layer in Middle of 4 Sensors
y = 80.568x - 1187.7
R^2 = 0.6752
Applied Load (lbf)
2500
2000
1500
1000
500
0
18.00
23.00
28.00
33.00
38.00
43.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure

WITH STRAPS

TEST 11



Date: 9/19/2006
Room: 16
Setup: Tire with Loading Apparatus (49.5 lb according to 077 scales)

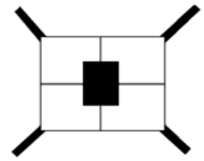
Position: Between 1&2 Layer
5250-5

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2006		13353	422.83	12956	412.87	23.43	36.64	18.05	11.27
1995		13203	418.08	12838	409.11	22.84	34.94	18.30	11.71
1658		11417	361.53	11054	352.26	21.10	32.62	17.13	10.80
1630		11469	363.17	11120	354.37	21.05	31.65	17.25	11.20
1244		9294	294.30	8929	284.54	19.65	28.94	14.98	9.83
1206		9160	290.06	8845	281.87	18.78	28.17	15.44	10.01
818		7105	224.98	6775	215.90	17.47	26.09	12.88	8.28
811		7111	225.17	6830	217.65	16.99	25.17	13.25	8.65
391		4578	144.97	4372	139.32	14.57	23.09	9.95	6.03
380		4570	144.71	4297	136.93	14.76	23.04	9.80	5.94
41		2071	65.58	1859	59.24	9.97	17.23	6.58	3.44
25		1554	49.21	1377	43.88	8.42	15.39	5.84	2.85

Position: Between 1&2 Layer
5250-6

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2004		11607	372.74	11346	366.83	16.41	26.43	22.71	13.88
2001		11489	368.95	11205	362.27	16.79	27.15	21.97	13.34
1643		9816	315.22	9542	308.50	16.26	25.75	19.39	11.98
1622		10069	323.35	9824	317.62	15.83	24.64	20.43	12.89
1232		7731	248.27	7473	241.61	14.86	23.43	16.71	10.31
1217		7817	251.03	7589	245.36	14.13	21.88	17.77	11.21
827		5774	185.42	5565	179.92	12.58	19.65	14.74	9.16
825		5520	177.26	5303	171.45	13.21	21.59	13.42	7.94
447		3473	111.53	3254	105.21	11.08	18.30	10.07	5.75
405		3575	114.80	3386	109.47	10.74	16.79	10.69	6.52
14		1066	34.23	924	29.87	6.49	11.23	5.27	2.66
13		971	31.18	758	24.51	5.61	10.12	5.56	2.42

TEST 11



Position: Between 1&2 Layer
5250-7

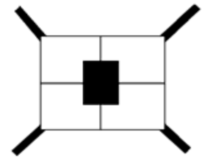
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)

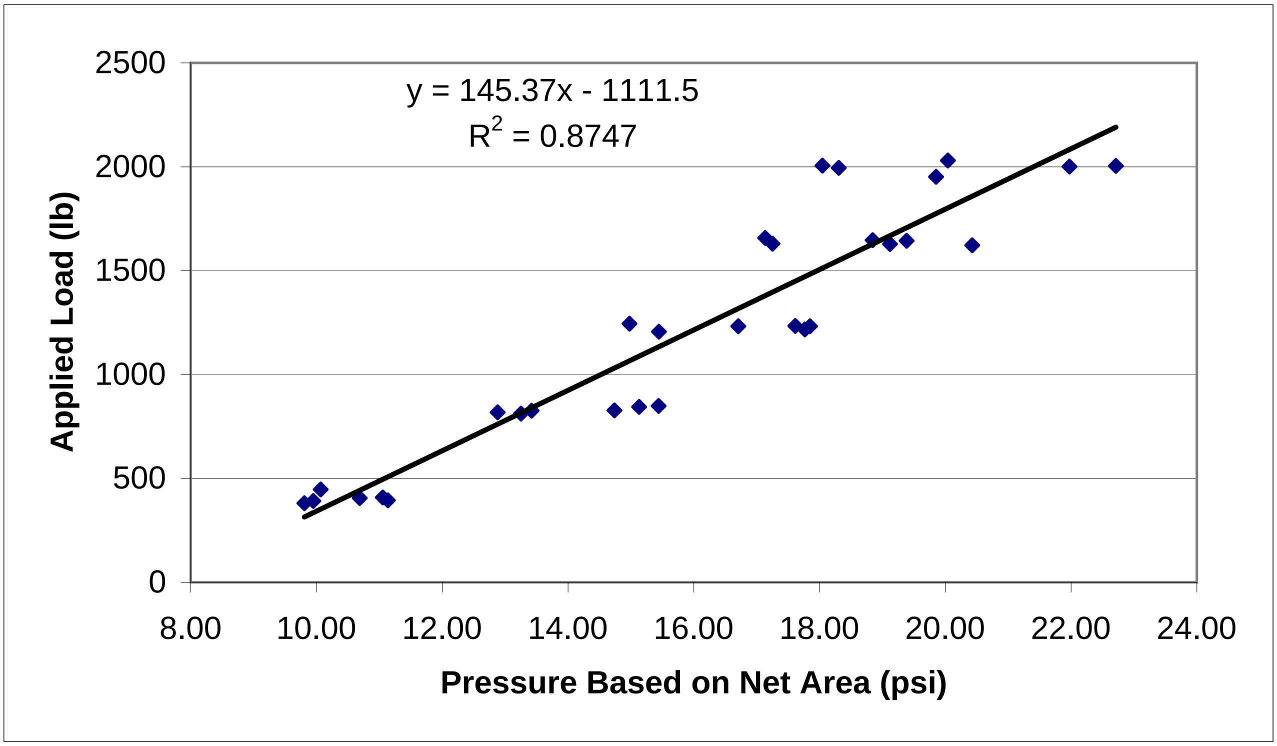
SENSOR DAMAGED

Position: Between 1&2 Layer
5250-8

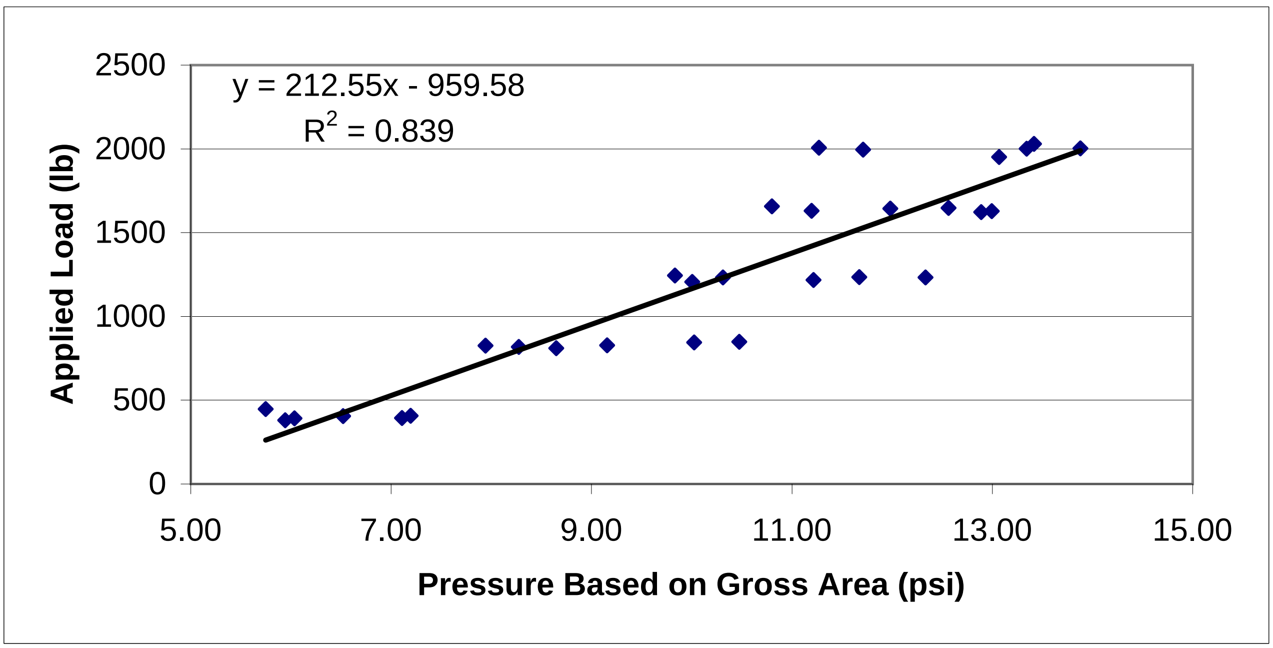
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2030		19169	528.65	18662	518.10	26.38	38.62	20.04	13.42
1951		18637	513.98	18113	502.86	25.89	38.48	19.85	13.07
1647		16668	459.68	16164	448.75	24.39	35.72	18.85	12.56
1628		16708	460.78	16217	450.22	24.10	34.65	19.12	12.99
1234		13725	378.52	13326	369.96	21.49	31.70	17.61	11.67
1233		13996	385.99	13590	377.29	21.63	30.59	17.85	12.33
849		10975	302.68	10648	295.61	19.60	28.22	15.44	10.48
844		10779	297.27	10448	290.06	19.65	28.94	15.13	10.02
408		6885	189.88	6597	183.15	17.18	25.46	11.05	7.19
394		6917	190.76	6617	183.70	17.13	25.85	11.14	7.11
29		2257	62.24	2101	58.33	11.91	20.28	5.23	2.88
17		2107	58.11	1913	53.11	11.13	19.94	5.22	2.66

TEST 11





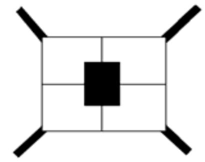
y = 145.37x - 1111.5
R^2 = 0.8747
Applied Load (lb)
Pressure Based on Net Area (psi)



y = 212.55x - 959.58
R^2 = 0.839
Applied Load (lb)
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure ***TEST 12***

NO STRAPS



Date: 9/19/2006
Room: 16
Setup: Tire with Loading Apparatus (49.5 lb according to 077 scales)

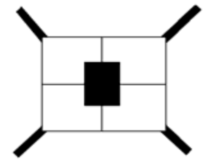
Position: Between 1&2 Layer
5250-5

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2000		13417	424.86	13075	416.67	18.25	22.51	23.28	18.51
1953		13512	427.87	13165	419.53	18.30	22.51	23.38	18.64
1671		11750	372.07	11430	364.24	16.84	19.75	22.09	18.44
1634		11934	377.90	11592	369.41	17.13	19.99	22.06	18.48
1236		9514	301.27	9278	295.67	14.91	17.67	20.21	16.73
1223		9812	310.70	9547	304.24	15.83	18.88	19.63	16.11
806		7540	238.76	7315	233.11	14.13	17.28	16.90	13.49
776		7072	223.94	6891	219.60	13.50	16.65	16.59	13.19
428		5066	160.42	4906	156.34	12.39	15.97	12.95	9.79
394		4797	151.90	4633	147.64	12.49	16.02	12.16	9.22
51		1697	53.74	1492	47.55	8.86	11.66	6.07	4.08
36		1506	47.69	1333	42.48	7.41	11.23	6.44	3.78

Position: Between 1&2 Layer
5250-6

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2017		10625	341.20	10403	336.34	15.34	21.44	22.24	15.69
2003		10630	341.36	10390	335.92	15.20	20.96	22.46	16.03
1651		8888	285.42	8677	280.54	14.37	19.75	19.86	14.20
1626		9095	292.07	8900	287.75	14.86	21.34	19.65	13.48
1222		6971	223.86	6805	220.01	13.07	18.34	17.13	12.00
1221		6755	216.92	6552	211.83	13.12	18.54	16.53	11.43
819		4645	149.17	4466	144.39	12.10	17.52	12.33	8.24
789		4806	154.34	4635	149.85	11.28	16.31	13.68	9.19
437		3043	97.72	2872	92.85	9.78	13.79	9.99	6.73
392		2532	81.31	2332	75.40	9.97	15.20	8.16	4.96
34		812	26.08	630	20.37	5.47	8.52	4.77	2.39
13		606	19.46	406	13.13	4.26	6.87	4.57	1.91

TEST 12



Position: Between 1&2 Layer
5250-7

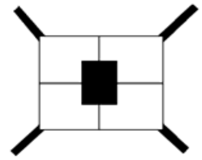
A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)

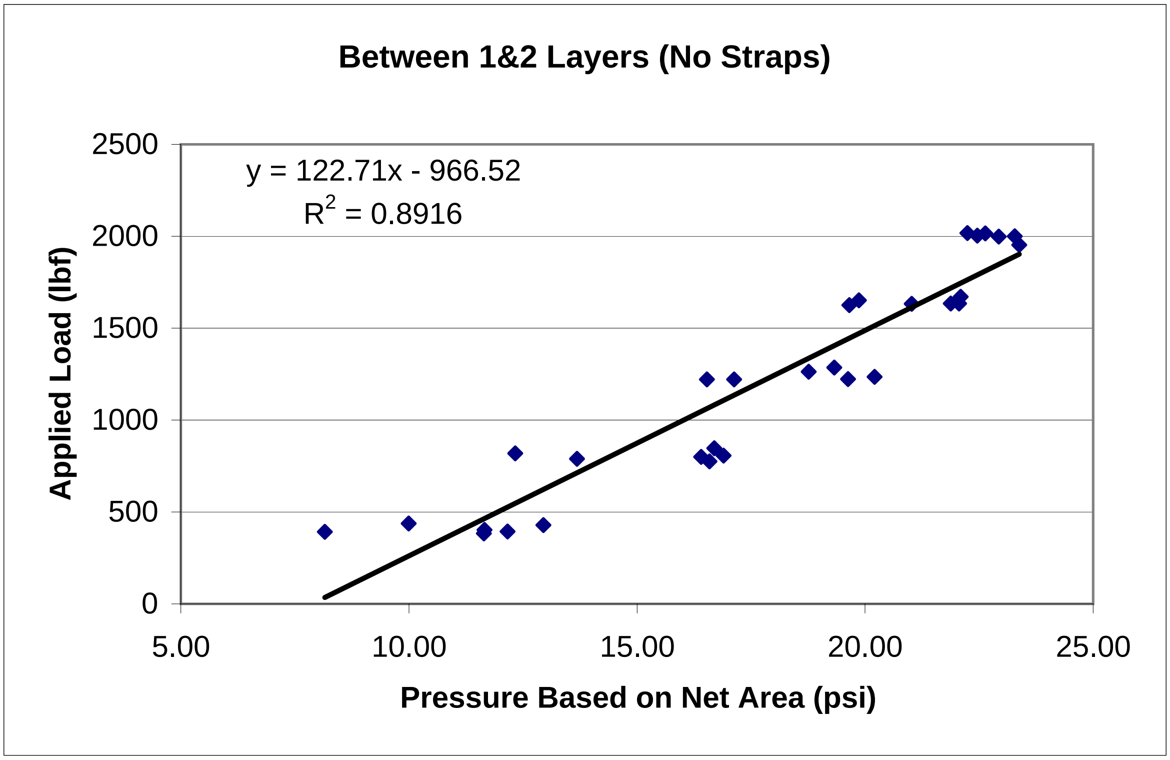
SENSOR DAMAGED

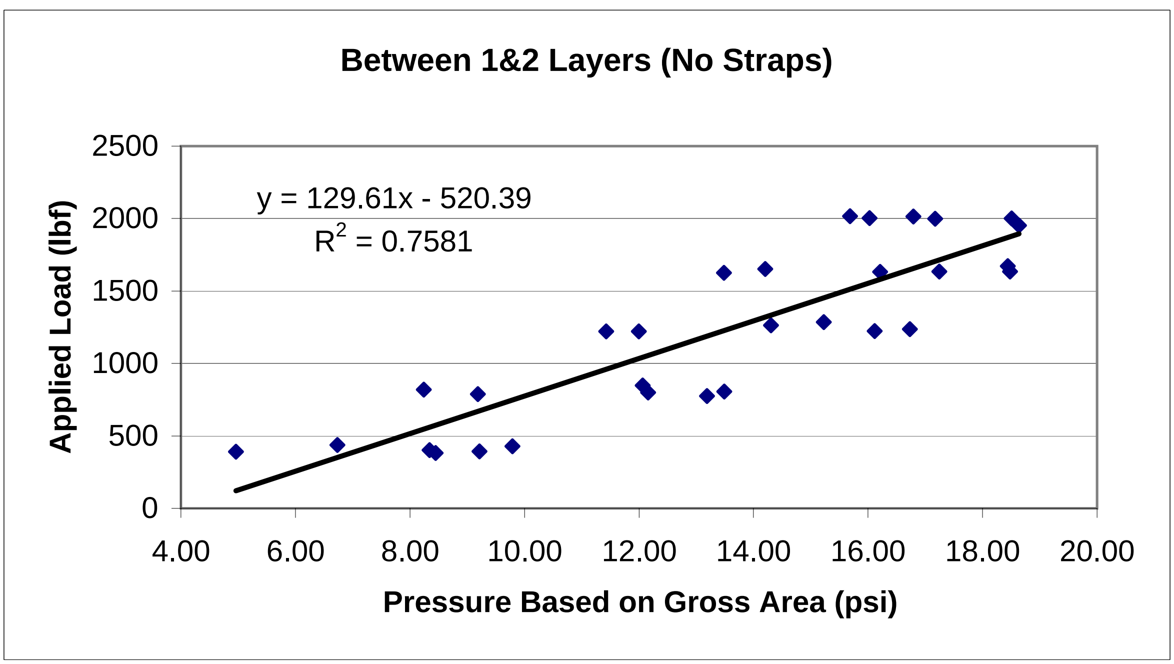
Position: Between 1&2 Layer
5250-8

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2015		15809	435.99	15253	423.46	19.26	25.22	22.64	16.79
1999		16096	443.91	15537	431.34	19.36	25.12	22.93	17.17
1635		14318	394.87	13800	383.12	18.05	22.22	21.88	17.24
1632		13834	381.52	13315	369.66	18.15	22.80	21.02	16.21
1285		12144	334.91	11704	324.93	17.33	21.34	19.33	15.23
1263		11560	318.81	11124	308.83	16.99	21.59	18.76	14.30
847		8903	245.53	8559	237.62	14.71	19.70	16.69	12.06
799		8870	244.62	8545	237.23	14.91	19.51	16.41	12.16
402		5647	155.74	5367	149.00	13.36	17.86	11.66	8.34
383		5456	150.47	5187	144.00	12.92	17.04	11.65	8.45
31		1629	44.93	1444	40.09	8.81	13.41	5.10	2.99
18		1464	40.38	1289	35.79	8.52	13.50	4.74	2.65

TEST 12

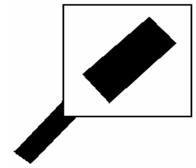



Between 1&2 Layers (No Straps)
y = 122.71x - 966.52
R^2 = 0.8916
Applied Load (lbf)
2500
2000
1500
1000
500
0
5.00
10.00
15.00
20.00
25.00
Pressure Based on Net Area (psi)


Between 1&2 Layers (No Straps)
y = 129.61x - 520.39
R^2 = 0.7581
Applied Load (lbf)
2500
2000
1500
1000
500
0
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure

TEST 13
CALIBRATIONS FOR TEST 14-16



Date: 10/5/2006
Room: 16
Setup: Tire with Loading Apparatus (49.5 lb according to 077 scales)

Sensor: 5250-5
FROM RADIAL CALIBRATION 9-19-06

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Calibration Factor (Based on Net Area) (Raw/lb)	E Averagng Tekscan Raw Sum (Gross Area)	F Calibration Factor (Based on Gross Area) (Raw/lb)	G Default Net Area (in2)	H Averaging Gross Area (in2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1995	2044.1	53463	26.15	53335	26.09	47.82	57.64	42.75	35.46
1977	2026.1	52923	26.12	52792	26.06	47.63	57.45	42.54	35.27
1627	1676.1	47807	28.52	47686	28.45	44.43	54.06	37.72	31.00
1612	1661.1	47311	28.48	47176	28.40	44.38	53.87	37.43	30.84
1247	1296.1	39862	30.76	39753	30.67	39.16	48.59	33.10	26.67
1217	1266.1	38770	30.62	38645	30.52	38.91	47.92	32.54	26.42
801	850.1	27113	31.89	27017	31.78	30.73	39.11	27.66	21.74
786	835.1	26218	31.40	26118	31.28	30.30	28.77	27.56	29.03
418	467.1	14747	31.57	14631	31.32	19.46	26.77	24.00	17.45
410	459.1	14295	31.14	14191	30.91	18.39	26.18	24.96	17.54
47	96.1	3875	40.32	3826	39.81	5.90	9.10	16.29	10.56
22	71.1	3050	42.90	2996	42.14	4.74	7.31	15.00	9.73
			29.67		**29.55**				

Sensor: 5250-5
FROM BIAS PLY CALIBRATION 9-22-06

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Calibration Factor (Based on Net Area) (Raw/lb)	E Averagng Tekscan Raw Sum (Gross Area)	F Calibration Factor (Based on Gross Area) (Raw/lb)	G Default Net Area (in2)	H Averaging Gross Area (in2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
1518	1567.5	45836	29.24	45720	29.17	38.48	47.43	40.74	33.05
1514	1563.5	46125	29.50	46013	29.43	38.67	46.03	40.43	33.97
1230	1279.5	38822	30.34	38731	30.27	34.90	41.14	36.66	31.10
1221	1270.5	38105	29.99	37990	29.90	34.75	39.69	36.56	32.01
839	888.5	27166	30.58	27060	30.46	28.31	33.44	31.38	26.57
815	864.5	27097	31.34	26992	31.22	28.12	31.85	30.74	27.14
433	482.5	15037	31.16	14945	30.97	17.71	21.10	27.24	22.87
413	462.5	14208	30.72	14117	30.52	16.84	20.13	27.46	22.98
78	127.5	4525	35.49	4471	35.07	6.63	8.86	19.23	14.39
39	88.5	3310	37.40	3252	36.75	5.47	6.49	16.18	13.64
			30.36		**30.24**				

WE WILL USE AN AVERAGE CALIBRATION FACTOR OF 0.25* (29.67+29.55+30.36+30.24) = 29.954

Sensor: 5250-6

FROM RADIAL CALIBRATION 9-19-06

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1975	2024.1	55976	27.65	55842	27.59	49.17	59.39	41.17	34.08
1957	2006.1	56228	28.03	56098	27.96	49.51	59.53	40.52	33.70
1633	1682.1	48145	28.62	48008	28.54	45.11	55.13	37.29	30.51
1608	1657.1	48328	29.16	48181	29.08	45.30	54.84	36.58	30.22
1249	1298.1	38545	29.69	38422	29.60	40.32	49.03	32.19	26.48
1182	1231.1	35627	28.94	35504	28.84	38.19	46.95	32.24	26.22
867	916.1	26988	29.46	26873	29.33	32.62	40.90	28.08	22.40
825	874.1	25110	28.73	25016	28.62	30.44	39.06	28.72	22.38
405	454.1	13220	29.11	13128	28.91	17.57	24.44	25.85	18.58
396	445.1	13275	29.82	13219	29.70	17.81	25.36	24.99	17.55
44	93.1	3096	33.25	3020	32.44	6.44	10.84	14.46	8.59
4	53.1	1904	35.86	1842	34.69	4.84	8.08	10.97	6.57
			28.92		**28.82**				

Sensor: 5250-6

FROM BIAS PLY CALIBRATION 9-22-06

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1719	1768.5	48891	27.65	48743	27.56	40.95	47.43	43.19	37.29
1606	1655.5	47268	28.55	47128	28.47	40.27	46.03	41.11	35.97
1242	1291.5	38736	29.99	38611	29.90	35.57	41.14	36.31	31.39
1165	1214.5	36683	30.20	36560	30.10	34.94	39.69	34.76	30.60
833	882.5	26706	30.26	26598	30.14	28.31	33.44	31.17	26.39
786	835.5	25787	30.86	25670	30.72	27.01	31.85	30.93	26.23
415	464.5	13774	29.65	13683	29.46	17.67	21.10	26.29	22.01
397	446.5	13927	31.19	13836	30.99	16.75	20.13	26.66	22.18
66	115.5	3909	33.84	3860	33.42	6.10	8.86	18.93	13.04
14	63.5	2491	39.23	2447	38.54	4.40	6.49	14.43	9.78
			29.80		**29.67**				

WE WILL USE AN AVERAGE CALIBRATION FACTOR OF 0.25* (28.92+28.82+29.80+29.67) = 29.30

Sensor: 5250-8

FROM RADIAL CALIBRATION 9-19-06

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2013	2062.1	61666	29.90	61503	29.83	52.32	63.84	39.41	32.30
2000	2049.1	60842	29.69	60682	29.61	52.03	63.60	39.38	32.22
1687	1736.1	54008	31.11	53859	31.02	48.84	60.02	35.55	28.93
1582	1631.1	50667	31.06	50542	30.99	46.85	58.52	34.82	27.87
1224	1273.1	40607	31.90	40468	31.79	39.59	49.71	32.16	25.61
1215	1264.1	40206	31.81	40080	31.71	39.40	49.61	32.08	25.48
838	887.1	28318	31.92	28202	31.79	30.69	39.88	28.91	22.24
801	850.1	27381	32.21	27260	32.07	30.06	38.53	28.28	22.06
435	484.1	15189	31.38	15095	31.18	19.80	27.25	24.45	17.77
432	481.1	15073	31.33	14987	31.15	19.75	27.06	24.36	17.78
58	107.1	3597	33.59	3535	33.01	6.78	11.57	15.80	9.26
57	106.1	3652	34.42	3588	33.82	6.68	11.52	15.88	9.21
			31.23		**31.11**				

Sensor: 5250-8

FROM BIAS PLY CALIBRATION 9-22-06

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1671	1720.5	55801	32.43	55667	32.36	43.32	48.88	39.72	35.20
1627	1676.5	54126	32.29	53996	32.21	42.40	48.30	39.54	34.71
1196	1245.5	42024	33.74	41882	33.63	35.72	40.66	34.87	30.63
1131	1180.5	40190	34.04	40047	33.92	34.75	39.59	33.97	29.82
832	881.5	30830	34.97	30698	34.82	28.85	32.82	30.55	26.86
794	843.5	29331	34.77	29198	34.62	27.83	31.94	30.31	26.41
470	519.5	18723	36.04	18601	35.81	19.31	22.89	26.90	22.70
459	508.5	18650	36.68	18540	36.46	18.92	22.60	26.88	22.50
45	94.5	4088	43.26	4027	42.61	6.92	8.95	13.66	10.56
43	92.5	4107	44.40	4047	43.75	6.15	8.81	15.04	10.50
			34.37		**34.23**				

WE WILL USE AN AVERAGE CALIBRATION FACTOR OF 0.25* (231.23+31.11+34.37+34.23) = 32.74

Sensor: 5250-9

FROM RADIAL CALIBRATION 10-5-06

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2000	2049.1	52319	25.53	52229	25.49	48.50	61.86	42.25	33.12
1600	1649.1	44483	26.97	44357	26.90	43.46	56.48	37.95	29.20
1200	1249.1	34129	27.32	34021	27.24	35.19	47.72	35.50	26.18
800	849.1	24487	28.84	24376	28.71	26.33	37.70	32.25	22.52
400	449.1	13478	30.01	13409	29.86	15.44	24.54	29.09	18.30
86	135.1	4040	29.90	3991	29.54	5.61	11.23	24.08	12.03
			27.74		**27.64**				

USE AN AVERAGE CALIBRATION FACTOR OF 0.5*(27.74+27.64) = 27.69

Sensor: 5250-10

FROM RADIAL CALIBRATION 10-5-06

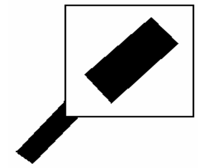
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in2)**	**Averaging Gross Area (in2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2000	2049.1	24134	11.78	24027	11.73	44.33	60.65	46.22	33.79
1600	1649.1	20032	12.15	19919	12.08	38.77	54.69	42.54	30.15
1200	1249.1	15393	12.32	15270	12.22	32.43	46.56	38.52	26.83
800	849.1	9993	11.77	9866	11.62	22.84	34.94	37.18	24.30
400	449.1	5148	11.46	5062	11.27	12.87	21.68	34.90	20.71
67	116.1	1451	12.50	1422	12.25	4.31	9.20	26.94	12.62
			11.90		**11.78**				

USE AN AVERAGE CALIBRATION FACTOR OF 0.5*(11.90+11.78) = 11.84

Tekscan Pressure Test in Asphalt Structure

RADIAL TIRE

TEST 14



Date: 10/5/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Position: Top of Asphalt

5250-10

TEST 14a

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2000		24514	2070.44	24378	2058.95	46.37	62.53	44.40	33.11
1600		18962	1601.52	18826	1590.03	40.17	56.19	39.58	28.50
1200		14590	1232.26	14447	1220.19	32.62	47.63	37.41	25.87
800		9370	791.39	9238	780.24	23.14	35.82	33.72	22.09
400		5050	426.52	4966	419.43	13.07	22.36	32.09	19.08
42		1060	89.53	1004	84.80	3.87	7.6	21.91	11.78

Position: Between 1&2 Layer

5250-9

TEST 14b

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2000		37635	1359.15	37500	1354.28	61.37	90.99	22.07	14.94
1600		33625	1214.34	33438	1207.58	59.73	90.17	20.22	13.47
1200		27896	1007.44	27710	1000.72	55.13	87.6	18.15	11.50
800		20909	755.11	20689	747.17	48.06	83.3	15.55	9.06
400		12780	461.54	12457	449.87	38.72	72.5	11.62	6.37
67		4076	147.20	3615	130.55	20.47	42.79	6.38	3.44

Position: Between 2&3 Layer

5250-8

TEST 14c

A Testing Machine Reading (lbf)	B Adjusted Testing Machine Reading (lbf)	C Default Tekscan Raw Sum (Net Area)	D Load Based on Net Area Calibration Factor (C/c.f.)	E Averagng Tekscan Raw Sum (Gross Area)	F Load Based on Gross Area Calibration Factor (E/c.f.)	G Default Net Area (in^2)	H Averaging Gross Area (in^2)	I Pressure Based on Net Area (psi)	J Pressure Based on Gross Area (psi)
2000		35325	1078.96	35108	1072.33	56	88.67	19.15	12.17
1600		31354	957.67	31136	951.01	53.82	88.04	17.67	10.88
1200		25655	783.60	25433	776.82	51.01	86.54	15.23	9.05
800		17680	540.01	17429	532.35	45.74	82.47	11.64	6.55
400		10654	325.41	10350	316.13	38.09	74.97	8.30	4.34
35		3969	121.23	3442	105.13	22.02	40.95	4.77	2.96

Position: Between 3&4 Layer ***TEST 14d***

5250-6

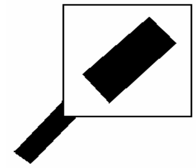
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2000		27436	936.38	27233	929.45	45.21	79.81	20.56	11.73
1600		23786	811.81	23584	804.91	43.12	78.36	18.67	10.36
1200		20472	698.70	20232	690.51	41.72	76.62	16.55	9.12
800		16478	562.39	16500	563.14	40.51	74.58	13.90	7.54
400		10745	366.72	10449	356.62	33.83	67.08	10.54	5.47
40		6079	207.47	5673	193.62	26.23	52.08	7.38	3.98

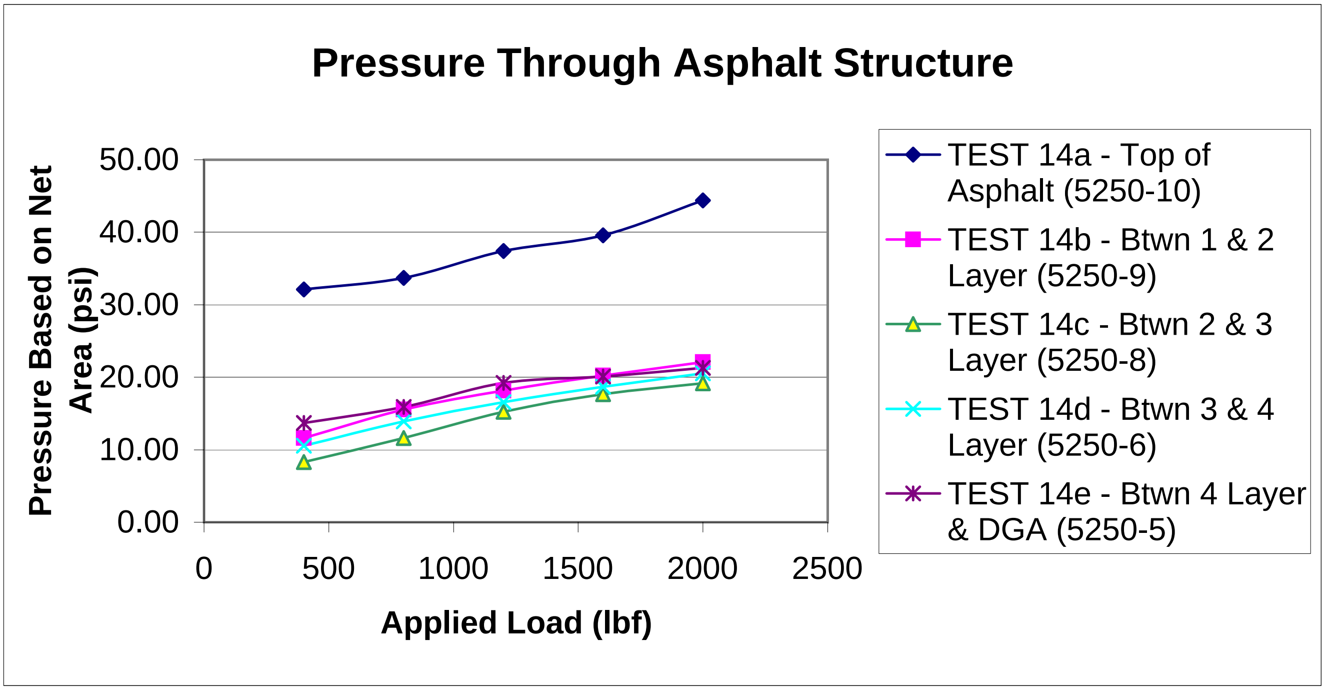
Position: Between 4th Layer and DGA

5250-5 ***TEST 14e***

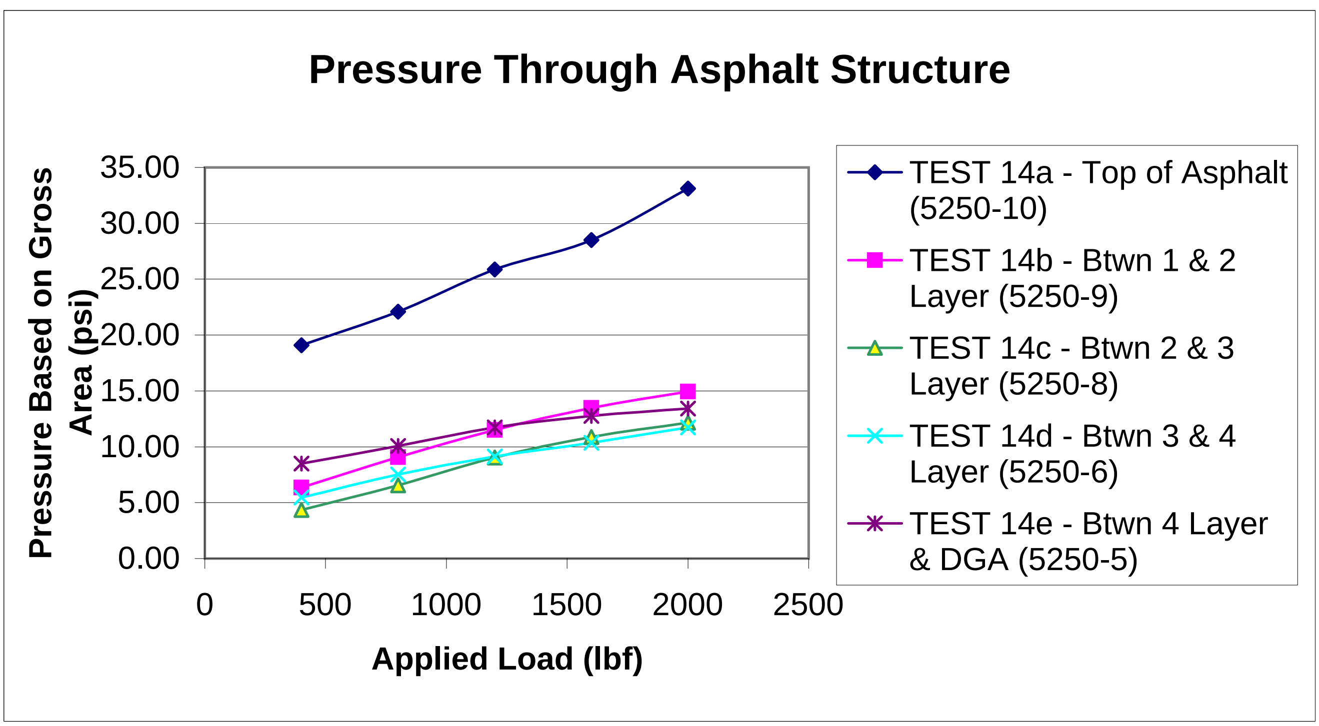
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
2000		26786	894.24	26475	883.86	41.53	66.65	21.28	13.42
1600		25081	837.32	24750	826.27	41.09	65.58	20.11	12.77
1200		21868	730.05	21572	720.17	37.51	62.19	19.20	11.74
800		18386	613.81	18022	601.66	37.85	60.89	15.90	10.08
400		14207	474.29	13860	462.71	33.78	55.85	13.70	8.49
38		9057	302.36	8688	290.04	27.93	48.21	10.38	6.27

TEST 14



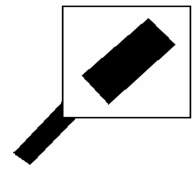


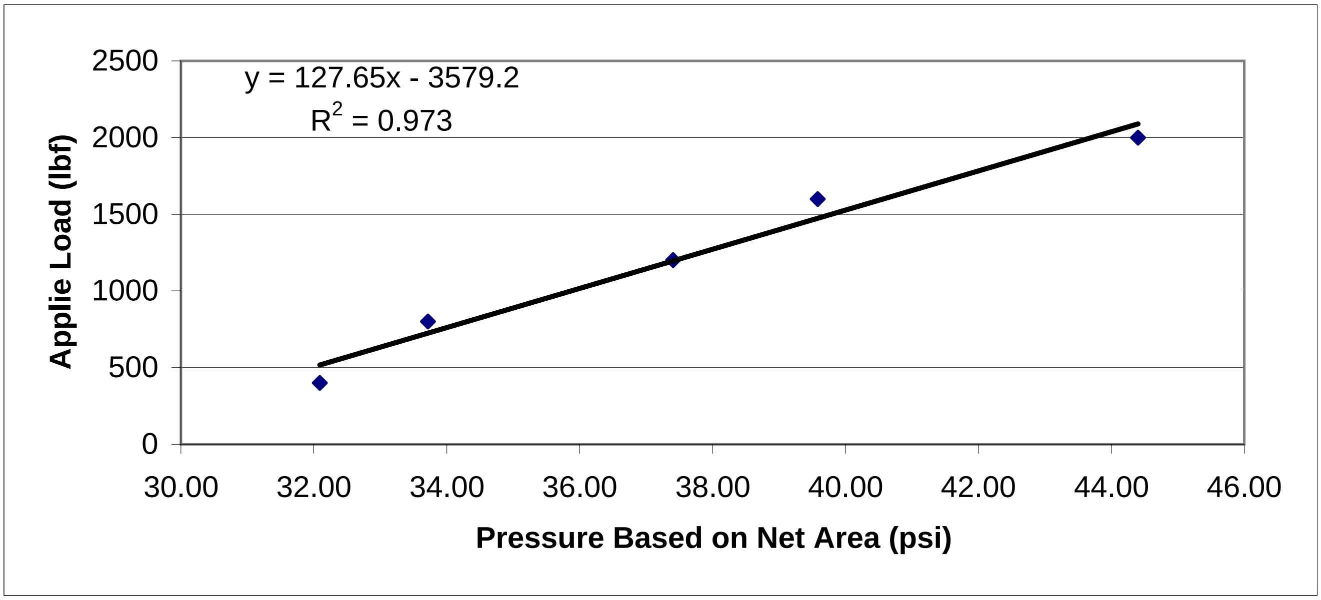
Pressure Through Asphalt Structure
Pressure Based on Net Area (psi)
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 14a - Top of Asphalt (5250-10)
TEST 14b - Btwn 1 & 2 Layer (5250-9)
TEST 14c - Btwn 2 & 3 Layer (5250-8)
TEST 14d - Btwn 3 & 4 Layer (5250-6)
TEST 14e - Btwn 4 Layer & DGA (5250-5)

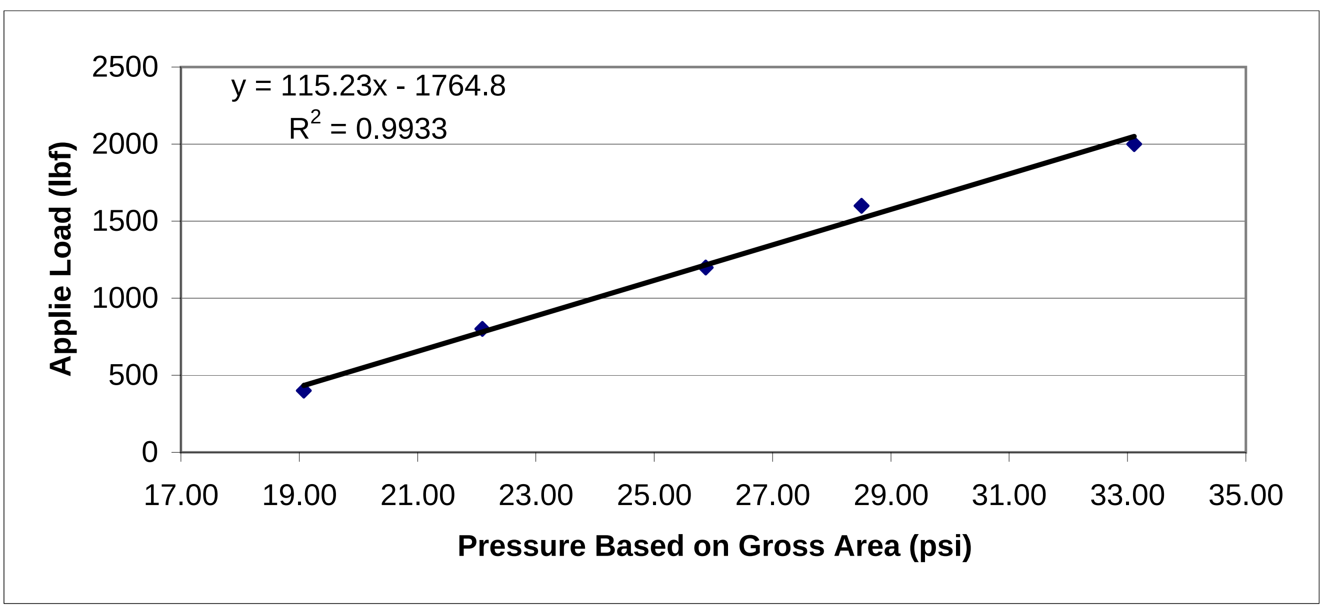


Pressure Through Asphalt Structure
Pressure Based on Gross Area (psi)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 14a - Top of Asphalt (5250-10)
TEST 14b - Btwn 1 & 2 Layer (5250-9)
TEST 14c - Btwn 2 & 3 Layer (5250-8)
TEST 14d - Btwn 3 & 4 Layer (5250-6)
TEST 14e - Btwn 4 Layer & DGA (5250-5)

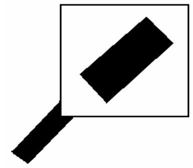
TEST 14a

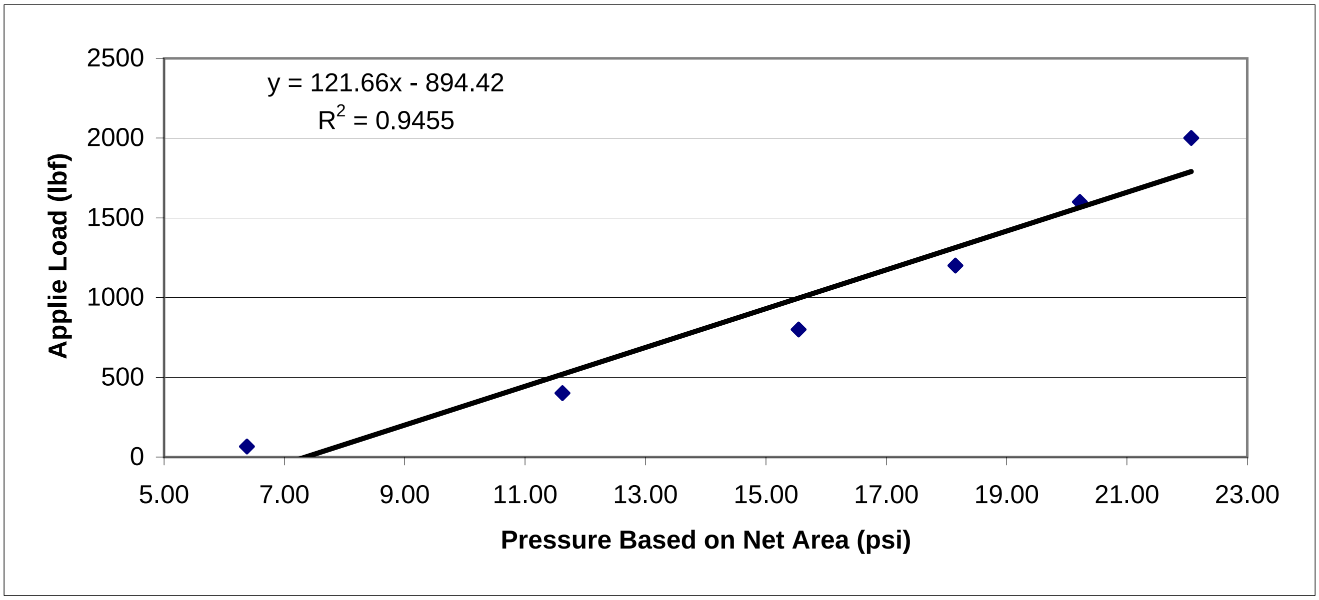



y = 127.65x - 3579.2
R2 = 0.973
Applie Load (lbf)
Pressure Based on Net Area (psi)
2500
2000
1500
1000
500
0
30.00
32.00
34.00
36.00
38.00
40.00
42.00
44.00
46.00

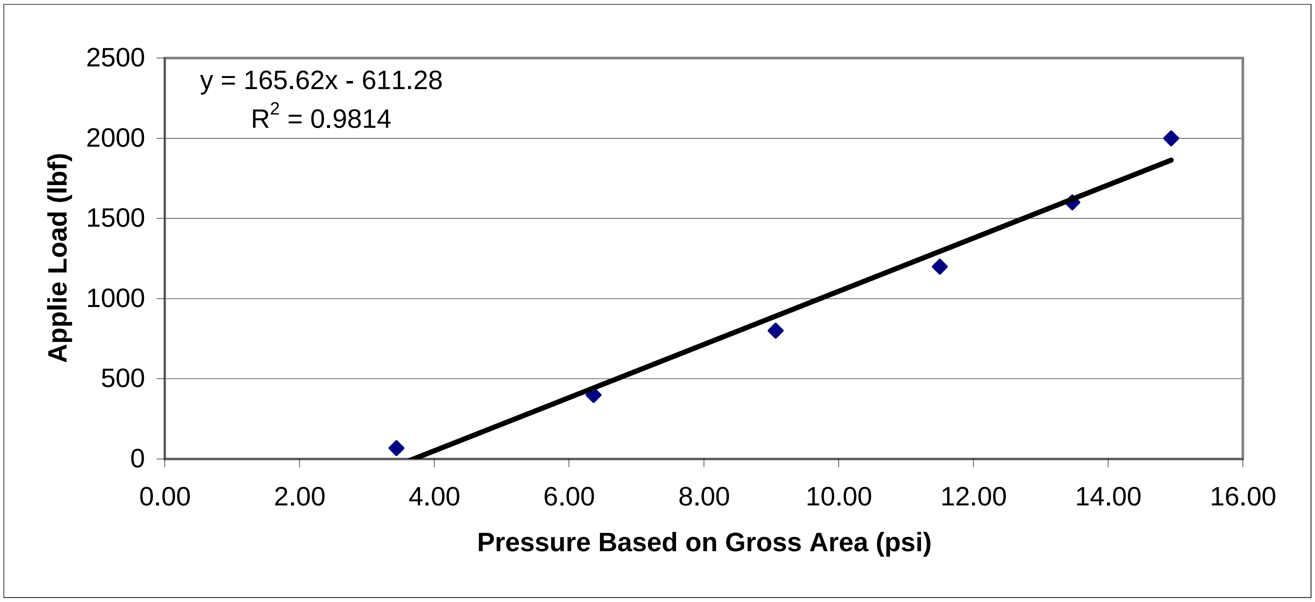

y = 115.23x - 1764.8
R2 = 0.9933
Applie Load (lbf)
Pressure Based on Gross Area (psi)
2500
2000
1500
1000
500
0
17.00
19.00
21.00
23.00
25.00
27.00
29.00
31.00
33.00
35.00

TEST 14b



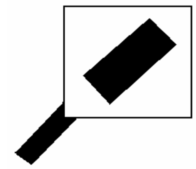


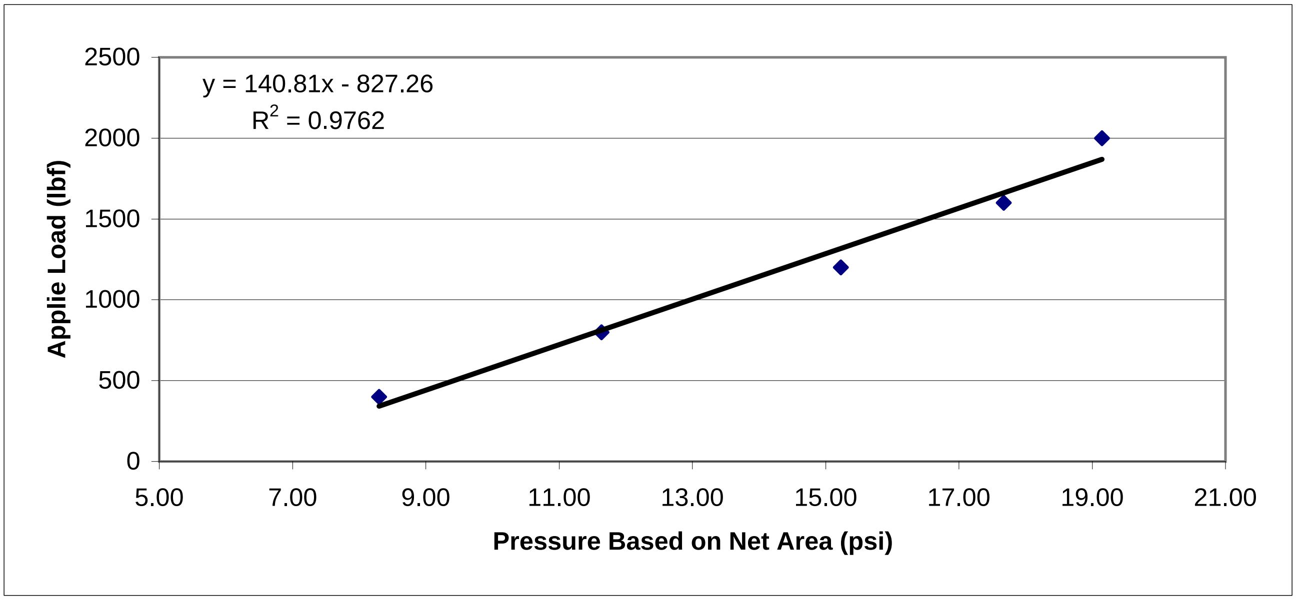
y = 121.66x - 894.42
R^2 = 0.9455
Applie Load (lbf)
2500
2000
1500
1000
500
0
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
Pressure Based on Net Area (psi)



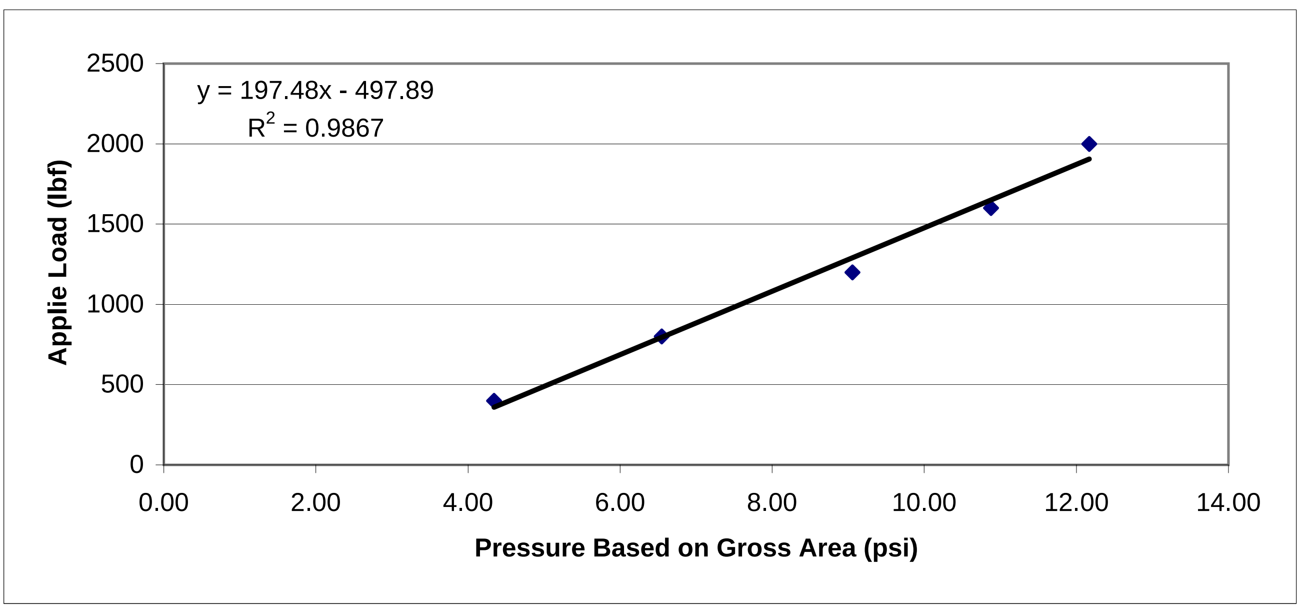
y = 165.62x - 611.28
R^2 = 0.9814
Applie Load (lbf)
2500
2000
1500
1000
500
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
Pressure Based on Gross Area (psi)

TEST 14c



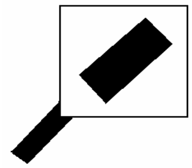


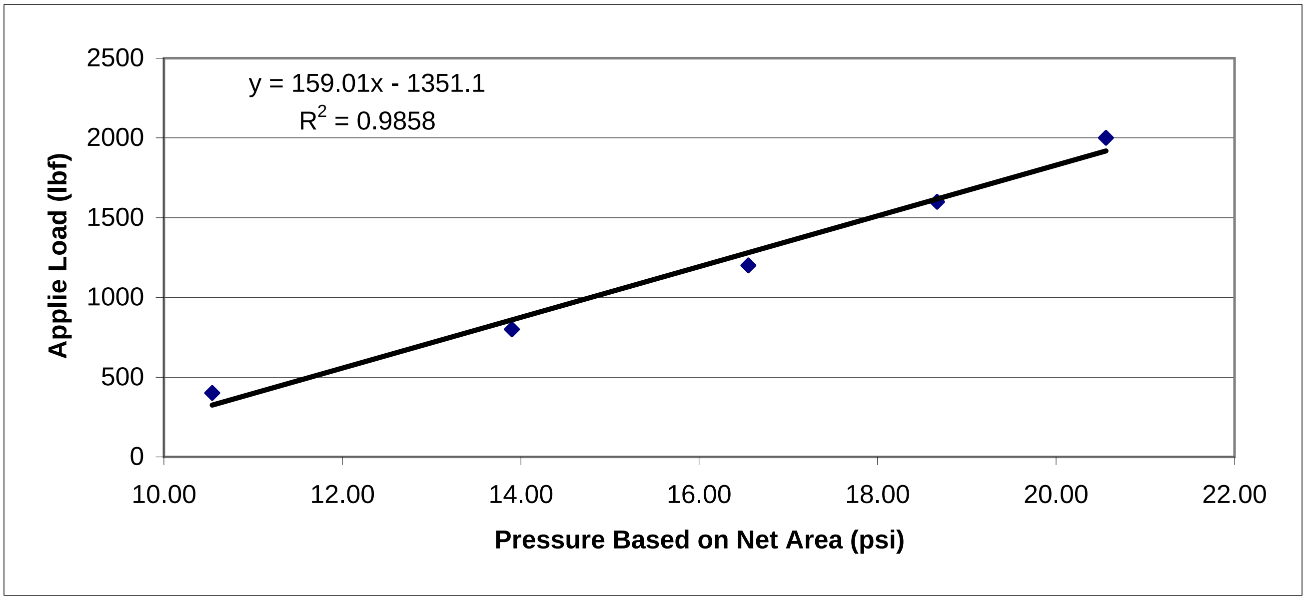
y = 140.81x - 827.26
R^2 = 0.9762
Applie Load (lbf)
0
500
1000
1500
2000
2500
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
Pressure Based on Net Area (psi)

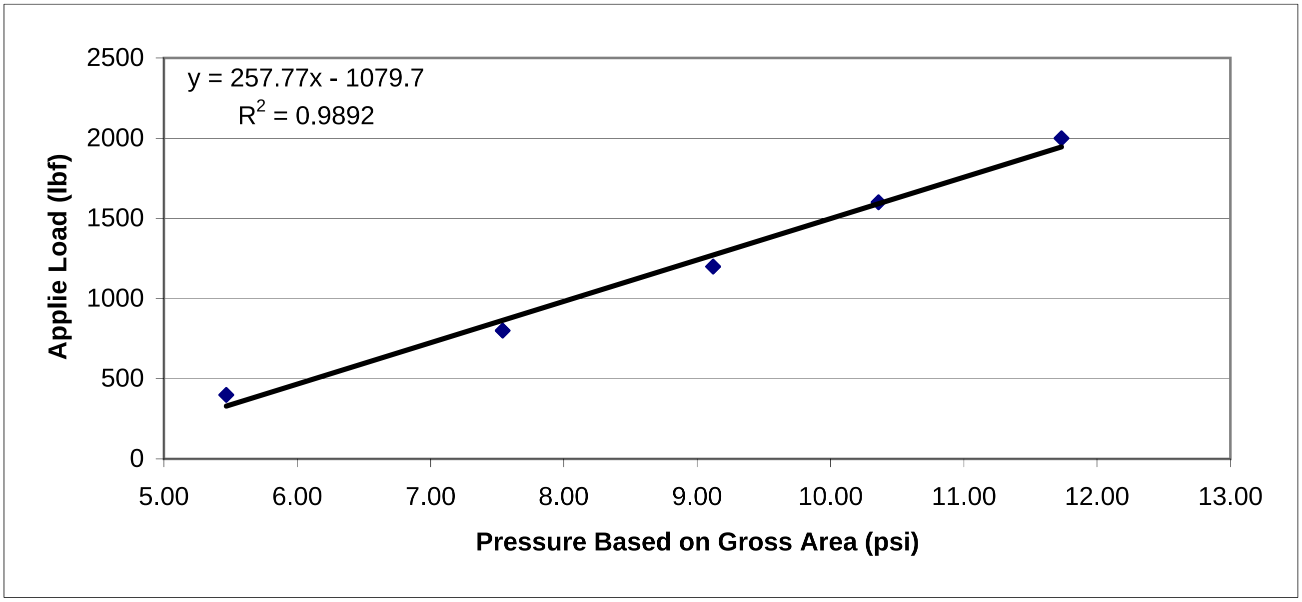


y = 197.48x - 497.89
R^2 = 0.9867
Applie Load (lbf)
0
500
1000
1500
2000
2500
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Pressure Based on Gross Area (psi)

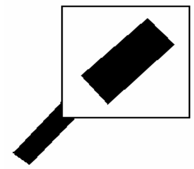
TEST 14d

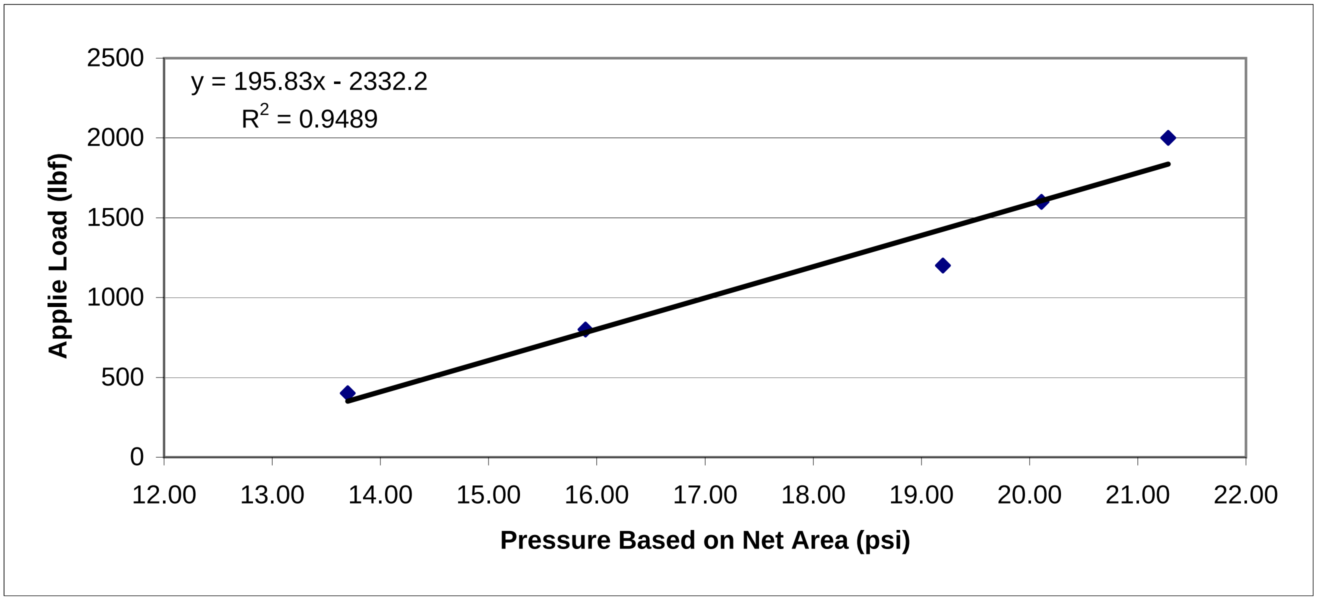



y = 159.01x - 1351.1
R2 = 0.9858
Applie Load (lbf)
2500
2000
1500
1000
500
0
10.00
12.00
14.00
16.00
18.00
20.00
22.00
Pressure Based on Net Area (psi)

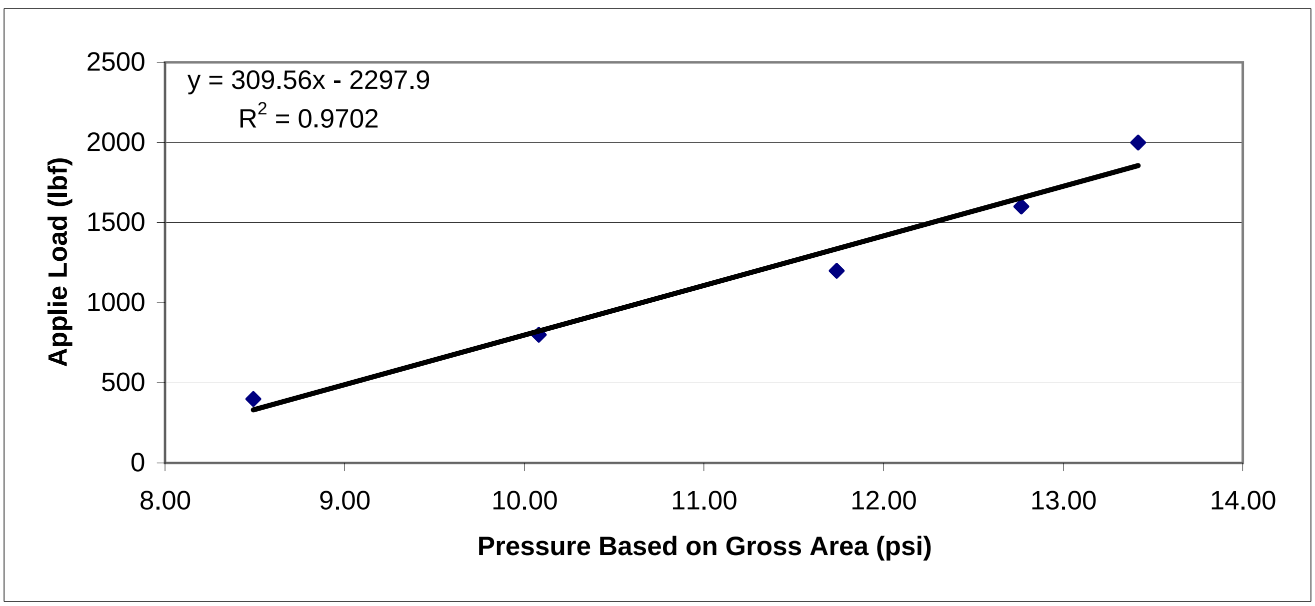

y = 257.77x - 1079.7
R2 = 0.9892
Applie Load (lbf)
2500
2000
1500
1000
500
0
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
Pressure Based on Gross Area (psi)

TEST 14e





y = 195.83x - 2332.2
R2 = 0.9489
Applie Load (lbf)
2500
2000
1500
1000
500
0
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
Pressure Based on Net Area (psi)

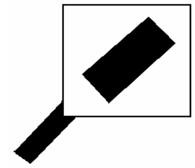


y = 309.56x - 2297.9
R2 = 0.9702
Applie Load (lbf)
2500
2000
1500
1000
500
0
8.00
9.00
10.00
11.00
12.00
13.00
14.00
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure

BIAS PLY TIRE

TEST 15



Date: 10/5/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Position: Top of Asphalt

5250-10

TEST 15a

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2000		23721	2003.46	23596	1992.91	40.99	52.61	48.62	38.08
1600		18659	1575.93	18530	1565.03	35.67	45.59	43.88	34.57
1200		14182	1197.80	14064	1187.84	29.19	38.14	40.69	31.41
800		9624	812.84	9522	804.22	20.62	28.12	39.00	28.91
400		5237	442.31	5164	436.15	12.78	18.1	34.13	24.44
42		1782	150.51	1723	145.52	5.23	8.71	27.82	17.28

Position: Between 1&2 Layer

5250-9

TEST 15b

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2000		37568	1356.74	37392	1350.38	61.42	90.6	21.99	14.98
1600		32905	1188.34	32734	1182.16	58.71	89.83	20.14	13.23
1200		26768	966.70	26599	960.60	54.79	89.01	17.53	10.86
800		20411	737.13	20240	730.95	49.95	86.54	14.63	8.52
400		13430	485.01	13198	476.63	42.3	80.97	11.27	5.99
67		4363	157.57	3910	141.21	22.41	48.35	6.30	3.26

Position: Between 2&3 Layer

5250-8

TEST 15c

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2000		36794	1123.82	36537	1115.97	53.92	84.85	20.70	13.24
1600		31934	975.38	31666	967.20	51.06	83.05	18.94	11.74
1200		26369	805.41	26099	797.16	47.19	79.96	16.89	10.07
800		20336	621.14	20086	613.50	43.66	76.81	14.05	8.09
400		13057	398.81	12774	390.16	38.53	70.66	10.13	5.64
35		5921	180.85	5574	170.25	26.67	51.26	6.38	3.53

Position: Between 3&4 Layer

5250-6

TEST 15d

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2000		27015	922.01	26834	915.84	47.38	80.39	19.33	11.47
1600		23846	813.86	23633	806.59	45.64	78.46	17.67	10.37
1200		19828	676.72	19579	668.23	43.12	75.7	15.50	8.94
800		16067	548.36	15798	539.18	40.99	72.41	13.15	7.57
400		11337	386.93	11010	375.77	36.64	65.44	10.26	5.91
40		6874	234.61	6500	221.84	29.09	53.97	7.63	4.35

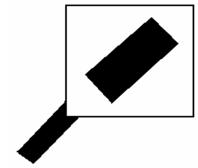
Position: Between 4th Layer and DGA

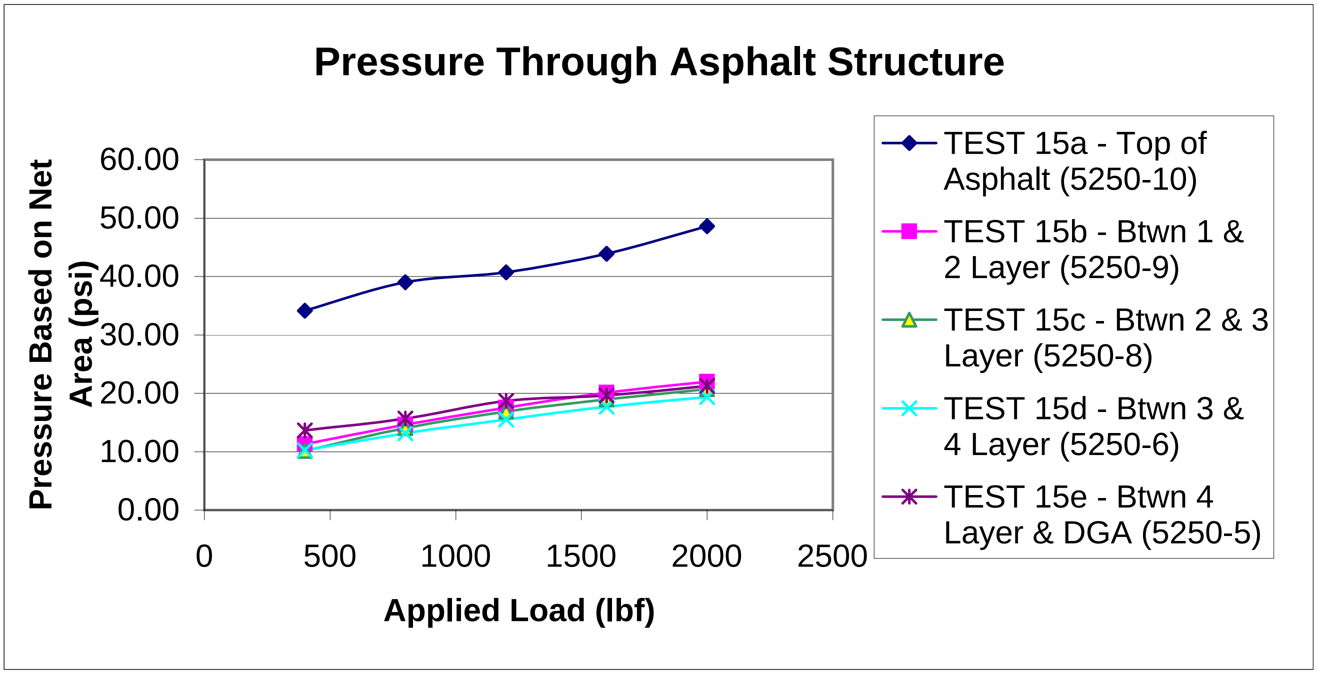
5250-5

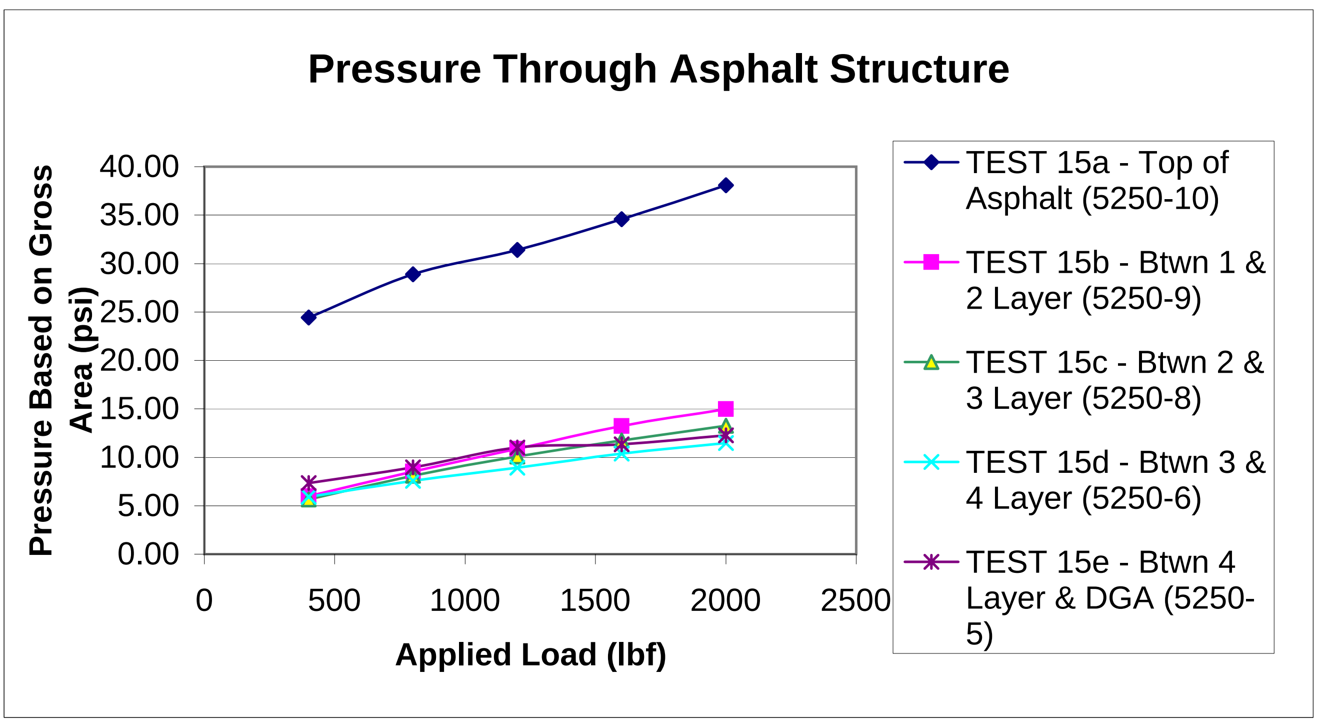
TEST 15e

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
2000		23202	774.59	22860	763.17	35.86	63.11	21.28	12.27
1600		20399	681.01	20061	669.73	34.12	60.06	19.63	11.34
1200		19146	639.18	18789	627.26	33.59	58.03	18.67	11.01
800		14993	500.53	14638	488.68	31.22	55.95	15.65	8.95
400		10742	358.62	10442	348.60	25.56	48.84	13.64	7.34
38		7594	253.52	7230	241.37	23.28	44.09	10.37	5.75

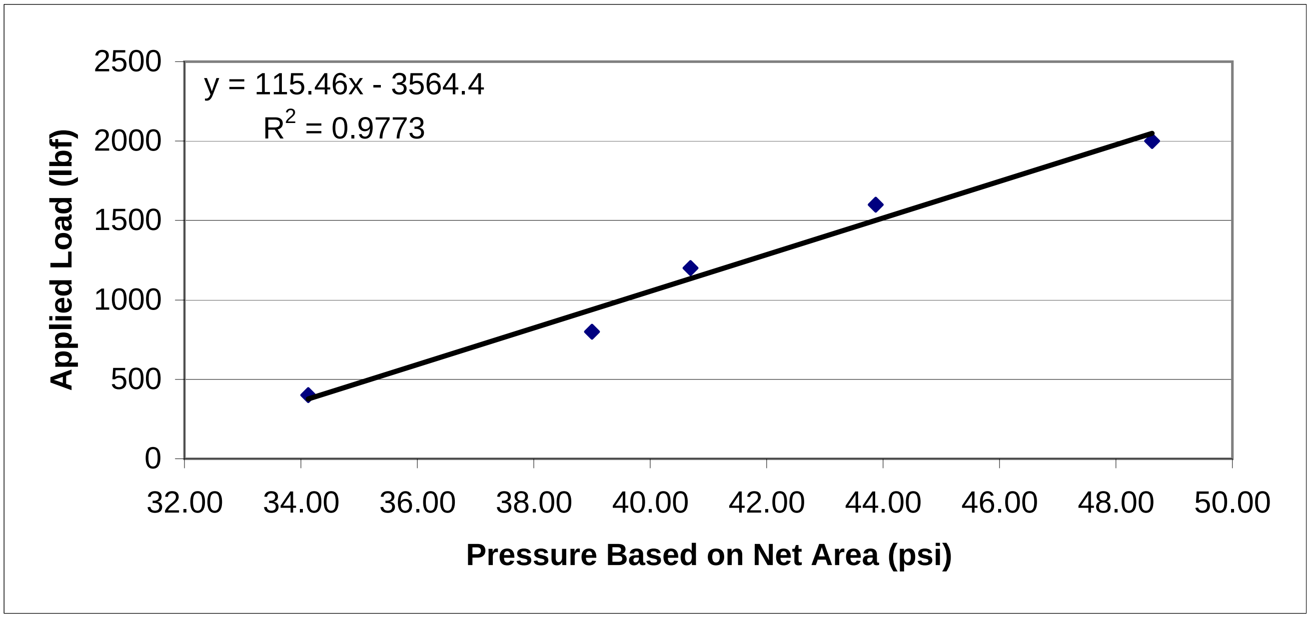
TEST 15



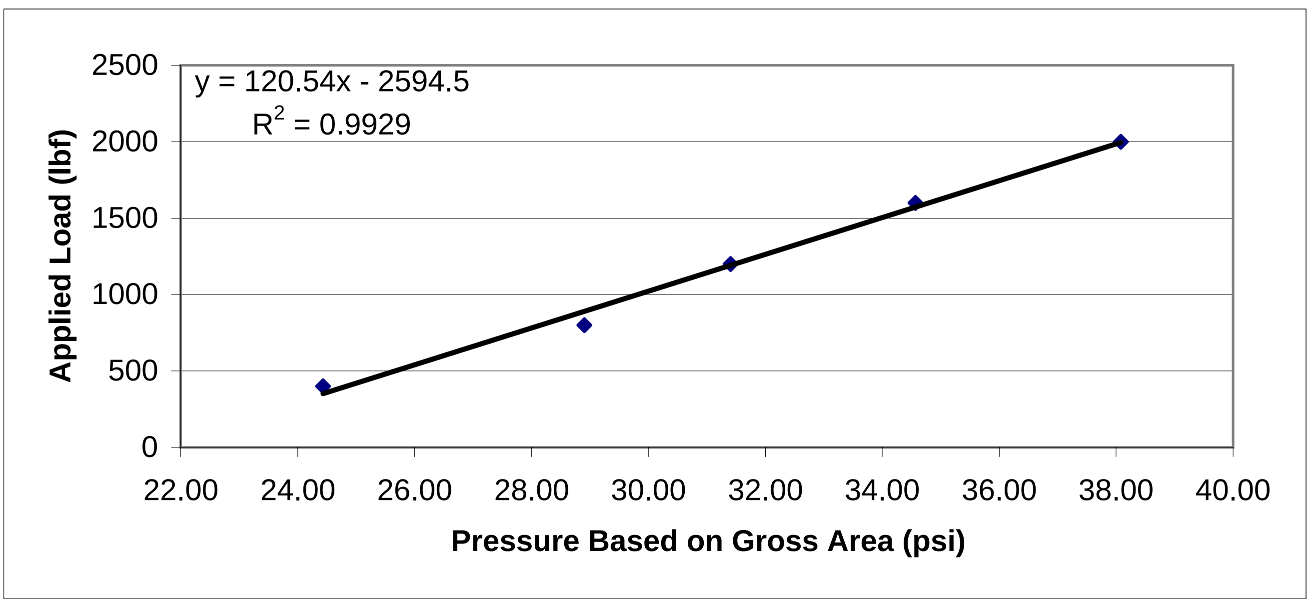

Pressure Through Asphalt Structure
Pressure Based on Net Area (psi)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 15a - Top of Asphalt (5250-10)
TEST 15b - Btwn 1 & 2 Layer (5250-9)
TEST 15c - Btwn 2 & 3 Layer (5250-8)
TEST 15d - Btwn 3 & 4 Layer (5250-6)
TEST 15e - Btwn 4 Layer & DGA (5250-5)


Pressure Through Asphalt Structure
Pressure Based on Gross Area (psi)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 15a - Top of Asphalt (5250-10)
TEST 15b - Btwn 1 & 2 Layer (5250-9)
TEST 15c - Btwn 2 & 3 Layer (5250-8)
TEST 15d - Btwn 3 & 4 Layer (5250-6)
TEST 15e - Btwn 4 Layer & DGA (5250-5)

TEST 15a

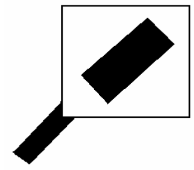


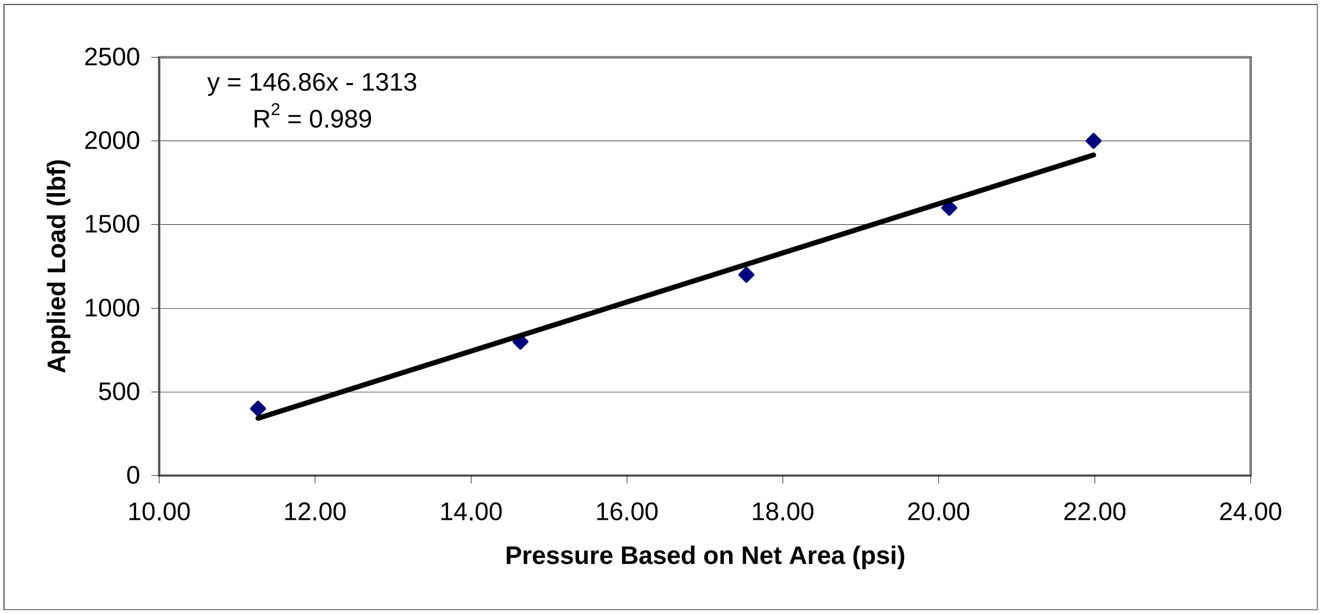
y = 115.46x - 3564.4
R2 = 0.9773
Applied Load (lbf)
2500
2000
1500
1000
500
0
32.00
34.00
36.00
38.00
40.00
42.00
44.00
46.00
48.00
50.00
Pressure Based on Net Area (psi)

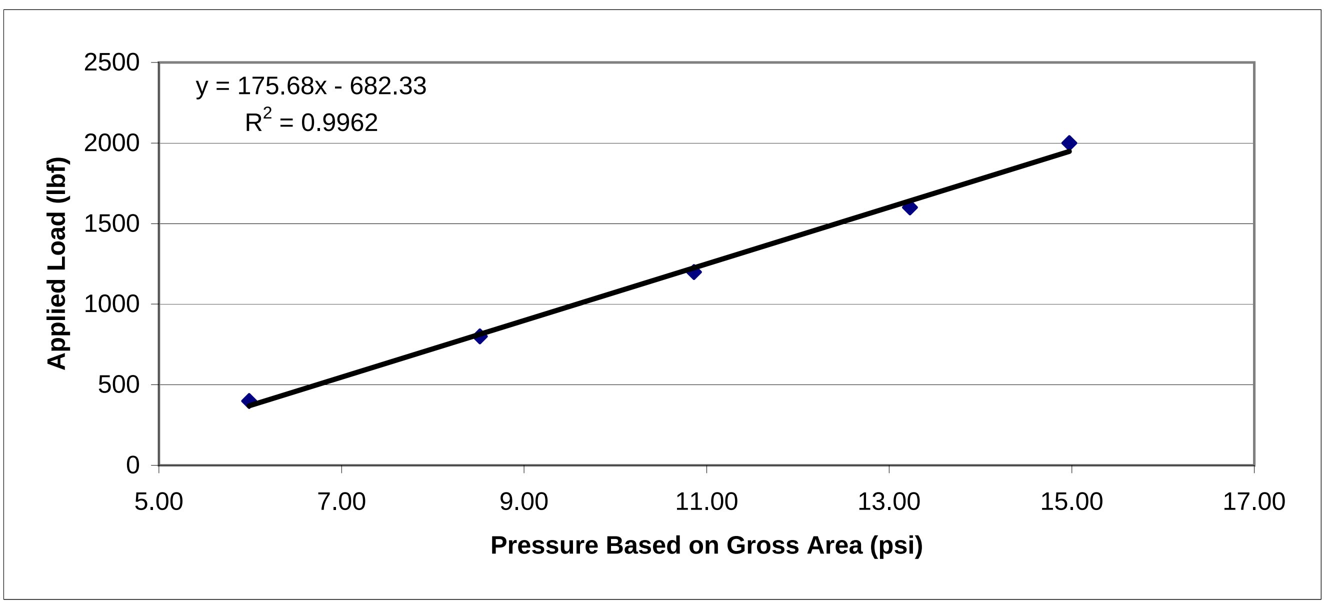


y = 120.54x - 2594.5
R2 = 0.9929
Applied Load (lbf)
2500
2000
1500
1000
500
0
22.00
24.00
26.00
28.00
30.00
32.00
34.00
36.00
38.00
40.00
Pressure Based on Gross Area (psi)

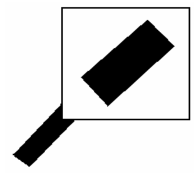
TEST 15b

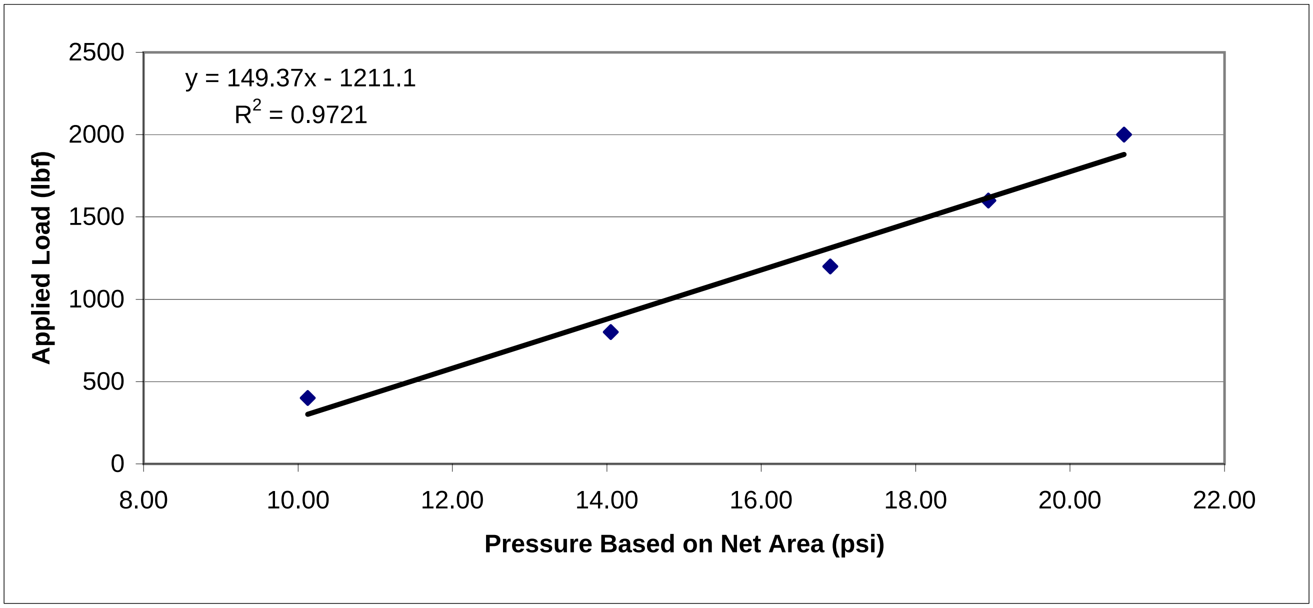


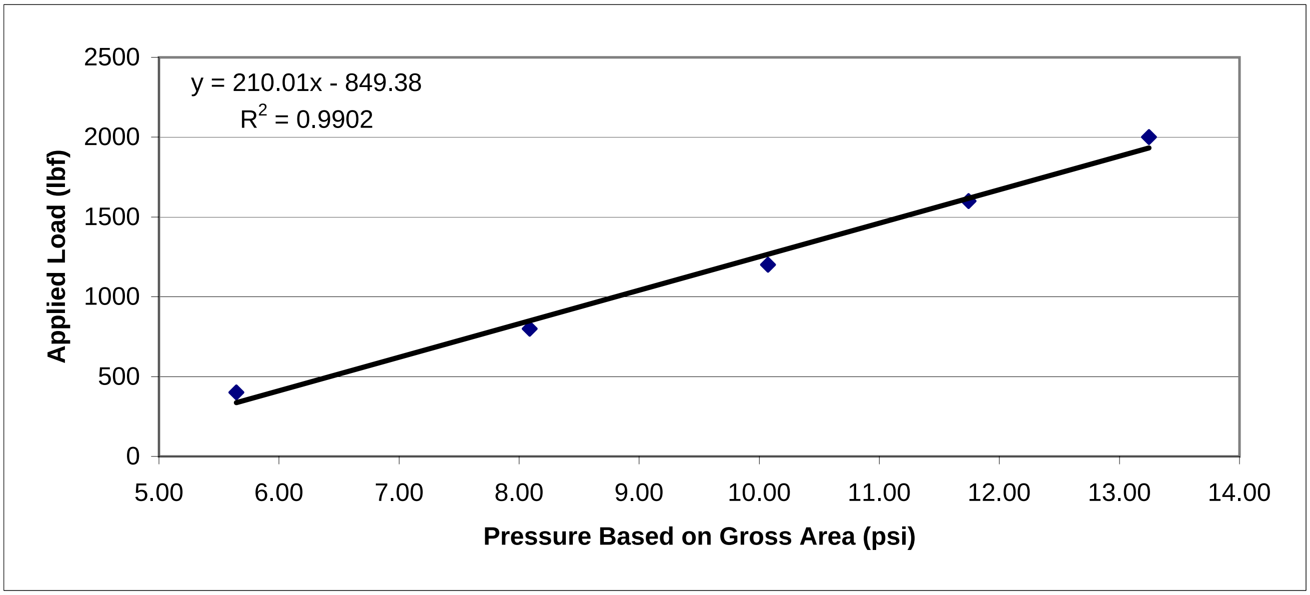

y = 146.86x - 1313
R2 = 0.989
Applied Load (lbf)
Pressure Based on Net Area (psi)
2500
2000
1500
1000
500
0
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00


y = 175.68x - 682.33
R2 = 0.9962
Applied Load (lbf)
Pressure Based on Gross Area (psi)
2500
2000
1500
1000
500
0
5.00
7.00
9.00
11.00
13.00
15.00
17.00

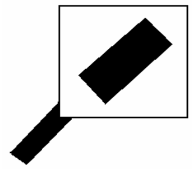
TEST 15c

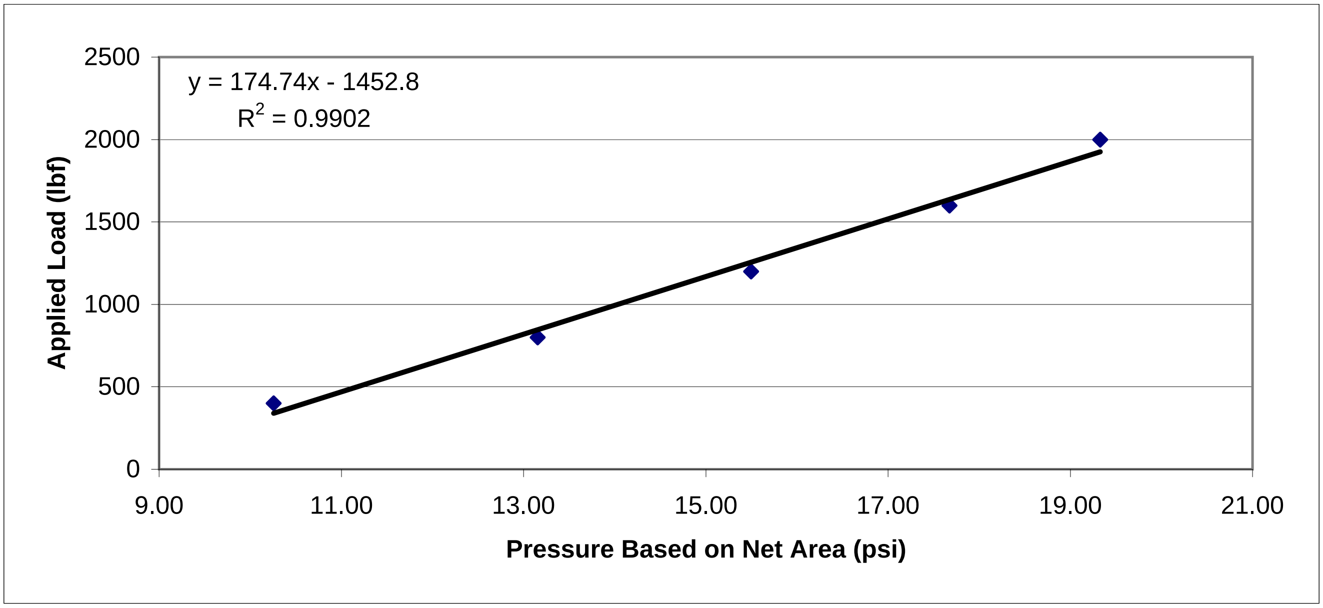


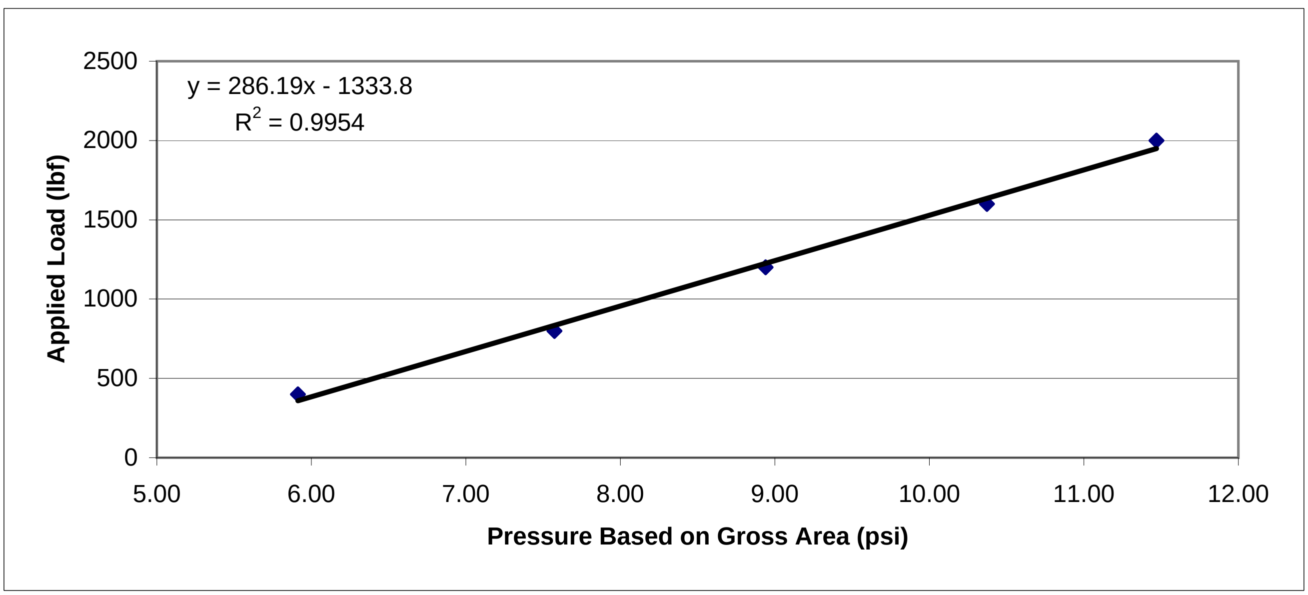

y = 149.37x - 1211.1
R2 = 0.9721
Applied Load (lbf)
2500
2000
1500
1000
500
0
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
Pressure Based on Net Area (psi)


y = 210.01x - 849.38
R2 = 0.9902
Applied Load (lbf)
2500
2000
1500
1000
500
0
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
Pressure Based on Gross Area (psi)

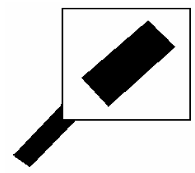
TEST 15d

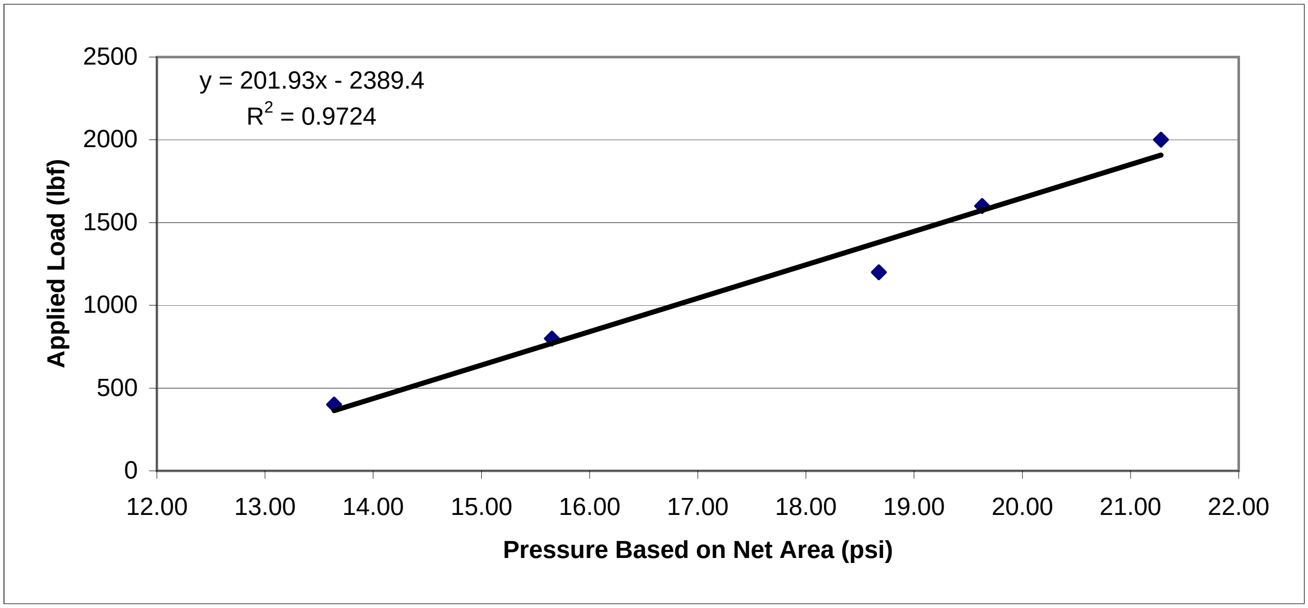



y = 174.74x - 1452.8
R^2 = 0.9902
2500
2000
1500
1000
500
0
Applied Load (lbf)
9.00
11.00
13.00
15.00
17.00
19.00
21.00
Pressure Based on Net Area (psi)

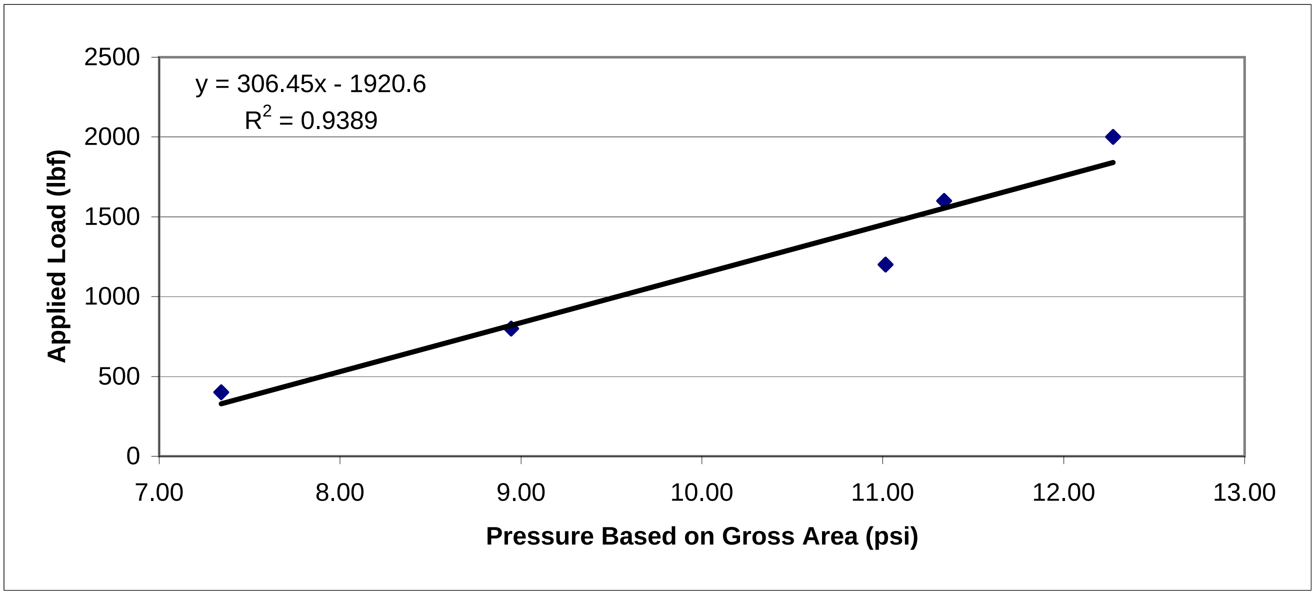

y = 286.19x - 1333.8
R^2 = 0.9954
2500
2000
1500
1000
500
0
Applied Load (lbf)
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
Pressure Based on Gross Area (psi)

TEST 15e





y = 201.93x - 2389.4
R^2 = 0.9724
Applied Load (lbf)
Pressure Based on Net Area (psi)

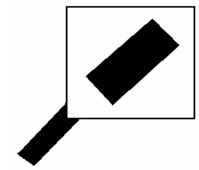


y = 306.45x - 1920.6
R^2 = 0.9389
Applied Load (lbf)
Pressure Based on Gross Area (psi)

Tekscan Pressure Test in Asphalt Structure

SMALL TRAILER TIRE

TEST 16



Date: 10/5/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Position: Top of Asphalt

5250-10

TEST 16a

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1000		10573	892.99	10509	887.58	18.05	25.22	49.17	35.41
800		8831	745.86	8774	741.05	15.92	22.46	46.55	33.21
400		4733	399.75	4688	395.95	10.16	14.81	38.97	26.99
64		1177	99.41	1157	97.72	2.61	4.65	37.44	21.38

Position: Between 1&2 Layer

5250-9

TEST 16b

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1000		23123	835.07	22911	827.41	49.51	84.36	16.71	9.90
800		19070	688.70	18861	681.15	45.74	82.81	14.89	8.32
400		11125	401.77	10790	389.67	36.54	73.62	10.66	5.46
65		2817	101.73	2277	82.23	16.17	33.73	5.09	3.02

Position: Between 2&3 Layer

5250-8

TEST 16c

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1000		25356	774.47	25125	767.41	52.27	86.49	14.68	8.95
800		21547	658.12	21295	650.43	50.58	85.09	12.86	7.73
400		13057	398.81	12803	391.05	43.12	80.2	9.07	4.97
77		5718	174.65	5198	158.77	28.65	53.53	5.54	3.26

Position: Between 3&4 Layer

5250-6

TEST 16d

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1000		20383	695.67	20127	686.93	47	77.63	14.62	8.96
800		17888	610.51	17635	601.88	45.83	76.76	13.13	7.95
400		11684	398.77	11360	387.71	40.85	69.99	9.49	5.70
52		7020	239.59	6631	226.31	32.72	58.61	6.92	4.09

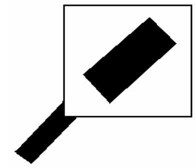
Position: Between 4th Layer and DGA

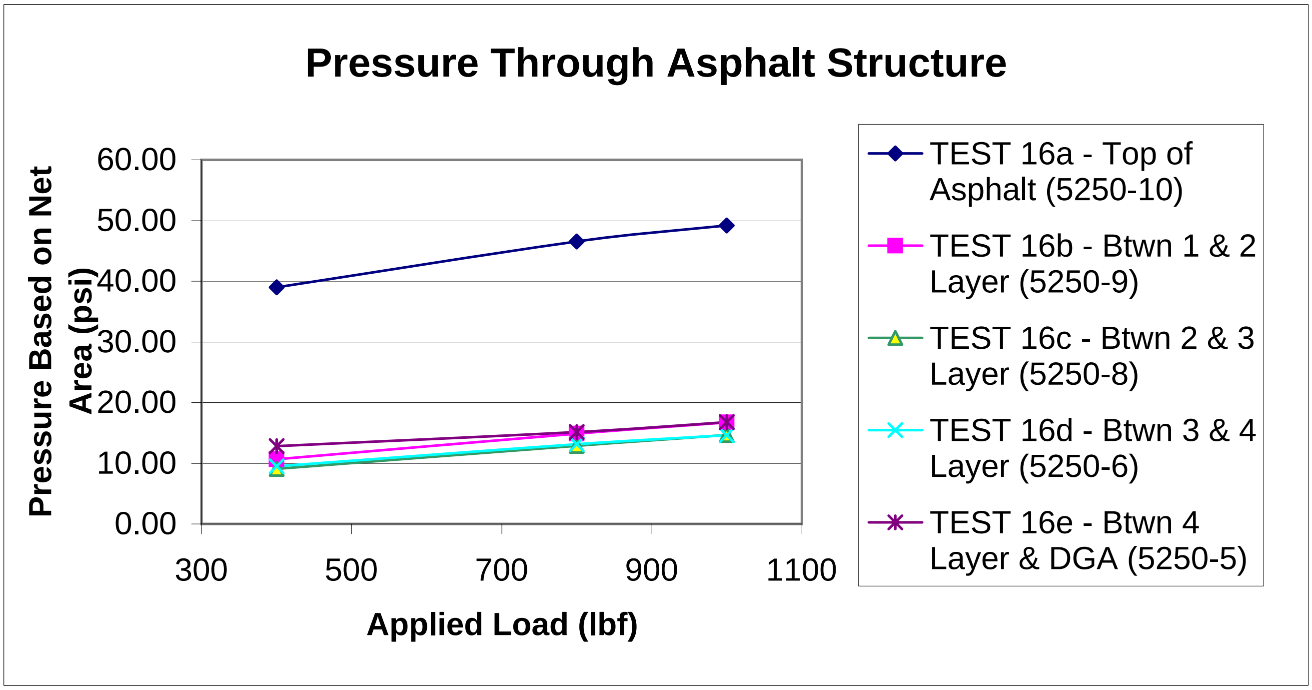
5250-5

TEST 16e

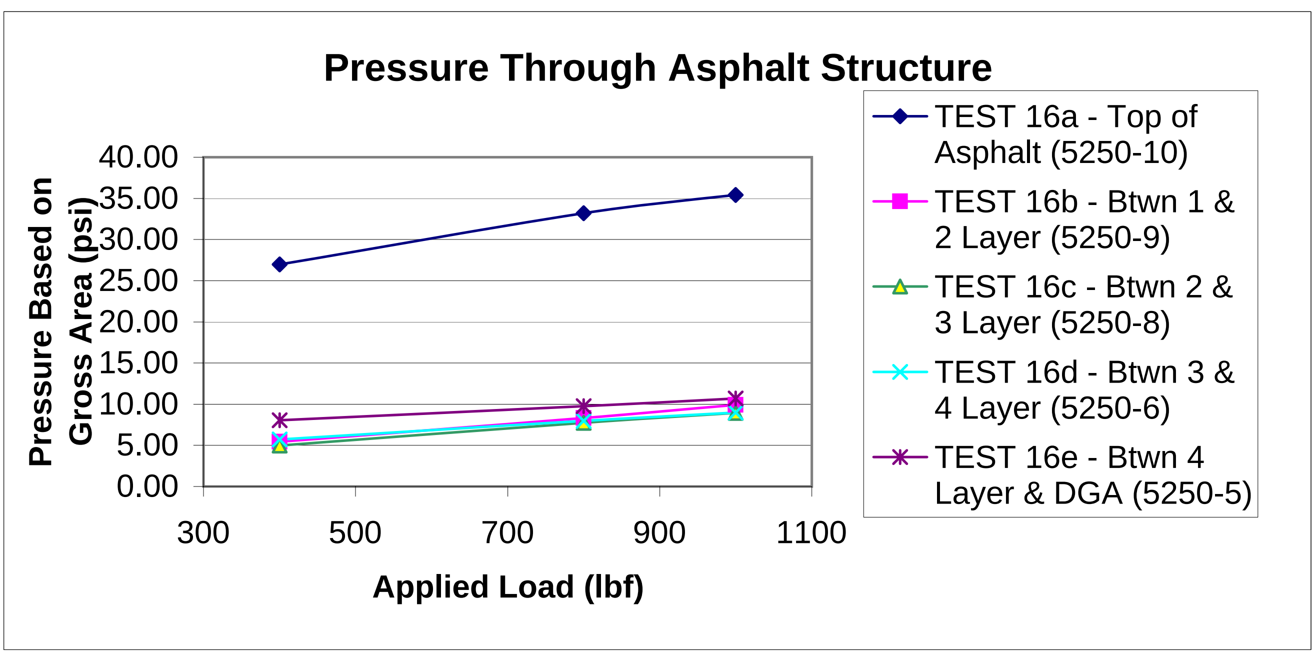
A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1000		19531	652.03	19225	641.82	38.28	61.08	16.77	10.68
800		17240	575.55	16909	564.50	37.27	58.95	15.15	9.76
400		13170	439.67	12845	428.82	33.49	54.64	12.80	8.05
38		8170	272.75	7804	260.53	29.57	46.9	8.81	5.82

TEST 16



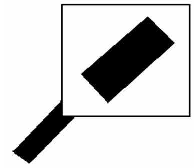


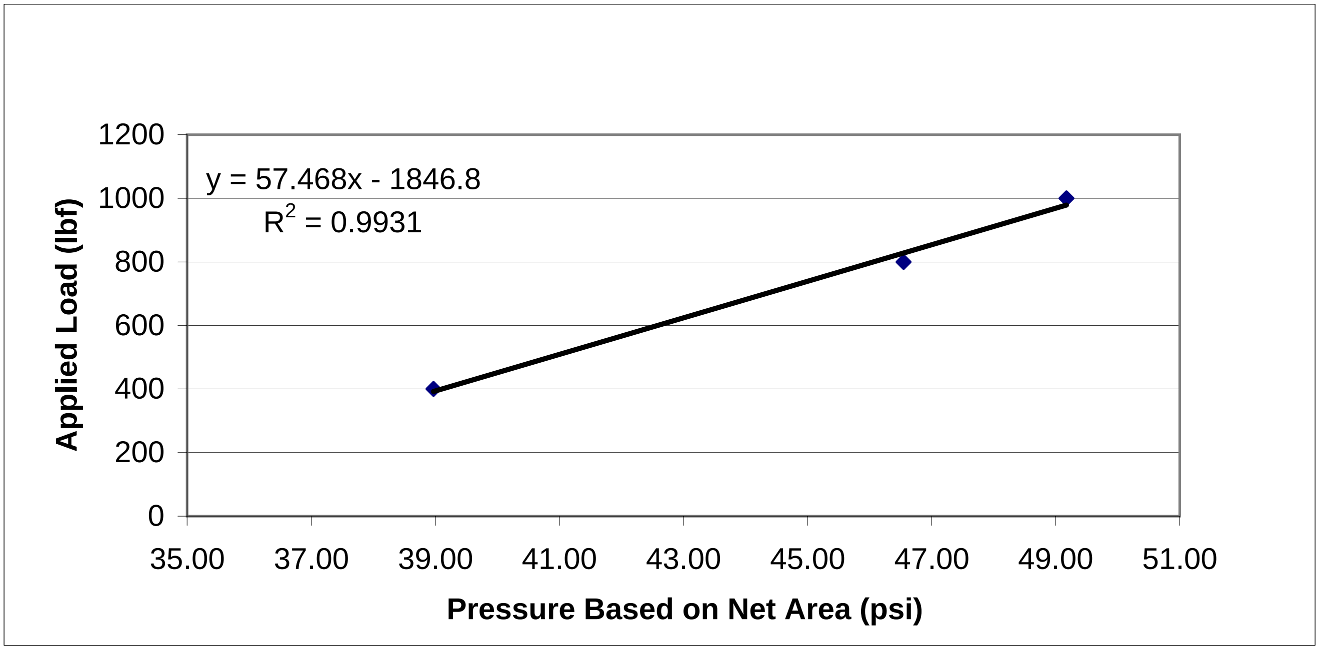
Pressure Through Asphalt Structure
Pressure Based on Net Area (psi)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
300
500
700
900
1100
Applied Load (lbf)
TEST 16a - Top of Asphalt (5250-10)
TEST 16b - Btwn 1 & 2 Layer (5250-9)
TEST 16c - Btwn 2 & 3 Layer (5250-8)
TEST 16d - Btwn 3 & 4 Layer (5250-6)
TEST 16e - Btwn 4 Layer & DGA (5250-5)

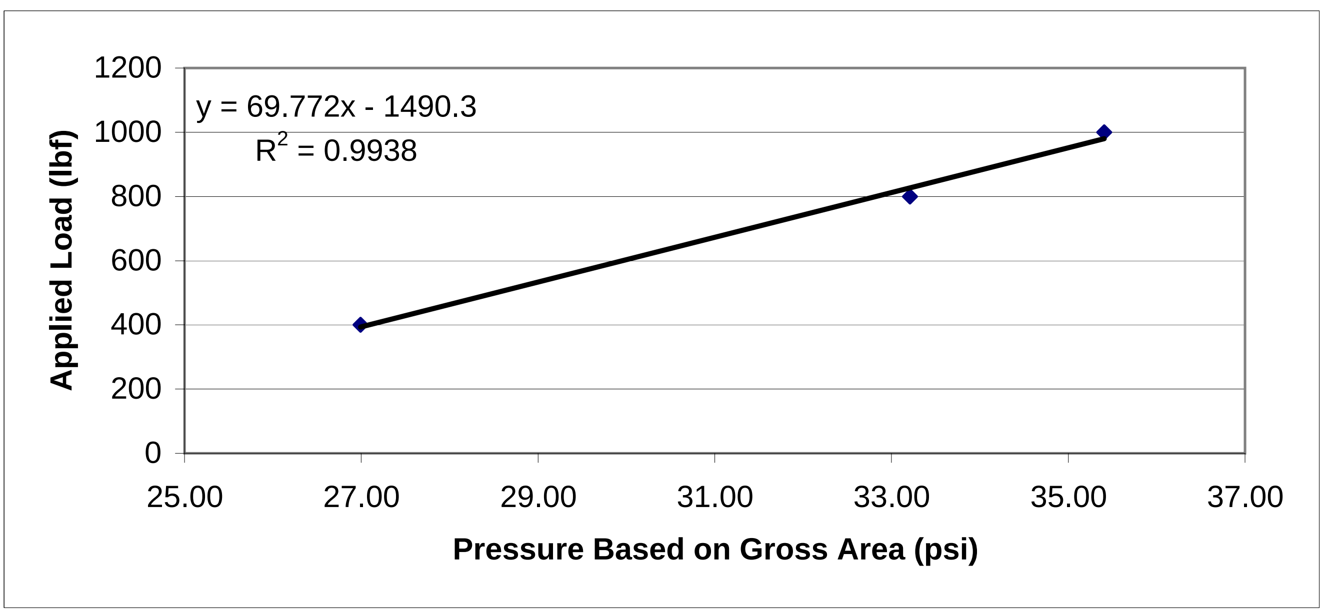


Pressure Through Asphalt Structure
Pressure Based on Gross Area (psi)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
300
500
700
900
1100
Applied Load (lbf)
TEST 16a - Top of Asphalt (5250-10)
TEST 16b - Btwn 1 & 2 Layer (5250-9)
TEST 16c - Btwn 2 & 3 Layer (5250-8)
TEST 16d - Btwn 3 & 4 Layer (5250-6)
TEST 16e - Btwn 4 Layer & DGA (5250-5)

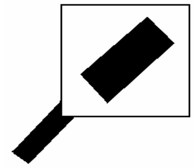
TEST 16a

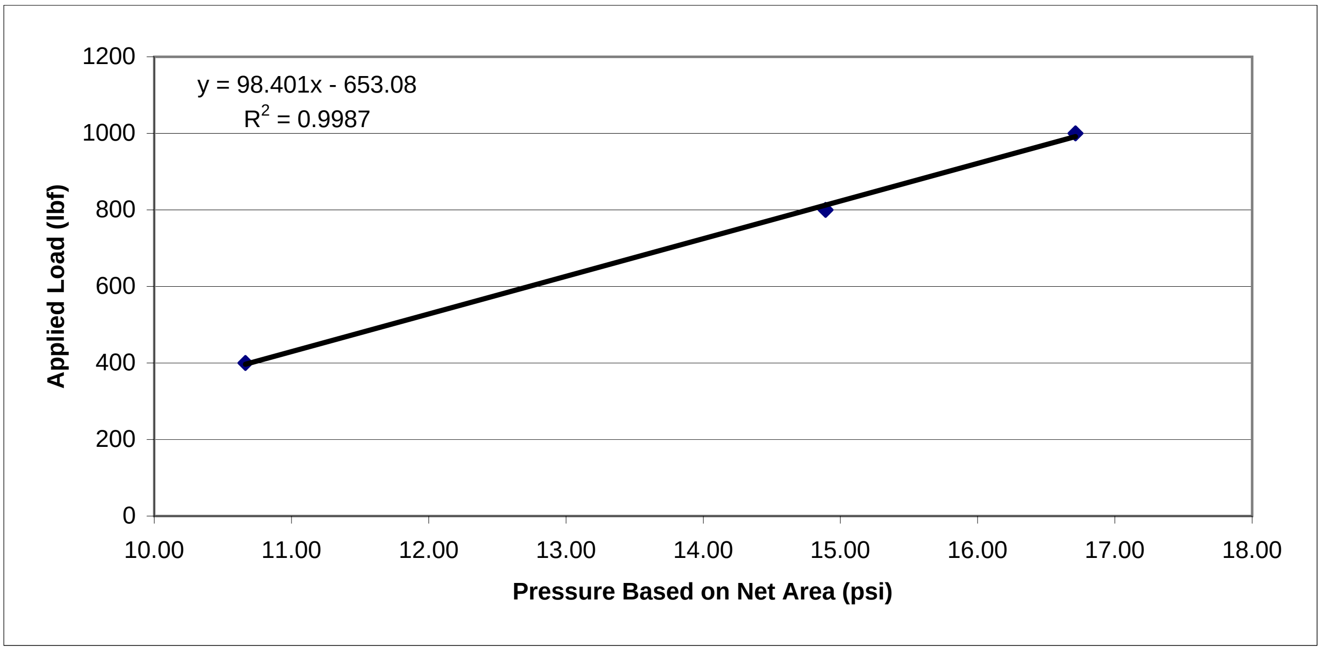



y = 57.468x - 1846.8
R2 = 0.9931
Applied Load (lbf)
1200
1000
800
600
400
200
0
35.00
37.00
39.00
41.00
43.00
45.00
47.00
49.00
51.00
Pressure Based on Net Area (psi)

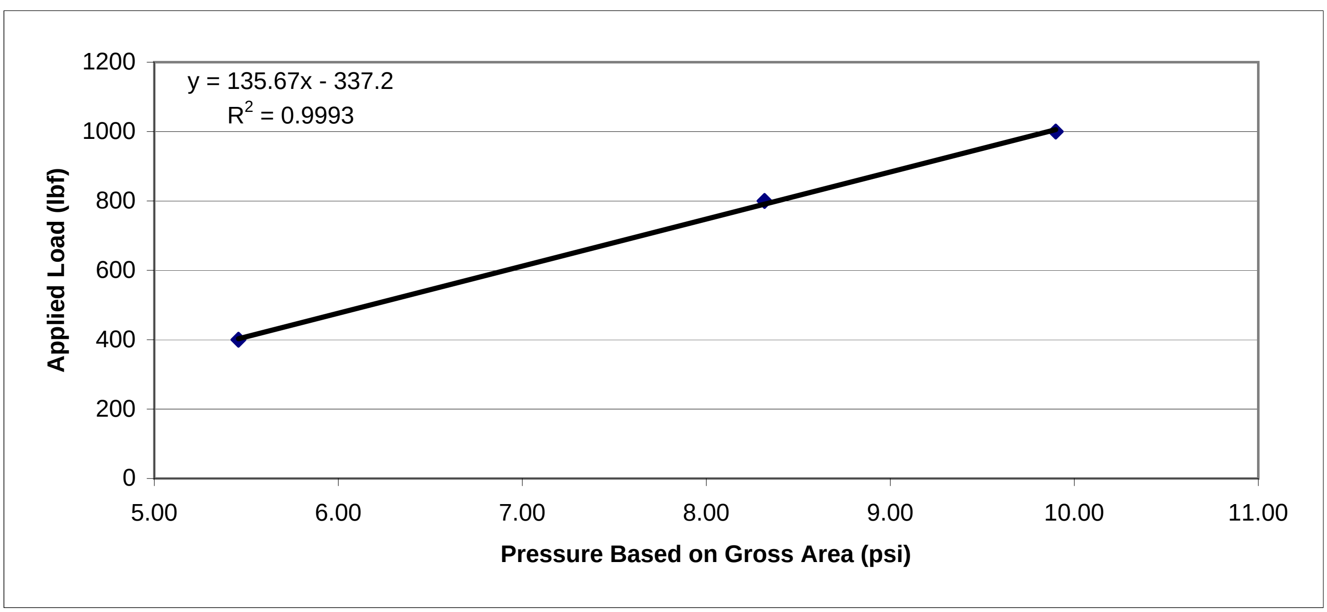

y = 69.772x - 1490.3
R2 = 0.9938
Applied Load (lbf)
1200
1000
800
600
400
200
0
25.00
27.00
29.00
31.00
33.00
35.00
37.00
Pressure Based on Gross Area (psi)

TEST 16b



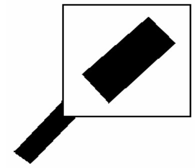


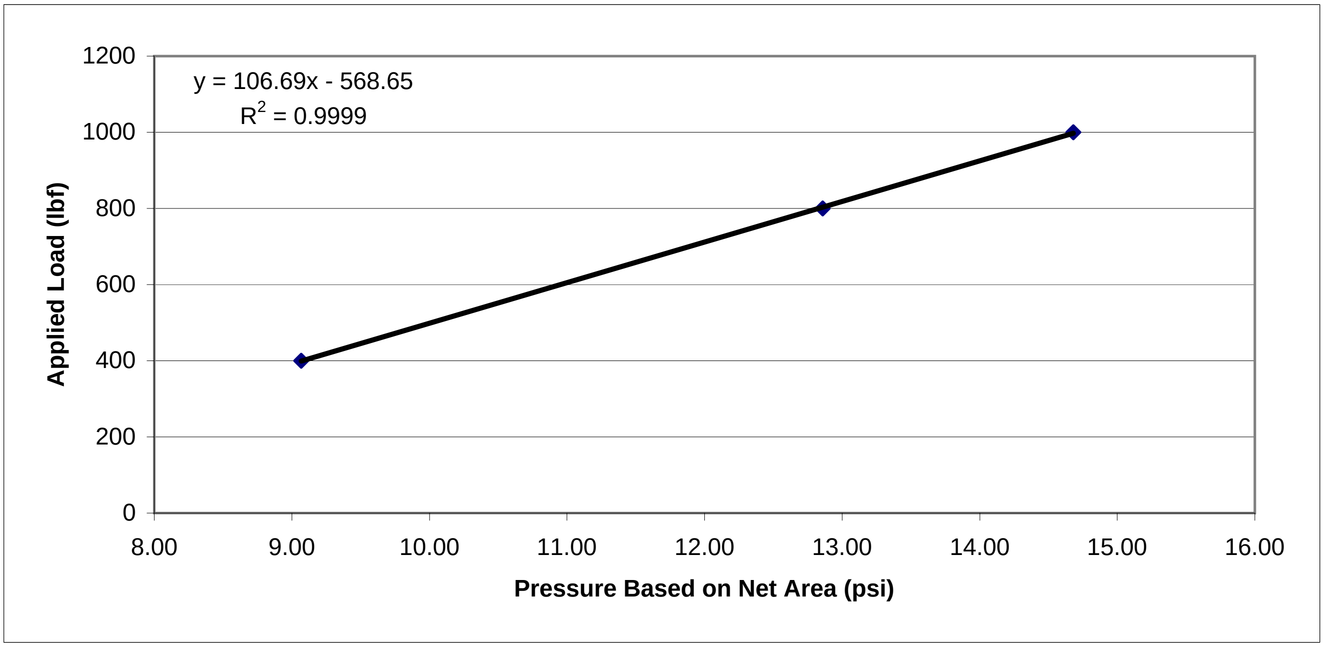
y = 98.401x - 653.08
R2 = 0.9987
Applied Load (lbf)
1200
1000
800
600
400
200
0
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
Pressure Based on Net Area (psi)



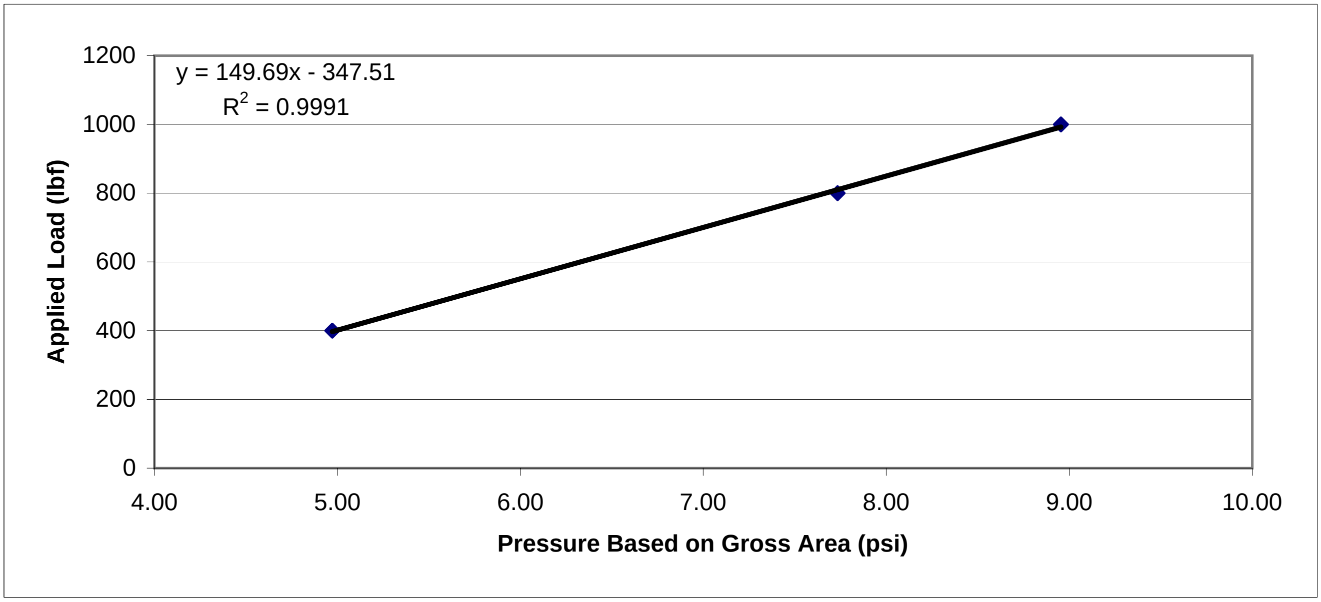
y = 135.67x - 337.2
R2 = 0.9993
Applied Load (lbf)
1200
1000
800
600
400
200
0
5.00
6.00
7.00
8.00
9.00
10.00
11.00
Pressure Based on Gross Area (psi)

TEST 16c



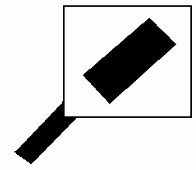


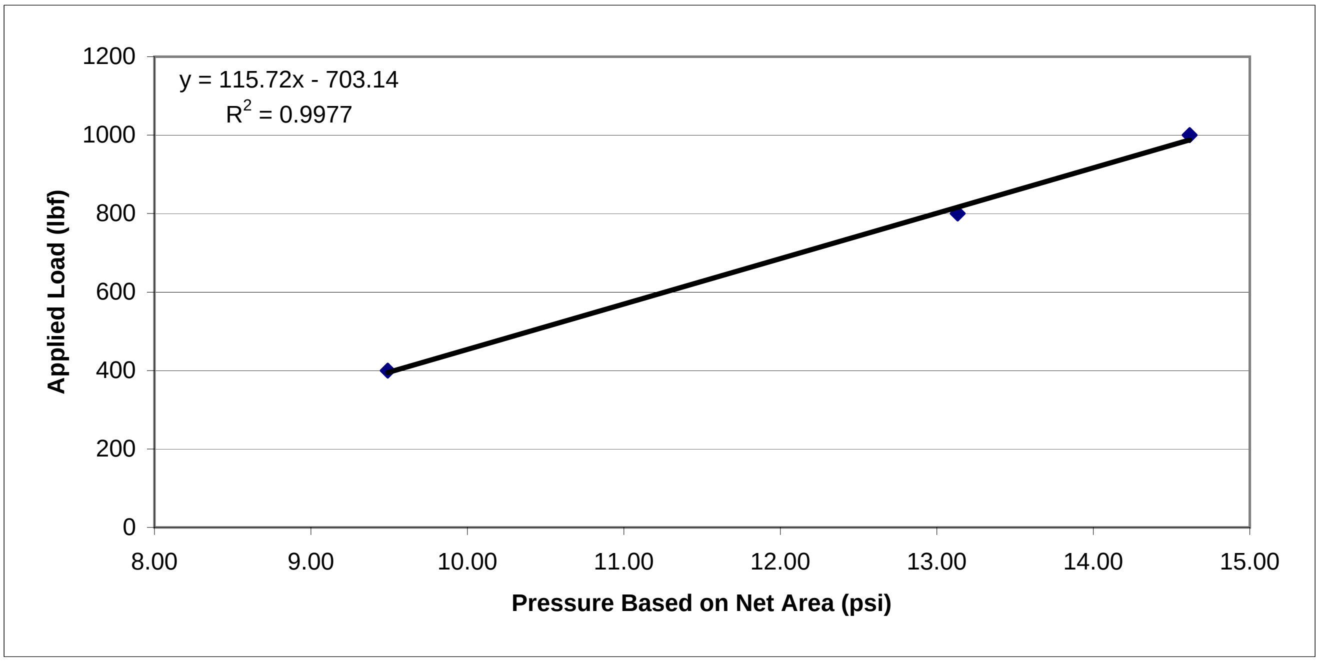
y = 106.69x - 568.65
R2 = 0.9999
Applied Load (lbf)
0
200
400
600
800
1000
1200
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
Pressure Based on Net Area (psi)

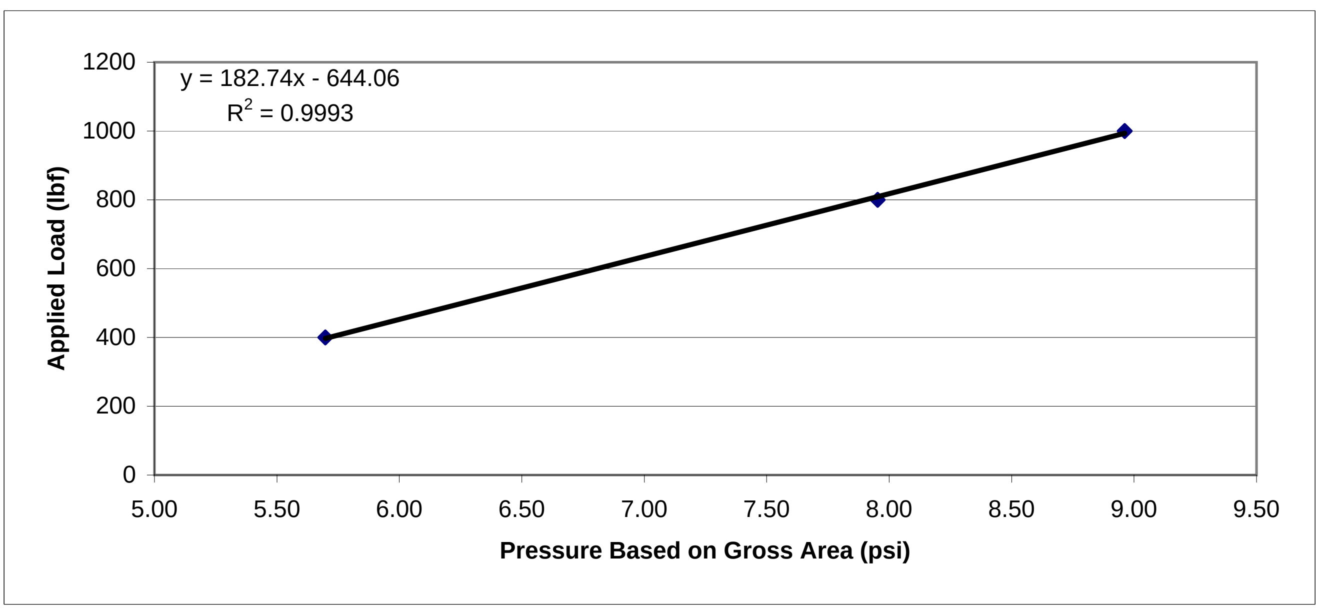


y = 149.69x - 347.51
R2 = 0.9991
Applied Load (lbf)
0
200
400
600
800
1000
1200
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Pressure Based on Gross Area (psi)

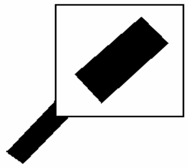
TEST 16d

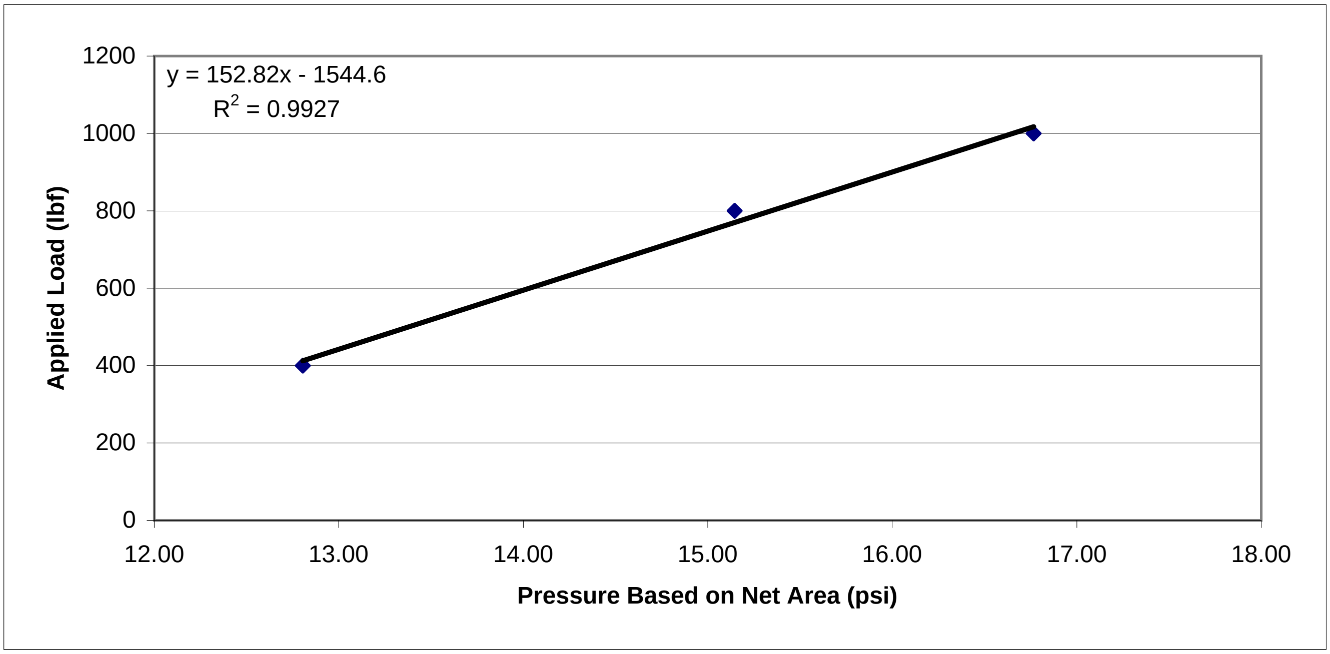



y = 115.72x - 703.14
R2 = 0.9977
Applied Load (lbf)
0
200
400
600
800
1000
1200
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
Pressure Based on Net Area (psi)

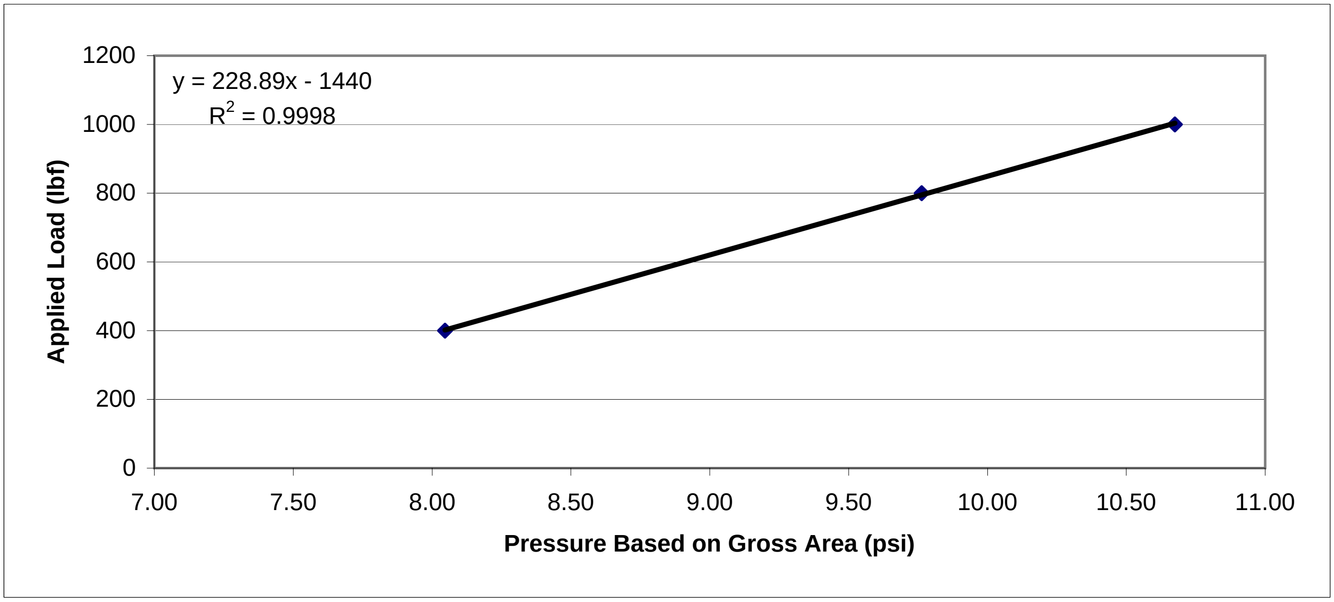

y = 182.74x - 644.06
R2 = 0.9993
Applied Load (lbf)
0
200
400
600
800
1000
1200
5.00
5.50
6.00
6.50
7.00
7.50
8.00
8.50
9.00
9.50
Pressure Based on Gross Area (psi)

TEST 16e





y = 152.82x - 1544.6
R^2 = 0.9927
Applied Load (lbf)
Pressure Based on Net Area (psi)
0
200
400
600
800
1000
1200
12.00
13.00
14.00
15.00
16.00
17.00
18.00



y = 228.89x - 1440
R^2 = 0.9998
Applied Load (lbf)
Pressure Based on Gross Area (psi)
0
200
400
600
800
1000
1200
7.00
7.50
8.00
8.50
9.00
9.50
10.00
10.50
11.00

Appendix F - Normalized Laboratory Data

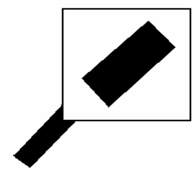
Tekscan Pressure Test in Asphalt Structure

9/4/2006

RADIAL TIRE

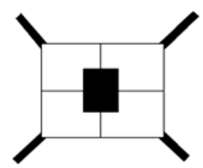
TEST 1 *Position: Top Layer (Calibration)*

Applied Load	Net Pressure	Gross Pressure
400	28.31	19.58
600	29.83	21.35
800	31.34	23.12
1000	32.86	24.89
1200	34.38	26.66
1400	35.90	28.43
1600	37.42	30.20
1800	38.93	31.97
2000	40.45	33.74



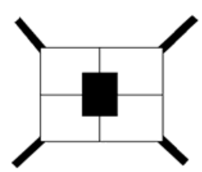
TEST 2 *Position: Top Layer Centered over 4 Sensors*

Applied Load	Net Pressure	Gross Pressure
400	21.38	16.24
600	24.88	19.24
800	28.37	22.24
1000	31.87	25.24
1200	35.36	28.24
1400	38.86	31.24
1600	42.35	34.25
1800	45.85	37.25
2000	49.34	40.25



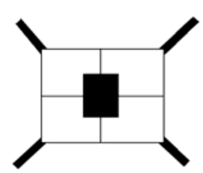
TEST 3 *Position: Between 1 & 2 Layer (No Straps)*

Applied Load	Net Pressure	Gross Pressure
400	6.58	2.53
600	10.52	5.77
800	14.45	9.01
1000	18.39	12.25
1200	22.32	15.48
1400	26.26	18.72
1600	30.19	21.96
1800	34.13	25.20
2000	38.06	28.44



TEST 4 *Position: Between 3 & 4 Layer (No Straps)*

Applied Load	Net Pressure	Gross Pressure
400	11.14	7.10
600	12.77	8.64
800	14.40	10.19
1000	16.03	11.73
1200	17.66	13.27
1400	19.29	14.82
1600	20.92	16.36
1800	22.55	17.90
2000	24.18	19.45

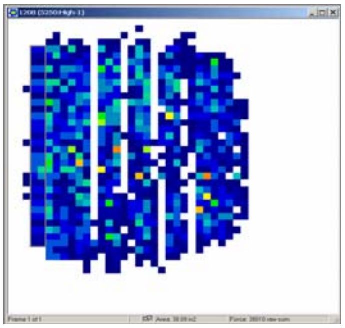


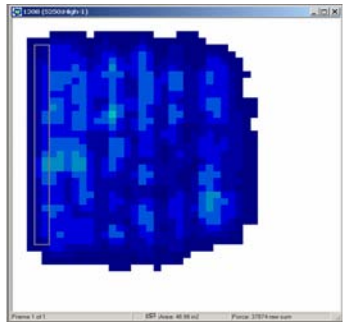
Tekscan Pressure Test in Asphalt Structure

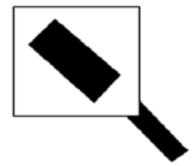
9/4/2006 ***RADIAL TIRE***

Note: All images are taken at approximately a 1200 lb load from Sensor 5250-8

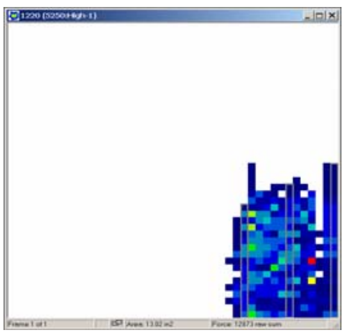
TEST 1 *Position: Top Layer (Calibration)*

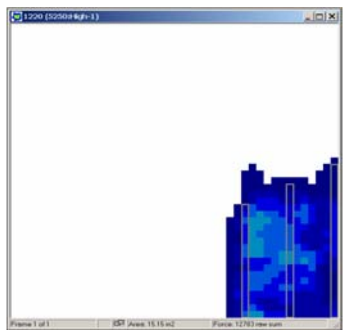


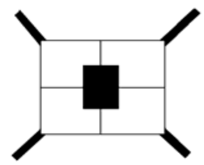




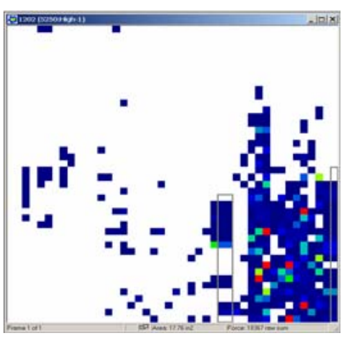
TEST 2 *Position: Top Layer Centered over 4 Sensors*

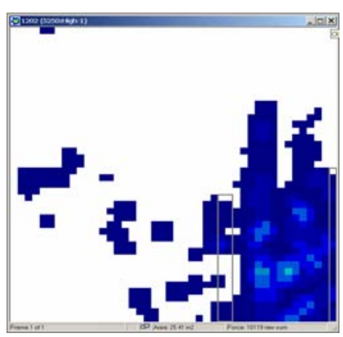


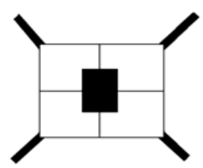




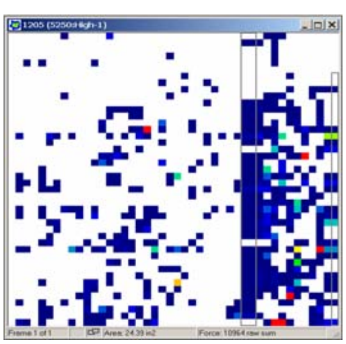
TEST 3 *Position: Between 1 & 2 Layer (No Straps)*

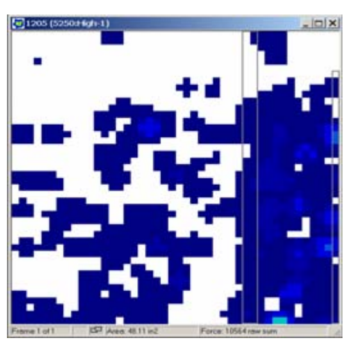


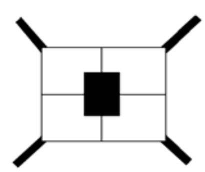


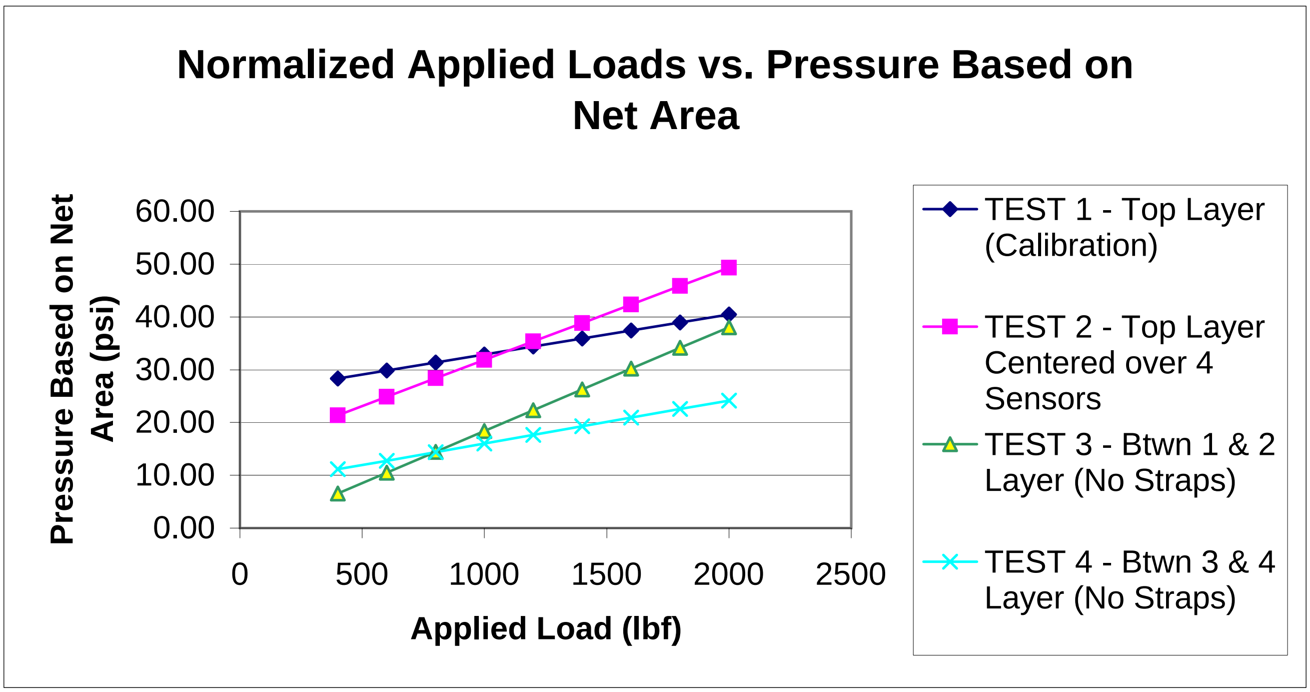


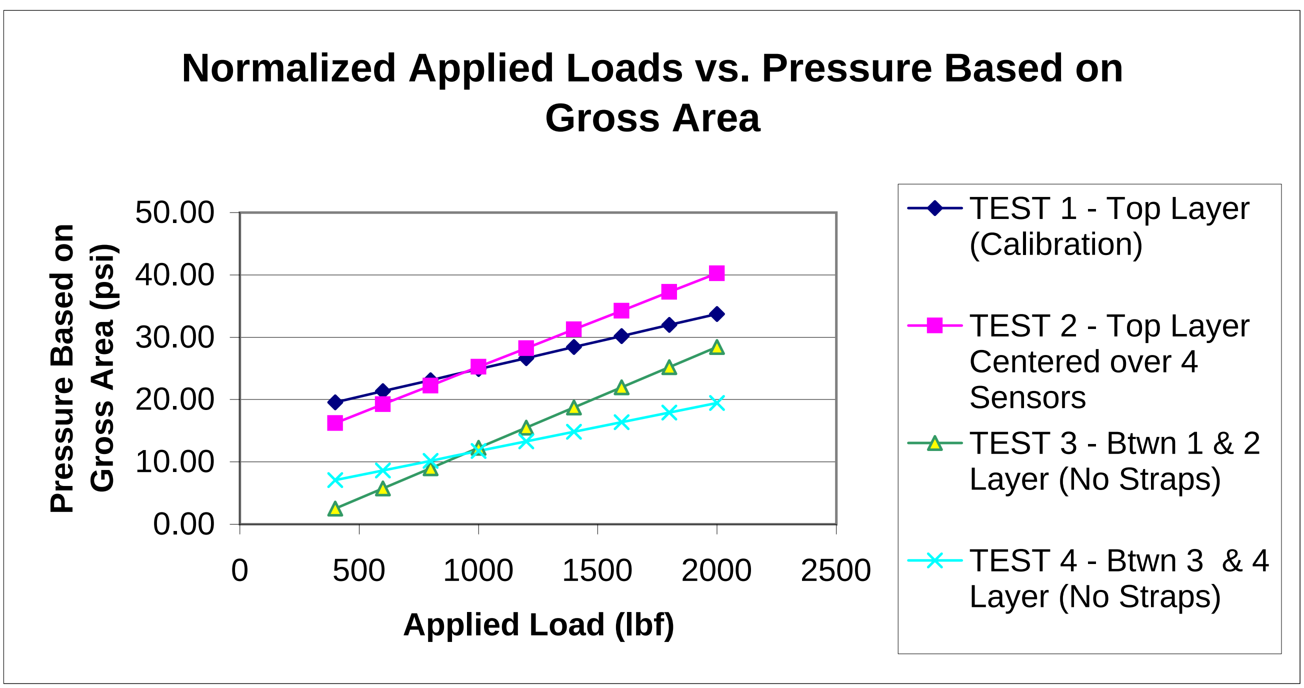
TEST 4 *Position: Between 3 & 4 Layer (No Straps)*








Normalized Applied Loads vs. Pressure Based on Net Area
Pressure Based on Net Area (psi)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 1 - Top Layer (Calibration)
TEST 2 - Top Layer Centered over 4 Sensors
TEST 3 - Btwn 1 & 2 Layer (No Straps)
TEST 4 - Btwn 3 & 4 Layer (No Straps)


Normalized Applied Loads vs. Pressure Based on Gross Area
Pressure Based on Gross Area (psi)
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 1 - Top Layer (Calibration)
TEST 2 - Top Layer Centered over 4 Sensors
TEST 3 - Btwn 1 & 2 Layer (No Straps)
TEST 4 - Btwn 3 & 4 Layer (No Straps)

Tekscan Pressure Test in Asphalt Structure

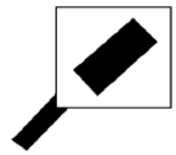
9/19/2006

RADIAL TIRE

TEST 5

Position: Top Layer (Calibration)

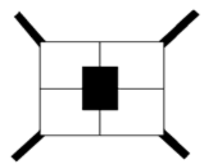
Applied Load	Net Pressure	Gross Pressure
400	23.79	17.27
600	25.80	19.34
800	27.81	21.42
1000	29.82	23.50
1200	31.83	25.57
1400	33.84	27.65
1600	35.85	29.73
1800	37.86	31.81
2000	39.87	33.88



TEST 6

Position: Top Layer Centered over 4 Sensors

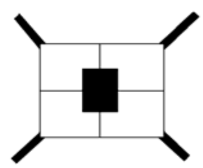
Applied Load	Net Pressure	Gross Pressure
400	12.23	8.87
600	16.12	12.10
800	20.01	15.32
1000	23.90	18.55
1200	27.78	21.78
1400	31.67	25.00
1600	35.56	28.23
1800	39.45	31.45
2000	43.34	34.68



TEST 7

Position: Between 1 & 2 Layer (With Straps)

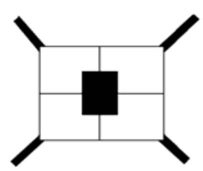
Applied Load	Net Pressure	Gross Pressure
400	10.40	6.40
600	11.77	7.34
800	13.15	8.28
1000	14.53	9.22
1200	15.90	10.16
1400	17.28	11.10
1600	18.65	12.04
1800	20.03	12.98
2000	21.40	13.92



TEST 8

Position: Between 1 & 2 Layer (No Straps)

Applied Load	Net Pressure	Gross Pressure
400	4.33	6.14
600	6.37	8.56
800	8.42	10.97
1000	10.46	13.38
1200	12.51	15.79
1400	14.55	18.20
1600	16.59	20.62
1800	18.64	23.03
2000	20.68	25.44

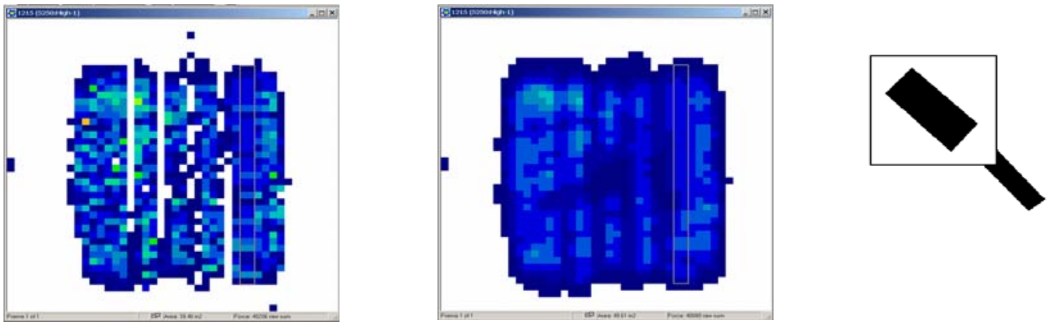


Tekscan Pressure Test in Asphalt Structure

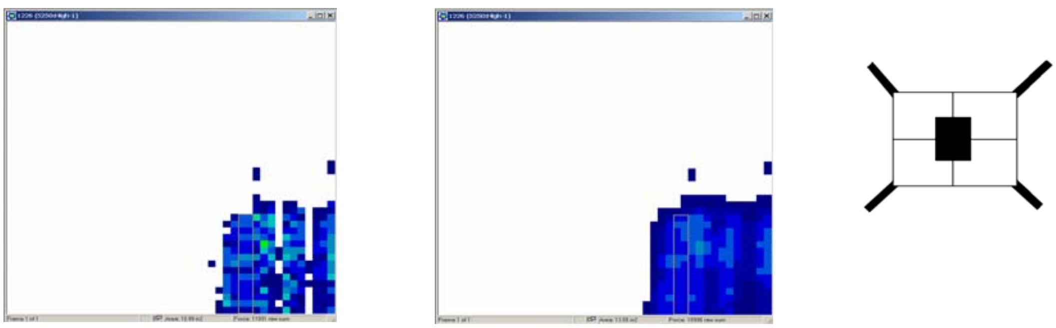
9/19/2006 ***RADIAL TIRE***

Note: All images are taken at approximately a 1200 lb load from Sensor 5250-8

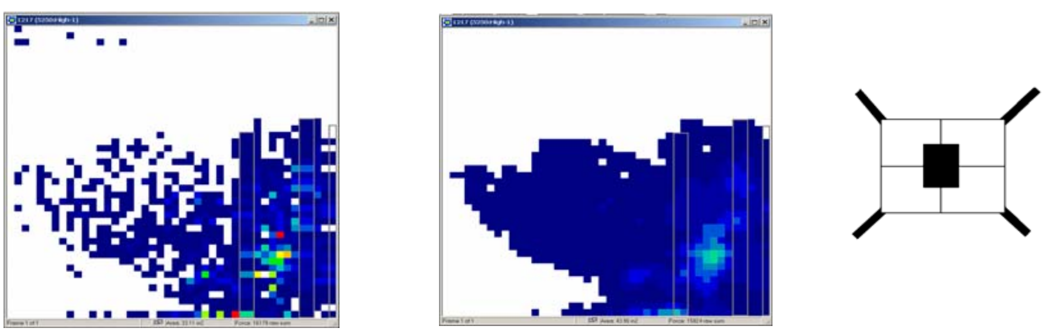
TEST 5 *Position: Top Layer (Calibration)*



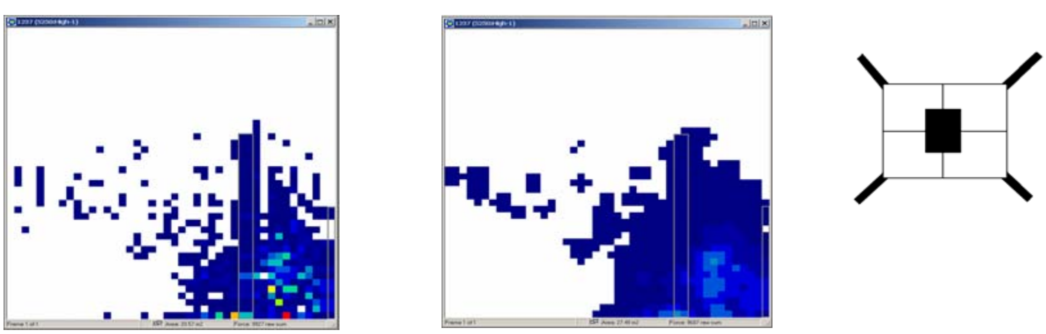
TEST 6 *Position: Top Layer Centered over 4 Sensors*

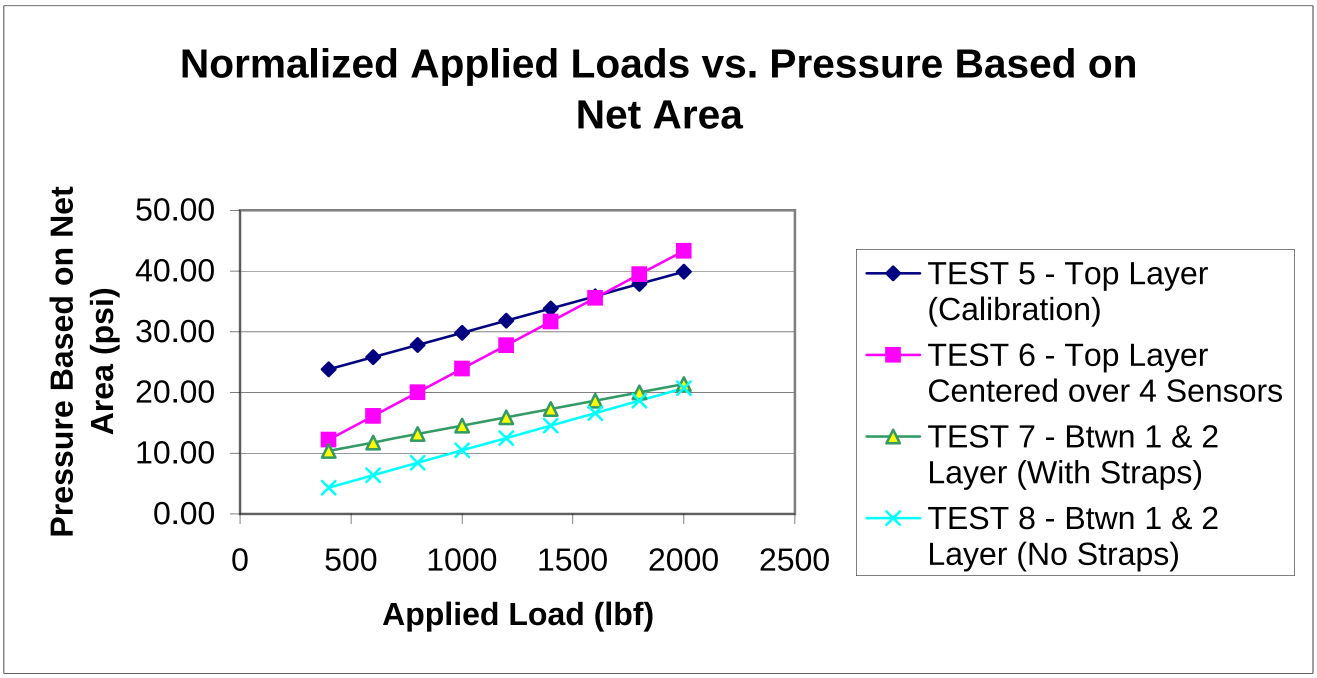


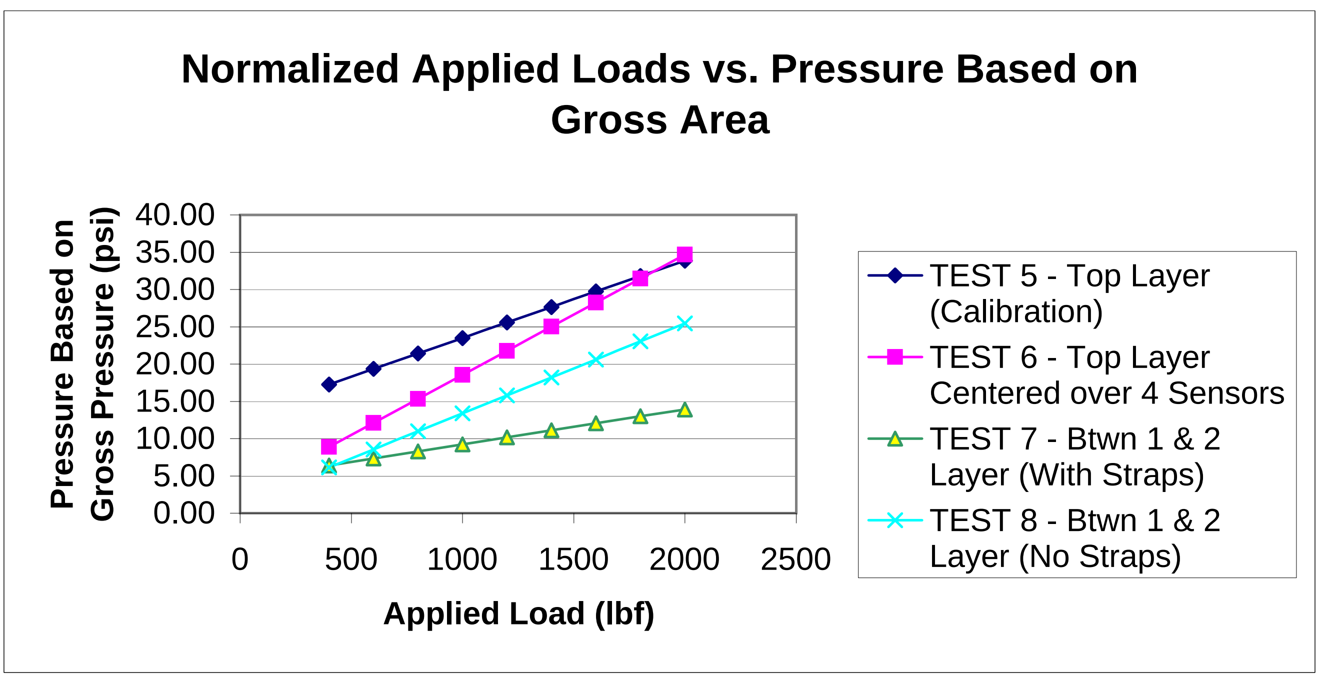
TEST 7 *Position: Between 1 & 2 Layer (With Straps)*



TEST 8 *Position: Between 1 & 2 Layer (No Straps)*




Normalized Applied Loads vs. Pressure Based on Net Area
Pressure Based on Net Area (psi)
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 5 - Top Layer (Calibration)
TEST 6 - Top Layer Centered over 4 Sensors
TEST 7 - Btwn 1 & 2 Layer (With Straps)
TEST 8 - Btwn 1 & 2 Layer (No Straps)


Normalized Applied Loads vs. Pressure Based on Gross Area
Pressure Based on Gross Pressure (psi)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 5 - Top Layer (Calibration)
TEST 6 - Top Layer Centered over 4 Sensors
TEST 7 - Btwn 1 & 2 Layer (With Straps)
TEST 8 - Btwn 1 & 2 Layer (No Straps)

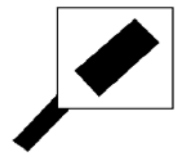
Tekscan Pressure Test in Asphalt Structure

9/22/2006

BIAS PLY TIRE

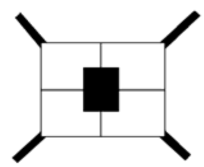
TEST 9 *Position: Top Layer (Calibration)*

Applied Load	Net Pressure	Gross Pressure
400	26.11	22.13
600	28.52	24.29
800	30.94	26.46
1000	33.35	28.63
1200	35.77	30.79
1400	38.18	32.96
1600	40.59	35.13
1800	43.01	37.30
2000	45.42	39.46



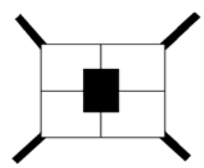
TEST 10 *Position: Top Layer Centered over 4 Sensors*

Applied Load	Net Pressure	Gross Pressure
400	22.34	19.71
600	25.02	22.19
800	27.70	24.67
1000	30.38	27.15
1200	33.07	29.64
1400	35.75	32.12
1600	38.43	34.60
1800	41.11	37.08
2000	43.79	39.57



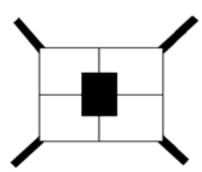
TEST 11 *Position: Between 1 & 2 Layer (With Straps)*

Applied Load	Net Pressure	Gross Pressure
400	10.40	6.40
600	11.77	7.34
800	13.15	8.28
1000	14.53	9.22
1200	15.90	10.16
1400	17.28	11.10
1600	18.65	12.04
1800	20.03	12.98
2000	21.40	13.92



TEST 12 *Position: Between 1 & 2 Layer (No Straps)*

Applied Load	Net Pressure	Gross Pressure
400	11.14	7.10
600	12.77	8.64
800	14.40	10.19
1000	16.03	11.73
1200	17.66	13.27
1400	19.29	14.82
1600	20.92	16.36
1800	22.55	17.90
2000	24.18	19.45

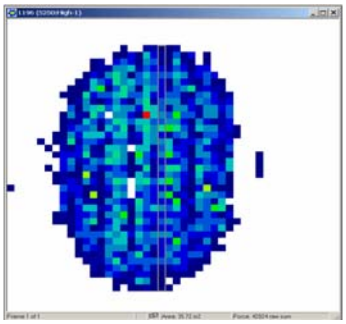
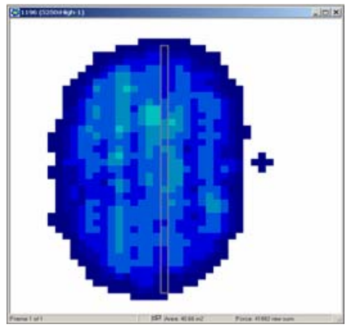
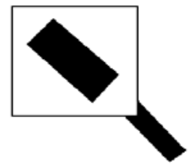


Tekscan Pressure Test in Asphalt Structure

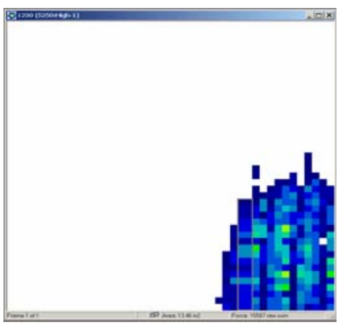
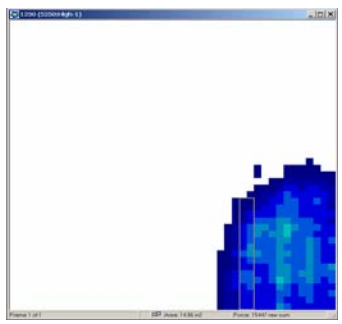
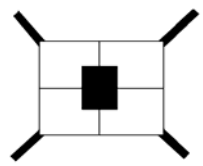
9/22/2006 ***BIAS PLY TIRE***

Note: All images are taken at approximately a 1200 lb load from Sensor 5250-8

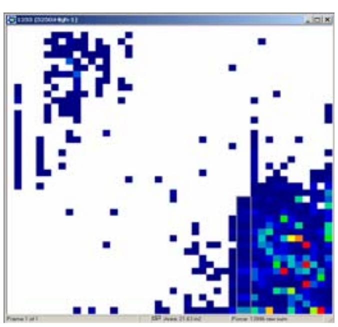
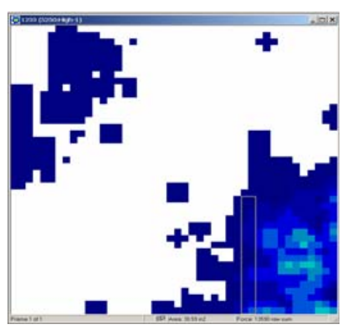
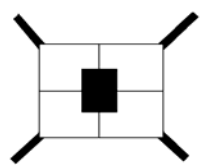
TEST 9 *Position: Top Layer (Calibration)*

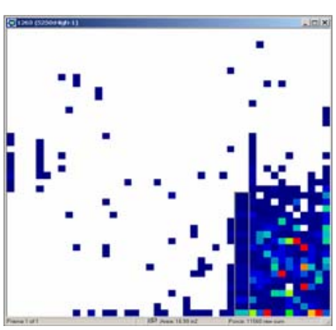
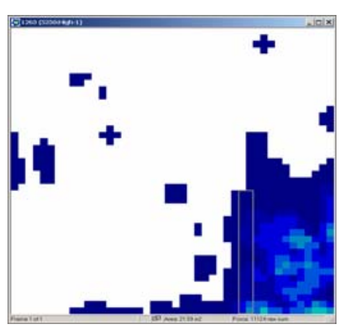
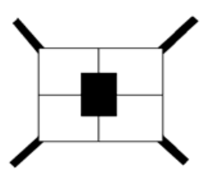
TEST 10 *Position: Top Layer Centered over 4 Sensors*

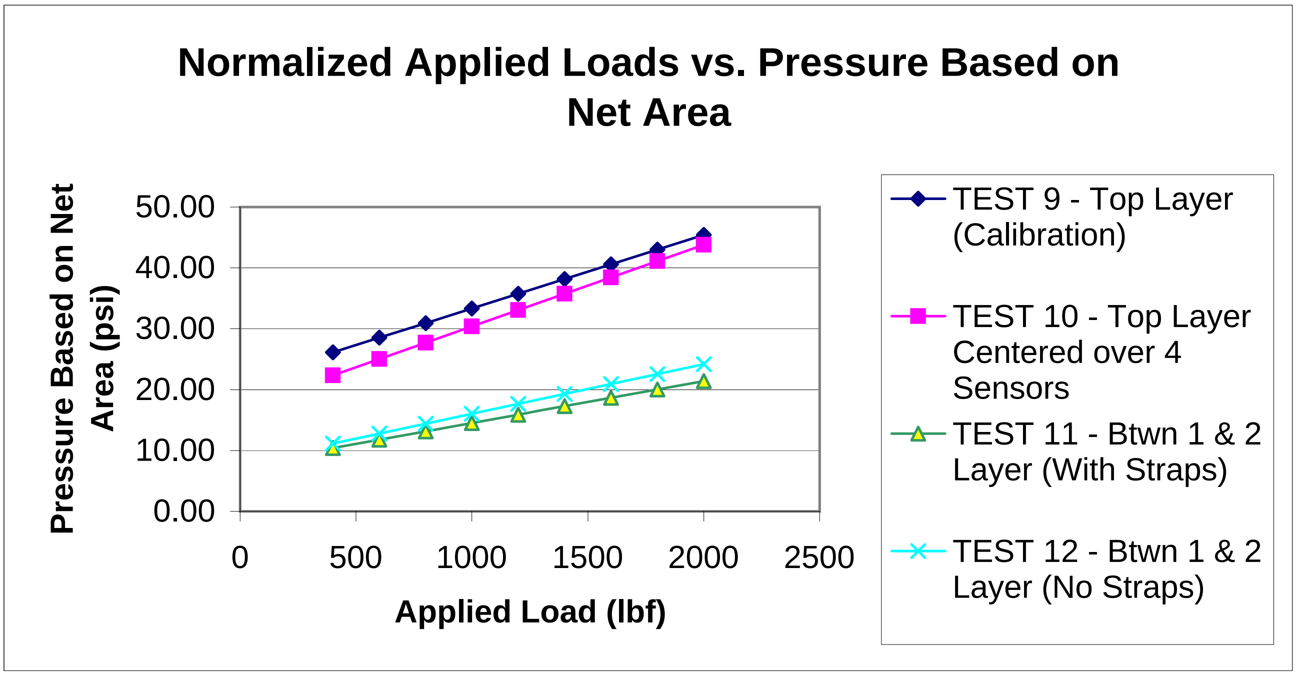




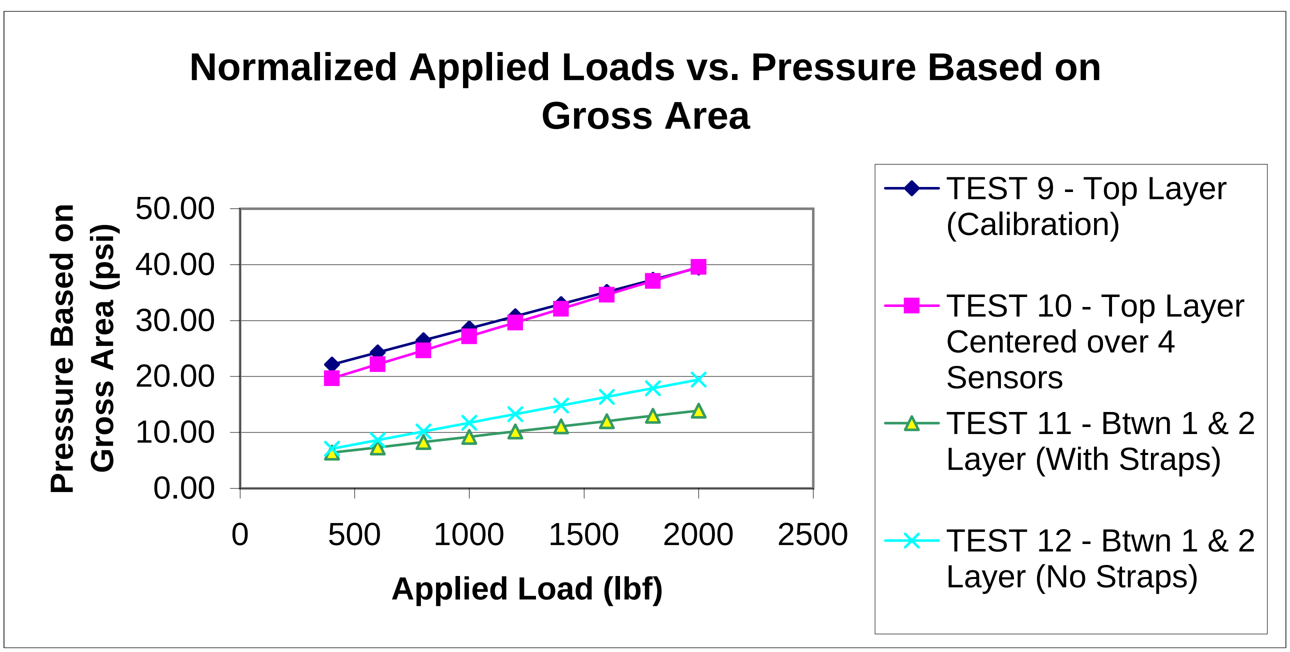
TEST 11 *Position: Between 1 & 2 Layer (With Straps)*

TEST 12 *Position: Between 1 & 2 Layer (No Straps)*


Normalized Applied Loads vs. Pressure Based on Net Area
Pressure Based on Net Area (psi)
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 9 - Top Layer (Calibration)
TEST 10 - Top Layer Centered over 4 Sensors
TEST 11 - Btwn 1 & 2 Layer (With Straps)
TEST 12 - Btwn 1 & 2 Layer (No Straps)

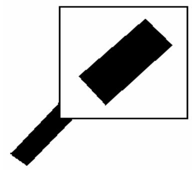

Normalized Applied Loads vs. Pressure Based on Gross Area
Pressure Based on Gross Area (psi)
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 9 - Top Layer (Calibration)
TEST 10 - Top Layer Centered over 4 Sensors
TEST 11 - Btwn 1 & 2 Layer (With Straps)
TEST 12 - Btwn 1 & 2 Layer (No Straps)

Tekscan Pressure Test in Asphalt Structure

10/5/2006 ***RADIAL TIRE***

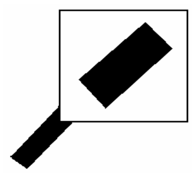
TEST 14a *Position: Top Layer (Calibration)*

Applied Load	Net Pressure	Gross Pressure
400	31.17	18.79
600	32.74	20.52
800	34.31	22.26
1000	35.87	23.99
1200	37.44	25.73
1400	39.01	27.47
1600	40.57	29.20
1800	42.14	30.94
2000	43.71	32.67



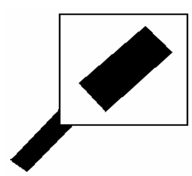
TEST 14b *Position: Between 1 & 2 Layer*

Applied Load	Net Pressure	Gross Pressure
400	10.64	6.11
600	12.28	7.31
800	13.93	8.52
1000	15.57	9.73
1200	17.22	10.94
1400	18.86	12.14
1600	20.50	13.35
1800	22.15	14.56
2000	23.79	15.77



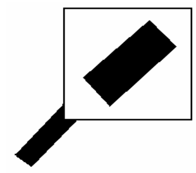
TEST 14c *Position: Between 2 & 3 Layer*

Applied Load	Net Pressure	Gross Pressure
400	8.72	4.55
600	10.14	5.56
800	11.56	6.57
1000	12.98	7.59
1200	14.40	8.60
1400	15.82	9.61
1600	17.24	10.62
1800	18.66	11.64
2000	20.08	12.65



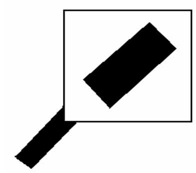
TEST 14d *Position: Between 3 & 4 Layer*

Applied Load	Net Pressure	Gross Pressure
400	11.01	5.74
600	12.27	6.52
800	13.53	7.29
1000	14.79	8.07
1200	16.04	8.84
1400	17.30	9.62
1600	18.56	10.40
1800	19.82	11.17
2000	21.07	11.95



TEST 14e *Position: Between Layer 4 & DGA*

Applied Load	Net Pressure	Gross Pressure
400	13.95	8.72
600	14.97	9.36
800	15.99	10.01
1000	17.02	10.65
1200	18.04	11.30
1400	19.06	11.95
1600	20.08	12.59
1800	21.10	13.24
2000	22.12	13.88

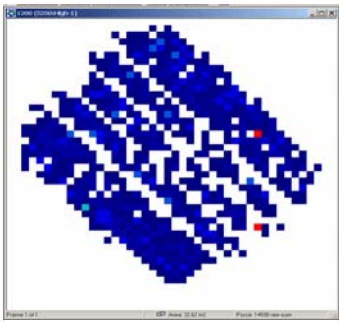


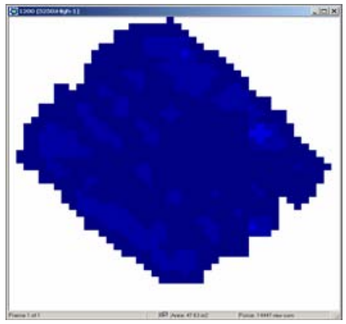
Tekscan Pressure Test in Asphalt Structure

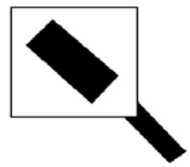
10/5/2006 **_RADIAL TIRE_**

Note: All images are taken at approximately a 1200 lb load

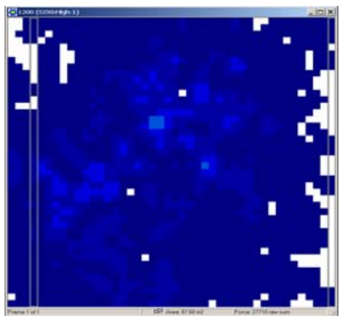
TEST 14a *Position: Top Layer*

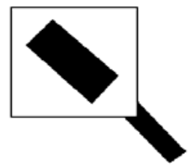




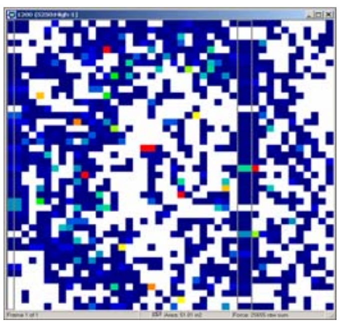


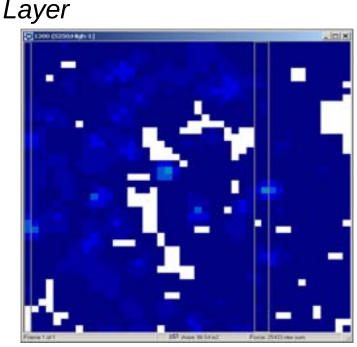
TEST 14b *Position: Between 1 & 2 Layer*

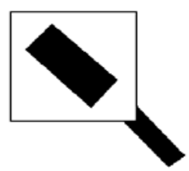




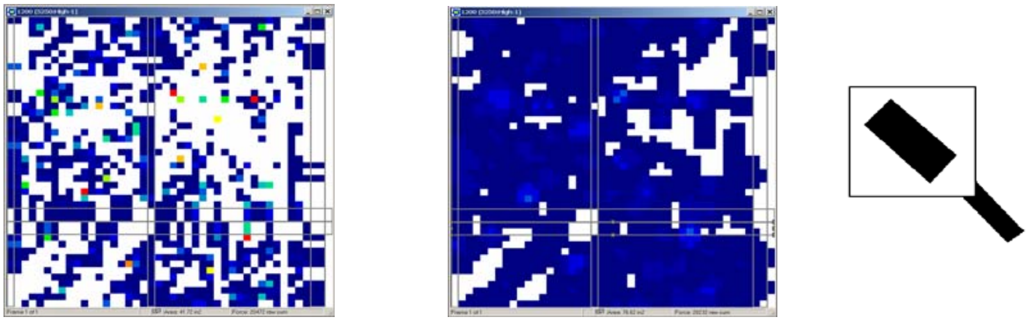
TEST 14c *Position: Between 2 & 3 Layer*



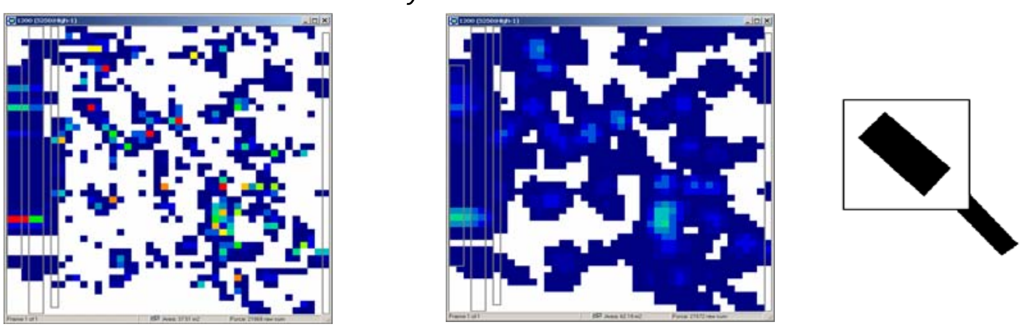




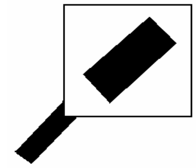
TEST 14d *Postion: Between 3 & 4 Layer*

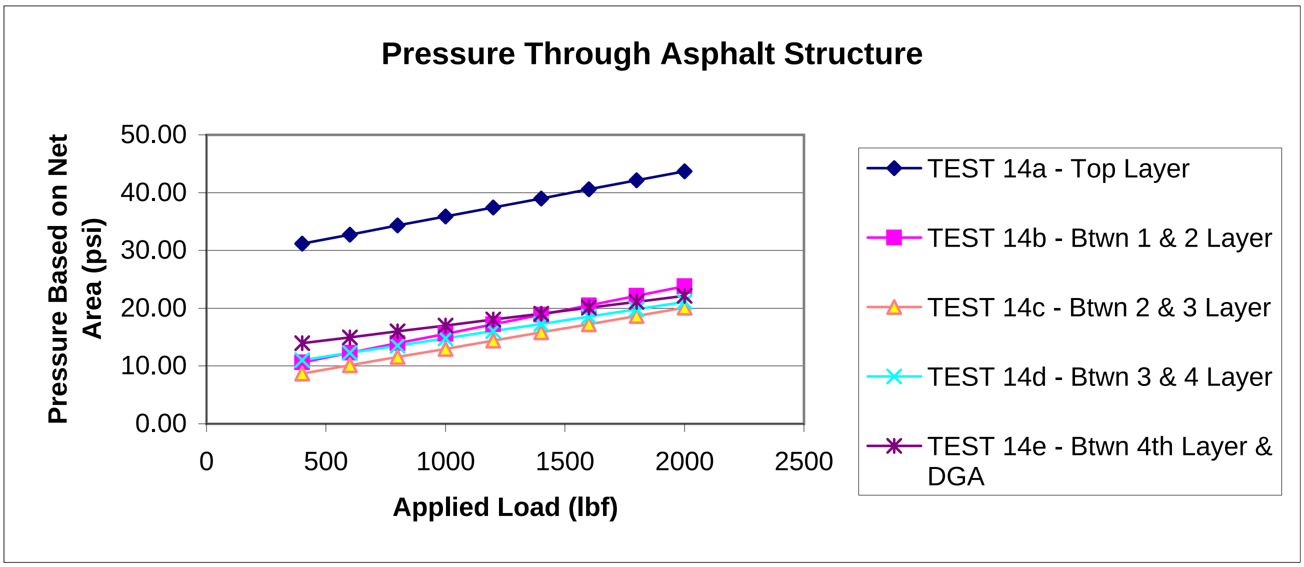


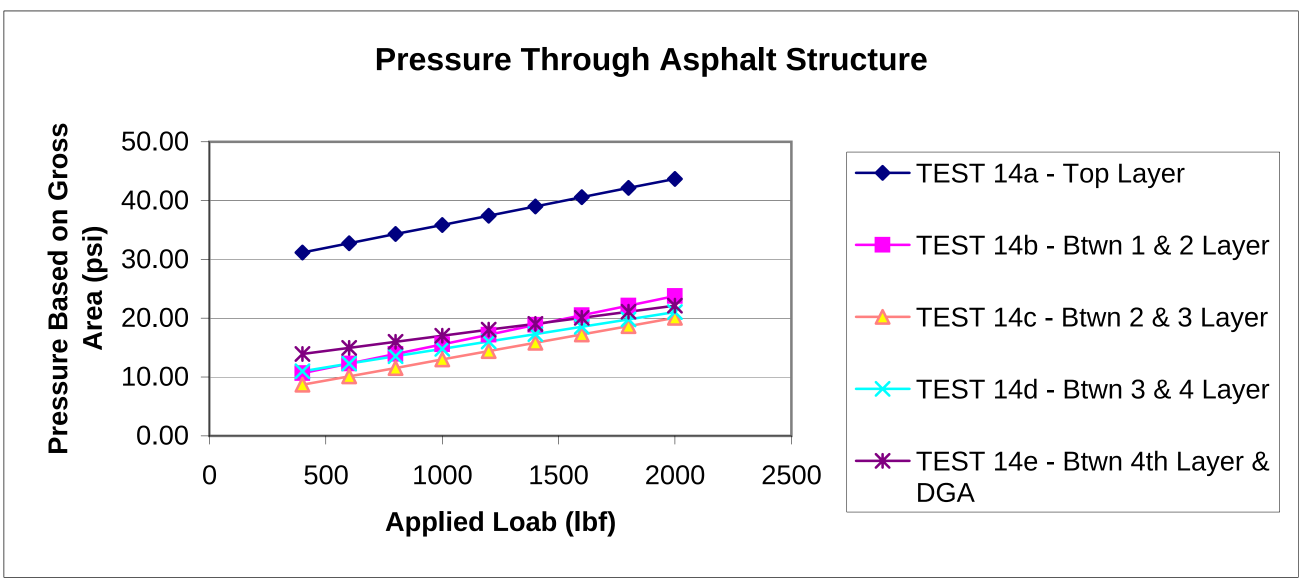
TEST 14e *Position: Between 4 Layer & DGA*



TEST 14




Pressure Through Asphalt Structure
Pressure Based on Net Area (psi)
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 14a - Top Layer
TEST 14b - Btwn 1 & 2 Layer
TEST 14c - Btwn 2 & 3 Layer
TEST 14d - Btwn 3 & 4 Layer
TEST 14e - Btwn 4th Layer & DGA

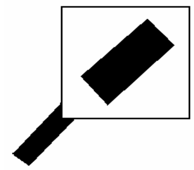

Pressure Through Asphalt Structure
Pressure Based on Gross Area (psi)
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Loab (lbf)
TEST 14a - Top Layer
TEST 14b - Btwn 1 & 2 Layer
TEST 14c - Btwn 2 & 3 Layer
TEST 14d - Btwn 3 & 4 Layer
TEST 14e - Btwn 4th Layer & DGA

Tekscan Pressure Test in Asphalt Structure

10/5/2006 ***BIAS PLY TIRE***

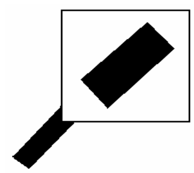
TEST 15a *Position: Top Layer (Calibration)*

Applied Load	Net Pressure	Gross Pressure
400	34.34	24.84
600	36.07	26.50
800	37.80	28.16
1000	39.53	29.82
1200	41.26	31.48
1400	43.00	33.14
1600	44.73	34.80
1800	46.46	36.46
2000	48.19	38.12



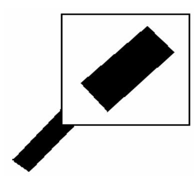
TEST 15a *Position: Between 1 & 2 Layer*

Applied Load	Net Pressure	Gross Pressure
400	11.66	6.16
600	13.03	7.30
800	14.39	8.44
1000	15.75	9.58
1200	17.11	10.71
1400	18.47	11.85
1600	19.84	12.99
1800	21.20	14.13
2000	22.56	15.27



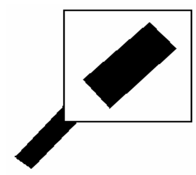
TEST 15c *Position: Between 2 & 3 Layer*

Applied Load	Net Pressure	Gross Pressure
400	10.79	5.95
600	12.12	6.90
800	13.46	7.85
1000	14.80	8.81
1200	16.14	9.76
1400	17.48	10.71
1600	18.82	11.66
1800	20.16	12.62
2000	21.50	13.57



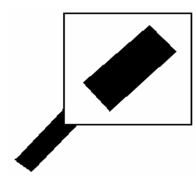
TEST 15d *Position: Between 3 & 4 Layer*

Applied Load	Net Pressure	Gross Pressure
400	10.60	6.06
600	11.75	6.76
800	12.89	7.46
1000	14.04	8.15
1200	15.18	8.85
1400	16.33	9.55
1600	17.47	10.25
1800	18.62	10.95
2000	19.76	11.65



TEST 15e *Position: Between Layer 4 & DGA*

Applied Load	Net Pressure	Gross Pressure
400	13.81	7.57
600	14.80	8.23
800	15.79	8.88
1000	16.79	9.53
1200	17.78	10.18
1400	18.77	10.84
1600	19.76	11.49
1800	20.75	12.14
2000	21.74	12.79

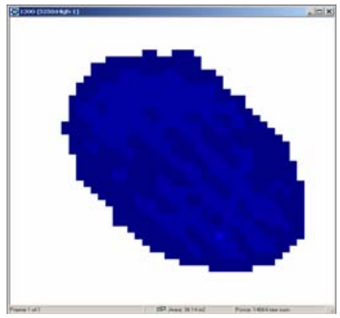
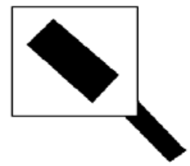


Tekscan Pressure Test in Asphalt Structure

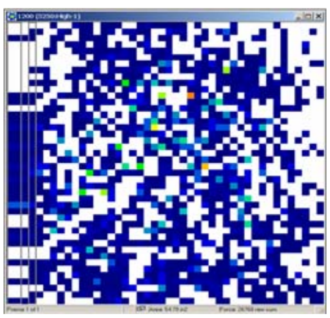
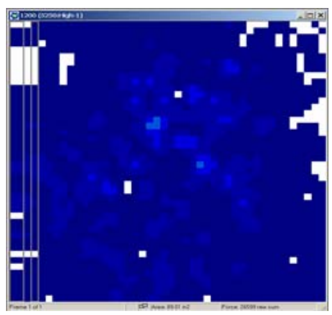
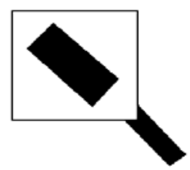
10/5/2006 ***BIAS PLY TIRE***

Note: All images are taken at approximately a 1200 lb load

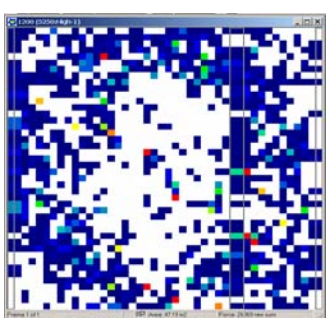
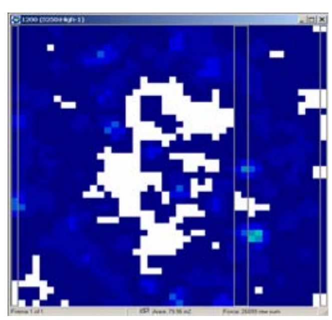
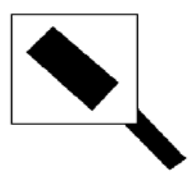
TEST 15a *Position: Top Layer*

TEST 15b *Position: Between 1 & 2 Layer*

TEST 15c *Position: Between 2 & 3 Layer*

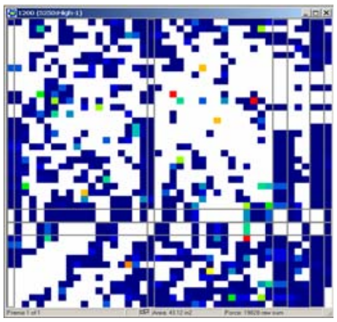




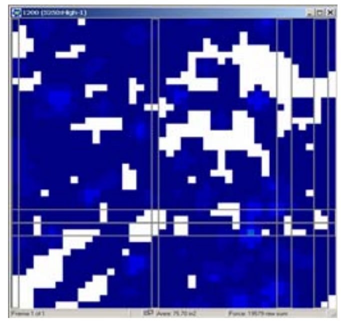
Tekscan Pressure Test in Asphalt Structure

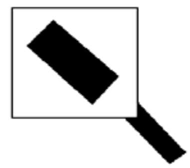
10/5/2006 ***BIAS PLY TIRE***

Note: All images are taken at approximately a 1200 lb load

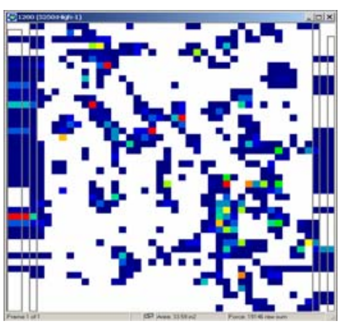
TEST 15d *Postion: Between 3 & 4 Layer*

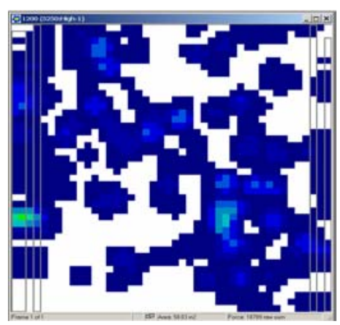


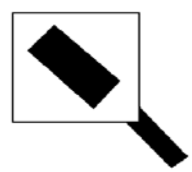




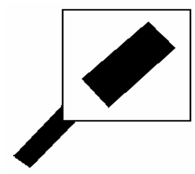
TEST 15e *Position: Between 4 Layer & DGA*

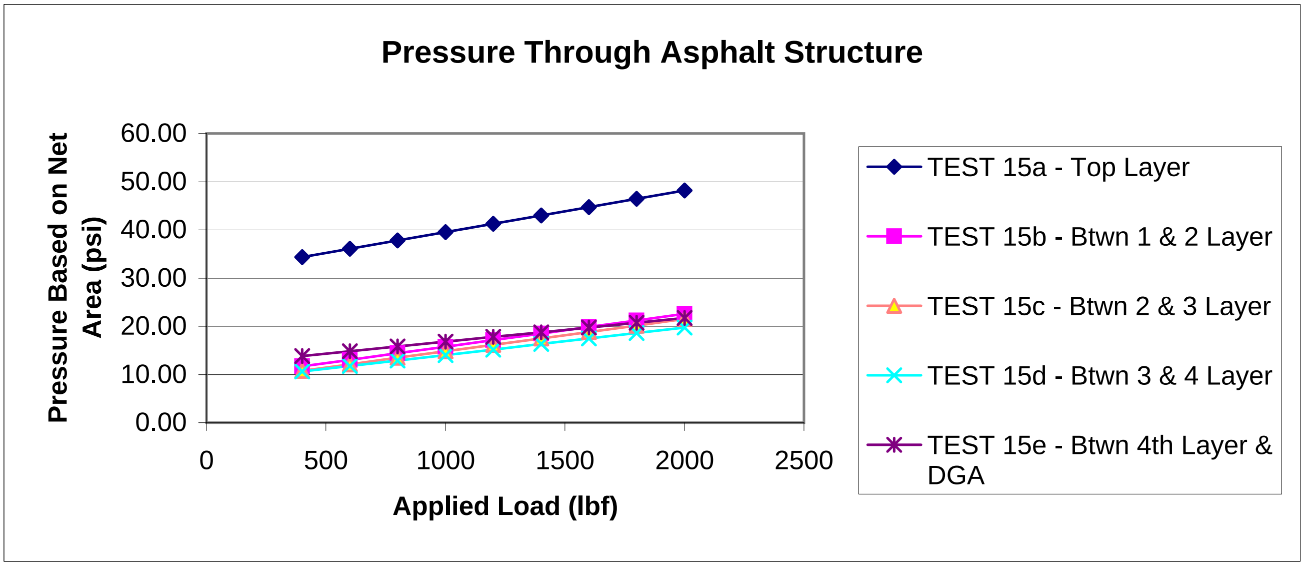




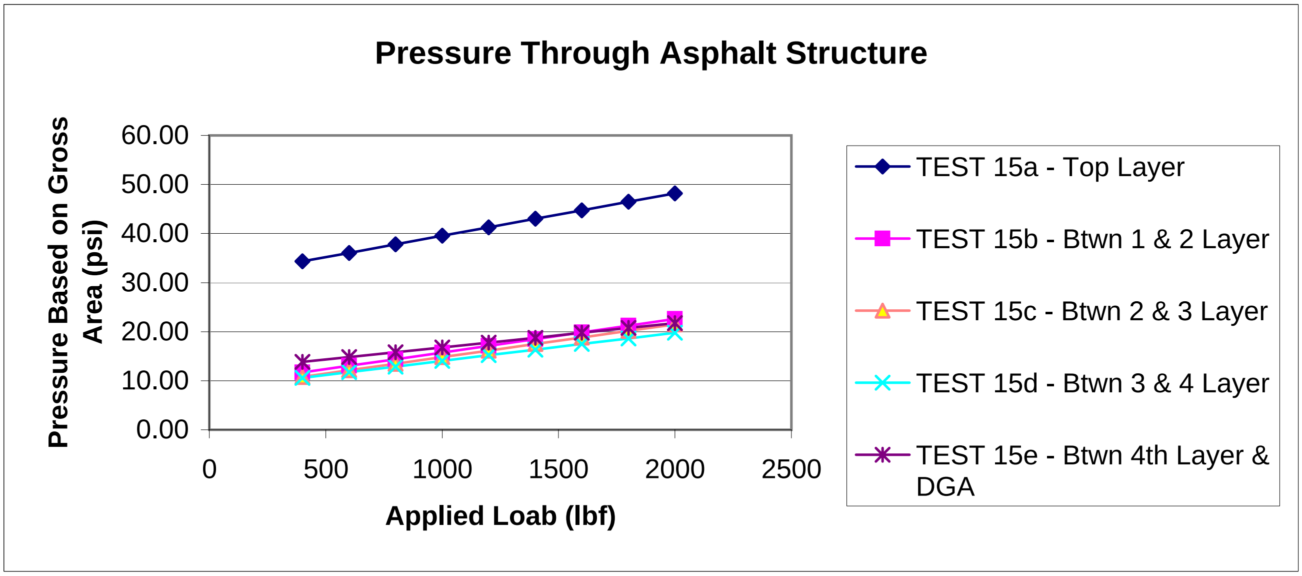


TEST 15





Pressure Through Asphalt Structure
Pressure Based on Net Area (psi)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 15a - Top Layer
TEST 15b - Btwn 1 & 2 Layer
TEST 15c - Btwn 2 & 3 Layer
TEST 15d - Btwn 3 & 4 Layer
TEST 15e - Btwn 4th Layer & DGA



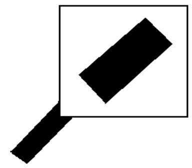
Pressure Through Asphalt Structure
Pressure Based on Gross Area (psi)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Loab (lbf)
TEST 15a - Top Layer
TEST 15b - Btwn 1 & 2 Layer
TEST 15c - Btwn 2 & 3 Layer
TEST 15d - Btwn 3 & 4 Layer
TEST 15e - Btwn 4th Layer & DGA

Tekscan Pressure Test in Asphalt Structure

10/5/2006

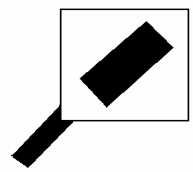
TEST 16a *Position: Top Layer (Calibration)*

Applied Load	Net Pressure	Gross Pressure
400	39.10	27.09
600	42.58	29.96
800	46.06	32.83
1000	49.54	35.69
1200	53.02	38.56
1400	56.50	41.42
1600	59.98	44.29
1800	63.46	47.16
2000	66.94	50.02



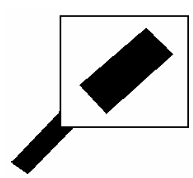
TEST 16b *Position: Between 1 & 2 Layer*

Applied Load	Net Pressure	Gross Pressure
400	10.70	5.43
600	12.73	6.91
800	14.77	8.38
1000	16.80	9.86
1200	18.83	11.33
1400	20.86	12.80
1600	22.90	14.28
1800	24.93	15.75
2000	26.96	17.23



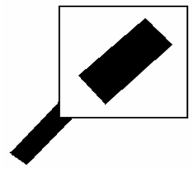
TEST 16c *Position: Between 2 & 3 Layer*

Applied Load	Net Pressure	Gross Pressure
400	9.08	4.99
600	10.95	6.33
800	12.83	7.67
1000	14.70	9.00
1200	16.58	10.34
1400	18.45	11.67
1600	20.33	13.01
1800	22.20	14.35
2000	24.08	15.68



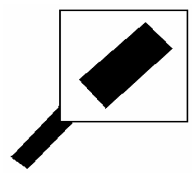
TEST 16d *Position: Between 3 & 4 Layer*

Applied Load	Net Pressure	Gross Pressure
400	9.53	5.71
600	11.26	6.81
800	12.99	7.90
1000	14.72	9.00
1200	16.45	10.09
1400	18.17	11.19
1600	19.90	12.28
1800	21.63	13.37
2000	23.36	14.47



TEST 16e *Position: Between Layer 4 & DGA*

Applied Load	Net Pressure	Gross Pressure
400	12.72	8.04
600	14.03	8.91
800	15.34	9.79
1000	16.65	10.66
1200	17.96	11.53
1400	19.27	12.41
1600	20.58	13.28
1800	21.89	14.16
2000	23.19	15.03

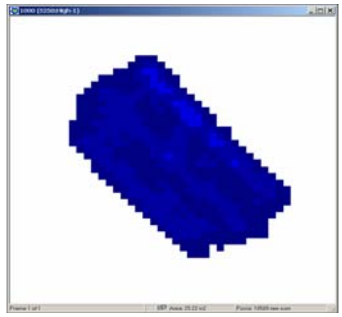
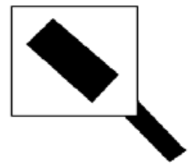


Tekscan Pressure Test in Asphalt Structure

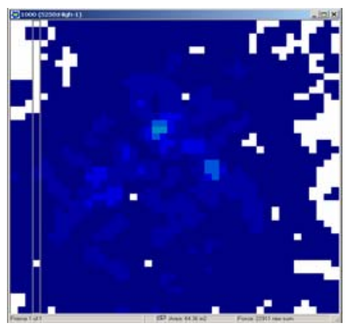
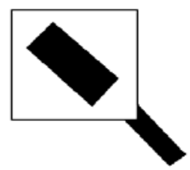
10/5/2006 ***SMALL UTILITY TRAILER TIRE***

Note: All images are taken at approximately a 1000 lb load

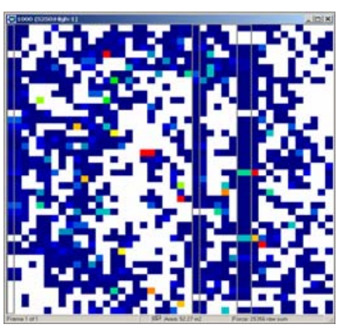
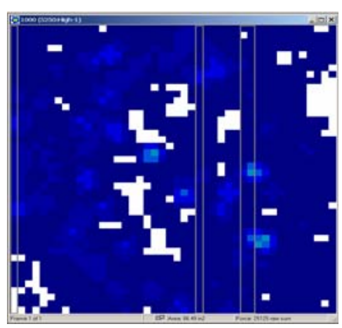
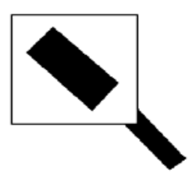
TEST 16a *Position: Top Layer*

TEST 16b *Position: Between 1 & 2 Layer*

TEST 16c *Position: Between 2 & 3 Layer*

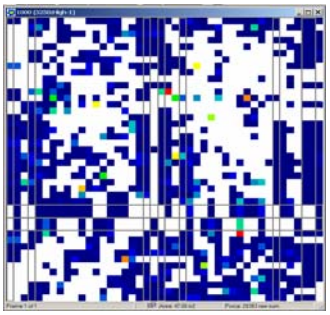




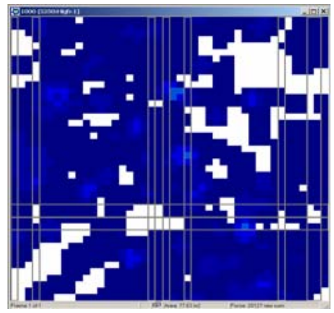
Tekscan Pressure Test in Asphalt Structure

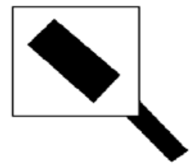
10/5/2006 ***BIAS PLY TIRE***

Note: All images are taken at approximately a 1000 lb load

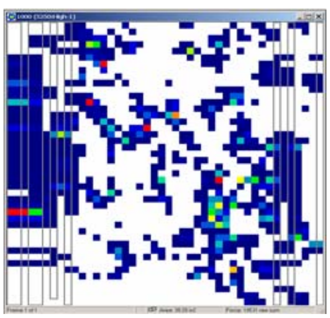
TEST 16d *Postion: Between 3 & 4 Layer*

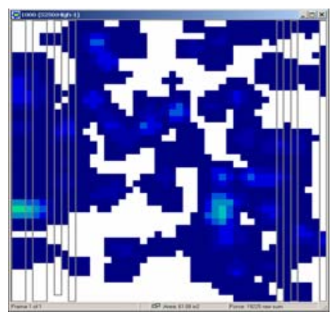


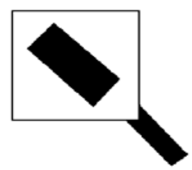




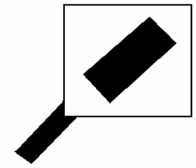
TEST 16e *Position: Between 4 Layer & DGA*

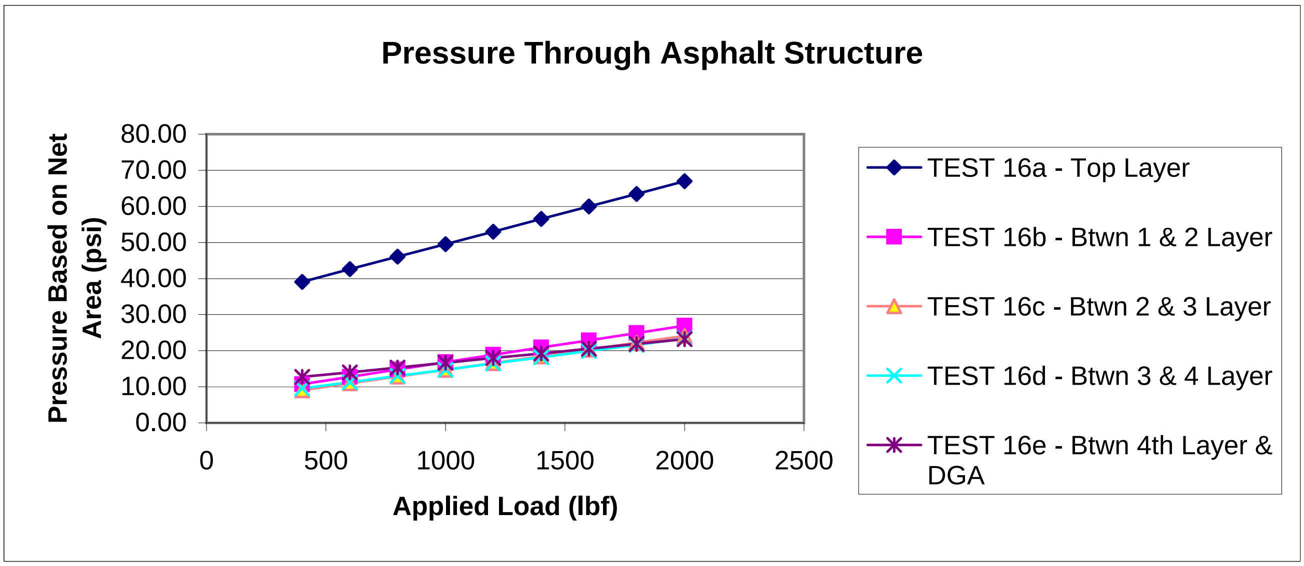




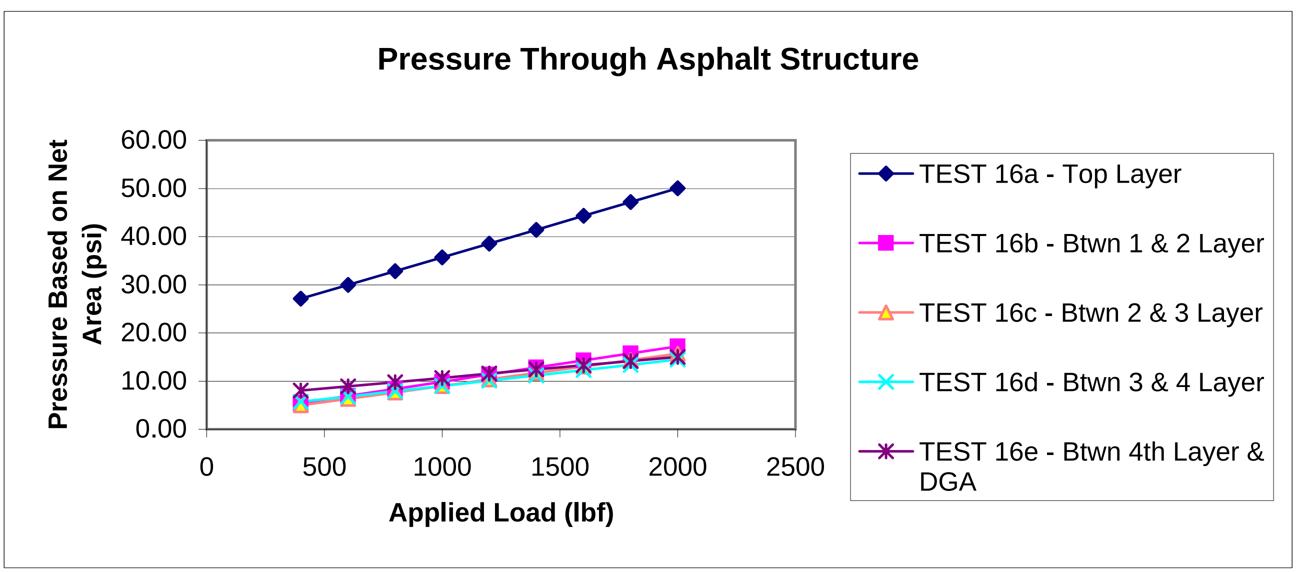


TEST 16





Pressure Through Asphalt Structure
Pressure Based on Net Area (psi)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 16a - Top Layer
TEST 16b - Btwn 1 & 2 Layer
TEST 16c - Btwn 2 & 3 Layer
TEST 16d - Btwn 3 & 4 Layer
TEST 16e - Btwn 4th Layer & DGA



Pressure Through Asphalt Structure
Pressure Based on Net Area (psi)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
500
1000
1500
2000
2500
Applied Load (lbf)
TEST 16a - Top Layer
TEST 16b - Btwn 1 & 2 Layer
TEST 16c - Btwn 2 & 3 Layer
TEST 16d - Btwn 3 & 4 Layer
TEST 16e - Btwn 4th Layer & DGA

Appendix G - Original Pavement Data

Tekscan Pressure Test in Asphalt Structure ***TEST 17***

Calibrations

Date: 10/25/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Sensor: 5250-9

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Calibration Factor (Based on Net Area) (Raw/lb)	Averagng Tekscan Raw Sum (Gross Area)	Calibration Factor (Based on Gross Area) (Raw/lb)	Default Net Area (in2)	Averaging Gross Area (in2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
21	70.1	1780	25.39	1730	24.68	3.68	7.31	19.05	9.59
44	93.1	2461	26.43	2416	25.95	4.07	8.23	22.87	11.31
800	849.1	25478	30.01	15380	18.11	26.86	38.24	31.61	22.20
800	849.1	27053	31.86	26948	31.74	27.98	38.72	30.35	21.93
1200	1249.1	37930	30.37	37864	30.31	36.83	49.13	33.92	25.42
1200	1249.1	39430	31.57	39390	31.53	37.51	49.71	33.30	25.13
1600	1649.1	47197	28.62	47144	28.59	42.98	55.66	38.37	29.63
1600	1649.1	49080	29.76	49029	29.73	43.12	56.19	38.24	29.35
			30.36		**28.34**				

Sensor: 5250-10

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Calibration Factor (Based on Net Area) (Raw/lb)	Averagng Tekscan Raw Sum (Gross Area)	Calibration Factor (Based on Gross Area) (Raw/lb)	Default Net Area (in2)	Averaging Gross Area (in2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
93	142.1	1682	11.84	1603	11.28	5.37	10.74	26.46	13.23
96	145.1	1495	10.30	1441	9.93	4.55	9.73	31.89	14.91
800	849.1	10799	12.72	10655	12.55	25.17	39.01	33.73	21.77
800	849.1	10576	12.46	10457	12.32	24.93	38.53	34.06	22.04
1200	1249.1	16257	13.01	16102	12.89	34.27	50.14	36.45	24.91
1200	1249.1	17122	13.71	16992	13.60	36.01	50.92	34.69	24.53
1600	1649.1	22866	13.87	22731	13.78	42.40	58.66	38.89	28.11
1600	1649.1	23511	14.26	23371	14.17	43.32	58.81	38.07	28.04
			13.34		**13.22**				

Sensor: 5250-8

TEST 17c

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
61	110.1	3488	31.68	3406	30.94	6.20	10.74	17.76	10.25
88	137.1	4633	33.79	4560	33.26	7.94	12.83	17.27	10.69
800	849.1	27668	32.59	27569	32.47	31.02	41.87	27.37	20.28
800	849.1	25416	29.93	25294	29.79	30.01	40.66	28.29	20.88
1200	1249.1	38283	30.65	38141	30.53	39.74	51.50	31.43	24.25
1200	1249.1	39013	31.23	38860	31.11	40.32	51.64	30.98	24.19
1600	1649.1	50170	30.42	50078	30.37	48.50	60.45	34.00	27.28
1600	1649.1	51143	31.01	57058	34.60	48.25	60.55	34.18	27.24
			30.97		**31.48**				

Sensor: 5250-6

TEST 17d

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
60	109.1	3151	28.88	3087	28.30	5.61	10.70	19.45	10.20
105	154.1	4476	29.05	4405	28.59	7.36	13.55	20.94	11.37
800	849.1	23964	28.22	23838	28.07	29.72	39.78	28.57	21.34
800	849.1	25629	30.18	25508	30.04	31.22	41.09	27.20	20.66
1200	1249.1	35670	28.56	35527	28.44	40.17	50.77	31.10	24.60
1200	1249.1	37333	29.89	37190	29.77	40.22	50.67	31.06	24.65
1600	1649.1	44361	26.90	44237	26.82	44.87	56.24	36.75	29.32
1600	1649.1	45436	27.55	45272	27.45	46.13	57.35	35.75	28.76
			28.55		**28.43**				

Sensor: 5250-5

TEST 17e

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
65	114.1	2418	21.19	2355	20.64	4.79	9.29	23.82	12.28
89	138.1	3184	23.06	3116	22.56	5.81	10.94	23.77	12.62
800	849.1	19356	22.80	19239	22.66	27.73	38.91	30.62	21.82
800	849.1	20110	23.68	19972	23.52	28.27	39.11	30.04	21.71
1200	1249.1	28202	22.58	28056	22.46	37.36	50.19	33.43	24.89
1200	1249.1	29691	23.77	29556	23.66	38.14	50.43	32.75	24.77
1600	1649.1	38398	23.28	38319	23.24	45.69	58.61	36.09	28.14
1600	1649.1	38045	23.07	37946	23.01	44.77	58.27	36.83	28.30
			23.20		**23.09**				

Tekscan Pressure Test in Asphalt Structure ***TEST 18***

Pressure Through Layers

Date: 10/25/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Position: Top of Asphalt

5250-9 ***TEST 18a***

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
47		3205	105.57	3172	111.93	4.89	9.15	22.89	11.54
1200		36853	1213.87	36771	1297.49	36.35	49.37	35.69	24.59
1200		38430	1265.81	38332	1352.58	36.98	49.66	36.58	25.49
			1239.84		**1325.04**			**36.14**	**25.04**

Position: Between 1 & 2 Layer

5250-10 ***TEST 18b***

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
71		2376	178.11	1874	141.75	12.78	26.38	11.09	6.75
1200		15779	1182.83	15486	1171.41	42.06	81.99	27.85	14.43
1200		16599	1244.30	16332	1235.40	43.17	82.86	28.62	15.02
								28.23	**14.72**

Position: Between 2 & 3 Layer

5250-8 ***TEST 18c***

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
21		5469	176.59	4988	158.45	26.52	55.37	5.97	3.19
1200		26719	862.74	26500	841.80	53.63	88.96	15.70	9.70
1200		27336	882.66	27116	861.37	53.92	89.25	15.98	9.89
								15.84	**9.79**

Position: **Between 3 & 4 Layer**

5250-6

TEST 18d

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
63		7755	271.63	7379	259.55	31.7	57.64	8.19	4.71
1200		22673	794.15	22440	789.31	48.55	79.86	16.26	9.94
1200		23721	830.86	23457	825.08	49.22	80.15	16.76	10.37
								16.51	**10.16**

Position: **Between 4th Layer & DGA**

5250-5

TEST 18e

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	**Adjusted Testing Machine Reading (lbf)**	**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
73		9774	421.29	9398	407.02	31.22	51.84	13.04	8.13
1200		19123	824.27	18781	813.38	38.91	62.97	20.90	13.09
1200		19553	842.80	19221	832.44	40.46	64.52	20.57	13.06
								20.74	**13.08**

Tekscan Pressure Test in Asphalt Structure — *TEST 19*

Tire Pressure Changes

Date: 10/25/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Position: Top of Asphalt - Tire Pressure 34 psi

5250-9 — ***TEST 19a***

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
66		4395	144.76	4350	153.49	6.58	11.86	23.33	12.21
1200		39763	1309.72	39671	1399.82	38.28	50.43	36.57	25.97
1200		40538	1335.24	40408	1425.83	38.82	50.53	36.73	26.42
								36.65	**26.20**

Position: Top of Asphalt - Tire Pressure 50 psi

5250-9 — ***TEST 19b***

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
57		4013	132.18	3957	139.63	5.61	9.68	24.89	13.66
1200		38856	1279.84	38763	1367.78	31.46	41.91	43.48	30.54
1200		40361	1329.41	40250	1420.25	32.14	42.3	44.19	31.43
1200		40578	1336.56	40470	1428.02	32.38	42.64	44.10	31.35
1200		40333	1328.49	40211	1418.88	32.28	42.35	43.96	31.37
								43.93	**31.17**

Position: Top of Asphalt - Tire Pressure 20 psi

5250-9 — ***TEST 19c***

A	B	C	D	E	F	G	H	I	J
Testing Machine Reading (lbf)	Adjusted Testing Machine Reading (lbf)	Default Tekscan Raw Sum (Net Area)	Load Based on Net Area Calibration Factor (C/c.f.)	Averagng Tekscan Raw Sum (Gross Area)	Load Based on Gross Area Calibration Factor (E/c.f.)	Default Net Area (in^2)	Averaging Gross Area (in^2)	Pressure Based on Net Area (psi)	Pressure Based on Gross Area (psi)
57		5053	166.44	5002	176.50	7.16	13.75	24.65	12.10
1200		38625	1272.23	38523	1359.32	45.79	61.42	29.69	20.71
1200		38533	1269.20	38439	1356.35	45.59	61.27	29.75	20.71
1200		39015	1285.08	38931	1373.71	45.64	61.32	30.10	20.96
1200		39105	1288.04	39010	1376.50	46.13	61.66	29.84	20.89
								29.84	**20.82**

Tekscan Pressure Test in Asphalt Structure ***TEST 20***

Tire Pressure Changes - Using Lab Calibration Factor

Date: 10/25/2006
Location: Vendor Street
Setup: Mercury Sable Front Right Wheel Running Back and Forth Over Sensor

Position: Top of Asphalt - Tire Pressure 36 psi

5250-9 ***TEST 20a***

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		28099	925.53	27989	987.61	24.78	34.12	37.35	28.95
1040		27013	889.76	26924	950.04	24.59	35.19	36.18	27.00
1040		27074	891.77	27000	952.72	24.49	33.88	36.41	28.12
1040		26545	874.34	26460	933.66	24.54	34.80	35.63	26.83
								36.39	**27.72**
Moved Sensor									
1040		26895	885.87	26812	946.08	25.75	34.65	34.40	27.30
1040		25634	844.33	25560	901.91	25.07	35.57	33.68	25.36
1040		26207	863.21	26092	920.68	25.31	34.41	34.11	26.76
1040		25871	852.14	25781	909.70	25.75	36.49	33.09	24.93
								33.82	**26.09**
							Total Average:	**35.11**	**26.90**

Position: Top of Asphalt - Tire Pressure 50 psi

5250-9 ***TEST 20b***

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		26215	863.47	26139	922.34	22.22	29.77	38.86	30.98
1040		25783	849.24	25701	906.88	22.70	31.65	37.41	28.65
1040		25973	855.50	25900	913.90	22.26	29.86	38.43	30.61
1040		25803	849.90	25726	907.76	22.65	31.94	37.52	28.42
								38.06	**29.67**
Moved Sensor									
1040		25975	855.57	25878	913.13	20.86	28.17	41.01	32.41
1040		25953	854.84	25874	912.99	21.39	30.69	39.96	29.75
1040		25624	844.01	25543	901.31	21.3	28.8	39.62	31.30
1040		25501	839.95	25429	897.28	21.68	30.49	38.74	29.43
								39.84	**30.72**
							Total Average:	**38.95**	**30.19**

Position: Top of Asphalt - Tire Pressure 20 psi

5250-9

TEST 20c

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		26724	880.24	26630	939.66	32.86	48.79	26.79	19.26
1040		24935	821.31	24863	877.31	32.77	48.69	25.06	18.02
								25.93	**18.64**
Moved Sensor									
1040		28088	925.16	28013	988.46	33.44	49.03	27.67	20.16
1040		28016	922.79	27944	986.03	35.09	51.11	26.30	19.29
1040		27312	899.60	27200	959.77	34.08	49.98	26.40	19.20
1040		26294	866.07	26209	924.81	34.07	49.37	25.42	18.73
								26.27	**19.11**
							Total Average:	**26.10**	**18.87**

Tekscan Pressure Test in Asphalt Structure ***TEST 21***

Field Calibration Factor

Date: 10/25/2006
Room: 16
Setup: Tire with Loading Apparatus (49.1 lb according to 077 scales)

Sensor: 5250-9

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		28099	27.02	27989	26.91	24.78	34.12	41.97	30.48
1040		27013	25.97	26924	25.89	24.59	35.19	42.29	29.55
1040		27074	26.03	27000	25.96	24.49	33.88	42.47	30.70
1040		26545	25.52	26460	25.44	24.54	34.80	42.38	29.89
			26.14		**26.05**				

Tekscan Pressure Test in Asphalt Structure — ***TEST 22***

Tire Pressure Changes - Using Field Calibration Factor

Date: 10/25/2006
Location: Vendor Street
Setup: Mercury Sable Front Right Wheel Running Back and Forth Over Sensor

Position: Top of Asphalt - Tire Pressure 36 psi

5250-9

TEST 22a

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		28099	1074.94	27989	1074.43	24.78	34.12	43.38	31.49
1040		27013	1033.40	26924	1033.55	24.59	35.19	42.03	29.37
1040		27074	1035.73	27000	1036.47	24.49	33.88	42.29	30.59
1040		26545	1015.49	26460	1015.74	24.54	34.80	41.38	29.19
								42.27	**30.16**
Moved Sensor									
1040		26895	1028.88	26812	1029.25	25.75	34.65	39.96	29.70
1040		25634	980.64	25560	981.19	25.07	35.57	39.12	27.58
1040		26207	1002.56	26092	1001.61	25.31	34.41	39.61	29.11
1040		25871	989.71	25781	989.67	25.75	36.49	38.44	27.12
								39.28	**28.38**
							Total Average:	**40.77**	**29.27**

Position: Top of Asphalt - Tire Pressure 50 psi

5250-9

TEST 22b

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		26215	1085.96	26139	1003.42	22.22	29.77	48.87	33.71
1040		25783	1068.06	25701	986.60	22.70	31.65	47.05	31.17
1040		25973	1075.93	25900	994.24	22.26	29.86	48.33	33.30
1040		25803	1068.89	25726	987.56	22.65	31.94	47.19	30.92
								47.86	**32.27**
Moved Sensor									
1040		25975	1076.01	25878	993.40	20.86	28.17	51.58	35.26
1040		25953	1075.10	25874	993.24	21.39	30.69	50.26	32.36
1040		25624	1061.47	25543	980.54	21.3	28.8	49.83	34.05
1040		25501	1056.38	25429	976.16	21.68	30.49	48.73	32.02
								50.10	**33.42**
							Total Average:	**48.98**	**32.85**

Position: Top of Asphalt - Tire Pressure 20 psi

5250-9

TEST 22c

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		26724	1107.04	26630	1022.26	32.86	48.79	33.69	20.95
1040		24935	1032.93	24863	954.43	32.77	48.69	31.52	19.60
								32.61	**20.28**
Moved Sensor									
1040		28088	1163.55	28013	1075.36	33.44	49.03	34.80	21.93
1040		28016	1160.56	27944	1072.71	35.09	51.11	33.07	20.99
1040		27312	1131.40	27200	1044.15	34.08	49.98	33.20	20.89
1040		26294	1089.23	26209	1006.10	34.07	49.37	31.97	20.38
								33.04	**20.79**
							Total Average:	**32.82**	**20.53**

Tekscan Pressure Test in Asphalt Structure — ***TEST 23***

Change Test Location - Using Lab Calibration Factor

Date: 10/25/2006
Location: Private Street to AAA
Setup: Mercury Sable Front Right Wheel Running Back and Forth Over Sensor

Position: Top of Asphalt - Tire Pressure 36 psi
5250-9

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Load Based on Net Area Calibration Factor (C/c.f.)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Load Based on Gross Area Calibration Factor (E/c.f.)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		22898	754.22	22817	805.12	23.14	33.83	32.59	23.80
1040		22794	750.79	22697	800.88	23.43	34.94	32.04	22.92
1040		22493	740.88	22411	790.79	22.80	33.20	32.49	23.82
1040		23013	758.00	22928	809.03	23.09	34.27	32.83	23.61
								32.49	**23.54**
Moved Sensor									
1040		22491	740.81	22411	790.79	22.31	33.4	33.21	23.68
1040		22125	728.75	22040	777.70	22.7	34.36	32.10	22.63
1040		21776	717.26	21690	765.35	21.83	33.25	32.86	23.02
1040		21710	715.09	21621	762.91	22.02	33.78	32.47	22.58
								32.66	**22.98**
							Total Average:	**32.58**	**23.26**

Tekscan Pressure Test in Asphalt Structure ***TEST 24***

Tire Pressure Changes - Using Field Calibration Factor (from Test 21)

Date: 10/25/2006
Location: Private Street to AAA
Setup: Mercury Sable Front Right Wheel Running Back and Forth Over Sensor

Position: Top of Asphalt - Tire Pressure 36 psi
5250-9

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		22898	875.98	22817	805.12	23.14	33.83	37.86	23.80
1040		22794	872.00	22697	800.88	23.43	34.94	37.22	22.92
1040		22493	860.48	22411	790.79	22.80	33.20	37.74	23.82
1040		23013	880.37	22928	809.03	23.09	34.27	38.13	23.61
								37.74	**23.54**
Moved Sensor									
1040		22491	860.41	22411	790.79	22.31	33.4	38.57	23.68
1040		22125	846.40	22040	777.70	22.7	34.36	37.29	22.63
1040		21776	833.05	21690	765.35	21.83	33.25	38.16	23.02
1040		21710	830.53	21621	762.91	22.02	33.78	37.72	22.58
								37.83	**23.26**
							Total Average:	**37.78**	**23.40**

Tekscan Pressure Test in Asphalt Structure — *TEST 25*

Field Calibration Unique to this Location

Date: 10/25/2006
Location: Private Street to AAA
Setup: Mercury Sable Front Right Wheel Running Back and Forth Over Sensor

Position: Top of Asphalt - Tire Pressure 36 psi
5250-9

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		22898	22.02	22817	21.94	23.14	33.83	44.94	30.74
1040		22794	21.92	22697	21.82	23.43	34.94	44.39	29.77
1040		22493	21.63	22411	21.55	22.80	33.20	45.61	31.33
1040		23013	22.13	22928	22.05	23.09	34.27	45.04	30.35
			21.92		**21.84**			**45.00**	**30.54**

Tekscan Pressure Test in Asphalt Structure ***TEST 26***

Tire Pressure Changes - Using Field Calibration Factor (from Test 25)

Date: 10/25/2006
Location: Private Street to AAA
Setup: Mercury Sable Front Right Wheel Running Back and Forth Over Sensor

Position: Top of Asphalt - Tire Pressure 36 psi
5250-9

A	B	C	D	E	F	G	H	I	J
Known Car Wheel Load (lbf)		**Default Tekscan Raw Sum (Net Area)**	**Calibration Factor (Based on Net Area) (Raw/lb)**	**Averagng Tekscan Raw Sum (Gross Area)**	**Calibration Factor (Based on Gross Area) (Raw/lb)**	**Default Net Area (in^2)**	**Averaging Gross Area (in^2)**	**Pressure Based on Net Area (psi)**	**Pressure Based on Gross Area (psi)**
1040		22898	1044.62	22817	1044.73	23.14	33.83	45.14	30.88
1040		22794	1039.87	22697	1039.24	23.43	34.94	44.38	29.74
1040		22493	1026.14	22411	1026.14	22.80	33.20	45.01	30.91
1040		23013	1049.86	22928	1049.82	23.09	34.27	45.47	30.63
								45.00	**30.54**
Moved Sensor									
1040		22491	1026.05	22411	1026.14	22.31	33.4	45.99	30.72
1040		22125	1009.35	22040	1009.16	22.7	34.36	44.46	29.37
1040		21776	993.43	21690	993.13	21.83	33.25	45.51	29.87
1040		21710	990.42	21621	989.97	22.02	33.78	44.98	29.31
								45.12	**30.18**
							Total Average:	**45.06**	**30.36**

References

Brian, M. (2006) Technical Article: *How the USB Port Works*. Accessed: February 9, 2006. <http://computer.howstuffworks.com/usb.htm>

Christian, S. (2005) "*Tire/Pavement Interface Pressure Measurements using Tekscan Sensors*". MSCE Report, University of Kentucky, July, 79 p.

Das, B. (2002) Principles of Geotechnical Engineer. Fifth Edition. Sacramento: Wadsworth Group, 589 p.

Geokon (2006) *Earth Pressure Cells Models 3500 & 4800*. Accessed: April 10, 2006. <http://www.geokon.com>

GlobalSpec (2006) The Engineering Search Engine. GlobalSpec, Inc. Accessed: 9/21/2006. <http://motion-controls.globalspec.com/>

Hildebrand, G. (2002) "Verification of Flexible Pavement Response From a Field Test." Danish Road Institute Report No. 121, 367 p.

Huang, Y. (2004) Pavement Analysis and Design. Second Edition. Upper Saddle Ridge: Pearson Prentice Hall, 775 p.

Luiz, G. (2005) Technical Article: *Bias Ply and Radial Tires*. October 1, 2005. Accessed: November 15, 2005. < http://www.off-road.com/ hummer /tech/bias-radial-tech.html>

Marshek, K., Chen, H., Connell, R., and Hudson, R. (1986) "Experimental Determination of Pressure Distribution of Truck Tire-Pavement Contact." Journal of the Transportation Research Board. No. 1070, pp. 9-14.

Marsili, R. (2000) "Measurement of the Dynamic Normal Pressure Between Tire and Ground *Using PVDF Piezoelectric Films." IEEE XPlore Release 2.1 17 Mar 2000. Accessed August 27, 2006 http://ieeexplore.ieee.org/Xplore/login.jsp?url= /iel5/19/18711 /00863916.pdf>*.

Rose, J.G., Brown, E.R. & Osborne, M.L. (2000) Asphalt Trackbed Technology Development: The First 20 Years. *Transportation Research Board 1713,* Transportation Research Board, pp. 1-9.

Rose, J.G. Walker, L.A. & Durrett, D.M. (2002) Panelized Asphalt Trackbed Rail/Highway Crossing Renewals: Procedures and In-Service Tests and Evaluations. *Proceedings of Railway Engineering-2002 5th International Conference and Exhibition*, London, 21p.

Rose, J.G. & Tucker, P.M. (2002) Quick-Fix, Fast-Track Road Crossing Renewals Using Panelized Asphalt Underlayment System. *Proceedings of the American Railway Engineering and Maintenance-of-Way Association 2002 Annual Conference and Expositions*, Washington, D.C., 34 p.

Rose, J.G., Li, D. & Walker, L.A. (2002) Heavy Haul Asphalt (HMA) Underlayment Trackbeds: Pressures/Deflections/Materials Properties Measurements. *Proceedings of Railway Engineering-2002 5th International Conference and Exhibition,* London, 18 p.

Rose, J. & Stith, J. (2004) Tekscan Sensors-Rail/Sleeper Interface Pressure Measurements in Railway Trackbeds. *Proceedings of Railway Engineering – 2004 7th International Conference and exhibition,* London, 21 p.

Ruth, B. E. (2006) "Transportation in the New Millennium: Asphalt Technology." Journal of the Transportation Research Board (A2D05: *Committee on General Issues in Asphalt Technology)*. Accessed: 20 Oct 2006 <http://onlinepubs.trb.org/onlinepubs/millennium/00007.pdf>.
2 p.

Satec (1997) Satec System Manual: NUVISION II Software. Satec Systems, Inc. pp 3.1-3.18.

Stith, J. (2005) "Railroad Track Pressure Measurements at the Rail/Tie Interface Using Tekscan Sensors". *MSCE Thesis,* at the University of Kentucky, May, 136 pp.

Tekscan (2003) I-Scan Pressure Measurement System: User's Manual Version 5.20, 155 p.

Tekscan (2006) I-Scan Pressure Measurement System. User's Manual Revision 1, 200 p.

Tyson, J. (2006) "How PCI Works." How Stuff Works. HowStuffWorks, Inc. Accessed: 9 Feb 2006 <http://computer.howstuffworks.com/pci.htm>.

Walker, L. A. (2002) "Evaluation of Hot-Mix Asphalt Underlayments in Railroad/Highway at Grade Crossing". *MSCE Thesis,* University of Kentucky, December, 163 p.

Wang, F., & Machemhl, R. (2006) "Mechanistic-Empirical Study of Effects of Truck Tire Pressure on Pavement - Measured Tire-Pavement Contact Stress Data." Journal of the Transportation Research Board No. 1947, pp. 136-145.

VITA

Justin Seth Anderson was born on January 21, 1983 in Danville, Kentucky. His parents are Steve and Jane Anderson. His elementary, secondary and high school education were completed in Danville, Kentucky. Upon graduation of high school in 2001, he attended the University of Kentucky where he received a Bachelor of Science in Civil Engineering in 2005. He began work on his Master's Degree in Civil Engineering in the Spring Semester of 2006, and since has been working toward obtaining this degree. Justin has published, with Dr. J.G. Rose, Long-Term Performance of Asphalt Underlayment Trackbeds for Special Trackwork Applications in the proceedings of the American Railway Engineering and Maintenance-of-Way Association 2006 Annual Conference and Exposition.