INVESTIGATION SURFACE CHARACTERISTICS OF CHIP SEALS UNDER HOT CLIMATE WITH NONDESTSRUCTIVE TESTS

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ABSTRACT

Chip Seals on unbound granular pavement most commonly used pavement type in Turkey. It is known that a lot of parameters effect on chip seal performance so it is important to known exactly the degree of these affected parameters. In this study, nondestructive tests were performed on a chip seal test section in Ýzmir Region of Turkish General Highways of Directorate along one year (TCK). The tests were repeated four times in one year. Sand circle test, British Pendulum test were performed and density of chip seal pavement was measured with electromagnetic surface contact method. Besides, surface temperatures were determined with thermal camera. Essentially the paper finds that Skid Numbers were decreased much more in rainy climates and surface macro texture were decreased due to traffic affect, hot temperature and aggregate wearing. This leads to bleeding problem on the chip seals. Also, chip seal density on the test section was increased because of the traffic affect.

Keywords: Chip Seal, Skid Number, Macro texture, Deteriorations

1. INTRODUCTION

Chip sealed pavements are the most used pavement type in Turkey due to the economic reasons. Turkey is the part of the countries in respect of the chip sealed roads length such as South Africa, Australia and New Zealand. A lot of factors can effect on the chip sealed pavements performance different from asphalt pavements. Consequently, some properties of before the construction and after the construction must be control to achieve the desired performance in chip seals. In order to obtain the appropriate design before the construction, bitumen and aggregate properties, cleanless of aggregate, calibration of construction machines, rolling, ambient temperature during the construction, traffic velocity control after the construction, drainage conditions, traffic load and a lot of other factors effects the chip seal's performance (SANRAL, 2005). One of the important factor effects on the pavements performance is traffic loads. Magnitude of the loads is one of the most important factor in whole of the failures occurred on the pavements (Whiteoak, 1990; Subagio, 2005; Karaşahin ve Gürer, 2007; Neaylon et.al., 2008). Loads that too much from standard axle load of 8,2 t damages the pavement as the loads divided by the standard loads and by 4 th exponents (Saltan, 2004). The scientist show that the influence of damage may be increased up to 6 th exponents in chip sealed or thin asphalt pavement when exceeded the legal axle loads (Whiteoak, 1990).

To evaluate of the performance of chip sealed pavement is fairly difficult than asphalt pavement. Gransberg and James stated that measuring of chip sealed pavement performance is different from the asphalt pavements (Gransberg and James, 2005). While rutting and roughness is important indicators of pavements performance in asphalt pavements, this type of failures are indirect indicator of pavements performance in chip sealed pavements. However raveling and flushing are the most important failure type in chip seals. Text method or device about measuring of raveling and flushing does not exist but scientist agreed that loss of macro texture also indicator of the flushing. Kuloglu and et al.(2004) stated that linear relation exist between amount of flushing and ambient temperature – traffic load – amount of bitumen. According to the Kuloglu and et al, most important factors in the flushing failure are traffic load, amount of bitumen and the ambient temperature. Macro texture is the most important performance indicator in the chip sealed pavements according to the New Zealand Specifications (TNZ, 2005). In addition to these varieties of skid numbers in chip seals also is a performance indicator. The aim of this study was to determine, chip sealed performance parameters under hot climate conditions with the nondestructive tests .

2. OBJECTIVES

The most important aim of this study was to determine the how macro texture, micro texture and chip seal density progress under the hot climate condition. For this purpose, a test road was chosen in İzmir Region of Turkish General Directorate of Highway and nondestructive tests were performed 4 different times in 1 year period and macrotexture, microtexture and density value variations were determined.

3. RESEARCH METHODOLOGY

Macrotexture, skid number and density are important performance indicators for Chip Seals. These parameters' values change over time and under traffic. 1200 m long road of 525-01 Highway (Didim-Söke Highway) was determined as test road which is exposed to hot climate conditions at most of the year. The highway has dual carriageway and 2 lanes on both ways and the test road was on Söke way's right line. The right line was chosen because of carrying the heavy traffic. The nondestructive tests and measurements were performed on shoulder (Point B), right wheel path (Point 1), between wheel paths (Point 2) and left wheel path (Point 3) at 200m intervals along the test road. The experimental study flow chart was given in Figure 1.

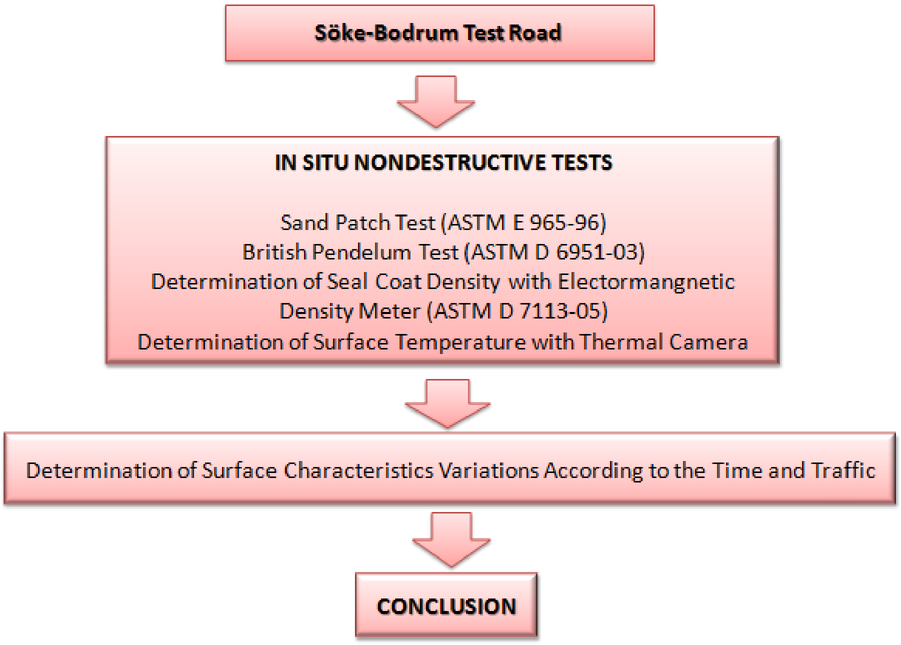

Figure 1. Experimental Study Flow Chart

To define the macrotexture of chip seal, the sand patch tests were performed according to ASTM 965-96 on the test road. Skid numbers of the points were determined with British Pendulum Test according to ASTM D 6951-03. Aggregate embedment, bitumen rise or the other factors may cause bleeding deterioration. When bleeding deterioration take place the density of chip seal changes. In order to determine the density of chip seal surface electromagnetic density gauge was utilized (ASTM D 7113-05).

The test road was constructed on July 2008 and opened to traffic at the same day. Chip seal was a single layer type chip seal. The nominal aggregate dimension was 12 mm and the bitumen penetration grade was 100/150. MC 30 cutback bitumen was used in primer coat. The physical properties of the aggregates are given in Table 1. The geometry of the road in project was flat and the pavement was constructed on embankment along the test road. The traffic composition of the road is given in Table 2.

Table1: Physical Properties of Aggregates

Aggregate Properties	**Value**	**Specification Limit**	**Specification**
Aggregate Type	Limestone	-	-
Bulk Spesific Gravity(g/cm^3)	2.649	-	ASTM C 127-88
Apparent Spesific Gravity(g/cm^3)	2.691	-	ASTM C 127-88
Los Angless Abrasion Value (%)	30.1	<35	ASTM C 131-89
pH	8.5	-	-
$MgSO_4$ Soundness Test (%)	0.199	<12	AASHTO T104
Flakiness Index (%)	21.8	<35	ASTM D4791-05
Aggregate Impact value (%)	14.14	<18	BS 812-112
Water Absorpsion (%)	0.701	-	ASTM C 127-88

Table2: 525-01 Highway Traffic Data (2008 and 2009)

Survey Year	AADT	Car	Pick-up	Bus	Truck	Tow Truck
2008	8333	6057	691	239	1032	314
2009	9466	7301	730	252	930	253

The nondestructive tests and visual inspections of surface conditions were carried out 4 times on the dates Aug 2009, Dec 2009, Apr 2010 and July 2010. At the first survey, polished aggregate, aggregate raveling, aggregate embedment and bleeding deteriorations were observed respectively in respect to their severity. Fatigue cracks were observed on subsequent surveys. Fatigue cracks first seen at the 3th survey between 1000-1200 meters of the test road. At the 4th survey under the left wheel path on 600 meters nearby rut deterioration progress was seen. Encountered deterioration types on the test road are illustrated in Figure 2.

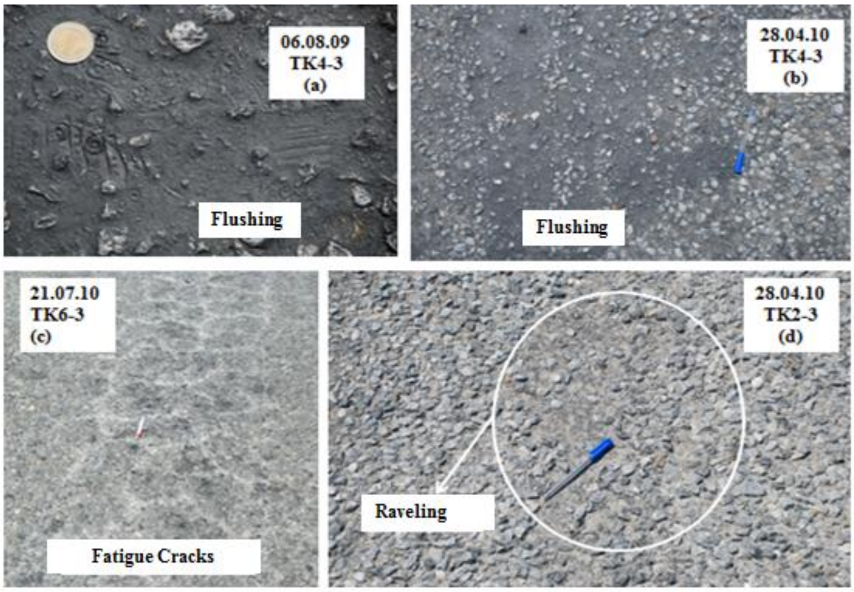

Figure2: Deterioration Types Encountered on the Test Road

4. RESULTS

4.1. Sand Patch Tests Results

Macro texture is the texture of the chip seal that can easily be seen with eye and dimensions of the wavelength and amplitude greater than 0,5 mm (TNZ, 2005). Macro texture is one the most important performance indicators of chip seals (Gürer, 2010). In order to determine the macro texture changes of the test road, sand-patch tests were carried out four different times. According to test results, macro textures of shoulder, right wheel path, between wheel paths and left wheel path are seen in Figure 3, 4, 5 and 6,respectively.

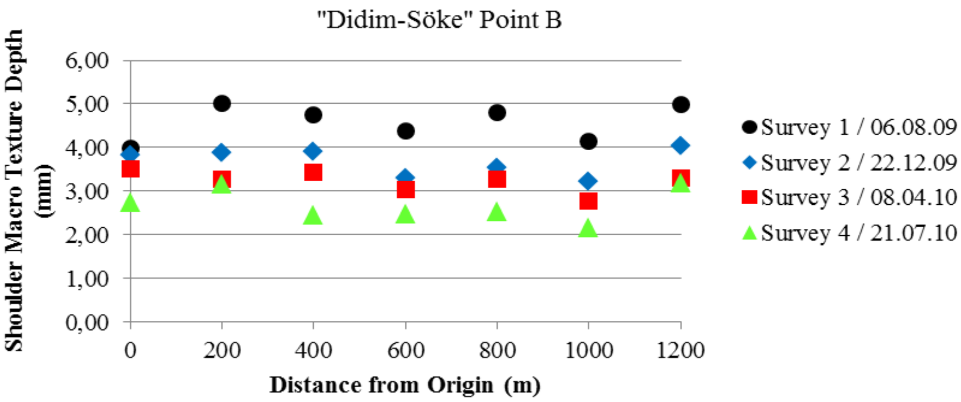

Figure 3: Shoulders Macro texture Depth Variations

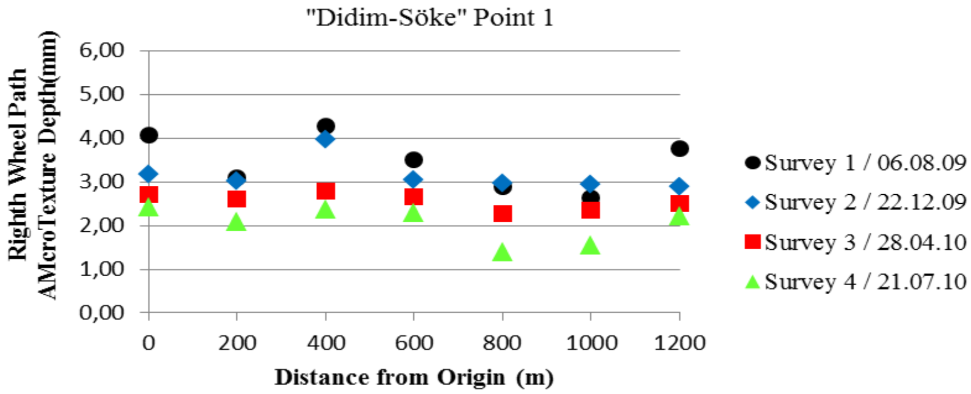

Figure 4: Right Wheel Paths Macro texture Depth Variations

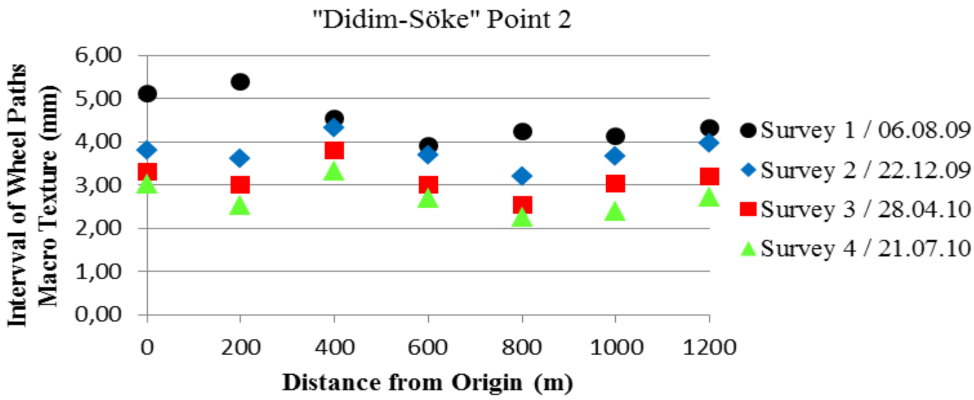

Figure 5: Interval of Wheel Paths Macro texture Depth Variations

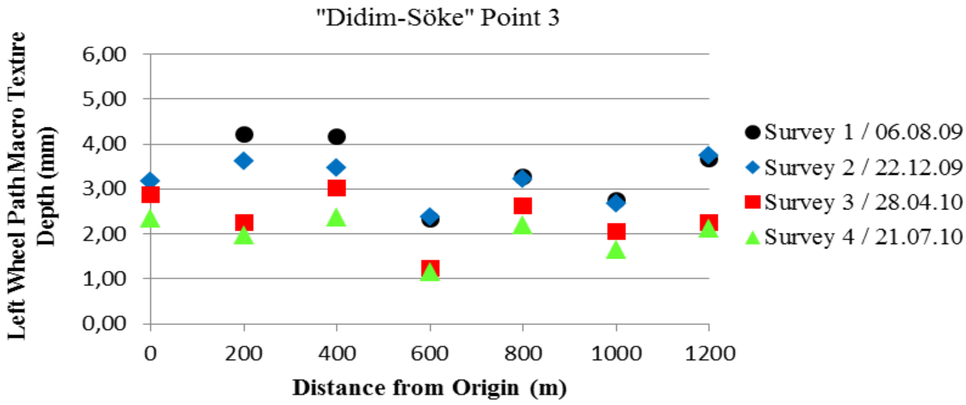

Figure 6: Left Wheel Paths Macro texture Depth Variations

At the end of first measurements macro texture values of points B, 1, 2 and 3 were determined 4.58, 3.46, 4.52 and 3.32 mm whereas macro texture results that were determined at the fourth measurements showed that values decreased to 2.68, 2.05, 2.72 and 1.97,respectively. These decreases much more on wheel paths (point number 1 and 3) as expected. Embedment and bleeding deteriorations were mostly seen between 600 and 800 meters of the test road . A lot of parameters effect on the embedment and bleeding deteriorations. Surface hardness, heavy vehicle traffic volume of the road and surface temperature when the heavy vehicle passing on the road, degradation due to rolling during the construction, aggregate abrasion because of the traffic effect are among the parameters which effect on the loss of texture and bleeding (Alderson, 2008). Especially, texture loss of points 1 and 3 test where wheel paths are concentrated confirms these statements indicated by Alderson.

4.2. British Pendulum Test Results

Other important performance parameter for Chip Seals is change of Skid Number. Especially in Pavement Management Systems Skid Number values changing is determined periodically. Friction resistance occurs between wheel tires and pavement surface and it is function of both macro texture and micro texture (Gransberg and James, 2005). chip seal aggregates abrade due to vehicle tires and water on the surface over time. Their sharp corners rounded and polished and this cause loss of surface texture. This situation leads to driving safety risk. Hence, after a period time chip seal needs to be rehabilitated. On the Chip Seal test road Skid Numbers were determined with British Pendulum Test device and skid number values of shoulder, right wheel path, between wheel paths and left wheel path are illustrated in Figure 7, 8, 9 and 10,respectively.

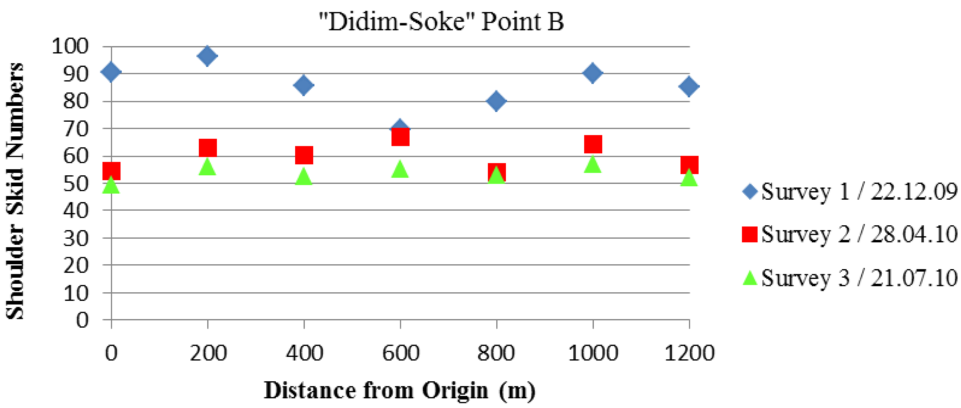

Figure 7:Shoulder Skid Number Variations

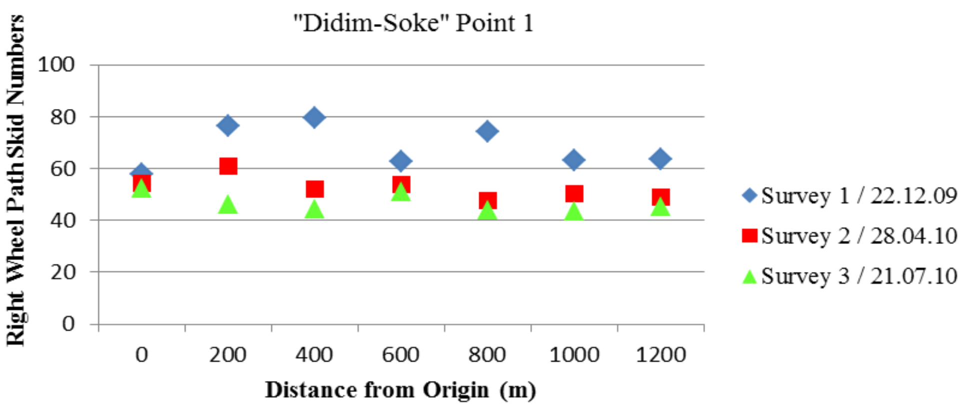

Figure 8:Right Wheel Path Skid Number Variations

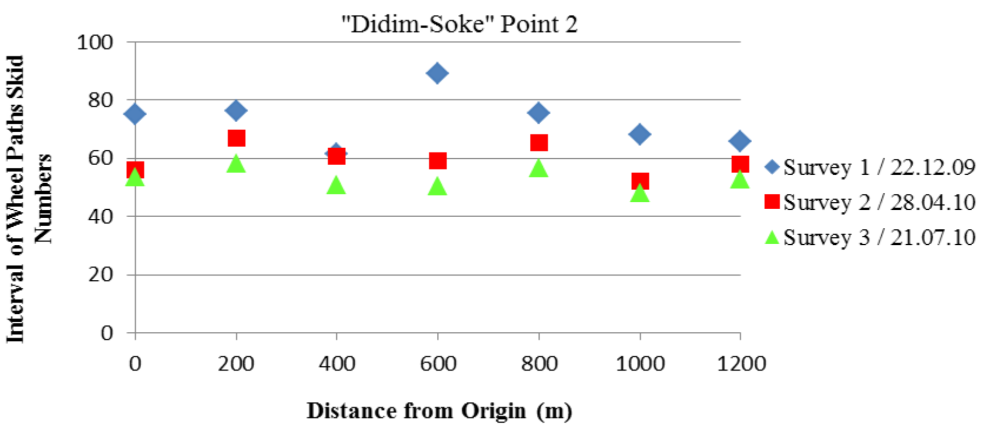

Figure 9:Interval of Wheel Paths Skid Number Variations

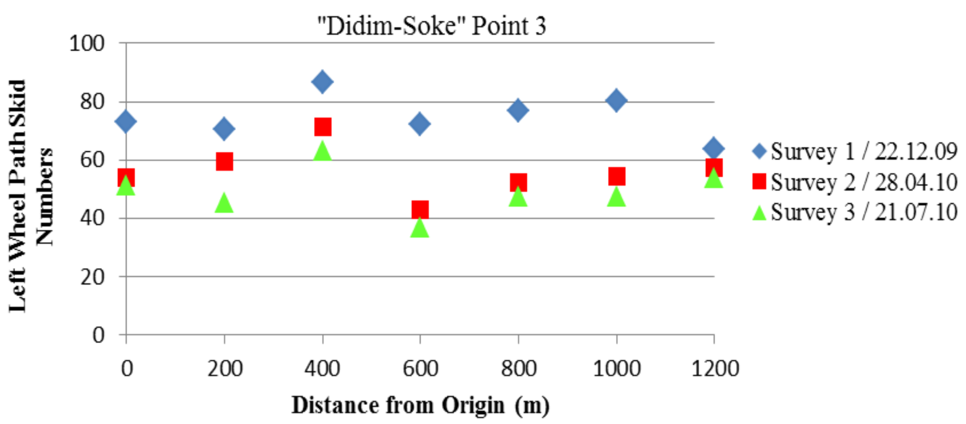

Figure 10:Left Wheel Path Skid Number Variations

On the Didim-Söke chip seal test road continuously decreasing trend was observed for Skid Numbers. Especially in the rainy autumn-winter season, decreasing of the skid number is much more apparent between 600 and 800 meters where texture loss seen. Woodside and Woodward (1998) conducted abrasion tests on the dry and wet aggregates and stated that moist aggregates have weaker strength than dry. Therefore, a high level of abrasion takes place if water in presence. As stated by Alderson (2008) aggregate abrasion accelerates under traffic. Finding derived from Didim-Soke inspection route confirms this idea. Average skid number values derived from second test on the B, 1, 2, and 3 points dropped were 85, 68, 73 and 75 to 54, 47, 53 and 49 respectively as a result of end of the fourth test. Skid number decreasing was identified point 1 and 3 where wheel paths are concentrated as well as macro texture loss at the same place. Fülop et al. (2000) reported that macro texture changes effect directly on the friction resistance.

4.3. Chip Seal Density Variations

Another important parameter for chip seals in terms of performance is density of the seal. Especially over time as a result of the aggregate embedment on the surface, abrasion or bitumen rising due to traffic and hot ambient temperature, air void decreases and density of the seal increases. For this purpose, changing of the seal densities were determined in four different times. In figure 11, 12, 13 and 14 density changes of the seal coats belong to B, 1, 2, 3 points are seen, respectively.

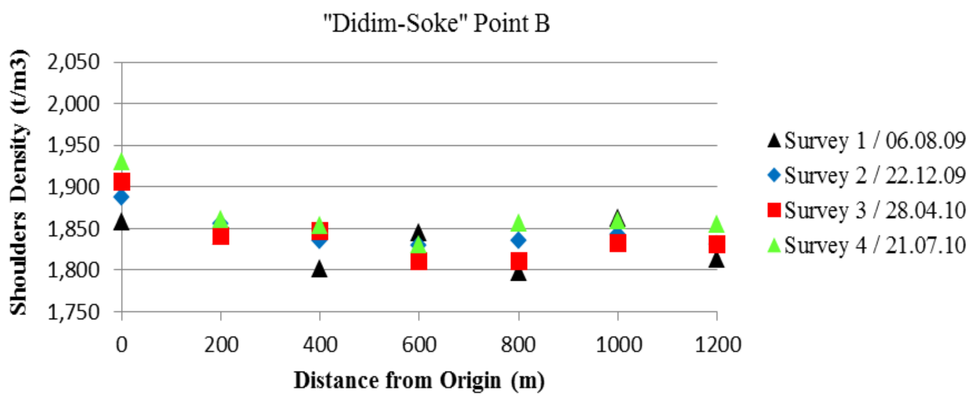

Figure 11:Shoulder Density Variations

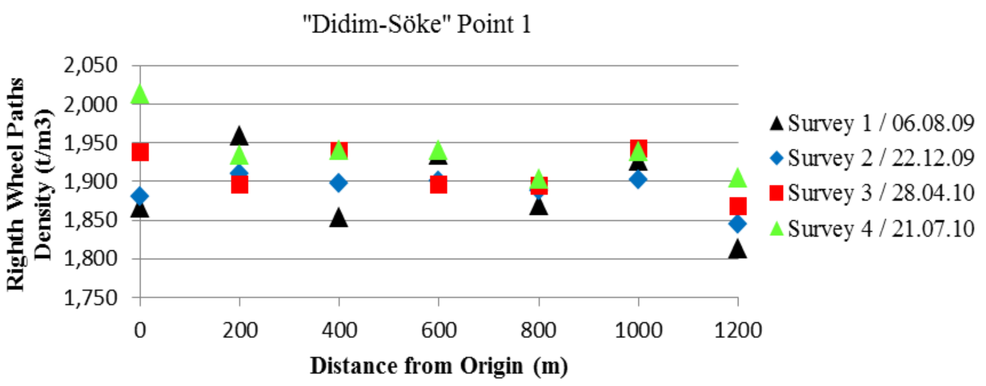

Figure 12:Right Whell Paths Density Variations

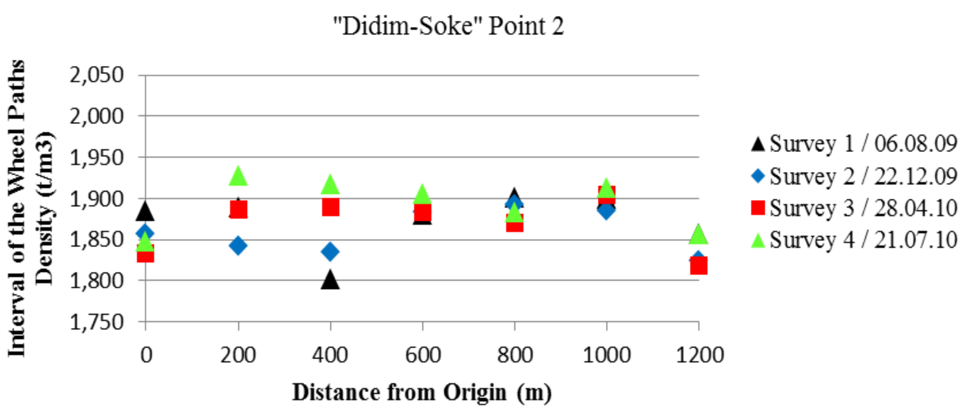

Figure 13:Interval of the Whell Paths Density Variations

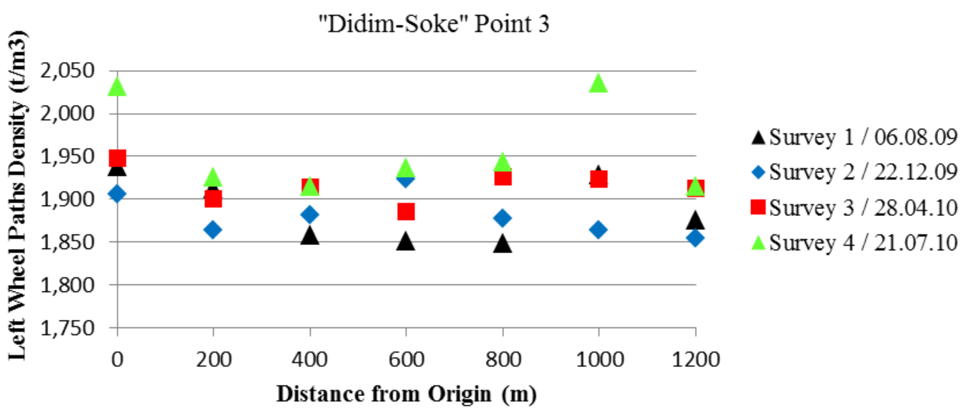

Figure 14:Left Whell Paths Density Variations

As it seen in Figure 12 and 14 aggregate embedment and bleeding deteriorations that are concentrated between 0-200 and between 600-800 meters have high chip seal density values on the wheel paths . Initially air void content between aggregates on the chip seal surfaces was high then air void decreased gradually due to effect of traffic and caused increase in density values. At the same time increasing of the surface texture loss and polished aggregate was lead to decreasing of the chip seal performance. Average density values that were measured at points B, 1, 2 and 3. on the first survey 1,831; 1,889; 1,874 and 1,888 t/m^3,respectively. On the fourth survey density values of the points that mentioned above were measured 1,864; 1,940; 1,894; 1,958 t/m^3,respectively. Although density increase on the B and 2 points where less exposed from traffic effect were limited density values increased in general over time as expected..

4.4. Surface Temperature Variations

Surface temperature also effects on the chip seal performance. Pavement surface temperature can reach to 60 ^{o}C depend on the air temperature of the pavement location (Gürer, 2010). Especially selection of the bitumen type to construction of chip seals affected by the maximum surface and ambient temperature. For this purpose surface temperature variation were measured with thermal camera when the tests were carried out and maximum surface temperature was recorded as 55 ^{o}C for test road in this study. Variation of surface temperatures can be seen in Figure 15.

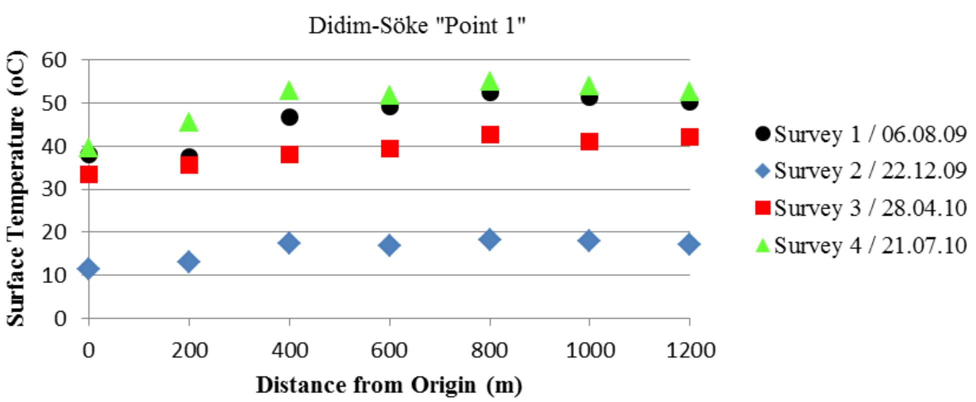

Figure 15: Didim-Söke Test Road Measuring Surface Temperature

5. CONCLUSIONS

Based on the results derived from the field test, the following conclusions can be drawn:

- Although the test road under the service about 2 years decreasing in the macrotexture depth higher than 2 mm. So it can be say that test road is good condition.

- Especially flushing deteriorations were determined in the part of the location of left wheel paths. The location is near the acceleration lane, the higher rate of aggregate loss after the construction, occurring in degradation in the aggregates due to steel wheeled rolling so rising the bitumen because of the hot climate and traffic are the main reasons the flushing deteriorations in this locations of the test roads.

- As stated by Woodside and Woodward (1998), it was determined that decreasing in the skid numbers of test roads was accelareted in the rainy seasons so the final values lower than 50 particularly in some test point of right, left and interval of the wheel paths.

- Observation of the how affected the surface parameters of chip seals by the climate, traffic, etc. is very important. Therefore to obtain the better performance from the chip sealed pavements, more test roads under the different condions should be investigate.

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