A STUDY TO DELINEATE CIRCUMSTANCES CAUSING RUTTING IN BRAND NEW ASPHALT PAVEMENTS AND DEVELOPING MITIGATION METHODS

Case History- Saluki Drive Pavement, Southern Illinois University Carbondale

Abstract

A pavement structure comprises of various layers, which are adhered together at the interfaces. They are designed to bear wheel load from different vehicles, change in climatic conditions, which mainly deal with bearing capacity and durability. Research has been progressing with new methodologies over the years, based on the pavement performance. The failure in a pavement can be dependent on various factors and its mitigation is based on proper understanding of the issue, and to what extent the damage has been occurred. The main reason for failure of a pavement is due to the development of material stresses, leading to problems such as depressions, cracking, potholes, rutting, upheavals and raveling. The present paper deals with the failure in an asphalt pavement, at Southern Illinois University Carbondale named saluki drive. The reason for the failure, repair and its mitigation in future are addressed by a local engineering firm called Holcomb. Core samples were drilled, and the samples were tested for moisture and bitumen content, and the reason for failure was determined.

Introduction

Pavement performance over the years has become an important study, based on durability and bearing capacity. Research is getting innovative in terms of using commercial products, to enhance the service life as well as recycled materials to promote sustainable environment. The following is the generalized literature review, based on the issues encountered in the failure of the saluki drive asphalt pavement.

Francesco et al. (2012) studied the issues caused in an interlayer bonding in asphalt pavement, based on stress strain distribution from traffic loads for pavement performance. Testing was carried out with three real scale pavement sections, each section consisted of two layers and three different interface conditions were used. Shear and torques tests were done on 1400 cores, for which fourteen laboratories across 11 countries were involved. The ultimate shear and its corresponding displacements were recorded, and shear strength was determined based on specifications like diameter, test temperature and speed, load applied and age of specimen. The results showed a dependency on size, as maximum shear stress at different temperatures for higher diameter cores were low compared to smaller diameter cores. Aged samples had maximum shear stress, there was a relation between test speed and maximum shear stress, no proper relation between shear and torque tests due to limited number of tests performed by the laboratories.

Gonzalo Valdes et al. (2010) observed the effect of high percentage of reclaimed asphalt pavement (RAP) in recycled asphalt mixtures. Two different aggregate size 12 mm and 20mm were used with 40% and 60% RAP. The variation of RAP in recycled mixture was studied and then mechanical properties were examined, based on stiffness modulus, indirect tensile strength, cracking and fatigue behavior. Their findings proved that more percentage of the recycled materials can be used with bitumen to replicate conventional asphalt mix, provided by applicable identification and appropriate usage of RAP stockpiles.

Yilmaz et al. (2012) examined the effect of water on deteriorations in asphalt pavement. Damages due to moisture is an international interest, as it leads to degradation of strength and durability of the pavement. Moisture breaks down the bond between the asphalt, filler, coarse and fine aggregates. Water related problems are site specific and needs proper understanding of the problem. Their findings also concluded that, the test methods carried out and the fluctuation in results is a challenging aspect to quantify the moisture effect.

Ali et al. (2005) analyzed the effect of Fine aggregate angularity (FAA) in comparison to resistance offered to rutting in hot-mix asphalt. Test samples were sourced from 30 different sites, of which 4 were sands and 26 were crushed aggregates which were crushed using distinct crusher types. Rutting test were performed using a simulation equipment, for samples having different angularities. Their results indicated that angularity can be determined by the mineralogical properties and the type of crusher used. Further, an increased resistance to rutting in hot-mix asphalt was observed with samples having high FAA. Sureyya et al. (2007) studied the rutting performance of asphalt mixtures containing polymer modifiers. One ordinary mix and five modified mixes were examined. The study was done to compare, LCPC wheel tracking test of French rutting tester using different loading criteria's and temperatures with mechanical tests like indirect tensile strength, static and repeated creep. Their findings indicated the use of additives, had an increase in resistance to permanent deformation, though having varying performance levels. With modified mixes, the resistance to rutting was more, static creep results did not have a proper trend as conventional mixes were better.

Hamid et al. (2017) investigated the rutting performance of Warm mix asphalt (WMA) containing high content of Reclaimed asphalt pavement (RAP) and compared with same graded HMA (Hot mix asphalt). An organic and a chemical additive was used in the WMA mixtures. The percentage of RAP used in mixes was 0, 25, 50 and 75 of total aggregates. Resistance to permanent deformation was determined by conducting dynamic creep and wheel track tests. Results demonstrated that, Chemical WMA had lower resilient modulus value and rutting resistance, also with increase in RAP in the mixes, rutting resistance and resilient modulus improved. Fereidoon et al. (2013) predicted the rutting performance of Warm mix asphalt (WMA) containing Reclaimed asphalt pavement (RAP). The percentage of RAP used in WMA mixes was 0, 15, 30, 50 and 60. Marshall and dynamic creep tests were done to see the brunt of RAP on rutting properties. Their results showed that using 60% RAP with WMA mix had efficient rutting properties due to increase in binder's viscosity, however use of high percentage of RAP led to increase in moisture sensitivity. To figure out moisture problems, indirect tensile strength was conducted and tensile strength ratio (TSR) OF 70% was found optimum with 50% replacement of RAP.

Okan et al. (2008) compared the rutting resistance of unmodified and SBS-modified superpave mixtures by accelerated pavement testing. SBS is an elastometer blended with bitumen to increase abrasion resistance and reduce the aging phenomena of the pavement. The use of polymers in the mix is to increase crack and rutting resistance. Rutting resistance is determined for modified and unmodified mixes, using a heavy vehicle simulator. Their findings indicated that, rutting in unmodified mix was due to a dual action of densification and shoving, whereas for modified mix, it was mainly due to densification. Alexander et al. (2012) evaluated the rutting susceptibility of polymer-modified asphalt mixtures containing recycled pavements. Asphalt pavement analyzer (APA) was used to carry out the rutting tests and Dynamic shear rheometer was used to evaluate the binders. For different polymers, the level of oxidation and polymer content were analyzed. They concluded that, the least affected mixes were binders which are hugely modified. Rutting was dependent on aggregate properties and addition of RAP binder to the mix resulted in receding the rutting.

Construction Background

The following pictures show the location of the saluki drive asphalt pavement and the detail of the surface course of a conventional flexible pavement. One side of the road connects the Interstate 51 and the other leads to the parking lot of the arena and to the campus of Southern Illinois University Carbondale. Most of the student parking facility is on either sides of this saluki drive, so the traffic volume was high during the school hours or during the graduation ceremonies, football and basketball game at the arena. It was a normal conventional mix, used for the pavement, as it is a local road connecting the highway and the school campus.

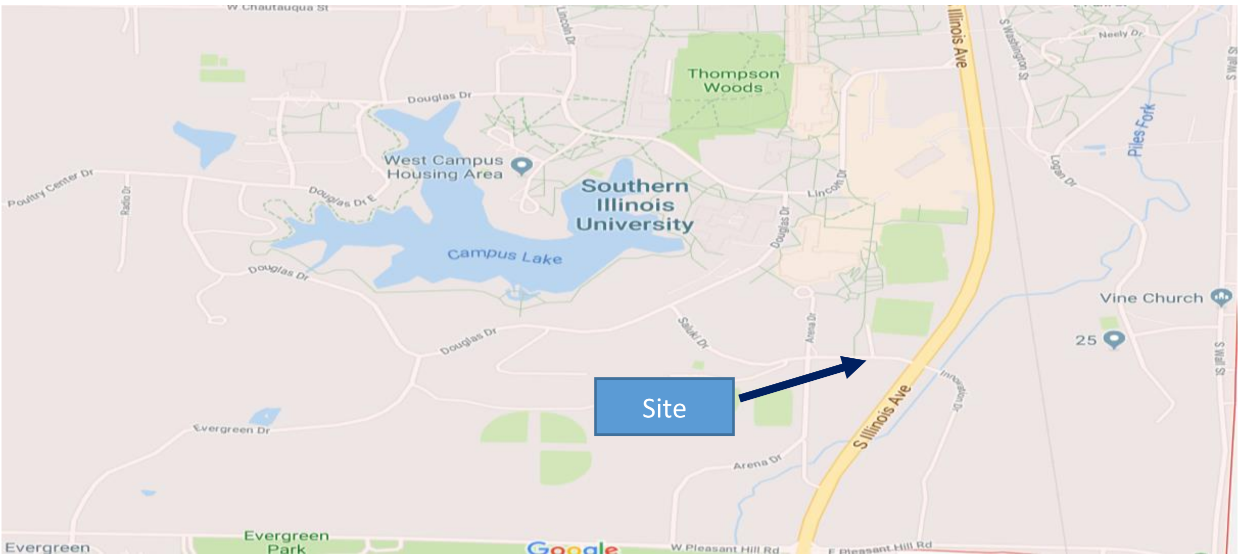

Fig 1: Project site and location pointed in the picture

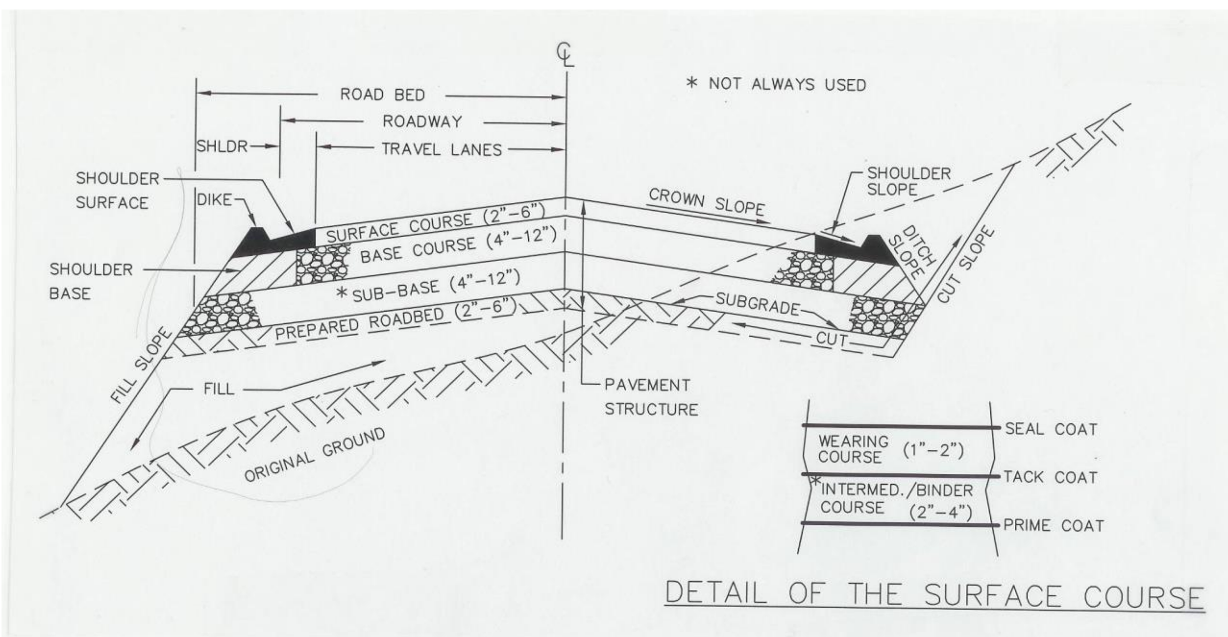

Fig 2: Conventional Flexible Pavement

Failure in the Saluki Drive Pavement

The saluki drive pavement showcased the rutting phenomena, in less than a month from when it was laid. As discussed in the literature, the causes of rutting may depend on various factors, proper investigation and the extent of the issue, can lead to a better solution. The following are the pictures explaining the failure of the pavement.

Fig 3: Rutting of the Saluki Drive Pavement

Fig 4: No proper bonding between the layers of the asphalt pavement

Fig 5: Sample cores drilled at the failure location

Fig 6: Water clog on the surface, due to inadequate drainage

Test Method

To figure out the reason for the rutting, bond failure, and the water clog on the surface, sample cores were tested for percentage of bitumen and split spoon samples were drilled and collected to see the crushed stone moisture percentage.

Fig 7: Core samples for bitumen content and split spoon sample for crushed stone moisture percentage

Results and Discussions

The following Table 1, presents the results of crushed stone moisture percentage, by drying the samples in the oven at a regulated temperature. The typical optimum moisture content (OMC) of crushed stone is from 5-7%. It can be clearly seen from our results that none of our moisture percentages fall in the optimum range, and this could be one of the issue for the failure of the saluki drive pavement.

Boring	Crushed Stone Moisture (%)
1	4.2
3	2.8
6	2.4
7	3.9/2.7
9	2.7

Table 1: Crushed Stone Moisture (%)

The following Table 2, presents the results of the percentage of bitumen content tested from the cores drilled at the failure location, using ignition method. According to IDOT specifications, the bituminous content should range between 4-6%. It can be seen that, all the cores tested do not fall in this range and is another reason for failure.

Core	Bitumen (%)
2(Surface)	6.11
2(Surface)	6.97
2(Surface)	6.26
2(Surface)	6.1

Table 2: Bitumen Content (%)

Also, Permeability of the surface course was found to be $3.9*10^{-4}$ cm/sec and the permeability of the binder course was found to be $1.6*10^{-4}$, i.e. surface course is more permeable than the binder course. In real life practice, the binder course should be more permeable than the surface course, so that water can seep through the surface course and then be able to drain through the binder course.

Lastly, The in place density of surface course is 90.4% of theoretical, and In-place density of binder course is 96.8% in our case. According to IDOT specifications, it should be at a minimum of 92.5-93%.

All these anomalies in the results based on the specifications led to the failure of the pavement.

Mitigation Methods

- The gradation of the aggregates have to be in compliance with the design and have to be less absorptive.
- The temperature of the bitumen and the mix design should be properly checked before mixing.
- Binder course should be more permeable than the surface course.
- Proper drum rolling should be carried out on the pavement to create an effective bonding between the pavement layers.
- Problems encountered in pavements are site specific, and proper understanding of the problem leads to resolving the issue efficiently as well as economically.

- In small projects, recycled materials can be used as they proved effective, economical and promote sustainable environment.

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