Stripping Distress on Hot Mixed Asphalt Pavement

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Abstract

Asphalt is sticky, black and viscous liquid substance which extensively known as bitumen and broadly useful in the construction of roads and bridge pavements. Its natural adhesive characteristics makes it possible to combine all required aggregate together to produce a greater amount of strength to sustain the higher traffic loads. Asphalt is naturally originated substance and it also could distinguish from the petroleum by products. A major application of asphalt material is to make high strength road pavements and as an adhesive to combine aggregates together for several applications. Deterioration or elimination of asphalt binder from aggregate layer due to the effect of moisture is generally named as the "stripping". Moisture damage or stripping distress is one of the most severe causes of damage in asphalt pavement. This paper will exhibit the stripping distress due to the water (moisture) effect on the bitumen pavements and how that damages could be cured. Asphalt roads may face destructions due to water or moisture vapor. These hazards may damage roads in such critical ways which results in temporary close-up or permanent renewal of that particular pavement. This paper will discuss remedies and maintenance techniques should be taken while the stripping characteristics affect the asphalt pavements and it will also cover the basic critical points should be taken in the consideration while constructing the asphalt pavement to reduce the stripping hazard effects on it. Recommendations are also made in the research to minimize the occurrence of such premature failure resulting from stripping distress.

Keyword- Asphalt pavement, moisture damages, pavement strength, stripping

I. INTRODUCTION

Moisture damage in asphalt pavement has been documented for long time. Stripping is considered as the moisture sensitivity for hot mixed asphalt pavement, which is major cause of deterioration in asphalt pavement. Stripping could be demonstrated by several other kind of distresses such as fatigue cracking, premature rutting, and raveling. Stripping is a substantial distress in asphalt pavement which is basically separation or loss of bond between asphalt binder and aggregate due the effect of moisture or moisture vapor. High moisture content in the asphalt pavement is major a cause of stripping distress.

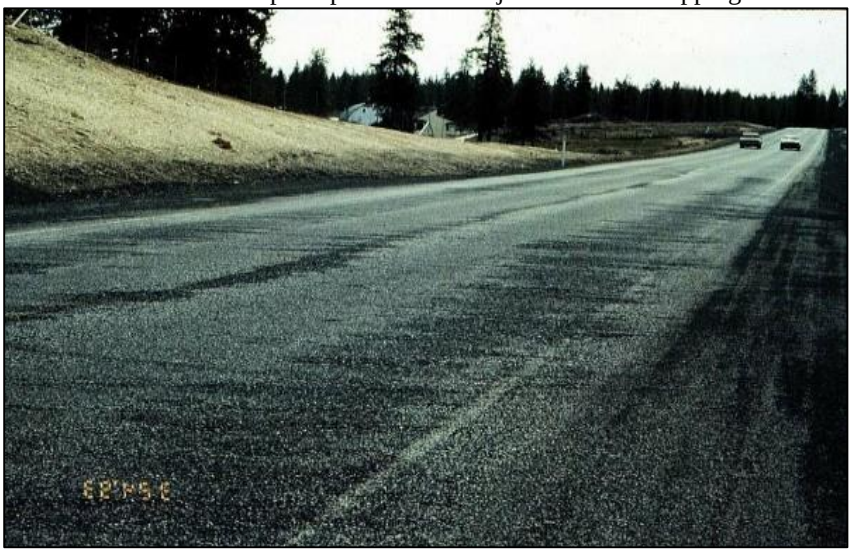

Fig. 1: Effect of stripping distress on HMA pavement layer.
http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/faqs.cfm

Fig. 2: Deterioration of pavement surface due to stripping distress.
http://www.pavementinteractive.org/article/raveling/

Stripping is a phenomenon which could began from the surface below of pavement and progress upward. When it begins from top and progress downwards it is usually known as raveling.

Figure 1 shows the severe effect of stripping on the HMA pavement surface. Type of asphalt binder, compaction, drainage conditions of pavement and permeability are major factors to be considered during the study of stripping distress in asphalt pavement. Poor drainage condition and undesired bond between asphalt binder & aggregate are major cause of stripping in HMA. Water content in the pavement may cause stripping as aggregate could have good affinity to water than binder. As a result, aggregate bonds will be deteriorated and result in stripping. However, some aggregates are more prone to asphalt over water which results in less stripping distress for the asphalt pavement. Additionally, permeability and surface water condition of pavement are also considerable causes for stripping distress.

Surface moisture content is most desirable factor for stripping analysis as most of the bond loss between aggregate and binder starts from pavement surface due to the moisture content from atmosphere and other outer sources. Figure 2 shows the surface deterioration of pavement due to stripping distress. Stripping distress adversely affect the pavement performance which cause unanticipated increment in maintenance cost.

This research will demonstrate the various methods to determine the stripping distress in Hot mixed asphalt pavement and it will also describe the causes and impacts of stripping distress in hot mixed asphalt pavement. There are various solutions and rectification clauses are described further in the report.

II. SCOPE OF THE STUDY

Stripping distress is majorly occurred phenomenon in asphalt pavements due to the moisture content. It is a loss of bond between aggregate and binder due to moisture or moisture vapor which create deterioration of pavement. This paper is inclined to distinguish various causes of stripping distress on HMA pavement and their relative effects. It will also classify several methods to determine the moisture presence and stripping in the hot mixed asphalt pavement. This proposed report is elaborative description of stripping distress causes and effect on Hot mixed asphalt pavement located in urban region. It will also illustrate the relative remedies for such distress in the asphalt pavement and recommendations to prevent asphalt from the effect of stripping distress due to the moisture content. This paper is envisioned to identify the stripping distress on Hot mixed asphalt pavement in urban region during the moderate season

III. OBJECTIVE OF RESEARCH

The main objective of the paper is to define the stripping distress on the hot mixed asphalt pavement and to offer the basic methodology to identify it. Additionally, this proposed research of striping distress in hot mixed asphalt is intended to classify various reasons for the defect along with the several panaceas to prevent the pavement from stripping distress. There are several objectives related to this paper described below.

- Identify the stripping distress in the Hot mixed asphalt pavement.
- Identify various methods to detect the stripping distress and moisture presence in asphalt pavement.
- Distinguish causes for the stripping distress on the hot mixed asphalt pavement.
- Recommendations and relative remedies to prevent asphalt pavement from stripping distress.

IV. METHODS TO IDENTIFY STRIPPING DISTRESS IN HOT MIXED ASPHALT PAVEMENT

Hot mixed asphalt performance due to presence of moisture has been a complex issue since long time. During last some decades, many asphalt technologists and state highway agencies have been in a quest of proper techniques to distinguish the stripping effect in hot mixed asphalt pavement. There were several tests came in consideration for measuring moisture presence in asphalt pavement since 1920 which includes sonic test (Andersland and Goetz 1956), Lootman's laboratory test(1978), Texas freeze-thaw pedestal test (1982), Texas boiling test (1984) etc. These attempts to identify the proper moisture sensitivity of asphalt pavement have been failed in many ways. In addition, many tests had big errors in identifying problem of stripping properly. After the several years of failing attempt, AASHTO and several other technologists came with some profound results on these tests.

The main identification of moisture sensitivity test is done in two ways, a quantitative tests and qualitative test. Boiling water test, freeze-thaw pedestal test and quick bottle test are came under the category of qualitative test which provides a subjective assessment of the stripping potential and immersion-compression test, indirect tensile test, and Marshall immersion test came under the group of quantitative tests for specific parameter such as strength before and after conditioning.

A. Significance of Moisture Sensitivity Tests

Moisture sensitivity tests are calibrated to identify the desired results in order to eradicate the problem of stripping in asphalt pavement. The implementations of these tests require a standardization of results which are generated through the various field observations. After the refereeing several literatures along with the laboratory experiments and field studies, the moisture susceptibility is highly correlated with the source of aggregate. There are several variable include to identify the moisture vulnerability of the asphalt pavements (Harvey et al. 202).

- Drainage and the current working condition of drainage system
- Pavement structure, including the severity of bond between the binder and aggregate, presence of minor cracks.
- Climate conditions, which determines the water presence and the amount of froze thaw action.
- Traffic condition, which is majorly considered for the stresses to mix during the weakened conditions from moisture.
- These are some relative significance of moisture sensitivity tests on the asphalt pavement. There are mainly two kind of tests performed in the asphalt to determine the moisture presence.

B. Tests on Loose Mixtures

These are the kind of tests performed on the asphalt-coated aggregate in the presence of water. For instance, boil test, film strip test and static/dynamic immersion test. These tests are moderately performed in laboratory with several asphalt and pavement samples. There are some disadvantages of the test is that the tests are not able to consider the pore pressure, traffic load, climate condition into account. However, these tests are most suitably useful for the comparison of different asphalt mixtures properties such as compatibility, strength of adhesion, and stripping.

1) Texas Boiling Test (ASTM D 3625)

It was developed by Kennedy et al (1982; 1984). This test requires adding asphalt-aggregate mixture to boiling water and bringing the water back to boiling after this addition.

The test is considered as subjective and qualitative, and visual inspection is major mode to judge the results of test. It is useful to get quick evaluation of various asphalt-aggregate combinations for relative measure of the bond quality and stripping resistance. The procedure has been standardized as ASTM D3625 (Effect of Water on Bituminous-Coated Aggregate Using Boiling Water).

2) Rolling Bottle Test

The test was established by Isacsson and Jorgensen of Sweden (1987). In this test, aggregate chips are covered with binder and water in glass jars. The rotations of jar create the agitation which is useful to measure the moisture susceptibility of aggregate. Occasionally, the coating of the stones is estimated visually.

C. Tests on Compacted Mixtures

This tests are conducted in laboratory compacted specimens or on field slabs. This test can consider mix physical and mechanical properties, water/traffic action, and pore pressure. The results of test can be measured quantitatively, which minimizes subjective assessment of test results. There are several drawback of this test such as long testing time, clearly tested equipment and more preside procedures.

1) Marshall Immersion Test

Marshall Immersion test is in conditional phase to identify the moisture susceptibility. This test is mostly useful as strength parameter rather than compressive strength.

2) Immersion–Compression Test ASTM D1075 (1949 and 1954) and AASHTO T165-55 (Effect of Water on Compressive Strength of Compacted Bituminous Mixtures)

It was originally published as ASTM D1075-49. Hence, it was the first test to be used for the evaluation of moisture sensitivity. The test is mostly done on compacted specimen. This test which majorly focused on the compressive strength of specimen which determine the moisture presence in the core.

These are various methods for the determining the moisture susceptibility in the asphalt pavement and it is mainly focused on the moisture content of aggregate along with several physical and mechanical properties.

V. FACTORS INFLUENCING STRIPPING DISTRESS

Moisture damage is a severe phenomenon to cause the major deterioration in asphalt pavement. There are several factors which are helpful to identify the moisture damage on hot mixed asphalt pavement such as, weather condition, asphalt binder characteristic, air voids, aggregate characteristics, and drainage condition of pavement. The stripping problem is basically occurred underneath the pavement layer which is typically difficult for determining the major cause for that. There are several important factors which could cause the stripping distress such as poor aggregate chemistry, poor drainage condition of the pavement, poor surface condition of aggregate which promote the poor bonding between binder and aggregate. Each factor is responsible to serve the moisture content in HMA which is typically decreasing the adhesion of binder and aggregate. These several factors affecting the moisture susceptibility in HMA.

A. Asphalt Binder Characteristics

Characteristics of asphalt binder are very important factor for the moisture sensitivity in pavement. Viscosity is important property because it may indicate the presence of asphaltenes. Higher concentration of polar molecules (asphaltenes) could create more adhesion tension and therefore, low viscous binder are more susceptible to stripping. There are several other components such as sulfoxides, carboxylic acids are also important for stripping potential.

B. Aggregate Characteristics

Characteristics of aggregate is also a major factor for the moisture susceptibility such as hydrophilic (attract water) aggregates are more likely to strip than the hydrophobic (repulse ware) aggregates. There are several properties which determines the characteristic of aggregates for moisture susceptibility.

1) Surface Chemistry

The aggregate which can bond with binder easily are less likely to generate stripping. In other words, more acidic aggregate surface is more influenced by stripping. However aluminium is more beneficial than sodium and potassium (Hicks 1991).

2) Porosity and Pore Size

It is a critical factor for stripping. The larger size of pore could create more space for moisture to get susceptible. High porosity is also considered a major problem as more porous pavement cause more absorption of moisture and which results in stripping and other degradation.

C. Climate

Wet climate condition, freeze-thaw cycles and temperature fluctuations can allow more moisture in pavement which increase likelihood of moisture damage.

D. Traffic Condition

Traffic load is considerable factor for the moisture damage in pavement. There are two main reasons which can accelerate the moisture damage in HMA due to traffic load. For instance, pore pressure buildup and hydraulic scouring. When water pores inside the pavement and couldn't get outs so, it would tend to compress by the load of traffic. Where water move along to the surface of pavement due to wheel passing, scouring action could remove the asphalt binder form the aggregate which results in the deterioration of pavement layer.

VI. PREVENTION MEASURES FOR THE STRIPPING DISTRESS IN HMA

There are several measures for the prevention of HMA from stripping distress. These measures could be any modification in construction practice, material selection, HMA additives or pavement design. There are several important prevention measures are described below.

A. Aggregate Selection

This is one of the most important factors for the pavement prevention. There are some suitable properties to be taken in to account during the design of pavement such as porosity, permeability or surface tension. Aggregate with low porosity and clean surface are best suitable for the stripping prevention in pavement.

B. Prevention of Moisture Penetration into HMA

Moisture content is major cause for the stripping distress in pavements. As a result prevention of moisture penetration could help to reduce the problem. There are numerous quantity affect the moisture content which is permeability, lift thickness, gradation and air void content.

Moisture content penetration could prevent by reducing permeability of pavement by manipulating void content, gradation and lift thickness. This manipulation could help to prevent moisture penetration in pavement. Additionally, fog seals, slurry seal or bitumen surface treatment are several waterproofing techniques to decrease the moisture content.

C. Anti-Strip Additives

Anti-strip additives are useful to reduce moisture susceptibility in the asphalt binder. It will increase the strength and occurrence of asphalt aggregate adhesion. There are numerous additives useful in asphalt such as chemicals and lime.

Chemicals are one of the additives useful in asphalt binder to prevent moisture effect. Chemicals are generally reducing the surface tension of the asphalt binder, which is useful for better wetting. Most chemicals contain amines and are added about 0.1 to 1.0 percentages by weight of asphalt binder. Chemical additives are added just prior to mixing which could help to make critical asphalt binder interface. Some additives are added to the aggregate before the asphalt binder mixing.

Lime is also an important additive for the moisture resistance in asphalt. Lime works as to exchange the negative ion from aggregate surface to positive calcium ion to create better asphalt binder-aggregate adhesion. 1 to 1.5 % of lime is usually added by the total aggregate weight. Moisture is essential to activate lime. Hence, Lime could be added as slurry or with slightly moist aggregate. These are some anti-striping agents to protect the asphalt pavement from moisture.

VII. CONCLUSION

Stripping distress has always been considered as a major detonation cause for asphalt pavement. There are several causes for stripping distress as mentioned in the report above. Stripping distress is always a major cause of many other distresses such as fatigue cracking, raveling and longitudinal distress. This paper has described various techniques for the determination of moisture susceptibility in hot mixed asphalt pavement and it has also mentioned various prevention measures to inhibit the stripping problem in hot mixed asphalt pavement. There are numerous ways to prevent asphalt from stripping. Hot mixed asphalt pavement has many deterioration problem since long time. Additionally, some critical problems such as stripping cause major degradation in the performance of pavement. Conclusively, Stripping is a major cause for pavement deterioration and various prevention measures such as preferred design mix, use of anti-stripping additives are considerably effective for prevention of HMA.

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