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Rutting Performance Of Hot Mix Asphalt (HMA) during 60 degree temperature

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ABSTRACT: *This project is to determine the Marshall properties at different bitumen content and to measure the rutting performance of the different cement content at 60 degrees. Hot mix asphalt (HMA) mixture compacted at two different cement content and 155 degree temperature has always been a concern to researchers. Compaction in modifier cement with different bitumen content may bring reverses the effect on HMA properties. Permanent deformation or Rutting is a surface depression in the wheel path caused by a consequence of plastic deformation and the consolidation of layers and sub grade. It is one of the main causes of road surface deformation. Thus, rutting a type of surface deformation becomes a major issue to be concerned of in the road construction industry.*

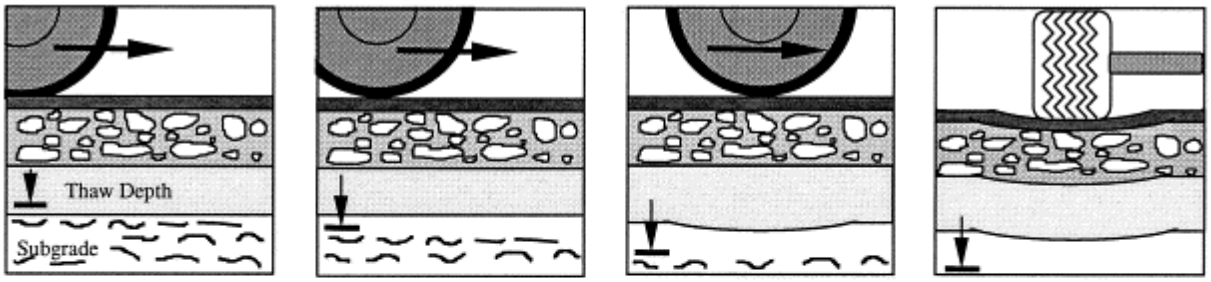
I. INRODUCTION:

Rutting is a surface depression in the wheel path where pavement uplift occurs along the side of the rut. Rutting may lead to pavement failure and potential of hydroplaning. Due to this, the design process has to be taken into consideration. The asphalt design mix must involve a proper proportioning. Compaction factor and the pavement thickness need to bear in mind. Rutting potential also can be minimized by limiting the stress inducting by moving wheel load besides maximizing its fatigue life. The influence of each of the properties of the mixture in the performance of asphalt pavement must be determined to balance all the properties of the specific application embedded in mixtures of hot mix asphalt compacted asphalt can be evaluated through their properties mixture. This is particularly the density, stability, flow and stiffness. Numerous test methods are being used to evaluate the performance of Hot Mix Asphalt (HMA). Permanent deformation (Rutting), fatigue cracking, thermal cracking, loss of surface friction, and stripping are the five main distress types of (HMA) pavements. All of these distresses can result in loss performance, but rutting is the one distress that is the most likely to be a sudden failure as a result of unsatisfactory HMA. Other distresses are typically long term and show up after a few years of traffic.

PROBLEM STATEMENT: Asphalt mixture (HMA) hot sidewalk runs the risk of suffering from permanent deformation, another term for permanent deformation is "rutting". The groove produced in the asphalt concrete layer seems to be a major issue in the soil. This will eventually result in a failure to maintain the asphalt pavement, this can lead to some serious risk in security, including increase in traffic and improvement of performance of the pavement. Hence, polymer modified asphalt (PMA) has been developed to eradicate such problems. (Whiteoak,1990)

TEMPERATURE EFFECT: The result of the studies shown that compaction temperature along with asphalt content, grade of asphalt, and aggregate gradation has significant cause to tensile strength. Hadley (1970) et.al has conducted an extensive laboratory study to find the effect of seven factors on the tensile properties of asphalt material. Review of the literature many reports indicate that effects of increasing compaction effort at low temperature on tensile strength. Kennedy et.al (1979) also conducted test to determine the effects of increasing compaction effort at low temperature on tensile strength and static modulus. The sample used for the study compacted at three different temperatures, 60ºC (140˚F) for rutting test. Kennedy was using two different compaction method that are methods used by Texas State Department of Highway and Public Transport (SDHPT) using a gyratory cycles and modified procedure involving a constant number of gyratory cycles.

RUTTING: Permanent deformation or rutting is a primary failure mode of HMA pavements (Williams, 2002). Rutting usually occur in the linear with wheel path. Rutting also known as permanent deformation can be defined as the accumulation of small amounts of unrecoverable strain as a result of applied loading to pavement (Maupin and David, 2006). It is seen as longitudinal depression which follows the line of the wheelpaths (Abdul Mutaliff, 1994).



1. Damage development during thaw when the pavement is too thin and the subgrade is frost-susceptible. As long as the thaw depth has not reached the subgrade (with ice formations), the bearing capacity is high.

2. When the subgrade begins to thaw, the excess water may cause a significant drop in strength.

3. The weak subgrade is pressed aside due to wheel loading and settlements migrate towards the asphalt surface.

4. After many passages, the deformations may become quite large. Such damage occurs relatively late in the thaw.

Fig. 1. Shows The Processes That Lead To Rutting Distress

Brown and Cross, (1989) concluded that the phenomena of rutting are an accumulation of permanent deformations and it is confined to the top layers of the pavement. These permanent deformations in the wearing course layer could be developed due to densification and plastic flow of this layer. They also recommend that rutting progress in two stages. Initial stage is that of densification of the bituminous concrete under moving traffic while the second stage is resulted due to plastic flow of bituminous concrete. Excessive binder, inadequate compaction, substandard materials, excessive loading or high moisture content can also create this problem (Abdelaziz and Mohamed Rehan, 2007). Besides that, rutting can also manifest because of a poor pavement subgrade. Two of the causes of a weak subgrade are moisture and poor compaction during construction work. A weakened subgrade issusceptible to higher stress attributable to traffic loading; thus there is an increased probability of rutting in the pavement.

MEASUREMENT OF RUTTING: The major portion of the irreversible deformation is due to shear stresses in the compacted material. Which suggests that better compaction if the asphalt layer should significantly improve rutting behavior. The rutting for any pavement will be determined by computing the mean rut depth and there three types of levels of rutting with difference in depth of the rut according to JKR as follows (AASHTO, 1986).

TABLE 1. Severity levels of rut depth

Severity Level	**Mean Rut Depth**
Low	6-12 mm
Medium	12 – 25 mm
High	more than 25

FACTOR WICH AFFECT PAVEMENT RUTTING :

[1] Tyre Inflation and Tyre Pavement Contact Pressure
[2] Consolidation and Field Compaction
[3] Aggregate
[4] Mineral filler
[5] Asphalt Type and Content
[6] Environmental factors

MARSHALL METHOD OF MIX DESIGN:

Prepare specimen for standard stability and flow tests as per AASHTO T 245 using blows/face.

[1] Determine bulk specific gravity of specimens as per AASHTO T 166
[2] Determine stability and flow values as per AASHTO T 245
[3] Voids analysis

TABLE 2. The test parameter of Marshall specimens

Parameter	Wearing course	Binder course
Stability, S	>8000 N	>8000 N
Flow, F	2.0-4.0 mm	2.0-4.0 mm
Stiffness, S/F	>2000 N/mm	>2000 N/mm
Voids in mix	3.0%-5%	3.0%-7.0%
Voids in aggregate filled with bitumen	70%-80%	65%-75%

Wheel Tracking Test: The wheel cracking test is the main test in this research to determine the effect of cement in depth of rutting . And to compare the different percentage of the cement that had been added to the mixture. load had been used in the test was 18Kg and that is the load always been consider in wheel crack test to in this mixture the percentage of bitumen is constant in this mixture and the percentage of bitumen is constant and had been calculated from the marshal properties which is the best result that found from the marshal Graphical Presentation and the percentage of cement it had been used according to what mentioned in the first chapter. The wheel tracking machine has only one wheel and it is connected with a computer since starting wheel crack machine supposed to wait 1 to one and half hour then the computer start drawing graphs and showing every data depth. This process takes around 45 minutes for each simple and data has been found should not exceed 4mm depth.

The procedures are;

[1] First, the well compacted samples are placed into oven for approximately 3-5 hours at a temperature of 60℃
[2] Temperature of the water path in the wheel tracking machine is maintained at 60℃
[3] Before conducting the test, samples are placed in the tracking machine and immersion in water path for 30 minutes
[4] The wheel is tracked back and forth with travel speed about 40 passes/min
[5] One cycle is defined as the backward and forward movement of the wheel over samples
[6] Rutting depth is recorded

II. RESULT AND ANALYSIS

Marshall Properties Of Different Bitumen Contents for ACW20

Laboratory mix design procedures and marshall calculation for the mix are subjected to a comprehensive marshall test. The final grading of the combined. Mineral aggregates are then mixed with an appropriate range of bitumen content due to different present age of cement content can be prepared and follow by marshall properties test. Final marshall properties of the different bitumen content are monitored and the result summarized in table 1 and 1.1below.

The average Marshall test values for unmodified sample

Bitumen Content %	Bulk SG	VFM	VIM	Stability	Flow
5	2.196	70.96	5.07	853.8	3.875
5.5	2.243	73.11	4.23	1013.79	4.243
6	2.250	78.56	3.72	956.79	4.607

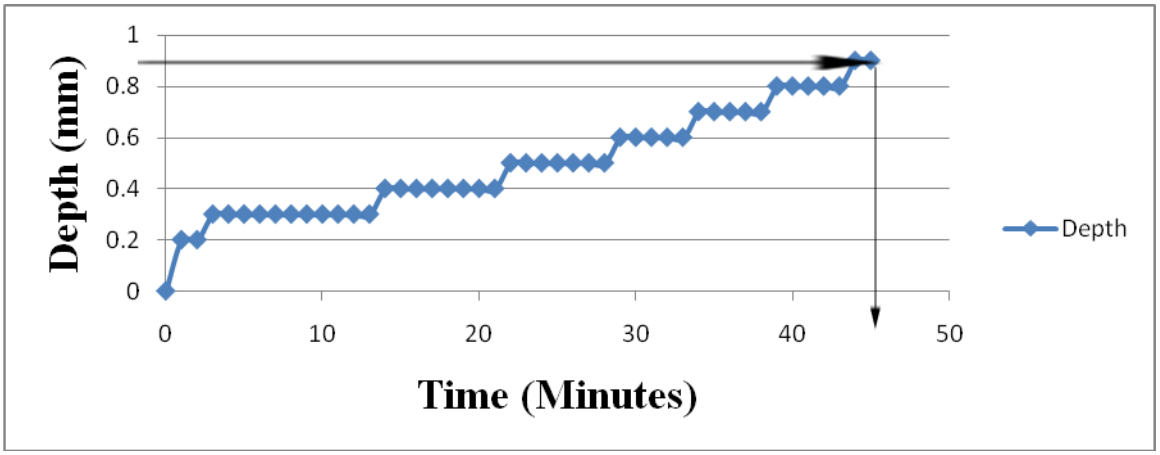
The average Marshall test values for modified sample (4% cement)

Bitumen Content %	Bulk SG	VFM	VIM	Stability	Flow
5	2.306	73.590	4.571	985.238	3.026
5.5	2.325	71.888	4.460	1197.230	3.589
6	2.399	79.530	3.505	973.973	4.117

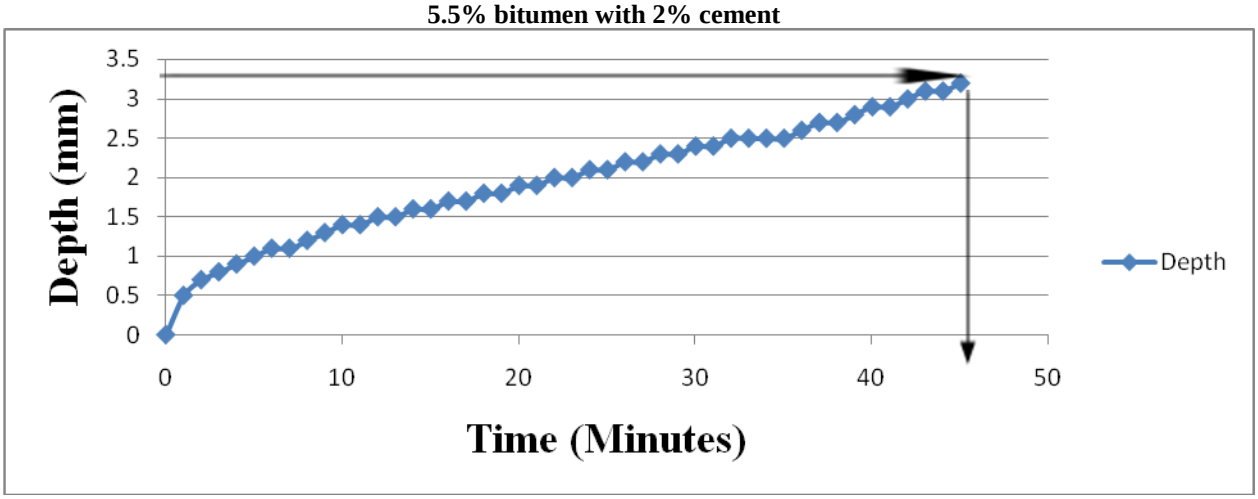
To determine the optimum bitumen content to two different percentages of cement that has been added to the mix. It is required to carry out some calculation and analysis of the Marshall test results obtained. The optimum bitumen content is determined by getting the average of Bulk SG, Voids Filled with bitumen, Voids in mixture, stability and Flow as stated in chapter 3 section 7 according to JKR/SPJ/rev 2005.

RESULT OF WHEEL TRACK TEST: This test has six samples have been designed to measure the depth of rutting in different bitumen content. The samples contain 2% and 4% of cement and 5%, 5.5% and 6% of the bitumen during 45 minutes. The wheel tracking machine has only one wheel and it is connected with a computer and all the data were shown in the screen of the computer.

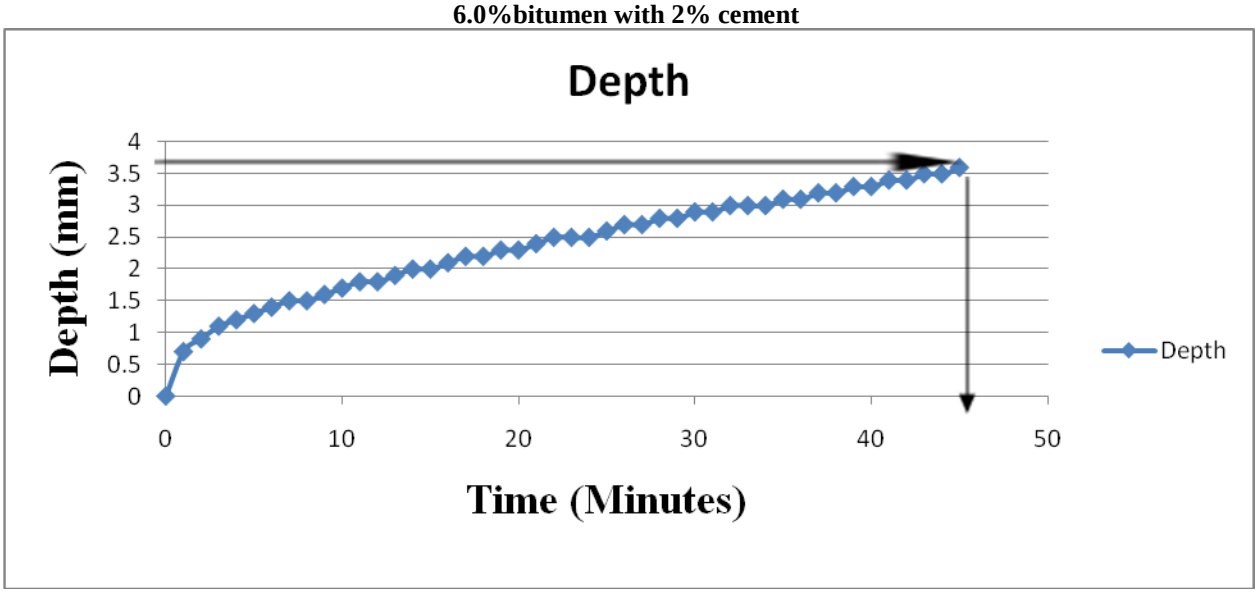
Wheel tracking result for sample bitumen with 2% cement content with 5% of bitumen



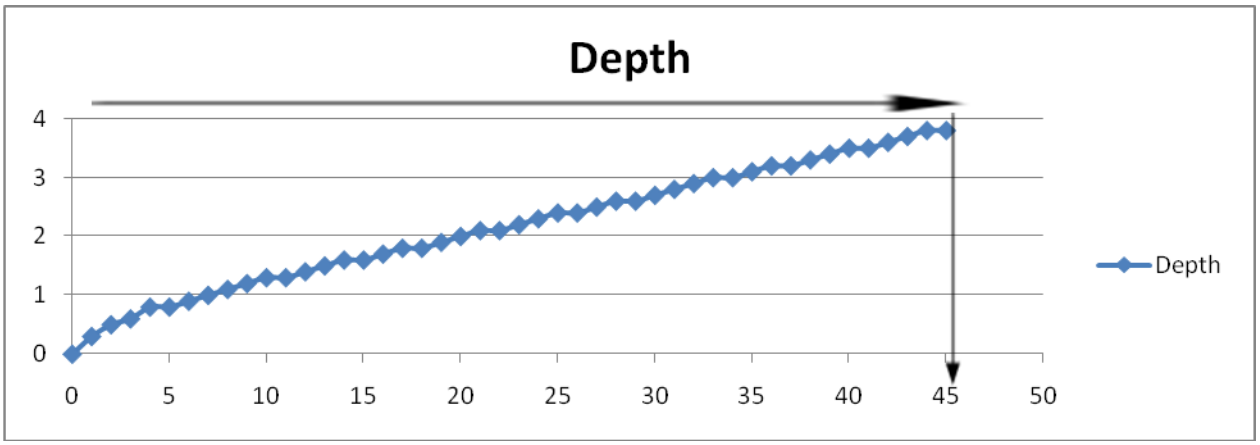
5.5% bitumen with 2% cement



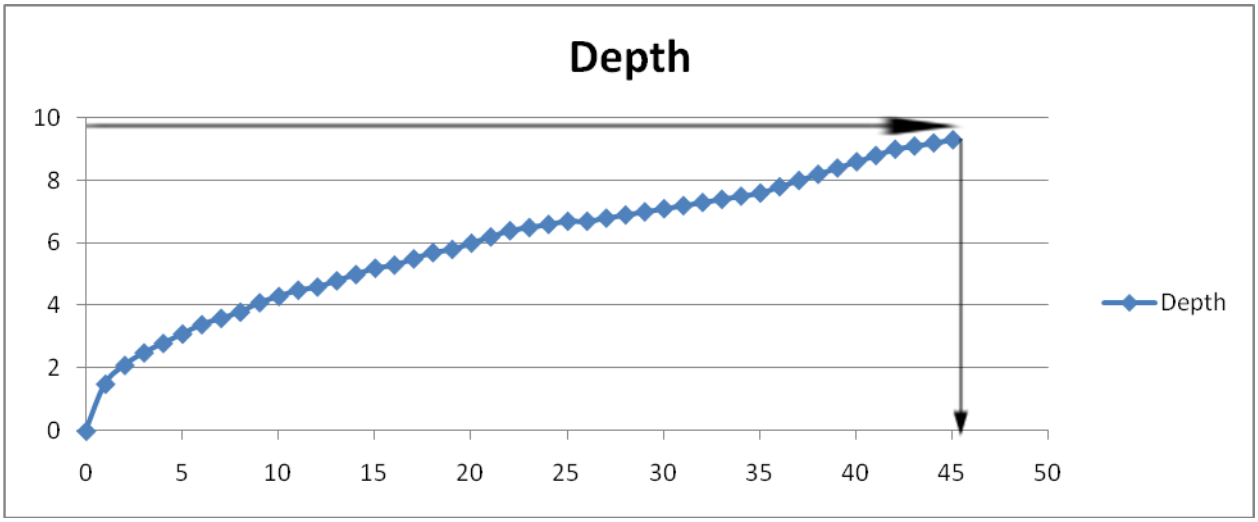
6.0%bitumen with 2% cement



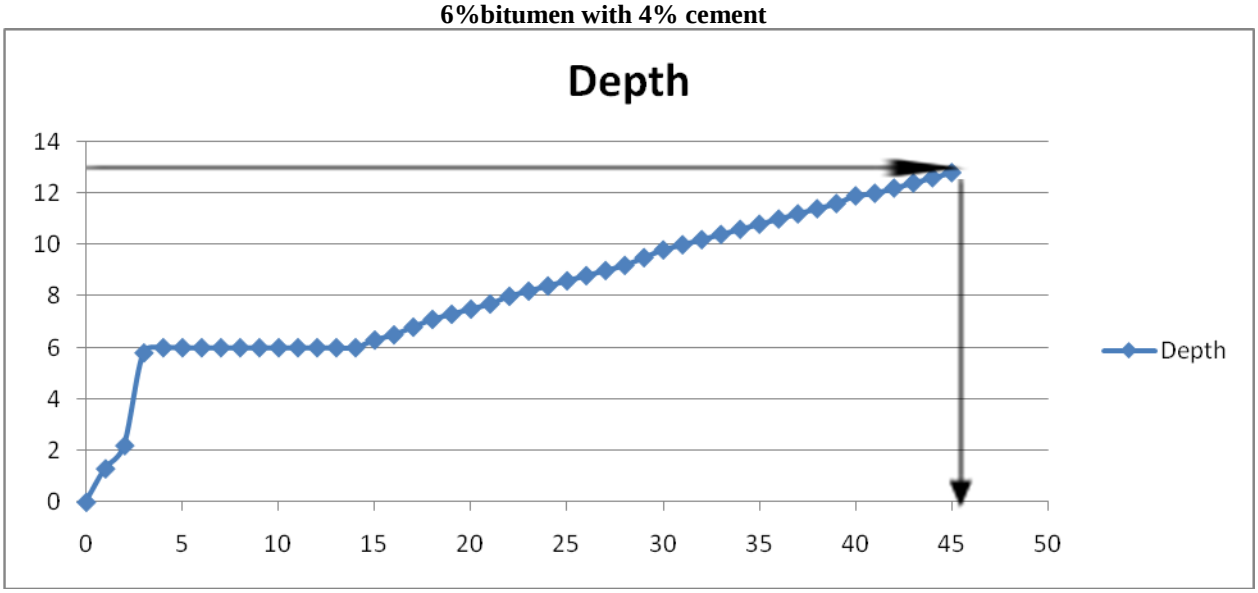
Wheel tracking result for sample bitumen with 4% cement content with 5% bitumen



5.5%bitumen with 4% cement



6%bitumen with 4% cement



SUMMARISE: Due to data collected for all the tests and analysis, found it that the best percentage of cement in marshal properties was the Unmodified mixes (Bulk SG , Stability , Flow , Voids filled with Bitumen and Voids in Mixture) and from that data found it the optimum bitumen content for each percentage of Cement . The optimum bitumen content that it had been used for the rutting mixer it found be getting the average of the optimum content for each percentage. The wheel tracking test , it found that when the cement and bitumen increasing the depth of rutting increasing compared to the small percentage of cement and bitumen. So the best result found was when using 2% of cement which is JKR stander with 5.0% of bitumen during 60° C.