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EXPERIMENTAL STUDY ON PERFORMANCE OF FLEXIBLE PAVEMENT MATERIALS WITH THE ADDITION OF ANTI-STRIPPING AGENT

Ms. G. HIMA BINDHU[1], G. PAVAN[2], P. SEETHA RAM[3], A. DAVID RAJU[4], G. MANOJ KUMAR[5]
[1]Assistant Professor, [2,3,4,5] B.tech IV year Student
C.E Dept
Usharama College of Engineering& Technology
Telaprolu, Krishna District, Andhra Pradesh, India

Abstract: Pavement performance and durability are affected by a variety of factors. The main elements that impact pavement are stripping and distortion. Hydrated lime can lessen these two factors and improve pavement characteristics. Hydrated lime has been discovered to be one of the most efficient additives because it is widely available and very inexpensive compared to other options. Hydrated lime is added in various quantities, such as 2%, 4%, 6%, 8%, and 10%, to examine characteristics. By weight, hydrated lime is used as a partial replacement for bitumen. We compare all of the attributes of bitumen to IS15462-2004 requirements using VG40 grade bitumen. The static immersion method can be used to determine the stripping value with and without the addition of hydrated lime. These combinations are created and evaluated using the Marshall Stability technique to evaluate permanent deformation at various percentages and temperatures, as well as bitumen characteristics with and without hydrated lime. All of the properties of bitumen, including stability, deformation, plasticity, hardness, and softening temperature, as well as stripping value, were examined with and without the addition of hydrated lime. Finally, we conclude that adding roughly 8% hydrated lime to a pavement mixture results in maximum stability, minimum flow value, and 0% stripping. As a result, the use of 8% hydrated lime in road construction provides longevity, resistance to significant moisture damages in areas with heavy rain, and resistance to deformation caused by large loads or recurrent traffic loads.
Keywords: Hydrated lime, Stripping, VG40 bitumen, Deformation, Moisture damage

I. INTRODUCTION

Flexible pavement will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the granular structure. Flexible pavement consists of four layers that are subgrade with existing soil, sub base, base course, surface course or pavement course or wearing course. Mix design is the process of choosing optimum content of stabilized various ingredients of the pavement. The general principle of mix design is that the mixture should provide satisfactory performance when constructed in the desired position of sub-grade. Design proportions of ingredients are generally based on analysis of the effect of various proportions on selected properties of mix. Before the design of pavement check the properties of aggregates. In this report mainly the hydrated lime is added in bitumen so the properties of bitumen are safe or not by different methods.

Stripping:

1. Stripping is the loss of adhesion between the aggregates and bitumen in the presence of moisture.
2. Stripping is caused due to heavy rain falls and moisture damage.
3. It is mostly occurred in heavy rain fall areas.
4. When stripping begins at the surface and progresses downward it is usually called ravelling.
5. Stripping may result in ravelling, loss of stability, load carrying capacity of hot mix asphalt pavement.
6. This type of failure is accumulated by water drop acting on the surface of pavement that are hydrophilic and hydrophobic surface contact.

Deformation:

1. The accumulation of permanent strains that are produced by repetitive traffic loads or wheel loads can cause deformation. It is also known as rutting.
2. This failure is in the form of wheel path.
3. Two types of rutting that are mix rutting and sub-grade rutting, mix rutting occurs when the subgrade does not rut yet the pavement surface exhibits wheel path depressions as the result of compaction or mix design problems. Subgrade rutting occurs when the subgrade exhibits wheel path depressions due to loading.
4. In the presence of pavement deformation is develops map cracking or alligator cracking or fatigue cracking in narrow path or in the form of wheel path.
5. Ruts are formed due to repeated application of loads along the same wheel path resulting longitudinal ruts.
6. Wearing of the surface course along the wheel path resulting shallow ruts

Hydrated lime:

The two of the main factors causing the development of distresses, such as fatigue cracking, moisture damage and permanent deformation, in pavements using additives has been found to be one of the effective techniques to improve pavement durability. Recently, the use of hydrated lime, as mineral filler and anti-stripping material has raised more and more interest. Hydrated lime has a wide range of particle size distribution and proportion.

Hydrated lime in hot mix asphalt (HMA) creates multiple benefits. A considerable amount of information exists in the current literature on hydrated lime's ability to control water sensitivity and its well-accepted ability as an antistrip to inhibit moisture damage. However, recent studies demonstrate that lime also generates other effects in HMA. Specifically, lime acts as an active filler, anti-oxidant, and as an additive that reacts with clay fines in HMA. Hydrated lime is an additive that increases pavement life and performance through multiple mechanisms. A number of additives to reduce moisture sensitivity and stripping are used in the United States. Hydrated lime is widely used as an antistrip additive. Others include liquid additives (e.g., amines, diamines, and polymers), Portland cement, fly ash, and flue dust. Pavement contractors usually prefer liquid antistrip additives as they are relatively easy to use.

The filler effect of the lime in the asphalt reduces the potential of the asphalt to deform at high temperatures, especially during its early life when it is most susceptible to rutting. The hydrated lime filler actually stiffens the asphalt film and reinforces it. Furthermore, the lime makes the HMA less sensitive to moisture effects by improving the aggregate-asphalt bond. . Hydrated lime is not simply an inert filler but reacts with the bitumen.

II. METERIALS

Properties of aggregates and its specifications:

Table 1. Properties of aggregates as per IRC27-1967

S.NO	Property	Test name	Permissible value %
1	Toughness	Impact test	< 30
2	Crushing strength	Crushing test	<30
3	Hardness	Abrasion test	< 30
4	Sp.gravity	Sp. gravity test	2.5-3.0
5	Porosity	Water absorption test	<2
6	Flakiness	Shape test(flakiness)	<15
7	Elongation	Shape test(elongation)	< 15

Properties of bitumen and its specifications:

This hydrated lime is added in bitumen, the properties of bitumen such as plasticity, hardness, sp. gravity, softening point etc. stability and flow value of bituminous mixture is determined by Marshall mix design with and without adding of hydrated lime , plotting the curves and also comparing the values of that bituminous mix.

Table 2. Properties of bitumen as per IS15462-2004

S.NO	Test name	Permissible limit
1	Ductility test(cm)	<50
2	Penetration test(mm)	<50(1div=0.1mm)
3	Softening point test(°c)	<60

III. METHODOLOGY

TESTS ON AGGREGATES:

These below methods can be used to determine the aggregates properties like toughness, Crushing strength, Hardness, Sp.gravity, elongation.

1. Impact test [IS2386 (PART-IV)-1963]
2. Crushing test [IS2386 (PART-IV)-1963]
3. Water absorption test [IS2386 (PART-III)-1963]
4. Specific gravity test [IS2386 (PART-III)-1963]
5. Los Angeles abrasion test [IS2386 (PART-IV)-1963]
6. Shape test [IS2386 (PART-I)-1963]

TESTS ON BITUMEN:

These below methods can be used to determine the bitumen properties like ductility, hardness, softening point.

1. Ductility test (IS1208-1978)
2. Penetration test (IS1203-1978)
3. Softening point test (IS1205-1978)

MARSHALL STABILITY TEST

Objective: To determine the stability value of bitumen and flexibility (flow value).

Equipment's required: ❖ Marshall stability test machine with flow meter and stability meter

❖ IS sieves20mm, 12.5mm, 10mm, 6.3 mm, and 4.75mm
❖ Marshal specimen mould (10cm dia. and 7.5cm)
❖ Heater
❖ Water bath
❖ Compaction rammer with 4.5 kg and free fall 45.7cm

Materials required: ❖ Coarse aggregates

❖ Fine aggregate
❖ Filler material
❖ Bitumen

Theory:

1. Marshall Stability and flow test provides the performance prediction measure for the Marshall Mix design method.
2. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute.
3. Load is applied to the specimen till failure, and the maximum load is designated as stability.
4. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading.
5. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.
6. Strength is measured in terms of the Marshall's stability of the mix which is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60ºc.
7. This temp. The flexibility is measured in terms of the flow value which is measured by the change in dia. of sample in the direction of load

PREPARATION OF TEST SPECIMEN:

1. Take 1200g of coarse aggregates, fine aggregates, filler material to produce the desired thickness.
2. Mix proportions are 20-12.5mm is 72gm, 12.5-10mm is 312gm, 10-4.75mm is 84gm, 4.75-2.6 is 204gm, filler is 480gm.

3. The aggregates are heated at a temperature of 175-190°c the compaction mould is assembly and rammer re cleaned and kept pre-heated to a temperature of 100ºc to 145°c.
4. The bitumen is heated at a temperature of 121-138ºc and the required amount of first trail of bitumen is added to the heated aggregate and thoroughly mixed using a mechanical mixer or by hand mixing with trowel. The mixing temperature for about 60 grades at 160°c.
5. The total quantity of the mix is placed in a mould and compacted by rammer with 75 blows. Invert the sample, and compact the other face with the same number of blows.
6. The compacting temperature should be about 149ºc for 60 grades.
7. After compaction, invert the mould. With the collar of bottom, remove the base and extract the sample by pushing it our extractor.
8. The compacted specimen should have a thickness of 63.5mm. Allow the sample to stand for a few hours to cool.
9. Obtain the sample mass in air and submerged, to measure density of specimen, so as to allow, calculation of voids properties.
10. The sample is kept in water bath about 2 hours and calculate the air voids and water absorption.

STABILITY TEST

In conducting the stability test, the specimen is immersed in a bath of water at a temperature of 60° ± 1°C for a period of 30 minutes. It is then placed in the Marshall stability testing machine and loaded at a constant rate of deformation of 5 mm per minute until failure. The total maximum in kN (that causes failure of the specimen) is taken as Marshall Stability. The stability value so obtained is corrected for volume (Table 6.6.1). The total amount of deformation is units of 0.25 mm that occurs at maximum load is recorded as Flow Value.
The total time between removing the specimen from the bath and completion of the test should not exceed 30 seconds.

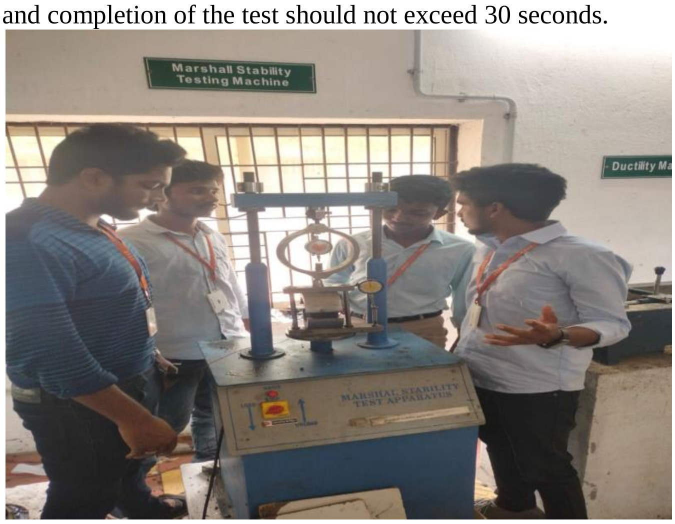

Figure 1. Marshall Stability test

STRIPPING VALUE TEST

Objective:
To determine the stripping value of road aggregates.
Equipment required:
❖ 500ml capacity beaker
❖ IS sieves 12.5mm, 10mm
❖ Weighing balance
❖ Thermostatically water bath
❖ Heater

Materials required:
• Bitumen sample
• Aggregate sample

Theory:
1. Loss of adhesion between the aggregates and bitumen in the presence of moisture that is called stripping.
2. The stripping value of aggregates is determined as the ratio of the uncovered area observed visually to the total area of aggregates, expressed as a percentage.
3. Bitumen and tar adhere well to all normal types of aggregates provided they are dry and are not exceptionally dusty.
4. This problem of stripping is experienced only with bituminous mixtures, which are permeable to water.
5. This test gives the procedure for determination of the stripping value of aggregates by static immersion method, when bitumen and tar binders are used.
6. This test is standardized by IS6241-1971.
7. The permissible stripping value of road aggregate is 5% as per IRC27

7.5 Procedure:
1. Take 200 grams of dry and clean aggregates passing 12.5mm and retained on 10mm sieves and heat up to 150ºc.
2. Take five percent by weight of bitumen binder and heat up to 160º C.
3. Mix the aggregates and the binder till they are completely coated and transfer the mixture in to a 500ml beaker and allow to cool at room temperature for about 2 hours.
4. Add distilled water to immerse the coated aggregates.
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5. Cover the beaker and keep in a water bath maintained at 40ºC taking care that the level of water in the water bath is at least half the height of the beaker.
6. After 24 hours the beaker is taken out cooled at room temperature and extent of stripping is estimated visually while the specimen is still under water.
7. Take the average values of stripping and noted down.
8. This stripping value is compared with stripping value of adding hydrated lime with different percentages like 2, 4, and 6,8,10.
9. So, we can choose the lower stripping value compared with all the values.

Figure 2. Aggregates after stripping test with addition of Hydrated lime

IV. RESULTS & DISCUSSION

Results for aggregates (AS PER IRC27-1967)
Table 3. Results for aggregates

S.NO	Test name	Obtained value%	Permissible limit %
1	Impact test	25	30
2	Crushing test	24	30
3	Abrasion test	20.7	30
4	Sp. gravity test	2.69	2.5-3.0
5	Water Absorption test	1.78	2
6	Shape test(flakiness)	12.8	15
7	Shape test(elongation)	12.1	15

Discussion: The above aggregate results show with in the permissible limits. Hence it is suitable for road construction.
Results for bitumen (USE CRMB60 AS PER IS154622004):

Table 4. Results for bitumen without addition of Hydrated lime

S.NO	Test name	Obtained value	Permissible value (IS15462-2004)
1	Ductility test(cm)	78cm	> 50
2	Penetration test(mm)	35mm	< 50 (1 Div. = 0.1mm)
3	Softening point test(°c)	52°c	60 °c

Discussion: The above results show the Ductility, Penetration, softening point are within the limits.
Table 5.Results for bitumen with 2% addition of Hydrated lime

S.NO	Test name	Obtained value
1	Ductility test(cm)	79.5
2	Penetration test(mm)	33
3	Softening point test(°c)	54

Discussion: The comparison of this test results shows the properties of bitumen improved by 2% addition of hydrated lime than the plain bitumen.
Table6. Results for bitumen with 4% addition of Hydrated lime

S.NO	Test name	Obtained value
1	Ductility test(cm)	82
2	Penetration test(mm)	31.5
3	Softening point test(°c)	55

Discussion: The comparison of this test results shows the properties of bitumen improved by 4% addition of hydrated lime than the plain bitumen.
Table 7. Results for bitumen with 6% addition of Hydrated lime

S.NO	Test name	Obtained value
1	Ductility test(cm)	83.5
2	Penetration test(mm)	30
3	Softening point test(°c)	57

Discussion: The comparison of this test results shows the properties of bitumen improved by 6% addition of hydrated lime than the addition of 4% hydrated lime
Table 8. Results for bitumen with 8% addition of Hydrated lime

S.NO	Test name	Obtained value
1	Ductility test(cm)	85
2	Penetration test(mm)	30
3	Softening point test(°c)	57

Discussion: The comparison of this test results shows the properties of bitumen improved by 8% addition of hydrated lime than the addition of 6% hydrated lime.
Table 9. Results for bitumen with 10% addition of Hydrated lime

S.NO	Test name	Obtained value
1	Ductility test(cm)	82
2	Penetration test(mm)	32
3	Softening point test(°c)	58

Discussion: The comparison of this test results shows the properties of bitumen improved by 8% addition of hydrated lime than the addition of 10% hydrated lime bitumen.

Result for Marshall Stability test with graph:
Table 10. Results for Marshall Stability test

S.NO	Material Addition % of $Ca(OH)_2$	Stability value(kg)	Flow value(mm)
1	0	1670.30	2.50
2	2	2240.56	2.70
3	4	2290.56	3.00
4	6	2325.35	3.30
5	8	2386.92	3.20
6	10	2285.36	2.80

Discussion: The above results that are evident from that use of hydrated lime gives the better results than the plain bitumen. The 8% hydrated lime gives maximum stability value and low flow value than the other percentages shown in above graph.
Hydrated lime content vs stability value graph:

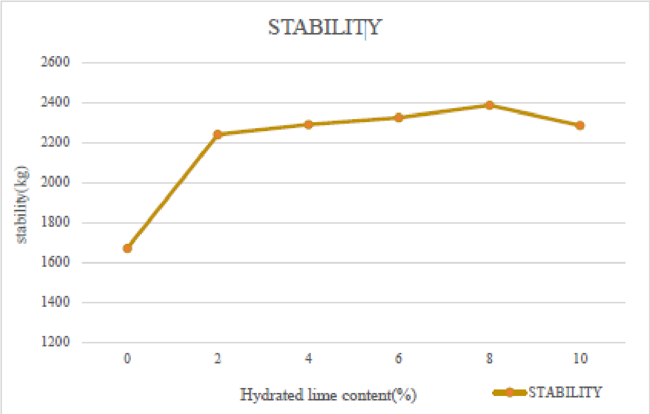

Figure 3. Plotting curve between Hydrated lime content(%) vs Stability(kg**)**

Hydrated lime content vs flow value graph:

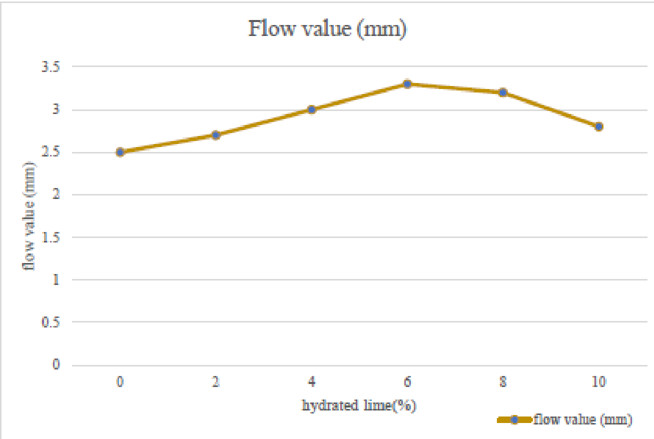

Figure 4. Plotting curve between Hydrated lime content (%) vs flow value (mm)

Results for stripping value test with graph Representation:

Table 11: Results for stripping value test

S.NO	Material % Addition of $Ca(OH)_2$	Stripping value%
1	0	5
2	2	4.2
3	4	3.5
4	6	2
5	8	0
6	10	0

Discussion: The comparison of this test results, stripping value of plain bitumen mixture is 4% and then it is compared with adding of different percentages with hydrated lime like 2,4,6,8,10 etc. the stripping value from addition of 8% to 10% is 0%. So, the anti-stripping mix is 6% hydrated lime and also compared with Marshall Stability and flow value.

Hydrated lime content vs stripping value graph:

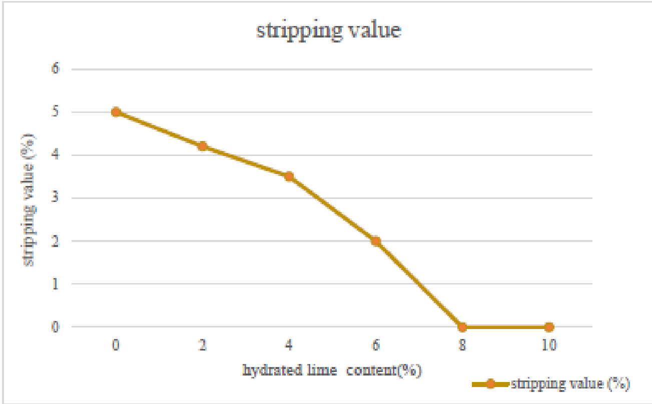

Figure 5. Plotting curve between Hydrated lime (%) vs Stripping value(%)

V.CONCLUSIONS

Hydrated lime is the anti-stripping agent for the design of flexible pavement. This type of agent is used to improve the properties of bitumen such that stability, flow value, plasticity, hardness. This helps to have a better binding of bitumen with hydrated lime and also reduces the air voids. This is also may result in reducing the rutting, ravelling and stripping value of asphalt pavement. The hydrated lime is used to improve the durability of pavement. These roads can with stand any areas to face the any problems of pavement mainly deformation and striping. This type of agent is used for the construction of flexible pavement to improve the quality and life span. Finally, the hydrated lime is adding and we conclude the mix proportion of pavement mixture based on the properties of mix. This may result shows

➢ This aggregate result gives the properties of aggregates are within the permissible limits as per recommendations those have properties of toughness, crushing strength, Sp. gravity, water absorption, shape, hardness. So, this type of aggregates is suitable for road construction.

➢ This bitumen results shows the properties of bitumen with and without adding of hydrated lime. We conclude that plasticity and hardness is improved in bitumen compared to without adding of hydrated lime but softening point value does not improve as per recommendations.

➢ This result shows stripping value of bitumen mixture is 5% without adding of hydrated lime. After adding of hydrated lime, with percentages of 2%,4%,6%,8%,10% the stripping value is reduced to zero at 8% of hydrated lime. we conclude that the mix proportion is taken as 8 or 10%.

➢ This result shows adding of 8% hydrated lime gives maximum stability value and flow value is minimum compared to other percentages. We conclude that the mix proportion of pavement mixture is taken as 8%.

Finally, we conclude that the mix proportion of 8% hydrated lime in pavement mixture gives better results than the other percentages. This result gives maximum stability, minimum flow value and stripping value is zero. So, 8% mix proportion is taken for the construction of road in any areas.it will also reduce the maintenance cost for construction.

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- IRC 27-1967 specification for road aggregates
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- IS 2386(PART-IV)-1963 for Crushing test
- IS 2386(PART-IV)-1963 for Los Angeles Abrasion Test
- IS 2386(PART-I)-1963 for Shape test
- IS 2386(PART-III) for sp. gravity and water absorption test
- IS 1208-1978 for Ductility test
- IS 1205-1978 for Softening point test
- IS 1203-1978 for Penetration test
- IS 6241-1971 for Stripping value test
- IRC 111-2009 for Marshall stability test

