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Effect of Varying Field Conditions on Stripping of Bituminous Roads

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Abstract: *Presence of moisture on road surface can result in loss of bond between aggregate and bitumen mix due to which stripping can take place leading to reduction in pavement life. Most of the studies all over the world conclude that stripping is mainly caused due to the presence of moisture on the pavement. In this paper the results of a laboratory study that considered increased immersion time of bituminous mix in water along with the effect of moving traffic on the road have been presented on aggregate from three different sources using two bitumen grades. It is found that stripping value is affected by source of aggregate and bitumen grade. Also, it is observed that increase in immersion time and application of traffic pressure affects the stripping value. The pH value of water in which aggregates were immersed was also varied. The increase in alkalinity of water was found to increase the stripping of aggregate.*

Keywords: *Stripping, Immersion time, Bitumen grade, pH value, Traffic pressure*

1. Introduction

Bituminous roads are greatly susceptible to moisture damage. Nowadays proper drainage facilities are lacking on the roads which is one of the main reasons for road damage due to stripping. Adequate drainage must be provided for prevention of damage of roads due to stripping as complete failure of the pavement can take place. The Indian standard describing the procedure of stripping test for the coarse aggregate is IS: 6241-1971 in which aggregate of specified size coated with bitumen is kept immersed in water for 24 hours at 40°C which takes moisture effect into account only [1]. An increase of almost 200% in stripping value with the application of external pressure on the aggregate at the time of stripping was reported by Shakya and Sachdeva[2].

Basic rocks i.e. hydrophobic in nature provide better adhesion as compared to acidic type rocks which are hydrophilic in nature [3]. Source of aggregate also affects the adhesion with bitumen as environmental conditions are not same for all locations.

Stiffer binder (40/60 pen) provides better moisture resistance for unmodified mixtures when compared with softer binder (160/220), based on loose bitumen coated moisture sensitivity tests [4].Based on results from loose bitumen coated moisture sensitivity tests bituminous mixtures containing limestone aggregate have better moisture resistance than granite aggregate.

In this study aggregate from different sources and different bitumen grade are used to check stripping value as per IS: 6241-1971 code.

1.1 Mechanism of Stripping

Stripping is generally defined as "the breaking of the adhesive bond between the aggregate surface and the bitumen". Several mechanisms have been suggested to explain the occurrence of stripping which appears to act individually or together to cause adhesion failure in bituminous mixtures.

Five different mechanisms that may be associated with stripping of bitumen film from aggregate surface are [5,6].

1. Detachment
2. Displacement
3. Spontaneous Emulsification
4. Pore Pressure
5. Hydraulic Scouring

1.2Causes of Stripping

Some of the aggregate are inherently susceptible to stripping. Some of the other factors for the moisture induced stripping of the HMA [7]**.**

i) Use of hydrophilic aggregate.
ii) Inadequate mix composition.
iii) Continuous contact of water with the coated aggregate.
iv) Initial over-heating of the binder or the aggregate or both.
v) Presence of dust or moisture on aggregate when it comes in contact with the bitumen.
vi) In the case of surface dressing, poor bond with the surface existing below, delay in spreading the cover aggregate over the sprayed bitumen, or insufficient compaction.
vii) Occurrence of rain or dust storm immediately after the construction.
viii) Opening the road to fast traffic before the binder has set.
ix) Concentration of soil salt in rain water coming in contact with the coated aggregate.
x) Use of improper grade.

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xi) Ageing of the bitumen leading to the embrittlement of the binder film.

1.3 Brief Methodology of Research

The research approach used in this study is detailed in Figure 1.

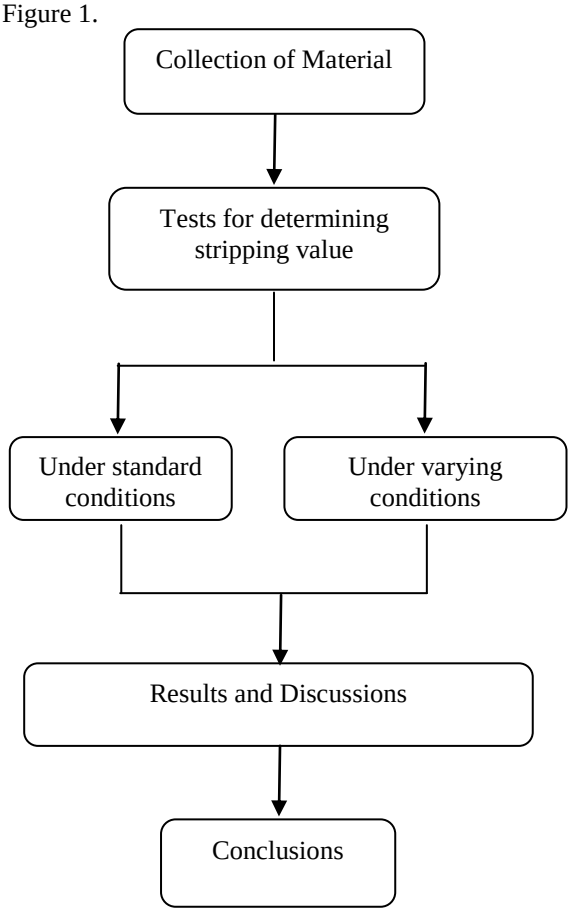

Figure 1 *Flow Chart Illustrating the Research Steps*

1.3.1Material Used

In the present work, bitumen (VG 30 and VG-10) grade from a local refinery and aggregate from three different sources were chosen to evaluate stripping value. Source of material and its type is given in Table 1. The three types of aggregate are shown in figure 2.

Table 1: *Source of Material and Type*

Material	*Type*
Coarse crushed Aggregate	*Type 1, Source: Yamuna Nagar Quarry, Color: Light bluish-white* *Type 2, Source: Dadri Quarry, Color: Light white-reddish* *Type 3, Source: Narnaul Quarry, Color: Dark bluish*
Bitumen	*VG-30 & VG-10 grade, Source: Panipat Refinery, 5% of mass of aggregate.*
Water	*Potable water*
HCL Acid	*For making water acidic (pH value <7)*
NaoH	*For making water alkaline (pH value>7)*

Figure 2: *Aggregate from different sources of Haryana*

1.4 Experimental Approach

The step wise procedure for preparation of sample and its testing under standard conditions is as per "Method of Test for Determination of Stripping Value of Road Aggregates (IS: 6241-1971) code which is as follows:-

- Take 200g of aggregate passing 20mm IS sieve and retained on 12.5mm sieve.
- Dry, clean and mix aggregate with 5% bitumen binder by weight of aggregate, bitumen binder is heated to 160^0C (110^0C in the case of tar binder).
- The aggregate are also to be heated prior to mixing to a temperature of 150^0C and 100^0C, when these are to be mixed with bitumen and tar respectively.
- The mixture is transferred to a 500 ml beaker after complete coating and allowed to cool at room temperature for about 2 hours.
- Distilled water is then added in the beaker to immerse the coated aggregate.
- The beaker is covered and kept in a water bath maintained at 40 ^{0}C, taking care that the level of water in the water-bath comes up to at least half the height of the beaker.
- After the expiry of 24 hours the beaker is taken out, cooled at room temp.
- The extent of stripping is estimated visually while the specimen is still under water.

1.5 Test Results and Discussion

The test is carried out under standard conditions and varying conditions to determine the change in the value of stripping on aggregate. In order to determine the effect of extended contact time of water on the value of stripping time the immersion time is increased from 1 day to 5 days. The traffic load and tyre friction effect was simulated by applying external pressure manually with a small tyre.

1.5.1Stripping of aggregate using VG-30 grade bitumen:

The bitumen-aggregate mixtures prepared from 3 types of aggregate from different source were tested by using VG-30 grade bitumen. The results are given in Table 2 and graphically represented in Fig. 3

Table 2: *Stripping of aggregate using VG-30 grade bitumen*

S. No.	Contact Time (Days)	Striping of Aggregate (%) for					
		Aggregate Type 1		Aggregate Type 2		Aggregate Type 3	
		Without Pressure	With Pressure	Without Pressure	With Pressure	Without Pressure	With Pressure
1	1	0	1	0	1	0	1
2	2	1	1	1	1	1	1
3	3	1	2	1.5	2.5	1	1.5
4	4	2	3	2.5	3	1.5	2
5	5	2.5	4	3	5	2	2.5

It is observed from fig. 3 that the stripping value of all aggregate types increases with increase in immersion time of aggregate in water. Similarly, the stripping value increases with application of external pressure for all the three types of aggregate considered in the study. Type 2 aggregate exhibited more stripping than Type 1 and Type 3 aggregate under both conditions of with and without the application of external pressure.

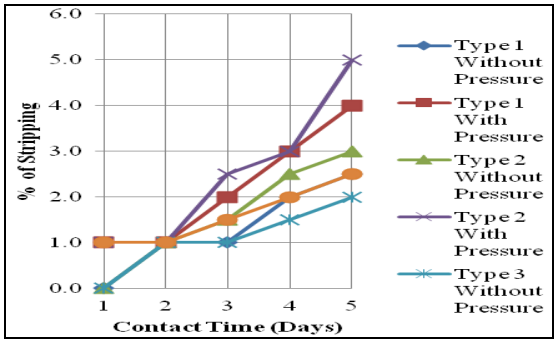

Figure 3: *Stripping of aggregate with VG-30 bitumen grade*

1.5.2Stripping of aggregate using VG-10 grade bitumen

The bitumen-aggregate mixtures were tested by using VG-10 grade bitumen. The results are given in Table 3 and graphically represented in Fig. 4.

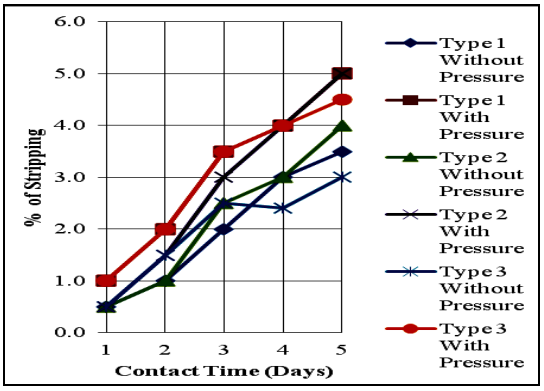

Figure4: *Stripping of aggregate with VG-10 bitumen grade*

It is observed from fig. 4 that the stripping value using VG-10 grade bitumen in this case also shows the same trend as it was offered with bitumen grade VG-30. Stripping value of all aggregate types increases with increase in immersion time of aggregate in water. Similarly, the stripping value increases with application of external pressure for all the three types of aggregate considered in the study.

Table 3: *Stripping of aggregate using VG-10 grade bitumen*

S. No.	Contact Time (Days)	Striping of Aggregate (%) for					
		Aggregate Type 1		Aggregate Type 2		Aggregate Type 3	
		Without Pressure	With Pressure	Without Pressure	With Pressure	Without Pressure	With Pressure
1	1	0.5	1	0.5	0.5	0.5	1
2	2	1	2	1	1.5	1.5	2
3	3	2	3.5	2.5	3	2.5	3.5
4	4	3	4	3	4	2.5	4
5	5	3.5	5	4	5	3	4.5

Type 2 aggregate exhibited more stripping than Type 1 and Type 2 aggregate when no external pressure is applied but Type 1 and Type 2 aggregate has stripping value 5% under application of external pressure, which is the maximum permissible limit of stripping value as per Indian Standards. Also, it is observed that Type 3 aggregate exhibits more stripping value with VG-10 grade bitumen than VG-30 grade.

VG-30 grade bitumen is harder than VG-10 so it exhibits greater resistance to stripping which is clear from fig. 3 and fig. 4.

1.5.3 Stripping value of coarse aggregate under Alkaline Condition

Type -2 aggregate with VG-30 bitumen grade mixtures were tested under alkaline condition. The results are given in Table 4.

It is observed from table 4 that the stripping value of coarse aggregate is affected by pH of water in without pressure and with pressure condition. It is observed that increase in alkalinity increases stripping value considerably under with pressure condition.

Table 4. *Stripping of aggregate under varying pH Condition*

Sr. No.	Contact Time (Days)	Striping of Aggregate (%) for			
		Alkaline Condition (pH=9)		Alkaline Condition (pH=11)	
		Without Pressure	With Pressure	Without Pressure	With Pressure
1	1	1	1	1	9
2	2	1	1	2	15
3	3	2	3	2.5	19
4	4	3	5	4	21
5	5	4	6	5	24

Fig. 5 shows stripping of Type 2 Aggregate under Alkaline Condition pH 11 with Pressure.

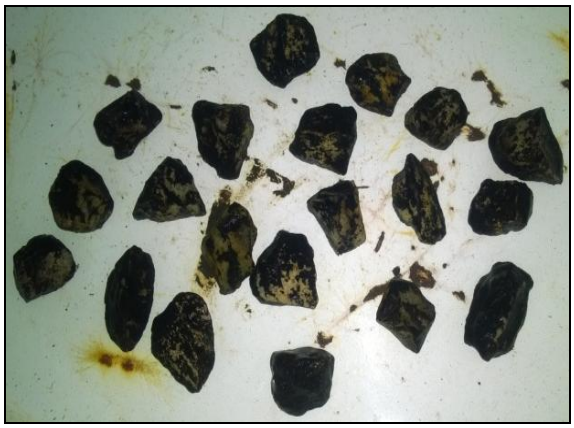

Figure 5: *Stripping of Type 2 Aggregate under Alkaline Condition pH 11 with Pressure*

1.6 Conclusions

It is clear from the study that the stripping of aggregate gets affected due to variation in the standard conditions. The main conclusions drawn from the study are:

- Stripping of aggregate increases with the increase in immersion time of water with coated aggregate.
- The stripping increases with application of external pressure on the coated aggregate which shows that the effect of traffic needs to be properly simulated in the laboratory test conditions.
- Choice of Bitumen grade also affects stripping of coarse aggregate. It has been found that VG-30 grade bitumen exhibits less stripping than VG-10 grade bitumen.
- The source of aggregate also affects stripping value. Type 1 and Type 2 aggregate obtained from Yamuna nagar and Dadri quarry respectively exhibited maximum stripping when used with VG-30 and VG-10 grade bitumen whereas the Type 3 aggregate from Narnaul quarry showed least stripping under most of the varying conditions of test.
- Stripping value of Type-2 aggregate increases with the increase in alkalinity of water.
- The standard lab methods for evaluation of stripping need to be rationalised that simulate the field conditions better to accurately predict the stripping behaviour of aggregate.

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