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# Study on Anti-Stripping Performance of Lime in Bituminous Mix

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**Abstract -** *Road infrastructure is generally considered an indicator of the economic development of any country. India was and still is a country where the majority of major roads are made of asphalt. During its service period, the flexible pavement exhibits various defects. Aggregates being stripped off bituminous roads are a typical problem in our country. Recent studies demonstrate that lime acts as an anti-oxidant, active filler, and additive to bituminous mix. Hydrated lime's effectiveness in asphalt mixtures is due to the strong interactions between the principal components, aggregate, and bitumen. The hydrated lime reacts chemically with the acids in the bitumen and improving the mixture's moisture resistance. In this study, lime was mixed using the slurry method since it is quite easy to do in our laboratory, whereas two other dry injection mixers and dry lime can only be made in asphalt mixers on the damp aggregate. The experimental test on stripping value of aggregate before and after mixing the lime was done as per IS.: 6241-1971. The optimal lime proportion was determined as 3% of the total weight of aggregate. The investigation concluded that the bituminous mix with lime reduces the stripping value. The pavement laid using these bituminous mixes would not strip from any portion of flexible pavement. This mixture may avoid faults like rutting, cracking, edge drops, and so on.*

***Key Words*: Hydrated lime, Stripping value, Slurry method, Bituminous mix, Moisture resistance, Flexible pavement**

## 1. INTRODUCTION

Transportation infrastructure investments have a critical but indirect role in the development process. To raise the overall standard of living and eradicate poverty, India must sustainably continue its growth momentum. In this sense, infrastructure is crucial as it is strongly linked to economic growth and poverty reduction [1]. Regions with poor transportation infrastructure typically have lower per capita income, a higher concentration of primary industry, and a lower population density[2].

Flexible pavements are preferred over rigid concrete roadways due to several advantages, including the ability to be strengthened and upgraded in stages as traffic increases. Flexible pavements are the least expensive in terms of both initial and maintenance costs [3].

Extensive road networks created at significant expense in India have been poorly maintained and used far more than their design values. Apart from insufficient capacity and pavement thickness, the main flaws in our highway system are poor ride quality, deteriorated and distressed bridges/culverts, congested stretches, and excessive axle loading. However, water infiltration can damage a pavement structure in a single season[4].

Bitumen properties such as acid number, molecular size distribution, and penetration grade had no effect on moisture sensitivity in a bituminous mix. Regardless of the bitumen employed, mixtures containing alkali metals (sodium and potassium) displayed rather high moisture sensitivity. The variation in moisture sensitivity is due to aggregate rather than bitumen[5].

Calcium-containing inorganic compounds with predominant carbonates, oxides, and hydroxides are generally known as lime. Calcium hydroxide is typically a white finely split powder with a diameter of less than 0.15 mm. This paper describes the most important benefits of adding lime to the bituminous mix. This mixed lime was expected to act as an anti-stripping agent[6]. The significant interactions between the principal components, i.e., aggregate and bitumen, and the combination of four effects, two each on the aggregate and bitumen, explain why hydrated lime is particularly successful in asphalt mixtures [7]. Hydrated lime alters aggregate surface properties, enabling a surface composition (calcium ions) and roughness (precipitates) that is more conducive to bitumen adherence.

The existing clayey particles adhering to the aggregate surface can be treated with hydrated lime, reducing their adverse influence on the mixture. In addition, hydrated lime reacts chemically with the acids in bitumen, slowing the age-hardening kinetics and neutralizing the influence of the "bad" adhesion boosters previously present in the bitumen, improving the mixture's moisture resistance[8].

The study was conducted to examine if hydrated lime could be employed as an anti-stripping agent in aggregate mixes for use in road pavements after being mixed with aggregates and bitumen.

## 2. MATERIALS AND METHODOLOGY

The materials used in the study are hydrated lime, bitumen, and aggregates. There are three methods for adding lime with aggregate. They are (i) Dry Injection into Drum Mixers, (ii) Dry lime on Damp aggregate method, and (iii) Slurry method [9]. The slurry method was used in this case. This process involves applying a slurry of lime and water to the aggregate at a measured pace, ensuring superior coverage of the stone surfaces. The aggregate can then be fed straight into the plant or marinated for a period of time in the stockpile to allow the lime to react with the aggregate [10]. Because the lime is attached to the stone, this approach produces the most negligible lime dispersion throughout the mix.

### 2.1 Test on Aggregates

For an experimental study on lime in the bituminous mix following tests are proposed to be carried out for aggregates[11].

- Aggregate Impact Test
- Aggregate Crushing Test
- Specific Gravity Test
- Water Absorption Test
- Shape Test
- Soundness Test

### 2.2 Test on Bitumen

For the same study, the following tests are proposed to be carried out for bitumen [12].

- Softening Point
- Penetration Value Test

### 2.3 Test on Bituminous Mix

To compare the stripping value of normal and lime mixed aggregates, the following tests are proposed to be carried out [13].

- Stripping test for aggregates
- Stripping test for lime mixed aggregates

The optimal hydrated lime content was determined by considering the maximum aggregate coverage after blending. The lime content of about 3% in aggregate weight (saturated-surface-dry condition) was used for the study. The above proportion was obtained based on a few trials by considering lime proportion and its surface [14].

## 3. RESULT AND DISCUSSION

The test for aggregate, bitumen, and the bituminous mix have been conducted as per Indian Standard. The obtained results of each test were compared with M.O.R.T.H. standards

### 3.1 Aggregate Impact Value

The aggregate impact test is recognized as a crucial test for determining the suitability of aggregates in terms of toughness. The Ministry of Road Transport and Highway (M.O.R.T.H.) has specified the maximum permissible aggregate impact value of coarse aggregates as 30% for use in highway road pavement.

**Table -1**: Observation of Aggregate Impact Value Test

| Description | Trial 1 (gms) | Trial 2 (gms) |
|---|---|---|
| Total weight of aggregate sample filling the cylindrical measure = W1 | 387 | 380 |
| Weight of aggregate passing 2.36 mm sieve after the test = W2 | 64 | 58 |
| Weight of aggregate retained on 2.36mm sieve after the test =W3 | 323 | 322 |
| Aggregate Impact Value %, (w2*100/w1) | 16.54 | 15.26 |
| Mean Impact value | 15.75 (16) | |

The aggregate impact value of aggregates is 16, which is less than M.O.R.T.H. specifications (30%). The impact value less than 20% can be used for highways as per I.R.C.

### 3.2 Aggregate Crushing Value

The aggregate crushing value test determines an aggregate sample's resistance to crushing under a gradually applied compressive load.

**Table -2**: Observation of Aggregate Crushing Value Test

| Description | Trial 1 (gms) | Trial 2 (gms) |
|---|---|---|
| Total weight of the dry sample, W1 | 3000 | 3000 |
| Weight of fines passing 2.36 mm I.S. sieve, W2 | 885 | 819 |
| Weight of fines retained on 2.36 mm I.S. sieve, W3 | 2115 | 2181 |
| Aggregate crushing value in % | 29.3 | 27.2 |
| Mean Crushing Value | 28.25 (28) | |

The aggregate crushing value is 27% which is less than M.O.R.T.H. specification (30%), so it can be used for highway works as per I.R.C.

### 3.3 Specific Gravity

Specific gravity, often known as relative density, is the ratio of a material's density to a reference substance. Water is generally taken as a reference substance.

**Table -3**: Observation of Specific Gravity Test

| Description | Observation (gms) |
|---|---|
| Weight of pycnometer W1 | 651 |

| | |
|---|---|
| Weight of pycnometer + coarse aggregates W2 | 1012 |
| Weight of pycnometer + coarse aggregates + water = W3 | 1706 |
| Weight of pycnometer + water = W4 | 1472 |
| Specific Gravity | 2.81 |

The specific gravity of aggregates using pycnometer is 2.81. As the permissible values range from 2.6 to 2.9, it can be used for highway construction.

### 3.4 Water Absorption Value

Water absorption reveals the aggregate's internal structure. Aggregates with higher absorption are porous in nature and are generally considered undesirable unless strength, impact, and hardness testing show that they are acceptable[15].

**Table -4**: Observation of Water Absorption Test

| Description | Observation (gms) |
|---|---|
| Weight of saturated surface- dry aggregate in air | 1000.6 |
| Weight of oven-dried aggregate | 995 |
| Weight of water | 5.6 |
| Water absorption value in % | 0.56 |

The water absorption value of aggregates is 0.56%. It generally ranges from 0.1 to 2.0 percentage for coarse aggregates usually used in road surface courses. Indian Roads Congress (I.R.C.) and Ministry Of Road Transport and Highways (M.O.R.T.H.) have specified the maximum water absorption value as 2.0 % for road construction.

### 3.5 Shape Test Value

Flaky and elongated particles in the coarse aggregates used to construct base and surface courses of road pavements are considered undesirable. These may cause inherent weakness with possibilities of breaking down during compaction and under heavy traffic loads.

### 3.5.1Flakiness Index Value

Flaky aggregates pack more tightly than cubical aggregates. They orient with fewer voids. As a result, flaky particles require a minimum binder.

**Table -5**: Observation of Flakiness Index Test

| Description | Observation (gms) |
|---|---|
| Total weight of 200 pieces of the aggregate sample taken | 498 |
| Weight the fraction of the aggregate that retained on the specified value of thickness gauge | 442 |
| Weight the fraction of the aggregate that passing the specified value of thickness gauge | 56 |
| Flakiness index % | 11 |

### 3.5.2 Elongation Index Value

Elongated aggregates cause intrinsic road weakness, and there is a risk of these aggregates fracturing due to strong stresses imposed by vehicular traffic or during compaction.

**Table -5**: Observation of Elongation Index Test

| Description | Observation (gms) |
|---|---|
| Total weight of 200 pieces of the aggregate sample taken | 498 |
| Weight the aggregates fraction that retained on specified value of elongation gauge | 90 |
| Weight the aggregates fraction that passing the specified value of elongation gauge | 408 |
| Elongation index % | 18 |

The combined index is determined by adding both flaky and elongation index values. Here, the combined index of aggregate is 29%. M.O.R.T.H. has specified that the maximum combined index value for aggregates is 30 % for road construction. Hence it is suitable for roadworks.

### 3.6 Soundness Test

The soundness test checks if aggregates have disintegrated owing to weathering. It covers freezing, thawing, and being in a marine environment, among other things. During this soundness test, however, the porous and weak aggregate loses weight.

**Table -5**: Observation of Soundness Test

| Description | Observation (gms) |
|---|---|
| Weight of oven-dry aggregate W1 | 1000 |
| Weight of aggregate after sodium sulphate's action in five cycles W2 | 964 |
| Loss in weight of aggregates | 40 |
| Water absorption value in % | 4 |

The Soundness of aggregates (unsound) is 4% which is less than the M.O.R.T.H. specification of 12% to be used for highway works.

### 3.7 Softening Point Test

The temperature at which a bituminous material softens further after reaching its arbitrary softness point is known as its softening point.

**Table -6**: Observation of Softening point test

| Description | Softening point(°C) | | |
|---|---|---|---|
| | Trial 1 | Trial 2 | Mean |
| Temperature @ which I ball touches the bottom plate | 48 | 50 | 49 |

| | | | |
|---|---|---|---|
| Temperature @ which II ball touches the bottom plate | 49 | 49 | 49 |

The Softening point value of bitumen is 49°C. The grade of bitumen is 60/70. The softening point has particular significance for materials to be used as joint and crack fillers.

### 3.8 Penetration Test

Bitumen penetration testing evaluates the hardness or softness of bitumen by measuring the depth in millimeters. A standard loaded needle will penetrate vertically in five seconds while the bitumen sample is kept at 25ºC.

**Table -7**: Observation of Bitumen Penetration test

| Reading | Trial 1 | Trial 2 | Mean |
|---|---|---|---|
| Penetrometer dial initial reading(mm) | 0 | 0 | 0 |
| Penetrometer dial final reading(mm) | 69 | 67 | 68 |
| Penetration value(mm) | 69 | 67 | 68 |

The average penetration value of the bitumen sample is 68mm. Since the grade of bitumen is 60/70, the penetration value should lie between 60 and 70.

### 3.9 Stripping Value of Aggregates

The stripping value of aggregates is calculated as the percentage of the exposed area viewed visually to the overall area of aggregates from the bituminous mix. Here the bituminous mix is completely immersed in distilled water for 24 hours.

### 3.9.1 Stripping Value of Aggregates Before Lime Mix

The stripping value of aggregates without lime mix is 3%, meaning 3 parts out of 100 are uncovered. I.R.C. has specified maximum stripping value of aggregates should not exceed 5%[13].

### 3.9.2. Stripping Value of Aggregates after Lime Mix

The stripping value of aggregates after mixing lime is 1%. It implies the uncovered area reduces by comparing with the above case. Stripping value reduced to 1% from 3% by lime mix.

## 4. CONCLUSION

The hydrated lime blending is effective in asphalt mixtures because of its strong interactions between the major components, i.e., aggregate and bitumen. The use of lime mixing at a 3% proportion helps in substantially improving the binding property, which reduces the stripping value of aggregates from 3% to 1%. Since lime is cheap, it is recommended to practice this study in the field so that efficient and economical flexible pavement can be laid. The hydrated lime exactly acts as an anti-stripping agent in the bituminous mix. The lime mixing shall be done in Bituminous concrete out of the different functional layers in flexible pavement.

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