

# APPLICATION OF SURFACE ENERGY MEASUREMENTS TO ASSESS MOISTURE INDUCED DAMAGE IN BITUMEN MIX

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**Abstract** - One of the main problems in transportation field is the early deterioration of pavements due to moisture damage. Moisture damage in bituminous pavement can be reduced by predicting moisture susceptibility. Surface energy property of bitumen and aggregate is directly related to the moisture susceptibility of bitumen pavement. By measuring surface energy of bitumen and aggregate an indication of moisture damage can be predicted. It is a new and accurate method compared to other existing methods like Stripping value test and also this method is capable of providing a guideline for the selection of bitumen and aggregate with focus on resistance to moisture damage.

**Key Words:** Surface energy, Indirect tensile strength Test, Marshall Test, Stripping value test, Moisture Susceptibility

## 1. INTRODUCTION

Bituminous concrete is one of the primary materials used to build and maintain roadways in the world. Each year it becomes more important that these materials perform at higher level to reduce the worse effects of increased traffic and climatic conditions. Moisture damage in asphalt mixes can be defined as loss of strength and durability due to the presence of moisture at the binder aggregate interface (adhesive failure) or within the binder (cohesive failure).

Nowadays Stripping test and Indirect tensile strength test is used for predicting the moisture damage. But Stripping test is generally found to be inconclusive and Indirect tensile strength test is difficult. So in this project we use surface energy measurement to predict the moisture susceptibility. It is a new and accurate method to predict the moisture susceptibility. Sample collection is presented in section 2. Surface energy measurements, Stripping value test results and Indirect strength test results are given in section 3. Concluding remarks are given in section 4.

## 2. SAMPLE COLLECTION

### A. Bitumen

Bitumen is collected from BPCL Kochi, Kerala, India. The samples are,

- VG 30
- NRMB (Natural Rubber Modified Bitumen)

- Bitumen Emulsion

### B. Aggregates

Aggregates are collected from Paittakulam marble shops and Chittethu Metal Crusher. The samples are,

- Marble
- Granite
- Gravel

The sample characteristics tested in Transportation Engineering Laboratory of Mar Athanasius College of Engineering Kothamangalam are as given below.

### A. Specific gravity of Bitumen and Aggregate

VG 30	- 1.007
NRMB	- 1.583
Gravel	- 2.700
Granite	- 2.698
Marble	- 2.840

### B. Impact Test on Aggregate (in %)

Gravel	- 25
Granite	- 14
Marble	- 10

### C. Water Absorbtion ( in %)

Gravel	- 0.6
Granite	- 1.2
Marble	- 0.8

## 3. TESTS CONDUCTED

### (i)Surface energy measurement

The Surface energy measurement was done at M G University College , Athirambuzha, Kottayam, Kerala. Contact angles of bitumen and aggregate were determined using Optical Tensiometer (an equipment used to determine contact angle from the recorded image of a water droplet on the material surface). Surface Wave 7 software was used for finding surface energy directly from the contact angle.



Fig.1.Optical Tensiometer

		Distilled water	0
		Alkaline	0
	NRMB	Acidic	0
		Distilled water	0
		Alkaline	0
Marble	VG 30	Acidic	20
		Distilled water	0
		Alkaline	20
	NRMB	Acidic	20.
		Distilled water	0
		Alkaline	20

The Surface energy values were obtained as shown below.

**Table -1:** Surface Energy Values for Bitumen

Bitumen Type	Contact Angle (in degrees)	Surface Energy(mJ/m <sup>2</sup> )
VG 30	49	61.622
NRMB	30	78.238
Emulsion	45	65.479

**Table -2 :** Surface Energy Values for Aggregates

Aggregate Type	Contact Angle (in degrees)	Surface Energy(mJ/m <sup>2</sup> )
Marble	39.43	70.58
Granite	38.28	71.59
Gravel	35.59	73.87

**(ii) Stripping value test**

Stripping value test is conducted to determine the effects of moisture upon the adhesion of the bituminous film to the surface particles of aggregate. This test is of significant value to ascertain the suitability of the two materials viz. Bitumen and aggregate.

The binder coated aggregates were immersed in distilled, acidic and alkaline water at a temperature of 40° C for a period of 24 hours.

**Table -3:** Stripping values obtained

Aggregate	Bitumen	Medium	Stripping (%)
Gravel	VG30	Acidic	0
		Distilled water	0
		Alkaline	0
	NRMB	Acidic	0
		Distilled water	0
		Alkaline	0
Granite	VG30	Acidic	0

The results of stripping value tests are not sufficient for understanding moisture damage. So another test i.e., Indirect Tensile Strength Test is used to determine the moisture susceptibility.

**(iii) Indirect tensile strength test**

The Indirect tensile strength test is a laboratory test which is used to evaluate the moisture susceptibility of a bituminous mix. Tensile strength ratio (TSR) is a measure of water sensitivity. It is the ratio of the tensile strength of water conditioned specimen,(its wet, 60°C, and 24h) to the tensile strength of unconditioned specimen(its dry) which is expressed as a percentage. A higher TSR value indicates that the mixture will perform well with a good resistance to moisture damage. The higher the TSR value more water resistant it will be.

The tensile characteristics of bituminous mixtures were evaluated by loading the Marshall specimens (which were made as per the MORTH specifications) along a diametric plane with a compressive load at a constant rate acting parallel to and along the vertical diametrical plane of the specimen through two opposite loading strips. This loading develops a relatively uniform tensile stress perpendicular to the direction of the applied load and along the vertical diametrical plane, ultimately causing the specimen tested to fail by splitting along the vertical diameter.

**4. CONCLUSIONS**

By comparing surface energy values of Bitumen and Aggregate it is seen that among the bitumen NRMB has the highest value of surface energy and VG30 has the least value of surface energy. Similarly considering the surface energy of aggregates Gravel has the highest value of surface energy and Marble has the least value of surface energy.

From the results of indirect tensile strength test bitumen mix of NRMB and gravel has the highest TSR value and Bitumen mix of Marble and VG 30 has the lowest TSR value.

The surface energy measurement gives the same result as that of the Indirect Tensile Strength Test. So the surface energy measurement can be used predict the moisture susceptibility and to provide a guideline for the selection of bitumen and aggregate.

## 5. REFERENCES

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