

# Strengthening of Flexible Pavement using Egg Shell as a Filler

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## ABSTRACT:

Construction of pavement involves huge outlay of investment. Addition of certain materials like limestone, coconut shell, egg shell, saw dust etc. It may save considerable investment as well as gives reliable performance. This project describes the use egg shell as filler in bituminous pavements in order to fill the air voids. It involves identification of proper mix by obtaining optimum bitumen content (OBC) and

optimum egg shell content by determining the Marshall Stability and flow values.

**KEYWORD:** Eggshell powder, OBC, air voids, Marshall Stability, flow

In India, the two major types of pavements generally laid are flexible pavements and rigid pavements. Each type has its own advantages and disadvantages. Flexible pavements are also called as bituminous pavement which is more economical and reliable compared to rigid (concrete) pavements. Flexible pavement consists of four components- soil sub grade, sub base course, base course and wearing course. Materials usually used in this type of pavement are bitumen, aggregate, and filler. The filler material is used as an addition to these components in order to avoid the voids formed in wearing coat. When it is mixed with bitumen and aggregate it fills the cavities and avoids the formation of cracks thereby creating a dense mix and increasing the viscosity of bitumen. It also acts as a reinforcement material and increases the compactive effects required to compact the specimen. Suitable

## 1 INTRODUCTION:

material combinations and modified bituminous binders have been found to result longer life for wearing courses depending upon the percentage of filler and type of fillers used. The common fillers used are lime, cement, quarry dust etc. Since the eggshell has the same composition as that of limestone, it can be used in the pavement as they are inexpensive when compared to others. Overloading of trucks and significant variations in daily and seasonal temperature of pavements have been responsible for development of distress symptoms like raveling, undulations, rutting, cracking, bleeding, shoving and potholing of bituminous surfaces. In order to find the appropriate mix proportion that will efficiently withstand the problems, optimum bitumen content (OBC) and optimum eggshell content has to be found out by experimental studies.

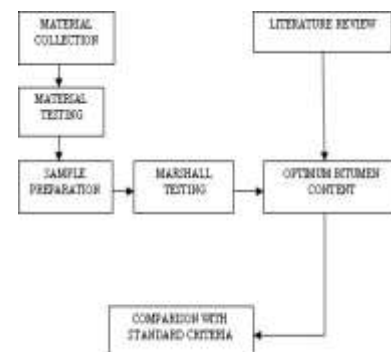
## 1.1 REASON FOR SELECTING THE BINDING MATERIALS

The properties of materials used in the pavement are analysed and tested individually. These tested materials are used in the preparation of various mix samples. With the help of these samples and results the optimum bitumen content and optimum eggshell content are obtained.

## 1.2 OBJECTIVE

- To study the properties of pavement materials (bitumen, aggregate).
- To examine the filler material (eggshell).
- To prepare the samples and perform the tests.

## 2. METHODOLOGY



**2.1 MATERIALS AND METHODS:**

**2.1.1 AGGREGATE:**

Aggregates should be strong and durable; they should also possess proper shape and size to make the pavement act monolithically. Aggregates are tested

**Table 2.1 showing the properties of coarse aggregates:**

TEST	OBSERVED VALUE	STD SPECIFICATION
Aggregate impact test	2.94%	<30%
Water absorption test	0.15%	<0.6%
Flakiness test	28.2%	<30%
Specific gravity	2.65	2.67

**2.1.2 BITUMEN BINDER:** The Bitumen makes up about 5 to 6 percent of the total Bitumen mixture, and coats and binds the aggregate particles together. It is a natural mixture of hydrocarbons which is generally black or brown in colour. It is available in various grades, out of which 60/70 is found to be suitable for higher traffic roads. The properties of bitumen are analysed by performing various tests.

**Table 1.2 showing the properties of bitumen (60/70 grade):**

TEST	OBSERVED VALUE	STD SPECIFICATION
Penetration test@ 25°C	65 mm	60/70 mm
Softening point test	45 °C	35-70 °C

Marshall Method of mix design has been adopted in this work. Accordingly aggregates with the grading 2 of IRC and bitumen 60/70 having properties as described in the tables have been used. The objective of bituminous paving mix design is to develop an economical blend of aggregates and bitumen. It uses several trial aggregate -bitumen binder blends (typically 5 blends with 3 samples each for a total of 15 specimens), each with a different bitumen binder

**Table 2.2 showing the mix proportions**

Description	Sample I	Sample II	Sample III	Sample IV	Sample V
% of bitumen	5.5%	6%	6.5 %	7 %	7.5%
% of eggshell	5 %	10%	15 %	20%	25 %
Weight in air, kg	1105 kg	1160 kg	1215 kg	1270 kg	1325 kg
Weight in water, kg	1155 kg	1212 kg	1270 kg	1330 kg	1400 kg
Diameter, cm	10	10	10	10	10
Height, cm	6.3	6.5	7.0	7.8	7.7

for strength, toughness, hardness, shape and water absorption. Aggregates can either be natural or manufactured. The size of aggregates used ranges from 19-20mm to 4-6mm. The test results are computed as follows:

Ductility test	78 cm	>75 cm
Viscosity test@ 60°C	1800 poise	1600-2400 poise
Specific gravity	0.99	0.97-1.02

**2.1.3 EGGSHELL AS A FILLER:** The properties of binders are often improved or enhanced by using additives or modifiers to improve adhesion (stripping resistance), flow, oxidation characteristics, and elasticity. Modifiers include oil, filler, powders, fibers, wax, solvents emulsifiers, wetting agents, as well as other proprietary additives.

Eggshell is brittle white and has a grainy texture. It is semi-permeable and resistant to fire and climatic changes.

TEST	OBSERVED VALUE	STD SPECIFICATION
Specific gravity	2.14	2.67
% passing sieve no.200	75-80%	75-85%

**Table 2.3 showing the eggshell characteristics:**

**2.2 MIX DESIGN**

content. Then, by evaluating each trial blend’s performance, optimum bitumen binder content can be selected. In order for this concept to work, the trial blends must contain a range of bitumen contents both above and below the optimum bitumen content. Therefore, the first step in sample preparation is to estimate optimum bitumen content. Trial blend bitumen contents are then determined from this estimate.

**3. RESULT AND DISCUSSION:** The results of Marshall Tests of specimens conducted are given in (Tables 3.1 and 3.2) respectively. The graphs (Figure 3.1 to 3.6) are plotted with various bitumen content to find OBC and eggshell content.

**3.1 STABILITY -FLOW ANALYSIS:** Maximum load required to produce failure in specimen when preheated and load is applied at a constant strain (5cm per min) is called as Marshall Stability. The deformation at the failure point expressed in the units of 0.25mm is called as flow value. From many trials, the average value for each mix is computed.

Table 3.1 showing stability-flow analysis:

BC (%)	ESC (%)	STABILITY(KG)	FLOW (mm)
5.5	5	580	4.73
6.0	10	650	4.48
6.5	15	680	4.45
7.0	20	710	4.91
7.5	25	740	4.45

**3.2 DENSITY-VOID ANALYSIS:** The bulk density, percent air voids, voids in mineral aggregates and void filled with bitumen are calculated using respective formulae [1].

Table 3.2 showing density-void analysis:

SAMPLE	P <sub>ca</sub> (%)	P <sub>mr</sub> (%)	P <sub>b</sub> (%)	G <sub>a</sub>	G <sub>t</sub>	V <sub>v</sub> (%)	VMA (%)	VFB (%)
BC=5.5% ESC= 5%	90.5	4.52	4.97	2.648	2.444	5.51	17.11	67.79
BC=6% ESC= 10%	86.2	8.62	5.17	2.619	2.415	3.519	15.64	77.50
BC=6.5% ESC=15%	82.3	12.35	5.35	2.59	2.387	3.268	15.79	79.29
BC= 7% ESC= 20%	78.7	15.75	5.51	2.572	2.365	6.3	18.63	66.17
BC= 7.5% ESC= 25%	75.47	18.87	5.66	2.543	2.342	19.86	30.37	34.62

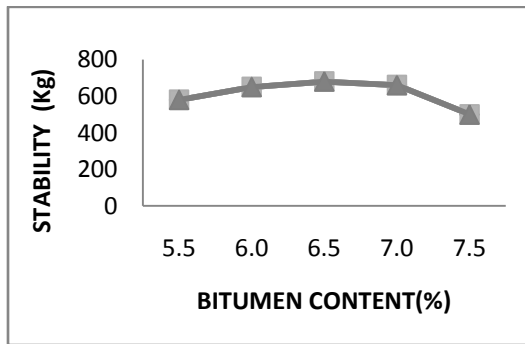


Figure 3.1 Stability vs. Bitumen Content

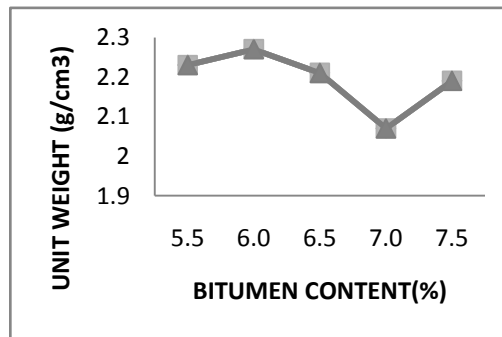


Figure 3.2 Unit weight vs. Bitumen content

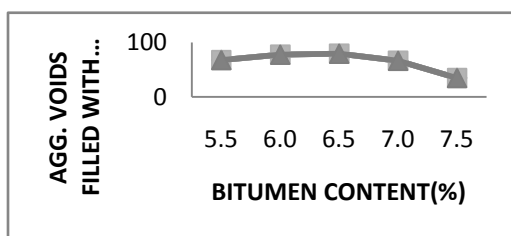


Figure 1.3 VFB vs. Bitumen Content

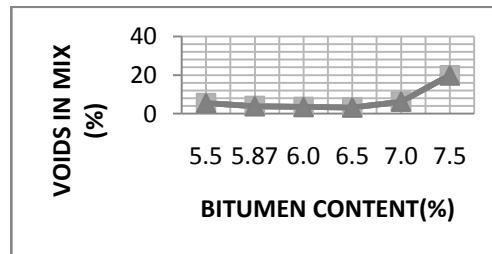


Figure 3.4 Air Voids vs. zBitumen Content

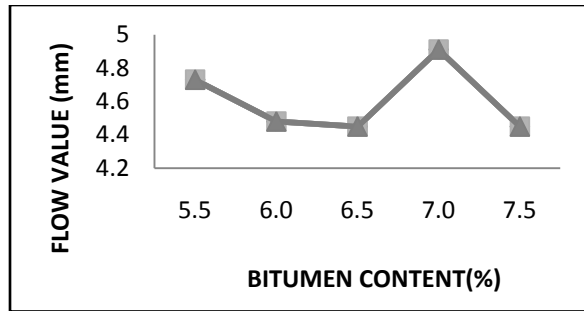


Figure 3.5 Flow vs. Bitumen Content

2. The value of OBC can be obtained from the graph of unit weight, stability and void in total mix plotted. The value of OBC based on the graph above is

Table 3.3 Summary of parameter on OBC value

DESCRIPTION	OBSERVED	STD VALUES
Stability, kg	680	650
Flow value, mm	4.46	4-6
% voids in mix, Vv	4	3-5
% voids in aggregate with bitumen, VFB	78.2	75-85
VMA, %	15.65	13-16

3. Thus the maximum eggshell content that has to be added to 6.12% of bitumen content is found to be 11.2%. It is evident that eggshell was able to fill the cavity between the aggregates and stick to the good cause with better compressed sample. The flow is proportional to the value of flexibility. Figure of flow shows the value was not constant.

**CONCLUSION:**

Based on this study, the use of eggshell as filler material in bituminous pavement produce positive result. This shows that eggshell is suitable to apply in the road construction. However, this study proves

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1. S.K.KHANNA-C.E.G.JUSTO, Highway Engineering.
2. IRC:29-1988 Specification for Bituminous Concrete for Road Pavement.
3. IS 73-2006 Indian Standard paving bitumen — specification

1 .Bituminous mixes containing eggshell as filler displayed maximum stability (Figure 2) at 6.5% content of bitumen having an increasing trend up to 6.5% and then gradually decreasing. The unit weight (Figure 1) is maximum at 6% of bitumen content and then decreases. The percentage of air voids (Figure 5) obtained was seen to be decreasing with increase in bitumen content. Air voids should range from 3-5<sup>[1]</sup> thus bitumen content corresponding to the 4% is 5.87%.

6.12%<sup>[1]</sup>. After OBC values have been derived, corresponding stability, flow, air voids in mix and VFB are summarized in Table 3.

4. Figure3 shows that high bitumen content will result in discharge problem due to large load and at high temperatures, hence pavement becomes brittle and prone to cracking if the bitumen used is too low or too high. So, 7.5% of bitumen content leads more voids in the mix which is not preferable. This indicates that mixes with high stability and very low flow value are not desirable.

that the addition of eggshell in the range of 10-15% in bituminous mix with OBC as 6-6.5% gives better strength compared to conventional mix.

4. Ravindra Tomar et al., 2013 “Effect of fillers on bituminous paving mixes”.
5. Yuliahmadila Binti Erfen et al.,” the appropriateness of egg shell as filler in hot mix asphalt”.
6. Chapter 4, Marshall Mix Design and Analysis, School of Engineering, Cochin University of Science and Technology.