Partial Replacement of Coarse Aggregates Using Cockle Seashells in Flexible Pavement

[1] M. Jyothi, [2] Sheikha Patel, [3] A. Monikkah
[1]Assistant Professor, [2]Student, [3]Student
[1]Department of Civil Engineering,
[1]Sethu Institute of Technology, Kariapatti, India

Abstract: ***Construction of pavement involves huge outlay of investment. Addition of certain materials like coconut shells, seashells, saw dust etc may save considerable investment as well as gives reliable performance. The main objective is to encourage the use of seashells in pavement construction to reduce the marine pollution caused by it. Also, the disposal of seashells is difficult and tedious. This project describes the use of cockle seashells as partial replacement for coarse aggregate in bituminous pavement. It involves identification of proper mix by obtaining of proper mix by obtaining bitumen content (OBC) and appropriate seashell content by determining the Marshall Stability and Flow values. In this research work experiments have been conducted with collection of material required and data required for Marshall mix design are obtained by tests. The coarse aggregate is partially replaced with seashells in 10, 15, 20, 25, 30 and 35%. The OBC was obtained to be 5.5% by Marshall Stability test. Results show that replacement of appropriate cockle seashell content is able to produce bituminous pavement with satisfactory strength. Replacement of 25% cockle shell enhanced the strength of pavement making it to be the highest as compared to any other replacement level.***

1. INTRODUCTION

There are two major types of pavements; flexible pavements and rigid pavements. Flexible pavements are also called bituminous pavement which is more economical and reliable compared to rigid (concrete) pavements. The road paving industry is interested in utilizing alternative and sustainable materials that satisfy in the production, placement and performance of road pavement. For alternative materials to be considered sustainable, they must be technically economically and environmentally viable. Recent studies focuses on the locally available waste to be used as aggregates. One such waste is the seashells obtained from coastal areas, freshwater lakes and riverine areas. Seashell is a hard, protective layer, a calcareous exoskeleton which encloses, supports and protects the soft parts of an animal (mollusks). *Bruce Marshall*, formerly Bituminous Engineer with Mississippi State Highway Department formulated Marshall method for designing bituminous mixes. The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature of 60°C. The flow is measured as the deformation in units of 0.25 mm between no load and maximum load carried by the specimen during stability test.

2. OBJECTIVE

- To study the properties of pavement materials (bitumen, aggregates).
- To examine the suitability of cockle sea shells as replacement of coarse aggregate in flexible pavement.

3. METHODOLOGY:

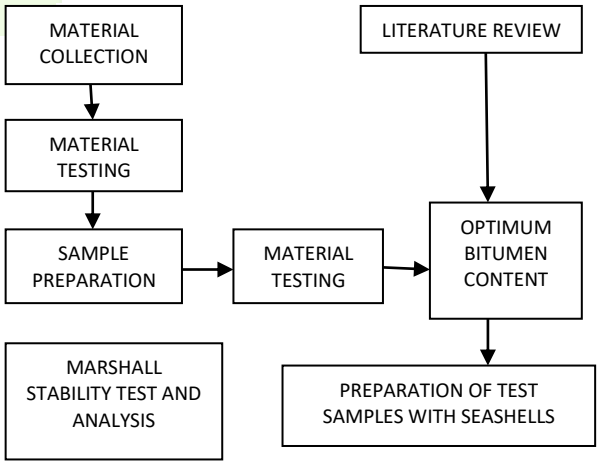

Fig. 2.1 Flow chart describing methodology

2.1 MATERIALS AND METHODS

2.1.1 Aggregates

Aggregates is a collective term for the mineral materials such as sand, gravel and crushed stones that are used with a binding medium to form compound materials. They should be strong and durable; they should also possess proper shape and size. Aggregates are tested for strength, toughness, hardness, shape and impact. Aggregates can either be natural or manufactured. The size of aggregates used from 19-20 mm-4-6mm. The test results are computed as follows:

Table 2.1 Test on aggregates

Aggregates	Test	Experimental values	Standard values
Fine aggregate	Specific gravity	2.742	2.4-3
Coarse aggregate	Impact strength	20.2%	20-30%
	Elongation Index	15.56%	10-20%
	Flakiness Index	29.9%	25-30%
	Crushing strength	24.5%	Maximum limit 30%

2.1.2 Bitumen Binder

The bitumen acts as a binder of the aggregate that ensures the structural strength and texture of the road surface. It makes up about 5 to 6 percent of the total bitumen mixture. It is available in various grades, for higher traffic roads, 60/70 is found to be suitable. The properties of bitumen are analyzed by performing various tests.

Table 2.2 Bitumen tests

Test	Experimental values	Standard values
Specific gravity	1.07	0.97-1.02
Penetration	215mm	100-200mm
Ductility	47cm	10-50cm

2.1.3 Cockle Seashell

Blood clam or cockle shell is a type of marine by-product. The ground seashells were used as the replacement. The seashell was crushed into small pieces using impact hammer. Seashell is a hard, protective layer, a calcareous exoskeleton which encloses, supports and protects the soft parts of an animal (mollusks). As they grow, the shell increases in size which becomes a strong compact casing for the mollusk inside. The specific gravity test was done on the seashells and was found to be 2.22. The seashells were crushed, passing through 5.6mm and retained on 2.36mm was used.

2.2 MIX DESIGN

Marshall Method of mix design has been adopted in this work. Accordingly aggregates with the grading 1 of IRC 29-1988 and bitumen having properties described in the tables have been used. The objective of bituminous paving mix design is to develop and economical blend of aggregates and bitumen. Several trial aggregate-bitumen binder blends have been used, each of different binder content. By evaluating each trial blend's performance, optimum bitumen binder content is obtained. The first step in sample preparation is to estimate OBC. Trial blend bitumen contents are then determined from this estimate.

Table 2.3 Determination of optimum bitumen content

Description	Sample 1	Sample 2	Sample 3
% of bitumen content (%)	5	5.5	6
Initial weight (g)	1219.5	1260	1267
Weight in water (g)	687	717	721.5
Weight in air (g)	1224	1263.4	1269.9
Diameter (cm)	10	10	10
Height (cm)	6.2	6.3	6.3
Stability (KN)	21.2	34.9	30.1
Flow (mm)	2.56	3.66	4.9
Unit weight (g/cc)	2.46	2.54	2.56
% of air voids (%)	4.5	3.4	2.9
Voids filled with bitumen (%)	61.53	83.87	82.52

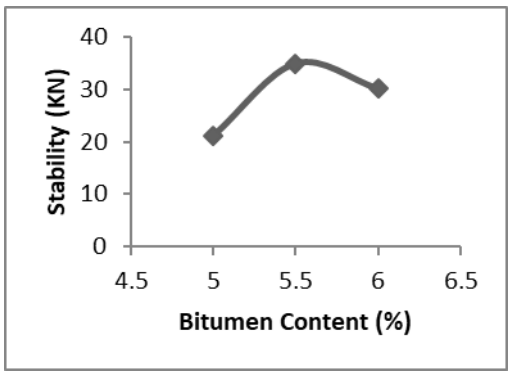

Fig. 2.2 Stability curve

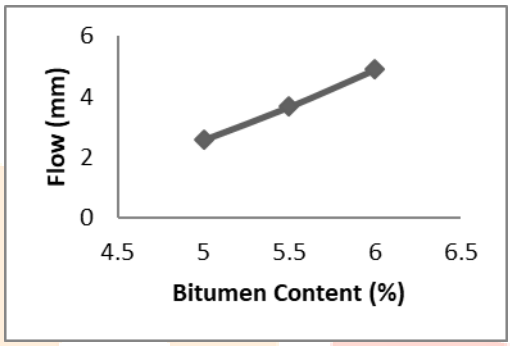

Fig. 2.3 Flow curve

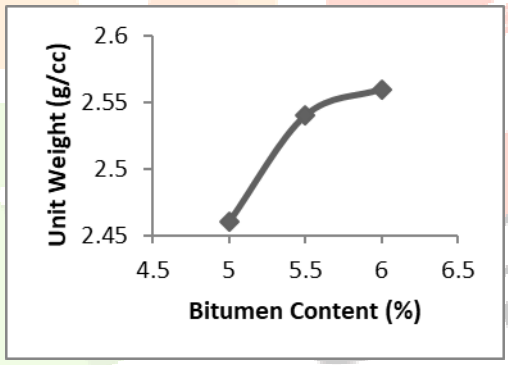

Fig. 2.4 Unit weight curve

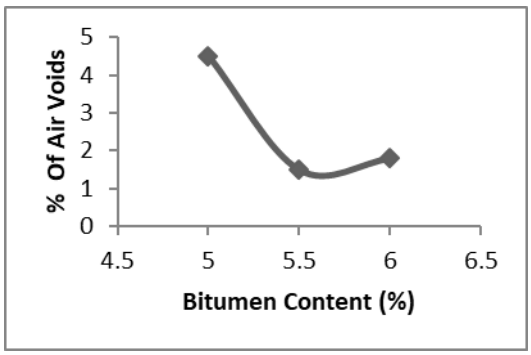

Fig. 2.5 Percentage of voids curve

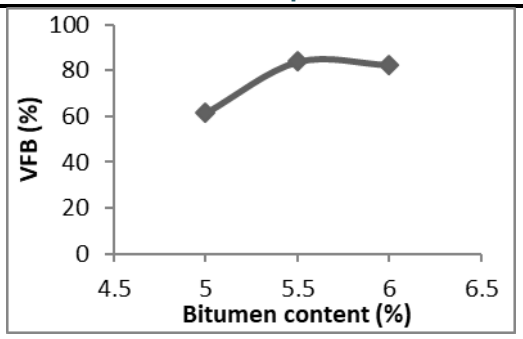

Fig. 2.6 Voids filled with ratio curve

The optimum bitumen content for the mix design is found by taking the average value of the following three bitumen contents found from the graphs of the test results.
(i) Bitumen content corresponding to maximum stability
(ii) Bitumen content corresponding to maximum unit weight
(iii) Bitumen content corresponding to the median of designed limits of percent air voids in total mix.

The optimum bitumen content was found to be 5.5%. Hence, the test moulds with cockle seashells content were made with 5.5%bitumen content and Marshall Stability test was carried out.

3. RESULTS AND DISCUSSION

The results of Marshall tests of specimens conducted are given in table respectively. The graphs (Fig. 3.1, 3.2, 3.3, 3.4, 3.5) are plotted with various seashell content with respect to stability, flow, unit weight, air voids and void filled with bitumen.

1. The stability increases initially, reaches the maximum value and then decreases with increasing seashell content. Excessive seashell content may not have binded uniformly as well as the aggregates. It may be noted that stability value for all the specimens was above the given range. Yet the highest stability is obtained at 25% of seashell content replacement.

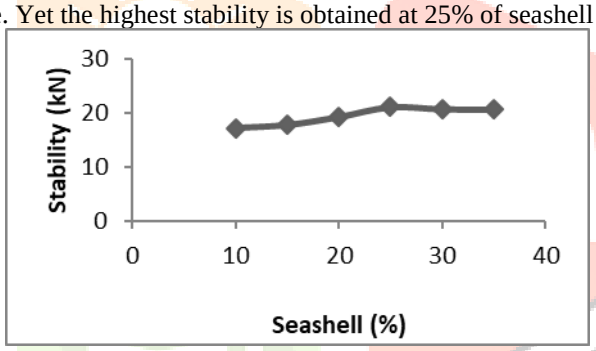

Fig. 3.1 Stability curve for seashell specimens

2. The flow value after replacing with seashells seems to reduce. It may be because of the stiffness of the seashells in the mixture, becomes less flexible and the resistance to deformation increases resulting in low flow value. However, flow values are located within specified range. The flow of all the specimens is in the required range.

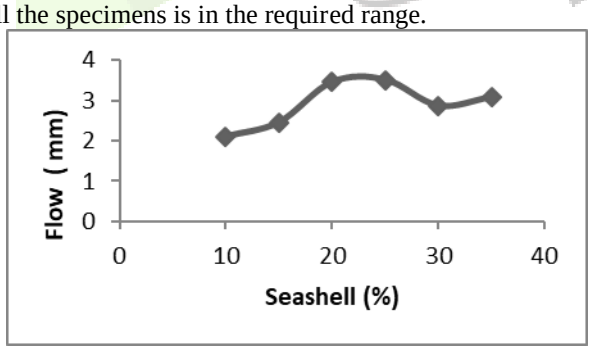

Fig. 3.2 Flow curve for seashell specimens

3. The unit weight is the weight per unit volume of a material. It is calculated dividing initial weight of each by its volume. It is shown clearly that at 25%, the unit weight is maximum.

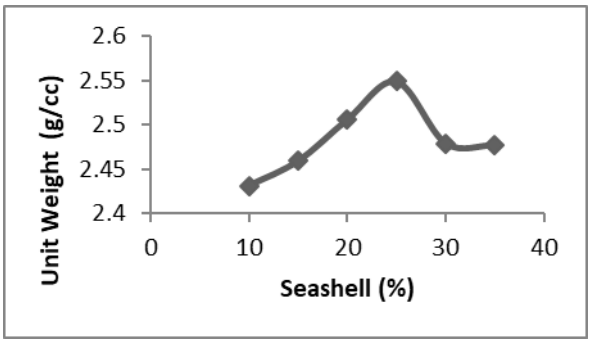

Fig. 3.3 Unit weight for seashell specimens

4. Air voids is the total volume of the small pockets throughout a compacted paving mixture. The air voids seem to increase with the addition of seashells. However, they are located within the specification range of 3-5% which supports the replacement with seashells. It may be noted that at 25% seashell content, the percent of air voids present in the mix is the least.

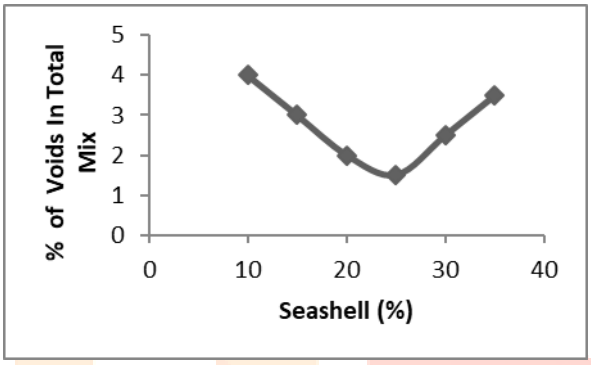

Fig. 3.4 % of voids for seashell specimens

5. The percentage of voids filled with bitumen increases till 25% of seashell content then decreases. The decrease of VFB indicates a decrease of optimum bitumen film thickness between aggregates, which will result in higher low-temperature cracking and lower durability of bitumen mixture since bitumen perform the filling and healing effects to improve the flexibility of mixture. Although, the value of VFB at 20%, 25% and 30% seashell content is within the range given in IRC 29-1988.

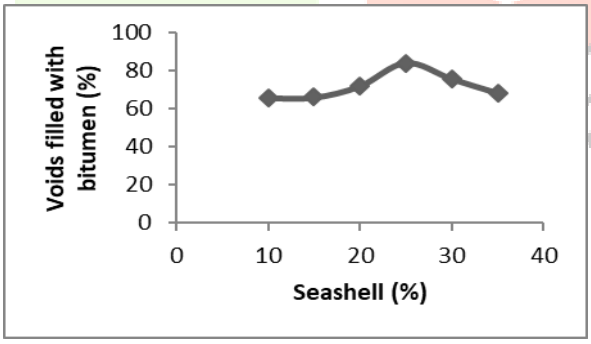

Fig 3.5 VFB curve for seashell specimens

4. CONCLUSION

Based on this study, the use of seashells as partial replacement for aggregate in bituminous pavement produced positive result. This shows that seashell is suitable to apply in the road construction. However, this study proves that the replacement of seashells in 25% in bituminous mix with OBC as 5.5% gives better strength.

5. REFERENCES

1.Olugbenga Joseph Oyedepo,Lekan Makanju Olanitori & Ebenezer Omoniyi Olukanni (2015), “Partial replacement of Palm Kernal Shell for aggregates in asphaltic concrete”, International Conference on Advances in Civil Engineering,pp.4-5.

2.K.Kiruthiha,G.Loshini,M.Thivya(2015),“Experiment of Strengthening of Flexible Pavement using Egg Shell as a Filler”, International Journal of Engineering Trends and Technology (IJETT) ,pp.5-6.

3.Tay Lay Tinga, Ramadhansyah Putra Jaya, Norhidayah Abdul Hassan, Haryati Yaacob and Dewi Sri Jayant (2016), “Review of utilization coconut shell in road construction”, Indian Journal of Science and Technology ,PP.5-6.

4.Indian Roads Congress 29-1988 Specification of Bituminous concrete for Road pavement, Indian Road Congress, New Delhi.