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EFFECT OF CEMENT MORTAR USED AS VOID FILLER ON UNIFORM GRADED BINDER COURSE

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ABSTRACT

Flexible pavement, a very common term in the transportation system of Bangladesh can be described to be composed of multiple layers (base and sub base coarse) along with a bituminous sealcoat which primarily acts as the protective shield for the pavements. Generally, sealcoat will provide a layer of protection blocking out the elements like water, oils, and U.V which can deteriorate the binder and expose the aggregate. Though bitumen serves as sealcoat but it has some drawbacks. Presence of water on the bitumen surface displaces the polar molecules and causes stripping and ultimately reaches the under laying layer and breaks the bitumen aggregate bonding. Moreover, it is greatly susceptible to temperature and evolves harmful gases and ultimately reduces the lifespan of pavements. Considering different drawbacks associated with bitumen this study was initiated to check the effectiveness of cement mortar as void filler and additive binder instead of bituminous sealcoat on binder courses and its economic effectiveness. In this research work mortar coating were provided in one face of Marshall Sample and its stability and flow value was determined to compare the result with the bituminous coating sample. The comparison of cost between the two different types was also done based on the per square meter cost of each type of coating.The analysis of the results showed that cement mortar as void filler instead of asphaltic coating gave improvement in the stability as well as flow value and it also proved to be much more cost effective in the primary level of the research.

Keywords: *sealcoat, cement mortar, void filler, binder course, cost effective.*

1. INTRODUCTION

Roads are and have always been, since time immemorial, an indispensable part of our lives and the most crucial element of a civilization. Hence, since remote past, man have always put a continuous effort to ensure the betterment of road making and have tried in every century the use of cutting edge technologies to expose newer and more advanced methods in the construction of roads and highways. And in the present context of Bangladesh Flexible pavement is a very common term. Flexible pavement is composed of a bituminous material surface course and underlying base and sub base courses.

Nowhere in the world is the climatic condition so wet as in the subtropical zones of the Indian subcontinent. The prevalence of heavy rainfall throughout this geographical location makes it an engineering challenge to construct roads and highways here. Though the conventional flexible pavement is consisted of bituminous seal coating to prevent the intrusion of unwanted water that ultimately damages the pavement but it is associated with some problems which reduces the ultimate life span of the pavement e.g. bitumen is highly reactive to water which contributes to the breakage of the bitumen aggregate bonding through chemical reaction or tire pressure etc as well as it evolves poisonous gas like, hydrocarbons and carbon mono-oxide during manufacture. Moreover, asphaltic road construction is hazardous and risky as well as troublesome.

But we need roads and we need roads to exist for a very long time so as to ensure not just maximum efficiency but also maximum effectiveness. The sole purpose of this study or research project is to find an alternate source of sealcoat other than bitumen which is used as the seal coat. Mortar can be used effectively to provide a protection to pavement by replacing the bituminous sealcoat. Mortar may be proved to be more resistant to water in comparison to Bitumen and this research attempts to find out if it truly is so. After the placement of the aggregates in the surface layer, mortar paste is placed to fill the voids in between to give a proper sealing effect. There have not been so many breakthroughs in this field of research and this project of the author is a unique one as the author tries to uncover some exceptionally new information. Whether or not the project manages to provide a solid foundation to the new proposition, a failure too will provide effective approach to further studies in the best interests of science and discovery. That is in actuality the main motivation of the author behind the conduction of this research.

2. METHODOLOGY

The whole methodology of the study can be divided into a number of steps which can be summarized as cited in the following flow chart:

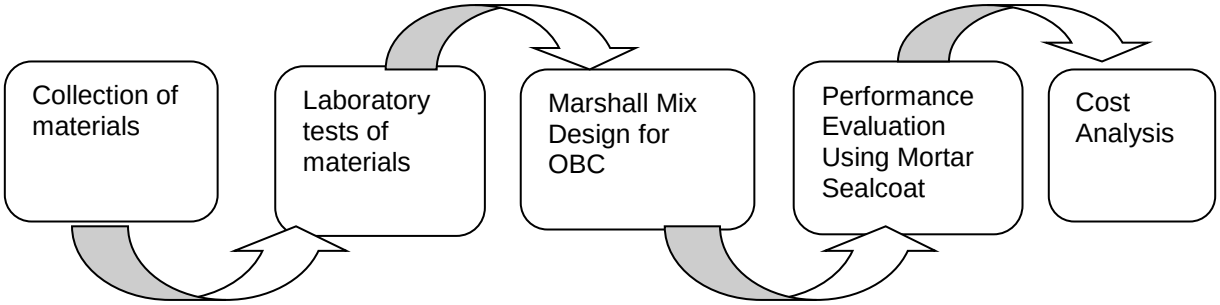

Figure 1: Work Flow Diagram

Thus, it is clear from the above figure that the whole procedure of the study includes collection of materials required and then the laboratory tests for the materials need to be done for checking its feasibility for use in the Marshall Mix Design. Then the optimum bitumen content is need to be determined and using the OBC more samples will be prepared for testing using mortar coating. Last of all the cost analysis is done for economic evaluation.

2.1 Collection of Materials

Material used in the research includes the collection of aggregates and binders as well as cement and sand.

2.1.1 Collection of Aggregate

Uniform graded crushed aggregates (19 mm down) were collected to achieve laboratory investigation and mix design. The aggregate gradation chart and the gradation curve obtained is as follows:

Table 1: Aggregate Gradation Chart

Sieve size (mm)	Sample by wt. retained (gm)	Percent retained (%)	Cumulative percent retained	Percent passing
19	0	0	0	100
12.5	625.1	62.51	62.51	37.5
9.5	152	15.2	77.71	22.3
4.75	105.5	10.6	88.31	11.7
2.36	66.4	6.6	94.91	5.1
1.18	40.4	4.04	98.95	1.05

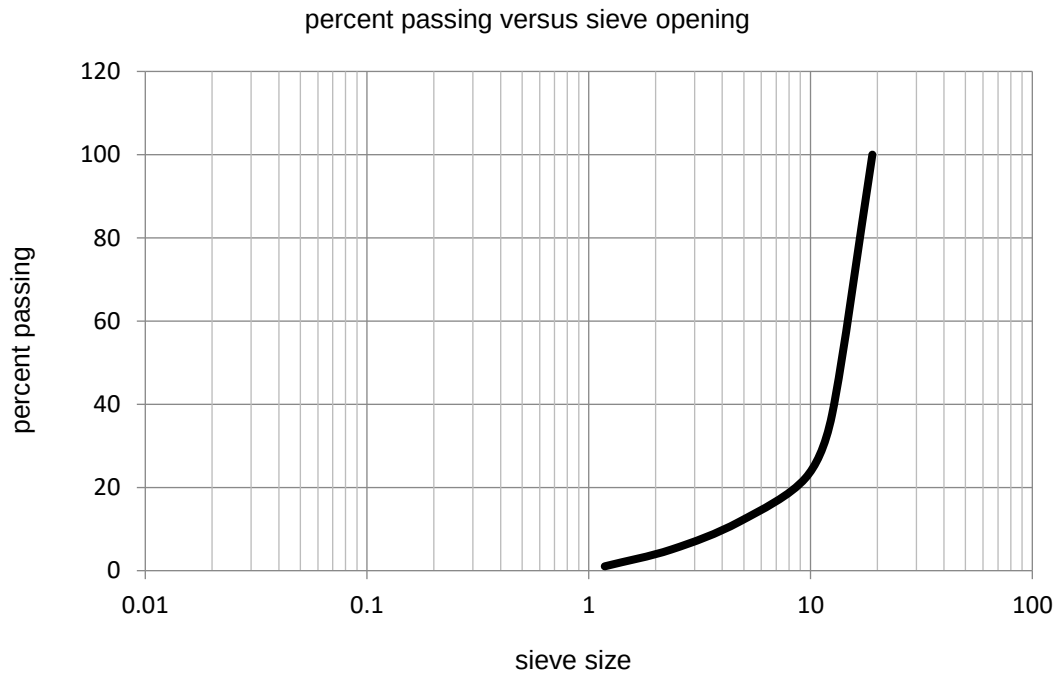

Figure 2: Particle Size Distribution Curve

2.1.2 Collection of Bitumen

Bitumen binder of grade 60/70 has been collected and to investigate the properties of binder, physical characteristics have been evaluated in the transportation laboratory, Department of Civil Engineering, Chittagong University of Engineering & Technology.

2.1.3 Collection of cement & Sand

Portland composite cement was collected for the study available in the laboratory. And the sand collected was Sylhet sand and the fineness modulus data of the sand is as cited below in the following table:

Table 2: Data for Fineness Modulus of Sand

Sieve nos.	Retained (gm)	Cumulative retained (gm)	Cumulative percent retained (%)
8(2.36mm)	14.30	14.30	2.91
16(1.18mm)	84.30	98.60	20.1
30(0.6mm)	103.70	202.30	41.21
50(0.3mm)	234.60	436.90	89
100(0.15mm)	54.00	490.90	100

2.2 Laboratory Tests

For the aggregates property tests have been done and the property tests of binder used were also done in the laboratory. For the aggregates impact test, Los Angeles tests, tests for water absorption, specific gravity, hardness test, sound tests etc. were done and the results were within the specified limit according to IRC limit. Moreover, tests of bitumen were also within limit and can be cited as follows:

Table 3: Bitumen Property Tests

Type of Test	Property values
Penetration Value(mm)	72
Ductility(cm)	100
Softening Point(degree Celsius)	48
Flash Point (degree Celsius)	308
Fire Point (degree Celsius)	320
Loss on Heating	.15%
Specific Gravity	1.031

2.3 Marshall Mix Design

Marshall Mix Design is an important step of this research. For the determination of OBC and suitability of the mortar as coating this design method has been used. The mix design determines the optimum bitumen content. Marshal Mix design is a standard laboratory method which is adopted in a large measure in different parts of the world for determining the strength and flow characteristics of paving mixes prepared. For a given gradation if aggregates and binder quality, the optimum binder content to be used is determined by this method. The method is being routinely used as a tool to evaluate the relative performance of different mixes. The Marshall Stability and flow test provides the performance prediction measure for the Marshal Mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute. Load is applied to the specimen till failure and the maximum load is designed as stability. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The flow value is recorded in .25 mm (0.01 inch) increments at the same time when the maximum load so recorded.

2.3.1 Problem Identification

During conducting the experiments using 19mm down coarse aggregates some problems were faced which can be summarized as follows: Since there were no filler materials, compaction of only coarse materials led to more voids as a result of which proper binding and compaction was not possible. So the amount of aggregates taken was lessening by 100gm to fit in the mold for proper compaction and binding. Again, due to the presence of coarser material (19 mm down) amount of bitumen content added need to be maintained properly as when bitumen content taken was 2% the sample did not get bonded. Again when the bitumen content was 4.5% then the sample got distorted when placed in the water bath. Due to the absence of filler material the stability and flow value of the samples were comparatively low. Moreover, because of larger voids weight of displaced water was less.

3. LABORATORY INVESTIGATION

The performance test will evaluate the feasibility of mortar as void filler instead of bitumen or asphaltic coating. The performance tests include the stability and flow test of the Marshall Sample with bitumen content as determined giving a mortar coating on it.

3.1 Shortcomings & Decisions

By analyzing the results and data it is obtained that since the samples are made of mainly coarse aggregates and there is absence of filler materials so the amount of displaced of water is comparatively less due to presence of comparatively larger voids and as a result it is not possible to determine the volume of bitumen, VMA, VFA and subsequently the OBC cannot be determined too. As a result, to continue the further research work bitumen content corresponding 4% was decided to use since it showed comparatively better strength and flow value.

3.2 Sample Preparation & Testing

Three Marshall Samples were produced using 4% bitumen content. Then the mortar coating was given in one face. The mortar was made slurry by using more percentage of water so that it attains enough liquidity to fill ups the voids present in the sample and make a firm bonding. The cement sand ratio taken was 1:3. Then the sample was kept for 28 days Air curing for hardening of mortar. After that the stability and flow tests of the three samples were done to compare the value with the samples of only bitumen content. The following table gives the result of the three samples:

Table 4: Marshall Sample Test Results

Serial nos.	Stability (KN)	Flow value (mm)	Average stability (KN)	Average flow value (mm)
1	7.00	1.975		
2	5.75	1.75	6.05	1.75
3	5.40	1.5		

4. RESULTS & OUTCOMES

After testing and calculation it was seen that the stability of the Marshall samples with mortar coating on one face is more than that of the samples those are without coating. The flow value of the samples also improved. The comparison between the results of samples having bituminous coating and mortar coating both having bitumen content corresponding to 4% is as follows

Table 5: comparison between the results for performance evaluation

properties	Asphaltic/bituminous coating	Mortar coating
Stability (KN)	4.89	6.05
Flow value (mm)	1.575	1.75

5. COST ANALYSIS

comparisons have been made and different ideas have been debated over and researched into to see the usability of mortar and bitumen as seal coat.

5.2 Pavement Comparison

The following figure describes the comparison between conventional road on low volume flexible pavement having bituminous sealcoat and the proposed pavement where the cement mortar penetrated through the voids and also acted as an additional binding material to serve the facilities like sealcoat.

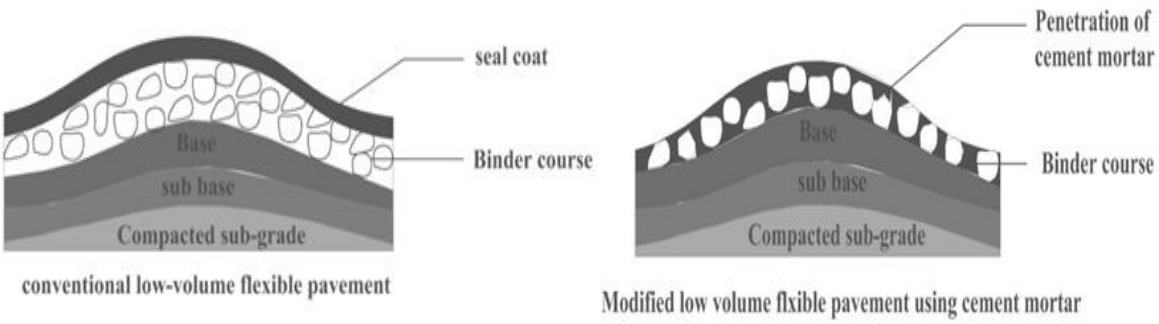

Figure 3: Comparison between Conventional & Modified Low Volume Flexible Pavement

5.3 Price Analysis

As seen from the figure 3 in the new modified road the sealcoat is totally being omitted and cement mortar is being placed as void filler instead thus the price of sealcoat is being saved. Moreover from Market analysis the following price may be assumed:

Table 6: Market Price of Materials

Item	Unit	Price in BDT
Cement	1 bag (1.25 cft)	450 – 470
Sylhet Sand	1cft	22 -25
60/70 grade bitumen	1kg	82.66

According to the schedule proposed on 2008 by Public Works Department (PWD) and Department of Roads and Highway of Bangladesh, the following costs may be assumed

Table 7: Comparison between the Prices of Materials

Item	Unit	Price in BDT
Mortar (6mm) with cement sand ratio 1:3	1 sq m	132
Bitumen (12mm)	1 sq m	215

It can be observed that the price of mortar is less than that of bitumen. However, bitumen also requires maintenance at regular intervals and the intervals are quite short in comparison to mortar. Mortar too requires maintenance but it lasts over a long period of time and does not need to be treated for maintenance as often as bitumen. Again, the labor cost of bituminous works is high as it requires exposure to risks and dangers. Labor cost of mortar works is comparatively low as it is comparatively simpler and workers are less exposed to risks.

6. CONCLUSION

As the sole purpose of the investigation of this research work was to find the acceptability and competence of mortar as a void filler and binder over bitumenous sealcoat, the author has tried various methods to test every possibility that may have borne an outcome to give statistics in affirmation or in negation to the thesis proposal. Whether or not the project work was a grand success is henceforth succeeded over by the fact that this research has opened doors to further investigation by means of which more conclusive results may be obtained.
The analysis of the results showed that cement mortar as void filler and binding material instead of asphaltic coating gave improvement in the stability as well as flow value and it also proved to be much more cost effective in the primary level of the research. To conclude the general section, it can be said that the use of mortar as a seal coat is to some extent, if not huge, more effective and has higher lifespan than bitumen.

7. RECOMMENDATION

To improve the quality as well as to increase the life span of the flexible road following recommendations have been suggested about the problems identified during investigation

- Modified bitumen can be used with the aggregates instead of nit bitumen.
- It would be preferable to use coarse aggregates which are smaller (like 12.5 mm down) than the aggregates used in the research work for improved bonding and compaction.
- For betterment of the strength of the mortar seal coat curing can also be used for further investigation.

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