Effect on Coal Bottom Ash in Hot Mix Asphalt (HMA) as Binder Course

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***Abstract*—The research conducted is Effect on Coal Bottom Ash in Hot Mix Asphalt. The purpose of this research is to Effect on Coal Bottom Ash applications as aggregates in road bases, sub-bases and pavement. This study focused in three parts objectives in determining the stability of asphalt mixture that is mixed with a certain percentage of bottom ash using Marshall Method, determining physical properties of bottom ash when mixed with asphalt and determining the quality improvement of the Marshall cube in terms of appearance and texture. This study is basically conducted by experimental work and finally resulted in graphical plots. Coal Bottom Ash is obtained from Tanjung Bin Power Plant and laboratory test for this research is conducted at UPM Pavement laboratory. Coal Bottom Ash content specimen has high stability and has a good surface texture. Further research can be conducted to identify pavement with coal bottom ash under Tropical weathering and to increase the design life span of pavements. Of waste materials which are industrial wastes like coal ash policies Coal Bottom Ash span stone used by plants in the country to generate of electricity coal combustion is the result of coal ash policies are not used and discarded without producing any harm. The result of Marshall Test and Resilient Modulus was compared between samples. From the experimental results, the use of coal bottom ash meets the specification as stated in SPJ/JKR/rev2008 even though there is a slight difference in the parameter value. From the results obtain in this research , bottom ash can be considered as one of the alternatives to modify HMA properties but further research on the ability and reaction in mix need to be clearly determined.**

***Index Terms*— Coal Bottom Ash, Hot Mix Asphalt, Materials and binder course**

I. Introduction

In road based construction, asphalt concrete is an important material to be used for construction of highways, pavements and parking lots. As for current road users are increasing in using the highways and roads, maximum maintenance for the road is necessary. Government has to allocate a big amount of money for this maintenance of roads and highways. There are no exact methods found in improving the quality of road construction in improving and reducing the outgoing currency. In the current highway engineering practices there are no proven long lasting roads, highways and pavements that resist deformation from imposed loads, skid resistant or can withstand the weathering forces.

Roads get easily damaged due to heavy loads and impacts. In considering to these factors, this study could help to improve the quality and the strength of asphalt used in pavement construction. So, how much research has been done for the benefit of coal ash policies to reduce or replace the normal hydrated lime is used as filler material in concrete hot mix pavement asphalt. Mixture basically of three main ingredients of bitumen, aggregate and act as filler .Bitumen adhesive agent between aggregate. Filler serves to fill the cavity between the voids, small voids that exist due to discrepancies in the aggregate and bitumen surface at once thicken the bitumen.

Hence coal Bottom Ash as a filler policy are expected to produce a quality pavement equal to or better than the use of hydrated lime as filler .Besides that addition to the use of this material is expected that the waste problem in the environment can be overcome and the road construction costs can be reduced

II. Literature Review

A. *Physical Properties*

Bottom ashes have angular particles with very porous surface textures. The ash particles range in size from a fine gravel to a fine sand with very low percentages of silt-clay sized particles. Bottom ash is predominantly sand-sized, usually with 50 to 90 percent passing a 4.75 mm (No. 4) sieve and 0 to 10 percent passing a 0.075 mm (No. 200) sieve. The largest bottom ash particle sizes typically range from 19 mm (3/4 in) to 38.1 mm (1½ in). Bottom ash is usually a well-graded material although variations in particle size distribution may be encountered in ash from the same power plant. Figure 1 compares the grain size distribution curves of bottom ash samples from several sources.

Typical physical properties of coal bottom ash are shown in Table 1. Coal bottom ash is with a high carbon content specific gravity lower. Coal ash produces policy with a low specific gravity has a porous texture, particle nature 'popcorn' that fell under the load or compaction.

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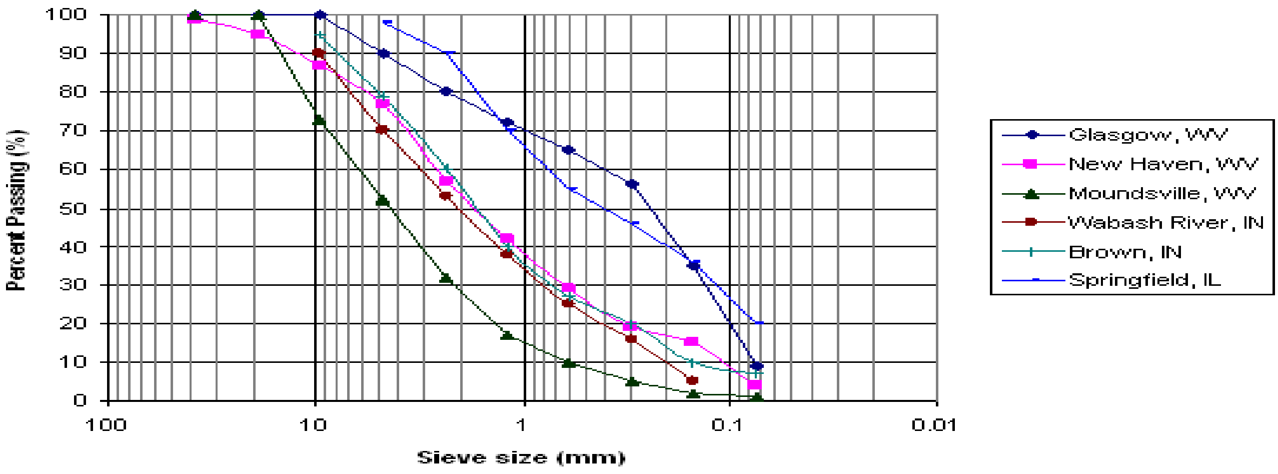

Fig 1: Grain size distribution curves of several bottom ash samples

TABLE 1
Typical physical properties of bottom ash

Property	**Bottom Ash**
Specific Gravity	2.1 -2.7
Dry Unit Weight	7.07 - 15.72 kN/m^3 (45 - 100 lb/ft^3)
Plasticity	None
Absorption	0.8 - 2.0%

A. Chemical properties of CBA

The chemical composition of coal bottom ash this material consists of silica, alumina and iron with small a number of calcium, magnesium, sulfate and calcium other. Content composition is very low at less than one percent and total silica, alumina and iron (siO2+Al2O3+Fe2O3) reached 88.5 percent.

The salt content or in some cases, the pH of the coal bottom ash is low, this . This material may pose the nature eroding ,when coal bottom ash used subbase or base layer, it has the potential to cause corrosion on metallic structures in contact with said yet so, coal bottom ash in this study used the road surface layer, therefore no erosion problems should be considered.

B. Sustainability of CBA material

CBA is a non-hazardous material which does not emit carbon dioxide into the atmosphere. Bottom ash emphasizes in reducing carbon dioxide emission. Since bottom ash is the waste products of coal fired power plant, this research can lead to the awareness of sustainable development of the society. This is very advisable in sustainable developments to reduce carbon dioxide emission and to recycle the waste materials.

At the present time, there is limited information on the influence of parameters using CBA in construction materials, especially HMA with bottom ash as the fine aggregate

As the test conducted by SIRIM it shows that CBA were related in 3 different factors which is:

i. Physical hazards such as explosiveness, ignitability and flammability are not inherent properties of the components in the waste sample.

ii. No toxic chemicals were identified in the compositions as major constituents.

iii. The ash sample is not harmful to the environment and does not contain infectious microorganisms (SIRIM).

III. METHODOLOGY

For the purpose of the study, the test that's being used is for UPM pavement laboratory. This chapter describes about the procedures and test methods used according to JKR/SPJ/1988 specification. A typical evaluation for use with Marshall Mix methods.

The first phase of the review process

- Provide materials to mix AC 14
- Do Sieve Analysis
- Combined aggregate grading appropriate to determine and meet the grading limits.
- Determine the specific gravity of aggregate
- Conventional mix design with use 4.0%, 4.5%, 5.0%, 5.5% and 6.0% bitumen content.
- Resilient modulus test performed on each sample.
- Obtain its optimum bitumen content and Marshall identified

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- A set of samples using the conventional bitumen content and features designed
- Analyze data

The second phase of the review process

- Provide materials to mix AC 14
- Do Sieve Analysis
- Combined aggregate grading appropriate to determine and meet the grading limits.
- Determine the theoretical maximum density
- Conventional mix design with use coal bottom ash 1.0%, 2%, 3.0%, 4.0%, 5.0% and 6.0% with bitumen content.
- Resilient modulus test performed on each sample.
- Obtain its optimum bitumen content and Marshall identified
- A set of samples using the conventional bitumen content and features designed
- Analyze data

IV. RESULTS

This chapter provides all the results and data obtained from the experimental test conducted by UPM pavement Laboratory. All the results are discussed and analyzed. This includes the material tests and density, stability and flow test on the Marshall specimens. To provide a clear description of the data and results, the values are described in the form of tables, graphs and figures. All the tables and graphs shown in this chapter are shown by using Microsoft Excel program.

Comparison of the results with the specification (JKR/SPJ)

TABLE 2
Optimum Asphalt Content Value

Property	Selected Asphalt Content (%)
4% VTM	**5.5**
Maximum Value of Bulk Density	**5.2**
Maximum value of stability	**4.5**
Maximum Value of VFA	**5.5**
Average	**5.1**

Table 2 shows Marshall Test results and calculations to obtain the optimum bitumen content. Obtained the optimum bitumen content was average 5.1%. Once the optimum content is known, the conventional sample set is designed to use 5.1% bitumen. These samples will be made where the control sample characteristics will Marshall compared with samples containing coal bottom ash.

C. NAPA Method

Table 3 shows comparisons of specifications by using NAPA Procedure, optimum asphalt content are determined by the median air void content of the specification. Based on the specification that stated in the project requirement, 4% is the median air void.

1. Optimum asphalt content 5.5% asphalt VTM is 4%.
2. Optimum asphalt content 5.5% asphalt, % VMA is 16.82%.
3. Optimum asphalt content 5.4% asphalt, % VFA is 75%.
4. Optimum asphalt content 4.5% asphalt, stability is 25kN.
5. Optimum asphalt content 4.5% asphalt, flow is 4mm.

TABLE 3
Comparison of specifications and standards

Properties	Specification	Result	Status
VTM	3.0% - 5.0%	4%	Accepted
VFA	70% - 80%	76%	Accepted
Stability	> 8kN	25 kN	Accepted
Flow	2 - 4mm	4 mm	Accepted

TABLE 4
Comparison between the Conventional Samples and coal bottom ash Samples Optimal

% Coal Bottom Ash	Bitumen (%)	Density (g/mm)	VTM (%)	VFB (%)	Stability (KN)	Flow (N/mm)	Resilient Modulus (Mpa)
0	5.1	2.318	3.70	75.62	15.69	3.37	4741
1	5.1	2.315	4.64	71.17	20.39	3.15	5498

Once the optimum ash content of coal bottom ash is obtained, the three-sample design and the use of coal bottom ash are at the optimum content of 1%. Marshall Characteristics of the sample set is then compared with conventional sample. Based on the Table 4, the conventional sample shows the voids filled bitumen high and low values of air voids than samples with the optimum content of coal bottom ash with porous particles causes the bitumen having holes. Particles thus could not complete filling of air voids present in the mixture as part large mixed bituminous coal has been absorbed by the bottom ash, and some used to bind the aggregate particles

Due to air voids directly proportional to the density, the higher air voids because reduces .This density indicates that the bitumen does not respond well when there is coal bottom ash in mixture. Spread bitumen to the aggregate

grain is not uniform because the bitumen content was reduced.
However, the stability of the samples containing coal bottom ash is higher than conventional. This sample showed that the presence of coal bottom ash can increase the internal friction between aggregate and make a stronger and stability .Flow mixture of diminishing is consistent with the stability of the increase samples. Shows a sample of reduced flow is not easy to deform under load maximum sample this modification is necessary to create a stronger pavement and strong.

TABLE 5
Resilient Modulus of the sample conventional and coal bottom ash sample Optimal

Coal Bottom Ash (%)	Bitumen (%)	Resilient Modulus (Mpa)
0	5.1	3732
1	5.1	5192

Table 5 shows a comparison value of the modulus of the conventional samples and samples containing a coal bottom ash percentage of the optimal. It can be seen that the value of the modulus of the samples containing optimum coal bottom ash content is higher than the conventional samples. This shows that the mixture containing coal bottom ash has a lower voltage when under load.

TABLE 6
Comparison of results with the specification

Table	Properties	Specification	Result	Status
4.0	VTM (%)	3 – 5	4.64	Accepted
4.0	VFB (%)	70% - 80%	71.17	Accepted
4.0	FLOW (mm)	2 - 4	3.15	Accepted
4.0	STABILITY (kN)	> 8	20.39	Accepted
4.0	RESILIENT MODULUS (Mpa)	3000	5498	Accepted

Table 6 shows the comparison of the results with the specification when asphalt content mixed with coal bottom ash. From the results above the final result may alter if such value is taken into account. In the calculation, it is assumed that the effective specific gravity of aggregate is 1.76 and the specific gravity of asphalt is 1.03.When calculating the value of bulk specific gravity and theoretical specific gravity for a compacted mixture percentage of VFB, VTM, Flow, Stability and Resilient Modulus as accepted requirement with the specification.

V. CONCLUSION

The use of coal ash as a base material in road construction is no longer limited to only subgred layer. This study has given new dimension to the use of coal bottom ash as a filler material in the HMA. The optimum content of coal bottom ash obtained from this study is 1%. Coal bottom ash cannot replace the use of conventional filler material as a whole. The use of hydrated lime is still required with coal bottom ash.

Based on the results obtained, the sample containing the coal bottom ash is better in terms of strength, stiffness, and the sample flow than conventional samples. Consequently, the pavement will become stronger and able to reduce the deformation of the pavement if loaded high traffic load. However, there are weaknesses in the use of coal bottom ash as filler where the air void content increased while reducing the density of the mixture. This has due to the chemical properties of bottom ash coal of high ash content silica a great effect on bonding bitumen and aggregates. Consequently, the three characteristics of the Marshall air voids, voids filled with bitumen and low density compared to the performance of the conventional samples even exceeded the prescribed specifications.

Although coal bottom ash cannot replace the use of hydrated lime as a whole, but believed that if the bitumen content of higher is used, it will be able to improve the effect of air voids, voids filled with bitumen and density. Balancing between the coal bottom ash content of the bitumen content is very important to get a quality pavement. Thus it can be concluded that the use of coal bottom ash can increase the strength of the pavement, but some modifications must be done to overcome the lack of use. If the coal bottom ash can be used in large quantities, this means that this waste can be recycled at a maximum and this will impact the environment .Study more carefully and deeply to be done to maximize the use of coal bottom ash in the HMA.

VI. RECOMMENDATIONS

Based on recent research studied and experimented relating to Performance Coal Bottom Ash in Hot Mix Asphalt has indicated the need of further research and studies. Accordingly are proposed future recommendations for research and studies that can be related to these studies.
To conduct further research in various proportions of CBA content in HMA.Using different types of bitumen, such as PG grade bitumen to test the effect of using coal bottom ash on the pavement. To conduct further research by using blended CBA in the form of dust replacing Portland cement. Conduct research on pavement using proportion of CBA under tropical weather. Investigate the characteristics of Marshall on the use of coal bottom ash to binder layer

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