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The Effect of Cow Dung Ash as A Filler on The Mechanical Characteristics of Hot Mix Asphalt

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Abstract: Highway pavements are being exposed to increasing traffic loads and severe environmental conditions, resulting in reduced service life. A lot of studies have been conducted to modify asphalt by using different materials, especially to replace the ordinary filler. Because the behaviour of the hot asphalt mix is influenced by the fillers. The use of unusual materials as fillers in asphalt mixes can help to improve the mix's characteristics. As a result, this study uses cow dung ash materials with various replacement ratios as fillers to investigate the mechanical properties of asphalt. In the asphalt mix, a replacement percentage of limestone (0%, 10%, 20%, 30%, 40%, 50%, 60%, 80%, and 100%) was utilized. After that, various tests were performed such as Marshall stability, Marshall flow, voids in mineral aggregate, theoretical maximum specific gravity, air voids. The results revealed a significant improvement in the asphalt mix's behaviour, as well as an increase in the replacement percentage. According to the findings, the 50% replacement rate has the highest Marshall stability which is equal to 11.11 with a 33.5% rise and the lowest flow of 3 with a 17.83% decrease when compared to the reference mix. As a result, cow dung ash can be used as a filler to modify the mechanical properties of the asphalt mix.

Keywords:

Asphalt mix, Cow dung ash, mechanical properties, Marshall flow, Marshall stability.

1. Introduction

The continued rapid expansion in traffic and the increase in allowed vehicle loads cause different stresses on the pavement, which results in decreasing the service life and requiring very costly maintenance to the surface layer. So the goal of highway researchers is to create pavements that are safe, cost-effective, long-lasting, and smooth, and are capable of carrying expected loads. Some of the previous studies have been highly concerned with enhancing the paving materials so that they can be more durable and more resistant to different kinds of loadings than ordinary paving materials. Achieving this goal, filler has a major effect on the characteristics and behavior of asphalt mixes, especially in terms of binding and aggregate interlocking(1). The characteristics of the mineral filler have been shown to have a considerable effect on the properties of HMA mixes in several studies. Due to the adoption of environmental laws and the licensing of dust collecting devices, most kinds of fines may now be reused in HMA mixes. The fines, on the other hand, vary



in terms of gradation, particle shape, surface area, void content, mineral composition, and physicochemical properties, changing the characteristics of HMA mixes(2). The performance and durability of asphalt are highly affected by the amount and quality of filler used in the bituminous roads. Various fillers, including as lime, cement, granite powder, stone dust, and fine sand, are frequently used in bituminous mixes. Lime, cement, and granite powder are all expensive resources that might be put to greater use. Fine sand, ash, waste concrete dust, and brick dust, for example, seem to be better filler materials than those with a sieve size of less than 0.075 mm(3). The use of waste powder as a filler in asphalt mixes has been a subject of significant study in recent years(4). Recycled waste lime(5), phosphate waste filler(6), ash from municipal solid waste incineration(7), baghouse fines(8), Fly ash from Jordanian oil shale(9), ceramic waste materials(10), materials from marble waste(11), and waste tires(12). All of these chemicals have been tested to see whether they can be used as fillers. It has been shown that high-performance HMA mixes may be made using recycled fillers(4).

As fillers, HMAs have utilized a range of industrial waste materials (ferrochromium slag, black carbon, marble powder, glass powder, ceramic, and so on). Üstümkol looked into the possibility of modifying HMAs using industrial waste. The inclusion of marble powder, fly ash, phosphor-gypsum, and glass powder as fillers allowed MS to meet Turkish highway building requirements(13).

The use of ceramic waste as a filler in HMA mixes is a great method to help the environment by reducing pollution. A few studies have looked at utilizing CW waste as aggregate in concrete and HMA; for example, Pacheco et al. looked into the feasibility of using ceramic waste as aggregate in concrete. The findings revealed that increasing the ceramic waste ratio increased the compressive strength of concrete specimens, while adding ceramic aggregate resulted in an HMA with better performance(14). Van de Ven et al. examined the use of ceramic waste from electrical insulators, plastic trash, and household waste. Ceramic waste, sintered domestic trash, and plastic waste may all be utilized as coarse aggregate in HMA, according to their results. Similar to control samples, when ceramic waste was added, the MS and flow values rose(15).

Marble waste is one kind of trash that may be used. I chopped marble blocks into tiny pieces to get the required smooth contours. During the cutting process, around a quarter of the marble is reduced to dust(16). Numerous studies on the use of marble waste as a filler in HMA mixes have been performed in industrialized nations. The bulk of these research have shown that using marble waste as a filler in HMA mixes with enhanced properties is feasible(17)(18).

Cow dung is causing a human health problem since it can be a source of many hazardous microbes. So a study investigates the use of this waste as ash to replace filler in hot asphalt mix. The findings of this study show a considerable enhancement of the mechanical properties of asphalt when using 4-8 % cow dung ash as a replacement of filler (19). In another study (20), cow dung ash was examined to modify the mechanical properties and durability of concrete by using it to partially replace cement content. The results show a noticeable improvement in concrete when using 15% cow dung ash to replace cement binder.

The main objectives of this research are to improve the mechanical performance of HMA by using cow dung ash as a filler in asphalt mixes and to find the optimum waste filler content for the best stability and flow results.

2. Materials and Methods

2.1. Raw materials

Local fine and coarse aggregates from the Karbala quarry were employed in this study. The specifications for material qualities were based on the Standard Specification for Road and Bridge Construction(21). Table (1) shows the physical parameters of the coarse and fine aggregates employed in this study. The fine and coarse aggregates were sieved, then separated and classed to create a gradation that was suitable with the surface layer's requirements and the Iraqi criteria. Simultaneously, asphalt binder with the qualities listed in Table (2) was provided from the Al-Nasseria refinery.

Table 1: Specifications for aggregate.

Property	Standard	Results
Specific gravity of coarse aggregate (g/cm ³)	ASTM C127	2.735
Bulk specific gravity of fine aggregate (g/cm ³)	ASTM C128	2.643
Water Absorption of coarse aggregate (%)	ASTM C127	0.451
Aggregate Impact Value (%)	ASTM C131	12.93
Los Angeles Abrasion Value (%)	ASTM C131	16.74

Table 2: The bitumen's physical features.

Test name	Average values	Standard	Limits
Penetration (25C°)	4.3 mm	ASTM D5	(4-5) mm
Flash point	234 C°	ASTM D92	232 C°
Fire point	346 C°	ASTM D92	>300 C°
Softening point	47.5 C°	ASTM D36	(30-157) C°
Ductility (5 cm/min)	41 cm	ASTM D113	>25 cm
Specific gravity	1.055	ASTM D70	-

Table 3: This study's gradation and gradation limitations for surface coarse.

Sieve size		Gradation limits	Used gradation
Inch	mm		
¾	19	100	100
½	12.5	90-100	96
3/8	9.5	76-90	82
NO.4	4.75	44-74	60
NO.8	2.36	28-58	44
NO.50	0.30	5-21	11
NO.200	0.075	4-10	7

2.2. Limestone

Limestone was utilized as a typical filler material, sourced from Karbala quarries, before being replaced with clay. Table (4) shows the physical parameters of limestone used as a filler in the asphalt mix.

Table 4: Limestone filler properties.

Sieve Diameter	Property	Standard	Value
0.75 >	Specific gravity		2.712
	Saturated specific gravity	ASTM C 127	2.695
	Water absorption (%)		0.125

2.3. Cow Dung Ash

Cow dung ash has pozzolanic properties, so it is considered one of the pozzolanic materials, as there is enough in all types of the world to produce manure residues that can be used on an industrial level

2.4. Testing Methods

The Marshall Method was used to make the asphalt mixtures(22). The asphalt mixture was subjected to mechanical tests, which are listed in the table (6).

Table 5: The mechanical testing carried out in this research.

Mechanical tests	Specifications
Marshall Flow (MF)	ASTM D6927 / AASHTO T 245
Marshall stability (MS)	ASTM D6927 / AASHTO T 245
Voids in the Mineral Aggregate (VMA)	ASTM D3203 / AASHTO T 269
Voids filled with asphalt (VFA)	ASTM D3203 / AASHTO T 269
Theoretical maximum specific gravity (Gmm)	ASTM D 2041 / AASHTO T 209
Volume of air (VA)	ASTM D3203 / AASHTO T 269

2.5. Test Plan

As indicated in table 7, asphalt concrete samples were made using six different percentages of cow dung ash to replace limestone filler, comprising (0%,10%, 20%, 30%, 40%, 50%, 60%, 80% and 100%). Three samples were prepared for each percentage to determine the amount of optimum NC and LS.

Table 6: Asphalt mixtures adopted in this study.

Mix No.	Sieve No.						Filler 7%	
	3/4	1/2	3/8	NO.4	NO.8	NO.50	LS	NC
1	100	95	83	59	43	13	100	0
2	100	95	83	59	43	13	80	20
3	100	95	83	59	43	13	60	40
4	100	95	83	59	43	13	40	60
5	100	95	83	59	43	13	20	80
6	100	95	83	59	43	13	0	100

3. Results

3.1. Marshall Stability

The results of Marshall stability shown in Figure 1 showed that cow dung ash had good results on the concrete mix, as with the increase in the percentage of replacement of fillers, the stability of Marshall increased, and this is evidence of the effectiveness of the additive. Through the results, it was found that the 50% replacement rate gave the best results.

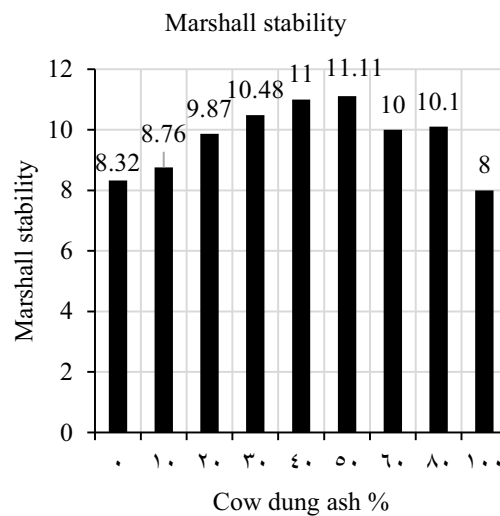


Figure 1. Marshall stability with cow dung ash.

3.2. Marshall Flow

Increasing the replacement ratio of cow dung ash did not only have a significant improvement on the Marshall stability, but this effect was clear on the Marshall flow. Through the results shown in Figure 2, the replacement percentage of 50% by cow dung ash results in the lowest Marshall flow among all other asphalt mixes.

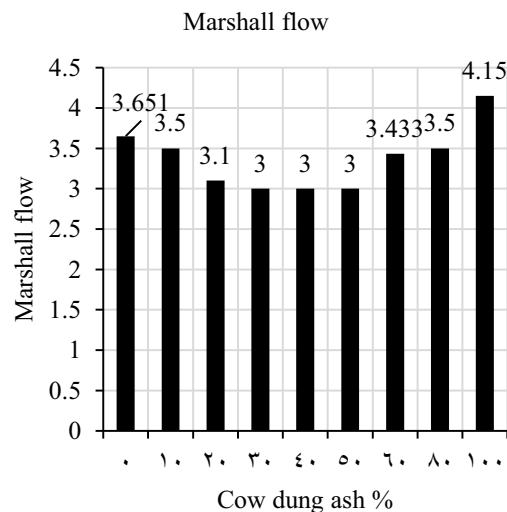


Figure 2. Marshall stability with cow dung ash.

3.3. Theoretical Maximum Specific Gravity

The results of the theoretical maximum specific gravity test shown in Figure 3 showed that the effect of adding cow dung ash had a noticeable effect, especially on the 50% replacement ratio, which showed this behavior due to the low percentage of pores compared to other mixtures.

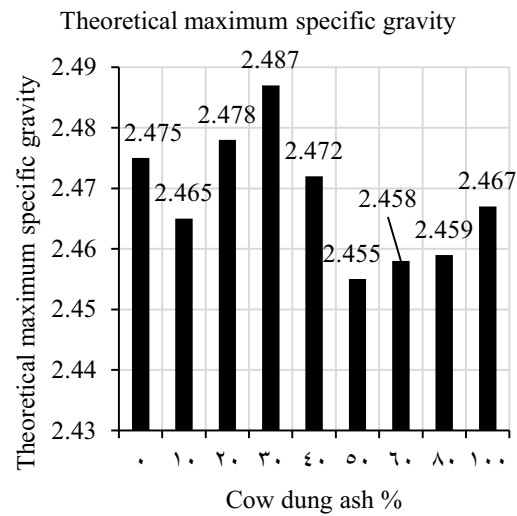


Figure 3. Theoretical maximum specific gravity with cow dung ash.

3.4. Air Voids

From Figure 4, it is shown that there is a noticeable decrease in the percentage of pores compared to the increase in the percentage of cow dung ash.

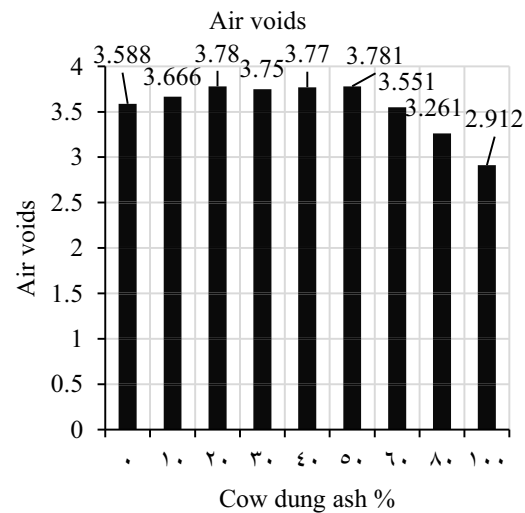


Figure 4. Air voids with cow dung ash.

3.5. Voids in The Mineral Aggregate

Figure 5 shows the increase in voids in the mineral aggregate with an increase in the replacement ratio for cow dung ash.

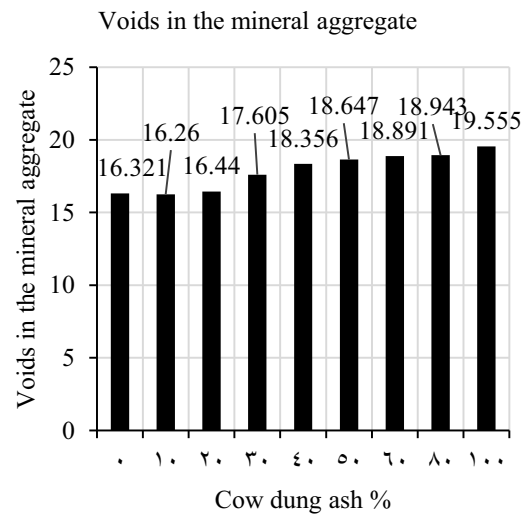


Figure 5. Air voids with cow dung ash.

3.6. Voids Filled with Asphalt

As it is clear in the previous results, with the increase in the percentage of replacement of cow dung ash, the properties of the sulfate improved in addition to their improvement in the properties of the asphalt mixture. As shown in Figure 6, the voids filled with asphalt increased with an increase in the proportion of ash replaced by cow dung.

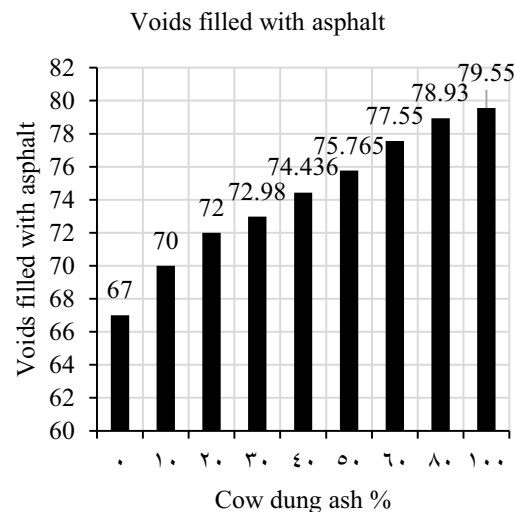


Figure 6. Voids filled with asphalt with cow dung ash.

4. Conclusions

From the result of this study, it can be concluded that: Using cow dung ash as a filler in asphalt mix improves the mechanical properties by increasing the Marshall stability and reducing each of the Marshall Flow and air voids. Comparing to the reference asphalt mix, the 50 percent replacement by cow dung ash has the greatest Marshall stability of 11.11 (33.5 percent increase) and the lowest flow of 3 (17.83 percent reduction). Based on the findings, it is obvious that the ideal percentage of replacement is 50%. Roads are one of the facilities that consume the rawest materials, so the use of common local waste that exists does not only have a good impact on the asphalt mixture but also has an aspect of sustainability.

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