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Laboratory Assessment of Cow Dung Ash Modified with Marble Powder as Filler Material in Asphalt Concrete in Terms of Marshall Stability and Flow Value

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Abstract

This research investigated the potential of using cow dung ash (CD) and waste marble powder (MP) as cost-effective fillers in asphalt concrete, comparing its performance and costs to traditional stone dust (SD) mixes. Using the Marshall Method, the study evaluated properties such as Marshall Stability, flow, and volumetric characteristics to determine whether cow dung ash modified with marble powder (CDMP) could offer advantages. Results showed that incorporating MP and CD into asphalt concrete improved its performance, with a mix of 3% MP and 6% CD (91% SD) achieving a 13.6% improvement in Marshall Stability compared to the traditional SD mix. However, higher CD content (above 7%) led to a slight decline in performance, suggesting that exceeding 7% CD may reduce effectiveness. The study also found that a 9% CDMP mix (3% MP, 6% CD, 91% SD) resulted in an optimal bitumen content of 5.29% and reduced asphalt concrete costs by approximately 6.19% compared to the traditional mix. The modified mixes met Department of Roads (DoR) standards, confirming the suitability of CDMP for asphalt concrete. These findings highlight the economic and performance advantages of using these waste materials as sustainable alternatives in asphalt concrete, offering an environmentally friendly and affordable solution. The study recommends promoting CDMP as a sustainable filler for flexible pavements and suggests further research to explore varying CDMP content, bitumen grades, and real-world applications

Keywords: Filler; Cow Dung Ash; Marble Powder; Marshall Stability; Bitumen Content; Cost-effective fillers; Asphalt Concrete

1. Introduction

Increasing traffic and heavier vehicle loads are shortening pavement lifespan and raising maintenance costs. Researchers aim to develop durable, cost-effective pavements using improved fillers to enhance asphalt performance (Kalkattawi et al., 1995). Studies have shown that the properties of Hot Mix Asphalt (HMA) are heavily influenced by the characteristics of the mineral filler (Kandhal et al., 1998). Filler type and amount significantly impact asphalt performance and durability. Expensive fillers like lime and cement can be replaced with more efficient options such as fine sand, ash, concrete dust, and brick dust of particle size less than 0.075 mm (Sutradhar et al., 2015). Recent studies show that waste powders, such as recycled lime, phosphate waste, ash from incineration, fly ash, ceramic waste, marble waste, and waste, tires improve HMA performance (Eisa et al., 2018).

Premature asphalt failure increases maintenance costs. Using materials that resist deformation can reduce these expenses. More cost-effective materials can also lower construction and upkeep costs. While lime and silica improve asphalt performance compared to stone dust, their high cost makes them expensive options for asphalt production (Al-Gurah & Al-Humeidawi, 2021). Replacing stone dust with cow dung and marble powder in asphalt concrete could enhance its properties. Cow dung is undigested plant matter, while marble dust is a byproduct of marble processing, with 20-30% of marble blocks becoming waste powder (Ulubeyli & Artir, 2015). Cow dung is an inexpensive and readily available resource for agriculture but can pose health risks if not managed properly, as it may harbor hazardous microbes. Using leftover marble dust and cow dung can address ecological issues while reducing asphalt concrete costs.

This study explores cow dung ash modified with marble powder (CDMP) as a partial replacement for traditional asphalt fillers to assess if CDMP enhances Marshall stability and flow. The research aims to identify

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the optimal CDMP and bitumen content to balance stability and flow while comparing production costs against conventional fillers like stone dust, lime, or cement. By using local waste materials, it seeks to enhance asphalt performance and sustainability in road construction. The findings could reduce costs and environmental impact, helping policymakers adopt more sustainable practices and potentially making CDMP a standard filler material.

2. Literature Review

A review of literature on fillers in asphalt concrete shows that fillers positively impact asphalt properties by filling gaps between coarse aggregate particles. Studies reveal that different fillers, even with the same bitumen content, can affect the asphalt mix's properties due to variations in particle size, shape, surface area, and surface roughness. Waste materials evaluated as fillers exhibited suitable physical and chemical qualities, and asphalt mixes with Dense Bituminous Mix (DBM) using these fillers showed mechanical and durability characteristics comparable to conventional mixes (Choudhary et al., 2018).

The parameters for the Mix Design of Asphalt Concrete are essential for evaluating the characteristics of aggregates and determining the types and percentages of bitumen used. The primary methods for asphalt mix design include the Marshall Method, Modified Marshall Method, Hveem Mix Design, and Superpave Mix Design (Institute, 2014; Zumrawi & Edrees, 2016). Among these, the most widely used are the Marshall Mix Design Method (M2DM) and the Modified Marshall Mix Design Method (M3DM), as recommended by the Asphalt Institute's MS-02 guide (Awan et al., 2022). Key features in the Marshall Mix Design are Marshall Stability (MS) and Marshall Flow (MF). MS is especially important in the design of the wearing course, as it reflects the pavement's ability to resist rutting and shoving. Flow, considered the opposite of stability, represents the elasto-plastic properties of asphalt concrete, which allow it to accommodate gradual movements and settlement in the subgrade without cracking (Hınıslıoğlu & Ağar, 2004; Kulo g ˇ lu, 1999).

Marble waste can be repurposed by cutting marble blocks into smaller pieces, generating dust from approximately 25% of the marble during the process (Karaşahin & Terzi, 2007). Research has shown that marble waste can be effectively used as a filler in Hot Mix Asphalt (HMA) mixtures, enhancing their properties (West & James, 2006). Globally, 30-70% of marble is lost as powder during processing, contributing to significant waste (Hebhoub et al., 2011; Ulubeyli & Artir, 2015). Containing CaO from $CaCO_3$, marble powder has been successfully used as a partial cement replacement (up to 15%), offering environmental benefits (Ashish et al., 2016).

Studies have tested cow dung ash (CDA) as a filler in asphalt, showing promising results. One study found that replacing limestone with 50% CDA improved performance, achieving a 33.5% increase in Marshall stability (11.11 kN) and a 17.83% decrease in flow (3 mm), enhancing asphalt's mechanical properties (Abdulrasool et al., 2022). Another study evaluated CDA as a partial replacement for granite dust in hot-mix asphalt. The optimal mix achieved 11.8 kN stability at 40% CDA and 6% bitumen, with reduced voids and improved flow, meeting Nigerian standards (Murana et al., 2023).

Several studies have explored the use of cow dung ash (CDA) and marble dust in improving concrete and asphalt performance. One study found that adding glass powder, marble dust, and CDA to concrete increased compressive strength by up to 21.96% after 7, 14, and 28 days of curing (Chouhan et al., 2022). Another study showed that replacing cement with 6% CDA resulted in increase in compressive strengths by 5.3% and 8.87 % respectively for M20 and M25 grades (Mathur & Chhipa, 2022). In hot-mix asphalt, the inclusion of 3% waste marble dust (WMD) improved Marshall stability, tensile strength, and reduced voids, offering an optimal mix for road pavements (Sang et al., 2021). Additionally, replacing 4-8% of asphalt filler with CDA significantly enhanced the mechanical properties of the mix (Alayaki et al., 2020).

3. Methodology

3.1 Data Collection and Testing

The study employed both primary and secondary data sources to gather comprehensive information. Primary data was collected from laboratory experiments and included tests on aggregates and bitumen, such as sieve analysis, Los Angeles Abrasion test, and specific gravity tests, along with data on the density and dimensions of Marshall samples. The laboratory tests were conducted at a lab in Birtamode, which served as the primary location for experiments and observations. Secondary data included specifications from the DoR and cost rates from the Morang District.

3.2 Material Selection

Coarse and fine aggregates were collected in accordance with the gradation requirements of the Standard Specification for Road and Bridge Works (SSRBW), 2016. Trials were conducted with different aggregate portions to ensure the combined gradation met the specified limits. Additionally, physical tests, including Los Angeles Abrasion (LAA), Aggregate Impact Value (AIV), specific gravity, and water absorption tests, were performed following the DoR specifications of Nepal.

In Nepal, paving grade bitumen is classified as VG10, VG20, VG30, and VG40 according to the SSRBW 2016 (including amendment, 2016). VG10 and VG30 are commonly used, with the choice influenced by average air temperature and traffic flow. Birtamod's yearly average temperature is 25.79 degrees Celsius. For this study, VG30 bitumen from IOCL (Indian Oil Corporation Limited) was used, meeting the specifications outlined in the SSRBW, which is based on the Indian Standard Specification IS: 73 (IS 73, 2013).

Figure 1 illustrates the fillers used for the study. Fillers materials were selected meeting the grading requirements presented in Table 1 as per American Society for Testing and Materials (ASTM D242/D242M-19, 2019). Marble dust, a waste material generated during marble processing, was collected from a local marble supplier which was tested to have a specific gravity of 2.44. Cow dung ash was obtained from a local cowshed. To produce cow dung ash, the cow dung was dried for 12 days, heated at temperatures around 420-550 degrees Celsius, cooled, crushed into powder form, and then sieved under IS 400 micron sieve, which was tested to have a specific gravity of 2.55. Stone dust, inorganic silt with low compressibility as per Unified Soil Classification System (USCS) and a byproduct of crushed stone, was collected from a local supplier, and was tested to have a specific gravity of 2.57.

Marble Powder | Stone Dust | Cow Dung Ash

Figure 1 Fillers Used

Table 1. Grading Requirements for Mineral Filler

IS sieve (mm)	Cumulative % Passing by Wt. of Total Aggregate
0.6	100
0.3	98-100
0.075	85-100

3.3 Aggregate and Bitumen Tests

Table 2 illustrates the tests on coarse aggregates and bitumen for construction suitability. Sieve analysis was conducted on four samples of coarse aggregates (19 mm, 10 mm, 4.75 mm, and dust) to assess particle distribution, while a cleanliness test evaluated dust content in soil sample. Aggregate tests included one sample each for crushing value, impact resistance, and abrasion, with a sample size of three for each test. Specific gravity and water absorption tests were also performed with a sample size of three. For bitumen, penetration, ductility, softening point, and specific gravity tests were conducted on one sample each, with a sample size of three for each test.

Table 2. Aggregate and Bitumen Test Samples

Test	Description of Samples	No. of Sample	Specification/code	Sample Size	Output
Sieve Analysis	Coarse Aggregate (19 mm down)	1	DOR (SSRBW, 2016)	1	Gradation analysis
	Coarse Aggregate (10 mm down)	1		1	
	Coarse Aggregate (4.75 mm down)	1		1	
	Coarse Aggregate (dust)	1		1	
Cleanliness (dust)	Soil Sample	1	IS:2386 Part 1, 2016a	1	Physical Properties
Test on Aggregate	Aggregate Crushing Value Test	1	IS: 2386 Part 4, 2016c	3	
	Aggregate Impact Value Test	1		3	
	Los Angeles Abrasion Test	1		3	
	Specific Gravity of mix	1	IS: 2389 Part 3, 2016b	3	
	Apparent Specific Gravity of mix	1	IS: 2389 Part 3, 2016b	3	
	water absorption of mix	1	IS: 2389 Part 3, 2016b	3	
Test on Bitumen	Penetration Test	1	IS: 1203-2022	3	Physical Properties
	Ductility Test	1	IS:1208-2023	3	
	Softening Test	1	IS: 1205-2022	3	
	Specific Gravity Test	1	IS: 1202-2021	3	

3.4 Marshall Tests

Marshall specimens were prepared per ASTM D6926 (2010) using bitumen, aggregates, and CDMP-modified filler (ASTM D6926-10, 2010). Aggregates and filler were oven-heated, and bitumen was gas-heated to 160°C. The mixture was then uniformly placed in a mold on a compaction pedestal lined with filter paper. Following this, 75 blows were applied to both faces of the mold as per SSRBW-2016 standards. The specimens were stored at room temperature for 24 hours. To validate the Marshall test results, three specimens were created for each proportion of fillers and bitumen concentration, following ASTM D6927 (2006) (ASTM D 6927, 2015).

The Marshall test involved 3 × 5 samples per bitumen percentage (4.5%–6.5%), totaling 15 samples per mix and 75 tests overall. CDMP filler replaced stone dust at 0%, 8%, 9%, 10%, and 11%, corresponding to stone dust ratios of 100%, 92%, 91%, 90%, and 89%, respectively. These combinations of samples were chosen based on findings from previous studies (Alayaki et al., 2020; Chouhan et al., 2022; Mathur & Chhipa, 2022; Sang et al., 2021). The test samples used for the study have been presented in Table 3.

Table 3. Marshall Test Samples

Mix	Composition (CD+MP+SD)	Binder Content (%)	Sample per binder content	Total Samples
A	0% + 0% +100% (Traditional Mix)	4.5, 5, 5.5,6, 6.5	3	15
B	5% + 3% + 92%	4.5, 5, 5.5,6, 6.5	3	15
C	6% + 3% + 91%	4.5, 5, 5.5,6, 6.5	3	15
D	7% + 3% + 90%	4.5, 5, 5.5,6, 6.5	3	15
E	8% + 3% +89%	4.5, 5, 5.5,6, 6.5	3	15

**Note: MP: Marble Powder; CD: Cow Dung Ash; SD: Stone Dust

4. Results and Discussion

4.1 Aggregate and Bitumen Tests

Tests such as aggregates were conducted as per IS 2386 Part III and IV. The results, shown in Table 4, meet the Standard Specifications for Road and Bridge Works (SSRBW) of Nepal (2016). The Los Angeles Abrasion Test (29.37%) and Aggregate Impact Value (20.13%) indicate good durability and toughness. The Aggregate Crushing Value (19.53%) and specific gravity (2.67) also comply with SSRBW standards. With low water absorption (0.37%), the aggregates exhibit excellent moisture resistance. Aggregates of 19 mm, 10 mm, and 4.75 mm were used in proportions of 37%, 11%, and 37%, with 15% mineral filler, following Grading-1 for bituminous concrete, and meeting SSRBW-2016 standards. The gradation curve in Figure 2 confirms compliance with required specifications.

Table 4. Physical test of aggregates

Name of test	Results	Specifications (SSRBW)
Los Angeles Abrasion Test (LAA)	29.37%	Max 30%
Aggregate Impact Value Test (AIV)	20.13%	Max 24%
Aggregate Crushing Value Test (ACV)	19.53%	Max 30%
Specific Gravity Test	2.67	2.5-3.0
Water Absorption Value	0.37%	Max 2%

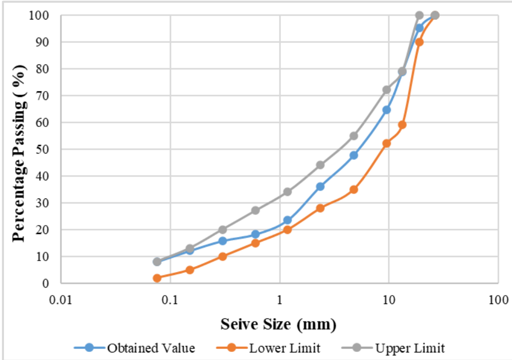

Figure 2. Grain size distribution curve of adopted aggregates

Tests for on bitumen were conducted as per IS standards, with results in Table 5. The specific gravity is recorded at 1.039 gm/cc, which was within the acceptable range. The penetration test shows a result of 47.67 mm, exceeding the minimum requirement. The ductility test reveals a value greater than 100 cm, significantly surpassing the minimum requirement. Lastly, the softening point is recorded at 49.85 °C, above the minimum requirement. Overall, these results demonstrate the material's effectiveness for its intended applications according to Nepal Standards.

Table 5. Bitumen test

Name of test	Results	NS 230:20461
Specific gravity (gm/cc)	1.039	1.01-1.06
Penetration test (mm)	47.67	45 min
Ductility test (cm)	>100	40 min
Softening point test (ºC)	49.85	47 min

4.2 Marshall Stability Tests

4.2.1 Marshall Quotient Analysis

Marshall Quotient is the asphalt mix's Marshall Stability to Marshall Flow ratio which is an empirical measure of the stiffness of mixtures. Marshall Stability measures the maximum load an asphalt sample can withstand before failure, reflecting its strength and structural integrity. Flow Value denotes the vertical deformation of an asphalt sample under load, indicating its flexibility and resistance to cracking.

Figure 3 shows the performance metrics of Marshall tests for different combinations. As bitumen content increases, Marshall Stability improves, reaching its peak at 5.5% bitumen, particularly in mix C, which shows the highest stability at 14.69 KN. Flow Values also increase with bitumen content, with the highest deformation observed at 6.5% bitumen. The Marshall Quotient, peaks around 5.5% bitumen, particularly for mix C .

Table 6 presents the statistical analysis of tests on Marshall Stability, Flow Value, and Marshall Quotient values which shows reliable and consistent results across different material combinations. The mean Marshall Stability ranges from 10.78 to 12.28 KN with low variability, while Flow Values (2.59 to 2.75 mm) show consistent deformation with minimal variation. The Marshall Quotient averages between 3.99 and 4.77, reflecting a good balance of strength and flexibility. Narrow confidence intervals for Flow Value indicate precision, and while some mixes show slight variability, the results suggest reliable performance.

Figure 4 compares the mean values of Marshall parameters under different mixes. The traditional mix (A) shows the lowest stability (10.78 kN) and highest flow (2.75 mm), indicating poor performance. Adding MP and CD improved results. Mix C achieved stability of 12.24 kN, showing a 13.6% improvement over Mix A. Mix D achieved the lowest flow (2.59 mm) and highest quotient (4.77 kN/mm), improving stability by 13.6% and reducing flow by 6.1% compared to Mix A. Mix E showed a slight decline in performance, with stability dropping to 11.88 kN, indicating that exceeding 7% CD may reduce effectiveness.

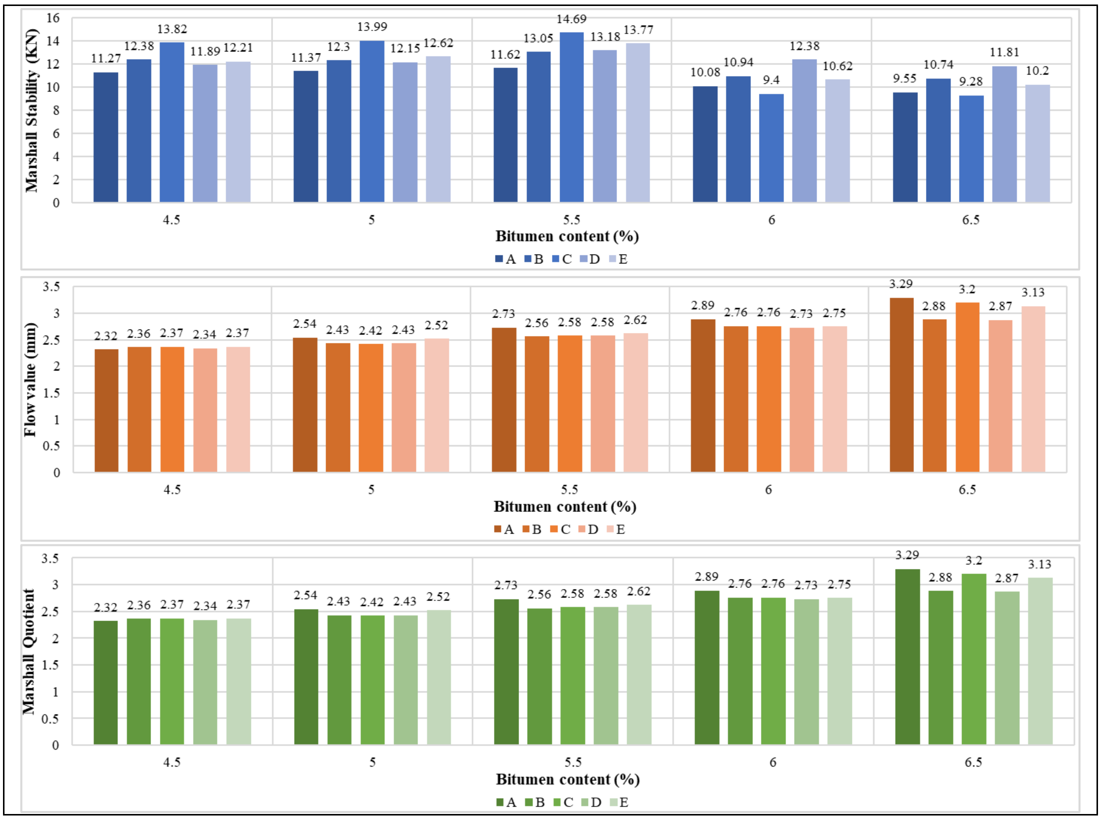

Figure 3. Marshall Stability, Flow Value and Marshal Quotient Values for different combination

Table 6. Statistical Analysis for Marshall Stability, Flow Value and Marshal Quotient Values under different combination

Parameters	Particulars	Mix A	Mix B	Mix C	Mix D	Mix E
Marshall Stability (KN)	Standard Deviation	0.91	1.00	2.66	0.55	1.47
	Mean	10.78	11.88	12.24	12.28	11.88
	Upper 95% confident level	11.57	12.76	14.57	12.76	13.17
	Lower 95% confident level	9.98	11.01	9.90	11.80	10.60
Flow value (mm)	Standard Deviation	0.37	0.22	0.34	0.22	0.29
	Mean	2.75	2.60	2.67	2.59	2.68
	Upper 95% confident level	3.08	2.79	2.96	2.78	2.93
	Lower 95% confident level	2.43	2.41	2.37	2.40	2.43
Marshall Quotient	Standard Deviation	0.79	0.71	1.45	0.44	0.90
	Mean	3.99	4.62	4.72	4.77	4.51
	Upper 95% confident level	4.68	5.24	5.99	5.15	5.29
	Lower 95% confident level	3.31	3.99	3.45	4.39	3.72

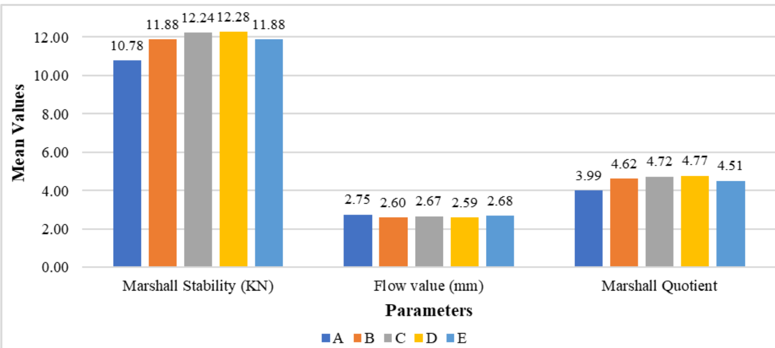

Figure 4. Mean of observed Marshall parameters

4.2.2 Volumetric Analysis

Volumetric qualities such as density and voids influence the asphalt mix's performance characteristics and durability. Voids in Mineral Aggregate (VMA) refers to the total volume of void spaces between aggregate particles in a compacted asphalt mix, which plays a crucial role in bitumen absorption and overall durability. Voids Filled with Bitumen (VFB) represents the percentage of VMA filled with bitumen, influencing the mix's resistance to moisture damage and deformation. Air Voids (AV) are the small air pockets within the compacted asphalt mix, essential for preventing excessive compaction while maintaining flexibility.

Figure 5 presents Bulk Density, AV, VMA, and VFB for different mixes. Bulk Density rises slightly with bitumen, balancing in mix C at 5.5% bitumen. AV decreases, reaching its lowest in mix C, indicating better compaction. VMA increases with air voids, especially in high-CD mixes. VFB peaks at 5.5% bitumen, notably in Mix C.

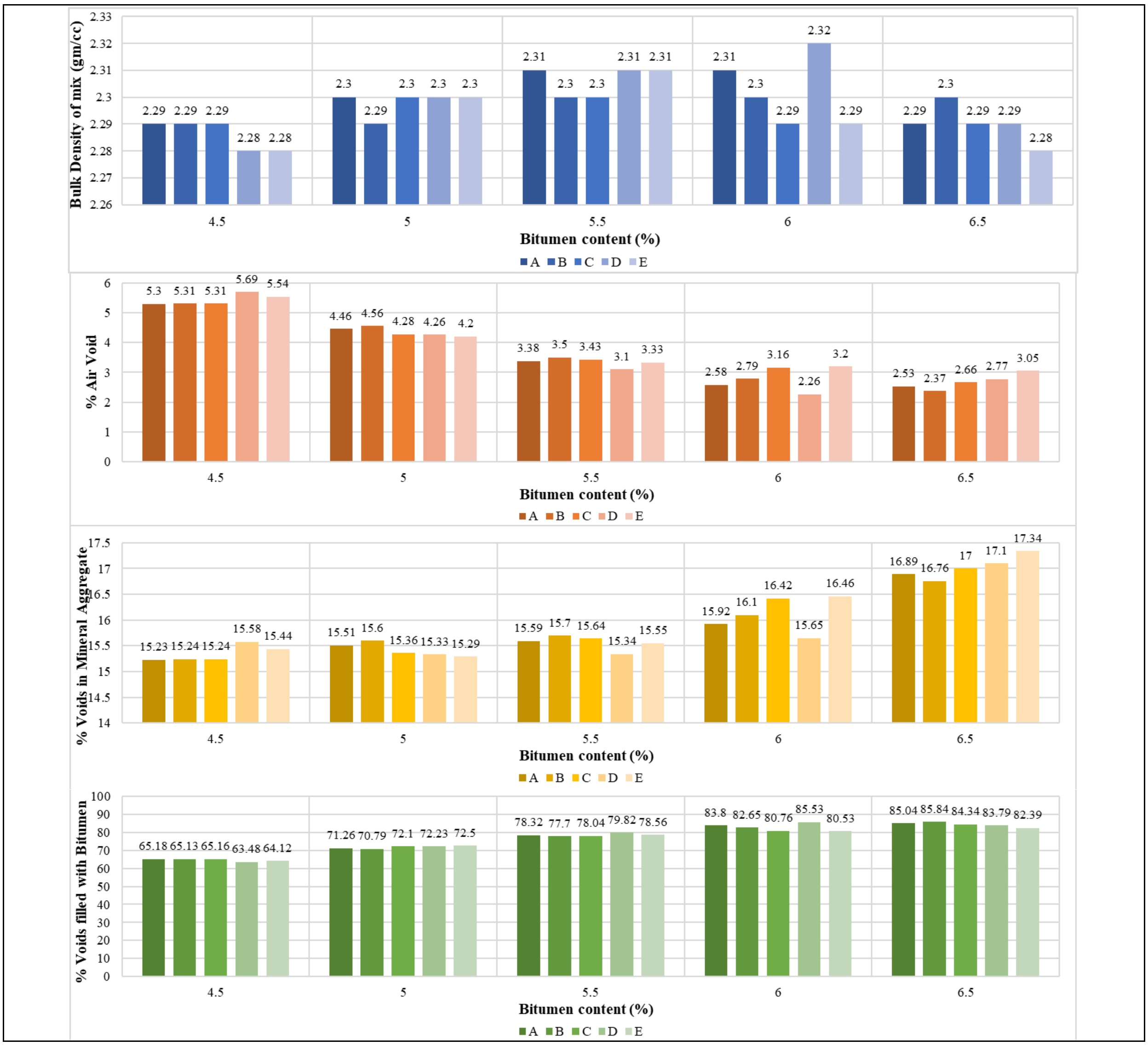

Figure 5. Bulk Density, Air Voids, Voids in Mineral Aggregate, and Voids Filled under different combination

Table 7 presents the statistical analysis of tests on Bulk Density, AV, VMA, and VFB which shows consistent and reliable results across the different material combinations. The mean Bulk Density values range from 2.29 to 2.30 gm/cc, with minimal variability, indicating stable and consistent density across mixes. AV percentages range from 3.62% to 3.86%, with moderate variation, suggesting that changes in mix composition, especially the proportion of CD, have a slight impact on air void content. VMA values show little variation, with means between 15.80% and 16.02%, reflecting consistent aggregate packing. VFB averages range from 75.62% to 76.97%, with moderate variability, indicating slight differences in the effectiveness of bitumen in filling voids.

Table 7. Statistical Analysis for Bulk Density, Air Voids, Voids in Mineral Aggregate, and Voids Filled under different combination

Parameters	Particulars	Mix A	Mix B	Mix C	Mix D	Mix E
Bulk Density of mix (gm/cc)	Standard Deviation	0.01	0.01	0.01	0.02	0.01
	Mean	2.30	2.30	2.29	2.30	2.29
	Upper 95% confident level	2.31	2.30	2.30	2.31	2.30
	Lower 95% confident level	2.29	2.29	2.29	2.29	2.28
% Air Void	Standard Deviation	1.21	1.22	1.04	1.37	1.04
	Mean	3.65	3.71	3.77	3.62	3.86
	Upper 95% confident level	4.71	4.78	4.68	4.82	4.77
	Lower 95% confident level	2.59	2.64	2.85	2.41	2.95
% Voids in Mineral Aggregate	Standard Deviation	0.64	0.58	0.75	0.74	0.87
	Mean	15.83	15.88	15.93	15.80	16.02
	Upper 95% confident level	16.39	16.39	16.59	16.45	16.78
	Lower 95% confident level	15.26	15.37	15.27	15.15	15.25
% Voids filled with Bitumen	Standard Deviation	8.44	8.49	7.57	9.12	7.43
	Mean	76.72	76.42	76.08	76.97	75.62
	Upper 95% confident level	84.12	83.86	82.71	84.96	82.13
	Lower 95% confident level	69.32	68.98	69.45	68.98	69.11

Figure 6 compares Bulk Density, AV, VMA, and VFB across mixes. Mix A (traditional) has a Bulk Density of 2.30 gm/cc with higher air voids (3.65%), indicating less compaction. Mix C slightly improves air voids (3.77%) and VMA (15.93%) while maintaining VFB (76.08%). Mix D has the lowest air voids (3.62%) and highest VFB (76.97%), enhancing durability. Mix E shows increased air voids (3.86%) and lower VFB (75.62%), suggesting excess CD may reduce performance.

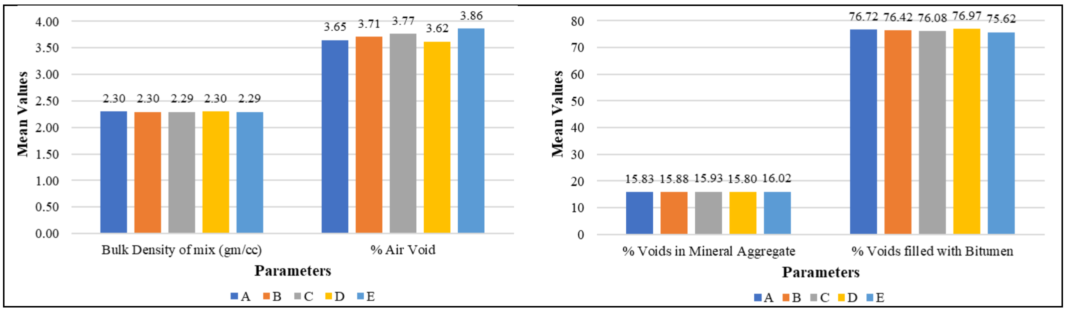

Figure 6. Mean of observed Volumetric parameters

4.3 Optimum Bitumen Content

The optimum bitumen content (OBC) in this study was calculated by averaging the bitumen values associated with three key parameters: maximum stability, maximum bulk density, and maintaining 4% air voids. Test data was used to plot graph shown in Figure 7 and Figure 8, with 5th-order polynomial trendlines identifying bitumen content for maximum stability, bulk density, and 4% air voids and Marshall parameters corresponding to OBC respectively. Table 8 presents the bitumen content for these parameters, leading to the OBC calculation. Table 9 illustrates the Marshall parameters at OBC in different combinations. Mix C provides the best results, with the highest stability (14.40 kN) and quotient (5.73 kN/mm). Density remains stable across all mixes (2.30–2.31 gm/cc), while air voids, VMA, and VFB show minor differences. Flow values indicate minimal deformation.

Table 8. Optimum bitumen content at different combinations

Marshall Parameters	Mix A	Mix B	Mix C	Mix D	Mix E
Bitumen at Max. Stability	5.35	5.40	5.35	5.55	5.40
Bitumen at Max. Density	5.80	5.85	5.40	5.95	5.45
Bitumen at 4 % air voids	5.23	5.25	5.12	5.13	5.10
OBC	5.46	5.5	5.29	5.54	5.32

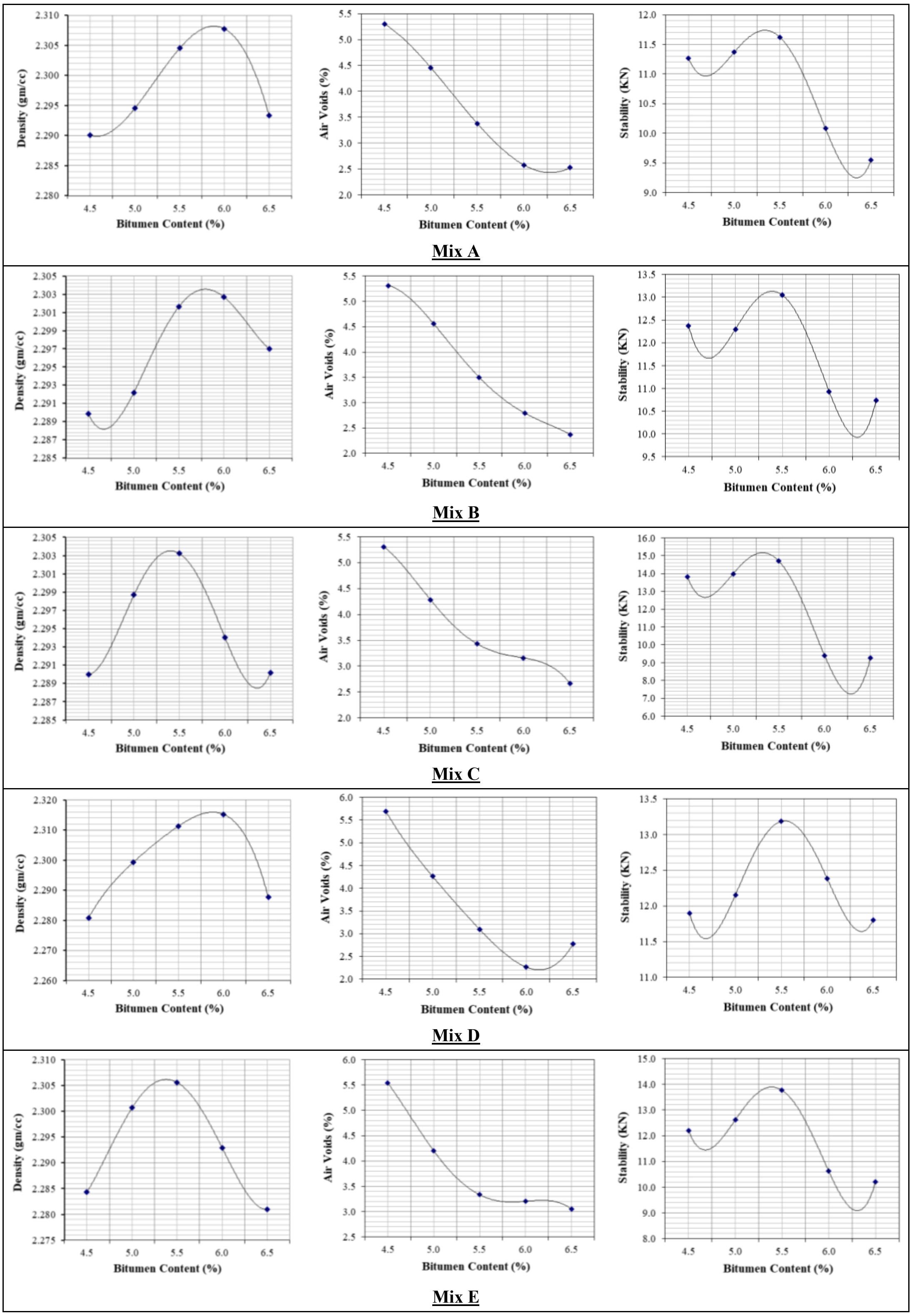

Figure 7. Charts to determine OBC

Table 9. Marshall parameters at Optimum Bitumen Content

Parameters	Unit	Mix A	Mix B	Mix C	Mix D	Mix E
Stability	kN	11.6	13.05	14.4	13.11	13.35
Density	gm/cc	2.3	2.3	2.3	2.31	2.3

Parameters	Unit	Mix A	Mix B	Mix C	Mix D	Mix E
Marshall Quotient	kN/mm	4.28	5.09	5.73	5.05	5.17
Air Voids	%	3.47	3.5	3.79	3.02	3.65
Voids in Mineral Aggregate	%	15.58	15.7	15.52	15.37	15.46
Voids filled with Bitumen	%	77.76	77.7	75.55	80.32	76.38
Flow	mm	2.71	2.56	2.51	2.6	2.59

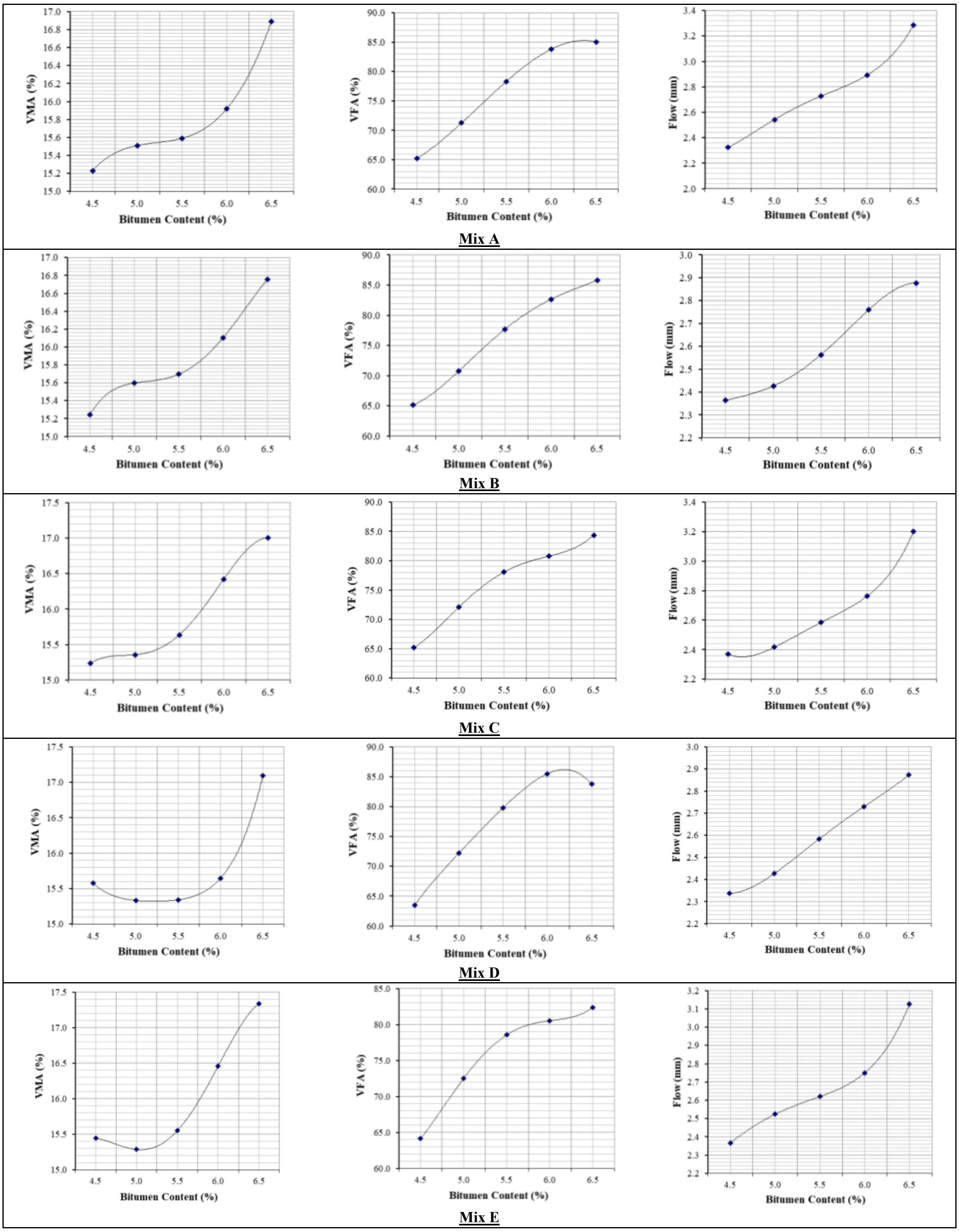

Figure 8 Charts to determine Marshall Parameters at OBC

4.4 Cost Analysis

Marble powder is not commercially available, leading to uncertainty in its pricing in the Nepalese market. To assess costs, telephone inquiries were made with various marble suppliers, and an average rate was used for analysis. Cow dung was sourced from a local cowshed. The average costs used for analysis were NRs. 10.5 per kg for marble powder and NRs. 6 per kg for cow dung.

The cost of paving one cubic meter of asphalt mix using 100% SD as a filler is Rs. 20,993.15. In contrast, the cost for paving one cubic meter of asphalt mix with a 9% partial replacement of stone dust by cow dung ash modified with marble powder (CDMP) and 91% stone dust is Rs. 19,694.68. This substitution results in a cost reduction of Rs. 1,298.47 per cubic meter when using cow dung ash modified with waste marble powder, representing a 6.19% decrease compared to using 100% stone dust as a filler.

4.5 Discussion

The study shows that using cow dung ash and waste marble powder as fillers improves asphalt's Marshall stability, enhancing strength and resistance to deformation for better durability. The optimal bitumen content of 5.29% balances performance and cost, preventing cracking and rutting. This approach reduces reliance on expensive materials, offering a cost advantage, especially in countries like Nepal. The 6.19% reduction in asphalt concrete costs supports its practicality. Additionally, using local waste materials provides an environmentally friendly solution by reducing landfill waste and lowering the carbon footprint. However, the long-term effectiveness of these fillers, especially in terms of weather resistance and aging properties, still requires further investigation to ensure that the asphalt remains durable in diverse environmental conditions. Using CD and MP as fillers in asphalt concrete helps reduce waste and promotes sustainability. While processing CD through burning may release CO_2 and pollutants, it also provides an environmentally friendly alternative to landfill disposal. Marble powder production, though energy-intensive, offers a way to reuse industrial byproducts. Both materials help reduce the need for traditional fillers, lowering environmental impact. With cleaner technologies, renewable energy, and optimized transportation, the potential environmental impacts can be minimized, making this approach a positive, sustainable solution for construction.

5. Conclusion

The study investigated the potential of utilizing cow dung ash modified with marble powder (CDMP) as modifiers in asphalt concrete, in comparison to traditional mixes using stone dust. The study utilized the Marshall Method for mix design and examined various properties such as Marshall Stability, flow, and volumetric characteristics to assess whether the modified mixes offered advantages over conventional ones under varied bitumen content and mix combinations. The study revealed incorporating marble powder (MP) and cow dung ash (CD) into asphalt concrete improves its performance compared to traditional stone dust (SD). The traditional mix, consisting solely of SD, exhibited low Marshall Stability and high Flow Value, indicating poor performance. When MP and CD were introduced, stability improved notably. A mix containing 3% MP and 6% CD with 91% SD showed a 13.6% improvement in Marshall Stability and maintained balanced air voids and VMA. However, mixes with higher CD content (above 7%) showed slight declines in performance, indicating that exceeding 7% CD may reduce effectiveness. The study found that a 9% CDMP content (consisting of 3% marble powder, 6% cow dung ash, and 91% stone dust) led to a minimal OBC of 5.29%. Furthermore, the use of CDMP reduced the cost of asphalt concrete by approximately 6.19% compared to mixes using 100% stone dust, indicating its cost-effectiveness. The volumetric and Marshall properties of the modified mixes met the standards set by the Department of Roads (DoR), affirming the suitability of CDMP for asphalt concrete. Recommendations include advocating for the use of CDMP as a filler in flexible pavements by government entities and conducting further research to evaluate the impact of varying CDMP content and bitumen grades, as well as real-world applications.

6. References

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