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Experimental Investigation on Use of Marble Dust as Partial Replacement of Stone Dust and filler in Bituminous Concrete Grade-2 using VG-40 binder

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Abstract: ***The increasing demand for sustainable pavement materials has encouraged the utilization of industrial waste in asphalt mixtures to improve pavement performance while reducing environmental impacts. This study investigates the combined use of Medium Marble Dust (MMD) and Very Fine Marble Dust (VFMD) in Bituminous Concrete (BC) Grade-2 prepared with VG-40 bitumen. The influence of marble dust on the mechanical and volumetric properties of bituminous mixes was ascertained by Marshall method and optimum replacement percentages were determined.***

Initially, the physical properties of aggregates, VG-40 bitumen, MMD, and VFMD were evaluated in accordance with relevant BIS codes and IRC/MORTH specifications. The Optimum Bitumen Content (OBC) for control mix by Marshall Mix Design method was determined as 5.51%. Medium Marble Dust was then used as a partial replacement for stone dust at replacement levels of 3%, 6%, 9%, and 12%, while 1% Very Fine Marble Dust with 1% cement was incorporated as a modified mineral filler. The prepared specimens were evaluated through Marshall Stability, Flow Value, Bulk Density, Air Voids (Va), Voids in Mineral Aggregate (VMA), Voids Filled with Bitumen (VFB), Marshall Quotient (MQ), and Indirect Tensile Strength (ITS) tests.

The results indicated that the incorporation of marble dust improved Marshall Stability, Indirect Tensile Strength, Particle Packing, and Volumetric Characteristics while reducing Air Voids and the consumption of conventional Stone Dust. The Modified mixtures also exhibited improved crack resistance and overall pavement performance. The study concludes that the combined use of MMD and VFMD is a Technically Feasible, Economical, and Environmentally Sustainable Alternative for producing urable BC Grade-2 mixtures, promoting the beneficial utilization of marble industry waste in flexible pavement construction.

Keywords: Bituminous Concrete Grade-2, Medium Marble Dust, Very Fine Marble Dust, VG-40 Bitumen, Marshall Stability, Indirect Tensile Strength, Sustainable Pavement.

I. INTRODUCTION

Amongst various surface courses, Bituminous Concrete (BC) Grade-2 which is well -graded and dense hot mix is widely used in flexible pavements for NH, SH, MDRs, urban roads, and other heavily trafficked pavements. It is well-graded mix coarse aggregates, fine aggregates, stone dust, mineral filler (cement or lime), and bituminous binder, which together form a dense, durable, and impermeable pavement layer providing good riding surface.

Marble dust: Marble dust is predominantly composed of calcium carbonate ($CaCO_3$) and possesses high fineness, good particle packing characteristics, and excellent filler properties. These characteristics make it a suitable alternative to conventional mineral fillers such as stone dust and cement in bituminous concrete. When incorporated into asphalt mixtures, marble dust fills the voids between aggregate particles, improves the adhesion between bitumen and aggregates, enhances the density of the mix, and reduces moisture susceptibility. Consequently, it may also modify key mix properties like Marshall Stability, Indirect Tensile Strength resulting in better rutting resistance, and enhanced pavement durability.

II. REVIEW OF LITERATURE

[1]Karasahin and Terzi (2007) investigated the use of marble waste as a mineral filler in hot mix asphalt. Their study reported that marble dust improved Marshall Stability, stiffness, and adhesion between bitumen and aggregates compared with conventional limestone filler. The authors concluded that marble waste could be effectively utilized as an alternative filler material, thereby reducing disposal problems and conserving natural resources.

[2]Binici et al. (2007), evaluated the influence of marble dust on asphalt mixtures and observed that its incorporation enhanced the mechanical properties and moisture resistance of the mixes. The study demonstrated that marble dust can successfully replace conventional filler without adversely affecting pavement performance while contributing to sustainable construction practices.

[3]Aruntas et al. (2010) examined the utilization of marble powder in asphalt concrete mixtures. The results indicated that marble dust improved mixture density and Marshall Stability by filling the voids between aggregate particles. The researchers recommended the use of marble waste as an environmentally friendly filler for asphalt pavements.

[4]Demirel (2010) investigated the effect of marble dust on asphalt concrete performance and reported that marble dust enhanced resistance to rutting and permanent deformation. The improved filler–binder interaction produced a denser asphalt matrix wi2th better durability under heavy traffic conditions.

[5]Baboo Rai et al. (2011) reviewed the environmental impacts associated with marble waste disposal and emphasized the necessity of recycling marble dust in construction materials. Their study concluded that the utilization of marble waste not only reduces environmental pollution but also lowers the consumption of natural resources and construction costs.

[6]Vaidevi (2013) evaluated the use of marble dust in pavement materials and found that the addition of marble dust improved the strength and durability of asphalt mixtures. The study suggested that marble dust can effectively replace conventional mineral fillers while maintaining satisfactory engineering properties.

[7]Huang et al. (2020) investigated sustainable asphalt technologies incorporating industrial by-products and concluded that fine mineral fillers significantly improve the volumetric and mechanical properties of asphalt mixtures. The study highlighted that waste fillers reduce air voids, improve moisture resistance, and increase pavement durability.

[8]Levy Sang et al. (2021) Levy Sang and co-workers investigated waste marble dust in asphalt mixtures and reported that an optimum marble dust content of approximately 3% with 4.5% bitumen produced the highest Marshall Stability and satisfactory volumetric properties. Excessive marble dust content, however, increased stiffness and reduced workability.

[9]Iqbal et al. (2022) studied the influence of marble dust as a mineral filler in asphalt mixtures and observed improvements in Marshall Stability, tensile strength, and moisture resistance. The study concluded that marble dust is an economical and sustainable alternative to conventional fillers.

[10]Khan et al. (2023) evaluated the mechanical performance of asphalt mixtures containing marble dust and reported improvements in Marshall Stability, dynamic modulus, and rutting resistance. They recommended an optimum marble dust content between 4% and 6% to achieve the best pavement performance.

III. GAPS IN LITERATURE REVIEW

These gaps represent where limited or insufficient information is available.

1) Most studies have investigated marble dust either as a filler or aggregate replacement, but not the combined use of Medium Marble Dust and Very Fine Marble Dust.
2) Limited research is available on BC Grade-2 mixes using VG-40 bitumen with marble dust.
3) The combined effect of marble dust on Marshall properties and Indirect Tensile Strength (ITS) both has not been comprehensively evaluated.
4) The optimum replacement level of Medium Marble Dust for achieving both improved pavement performance and sustainability is yet to be established.

IV. OBJECTIVES OF STUDY

Broadly, it was intended to ascertain the degree of replacement of Marble Dust in Bituminous mixes. The replacement as filler and fine aggregate was separately determined through experimental work. The following are specific objectives:

1) To determine the Optimum Bitumen Content (OBC) of (a) control mix with 2% cement as filler in Bituminous Concrete Grade-2 mix and (b) with 1% cement and 1% very fine marble dust as filler material using VG-40 grade bitumen.
2) To determine the Optimum Bitumen Content (OBC) and evaluate the Marshall Stability characteristics, flow value, bulk density, air voids, voids in mineral aggregate (VMA), voids filled with bitumen (VFB), and etc for BC Grade-2 mix at varying percentages of medium fine marble dust replacement (3%, 6%, 9%, and 12%) of stone dust and compare them with the control mix.
3) To assess the Indirect Tensile Strength (ITS) of BC Grade-2 mixes at the optimum bitumen content for various marble dust replacement percentages (3%, 6%, 9%, and 12%).
4) To identify the optimal percentage of very fine and medium fine marble dust as a replacement for stone dust in Bituminous Concrete Grade-2.

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V. RESEARCH METHODOLOGY

The present research was carried out to evaluate the suitability of Medium Marble Dust (MMD) as a partial replacement for stone dust and Very Fine Marble Dust (VFMD) as a mineral filler in Bituminous Concrete (BC) Grade-2 using VG-40 bitumen. The experimental programme was conducted in accordance with the provisions of MORTH (5th Revision), IS 73:2013, and relevant ASTM standards. The research methodology adopted in the study is described below.

1) Step 1: Collection and Characterization of Materials

The materials used in this investigation included:

- VG-40 bitumen
- Coarse aggregates (19 mm, 13.2 mm and 6.7 mm) and Fine aggregates stone dust
- Ordinary Portland Cement (OPC)
- Medium Marble Dust (MMD) and Very Fine Marble Dust (VFMD)

The physical properties of all materials were determined before mix preparation to ensure their suitability for BC Grade-2. The following laboratory tests were conducted:

Tests on Bitumen

- Penetration Test, Softening Point Test, Specific Gravity Test.

Aggregate Tests

- Specific Gravity test, Los Angeles Abrasion test, Aggregate Impact Value test, Water Absorption test, Flakiness and Elongation Index Test

Marble Dust Tests

- Specific Gravity and Particle size classification.

Collection of Material

Collection of Bitumen from Hot Mix Plant near Mohali.

Collection of Marble Dust from Marble Market, Dhanas, UT Chandigarh

2) Step 2: Preparation of Control Mix

Bituminous Concrete Grade-2 mix was prepared using natural aggregates, stone dust, 2% cement as mineral filler, and VG-40 bitumen at bitumen contents 5.28%, 5.44%, 5.51%, 5.59% and 5.73%.

Marshall specimens of 100 mm diameter and approximately 63–70 mm thickness were prepared using the Marshall compaction method. Each specimen was compacted with 75 blows on each face, suitable for heavy traffic conditions.

3) Step 3: Determination of Optimum Bitumen Content (OBC)

The prepared specimens were tested according to ASTM D6927 and Marshall parameters e.g., Marshall Stability, Flow Value, Bulk Density, Air Voids (Va), Voids in Mineral Aggregate (VMA) and Voids Filled with Bitumen (VFB) were determined.

4) Step 4: Preparation of Modified Bituminous Mixes

After determining the OBC, addition of marble dust was done in two experimental phases.

Phase I: Replacement of Stone Dust with Medium Marble Dust using 2% cement filler

Prepare the control mix using 2% cement filler with VG- 40 bitumen.

Stone dust was partially replaced with Medium Marble Dust (MMD) by 3%, 6%, 9% and 12% with mineral filler being Cement 2%, at the optimum bitumen content as determined above.

Phase II: Replacement of Stone Dust with Medium Marble Dust using 1% cement and 1% very fine marble dust filler

The control mix using 1% cement and 1% very fine marble dust filler with VG- 40 bitumen was prepared.

Stone dust was partially replaced with Medium Marble Dust (MMD) by 3%, 6%, 9% and 12% with mineral filler being Cement 2%, at the optimum bitumen content as determined above.

5) Step 6: Indirect Tensile Strength (ITS) Test

The ITS test was conducted on samples corresponding to optimum values of binder and very fine marble dust, medium marble dust to evaluate Crack resistance and Tensile strength.

6) Step 7: Analysis of Test Results

The experimental results obtained from the Marshall Stability and ITS tests were analyzed and compared with the control mix.

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VI. MATERIAL TESTING AND RESULTS

A. *Tests on Bitumen*

VG-40 Bitumen is used

Table 1: Physical properties of bitumen used for BC Grade 2 (VG-40)

Physical properties	Result	Required as per Is-73 2013
Penetration, 1/10th mm	42	40-50
Softening point	62°C	50 °C min.
Specific gravity	1.02	0.99 (min.)

B. *Tests on Marble dust*

Table 2: Physical properties of marble dust.

Physical properties	Specific Gravity	Required as per code
Medium Marble Dust	2.69	2.60-2.75
Very Fine Marble Dust	2.64	2.60-2.75

C. *Tests on Aggregate*

Table 3: Physical properties of aggregate used

Physical properties	Determined values	Required values as per IRC: SP:139-2023
Specific Gravity	2.6	-
Impact value (%)	16.49%	Max 24%
Elongation index (%)	12.1	Max 30% (E.I. + F.I.)
Flakiness index (%)	16.1	
Combined Flakiness and Elongation index (%)	28.2	
Water absorption (%)	0.80	Max 2%
Abrasion value (%)	22.1%	Max 30%

VII. RESULTS AND DISCUSSION

The Marshall Stability Test results for various mixes are presented in Figures 1 to 12.

A. *Mix Design of Bituminous Concrete Grade-2 (control mix with 2% cement filler)*

Five control bituminous mixes were prepared with 2 % cement filler and binder content of 5.28%, 5.44%, 5.51%, 5.59% and 5.73% to determine the optimum binder content (OBC) using the Marshall method.

Table 4: Marshall test parameters results for various binder contents with 2% cement filler (control mix)

Bitumen Content (VG-40)	5.29%	5.44%	5.51%	5.59%	5.73%	Requirements for BC Mix
Specific Gravity of VG40 Bitumen	1.02	1.02	1.02	1.02	1.02	-
Total Aggregate Mix (g)	1200	1200	1200	1200	1200	-
Total weight of mix	1267	1269	1270	1271	1273	-
Diameter of specimen, mm	100	100	100	100	100	-
Thickness of specimen, mm	65.5	67.5	67.7	67.0	67.5	-
Mass of specimen in air, g	1255	1256.5	1257.7	1259	1263.5	-
Mass of specimen in water, g	717.5	718.5	719.2	720	721.5	-
Mass of specimen in SSD condition, g	1258.5	1258	1259.5	1261	1265	-
Volume of specimen, cc	541	539.5	540.2	541	543.5	-
Bulk Specific gravity of mix, g/cc	2.320	2.329	2.328	2.327	2.325	-
Theoretical Specific Gravity, %	2.431	2.425	2.422	2.420	2.415	-
Volume of bitumen, (Vb) %	12.03	12.42	12.58	12.75	13.07	-
Voids in mineral aggregate, (VMA) %	16.61	16.41	16.51	16.61	16.83	-
Voids filled with bitumen, (VFB) %	72.41	75.66	76.20	76.74	77.68	75 to 85
Air voids, (Va) %	4.58	3.99	3.92	3.86	3.76	3% to 5%
Marshall stability, kN	16.79	22.00	20.03	18.06	16.63	Min 9 kN
Marshall Flow, mm	3.30	3.80	3.95	4.10	4.70	2 to 4
Marshall Quotient, kN/mm	5.09	5.79	5.0	4.41	3.54	-

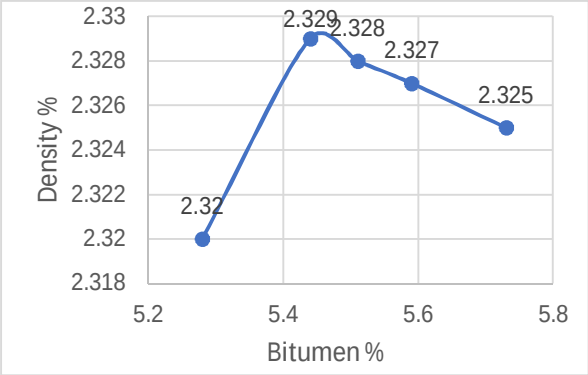

Fig 1: Density v/s Bitumen%, 2% cement filler (BC Grade 2 VG-40)

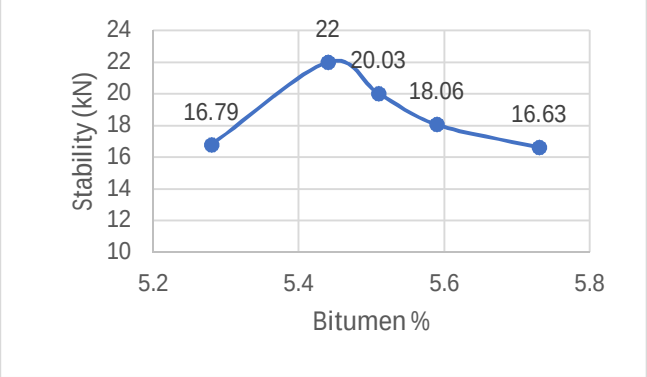

Fig 2: Stability v/s Bitumen%, 2% cement filler (BC Grade 2 VG-40)

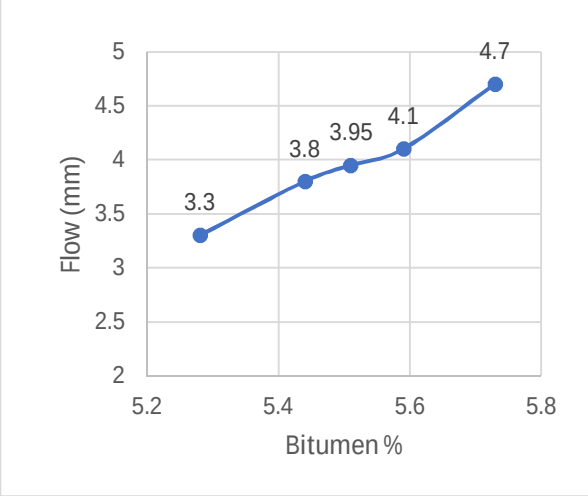

Fig 3: Flow v/s Bitumen%, 2% cement filler (BC Grade 2 VG-40)

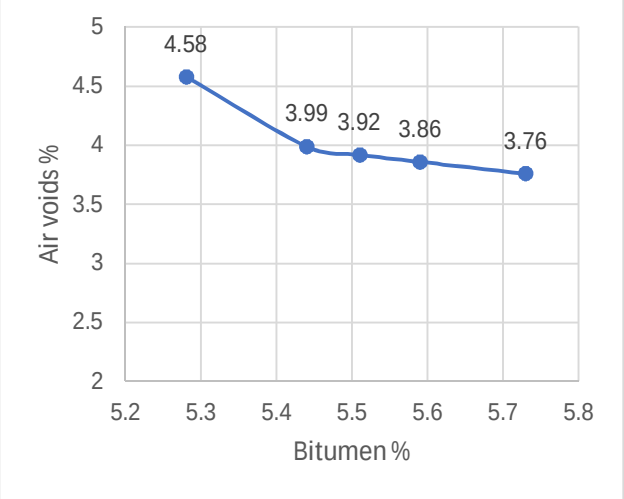

Fig 4: Air void v/s Bitumen %, 2% cement filler (BC Grade 2 VG-40)

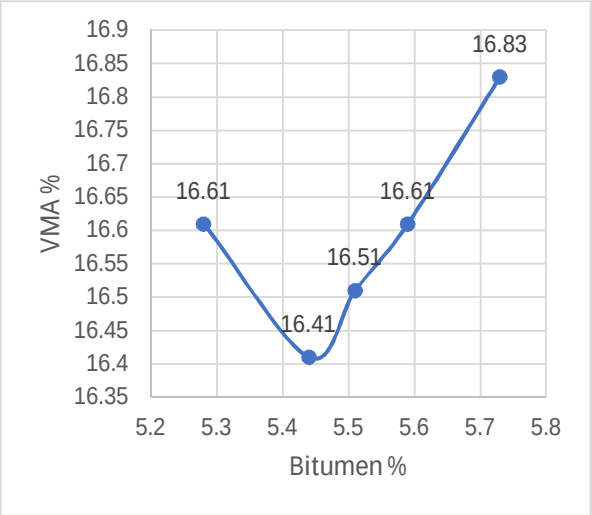

Fig 5: VMA v/s Bitumen %, 2% cement filler (BC Grade 2 VG-40)

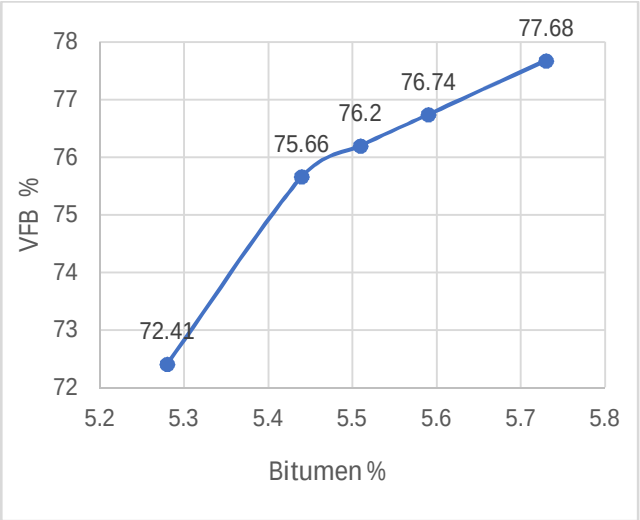

Fig 6 VFB v/s Bitumen%, 2% cement filler (BC Grade 2 VG-40)

The optimum binder content (OBC) of the bituminous mix was found to be 5.51% by the weight of the total mix, providing the best balance of Marshall Stability, flow value, and air voids as per standard. At this binder content, the mix exhibits optimum durability, adequate aggregate coating, sufficient flexibility, and improved resistance to cracking and temperature variations.

B. Result by using the varying percentage of Medium marble dust with 2% cement filler.

To determine the optimum percentage of medium marble dust to replace the stone dust using 5.51% bitumen binder and 2% cement filler, results of samples prepared with varying percentage of MMD are given Table 5.

Table 5: Marshall test parameters results for replacement of stone dust with medium marble dust at various percentages with optimum binder content using 2% cement filler.

Bitumen Content (VG-40)	5.51%				Requirements for BC Mix
Percentage of Medium Marble Dust, %	3%	6%	9%	12%	-
Diameter of specimen, mm	100	100	100	100	-
Thickness of specimen, mm	68.3	69	67.1	67.9	-
Mass of specimen in air, g	1264	1263.5	1260.5	1264.7	-
Mass of specimen in water, g	722	723.5	727.5	722.5	-
Mass of the specimen in SSD condition, g	1264	1265	1262	1266	-
Volume of specimen, cc	542	541.5	534.5	543.5	-
Bulk Specific gravity of mix, g/cc	2.332	2.333	2.358	2.327	-
Theoretical Specific Gravity, %	2.425	2.428	3.454	2.434	-
Volume of bitumen, (Vb)%	12.6	12.60	12.75	12.57	-
Voids in mineral aggregate, (VMA) %	16.46	16.53	16.63	16.98	-
Voids filled with bitumen, (VFB)%	76.53	76.27	76.62	74.02	75 to 85
Air voids, (Va) %	3.85	3.92	3.89	4.41	3% to 5%
Marshall stability, kN	25.27	19.67	19.56	17.67	Min 9 kN
Marshall Flow, mm	4.20	4.25	4.10	3.90	2 to 4
Marshall Quotient, kN/mm	6.0	4.66	4.78	4.53	-

The results show that stone dust can be replaced by medium marble dust up to **12%**, as the mix still satisfies the required IRC code parameters.

C. Mix Design of Bituminous Concrete Grade-2 (control mix with 1% cement and 1% very fine marble dust filler)

Bituminous Concrete mix was prepared with 1 % cement and 1% very fine marble dust filler at binder content of 5.28%, 5.44%, 5.51%, 5.59% and 5.73%. The results are given in Table 6.

Table 6: Marshall test parameters result for various binder content using 1% cement and 1% very fine marble dust filler (control mix)

Bitumen Content (VG-40)	5.29%	5.44%	5.51%	5.59%	5.73%
Specific Gravity of VG40 Bitumen	1.02	1.02	1.02	1.02	1.02
Total Aggregate Mix, g	1200	1200	1200	1200	1200
Total weight of mix	1267	1269	1270	1271	1273
Diameter of specimen, mm	100	100	100	100	100
Thickness of specimen, mm	68.6	68.8	68.8	68.8	69.6
Mass of specimen in air, g	1264	1264	1265	1266	1268
Mass of specimen in water, g	721.5	724.5	725	725.5	727.5
Mass of specimen in SSD condition, g	1264.5	1265	1265.5	1266	1270
Volume of specimen, cc	543	540.5	540.5	540.5	542.5
Bulk Specific gravity of mix, g/cc	2.328	2.339	2.340	2.340	2.337
Theoretical Specific Gravity %	2.449	2.444	2.441	2.438	2.433
Volume of bitumen, (Vb)%	12.07	12.47	12.65	12.83	13.14
Voids in mineral aggregate, (VMA) %	17.02	16.77	16.77	16.77	17.08
Voids filled with bitumen, (VFB), %	70.89	74.33	75.41	76.49	76.95
Air voids, (Va) %	4.95	4.30	4.12	3.94	3.94
Marshall stability, kN	18.54	19.38	19.80	20.22	18.53
Marshall Flow, mm	3.45	3.65	3.82	4.0	4.65
Marshall Quotient, kN/mm	5.37	5.31	5.18	5.05	3.98

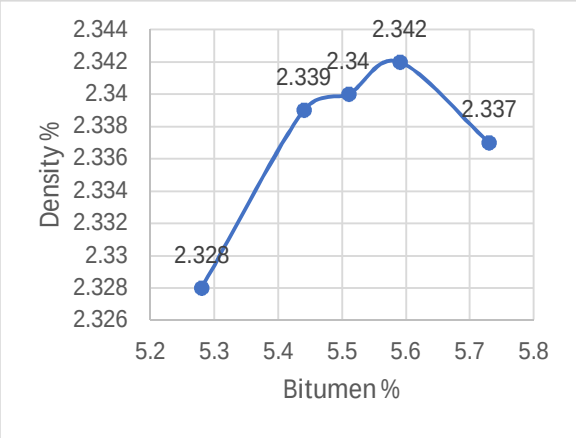

Fig 7: Density v/s Bitumen%, 1% cement & 1% VFMD filler (BC Grade 2 VG-40)

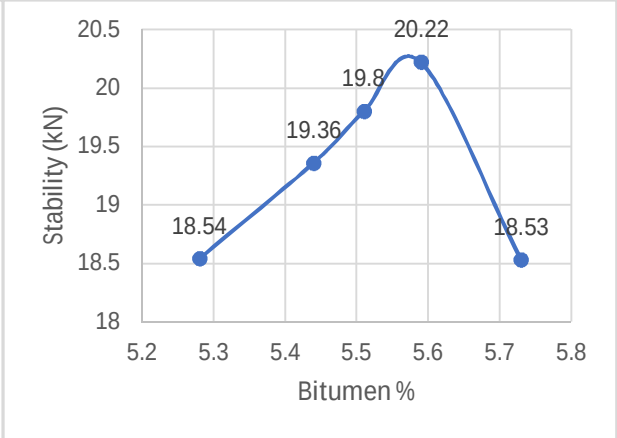

Fig 8: Stability v/s Bitumen %, 1% cement & 1% VFMD filler (BC Grade 2 VG-40)

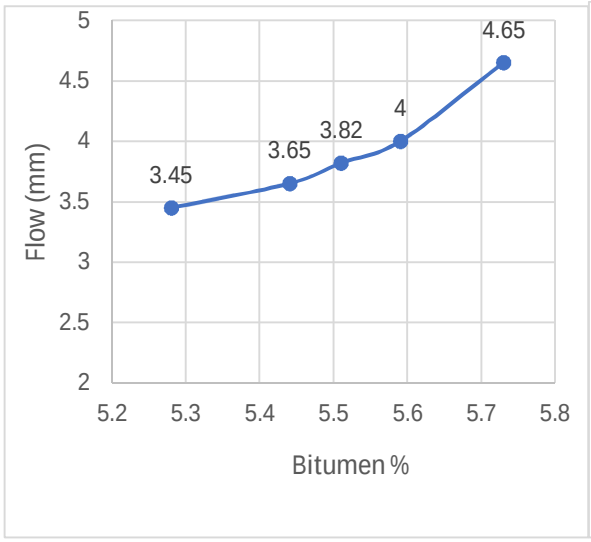

Fig 9: Flow v/s Bitumen %, 1% cement & 1% VFMD filler (BC Grade 2 VG-40)

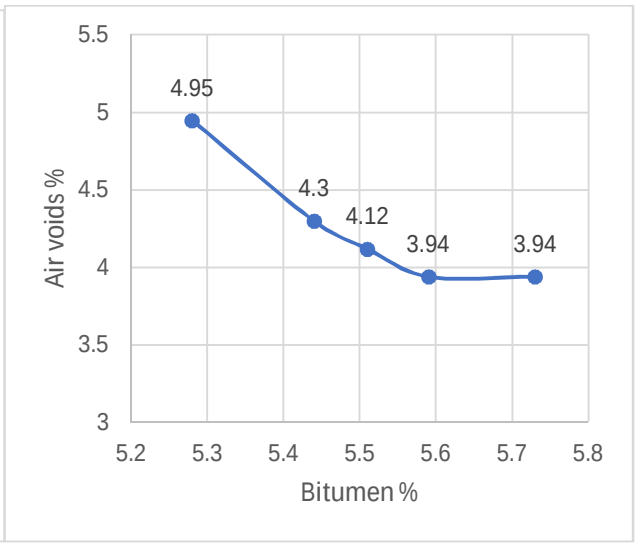

Fig 10: Air void v/s Bitumen %, 1% cement & 1% VFMD filler (BC Grade 2 VG-40)

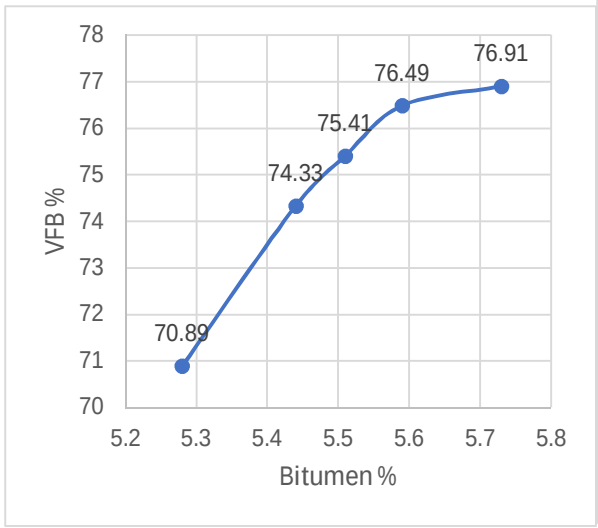

Fig 11: VFB v/s Bitumen %,1% cement & 1% VFMD filler (BC Grade 2 VG-40)

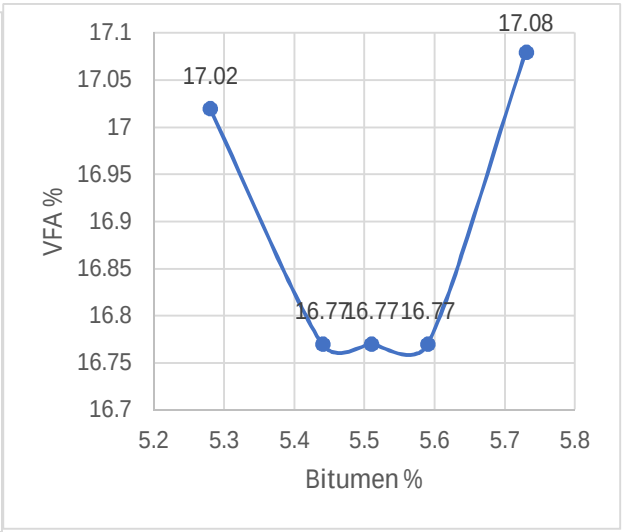

Fig 12 VMA v/s Bitumen %, 1% cement & 1% VFMD filler (BC Grade 2 VG-40)

The optimum binder content (OBC) of the bituminous mix was found to be 5.51% by the weight of the total mix, providing the best balance of Marshall Stability, flow value, and air voids as per standard. At this binder content, the mix exhibits optimum durability, adequate aggregate coating, sufficient flexibility, and improved resistance to cracking and temperature variations.

D. Result by using the varying percentage of Medium marble dust with 1% cement and 1% very fine marble dust filler.

To determine the optimum percentage of medium marble dust to replace the stone dust using 5.51% bitumen binder and 1% cement and 1% very fine marble dust filler, results of sample prepared with varying percentage of MMD are given Table 7.

Table 7: Marshall test parameters for replacement of stone dust with medium marble dust at various percentages at OBC using 1% cement and 1% very fine marble dust filler.

Bitumen Content (VG-40)	5.51%			
Medium marble dust percentage %	3%	6%	9%	12%
Specific Gravity of VG40 Bitumen	1.02	1.02	1.02	1.02
Total Job Mix (gm)	1200	1200	1200	1200

Total weight of mix	1270	1270	1270	1270
Diameter of specimen, mm	100	100	100	100
Thickness of specimen, mm	68.35	68.2	68.7	69
Mass of specimen in air, g	1266.2	1267	1262	1261
Mass of specimen in water, g	727.5	727.25	725	722.7
Mass of the specimen in SSD, g	1267	1267	1263	1261.25
Volume of specimen, cc	539.5	539.7	537.7	538.5
Bulk Specific gravity of mix, g/cc	2.347	2.347	2.346	2.341
Theoretical Specific Gravity %	2.443	2.385	2.450	2.430
Volume of bitumen, (Vb) %	12.68	12.68	12.68	12.65
Voids in mineral aggregate, (VMA)%	16.63	14.27	16.90	16.29
Voids filled with bitumen, (VFB)%	76.24	77.27	77.57	77.65
Air voids, (Va)%	3.95	3.59	4.22	3.64
Marshall stability kN	19.77	19.17	15.74	13.90
Marshall Flow, mm	4.2	3.77	3.60	3.50
Marshall Quotient, kN/mm	4.71	5	4.38	3.97

The results show that stone dust can be replaced by medium marble dust up to 6%. After a 6% replacement of stone dust, the stability decreased.

E. Indirect Tensile Strength Testing

After fixing the OBC at 5.51%, the Indirect Tensile Strength test was conducted on 2% cement, 1% cement filler and 1% very fine marble dust for varying percentage of MMD.

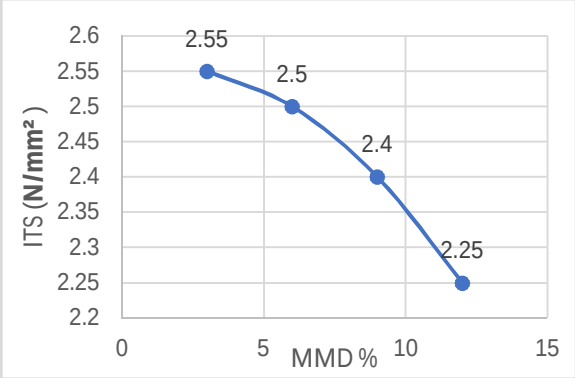

Fig 6.13 ITS v/s Medium Marble Dust using 2% cement filler (BC Grade 2 VG-40)

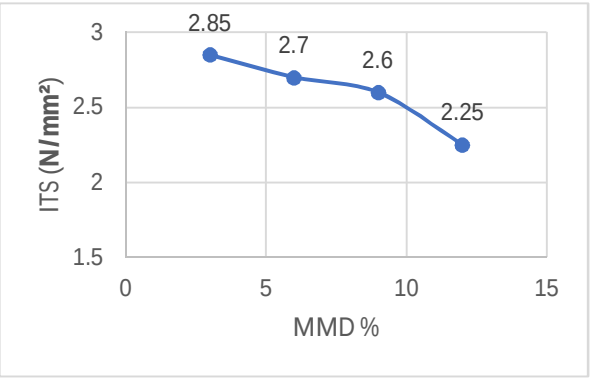

Fig 14: ITS v/s Medium Marble Dust 1% cement and 1% very fine marble (BC Grade 2 VG-40)

VIII. CONCLUSIONS

Based on the experimental work and the study, the following conclusions can be drawn:

1) For the mixture with 2% cement filler, five bitumen contents (5.44%, 5.51%, 5.58%, 5.59% and 5.73%) were evaluated. The tests indicate an optimum bitumen content of 5.51%, which provides the most suitable balance of strength, stability, and workability for the specified mix.
2) The stone dust was replaced with medium marble dust at 3%, 6%, 9%, and 12% using 2% cement filler and 5.51% bitumen content. The results show that stone dust can be replaced by medium marble dust up to 12%, as the mix still satisfies the required IRC code parameters.

3) For the mix containing 1% cement and 1% very fine marble dust, bitumen contents of 5.28%, 5.44%, 5.51%, 5.59%, and 5.73% were tested, the optimum bitumen content was found to be 5.51%, indicating that there is no change in the Optimum Binder Content.

4) Using 1% cement and 1% very fine marble dust as filler, and an optimum bitumen content of 5.51%, stone dust was partially replaced with medium marble dust at 3%, 6%, 9%, and 12%. The results showed that the mix remained stable up to 6% replacement, while still satisfying the required IRC code parameters. However, the mix showed reduced stability beyond 6 % replacement even though upto 12% replacement, it still meet the applicable IRC code requirements. This implies that 1 % of Cement and 12 % of Stone Dust can be replaced.

5) Air voids, Voids in mineral aggregate, Voids filled with bitumen, Density and Flow value remain within IRC code parameters.

6) Indirect Tensile Strength decreased slightly from 2.55 N/mm^2 at 3% MMD to 2.25 N/mm^2 at 12% MMD in mix with 2% cement filler. This however can be ignored as Indirect Tensile Strength is within the requirements.

7) Indirect tensile strength decreased from 2.85 N/mm^2 at 3% MMD to 2.25 N/mm^2 at 12% MMD in 1% cement and 1% very fine marble dust filler. However Tensile strength remain within requirements. It reduces beyond 6 % replacement.

8) Overall, utilizing industrial marble waste as an alternative asphalt filler proves to be highly viable.

9) It provides road sector with a budget-friendly way to scale back on natural stone quarrying without sacrificing the essential durability of Bituminous Concrete Grade-2.

IX. FUTURE SCOPE

The following are the limitations of the study, and researchers can use these limitations for further studies:

1) 1 To complete the investigation of VG-40 grade binder is used. Similar patterns may be utilized to study the behaviour of other grades, such as VG-10, VG-20, and VG-30

2) The study focuses on next four percentage of medium marble dust, starting at 15%.

3) Research has been done on Bituminous concrete grade-2. It is possible to research bituminous concrete grade 1 and other dense/semi-dense mixes like DBM and SDBC.

4) Similar experiments may also be carried out with several modified binders, such as CRMB, PMB, and NRMB.

5) It has opportunities for road sector engineering companies.

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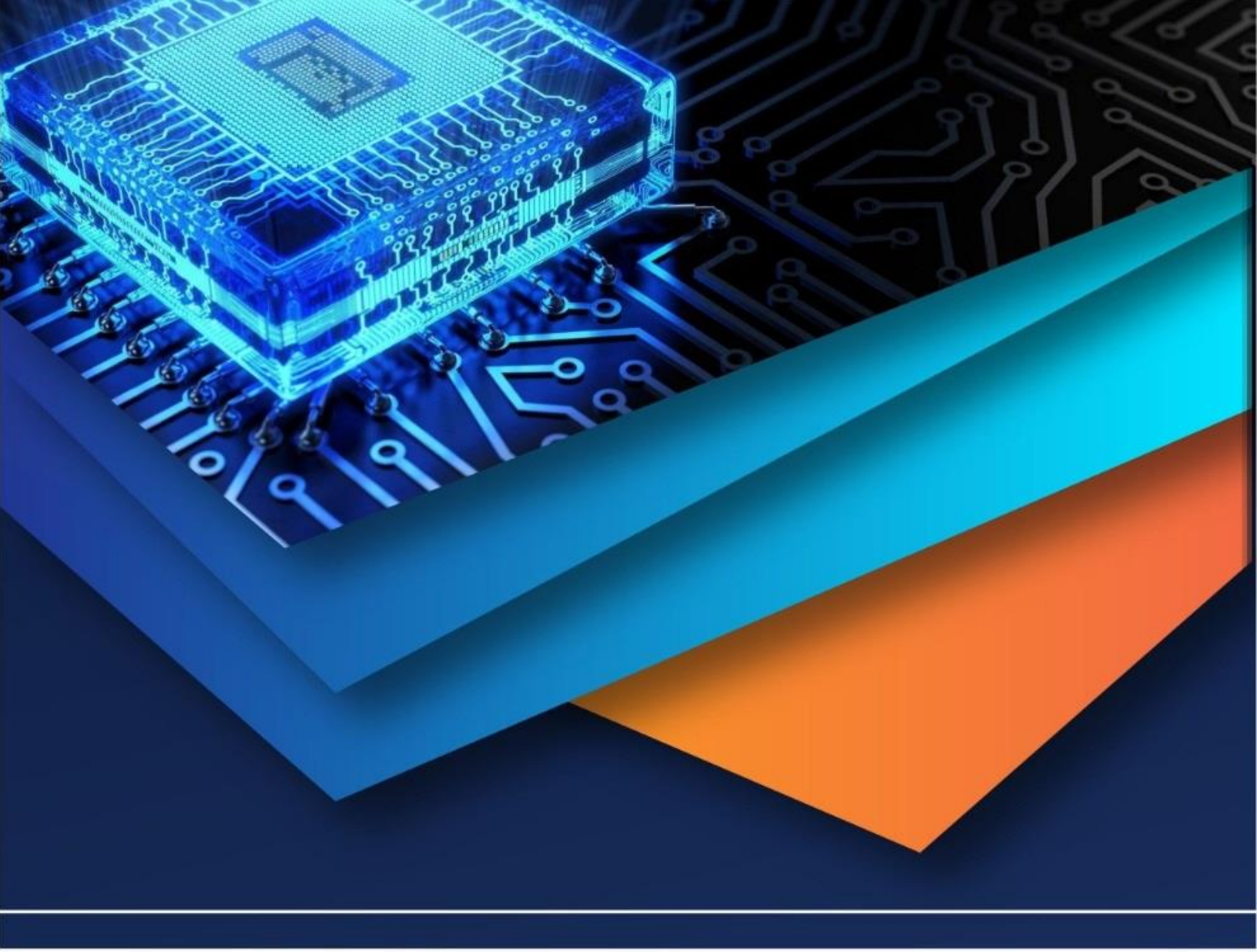

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