Study of Effect of Variation of Filler Type and its Proportion in Bituminous Mixes

Prahallad B S[1], Jaya R Shinganmakki[2], Swathi J[3], Mohan M[4]

[1]P.H.D Scholar, Department of Highway Technology, RASTA-Center for Road Technology, Bengaluru, Karnataka, India
[2]Associate Professor, Department of Highway Technology, RASTA-Center for Road Technology, Bengaluru, Karnataka, India
[3]M-Tech Scholar, Department of Highway Technology, RASTA-Center for Road Technology, Bengaluru, Karnataka, India
[4]M-Tech Scholar, Department of Highway Technology, RASTA-Center for Road Technology, Bengaluru, Karnataka, India

---***---

Abstract - *Bituminous mixes are vital components of modern infrastructure, and maximizing their qualities is crucial for providing long-lasting and resilient road surfaces. This study investigates the impact of changing the filler kinds and content in bituminous mixes. Mineral powders, polymers, and recyclable materials were all systematically mixed into bitumen- aggregate mixes in various amounts. The mechanical, rheological, and aging properties of the modified bituminous mixtures were investigated using a complete set of laboratory tests. The research exposes unexpected links between filler qualities, content levels, and overall performance. Standard tests were used to evaluate mechanical qualities such as stiffness, resistance to deformation, and fatigue behavior. The rheological properties of the mixes were also evaluated in order to better understand their workability and flow characteristics. The findings offer substantial knowledge into modifying bituminous mix formulations to achieve a balance that optimizes mechanical characteristics and long-term durability. This research contributes to the advancement of sustainable and efficient highway building materials, thereby enhancing the overall quality and service life of transportation infrastructure.*

Key Words: **Filler1, Marshall properties2, Volumetric properties3 and Indirect Tensile Strength4.**

1. INTRODUCTION

Bituminous mixes, which are used in road building and pavement applications, are made composed of aggregates and bitumen binder and provide transportation infrastructure with durability and structural stability. Improving their performance is in line with the changing needs of modern transportation. The changing of filler type and content is a main point. Fillers, which are finely divided materials added to improve specific characteristics of bituminous mixes, have the potential to improve mechanical, rheological, and aging qualities.Their changing composition and content allow for customized blend attributes to fulfill individual needs. Given the stress imposed by elements such as traffic loads and temperature fluctuations, ensuring the performance of bituminous mixes is critical for the long-term viability and sustainability of road networks. This study looks into the effect of filler type and content on bituminous mix performance, as well as the interactions between fillers and bitumen-aggregate.

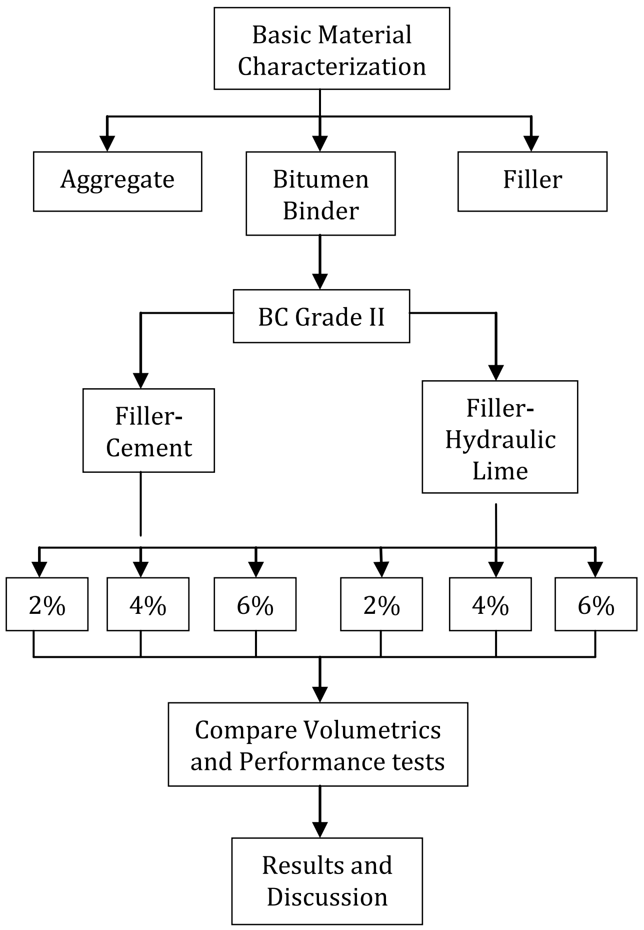
1.1 Role of Fillers in Bituminous Mixes

Fillers in bituminous mixes are finely powdered ingredients that improve mechanical strength, binder-aggregate adhesion, and durability. They increase rigidity, prevent deformation, and prevent cracking, which is essential for load-bearing and minimizing pavement distress. Fillers help to achieve optimal workability and compaction during construction by affecting rheology. Their ability to fill vacant spaces assures dense mixes, decreasing water infiltration and increasing stability. Fillers save money by substituting more expensive components and help the environment by using recycled materials. Overall, fillers enable engineers to alter the qualities of asphalt mixes, resulting in durable, flexible, and environmentally friendly road infrastructure.

2. MATERIALS

Asphalt is a bituminous mix that combines aggregates (such as crushed stone, gravel, and sand) with bitumen, a sticky binder. Bitumen binds, gives flexibility, and waterproofs while aggregates provide load-bearing strength. Fillers such as limestone dust and fly ash improve cohesiveness and moisture resistance. The composition of the mix varies according to climate, traffic, and purpose, with the goal of creating long-lasting, high-quality pavement. We used VG-30 binder, aggregates, hydraulic lime, and cement with variable filler proportions of 2%, 4%, and 6% for BC grade II.

3. METHODOLOGY



4. LITERATURE REVIEW

Gazi Mohammad Harun-Or-Rashid, Mohammad Mohayminul Islam

The study emphasizes the value of bituminous pavements that are both economical and environmentally friendly. As alternatives to expensive fillers like cement, researchers are looking into alternative waste products including marble dust, stone dust, fly ash, etc. Resultsthat were satisfactory in Marshall properties point to their ability to take the place of conventional fillers and provide a greener paving method.

Ezekiel A Adetoros

The research assessed fly ash, stone dust, and hydrated lime fillers' impact on Nigerian road asphalt quality. Hydrated lime yielded optimal stability (6% bitumen, 7% filler) and minimal airvoids/VMA (6% bitumen, 10% filler), suggesting durable, cost-effective pavements suitable forheavy traffic. Hydrated lime is recommended as the preferred filler for improved road performance and reduced construction expenses.

Kon Reddy Rajitha and Tejaswi Koramutla

The paper analyzes the impact of diverse additives on bituminous pavement characteristics, comparing conventional fillers (fly ash, brick dust) and unconventional ones (cement, lime, stone dust). Optimal bitumen content and effects on stability, flow, unit weight, air voids, andVMA are studied. Unconventional fillers exhibit promises for cost reduction and eco-friendly waste disposal in pavement construction.

Dallas N. Little and J. Claine Petersen

The effects of hydrated lime and calcium carbonate fillers in bitumen on microcrack behavior, healing, and flow throughout pavement temperatures are highlighted by rheological tests. The paper highlights effective filler uses through rheological models and bitumen microstructure hypotheses, highlighting the significance of micro-nanoscale interactions.

5. LABORATORY TESTS AND ANALYSIS

Marshall stability and performance experiments were conducted on bitumen mixes with varying filler and quantities to establish the ideal filler and percentage. The results of the tests are listed below.

Table -1: Marshall properties of BC-II mix using lime at their respective optimum bitumen content (OBC)

Filler type/ Properties	Lime			Requirement as per MORTH
	2%	4%	6%	
OBC (%)	5.6	5.73	5.6	5.4 minimum
Stability (kg)	1802.39	1632.48	1685.12	900
Air voids (%)	3.98	3.1454	3..72	2 - 5

Table 2: Marshall properties of BC-II mix using cement and fly ash at their respective optimum bitumen content (OBC)

Filler type/ Properties	Cement			Requirement as per MORTH
	2%	4%	6%	
OBC (%)	5.7	5.76	5.6	5.4 minimum
Stability (kg)	1718.59	1656.03	1473.29	900
Air voids (%)	3.57	3.089	3..72	2 - 5

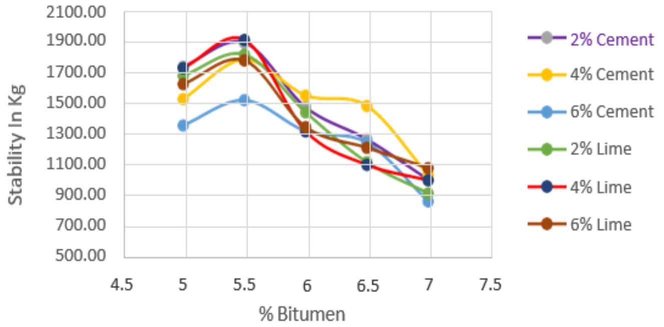


Chart -1: Bitumen content v/s Stability

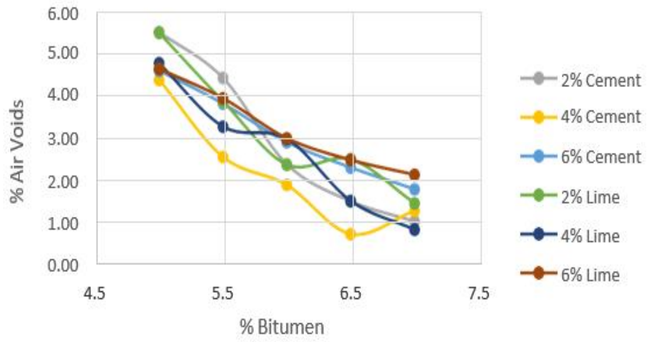


Chart -2: Bitumen content v/s Air voids

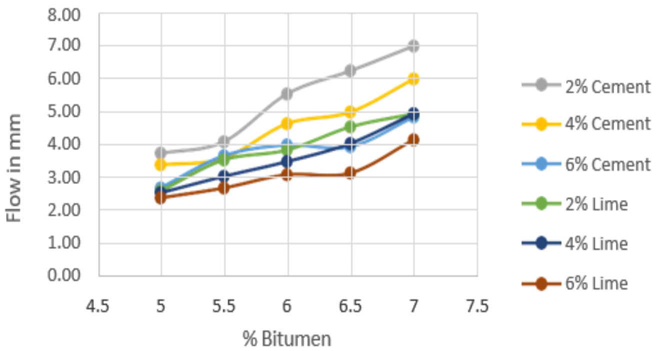


Chart -3: Bitumen content v/s Flow

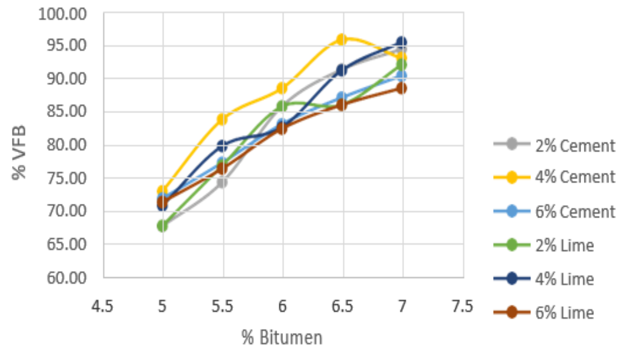


Chart -4: Bitumen content v/s VFB

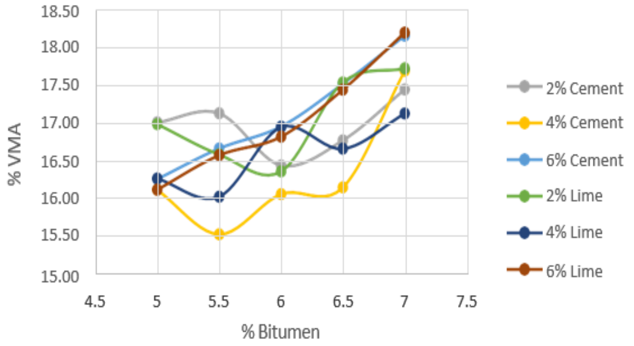


Chart -5: Bitumen content v/s VMA

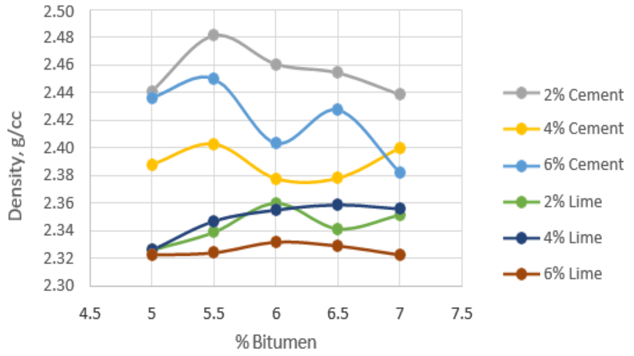


Chart -6: Bitumen content v/s Density

Table -3: Summary of performance test using Lime, Cement and Fly ash as fillers at their respective OBC.

Filler type/ Properties	Lime			Cement		
	2%	4%	6%	2%	4%	6%
Rut Depth, mm	4.3			5.7		
Static indirect tensile strength (unconditioned)	658.45	764.6	747.4	923.76	897.56	823.4
Static indirect tensile strength (Conditioned)	643.87	643.87	652.8	798.3	742.89	719.33
TSR%	97.79	84.21	87.34	96.95	80.42	80.14
Fatigue Studies No. of cycles (10% Stress)	5784	5318	4479	7823	5634	4567

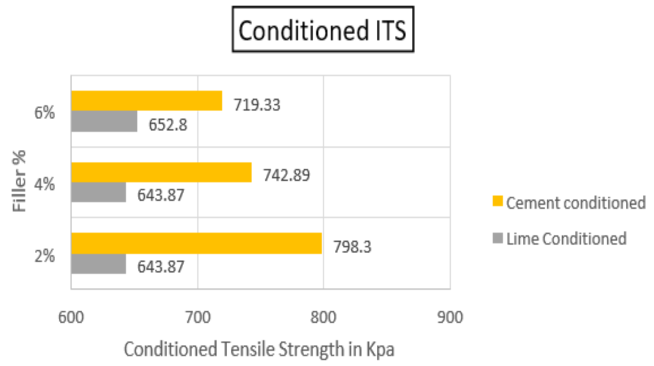


Chart -7: Variation of conditioned ITS w.r.t Filler type

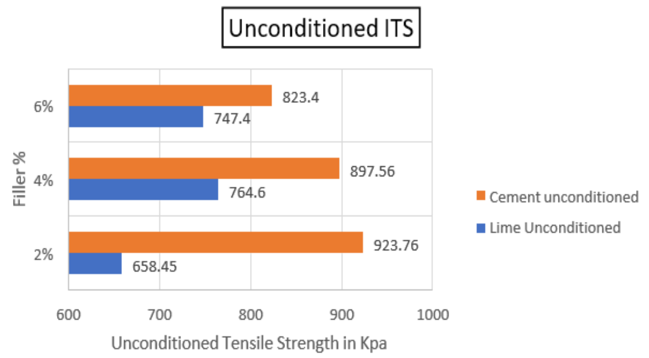


Chart -8: Variation of unconditioned ITS w.r.t Filler type

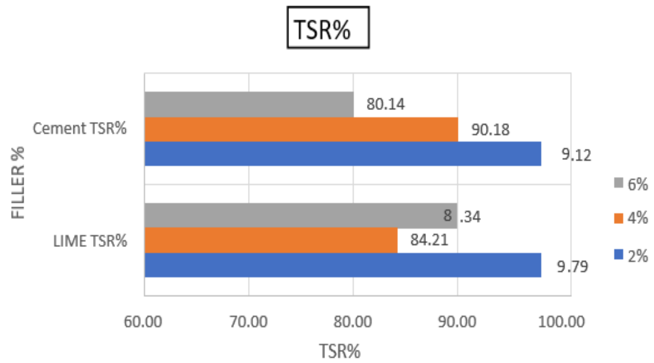


Chart -9: TSR (%) v/s Filler (%)

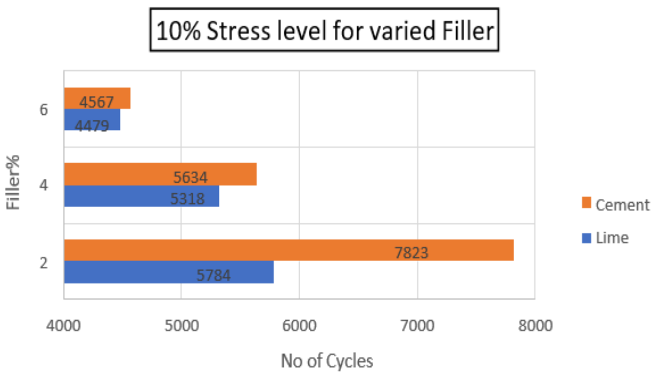


Chart -10: No. of cycles v/s Filler (%) for varied Filler

6. CONCLUSIONS

- The study that looked at the effect of filler type and quantity in bituminous mixes yielded useful insights into the performance and attributes of asphalt mixes. Comprehensive testing and analysis revealed that the filler Cement and its proportion 2% (cement 2%) had a considerable influence on the mechanical, durability, and rheological qualities of bituminous mixes. The study discovered that 2% cement improves the cohesion and adhesion of the mix, resulting in enhanced resistance to cracking, rutting, and moisture damage.
- Furthermore, 2% cement filler material has been shown to play a critical role in achieving appropriate aggregate-asphalt-filler interactions. 2% cement is regarded an adequate filler fraction that helps to greater void-filling and densification within the mixture, leading in improved load-bearing capacity and overall pavement performance.
- However, more research and testing are needed to refine and build on these findings. Additional research could look into the long-term impacts of different filler types and quantities under varied environmental and traffic circumstances. Overall, this research highlights the importance of filler material selection and proportion in constructing long- lasting and sustainable bituminous mixes for road construction and maintenance.

REFERENCES

[1] Gazi Mohammad Harun-Or-Rashid and Mohammad Mohayminul Isla, "A Review Paperon: Effect of Different Types of Filler Materials on Marshall Characteristics of Bitumen Hot Mix".

[2] Oladapo, S.A. and Adetoro, A.E, "Comparative Analysis of Effects of Filler Materials on Performance of Asphalt".

[3] Kon Reddy Rajitha, Tejaswi Koramutla, "Effect of Fillers on Bituminous Paving Mixes".

[4] Dallas N. Little[1] and J. Claine Petersen, "Unique Effects of Hydrated Lime Filler on the Performance Related Properties of Asphalt Cements: Physical and Chemical InteractionsRevisited"

[5] ASTM D 6927-15. (2015). Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures. Annual Book of American Society for Testing materials ASTM Standards, 1–7.

[6] ASTM D6931-17. (2017). Standard Test Method for Indirect Tensile (IDT) Strength of Bituminous Mixtures 1. 3–7.

[7] ASTM: D 2041-03a. (2003). Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures. ASTM International, 1–7.