Modification of Bituminous Pavements Using Steel Fibres

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***Abstract* -According to the problems that face the Indian highway system, a significant portion of the roads face long-term wear, creep, and rutting of the asphalt layers. These distresses may be occurred due to the shortage in the mechanistic properties of either of the binder and/or the asphalt mixtures as well as the increasing of traffic loads. In order to avoid earlier damage and failure, this study compares steel fiber modified hot mix asphalt mixtures with standard mix to examine how well they function. An experimental programme was designed and put into place to achieve this goal. Six HMA combinations were tested, including control mixtures, with steel fiber contents of 0.25%, 0.5%, 0.75%, 1%, 1.25%, and 1.5% by weight to the aggregate of HMA. In this study, the steel fibers were chosen as additive in hot asphalt mixtures for its good tensile strength, durability, ductility, stiffness and flexural properties. In addition, the interface between steel fiber and asphalt concrete has a high bonding strength.**

Performance of the different hot asphalt mixes was evaluated using the Marshall and ITS tests. The scope of the study included studying the performance of both unmodified and modified mixtures by steel fibers. The results of the investigations indicated that the addition of 1% steel fiber by aggregate weight improved the Marshall stability, flow, Marshall quotient, volumetric properties and the indirect tensile strength. The results also indicated that the addition of steel fiber did not improve the moisture susceptibility for all conditioning periods compared with control mixtures.

***Index Terms*—Steel Fiber (SF); Hot Mix Asphalt (HMA); Marshall Stability; Marshall Quotient; indirect tensile strength (ITS).**

I. INTRODUCTION

Generally, we have three types of pavements that are observed in our country they are earthen roads, concrete pavements also called as cc pavements or permanent pavements and bitumen pavements or flexible pavements [1]. While constructing the earthen road we are use locally available material that is soil, gravel and coarse aggregates and water.

Similarly For concrete pavements simply cc pavements we are adding additional cement concrete on the top of earthen roads to resist the more loads compare to the earthen roads and the cost of construction also increases but decreases the pavement deformations and maintenance cost as compared to the earthen roads [3]. These permanent pavement provides extreme smooth surface so that it may leads to accidents during the rainy seasons and for heavy moving vehicles due to slippery nature, generally these type of pavements are adopted where ever the moisture content more in the subsurface or water logging areas because the reaction between the concrete and water leads to increases the strength of the concrete so that load carrying capacity increases, while constructing the permanent pavements it requires joints so that the cost of construction increases as compared to the bitumen pavements or flexible pavements [5].

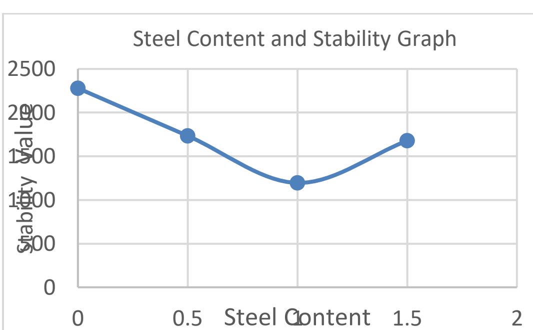
For bitumen pavement construction again up to the bottom of bitumen layer (bitumen + aggregates as per specific grading) we follow same procedure that we adopt for earthen pavements, it provides smooth and safe surface to the vehicles due its bonding nature between bitumen and tyres is good, but during the high temperature conditions the continuous movements of heavy load vehicles movements creates the pot hole, ruts and cracks formation takes place. due to this pot holes, ruts and cracks, vehicle damage occurs, also feels uncomforting journey to the pavement users, sometimes these pot holes and ruts act as a death canters [7].

To provide the pot holes, ruts and cracks free pavements we are modifies the existing bitumen pavements by adding stainless steel fibres. These stainless-steel fibres provide good bonding between bitumen, aggregate so the bonding nature will be increases simultaneously load carrying capacity increases, the formation of ruts, pot holes, and cracks will be minimized so that the maintenance cost will be decreases drastically as compare to the nominal bitumen pavements and also provides the safe and secure ride experience to the pavement users.

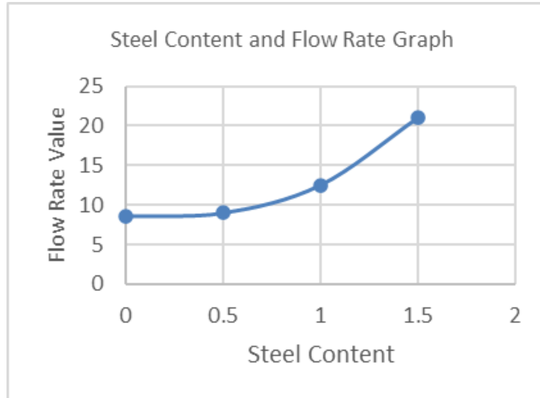
II. EXPERIMENTAL INVESTIGATION

The selection of suitable materials that are aggregates, bitumen, and stainless steel, are based on a several lab experiments conducted on these materials. The basic experiments conducted on aggregates are loss angels abrasion test and impact test it gives the aggregate durability against and impact loads and movements, and similarly to determine the grade of bitumen some of lab tests conducted on bitumen and that are penetration test, viscosity test, flow test, and specific gravity based on above mentioned test results we can finalized the grade of bitumen and properties of bitumen and suitability of bitumen for this project some of the basic grades of bitumen. The literature was thoroughly reviewed to identify the optimal fiber dosage for Marshall Mix Design. After analyzing various studies, dosages of 0.5%, 1.0%, and 1.5% by weight were chosen to determine the Optimum Binder Content via Marshall Mix Design. The fibers were mixed with aggregate and bitumen using the dry method. Subsequently, a comparative analysis was conducted, comparing the results of unmodified asphalt concrete with those modified with 0.5%, 1%, and 1.5% stainless steel fibers. Conclusions were drawn based on the experimental findings.

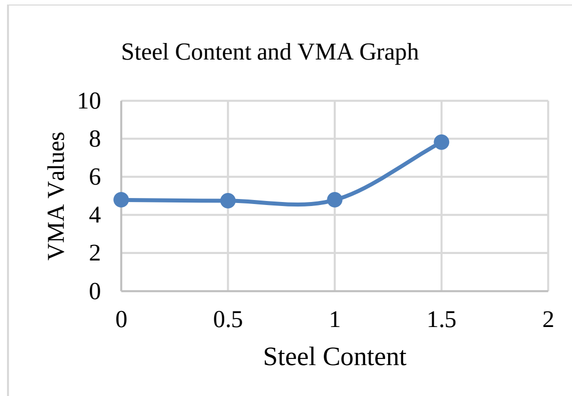
III. RESULTS



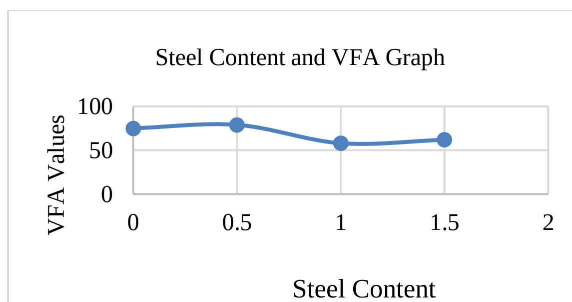
Steel Content vs Stability Graph



Steel Content vs Flow rate



Steel Content vs VMA Graph



Steel Content vs VFA Graph

VII. CONCLUSION

In conclusion, the modification of pavements with steel fibers presents several notable findings and outcomes based on the collected date:

- Aggregate and bitumen content: The pavement samples exhibited consistent aggregate and content of 95% and bitumen content of 5% ensuring uniformly across different mixtures
- Dry weight and SSD: The dry weight and saturated surface dry (SSD) weight measurements

indicated variations across different percentage of steel fiber additions with slight fluctuations observed in the dry weight

- Weight in the water: The weight samples in the water showed a gradual increased with higher percentage of steel fibers, suggesting a potential influence on water observation properties.
- Stability and corrected load: The stability values, calculated based on the collected data, demonstrated a decrease with increasing percentages of steel fibers, Indicating a potential trade-off betw00000000000000een stability and steel fiber content.
- Maximum specific Gravity of mix: The determination of maximum specific gravity highlighted a consistent value across different mixtures, indicating minimal impact from steel fiber additions on this parameter.
- Percentage of Air voids: The analysis of air voids revealed slight variations with different steel fiber percentages, with the highest value observed at 1.5%, suggesting a potential influence on pavement porosity
- Voids in mineral aggregate (VMA): VMA calculations indicated a marginal increase with higher steel fiber percentages, suggesting a potential impact on the voids within the mineral aggregate, which could affect the overall pavement performance.
- Overall implications: The collected suggested the addition of steel fibers to pavements can influence various properties, including stability, water absorption, and void characteristics. These findings underscore the importance of carefully balancing steel fiber content to achieve optimal pavement performance while considering factors such as stability, porosity, & durability.

REFERENCES

[1]Yang, H., Ouyang, J., Jiang, Z., & Ou, J. (2023). Effect of fiber reinforcement on self-healing ability of asphalt mixture induced by microwave heating. *Construction and Building Materials*, *362*, 129701.

[2] Shaffie, E., Mohd Nasir, A. A., Putra Jaya, R., Arshad, A. K., Mohamad Rais, N., & Al-Saffar, Z. H. (2023). Statistical approach model to evaluate permanent deformation of steel fiber modified asphalt mixtures. *Sustainability*, *15*(4), 3476.

[3] Yousif, R. A., Tayh, S. A., Al-Saadi, I. F., & Jasim, A. F. (2022). Physical and Rheological Properties of Asphalt Binder Modified with Recycled Fibers. *Advances in Civil Engineering*, *2022*.

[4] Swami, S. P. (2021). Effect of addition of Medium Steel Fibers on Dense Bituminous Macadam.

[5] Paluri, Y., Noolu, V., Mudavath, H., & Kumar Pancharathi, R. (2021). Flexural fatigue behavior of steel fiber-reinforced reclaimed asphalt pavement–based concrete: An experimental study. *Practice Periodical on Structural Design and Construction*, *26*(1), 04020053.

[6] Eisa, A. S., Elshazli, M. T., & Nawar, M. T. (2020). Experimental investigation on the effect of using crumb rubber and steel fibers on the structural behavior of reinforced concrete beams. *Construction and Building Materials*, *252*, 119078.

[7] Rashid, M., Hassan, M. F., Danish, A., & Ahmed, A. (2020). The effect of using jute fiber on deformation resistance of asphalt concrete.

[8] Fang, H., Sun, Y., Liu, Q., Li, B., Wu, S., & Tang, J. (2017, March). Ice melting properties of steel fiber modified asphalt mixtures with induction heating. In *IOP Conference Series: Materials Science and Engineering* (Vol. 182, No. 1, p. 012042). IOP Publishing.

[9] AASHTO TP-62. (2007) Standard method of test for determining dynamic modulus of hot-mix asphalt (HMA). American Association of State Highway and Transportation Officials (AASHTO), Washington DC, USA.

[10] AASHTO TP-62. (2007) Standard method of test for determining dynamic modulus of hot-mix asphalt (HMA). American Association of State Highway and Transportation Officials (AASHTO), Washington DC, USA.

[11] AASHTO T-283. (2003) Standard method of test for resistance of compacted asphalt mixtures to moisture-induced damage. American Association of State Highway and Transportation Officials (AASHTO), Washington DC, USA.

[12] AASHTO R-30. (2002) Standard practice for mixture conditioning of hot-mix asphalt (HMA). American Association of State Highway and Transportation Officials (AASHTO), Washington DC, USA.