iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** II **Month of publication:** February 2025

DOI: https://doi.org/10.22214/ijraset.2025.66825

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue II Feb 2025- Available at www.ijraset.com

Review on Trend Evaluation between Marshall Stability and I.T.S. Values for D.B.M. using various Binders with Waste Plastic

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Abstract: ***The pavement designer must be concerned about the most important effects of the road pavement, among them cracking, rutting, displacement fatigue, and distortion. The Marshall stability test is used to measure the strength under compressive load of the bituminous mix simulating rounded wheel shape, while the indirect tensile strength test is used for estimating the tensile property of the mix. It is known that incorporating waste plastic judiciously leads to improvement in mix properties e.g. Stability and Moisture Susceptibility. However, it need to be seen that it might not have a negative impact on the DBM mix's tensile properties. There is need to get insights as whether the I.T.S. values shall also be optimum at the binder content which provides maximum Stability. There have been many research studies conducted on Marshall stability and Indirect Tensile Strength tests separately, as well as a few number conducted in simultaneously. However, no single research has been performed in combination for DBM incorporating waste plastic utilizing various Grade binder. Hence a study may be undertaken to look at the trend evaluation between these two parameters. This research shall assess the trend between Marshall stability and Indirect Tensile Strength values for DBM Grade-II using VG-30 and VG-40 grade binder with or without waste plastic and clarify whether it is appropriate for the mix design. The pavement designer will benefit significantly from this study's wealth of knowledge in order to perform both tests.***
Keywords: Marshall Stability, Indirect Tensile Strength (I.T.S.), DBM, Waste Plastic, Sustainability.

I. INTRODUCTION

Road infrastructure plays a crucial role in a country's economic development and social progress. The durability and performance of road pavements are of paramount importance, necessitating continuous research and innovation in bituminous mixture design and evaluation techniques. Dense Bituminous Macadam (DBM) is a commonly used bituminous mix used as binder course in flexible pavements, known for its strength and durability. Marshall Stability Test is commonly used for design of dense bituminous mixes to determine optimum binder content. It is standard method for evaluating the strength of bituminous mixtures and provides valuable insights into the mixture's resistance to plastic deformation under load. On the other hand, the Indirect Tensile Test assesses the tensile strength and cracking resistance of the mixture. Both these parameters vary w.r.t. binder content. The variation of Stability value and I.T.S. with binder content is of interest for getting more insights. In addition, use of Plastic Waste in controlled quantity is found to enhance the performance of bituminous mixes. This review focuses on evaluating the trends between two essential performance tests for dense bituminous mixes. Additionally, the review explores the impact of incorporating waste plastic into these mixtures, addressing both engineering performance and environmental sustainability aspects. By analysing the trends between these two tests, this review aims to provide a comprehensive understanding of the mechanical behaviour of DBM mixtures under different loading conditions.

Through a systematic analysis of existing literature and research findings, this review seeks to identify correlations, discrepancies, and trends between Marshall stability and I.D.T results for dense bituminous mixes. The findings shall provide guidelines to carry a specific study on DBM mixtures. The study shall specifically examine DBM mixtures prepared using VG-30 and VG-40 bitumen. These viscosity-graded binders are widely used in road construction due to their superior performance characteristics. The comparison between VG-30 and VG-40 binders, both with and without waste plastic, will provide valuable information for pavement engineers and researchers in optimizing mixture designs and selecting appropriate binder grades for specific project requirements.

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A. Marshall Stability Test

The Marshall stability test is a standard method used to evaluate the strength and flow characteristics of bituminous mixtures in road construction. This test assesses the maximum load a compacted specimen can withstand at a standard temperature of 60°C (140°F) before failure occurs.

Key aspects of the Marshall stability test include:

1) Specimen preparation: Cylindrical specimens are prepared using a specified compaction method and allowed to cool to room temperature.
2) Temperature conditioning: Specimens are placed in a water bath at 60°C for 30-40 minutes before testing.
3) Loading: The specimen is placed in a loading apparatus and subjected to compression along its diametrical axis at a constant rate of deformation.
4) Measurements: The test measures two primary parameters:
    a) Stability: The maximum load resistance in kN before failure.
    b) Flow: The deformation of the specimen at the point of maximum load, measured in mm
5) Analysis: Results are used to determine the optimal binder content and assess the mixture's resistance to permanent deformation under traffic loading.

The Marshall stability test provides valuable information about the strength and deformation characteristics of bituminous mixtures, helping engineers design pavements that can withstand traffic loads and environmental conditions.

B. Indirect Tensile Strength Test

The indirect tensile test is a method used to evaluate the tensile strength of bituminous mixtures. Key aspects of this test for bituminous mixes include:

1) Specimen preparation: Cylindrical specimens of the bituminous mix are prepared according to specified dimensions and allowed to cool to the test temperature.
2) Test setup: The specimen is placed horizontally between two plain loading strips in a compression testing machine.
3) Loading: A diametric compressive force is applied along the length of the cylinder at a constant rate until failure occurs.
4) Stress distribution: The applied load creates a relatively uniform tensile stress perpendicular to the loading direction, causing the specimen to fail by splitting along the vertical diameter.
5) Measurements: The test measures the maximum load at failure and the corresponding horizontal deformation.
6) Calculation: The indirect tensile strength is calculated using the maximum load, specimen dimensions, and a formula that accounts for the stress distribution.
7) Applications: Results are used to assess material properties such as tensile strength, elastic modulus, and susceptibility to moisture damage.

This test provides valuable information about a bituminous mix's ability to resist cracking under tensile stresses, which is crucial for predicting pavement performance and durability.

Following formula use to determine the Indirect Tensile strength

$\sigma = [(2P)/ \pi Dt]$

Where σ = Horizontal tensile stress / tensile strength, N/mm2, P= Failure Load N, D= Diameter of the specimen in mm, T= Thickness of the specimen in mm

Loading arrangement of Marshall Stability and ITS test is shown below:



Figure 1: Marshall Stability test



Figure 2: ITS test

II. NEED AND SCOPE OF STUDY

It becomes pertinent to ascertain behaviour of pavement materials under various loading conditions in order to ensure their adaptability and sustained performance. Marshall stability and Indirect Tensile Strength tests are used to determine the pavement's resistance. Numerous investigations have been conducted on both experiments. However specific research studies are required on various mixes incorporating different binders and additives. The proposed is intended to evaluate the trend between the Marshall stability and Indirect Tensile Strength of DBM using VG-30 and VG-40 grade bitumen along with addition of waste plastic. It would further ascertain as whether the indirect tensile test is more appropriate than the Marshall stability test. It differs significantly from the research previously conducted by a number of researchers.

III. REVIEW OF LITERATURE

A literature review helps the researchers in understanding the gaps and difficulties in the field of study. It contains more information and data about the gaps in the study. The review explains, summarizes, assesses, and makes sense of the literature.

Changra A, Singh G. (2023) evaluated the Marshall stability values with different binder content by using crumb rubber as a filler material. This study established that the physical characteristics of modified bitumen and the Marshall Stability values of the mixtures can be improved by adding crumb rubber. The incorporation of crumb rubber can enhance bitumen's properties and help in increasing the life of flexible pavements in addition to generating less tire waste. In addition to crumb rubber with VG-30 bitumen, its penetration properties dropped sufficiently. Further increase of the modifier concentration, the penetration value decreases. The penetration value of virgin bitumen decreases to 61%, 58%, and 49% when altered with crumb rubber of 5%, 10%, and 15%, respectively. The Marshall stability value of the modified mix is higher as compared with the ordinary mix. The stability value increases with the increase of the modifier content. This concludes that a stiffer binder raises the mix's stability value, which is backed up by a larger modifier content. The improvement was 10–25% for every 5–15% increase in crumb rubber.

Hasban A, Waje A, Shinde S, Binayake R. A, and Vhatte V (2022) This study aims to explore the utilization of recycled plastic (P.E.T) and steel slag aggregate (SSA) in modifying bituminous mixtures. The objectives were to enhance flexible pavement performance and reduce environmental plastic waste. Two methods, wet and dry, exist for incorporating waste plastics into bituminous mixes. This research employs the wet process on BC(grade1) mix as recommended by MoRTH . The Marshall mix design method, using Penetration grade 60/70 binder, was applied to determine optimal binder content for conventional and modified mixes, as well as ideal plastic and steel slag proportions. Marshall Specimens were prepared with bitumen contents of 4%, 4.5%, and 5.0% by weight to identify optimal bitumen content. P.E.T content varied from 0% to 10% by weight of bitumen in 2% increments, while steel slag aggregate content was tested at 5%, 10%, and 15% to establish respective limits and properties. The wet process was used to assess Marshall Stability, Flow value, Marshall Quotient, Air voids (Vv), Voids in Mineral Aggregates (VMA), Voids Filled with Bitumen (VFB), and Retained Stability. These results were then compared with standard BC mixes. Test outcomes clearly demonstrated that Marshall Test values for modified mixes significantly exceeded those of conventional bituminous mixes. Gupta L. & Suresh G. (2018) evaluated the Indirect Tensile Strength by using stone dust and cement as filler material of bituminous concrete. The tensile strength of the bituminous concrete is crucial in pavement application. The Marshall mix design approach is used to determine the optimum binder content of the bituminous mix by using stone dust and cement as filler material. The important properties of the bituminous mix were determined using ideal binder content. The Indirect Tensile Strength and TSR values of the bituminous mix were determined using test temperatures of 15°C, 20°C, 25°C, 30°C, and 35°C. Based on the test data, it is found that the Indirect Tensile Strength and T.S.R values of the bituminous mix were higher when filler used cement as compared to using stone dust as filler material. It may be concluded that the superior filler material is cement as compared to stone dust in respect of mix properties, Indirect Tensile Strength, and T.S.R values.

Gupta L, Bellary A. (2018) Customized bituminous mixes, known as warm mix asphalts (WMA), can be produced, placed, and compacted at lower temperatures than traditional bituminous mixes. VMA was prepared by using a chemical additive with the conventional bituminous mix to enhance the performance of the pavement. This study focuses on comparing the behavioural similarity of conventional bituminous mix and WMA. Lime (1% & 2%) is used as a filler material to prepare the bituminous concrete mix and WMA. As a chemical additive, Zycotherm (1% by weight of bitumen) is used for WMA. The Marshall test is applied for the determination of optimum binder content. To evaluate optimum binder content of the bituminous mix and the WMA by analyzing Marshall properties, Indirect Tensile Strength (I.T.S), and Tensile Strength Ratio (T.S.R) test values. The minimum acceptable test result laid out in the MoRTH is satisfied in all respects. On the basis of laboratory tests performed, it may be concluded that the bituminous mix is superior to WMA, but it satisfies the minimum requirement, so WMA may be used as and when required.

Bansal S. et al. (2017) studied to develop a modified bituminous concrete mix by using rubber and plastic waste materials. In this study, the efforts given to create a modified binder for bituminous concrete mixes by using waste plastic products to partially replace bitumen. Marshall Stability Analysis was conducted on the samples using waste plastic (4%, 6%, 8%, and 10%) and crumb rubber (5%, 10%, and 15%) to partially replace the "Optimum Bitumen Content". According to experimental data, bitumen can be partially substituted with waste plastic to increase strength by up to 16%, while rubber material can increase strength by roughly 50% when compared to the conventional mix. It may be concluded that the addition of waste plastic product in the modified binder can enhance the strength and density of the bituminous concrete.

Kader S. A. Abd et al. (2017) This research aims to identify the ideal bitumen content (OBC) for asphalt mixtures incorporating various percentages of waste plastics and examine the stability characteristics of these modified compositions. The study determined Marshall stability and flow values, as well as density, air voids in total mix, voids in mineral aggregate, and voids filled with bitumen to ascertain the OBC for mixtures containing 4%, 6%, 8%, and 10% waste plastic by weight of bitumen as an additive. Findings revealed that the OBC for plastic-modified asphalt mixtures at these percentages were 4.98, 5.44, 5.48, and 5.14, respectively. While the control specimen exhibited better volumetric properties than the plastic-modified mixtures, the addition of 4% waste plastic demonstrated enhanced stability compared to the control sample.

Abdullah M. E. et al. (2017) study the engineering characteristics of asphalt mixtures that incorporate waste plastic at several percentages—4%, 6%, 8%, and 10% by weight of bitumen. The various laboratory tests were conducted for this study, such as stability, tensile strength, resilient modulus, and dynamic, etc. In this study it is obtained that the mixture containing 4% plastic had the highest stability. However, when the amount of plastic additive increases, the stability somewhat declines. It is also found that the modified asphaltic concrete with 8% plastic content has the maximum tensile strength. The maximum robust modulus, 3422 MPa at 25°C and 494 MPa at 40°C, is found in the modified asphalt mixture containing 8% plastic. At 8% plastic addition, the greatest creep modulus measured was 73.30 MPa. It can be concluded that the asphalt mixture's maximum value qualities were obtained when 8% plastic was added. Lastly, it may be concluded that the ideal value-adding percentage is 8% plastic.

Mishra B. and Gupta M. K. (2020) This study evaluates the usage of low-density polyethylene waste carry bags that have been shredded and mixed with BC in flexible pavements by WM and DM. Two methods, namely the dry method (DM) and the wet method (WD), are used for the comparison of the bituminous concrete incorporated with low-density polyethylene waste. Marshall stability and indirect tensile tests were performed together to compare the suitability of the test method used in the bituminous concrete mix incorporating waste plastic. After successfully carrying out the test and performing the comparison, it is found that waste plastic can be effectively used in bituminous concrete (BC) mixtures for flexible pavements. Finally, it may be concluded that due to its simplicity, affordability, environmental friendliness, and superior results, DM was determined to be the most efficient and superior choice.

Habeeb H, Chandra S, and Nashaat Y. (2014) This investigation determined how bituminous mixtures' moisture damage becomes affected by aggregate gradation. This study was performed using three grades of aggregate and two types of binder, such as VG-30 and PMB-40, for the DBM and BC mixers. Marshall specimens are prepared to find the moisture susceptibility test like retained stability and tensile strength ratio. Marshall stability and indirect tensile strength tests are taken into consideration for the analysis. To examine the effect of moisture on creep behaviour, the static creep test was performed on conditioned and unconditioned specimens. The findings show that PMB-40 mixtures have greater Marshall stability and flow characteristics than VG-30 mixes. It is observed that in order to determine how gradation affects the moisture susceptibility of mixes, the decrease in maintained stability, Indirect Tensile Strength (I.T.S), and increase in creep are assessed for finer, coarser, and normal aggregate gradations. When results are compared with other moisture susceptibility parameters, it is found that the least affected parameter is retained stability.

Saharia M. and Singh K. L. (2022) in this study evaluate the laboratory investigation of bitumen binder modified with waste plastic. Different percentage of plastic such as 1%, 2%, 3%,4% and 5% by weight of Bitumen is used for the sample preparation. Conventional and polymer modified bitumen's basic physical properties were carried out and analysed carefully. For the determination of physical properties, Marshall stability and indirect tensile strength tests were used. The results obtained from carrying out tests are used to find the optimum binder content and percentage of plastic used. The Marshall stability value found more nearly 69.65% for PMB as compared to the unmodified binder. It is also observed that the indirect tensile strength test values of the PMB are found to be 0.70 times higher as compared to the unmodified binder. The optimum plastic content was found to be 3% by weight of binder. Finally, it may be concluded that the polymer-modified binder exhibits better results compared to the unmodified binder strength, durability, and thus performance as bituminous pavement.

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Bostancioğlu M. and Oruç Ş. (2015) This study evaluate the effect of utilisation of activated carbon (CA) and furan resin (FR) on asphaltic mixture performance. For this study, modified asphalt is prepared by the use of modifiers such as activated carbon and furan resin. In order to analyse the feasibility of utilizing CA and FR, asphalt mixtures were made in this study using 10%, 15%, and 20% CA and 4%, 5%, and 6% FR mixing ratios based on the binder weight. As per the records obtained, FR modification raised the Marshall quotient by 25%, and the use of CA and FR greatly boosted the Marshall stability by 9%. On the basis of indirect tensile stiffness values, it was observed that by the addition of 10% CA and 5% FR, the stiffness modulus of the modified mixer increases more than 10% than the unmodified mixer. The by the modification of the mixer the indirect tensile strength values changes effectively it is observed that the indirect tensile strength increases 19 % in addition 20% CA and 12% increases in addition of 6% of FR. It is also found that in 5% FR modification, the ITS values are higher at 87%, but I.T.S values decrease for control mixes from 83% to 70%, 72%, and 75%, respectively, with 10%, 15%, and 20% CA modification. Therefore, this study shows that CA modification reduces the durability of the modified mixer. It may have concluded that FR modification enhances the durability where CA modification deteriorates the durability of the mixer and modification of CA and FR improves rutting resistance and shows excellent performance.

Morova N. (2024) This study determined the suitability of waste phonolite as a filler in flexible asphaltic pavement construction. The main objective of the study is to determine the suitability of the waste phonolite as a filler in the preparation of hot mix asphalt (H.M.A). For this study, the test samples were made by the use of 4%, 5%, and 6% Phonolite Waste mineral filler and 5% limestone (LS). The mineral filler finer than IS sieve 200 microns is used. During test sample preparation, the waste phonolite and limestone filler (3.5%, 4%, 4.5%, 5%, 5.5%, and 6% weight of bitumen were added. The bituminous mix design was performed by using each ratio and determining the optimum bitumen ratio. Specimens of bituminous hot mixture were made using OBR. Following the freeze-thaw (F-T) cycle, the prepared Marshall samples were used to determine the Marshall stability (M.S), moisture damage resistance, Retained Marshall Stability (R.M.S), and Indirect Tensile Strength (I.T.S) tests. In accordance with the Turkish Highway Technical Specification (HTS), the results were assessed. Consequently, it was concluded that the PW may be utilized as a filler in HMA when traffic was low-intensity.

IV. FINDINGS DRAWN FROM LITERATURE REVIEW

1) Both Marshall Stability and I.T.S values peak at an optimum plastic dosage, typically around 8% by weight of the binder. Beyond this dosage, the mix may become brittle, leading to a decline in both stability and tensile strength.
2) VG-30 binder, when modified with waste plastic, provides adequate performance for moderate traffic conditions but may be less resistant to rutting at higher temperatures compared to VG-40.
3) VG-40 binder modified with waste plastic demonstrates better performance under high-temperature conditions due to its higher viscosity, making it suitable for regions with heavy traffic loads and warmer climates.
4) Studies indicate that the incorporation of waste plastic into VG-30 and VG-40 binders improves Marshall Stability due to increased binder stiffness and enhanced cohesion between aggregates.
5) VG-40 tends to exhibit higher stability values than VG-30 when modified with waste plastic, attributed to its higher viscosity and performance grade.
6) The trend shows an optimal percentage of plastic addition (commonly 6-10% by weight of bitumen) beyond which stability may decrease due to over-stiffening or improper mixing.
7) Waste plastic modification enhances the tensile strength of DBM mixes by improving the bonding between aggregates and the binder.
8) I.T.S values show a consistent upward trend with plastic modification, with VG-40 showing slightly higher ITS values compared to VG-30 due to its superior temperature susceptibility and resistance to deformation.
9) The increase in I.T.S values also correlates with improved moisture resistance and reduced stripping potential.
10) The trends in Marshall Stability and I.T.S values are influenced by factors such as mix design, aggregate gradation, and testing temperatures.
11) Consistency in testing protocols is crucial for reliable comparison and evaluation of the performance trends between VG-30 and VG-40 binders with waste plastic.

V. GAPS IN LITERATURE REVIEW

1) Most studies have evaluated Marshall Stability and Indirect Tensile Strength (I.T.S) values using individual binders (VG-30 or VG-40) rather than a comparative analysis between them when modified with waste plastic.

2) There is insufficient data on how different binder grades interact with waste plastic under similar conditions, leaving a knowledge gap in understanding their comparative performance.
3) Current literature mainly focuses on short-term experimental results of Marshall Stability and I.T.S values on selective mixes without assessing long-term durability and performance under varying climatic conditions.
4) A deeper analysis of how waste plastic-modified binders (VG-30 and VG-40) impact the aging characteristics of Dense Bituminous Macadam (DBM) is missing.
5) There is a need for standardized protocols to evaluate the Marshall Stability and I.T.S values for waste plastic-modified DBM mixes with VG-30 and VG-40 binders.
6) The interaction mechanisms between waste plastic and different grades of binders (VG-30 and VG-40) are not well understood.

VI. EXPECTED OUTCOMES

That, keeping in view the existing literature review, it is proposed that
1) Identification of the trend relationship between Marshall Stability and I.T.S values for DBM Grade-2 mixes.
2) Insights into the comparative performance of VG-30 and VG-40 binders with waste plastic under laboratory conditions.
3) Recommendations for optimal plastic dosage and binder selection for sustainable and high-performance road construction.

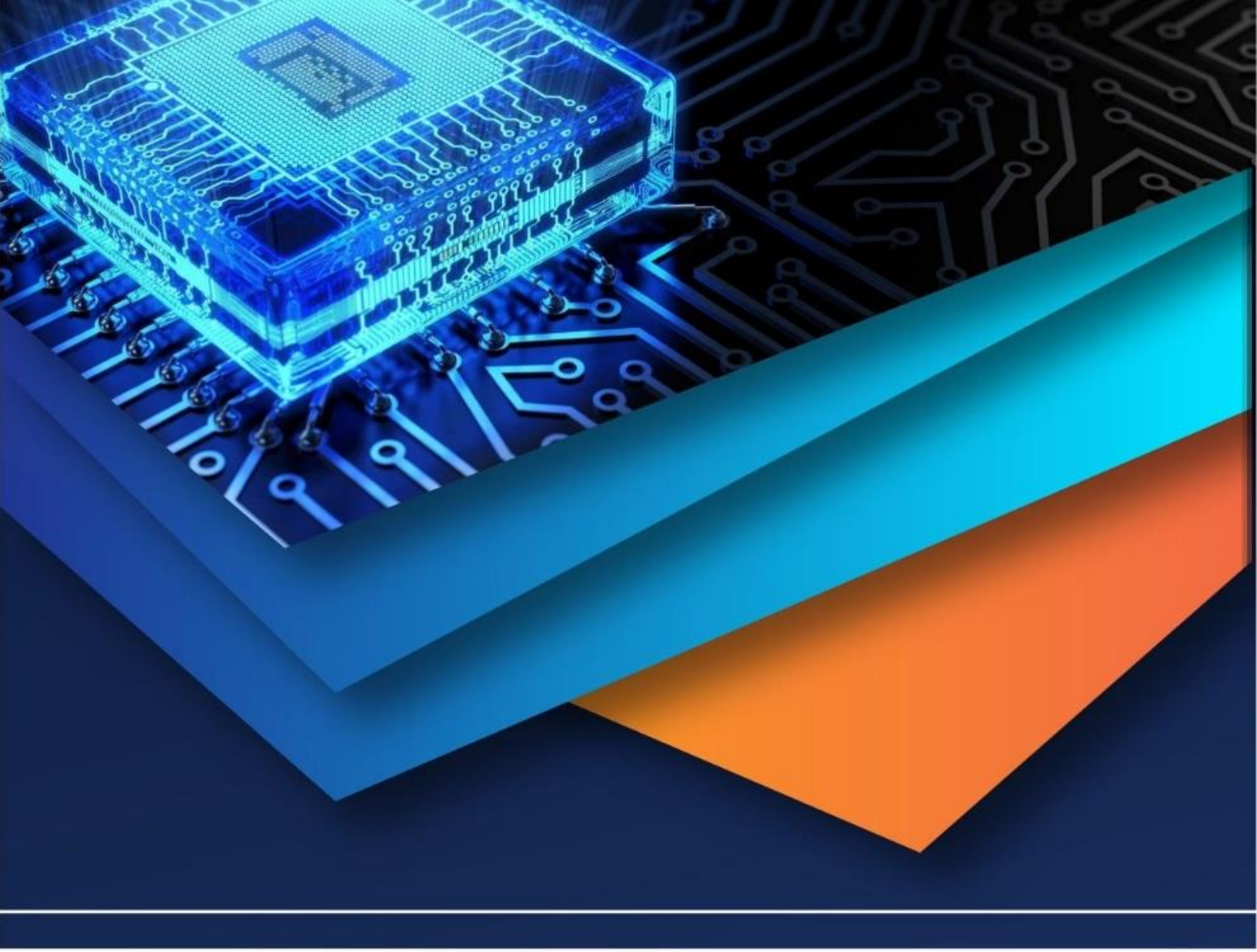
VII. CONCLUSION

The review examined several studies on Indirect Tensile Strength and the Marshall Stability test. The main motto of this review is to find the trend between Marshall stability and indirect tensile strength tests, as very few studies were performed together. Although here reviewed, several studies individually, or few numbers together, it is found that both the tests were performed considering different variations of the waste or filler, such as waste plastic, rubber crumb, chemical additives, cement, stone dust, etc. From this review it is found that in addition to the waste or filler, the Marshall stability and indirect tensile strength values increase. The study also came to the conclusion that more research in this field will determine the trend between DBM Marshall Stability and Indirect Tensile Strength values at various binder contents and will interpret the results to determine whether these tests are suitable for the mix design.

REFERENCES

[1] A. Changra and E. G. Singh, “Comparison of Marshall Stability values of the different bitumen mixes with crumb rubber,” IOP Conference Series: Earth and Environmental Science, vol. 1110, no. 1, p. 012034, Feb. 2023, doi: 10.1088/1755-1315/1110/1/012034.
[2] A. Hasban, A. Waje, S. Shinde, R. A. Binayake, and V. Vhatte, “Study of Effective Utilization of Waste P.E.T (Plastic) and Steel Slag to Enhance the Performance of Bitumen Based Pavement,” International Journal for Research in Applied Science and Engineering Technology, vol. 10, no. 4, pp. 3172–3177, Apr. 2022, doi: 10.22214/ijraset.2022.42031.
[3] Gupta L. & Suresh G., “Determination of Indirect Tensile Strength of bituminous concrete mix prepared using stone dust and cement as filler materials”, International Congress and Exhibition Sustainable Civil Infrastructures: Innovative Infrastructure Geotechnology, Springer, pp. 249-261, 2017.
[4] L. Gupta and A. Bellary, “Comparative study on The Behavior of Bituminous Concrete Mix and Warm Mix Asphalt Prepared Using Lime and Zycotherm as Additive,” Materials Today: Proceedings, vol. 5, no. 1, pp. 2074–2081, Jan. 2018, doi: 10.1016/j.matpr.2017.09.203.
[5] S. Bansal, P. Bajpai, and A. Kumar Misra, “Evaluation of modified bituminous concrete mix developed using rubber and plastic waste materials,” International Journal of Sustainable Built Environment, vol. 6, no. 2, pp. 442–448, Aug. 2017, doi: 10.1016/j.ijsbe.2017.07.009.
[6] S. A. Abd Kader et al., “Stability and Volumetric Properties of Asphalt Mixture Containing Waste Plastic,” MATEC Web of Conferences, vol. 103, p. 09002, Jan. 2017, doi: 10.1051/matecconf/201710309002.
[7] M. E. Abdullah et al., “Effect of Waste Plastic as Bitumen Modified in Asphalt Mixture,” MATEC Web of Conferences, vol. 103, p. 09018, Jan. 2017, doi: 10.1051/matecconf/201710309018.
[8] B. Mishra and M. K. Gupta, “Use of plastic waste in bituminous mixes by wet and dry methods,” Proceedings of the Institution of Civil Engineers - Municipal Engineer, vol. 173, no. 2, pp. 87–97, Jun. 2020, doi: 10.1680/jmuen.18.00014.
[9] H. Habeeb, S. Chandra, and Y. Nashaat, “Estimation of moisture damage and permanent deformation in asphalt mixture from aggregate gradation,” KSCE Journal of Civil Engineering, vol. 18, no. 6, pp. 1655–1663, Jul. 2014, doi: 10.1007/s12205-014-1356-7.
[10] M. Saharia and K. Lakshman Singh, “Effect of plastics in applications of bituminous pavement: A laboratory study,” Materials Today: Proceedings, vol. 65, pp. 3362–3368, Jan. 2022, doi: 10.1016/j.matpr.2022.05.473.
[11] M. Bostancioğlu and Ş. Oruç, “Effect of activated carbon and furan resin on asphalt mixture performance,” Road Materials and Pavement Design, vol. 17, no. 2, pp. 512–525, Oct. 2015, doi: 10.1080/14680629.2015.1092465.
[12] N. Morova, “Use of Waste Phonolite as Filler Material in Flexible Asphalt Pavements,” Materials Science, vol. 30, no. 1, pp. 96–105, Feb. 2024, doi: 10.5755/j02.ms.34101.
[13] MoRTH (Ministry of Road Transport and Highways), “Specifications for road and bridge works”, Indian roads congress, New Delhi, India, 2013.
[14] ASTM D6927-06, Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures. West Conshohocken, Pennsylvania: American Society for Testing and Materials.2006.
[15] ASTM D6931–17, “Standard Test Method for Indirect Tensile (IDT) Strength of Asphalt Mixtures” West Conshohocken, Pennsylvania: American Society for Testing and Materials. 2017.
[16] IRC-37-2018, “Guidelines for the Design of Flexible Pavements (4th revision)”, Indian Road Congress, New Delhi, India, 2018.

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