International Journal of Scientific Research in Engineering and Management (IJSREM)
Special Edition - Volume 09 ICITES -2025 SJIF Rating: 8.586 ISSN: 2582-3930

Optimization of Zycotherm Dosage and pH Effects on Stripping of Bituminous Pavement

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Abstract - In India, flexible pavement is widely used. It is frequently used in road construction due to economical rate, excellent riding quality, simple maintenance requirements and high skid resistance. However it is vulnerable to numerous distresses including cracks and permanent deformations, which can negatively impact both its performance as well as it's service life. Stripping of bituminous pavements is a major pavement distress causing a decline in pavement durability which increases need for reconstruction and maintenance. It is vital to counter this phenomenon by incorporating innovative and advanced additives like antistripping agents into pavement mixture. This experiment investigates the effectiveness of Zycotherm, an antistripping agent (ASA) in bituminous pavements. The results show that Zycotherm significantly improves stripping resistance and durability. The optimum dosage of Zycotherm required for achieving maximum benefits is obtained by using improved boiling water test. While analysing influence of pH on the performance of bituminous pavements, it is observed that stripping significantly increase at a pH of 9, slightly increase at a pH of 4, and decrease at a pH of 7. By using ASA, it is found that stripping percentage could be reduced significantly in varying pH conditions. The findings of this study provide valuable insights into the use of Zycotherm as an ASA and the importance of considering pH effects in bituminous pavement construction which helps in overall cost reduction and promotes sustainability by minimizing raw material usage.

***Key Words*:** Zycotherm, Antistripping agent, Stripping resistance, Durability, pH effects, Optimum dosage

1.INTRODUCTION

1.1General Introduction

Bituminous pavement is one of the most commonly used pavement, widely known for its ability to provide smooth rides, cost effective nature and ease of construction. However these bituminous pavements are also subjected to develop deterioration due to heavy traffic loads, great pressure and other environmental factors. One of the major reasons for the deterioration of pavement is stripping. Stripping is actually the detachment of binder from aggregate that results in various problems like providing a rough and uneven type of texture to the pavement, appearance of bowl shaped depressions on the surface of pavement, reducing the tyre pavement friction there by leading to possibility of accidents and also resulting in increase in rate of penetration of water into the pavement there by leading to further damage such as cracking and rutting of the pavement which there by decreased the strength and durability of pavement road. Reduction in maintenance of pavement minimizes the emission of toxic fumes like CO2, CH4 and N2O which are greenhouse gases, resulting in sustainability

1.2 Cause of stripping

Stripping may occur due to a number of reasons and moisture content is one of the main reasons behind stripping. The pavement is kept strong by the adhesion between the binder and aggregate. Water have the ability to penetrate between this bond and through there capillary action they weaken the bond and disintegrate the binder and aggregate. Some aggregates are hydrophilic in nature and their higher affinity towards moisture content breaks the aggregate binder bond. Heavy traffic can also be a reason towards occurrence of stripping. The continuous loading and unloading can accelerate weakening effect moisture content and there by cause stripping. Various environmental factors like variation in temperature, freeze-thaw cycle, change in the pH of water all significantly contribute the stripping of bituminous pavement.

The pH value of moisture content present at that area also significantly contribute towards the degree of damage that the pavement may face. Different localities have different rage of pH value for moisture content. In coastal areas the pH value may be significantly high like up to 9 and in some areas the occurrence of acid rain is very high and at that regions the pH may vary up to even 4. It is observed that the variation of pH. have also significantly contributed to the stripping of bituminous pavement.

1.3 Need for Antistripping agent (ASA)

A wide variety of antistripping agents are available in our market which are specially designed to enhance the adhesion between binder and aggregate. By using innovative additives like ASA to reduce the stripping value of bituminous pavement, it is possible to minimise the use of resources that will be needed to repair the pavement. This significantly reduces the waste generated and also reduces the generation of emission of toxic fumes and significantly reduces the carbon footprint. Thus ASA helps to achieve sustainable pavements, which reduces environmental impact and improve resource utilization. Indirectly, it results in obtaining a sustainable infrastructure and helps in a nation's growth.

2. ANTI STRIPPING AGENT (ASA)

2.1 General

An antistripping agent is a chemical additive that is widely popular in transportation industry. Its main purpose is to improve the adhesion between aggregate and binder so as to prevent the occurrence of stripping or separation of aggregate and binder from each other. It's important to prevent stripping because it results in failure by initiating most of pavement distresses and reducing the lifespan of pavement road. Water seeps into road which results in generation of potholes, cracks and rutting. This causes costly repair and dangerous driving conditions. It is added by percentage weight of bitumen used.

2.2 Zychotherm

Among the antistripping agents available, Zychotherm is one of the most efficient antistripping agent available as it has excellent adhesive properties when compared to others. It is more cost effective as small quantity is sufficient to impart desirable anti stripping properties and environmentally friendly when compared to other stripping agents available in market which there by contribute to less environmental impact and there by contributing towards sustainable form of construction practice

3.LITERATURE REVIEW

3.1 The Effect of Anti-Stripping Agent (ASA)

The incorporation of anti-stripping agents significantly enhances the moisture resistance and durability of bituminous mixes. Studies have consistently shown that these agents reduce stripping potential by 25-50%, improve tensile strength by 12-25%, and enhance retained stability by 8-20% (Alam, M. N et al.,2020; Tripathi, P et al., 2020). Optimal dosages of 0.05% Zycotherm, 0.075% Hydrated Lime, and 0.1% Liquid Anti-Stripping Agent (LASA) have been identified. Anti-stripping agents modify the rheological properties of asphalt binders, minimizing moisture-induced damage and extending pavement lifespan. Research has also demonstrated that anti-stripping agents improve asphalt-aggregate bonding, reducing moisture susceptibility (Alam, M. N et al.,2020). By incorporating anti-stripping agents into pavement design and construction, engineers can improve pavement durability and safety, reducing maintenance needs and costs.

Furthermore, anti-stripping agents have been shown to enhance the performance of bituminous mixes under various environmental conditions. For instance, studies have demonstrated that anti-stripping agents improve the resistance of bituminous mixes to freeze-thaw cycles and wet-dry cycles (Tripathi, P et al., 2020). Additionally, anti-stripping agents have been found to reduce the oxidative aging of asphalt binders, thereby extending the lifespan of pavements. The use of anti-stripping agents has also been shown to improve the workability and compactability of bituminous mixes, making them easier to construct and maintain. Overall, the incorporation of anti-stripping agents is a crucial step towards developing durable and sustainable pavement infrastructure

3.2 Effect of pH on Stripping

The pH level of water significantly affects the stripping potential of bituminous mixes. Research has shown that acidic water (pH 4-5) increases stripping potential by 20-30% compared to neutral water (pH 7) (Feng, S et al.,2020). Alkaline water (pH 9-10) reduces stripping potential by 10-20% (Baig, M. I et al., 2015). The pH level influences the asphalt aggregate interface, with acidic water weakening the bond and increasing moisture susceptibility. Understanding the effects of pH on stripping potential is crucial for developing durable and sustainable pavement infrastructure. Engineers should consider the pH level of water when designing and constructing pavements, particularly in areas with high rainfall or flooding. The use of anti-stripping agents and coconut shell charcoal ash can mitigate the effects of pH on stripping potential. Additionally, researchers recommend conducting further studies on the effects of pH on pavement performance to develop more effective and sustainable pavement solutions. Researchers investigating the effects of pH on bituminous mix performance have employed experimental designs involving varying pH levels, typically ranging from acidic (pH 4-5) to alkaline (pH 9-10) (Shan Fenga, 2020). Bituminous mix samples are prepared and exposed to different pH levels using buffered solutions (e.g., HCl, NaOH). The samples are then evaluated for their mechanical properties, such as tensile strength (ASTM D4867) and retained stability (AASHTO T283). The effects of pH on asphalt-aggregate bonding and moisture susceptibility are evaluated using techniques such as scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), and Fourier transform infrared spectroscopy (FTIR). Statistical analysis is used to determine the relationship between pH levels and bituminous mix performance.

4. METHODOLOGY

Methodology adopted for the study is depicted in Fig.1.

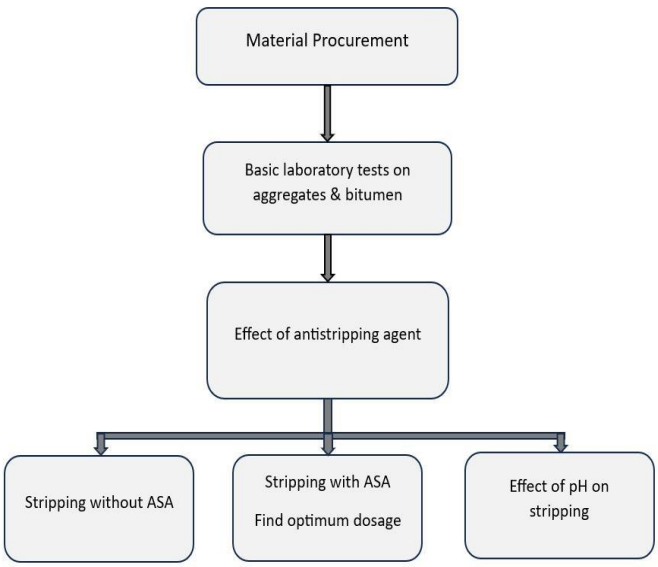

Fig-1: Flow chart of methodology

5. RESULT AND DISCUSSION

5.1 Optimum Dosage of ASA

The Improved Boiling Water test was done without adding ASA and stripping percentage was calculated. After that zycotherm were used with various percentage like 0.02%,0.04%,0.06%,0.08%,0.1% and 0.12% by weight of bitumen to check optimum dosage of zycotherm. From fig 2.,it is clear that after 0.08% of ASA, no significant reduction in percentage of stripping is achieved and further increase will only increase the cost. Hence the optimum dosage of ASA is fixed as 0.08%.

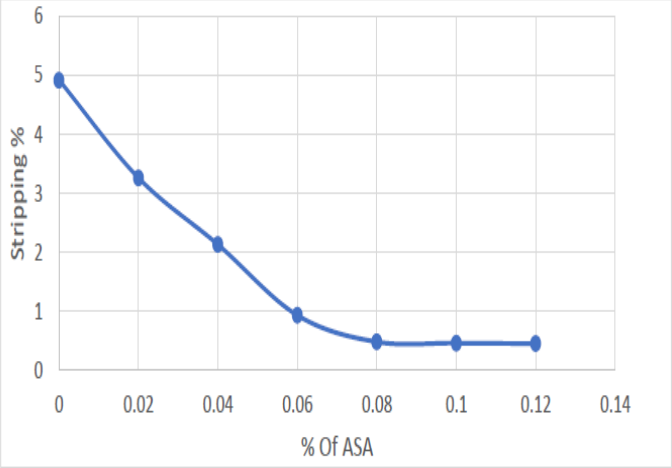

Fig-2: Variation of Stripping percentage with ASA

5.2 Effect of pH on stripping without and with ASA

The effect of pH on stripping was calculated by testing the stripping with water having varying pH . pH values considered for studying was 4,7&9.4 is adopted with reference to acid rain and industrial effluents;pH of 9 is considered to simulate the condition of leaching of agricultural fertilizers during heavy rainfall and flooding coming in contact with pavement near agricultural lands.

Table 2 depicts the effect of varying pH on stripping properties of aggregate with & without ASA. Fig3 shows the variation of stripping percentage with varying pH value

Table -2: Effect of varying pH on stripping % with &without ASA

pH values	4	7	9
Without ASA	5.23	4.89	6.76
With ASA	1.41	0.82	1.83

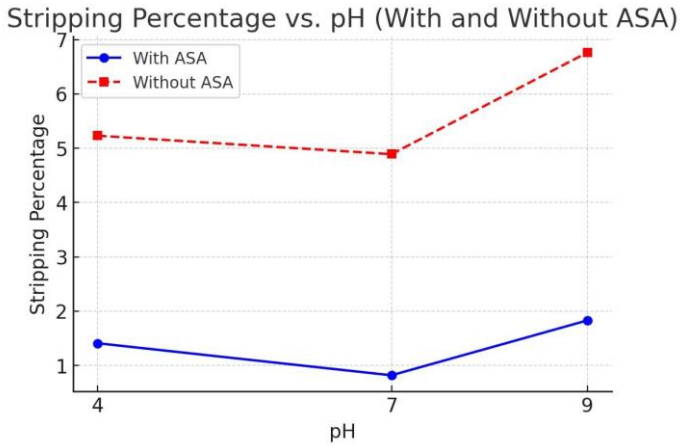

Fig -3: Variation of Stripping percentage with & with ASA with pH Value

Figure 4 shows comparative analysis of effect of varying pH level on stripping percentage with and without ASA. Percentage reduction in stripping percentage for pH value of 4,7 and 9 after adding ASA (0.08%) is 73%, 83.2% and 72.9% respectively. The addition of Anti Stripping Agent(ASA) significantly increased the resistance to stripping in environment when the pH levels are not neutral

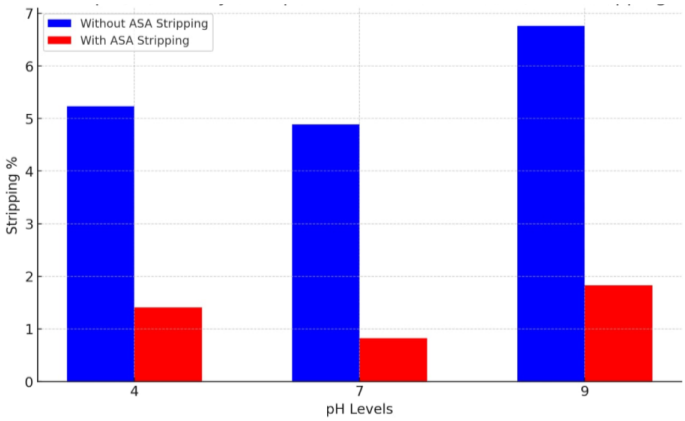

Fig -4: Comparative Analysis of effect of pH Levels on stripping percentage with and without ASA

6. SUMMARY AND CONCLUSION

6.1 Summary

Indian roads are exposed to heavy rainfall, high temperatures, and extreme weather conditions, due to its diverse climatic conditions. This can cause the asphalt binder to separate from the aggregate, resulting in stripping. This can lead to a range of problems, including potholes, cracks, and rutting, which can compromise the safety and durability of the pavement. Furthermore, leads to reduce the lifespan of Indian pavements, requiring frequent repairs and replacements, and increasing maintenance costs.In such scenarios ,one of the effective remedy is using Antistripping agent(ASA), Antistripping agents are essential for bituminous pavements as they provide numerous benefits. Firstly, they prevent stripping, which occurs when the asphalt binder separates from the aggregate, preventing aggravation of various pavement distresses. By preventing this separation, antistripping agents ensure the pavement's integrity. Additionally, they improve adhesion

between the asphalt binder and aggregate, creating a strong bond that enhances the pavement's durability. Antistripping agents also reduce moisture damage, which can weaken the bond between the asphalt binder and aggregate. By preventing stripping and improving adhesion, antistripping agents help extend the lifespan of the pavement. Furthermore, they enhance safety by reducing the likelihood of potholes and other defects that can cause accidents.Overall, antistripping agents play a vital role in ensuring the long-term performance and durability of bituminous pavements.

The pH of water and moisture in contact with bituminous pavement is an important parameter which can cause stripping and hence the durability of pavement. The pavements are generally affected with water or moisture due to acid rain, industrial runoff containing various chemicals, agricultural runoff comprising pesticides and fertilisers etc. having varying pH levels. By using ASA, it is found that stripping due to pH variation can be reduced to great extent enhancing long term performance and durability of bituminous pavement.

6.2 Conclusion

The dosage of antistripping agents has a significant impact on the effectiveness of the treatment. This experimental study reveals that an optimum dosage of 0.08% Zycotherm can be used to significantly enhance the stripping resistance and durability of asphalt mixtures, providing a valuable contribution to the development of more sustainable and resilient pavement infrastructure.Percentage reduction in stripping percentage for pH value of 4,7 and 9 after adding ASA(0.08%) is 73%, 83.2% and 72.9% respectively.

ASA is an innovative additive used in asphalt pavement construction which is closely tied to sustainable development, thereby ensuring sustainable cities. By improving the durability of asphalt pavements, ASAs reduce the need for frequent repairs and replacements, thereby decreasing the consumption of natural resources such as aggregates and asphalt binders. This, in turn, leads to a reduction in the environmental impacts associated with extracting and processing raw materials. Additionally, ASAs help to conserve natural resources, reduce waste, and decrease greenhouse gas emissions by minimizing the need for maintenance activities. Furthermore, the use of ASAs contributes to improved safety by reducing the risk of accidents caused by potholes and other pavement defects. Overall, the use of ASAs in asphalt pavement construction is an important step towards achieving sustainable development goals, including reducing waste, conserving natural resources, and promoting a circular economy.

ACKNOWLEDGEMENT

This work was supported by Saintgits College of Engineering (Autonomous) Kottayam – 686532, Kerala. We acknowledge the facilities and resources provided by the institution.

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