

RESEARCH ON BITUMINOUS ROAD WITH EGG SHELL AS FILLER AND PLASTIC WASTE

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Abstract - Asphalt paving requires a large financial investment. The addition of some waste materials, such as steel slag, sawdust, coconut shells, etc., can perform effectively while saving a significant amount of money on investments. The introduction of egg shell powder as a sustainable modifier is the focus of this study in order to achieve the goals of lowering the weight percentile, cutting expenses, and enhancing the economic viability of hot mix asphalt. One of the latest innovations in construction cost reduction is the use of waste materials, one of which is eggshell as modifier. The expansion of several enterprises and the rise in population are the two main sources of garbage. Plastic garbage is the form of waste that poses the greatest threat to the environment.

The fundamental issue with plastic waste is that it cannot biodegrade. Recent studies claim that adding plastic waste to bitumen gives it the desired mechanical characteristics. Bitumen is generally used to build flexible pavements, and combining it with plastic trash increases the mix's water resistance, capacity, and stability. The complementary use of conventional destructive test methods and cutting-edge non-destructive testing (NDT) technologies is necessary for an effective quality control and acceptance (QA/QC) strategy for building hot mix asphalt (HMA) pavements.

Key Words: Bitumen, Egg Shell, Plastic, Asphalt mix, Dynamic modulus, Ultrasonic pulse velocity, Bulk density

1.INTRODUCTION

In order to improve the physical and chemical qualities of pavement while simultaneously lowering the cost of construction, waste products are now employed as a filler or modifier. Since a few years ago, numerous studies have been conducted to find ways to improve the procedures used in road construction. Portland cement (OPC) is one of the most significant filler materials that is utilised, but because of the rising demand for cement, employing filler materials is strongly recommended as a solution.

Eggshell is one of the simplest materials to use as filler. Concerns have been raised about the disposal of different waste types in various locations from diverse sources for a very long time. Different kinds of environmental pollution are impacted by these materials. Since plastic is not biodegradable, it is inexhaustible in the environment and begins to accumulate at an increasing rate. When building flexible pavements, using plastic and bitumen not only makes them smoother and stay longer. However, it aids in project cost reduction and also helps to create a more environmentally friendly workplace.

1.1 BITUMEN

Bitumen is a thick, oily byproduct that is dark black and viscous and is made from hydrocarbon mixes that have had their volatile components removed through natural or manmade processes. Petroleum removes bitumen from fractional distillation while there is air present. A well-assembled bituminous mix is chosen as the end

product because it is thought to be strong, long-lasting, economical, and environmentally benign.

The naturally occurring combination obtained through the distillation process. The primary goal is to employ bitumen as a better-quality binder material that adheres and is waterproof. Because of the bitumen's viscoelastic properties, it is quite easy to cause long-lasting deformation and fissures. Depending on the petroleum source, bitumen's chemical make-up varies. Bitumen is used to build almost 85% of the pavements in the globe, making it a more practical and popular choice.

About 5-6% of the overall bitumen mixture is made up of bitumen, which coats and bonds the aggregate particles. It is a naturally occurring combination of hydrocarbons that is often dark brown or black in colour. It comes in a variety of grades, but 60/70 is seen to be the best choice for highways with heavy traffic.

1.2 ORGANIC WASTE (EGG SHELL)

Egg shell powder is one of a material, it can be reused and Egg shell has the chance of use in asphalt concrete applications. Egg shell waste is considered as food waste, that is subjected to ample scrutiny, and similar alternative material for road pavement construction. The eggshell powder is an alternative to increase the properties of usual asphalt binders in the bitumen mixture. Eggshell shall be used as filter material and mostly in powder form to fill up the voids in the bituminous mix for pavement construction. additional filler can increase the strength and with the almost about 47% of skeletal calcium it has high resistance to fire and seasonal change. With the high CaO content and other properties such as Al_2O_3 , SiO_2 , Cl, MnO, etc, it has a brittle in nature, which can form a fine substant. Most of the eggshells used in the study were achieved by collecting from air-dried and crushed into smaller particles.

Eggshell consists of various mutually growing layers of $CaCO_3$, the inner most layer maxillary 3 layer grows on the outermost egg membrane and creates the base on which palisade layer contribute the thickest part of the eggshell. The top layer is a vertical layer covered by the organic shield. The eggshell contains calcium, magnesium carbonate (lime) and protein. In other countries, it is the approved practice for eggshell to be dried and used as a feeding of calcium in animal feeds. The quality of lime in eggshell waste is affected greatly by the extent of exposure to sunlight, raw water and sever climatic conditions. Eggshell is the brittle white and has a grainy texture surface. It is semi permeable and resistant to fire and climatic changes

1.3 INORGANIC WASTE (PLASTIC)

The term "plastic," sometimes known as "Polyethylene" or "polythene," is accepted worldwide. Bitumen's melting point rises due to plastic. The innovative technology of using plastic in road construction not only gives the road strength but also extends the life of the road. For better road performance, aggregates are covered with plastic. Due to the improved bonding and connected surface area between polymers and bitumen, this helps to have a better binding of bitumen with plastic waste coated aggregate.

The incorporation of tiny amounts of waste plastics—5 to 10% by weight of bitumen—helps to greatly increase the Marshall stability, strength, fatigue life duration, and other desired qualities. This suggests that waste plastics have a high potential for application in bituminous construction. In our nation, the majority of paved roads have a wearing coat and a powdery sub foundation. Plastic is a versatile material. Plastic appeared to be an expensive and insignificant raw material as a result of the industrial revolution and its large-scale manufacture.

Today, the use of plastics has essentially transformed every active economic area, from agriculture to packaging, vehicle,

electronics, electrical, building construction, and communication. Researchers discovered that plastic, a non-biodegradable material, can stay on earth for 4500 years without degrading.

The use of plastics in modern society has essentially transformed every active economic area, from agriculture to packaging, automobiles, electronics, and electrical, as well as the building and communication industries. Non-biodegradable plastic has been shown to remain on earth for 4500 years without degrading, according to study.

The bituminous mix's performance qualities were found to be improved by covering the aggregate with waste plastic. Recycled polythene carry bags were shred into tiny pieces (4.75 mm & 2.36 mm), which were then coated over mix aggregates at a particular temperature. Bituminous mixtures were created using cement as a filler and VG-30 bitumen, plastic-coated aggregates, and regular aggregate. When plastic waste makes up more than 30% of the mix weight, it significantly increases the abrasion and slip resistance of flexible pavement and also makes it possible to obtain splitting tensile strength values that meet the specified limitations. When mixing and laying roads with plastic garbage, all of this should be done with awareness. For India, the plastic road would be advantageous. Durable and environmentally friendly plastic roads are more advantageous in humid, hot climates. Additionally, this will relieve the earth of all plastic garbage.

1.3.1 TYPES OF PLASTIC

- Polyethylene Terephthalate (PET)
- High density Polyethylene (HDP)
- Low density Polyethylene (LDP)
- Polyvinyl Chloride (PVC)
- Polypropylene (PP)
- Polystyrene (PS)
- Other plastic

1.3.2 WHY USE OF PLASTICS

Polymers have number of vital properties which exploited alone all together make a significant and expanding contribution to construction needs.

- 1) Durable and corrosion resistant
- 2) Good insulation for cold, heat and sound saving energy and reducing noise pollution.
- 3) It is economical and has a longer life.
- 4) Maintenance free
- 5) Hygienic and problems
- 6) Ease of processing
- 7) Light weight

1.4 STATEMENTS OF PROBLEMS

The field tests that were conducted on the plastic trash in road construction showed that it could withstand stress and that it could be utilised as an addition to extend the life of the pavement and improve road stability while using less bitumen. The creation of plastic garbage has increased as a result of the world's fast urbanisation and growth. Plastic is not biodegradable, thus it stays in the environment for a long time. Additionally, it is dangerous to dispose of plastic waste at land fills because hazardous chemicals seep into the soil, groundwater, and contaminate water sources. The disposal of plastic waste has become a major issue for the civic authorities, particularly in the municipal areas, due to littering behaviours, an inadequate waste management plan, and municipal areas.

1.5 LITERATURE REVIEW

1.5.1 Sneha Elangbam, Waseem Akram (2021):-

When taking into account the numerous reviews, the involvement of diverse eggshell content can be readily seen, demonstrating that using eggshell as a filler material may generally yield positive effects. Additionally, the application

may be advantageous because it is a readily accessible waste byproduct. To summarise findings from numerous studies conducted by various academics, eggshell can partially replace concrete. Not to mention, lower construction costs result in more creative green pavement designs. According to the majority of research, ESP content that is favourable ranges between 3.5% to 5%, depending on the environment and tests involved. Given that the majority of eggshell wastes are burned or dumped at landfills, the implementation of such pavements might significantly alter a nation like India. Even yet, more studies and tests in this area are required to improve the use of eggshells as a filler material. The aforementioned information can be utilised as a guide for additional research, which will aid in developing a more environmentally friendly way to apply eggshell. Consequently, a lot more work may be accomplished, and it will provide another justification for building infrastructure that is both inexpensive and environmentally beneficial.

1.5.2 Ahlam alzerjawi, Sady tayh, Rana amir yousif (2018)

After looking at the project's outcomes, it can be said that viscosity increased significantly, despite the apparent fall in penetration value. As the additive fraction increased, the flash point temperature improved. Due to the modest differences in the values obtained, the additive has little impact on the softening point temperature. The hot mixture's mechanical qualities performed best when 5% eggshell powder was added. According to the overall findings, egg shell powder could be regarded as a promising modifier for asphalt mixture.

1.5.3 K. Kiruthiha, G. Loshini, M. Thivya, Mr. Vignesh Kumar (2015)

Pavement construction requires a significant financial expenditure. Addition of specific substances like sawdust, eggshells, coconut shells, limestone, etc. It offers dependable performance and can save a lot of money. In order to fill the air voids in bituminous pavements, this project explains the

usage of egg shell as a filler. It entails identifying the right blend by finding the Marshall Stability and Flow values and producing the optimal bitumen content (OBC) and optimal egg shell content.

1.5.4 Ghadah Ghassan Masued (2019)

The primary conclusion regarding the usage of eggshell powder as a filler ingredient in hot mix asphalt concrete can be summed up as follows based on all test results obtained in this study: 6% ESP is a superior ratio than other ratios because it increases density, stability, flow, and tensile ratio value when added to asphalt mixture (within the limits of this study). Based on the aforementioned findings, it is recommended to add eggshell powder to asphalt mixtures in amounts between (1-6) percent; greater ratios may result in results that are less than ideal. The specimen with an eggshell has a greater tensile strength ratio (TSR) than the specimen without a shell. A higher tensile ratio indicates that the mixture performs well, has a lower specimen strength reduction in water, and is more resistant to water soaking conditions. Since the shell has a larger tensile ratio than the other specimens, it is therefore more resistant to moisture damage. When eggshell powder is added to asphalt mixture, the indirect tensile strength (ITS) decreases considerably less, and this behaviour is advantageous in particular circumstances when resistance to the water effect is necessary.

1.5.5 Xuancang Wang, Guanyu Ji, Yi Zhang, Yuchen Guo, and Jing Zhao (2020)

Eggshell powder has a rough and porous microstructure, according to tests. This suggests that eggshell powder might absorb more asphalt substance and so impact how well asphalt performs. The results of the FT-IR test showed that the chemical structure of the bitumen-binding materials could not be changed by the eggshell powder, and that the processes of physical miscibility between the asphalt materials and eggshell powder were the key ones. Asphalt

traditional performance testing showed that ES decreased the plastic deformation capacity while increasing the consistency, hardness, and thermal stability of bitumen materials. This is a preliminary sign that eggshell powder can improve bitumen's high-temperature properties. Eggshell powder was shown to be able to increase $|G^*|$, decrease the phase angle, and improve $|G^*|/\sin$ in DSR temperature and frequency sweep studies. This further suggested that eggshell powder could improve bitumen's high-temperature properties. According to MSCR, adding eggshell powder enhanced R and decreased J. This proved that eggshell powder could improve asphalt materials' resistance to persistent deformation.

1.5.6 Maaz Allah Khan, Rajneesh Kumar (2020)

Aggregates are coated with plastic to improve the performance of roadways. Due to greater bonding and increased area of contact between polymers and bitumen, this aids in better binding of bitumen with plastic waste coated aggregate. The vacancies are also decreased by the polymer covering. This stops trapped air from oxidising bitumen and absorbing moisture. Due to this, rutting and raveling have decreased and pothole development has stopped. The roads are more durable and can endure heavy traffic.

1.5.7 Pratiksha Singh Rajput R. K. Yadav (2016)

The following findings are made in light of the laboratory test results on S.D.B.C. that contained various amounts of waste plastic. The Marshall stability value increases as the percentage of waste plastic in the mixture rises, and the mixture with 12% plastic by weight of bitumen is the most stable. The stability value has fallen at 14% plastic content. Therefore, 12% is determined to be the ideal plastic content. With the inclusion of plastic in the mixture, the flow value continuously rises. With the inclusion of the plastic waste in the mix, the percentage of air voids gradually reduces and VFB continuously rises. The results of the aforementioned

test indicate that adding plastic trash to a semi-dense bituminous concrete mix greatly enhances the performance of the mixture. The strength and voids parameters both met the MORTH specification's requirements. The ideal plastic percentage was found to be 12% of the bitumen weight.

1.5.8 Azmat Shaikh, Nabeel Khan, Faisal Shah, Devendra Shukla, Gaurav Kale (2017)

The new mix has improved Marshall Characteristics, as shown by the behaviour of the modified BC made from plastic waste. Marshall Stability value is seen to rise with plastic content, while Marshall Flow value is seen to fall with the addition of polythene, meaning that the resistance to deformations under heavy wheel loads is seen to rise. We may infer from all the studies that were done that adding plastic debris improves a bituminous road's varied characteristics. By modifying the polymer in the pavement mix, we can guarantee that the mix will be more stable and lasting. This modest study gives us a better pavement with better strength and a longer lifespan in addition to making good use of the non-biodegradable plastic waste. The volume of plastic garbage that needs to be disposed of by incineration and land filling will be reduced as a result of this study, which will benefit the environment. It will not only give value to plastic trash but also create an environmentally beneficial technology.

1.5.9 R. Manju Anand, Sathya .S (2017)

For the roads to operate better, plastic is combined with bitumen and aggregates. The aggregates' polymer coating decreases voids and moisture absorption. As a result, there are fewer ruts and no potholes are created. Plastic pavement is more durable than flexible pavement and can resist heavy traffic. By using plastic mix, you can boost the road's strength and performance while reducing the bitumen concentration by 10%. Environmentally friendly is this new technology. Vehicle pollution can be decreased by using

smoke-absorbing material (titanium dioxide) in polymer blends with a 10% percentage.

1.5.10 Nitin Dutt Sharma, Anupam Sharma (2018)

It demonstrates that the characteristics of aggregate and bitumen increase as the amount of waste plastic in bitumen increases. When compared to traditional flexible pavements, the use of waste plastic in flexible pavements produces good results. Based on the Marshal Stability test, the best use of plastic is up to 10%. As an environmentally benign method, this has increased the importance of limiting the disposal of plastic trash. Numerous benefits have come from coating aggregate with polymer, all of which ultimately contribute to the improvement of flexible pavement quality.

1.5.11 Zhiyong Jiang, Giovanni Cascante.(2006).

While the observed association with density is only mild, the wave amplitude exhibits a strong correlation with the number of gyrations. The increase in density reflects higher particle-to-particle interaction between the asphalt coated particles during gyrations. Additionally, the quantity of gyrations encourages improved bonding at the aggregate-asphalt interface, preserving good matrix continuity. Regardless of density, which depends on the aggregate sizes present in the mix in addition to the number of gyrations, wave attenuation is smaller for samples prepared with a higher number of gyrations. Therefore, if there is good bonding at the aggregate-asphalt interface to ensure continuous medium of travel, the damping or attenuation is reduced. Traditionally, density has been used to evaluate the in-place mixture's quality. A reasonable number of gyrations depending on the traffic volume are chosen for mix preparation to imitate field conditions in the lab. For mixtures with similar volumetric designs, it is anticipated that density rises with the number of gyrations. But as evidenced in this instance, it might not always be the case (Figure 8). Similar circumstances may develop during building, and in some cases, a greater density value may not

be a reliable indication of quality work. As a result, wave characteristics like amplitude readings along with density will offer a trustworthy evaluation of the pavement quality. The strong association between the dynamic modulus and wave amplitude shows the potential advantage of using the wave parameters to evaluate the quality of in-place asphalt concrete.

1.5.12 L. C. SPENCER, SHATTOCK (1962)

K. G. MARTIN, C.S.I.R.O.'s Division of Building Research - Since paper No. 40 is a review, it could be helpful to let the authors know that much more research has been done on bitumen's elasticity modulus than is mentioned in their publication. There are a few references provided, although they are by no means all-inclusive: 2, 3, 4, and 5. Overall positive Volume T, 1962, 1979, and 1980 Discussion and conclusion: LTRASONIC TESTING OF ROAD MATERIALS For a wide variety of bitumen, there is agreement among different writers; all have employed vibrational test techniques in the vicinity of the range of 0.5 to 500 ci s.

1.5.13 Yuliahmadila Binti Erfen, Khairul Nizam Bin Mohd Yunus (2015)

According to this study, using eggshell as a filler in hot mix asphalt concrete produces good results and complies with PWD specifications. This demonstrates that eggshell was safe to use as a road surface. However, because eggshell is physically brittle when subjected to strong loads, this study is appropriate for use on infill. The best eggshell percentage rate ranged from 3% to 5% based on the results.

1.5.14 Ahlam Alzerjawi, Rana AMIR Yousif, Sady Tayh (2018)

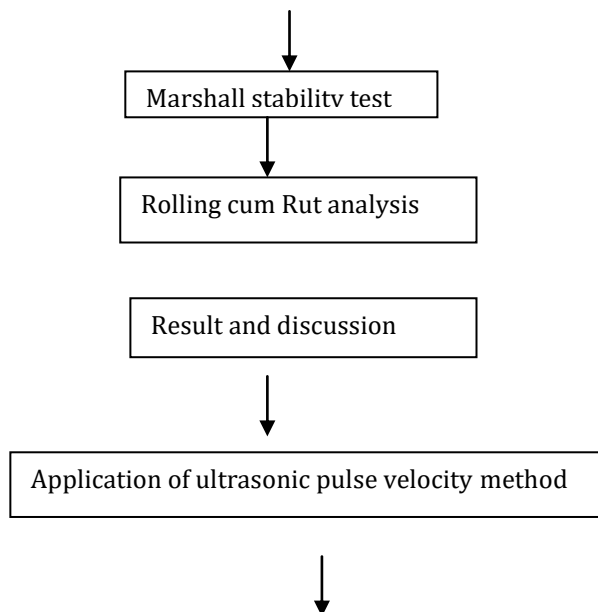
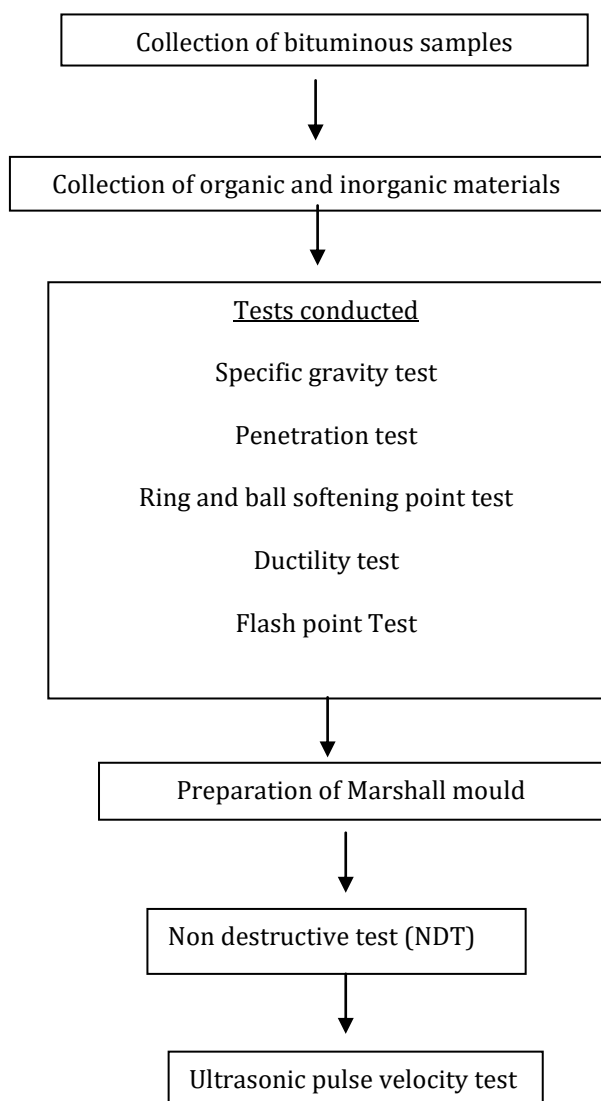
After analysing the project's outcomes, it is determined that: 1- Viscosity increased significantly, despite the apparent fall in penetration value. 2- Increasing the additive proportion increased the flash point temperature. 3. Due to the slight

differences in the values obtained, the additive has little impact on the softening point temperature. 4- The hot mixture's mechanical qualities performed best when 5% eggshell powder was added. According to the overall findings, egg shell powder could be regarded as a promising modifier for asphalt mixture.

1.5.15 Pejooan Tavassoti, Xuan Chen, Ilker Boz, Mansour Solaimanian (2016)

To get a better estimate of the limiting maximum modulus as the upper boundary limit of the modulus master curve, the high frequency modulus of asphalt mixes obtained at 25 °C by UPV test can be used.

2. Methodology



CONCLUSION

When taking into account the numerous reviews, the involvement of diverse eggshell content can be readily seen, demonstrating that using eggshell as a filler material may generally yield positive effects. Additionally, the application may be advantageous because it is a readily accessible waste byproduct. To summarise findings from numerous studies conducted by various academics, eggshell can partially replace concrete. Not to mention, lower construction costs result in more creative green pavement designs. According to the majority of research, ESP content that is favourable ranges between 3.5% to 5%, depending on the environment and tests involved.

Aggregates are coated with plastic to improve the performance of roadways. Due to greater bonding and increased area of contact between polymers and bitumen, this aids in better binding of bitumen with plastic waste coated aggregate. The vacancies are also decreased by the polymer covering. This stops trapped air from oxidising bitumen and absorbing moisture. As a result, there is less rutting and ravelling and no

pothole formation. The roads are more durable and can endure heavy traffic.

One type of non-destructive testing that has solidified itself as a useful tool for engineers is the ultrasonic pulse approach. Although its potential has by no means been fully realised, its applications to roadway engineering are fast developing. The current standard for testing road materials relies on single or static loads. But since road loads is essentially temporary, developing acceptable theories will require an understanding of the materials' dynamic behaviour.

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