Review of The Literature on The Use of Rice Husk Ash as a Sustainable Filler Substitute in Hot Rubber Asphalt Mixtures for Road Pavements' Wearing Course

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Abstract. The province of South Sumatra has a rice cultivation area of 496,241.65 hectares and the largest production of 2.55 million tonnes on the island of Sumatra in Indonesia, which has a lot of land for rice cultivation with a harvested area of about 10.41 million hectares. However, because rice husks have low protein content and high ash content, most of it is burned, buried or dumped into water as garbage, which negatively affects local ecosystems and causes air and water pollution. With increasing pollution and the rising cost of building materials, several scientists have been looking at this area of study to find ways to harness the potential of rice husk ash. Rice husk ash is an interesting waste product due to its high silica content, relatively high level and extensive application as an inorganic material. Silica has good potential because it has a large surface area and adsorbs and adheres strongly. Amorphous silica with high purity is the best silica that can be found. Silica has been studied as a potential additive for hot asphalt mixtures to reduce air gaps and increase indirect tensile strength and indirect tensile modulus. Silica can also make asphalt more cohesive and viscous, improving its performance at high temperatures. It can also make asphalt more resistant to oxidative ageing and improve its performance at higher temperatures. Especially in regions where a lot of rice husk waste is generated, rice husk ash can therefore be used as an alternative to conventional mineral fillers in hot asphalt mixes.

Keyword: Rice Husk Ash, Asphalt Mixtures, Road Pavements' Wearing Course

1. Introduction

Huge amounts of rice are grown and produced worldwide every year. With a harvest area of over 10.41 million hectares and a production of 54.42 million tons of milled dry rice, Indonesia, one of the major agrarian nations in Southeast Asia, has many territories for growing rice. If converted into rice, Indonesia's rice production would equal to 31.36 million tons in 2021, resulting in high rice production and high levels of rice husk production in rice mills. One of the most important agricultural waste products is rice husk extracted from the outer layer of rice grains during milling. Unfortunately, because rice husks have low protein content and high ash content [1], most of them are burned, buried, or dumped into water as waste, which

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negatively affects local ecosystems and causes air and water pollution. This leads to various problems, including landfill problems and environmental degradation.

In recent years, the recycling of waste in road construction has also become more important. One of them entails replacing or altering the composition of aggregates or fillers and adding natural polymer materials so that asphalt pavements can be built in a green, sustainable, and environmentally friendly manner, ultimately helping to preserve nature by lowering the demand for materials from extracted natural sources [2]. For many years, it was believed that rice husk ash had no purpose or benefit. Several academics have shown interest in this study area in recent years due to the growing effects of pollution and the rising costs of building materials [3]. They hope to find ways to utilize the potential of rice husk ash fully. Because soil is frequently brittle and has limited stability for heavy loads [4] numerous researchers have utilized rice husk ash as an example. Rice husk ash is also used as a filler in the concrete industry [5-7]. Although rice husk ash has a wide range of applications, particularly in concrete mixes and as a filler in hot asphalt mixtures [8-9], there is limited information in the literature on how rice husk ash affects the physical and rheological properties of asphalt when used as a binder.

Silica and leftover carbon black make up rice husk ash (RHA) from combustion. The major component of RHA is amorphous silica, which is evident from the mineralogical examination. It is demonstrated in [10] that RHA possesses chemical properties with a high surface area and a strong absorption power. Due to its high silica concentration, relatively high level, and extensive application as an inorganic material, rice husk ash is an intriguing waste product. Silica has good potential because it has a large surface area and strong adsorption and adherence. Amorphous silica with great purity is the best silica that can be found [11]. Rice husks must be heated to a controlled temperature of 8000C in order to produce silica with a high degree of purity and chemical reactivity, according to research by Shen et al [12].

According to Tan et al. [13], silica can be included in hot asphalt mixes to reduce air gaps and boost their indirect tensile strength and indirect tensile modulus. Silica can also enhance asphalt's performance at high temperatures by enhancing its cohesive strength and viscosity. According to Abdutalib et al [14], the addition of fillers such as silica fume has the potential to increase the resistance of asphalt to oxidative aging and improve its temperature performance. To replace traditional mineral fillers in hot asphalt concrete mixes with rice husk ash alone, especially in regions with a lot of rice husk waste [15].

Asphalt is a naturally occurring polymer with a low molecular weight that is mostly utilized as a binder and is created via catalytic cracking of hydrocarbons and fractional distillation of crude oil [16]. Rubber is one of the additional components used in polymer asphalt, a modified version of asphalt. This kind of polymer is being used to improve the rheology of the asphalt, and it is more elastic than penetrating the asphalt. In addition to Malaysia and Thailand, Indonesia is one of the biggest producers and exporters of natural rubber worldwide. The current situation has resulted in an oversupply in the nation. It has an impact on the reduction in national rubber prices because there is a low demand for raw rubber exports. To combat this, the government aims to take advantage of rubber's potential in the infrastructure sector through the Ministry of Public Works and Public Housing. One way it does this is by processing rubber into rubber asphalt, a new material added to the production of asphalt to boost domestic rubber consumption.

2. Rice Husk Ash Properties

The rice husk, which is the top layer of the grain, is a byproduct of milling. Between 20 to 35 percent of the weight of rice is made up of the hulls, and 15 percent of the weight is made up of the ash from the hulls [17]. The robust outer layer known as the rice husk keeps the rice grains safe and separates them from the kernels during milling. The rice husk, which contains between 30 and 50% organic carbon, is a typical waste product in every country where rice is farmed. To achieve entire grains of brown rice, the raw grain is typically milled by removing the husks. White rice is produced via a further milling procedure in which the bran layer is eliminated. Currently, 700 million tons of rice are produced worldwide. About 20% of rice weight is rice husk, which is composed of cellulose (50%), lignin (25-30%), silica (15-20%), and moisture (10-15%). Rice husks have a low specific gravity, ranging from 90 to 150 kg/m3 [18]. Sources of RHA include countries in the Far East, Southeast Asia, China, Indonesia, and other countries that grow rice. The combustion of rice husks produces RHA. The predominant residue after combustion, which replaces most of the volatile components of rice husk, is silicate. (1) Rice husk content, (2) combustion temperature, and (3) combustion duration affect ash properties. The combustion conditions have a significant effect on the chemical composition of RHA, and the combustion temperature must be selected so that the silica remains in an amorphous state. Table 1 shows the chemical composition of the shell ash after purification at different temperature treatments.

Table 1. Chemical composition of rice husk ash at different temperatures [17].

Substance (%)	**Temperature**				
	Original	400^{o}C	600^{o}C	700^{o}C	1000^{o}C
SiO2	88.97	91.53	94.89	96.65	98.01
MgO	1.17	1.13	0.84	0.51	0.59
SO3	1.12	0.83	0.81	0.79	0.09
CaO	2.56	2.02	1.73	1.60	1.16
K2O	5.26	6.48	6.41	3.94	1.28
Na2O	0.79	0.76	1.09	0.99	0.73
Fe2O3	0.29	0.74	0.46	0.00	0.43

According to ASTM C-618, the content of SiO2, Al2O3 and Fe2O3 in hot mix asphalt is the decisive factor. Since components containing silicates and aluminium tend to have pozzolanic properties that can bind aggregates and strengthen the pavement, the presence of these oxides can affect the strength of the road. The particles of the rice husk ash sample are in the form of a combined grain size (non-spherical and non-agglomerated, regularly shaped particles), which, according to the scanning electron microscopy results shown in [10] (SEM), should further improve the engineering properties, such as preventing cracks in the asphalt mixture caused by internal friction.

The ash must be processed to a very fine particle size to produce pozzolanic activity, which may make its use economically unviable. Amorphous silica makes up most of the ash produced during controlled combustion, which takes about an hour at temperatures between 500 and 700 °C. The presence of this silica and the large surface area of the ash give it its reactivity. After combustion, rice husks lose between 78.78 and 80.2% of their original weight. The husk ash usually has a silica content between 90 and 96%. The silica in the husk is in hydrated, amorphous form [17]. According to studies by Alaeldin et al [1] and Zhen Lu et al [19], the addition of silica to rice husk ash can improve mechanical properties, marshall stability, stiffness modulus, rutting resistance, and tensile and moisture strength.

3. Rubber Asphalt Research Tracking Using Modifier Filler

Isoprene, the main component of rubber, has a long chain molecule (C5H8); this chain length signifies the presence of a strong double bond between the isoprene units, which is not easily broken, making the physical properties of rubber elastic. The rubber track is spiral and spring-like due to the "CIS" molecular structure, which makes the rubber elastic (viscoelastic). The properties of natural rubber are also strongly influenced by the proportion of non-rubber components, which ranges from 5to 10%.

For the rubber's three-dimensional structure to demonstrate its stable elastic capabilities, the repeating isoprene unit also has a double bond that is simply crosslinked or vulcanized. In order to transform plastic-sensitive materials into technologically usable materials by creating cross-linked molecular networks, or from thermoplastics to plastics, vulcanization is the process of adding vulcanized materials (sulfur, peroxide, metal oxides, resins, quinones, etc.) to latex.

Natural rubber is one of the polymers that can be effectively put to asphalt. Natural rubber can increase the stability of asphalt pavements due to its better stability, superior fatigue resistance, and good tear strength. The rubber material used to modify asphalt is separated into two categories: Natural Rubber Latex (NRL), which is made directly from rubber latex, and Styrene Butadiene Rubber, which is made from artificial (synthetic) rubber (SBR). The performance of the pavement can be enhanced by using NRL, which can stiffen the road surface. NRL must be reprocessed using the centrifuge method [20] to lower its water content because it has a relatively high water content when it is taken from plants. Processed NRL is anticipated to have up to 60% more rubber.

Several decades of study have shown that adding natural rubber to asphalt may enhance its functionality. Also, since 1969 [21], a lot of study has been done on the effects of different raw latexes on the characteristics of asphalt, including skimmed latex, Revertex latex, high and low ammonium latex, and centrifuged latex. When asphalt liquid natural rubber's characteristics in soft asphalt were examined in 1998, the findings revealed that the addition of 5–10% NRL raised the softening point while maintaining a constant shear strength.

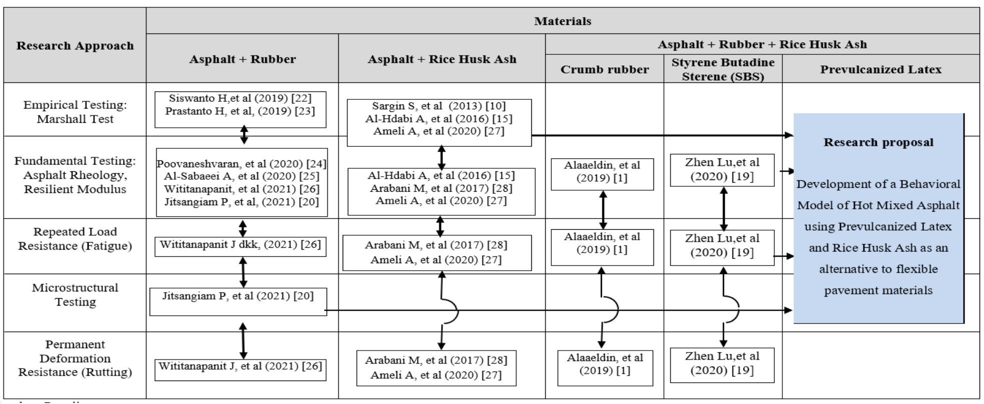

Figure 1. Summary tracking of asphalt rubber research

Studies on rubber asphalt and rice husk ash used as fillers and modifiers in asphalt mixtures are closely related to previous research. Numerous researchers have also studied hot mix asphalt using these materials as binders and fillers. The following are the findings of some of these investigations on the inclusion of rubber in hot asphalt mixtures (show Figure 1). According to the several research mentioned above, adding natural rubber to asphalt mixtures may enhance their functionality and raise their resistance to fatigue and irreversible deformation. A rubber's capacity to increase Marshall stability, stiffness, tensile strength, temperature resistance, and shear resistance can be attributed to its kind. Natural rubber, latex, and crumb rubber are the most popular types of rubber; nevertheless, there are currently few investigations on heated, hot asphalt mixtures for modified rubber, such as prevulcanized rubber.

4. Proposed Further Research

Based on the tracking results in Figure 1, it was discovered that there is still little research on the use of rice husk ash in hot asphalt mixtures. Since there have only been two previous researchers who have studied rubber asphalt with rice husk ash, there is very little information about research developments pertaining to the nature of the hot mix of rubber asphalt with rice husk ash, so the proposed research this time uses prevulcanized latex rubber material and rice husk ash in the hot asphalt mix. Prevulcanized Latex, a latex compound created by combining concentrated latex with vulcanizing agents, is to be used, according to the rules. Costs associated with producing rubber asphalt could be decreased if rice husk ash could take the place of this traditional filler.

Previous research have not demonstrated that asphalt binder treated with rice husk ash and prevulcanized latex performs any better than regular asphalt binder. to observe the effects of adding rice husk ash and prevulcanized natural rubber latex to hot asphalt mixes on the functionality of asphalt binders at high temperatures using various macrostructural and microstructural laboratory experiments. Based on these findings, it might be suggested that additional research be done on the kind of prevulcanized latex rubber that has not yet been investigated. This study used prevulcanized latex rubber in the Asphalt Concrete-Wearing Course (AC-WC) graded surface mix to fully understand the properties of hot asphalt combination of rubber and rice husk ash. One study gap that the author will fill is the usage of prevulcanized latex rubber in the research proposal.

5. Conclusion

Many scientists have been studying this area of study to find strategies for utilizing the potential of rice husk ash due to the growing effects of pollution and rising costs of building materials. Due to the tendency of components comprising silicates and aluminium to have pozzolanic qualities that can bind aggregates and strengthen the pavement, the presence of this oxide may affect how strong the road is. The goal of the planned study was to determine how adding prevulcanized latex rubber and rice husk ash would affect the effectiveness of asphalt binders. Prevulcanized latex is chosen because it is simple to combine hot asphalt with it and because it can be made locally by farmers.

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