ISSN: 05693772

STUDY OF MATERIALS FOR THE WATERPROOFING OF ASPHALT PAVEMENT AND REDUCTION OF WEAR DUE TO WATER INFILTRATION

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abstract: This research focuses primarily on the collection and analysis of information related to the waterproofing of asphalt pavement to reduce the damage caused by water infiltration. It also aims to identify alternatives to increase the strength and service life of the pavement, thereby reducing maintenance costs and time. Based on the references found through research, analysis, and characterization, the study seeks to contribute to the future design of pavements with significantly improved waterproofing properties, which will support the enhancement of the road network in the city of Sincelejo.

*Keywords:*Pavements, asphalt, waterproofing, durability, strength, maintenance, aggregate, costs, time, water, climate

1. Introduction

Since ancient times, human beings have sought ways to move more easily. This need led to the creation of primitive paths, which over time evolved into modern highways. Throughout this process, the techniques, methods, and technologies used in road construction have also been refined. Thanks to accumulated experience, there are now different types of pavements, such as flexible (asphalt), rigid, and composite types.

A pavement is made up of several carefully layered components designed according to technical and regulatory criteria. These structures must be strong enough to withstand traffic loads, harsh weather conditions, and the effects of water. Additionally, they must offer a safe, comfortable, and visible surface to prevent driver fatigue. Globally, the expansion of automobiles prompted rapid growth in road networks during the 20th century. In Colombia, the development of road infrastructure began around 1930, and by 1945, there were already paved sections.

Well-maintained roads are essential for the social and economic progress of cities. Therefore, when planning urban infrastructure works, it is vital to prioritize routes with high vehicle flow that connect key areas such as educational institutions, tourist sites, hotels, and restaurants. These main roads, being the first to be built, suffer greater wear due to their prolonged use, resulting in visible structural deterioration.

Date: Received: July 3, 2025.

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In urban environments, road damage tends to worsen over time due to the growth of the vehicle fleet, the circulation of overloaded vehicles, adverse weather conditions, drainage problems, and subsequent underground utility works. All these factors cause increasingly evident failures that not only compromise road safety but also affect mobility and cause damage to vehicles.

Pavement engineering has focused its advances on flexible-type structures, especially those with asphalt layers as the driving surface. These structures have undergone multiple improvements in both materials and thicknesses to increase their resistance capacity without resorting to more expensive solutions such as concrete.

In the context of urban development in departmental capitals, promoting efficient connectivity between strategic areas is key. Pavements, especially flexible ones, play a vital role in that growth. However, one of the most frequent challenges is the accelerated deterioration of these surfaces, particularly due to the action of water. Although pavements are designed to withstand the constant passage of vehicles, water can infiltrate, erode materials, and generate cracks that eventually develop into potholes and deep fissures.

The city of Sincelejo, capital of the department of Sucre, has a road network made up of both rigid and asphalt pavements. However, many of its asphalted streets are in critical condition, increasing the risk of accidents and endangering the safety of its residents.

Maintaining roads in good condition not only ensures smoother circulation but also improves the safety and overall well-being of the population. It is therefore necessary to seek alternatives that can extend the service life of roads, increase their resistance to growing traffic, and minimize deterioration caused by water.

In this context, the design of highly waterproof pavements emerges as an innovative solution to extend the service life of roads, reduce maintenance costs, and improve the safety and durability of road infrastructure in Sincelejo.

2. Methodology

2.1. **Case Description.** This research seeks, through a theoretical study, to design a new highly waterproof asphalt pavement in compliance with Colombian technical regulations for the improvement and construction of a new intermunicipal asphalt pavement system. This system aims to compete with rigid pavement in terms of service life, while also increasing durability, strength, comfort, and reducing maintenance costs.

Figure 1. Interurban waterproof asphalt pavement system in the city of Sincelejo (Sucre, Colombia). Adapted from [16]

2.2. **Case Study.** Through a theoretical study based on various bibliographic sources and research, the collected information was analyzed and synthesized for better management and development of the study. This included the characterization of physical and chemical aspects used in asphalt pavement design, such as the aggregates involved, to identify relevant features for enhancing the waterproofing of asphalt pavement.

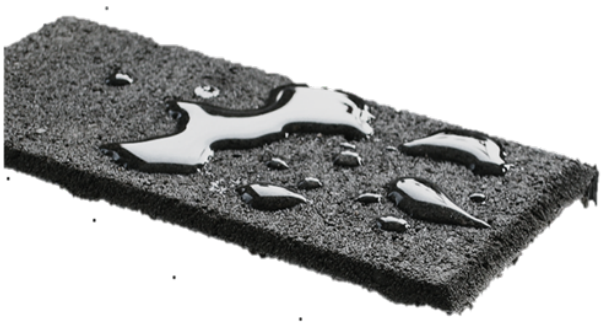

FIGURE 2. Expected result of waterproof asphalt pavement. Taken from [15]

2.3. **Research Stages.** To ensure a better development of the study, this research was carried out in stages:

The first stage involves the collection and analysis of information to identify the materials used in asphalt pavement. It also aims to establish the necessary foundations for future analysis of these materials' characteristics and find solutions to the deterioration caused by water infiltration in the pavement structure.

The second stage focuses on the physicochemical characterization of the studied materials to achieve a better understanding and development of the research, framed in the individual analysis of materials used in asphalt pavements.

The third stage analyzes this information to provide a stronger conceptual foundation for the research. The fourth stage focuses on designing a highly waterproof pavement with improved functionality for roads, providing greater efficiency, durability, and resistance.

Finally, asphalt modified for waterproofing will be used in paving streets in the northern area of Sincelejo as a field study to observe pavement behavior under normal conditions.

2.4. **Theoretical Study.** Flexible pavements consist of a layer called the surface course, supported by two layers known as the base and sub-base. The entire structure rests on the subgrade, which bears only a small portion of the vehicular load.

Asphalt is a material that can be found naturally in deposits or obtained as a by-product from the distillation of certain petroleum crudes. It has specific properties that make it ideal for paving work, primarily cohesion and adhesion to granular materials. It is solid in consistency, softens and becomes liquid when heated, which allows it to coat the aggregates during the hot mix asphalt production process.

Asphalt behavior varies depending on temperature and loading time. It becomes harder at low temperatures and softer at high temperatures. Therefore, the type of asphalt must be selected according to the local climate.

Asphalt is composed of asphaltenes (high molecular weight polycyclic substances forming solid particles that constitute the dispersed phase in asphalt), resins, aromatics, and saturates. Asphaltenes provide hardness, while resins bind the asphaltenes and give adhesive capacity. They are semi-solid or pasty and lighter in color than asphaltenes. They have a lower molecular weight, are dissolved in crude oil, partially soluble in hexane, and insoluble in propane. They maintain the stability of the colloidal system by facilitating interactions between asphaltenes and maltenes. A higher resin content results in more ductile and softer asphalt. Aromatics and saturates are oils that give workability and represent low molecular weight hydrocarbons. They are liquid at room temperature and form the continuous phase in the colloidal system.

Asphaltenes give asphalt its hardness, while maltenes provide adhesiveness and ductility. Resins and carbene compounds influence viscosity or flow properties. Asphalt is a complex

mixture of high molecular weight hydrocarbons with significant proportions of heteroatoms (oxygen, sulfur, nitrogen) and certain metals like vanadium and nickel. Most asphalts also contain soluble organic salts in the form of microcrystals.

Waterproofing asphalts, or oxidized asphalts, are produced by bubbling air through asphalt heated to 200–300°C. Oxygen reacts with maltenes and resins to form asphaltene-like molecules through polymerization, bridging between molecules, or dehydrogenation and C-C bond formation. These reactions begin around 220°C, and the reaction rate doubles with every 25°C increase. However, temperatures above 280–300°C should be avoided, as they can cause harmful exothermic combustion or endothermic thermal cracking reactions.

A stone aggregate is a hard, inert mineral material used in graded particle form as part of a flexible pavement. Aggregates are used both in granular base layers and for asphalt mix production. Aggregates constitute 90–95% by weight and 75–85% by volume of most pavement structures. Therefore, the quality of the aggregate is a key factor in pavement performance. Aggregates may be natural or processed. Based on size, they are classified into gravel, sand, and mineral filler. Materials may come from open-pit quarries or riverbeds (alluvial aggregates). Processed aggregates are crushed and screened before use. Rock is crushed to make the particle shape angular and improve size distribution (gradation).

Asphalt mix is a combination of asphalt binder and aggregates in precise, predefined proportions. These relative amounts determine the mix's properties. Asphalt mixes can be hot-mix or cold-mix, with hot-mix being more common and the main focus of this study. Various methods exist to determine the material quantities for hot-mix asphalt, including the Marshall and Hveem methods, both widely used internationally.

This methodology aims to integrate theoretical and experimental analysis of materials to develop practical and sustainable solutions that optimize the performance and waterproofing of asphalt pavements under real usage and climate conditions in the city of Sincelejo.

3. Results

3.1. **Research Results.** After conducting the research processes using information from various sources, it was possible to collect, analyze, and synthesize the main topics addressed in this study, thereby facilitating the future development of the following phases.

3.2. **Research Impact.** Greater clarity was achieved in understanding the processes, materials, and aggregates involved in the design of asphalt pavement. This allows for the next phases to be carried out, aiming to design a highly waterproof pavement that meets legal, safety, and comfort standards. Additionally, it seeks to reduce maintenance time and costs by extending the pavement's service life, durability, and strength. A field study will also be conducted to analyze its performance, through the development of an intermunicipal asphalt pavement system that connects key locations in Sincelejo.

These results provide a foundation for implementing durable and waterproof pavements that contribute to the efficiency, effectiveness, and sustainability of road infrastructure maintenance.

4. Conclusions

Upon completing this theoretical research phase, it can be understood that there are various ways to design waterproof pavement, starting from its chemical composition, the nature of its aggregates, production modifications, and the incorporation of materials and additives that enhance its properties to achieve more efficient characteristics. This will allow for the execution of the experimental phase for the design of waterproof asphalt pavement, which in turn will be used for the construction of a new interurban system in the city of Sincelejo, improving mobility in the area.

The importance of innovative technologies for waterproofing asphalt pavements is highlighted, as they contribute to the safety and well-being of the community in the municipality of Sincelejo.

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