



COMPARATIVE ANALYSIS FOR VIABILITY OF PAVING BETWEEN RUBBER AND CONVENTIONAL ASPHALT

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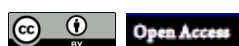
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ABSTRACT

Most road pavements in Brazil are of low quality, safety and comfort. But the drawbacks go far beyond these more visible issues. Among the most important, we can highlight: sliding of asphalt plates caused by infiltrations, sudden narrowing of the track, collapsed barriers and worn bridges. These problems add up to others, causing accidents, delays, and road deaths in Brazil. As a result, the paper aims to present a comparative analysis to demonstrate the feasibility of using rubber asphalt compared to common asphalt. To answer the research objectives, the methodological choice was a bibliographical review of the integrative type. It was emphasized the importance of a study that considered, besides the cost-benefit, the environmental question, the comfort and the safety for the users of paved roads.

Keywords: Asphal Rubber, Highways, Asphal.

I. INTRODUCTION

Civil Engineering is the area of greatest importance when it comes to structure. It allows projects and constructions of buildings, roads, tunnels, subways, dams, ports, airports among other works to be built. Choosing the most appropriate locations for a construction, analyzing the strength and safety of the site and the material used in the project and monitoring the progress of the project are also attributions of that area.

Thus, the existence of cities is closely linked to the progress of this profession. However, this activity goes far beyond the merit of constructions. It shows that planning is necessary in order to make our daily life easier. We need to think, calculate, test and even try to guess future complications so that our routine is more pleasant. This avoids problems, wear and tear, causes us to live with less stress and tension.

The civil construction is recognized as one of the main activities for economic and social development. By contrast, it is a

major cause of copyright, that is, terms of natural resources, the change of landscape or the generation of waste [15].

The construction industry has been looking for more efficient building systems in order to increase productivity, reduce waste and meet growing demand [4].

For civil construction the modification of the landscape with the sustainable use of natural resources is one of its main purposes. In a construction solid waste and impacts to the environment end up being generated, but in several times, can be diminished or compensated. When it comes to asphalt paving safety is one of the basic requirements.

Before we go directly to the study of a road, we must emphasize its economic, political, social and ecological influence on the region to be crossed by it. Well-planned highways improve the economic development of cities. The products circulate more quickly, making possible the consolidation of the regional economy.

Tourism today requires well-structured highways that stream traffic, avoiding accidents and wasting time in rows.

According to the National Transportation Confederation (CNT) and Economic Research Institute of Brazil (IPEA), the goal of a highway is to promote a comfortable, economical and safe way to transport people and material goods [10].

The 2018 truckers strike, which for more than 10 days paralyzed Brazil, showed the country's dependence on road transport. After all, it is over the roads that are transported over 60% of all loads. There are not a few complaints about road conditions, and with that, it is essential to search for new solutions [10]. This example can be seen in table 1:

Table 1: Percentage of Transport Use.

Country	Maritmo/Waterway	Railway	Road
Canada	36	52	13
Germany	29	53	18
USA	25	50	25
Brazil	17	21	62
Argentina	23	23	44

Source: [10].

According to the Brazilian Institute of Geography and Statistics (IBGE), road transport predominates in Brazil, concentrated mainly in the Center-South region of the country. In addition, there is the fact that the number of vehicles in the country is growing continuously, generating the need for an asphalt mesh that provides safety, comfort and durability. Another alarming factor that this growth is increasing is the great number of discarded tires [3].

Therefore, the use of the rubber of these discarded tires in the manufacture of rubber asphalt generates a sustainable solution to this problem.

This article aims to compare and analyze the conventional asphalt and asphalt with the use of rubber in its composition, showing its advantages and disadvantages, and present a more sustainable alternative to the market.

II. THEORETICAL REFERENCE

The 2018 truckers strike, which for more than 10 days paralyzed Brazil, showed the country's dependence on road transport. After all, is on the roads that are transported more than 60% of all Brazilian loads. The complaints about road conditions are not few, and with that, it is essential to search for new solutions [16].

The National Confederation of Transport (CNT, 2016) survey shows that the expansion of the Brazilian paved road network grew only 11.7% in 10 years, while the vehicle fleet growth was 110.4%. With this we can notice a great demand due to the volume of traffic, and the survey pointed to a poor condition of the highways which also implies an increase in the number of accidents [16].

In order for the road works to improve pavement conditions, it is necessary to study new materials added to the mix of asphalt concrete. The development of these materials must be

more resistant, thus reducing the defects of the functionality and structure of the roads, such as cracks and pathologies of deformations.

One of the alternatives found for this problem was the asphalt-rubber, because it presents a higher quality than the conventional asphalt. Road problems, can be seen in figure 2:



Figure 1: Stretch of the BR 230 in the Ceará
Source: [16].

Taking this information as a basis, a bibliographic study was done on this form of paving using articles and studies on its comparison with conventional asphalt, can be seen in figure 3:

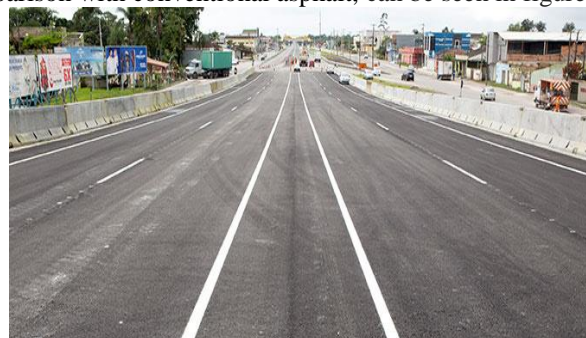


Figure 2: Pavement with asphalt rubber
Source: [13].

In Brazil, 80% of the roads are not asphalted. For 1.7 million kilometers of roads in Brazil, it is responsible for 58% of the national cargo volume. However, 80.3% are not paved. In total, the country has 12.1% of paved highways and 7.6% are just disposals [15].

An example of an unpaved road is the Transamazônica, located in the north of Brazil. This highway remains unfinished until today. According to the project, it would serve to channel production from Brazil to the Pacific [16]. This road can be seen in figure 4:



Figure 3: Highway Transamazônica BR-230
Source: [16].

To build 4,073 km of the Transamazonica, the government spent \$ 1.5 billion at the time (today \$ 7.7 billion). More than half the road, 2.2 thousand km, is still not paved [14].

The Transamazônica highway was to be a road of 5,000 kilometers that crossed the Amazon forest, from João Pessoa in the Northeast to the border with Peru. It was one of the most ambitious economic resettlement development programs ever invented, and one of the biggest failures.

The paving of this highway is of fundamental importance for Brazil, since this region has an incalculable wealth. It is also important for families living on the roadside, This road can be seen in figure 5:



Figure 4: City of Uruará on the banks of the Transamazonica, in the center of the Amazon
Source: [16].

III. MATERIALS AND METHODS

III. 1 DEFINITION OF THE CONCEPTS AND MAIN RESEARCH PARAMETERS

The first stage consists of determining the basic concepts that should be explored by the research.

Specifically, for the search strategy and for the accomplishment of the bibliographic search it is necessary to define the contextualizing environment, the research problem and the general objective of the research, which have as purpose to enable the definition of the main key concepts. The analysis of the context, the definition of a problem and the guiding questions initiate the process of scientific research, thus motivating the researchers to search for information on a certain theme on a bibliographic basis [17].

The aim is to fully exploit the potential of existing and available bibliographic databases and the information technology tool for the treatment of this data.

As a result, the bibliographical review article will address publications with the following parameters:

- Publications that discuss the techniques of using rubber asphalt;
- Publications showing comparative testing of rubber asphalt with conventional asphalt;
- Publications that disclose techniques or methods, which present the benefits of rubber asphalt;
- Publications presenting in the topic degree of "high" and "average" arguments and ideas related to the subject of this work.

III. 2 DEFINITION OF THE RESEARCH STRATEGY

Once the search knowledge area is determined, the keywords that will be used to search for references must be chosen.

Thus, from these key concepts found the Boolean search logic is used for the construction of the keyword tree [8].

The strategy of structuring the tree is intended to unfold the objectives of research in keywords, both vertically and horizontally. In the vertical sense, the intention is to establish distinct and complementary thematic areas that allow the research done to be comprehensive. In the horizontal sense, the thematic areas are subdivided into several branches, thus guaranteeing the depth and specialization of the research [4].

Using Boolean search logic, where keywords are linked with the connectors "and" and "or", the researcher must remember that the strategy of using the connectors is very important because it explains the existence of many or few articles found. When the searcher uses the "and" in the linking of the keywords, the search action is restrictive, since the search will only find article when there are together the keywords connected by "and" [19].

When the searcher uses "or" in the keyword link, the search action is opened because they will find articles that have at least one of the keywords linked by "or". That way, choosing the connectors and where to position them in the keyword tree is strategic. Lastly, search engines are defined as the most appropriate to the research topic, according to their relevance and the ease of obtaining and processing the data [19].

As a result of this, this bibliographic review article was developed through scientific searches of Scielo, Scopus, IEEE, Google Scholar, among others, using the key words: "conventional asphalt"; "Rubber asphalt"; "Comparison" + "asphalt"; "Asphalt comparison" and "asphalt" + "rubber and conventional".

III. 3 METHOD FOR ANALYSIS OF RESULTS

The method for analyzing the results was delineated according to the flow chart of figure 6:

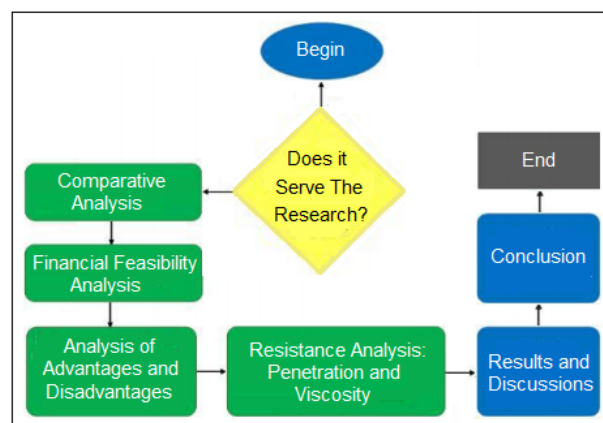


Figure 5: Fluxo do processo de obtenção e análise dos resultados.
Source: Authors, (2019).

In the first stage of the study a comparative analysis was carried out between asphalt rubber, conventional asphalt and asphalt with addition of polymers.

In the second stage an evaluation of the financial feasibility of projects with the use of asphalt-rubber in relation to conventional asphalt.

In the third stage an analysis was made on the advantages of asphalt-rubber in relation to conventional asphalt. The most relevant parameter used in this step was the composition of the asphalt.

After the three steps, the results on the comparison between the objects of the study were analyzed and presented: asphalt-rubber and conventional.

III. 4 TYPE OF RESEARCH

To answer the research objectives, the methodological choice was a bibliographic review of the integrative type.

The integrative bibliographic review emerged as an alternative to rigorously review and combine studies with different methodologies. It has the potential to promote review studies in several areas of knowledge, maintaining the methodological rigor of systematic reviews [9].

The integrative review method allows the combination of data from the empirical and theoretical literature that can be directed to the definition of concepts, identification of gaps in the areas of studies, review of theories and methodological analysis of the studies on a certain topic [9].

The combination of research with different methods combined in the integrative review extends the possibilities of literature analysis.

IV. RESULTS AND DISCUSSIONS

In the first stage of the study a comparative analysis was carried out between asphalt-rubber, conventional asphalt and asphalt with addition of polymers. The study evidenced the technical characteristics of the rubber asphalt, besides making a comparison between it and the conventional asphalt. Through laboratory tests it has been demonstrated that this method of paving is presented as feasible in all aspects, which are environmental, economic and technical, as can be seen in table 2:

Table 2 - Comparison of Stability through assays.

Comparative - Stability			
	Conventional asphalt	Asphalt Polymer	Asphalt Rubber
Reading	626,67	793,33	880,00
Correction Factor	1,03	1,03	1,01
Read Corrected	645,84	816,66	889,21
Stability kilogram strength	989,42	1251,13	1362,27

Source: [1].

In the second stage of the study, an assessment was made of the financial feasibility of projects with the use of asphalt-rubber

in relation to conventional asphalt and the result was extremely economic viability.



Figure 6: Physical Structure of Asphalt Rubber. Source: Authors, (2019).

Although the cost of running a paving with rubber asphalt is slightly higher than that of conventional asphalt, it generates a saving of 9%, as it has a higher elastic recovery than the conventional one, preventing the cracking of the pavement cover, and generating a lower maintenance need, as can be seen in figure 6:

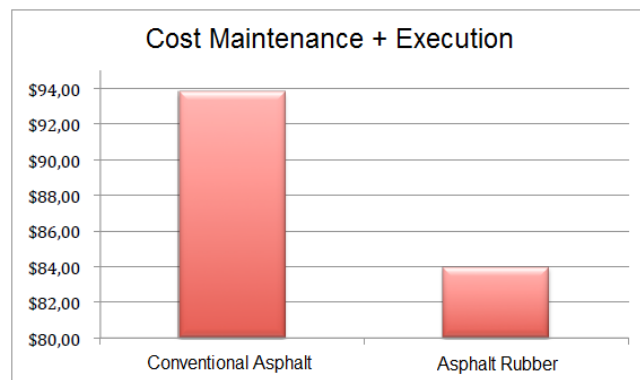


Figure 7: Ratio of Maintenance + Execution cost. Source: [13].

In the third stage of the study, an analysis was made of the advantages of asphalt-rubber over conventional asphalt. The most relevant parameter used in this step was the asphalt composition. The asphalt-rubber and conventional was compared through the result obtained with budget research of local works, which resulted in similar costs, (table 3).

Table 3: Comparison table of costs.

Greatness	Calc.	Unity	Type of Asphalt		
			CAP 50/70	ASFALTO BORRACHA (ECOFLEX)	
A	Amount of Asphalt Mass CBUQ produced	-	ton	26.250	18.375
B	Machining Cost/Application per ton of applied CBUQ	-	R\$/ton	200,00	230,00
C	Mass Quantity x Machining/ Application Cost	A x B	R\$	5.250.000,00	4.226.250,00
D	Asphalt Content	-	% peso	5%	5,5%
E	Cost of Asphalt per Ton	-	R\$/ton	1.150,00	1.550,00
F	Cost of Asphalt in CBUQ	A x D x E	R\$	1.509.375,00	1.566.468,75
G	Total Cost of the Work	C + F	R\$	6.759.375,00	5.792.718,75

Source: [18].

Using the data collected, the articles carry a study of tests that compare the capacity of asphalt-rubber and that of conventional asphalt.

For the penetration test, the authors followed the guidelines given by NBR 6576 that indirectly determines the viscosity of the binder material, which resulted in the asphalt rubber being more rigid than the conventional one.

In the viscosity test, the Brookfield Viscosity Test was carried out in accordance with the guidelines of NBR 15529, where rubber paving showed lower viscosity than conventional.



Figure 8: Rotational Viscometer, used for the Brookfield Viscosity Test.

Source: [18].

In order to identify the minimum flash point, it was carried out in a closed environment, free of drafts to avoid odors, as requested in the standard NBR 11341. It is with the flash point that we identified the temperature limit where the asphalt binder becomes characterized as a flammable product, where asphalt rubber reached 292 ° C, which is well above the expected value of 235 ° C.

For the softening point test, which is the temperature at which the asphalt reaches that softens it in such a way that a certain flow condition is reached, that the asphalt begins to lose its resistance to deformation. Through tests determined by NBR 6560, it was found that asphalt rubber is more resistant to deformation.

For the elastic recovery of the binder, the technical standard NBR 15086/2006 was used, but the conventional bituminous material does not have enough elasticity for its accomplishment, which did not allow a comparison between the materials, but it was observed that it is the rubber mixed with the binder which results in its resistance greater than the permanent deformation.

According to the above, it can be reported that the use of the ground rubber of the tires in the asphalt mixture can generate coatings more resistant to the permanent deformation of cracks and cracks. Furthermore, it is reported lowest aging, durability, better adhesion of the tire to the floor, leading to greater stability and safety, greater resistance to the formation of wheel tracks, reduction of aquaplaning, among others.

V. CONCLUSION

By means of the bibliographical review given by the articles and norms presented in this article, a comparison can be made

between conventional asphalt and rubber asphalt, analyzing its execution and repair costs, as well as its physicochemical characteristics.

In the environmental issue, the use of rubber paving is a great ally considering the removal of waste tires from the environment. Millions of tires end up being discarded in nature every year causing damage to the environment, but the inclusion of these tires in the manufacture of asphalt generates a correct destination for them, avoiding problems in the environment.

With the results obtained by the proposed tests, the rubber asphalt presented better characteristics than the conventional one, presenting better results in terms of viscosity, penetration, resistance, and with that, presenting a superior durability than the conventional one.

The technical feasibility of the use of this residue in asphalt mixtures is verified, however, as for the economic feasibility some points can be highlighted, such as the energy expenditures and equipment for grinding tire rubber for the production of its raw material.

As a result, it can be concluded that rubber-asphalt is a great alternative for paving use for the highways because it is satisfactory in its application results, and because it is a mode of transport of fundamental importance for the country, it continuously requires new resources.

VI. ACKNOWLEDGEMENTS

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