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Abstract

As road transport is the predominant type of transport for the traffic of people, vehicles and cargo, it is extremely important to ensure the quality of the country's road pavement. Good pavement ensures comfort, safety and economy to road users. There are several types of coatings to be used depending on the project, the traffic demand of the road to be paved and others. Thus, the main objective of this research is to show the feasibility of using cold premixed asphalt in the city of Coari, municipality of the interior of Amazonas. For this, an investigation was conducted in bibliographies, in order to support the study. A budget based on DNIT unit cost compositions was made to compare the costs required to apply this asphalt mix with hot-machined concrete, as this is the most commonly used for pavement construction. Checking the advantages and disadvantages of its use to evaluate its application in the municipality in question. As the cold premix showed to meet most of the requirements for good paving, having a better cost-benefit ratio, it was found that it can be used on low and medium traffic roads, bringing several positive aspects in operational issues. and economical.

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Abstract

As road transport is the predominant type of transport for the traffic of people, vehicles and cargo, it is extremely important to ensure the quality of the country's road pavement. Good pavement ensures comfort, safety and economy to road users. There are several types of coatings to be used depending on the project, the traffic demand of the road to be paved and others. Thus, the main objective of this research is to show the feasibility of using cold premixed asphalt in the city of Coari, municipality of the interior of Amazonas. For this, an investigation was conducted in bibliographies, in order to support the study. A budget based on DNIT unit cost compositions was made to compare the costs required to apply this asphalt mix with hot-machined concrete, as this is the most commonly used for pavement construction. Checking the advantages and disadvantages of its use to evaluate its application in the municipality in question. As the cold premix showed to meet most of the requirements for good paving, having a better cost-benefit ratio, it was found that it can be used on low and medium traffic roads, bringing several positive aspects in operational issues. and economical.

Keywords: Paving; Asphalt coatings; Cold premixed;

1. Introduction

Road transport is responsible for most of the production flow of Brazilian industries, making it necessary to invest in infrastructure, redefine priorities and implement measures to provide safety to highway users, focusing on quality pavements to resist this traffic characteristic [1] [2]. Because poor quality or defective

pavements damage vehicles and increase fuel consumption and travel time, making operating costs more expensive, influencing the price of products that reach the consumer and compromise the country's competitiveness in the international market [3].

Thus, it is essential to look for ways to reduce the costs required for paving, either in the choice of coating or in the application means. In this sense, cold premixed asphalt coating has been growing as an alternative to low cost, good quality paving that is not environmentally friendly and offers operational advantages over other types of coating. Therefore, this research aims to study the feasibility of using this coating in the city of Coari, evaluating its characteristics, benefits presented by its application and costs compared to the use of hot-machined concrete, which is more common.

2 Theoretical Foundation

2.1 Paving

For [4], paving, as a fundamental principle in the evolution of transport, arose from the need for displacements to be possible at any time of the year, making it necessary to stabilize the roadbed. [2] corroborates this idea by stating that the difficulty of transporting cargo and people by natural roads made paving the roads necessary.

A better bearing track, according to [2], brings users a significant reduction in operating costs, as operating and maintenance costs are directly related to the surface conditions of the pavements. The precariousness of the road infrastructure has an impact on the country's productive capacity, since it influences product costs, which affects the Brazilian economic situation, highlighting the need for more urgent investments that should improve the road situation [5] [6].

2.1.1 Floorings

The Federation of Industries of the State of São Paulo [7] defines pavement as a system or structure of finite thickness and specific material, built to withstand the stresses of vehicle traffic and weather, providing users with better conditions. bearing with comfort, economy and safety.

The function of this system is to receive the traffic efforts and to transmit them to the lower layers moderately, since they usually have less resistance. In this way, the loads are passed in attenuated way to prevent deformations or ruptures in the pavement that affect the use of the road. A typical cross section of the pavement consists of: subgrade, subgrade reinforcement, subfloor, base [8].

According to [4] and [8], there are two traditional classifications for pavement: rigid and flexible, in which they are normally used in their composition, concrete and asphalt material, respectively.

Rigid floors are those that have a layer of hardness much higher than that of the lower layers, are poorly deformable and almost completely absorb the stresses from the traffic flow. Flexible pavements, as they are composed of several layers, deform to a certain extent and do not break, are normally sized and compressive flexural traction, which lead the structure to permanent deformations and fatigue rupture [9] [4].

2.1.2 Coatings

Being the last layer of the pavement structure and in which the vehicles travel, the coating receives directly the actions of the traffic, it is intended to improve the rolling surface in terms of comfort and safety, and must resist the loads caused by traffic and traffic. weathering to increase the durability of the structure [1] [4].

The thickness of the coating is directly related to the quality of the subgrade, as it depends on its resistance to be thicker or not. Because it needs to be of good quality and strength to ensure good rolling on the track, the material required for the coating is the most costly structure [10].

The asphalt coating is the most used in the Brazilian paved road network. The material employed therein is composed of a mixture of aggregates and asphalt binder. As such a commonly used coating, asphalt is one of the main raw materials used in the construction and maintenance of roads and highways [1]. Its intense use is because it provides strong aggregate joining, is waterproofing, durable and resistant to the action of most acids, alkalis and salts, and can be used heated or emulsified, in broad combinations of mineral skeleton, with or without additives [11].

Asphalt for paving in Brazil, according to [7] has four forms of production and commercialization: petroleum asphalt cement - CAP, diluted petroleum asphalt - ADP, asphalt emulsions - EA and modified asphalt.

For a certain asphalt to be considered suitable for paving, simple measures of the physical characteristics of the binder are used, for its ease of execution in the laboratories. There are two main characteristics that are used, namely: “hardness”, which is measured by penetrating a standard needle into the binder sample, and flow resistance, measured by viscosity tests. Over the years, other criteria have been added to indirectly assess future binder performance in paving works [11].

2.2 Pre-Mixed Cold Asphalt

Cold premixed asphalt, according to the Paraná State Department of Roads - DER / PR [12] p.05, “is the asphalt mixture performed at room temperature, in an appropriate plant, composed of mineral aggregates and emulsion. asphalt, cold spread and compacted ”.

The origin of cold premixed asphalt, or simply PMF, was in the United States around 1950, using open grading on bases and coatings. This technique arrived in Brazil from 1966 only in regularization layers and bases and only in 1980 began the use of PMFs in the form of dense graduation in thin coatings [13].

According to Cerentini [14] and DER / PR [12], the PMF can be divided into the following categories:

a) Open - PMFA: has a large volume of voids, greater than 20%, in its structure, and has open grain size;

b) Semi-Dense - PMFSD: presents little graded grain size and void volume ranging from 10 to 20%;

c) Dense - PMFD: has a low void volume, less than 10%, and a well graded particle size.

According to ABEDA [13], open-type PMF as an asphalt coating has the advantage of high roughness, allowing for high tire-pavement grip quality, increasing skid safety. As an intermediate or transitional layer it can serve as a bond, joining its resilient modulus of the asphalt concrete bearing layer with the underlying granular layer of less strength. It is an excellent solution for medium and light traffic lanes because of the ease of production, storage, transportation, application and handling in the field. In addition, having a longer storage period than dense PMF allows flexibility in service scheduling and immediate release of the

executed layer to traffic, thus allowing the construction of the work in stages.

The dense and semi-dense PMF, as an asphalt coating, presents a great structural and functional behavior for medium traffic volume roads, having a good mechanical and safety performance and rolling surface comfort. Dense PMF has a storage period of up to 7 days and work should only be conducted when ambient conditions are appropriate, ie with ambient temperature above 10 ° C and stable weather without rain [13].

2.2.1 Components of Cold Premixed Asphalt

The constituent materials of the cold premix are mineral aggregate, filler and asphalt emulsion, which must follow the standards prescribed by [11]. The main characteristics of these are indicated by [13] as follows, shown in Figure 1:

AGGREGATE BIG	They are stone materials (crushed rock, crushed slag, crushed or uncrushed gravel), durable free of clods, harmful substances and good adhesion to asphalt binders.
AGGREGATE SMALL	Stone dust, washed river sand (except pit sand) or a mixture of both, provided that it is of adequate shape and strength and does not contain clods of clay and other impurities. The maximum amount of sand allowed is 20% of the total aggregate to be confirmed in the project.
FILLING MATERIAL (FILER)	Portland cement, hydrated lime or limestone powder are mineral materials of known particle size and free from clays or other impurities. Portland cement and hydrated lime, as well as composing the particle size curve, improve the cohesion and workability of the asphalt mass assisting the emulsion rupture and curing processes: while limestone powder acts only in the particle size.

Figure 1: Constituent materials.
Source: [13].

Due to the importance in the composition of the PMF, the choice of aggregate should be judicious, and its performance should be known through the analysis of its properties and behavior when used in an asphalt mixture [15]. Another important component of PMF is the asphalt emulsion, which works as an alternative to PAC and is defined by [11] as a stable dispersion between asphalt and water.

To maintain emulsion stability, this mixture requires an auxiliary product called an emulsifying agent, which allows the asphalt globules to remain suspended in water for a certain period of time [11]. For this to occur, emulsifiers have a polar part that has affinity for asphalt hydrocarbons and an apolar part with affinity for water molecules. In general, asphalt emulsions consist of 30% to 50% water, 50% to 70% asphalt cement and the amount of emulsifier used in this mixture does not exceed 2.5% [16].

Asphalt globules are obtained by a colloid mill specially prepared to break down the asphalt [13]. This breakage or rupture occurs when the asphalt globules, dispersed in water, come into contact with the surface of mineral aggregates in a bituminous mixture, undergoing ionization by these aggregates, resulting in the formation of a water-insoluble compound that precipitates. on this surface. Some of the water is absorbed by the aggregate and some is lost by evaporation. The aggregate is covered with a water-repellent grease film and fixes the binder to the aggregate, thus asserting its binding properties [17].

The choice of type and concentration of emulsifying agent end up conferring electric charges, positive or negative and in some cases do not confer ionicity to the asphalt globules, making it possible to classify

them according to their particle charge, being known as anionic for the particles. negatively charged or cationic for positively charged [13] [11]. Cationic emulsion is the most used in paving because it usually meets the conditions required for numerous phases of services economically [17].

EAs are also classified according to the breakthrough time and the asphalt content contained in their composition [18], specifies that for open and medium break premixtures, emulsions of types RM-1C and RM-1 will be used. 2C differentiated by the degree of asphalt content. For dense or semi-dense, the slow break type RL-1C is applied, according to what is specified in the project.

2.2.2 Executive Process

In the process of building a PMF layer, the dosage should be accompanied by the general specifications of the paving project, and the pavement construction services should be subdivided into four categories: mixing, conveying, spreading and compacting [15].

Mixing aggregates with emulsion should be processed in specific equipment such as concrete mixers or plants, fixed or mobile, and it is advisable to use a plant with 3 silos because it is usual to use 3 types of materials such as gravel, gravel and sand [15].

The fixed plants are the same used in the production of mixtures of soils, gravel, soil-cement and others. Those with the highest production capacity are those that have individual aggregate silos that unload them on a conveyor belt leading them to the mixer to be injected with the asphalt emulsion [19]. Mounted on truck chassis, mobile plants are functional and practical as they can be put into operation within hours. Smaller in situ production plants are employed in a restricted manner to a small amount of premix for routine corrective hole-type preservation [7].

The PMF produced is transferred to dump trucks that transport it and unload it in an appropriate depot or on the road to be spread by motor grader or directly on the paver. In hole or small discontinuous segment services, spreading is manual [7].

The compaction process depends on the type of mixture to be considered. In open and semi-dense PMFs, compaction can be started immediately after spreading, or give a cure of 1 to 4 hours due to the small wetting water content. For dense PMFs, compaction should be performed near the optimum moisture determined in the laboratory, as the hot in the field is considered equal to that in the laboratory, although this depends on the type of roller used in the compaction and its respective energies [15].

As for deposits for asphalt emulsion, they must be completely sealed, avoiding contact of this material with air, water and dust, having capacity for at least three days of service, the tanks must have devices for homogenization and heating, as well as, thermometers for temperature control if required. In addition, the connection of the tank with the plant mixer should have a system that allows perfect flow control of the bituminous binder. Aggregate deposits must have silos divided into compartments to properly separate and store fractions of aggregates, and must also have silos storage capacity at least three times the capacity of the mixer. Water deposits, on the other hand, must be able to hold the water to be used [12].

The flowchart below, Figure 2, presents the order of instructions for making a layer of PMF in a very brief way.

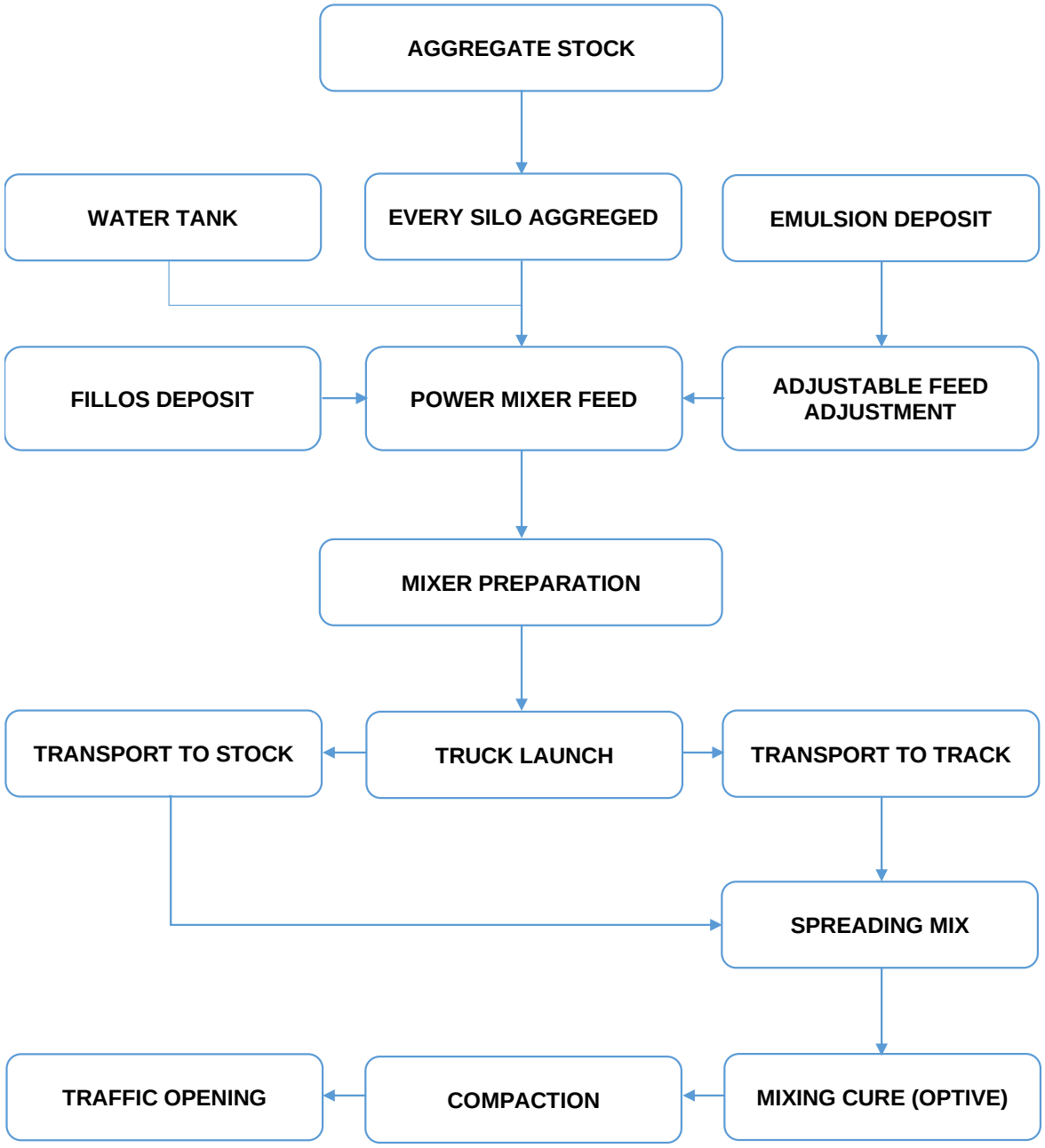

Figure 2: Executive process of a PMF layer.
Source: Adapted from [13].

3 Methodology

To prepare the study on the application of cold premixed asphalt in road pavements, readings and studies on the above-mentioned themes in the theoretical foundation were performed.

The city in which the research is focused is Coari, a municipality in the state of Amazonas, shown in Figure 3, with 57,921.9 km² in length, 75,909 inhabitants in the last census and previously known for banana production, today standing out for oil production. and natural gas.

Figure 3: Coari Municipality.
Source: [25].

After conducting a study on asphalt pavements, the required budget for PMF application was made using DNIT's SICRO 2 spreadsheets, compared to the costs of using a hot-rolled bituminous concrete coating - CBUQ, which is the most commonly used. used. Then, an evaluation of the performance of the coating is made, its feasibility of use according to the knowledge acquired through the theoretical foundation.

4 Results and Discussion

4.1 Executive Cost

The [20] SICRO 2-unit cost compositions from Amazonas from November 2016 were used to compare the costs of using PMF and CBUQ. In the execution of cold premixed coating, taking into account the unit cost of execution of the service and machining, the total unit cost of R $ 218.80 is reached, as shown in Figure 4.

DNIT – Road Cost System			Road Construction	SICRO 2
Reference Unit Cost	Mês: November/2016		AMAZONAS	RCTR0320
2 S 02 530 50 – Cold premixed AC/BC			Team Production: 22,00 m³	*Real Values*
			Custo Unitário de Execução	33,82
Auxiliary Activities	Quant	Uni	Unit price	Unit cost
1 A 01 397 52 – Machining P.M.F. AC/BC	1,00	M³	129,08	129,08
			Total cost of activities	129,08
			Total direct unit cost	162,90
			Indirect Income and Expenses (34.32%)	55,91
			Total unit price	218,80

Figure 4: Unit cost of cold premix.
Source: Adapted from [18].

In the cost composition of CBUQ, considering the same unit costs of the PMF, the figure is R $ 120.34, as

shown in Figure 5. However, it is noted that the unit of execution of this coating is in ton. Therefore, when making the conversion, considering its density around 2.4 t / m3, we found a total unit price of R $ 286.52, which is slightly more expensive than the PMF service.

DNIT – Road Cost System			Road Construction	SICRO 2
Reference Unit Cost	Mês: November/2016		AMAZONAS	RCTR0320
2 S 02 540 51 – CBUQ – bearing cover AC/BC			Team Production: 75,00 t	*Real Values*
			Custo Unitário de Execução	09,22
Auxiliary Activities	Quant	Uni	Unit price	Unit cost
1 A 01 390 52 – CBUQ machining (bearing cover) AC / BC	1,00	t	80,37	80,37
			Total cost of activities	80,37
			Total direct unit cost	89,59
			Indirect Income and Expenses (34.32%)	30,75
			Total unit price	120,34

Figure 5: CBUQ unit cost.
Source: Adapted from [18].

Costs between coatings do not have a high price difference, so it is a variable that does not give much weight when choosing between the two mixtures.

4.2 PMF Behavior as Coating

As we have seen from the theoretical foundation, cold premixed asphalt mix comes as a good alternative in paving because of its ease of application, lower costs than other coatings, among other advantages.
Despite being a more basic mixture, this asphalt coating, as emphasized by Vieira [15] and ABEDA [13], has a high roughness allowing a higher quality in relation to the grip of the tires with the rolling surface. In addition to being easy to produce, store, transport, apply and handle in the field, it is an ideal solution for roads where vehicle traffic is light or medium.
Regarding hot asphalt mixtures, the main advantages of using cold premix, according to Batista [21], begins with the need not to heat asphalt binder and aggregates for its manufacture and application on site. And because they are manufactured and applied at room temperature, they bring advantages such as: reduction of pollutant emissions, possibility of less complex mobile preparation plants, which provides a reduction of costs and transportation in works, as well as easier use of local aggregates. .
It is also possible to highlight its good affinity with any type of aggregate, which enables the use of wet aggregates, avoiding the waste of fuel to dry them and allows storage at room temperature in simple installations, thus avoiding the risk of fire and explosion [22].
However, despite its many advantages, PMF is still limited in its applications because depending on the traffic load on the road, its use may not be as beneficial as using CBUQ. For hot-machined concrete, PMF deteriorates and ages faster and its strength develops more slowly [15]. In order to opt for the use of one or another one must take into account the project criteria, its destination and the available resources.
For [22], there should be three main concerns about PMFs, namely: the high porosity of their compacted

mixture, the low initial resistance due to water of their composition and the long cure time caused by water evaporation and volatiles, and must be exceeded to achieve their maximum performance.

4.3 Feasibility of PMF use in COARI

The city of Coari is 463 km from Manaus by water and is bordered by the Solimões River. It is only accessible by air or water, with no connection to the national road network or neighboring cities [23]. According to [24], only 21.3% of the population has urban dwellings on public roads with adequate urbanization, containing manhole, sidewalk, paving and curb.

According to the [25], the city has a road network of 50 km of paved roads and 60 km of its 15 back roads. Currently, in 2019, Coari Prefecture has been doing asphalt resurfacing work throughout its road network, as shown in Figures 6.

Figure 6: Resurfacing in Coari Street.
Source: [25]

As it is a municipality with few inhabitants in relation to the capital and not having such a heavy vehicle traffic and assuming that the volume of public transport and cargo traffic is also light, asphalt pavement using cold premixed it's viable. As stated earlier, PMF is more effective on light and medium traffic roads, and the low cost and ease of transport and application of PMF would make it more applicable in the city than other more complex coatings.

Another observation to be made is regarding the climate, being a city of tropical climate, the ambient temperature is favorable to the execution of paving with cold asphalt mixture that needs to be executed at temperatures above 10 ° C. However, the downside is the city's rainfall, which is high throughout most of the year with Coari rainfall averaging 2290 mm, according to Climate-data.org [26].

5 Final Considerations

The use of cold premixed asphalt is still being applied more in layers of regularization and reinforcement of pavement structure than as asphalt coating. This as a coating is best used on roads where traffic demand is not so demanding, having the job of providing safety and comfort to users.

This research aimed to analyze the feasibility of using PMF in Coari, taking into account its characteristics

as coating and the advantages and disadvantages of its application, comparing the costs required with hot-machined concrete. When this comparison occurs, PMF only lags behind its slow development of resistance, its low efficiency on heavy roads and faster aging and wear, as in other respects PMF comes out ahead. These advantages make it possible to use cold premix in cities that want to pave and do not have as many technological or financial resources. Therefore, in view of the aspects mentioned during the work, it is concluded that when well designed and well executed, cold premixed asphalt can be used both as a reinforcement of the pavement structure and as a coating on low and medium roads. traffic demand.

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