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Analysis of the characterization of the adhesion property in intermediate layers of asphalt pavement

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A B S T R A C T

The present study analyzes the characterization of adhesion properties in intermediate layers of asphalt pavement, a critical factor influencing road durability and performance. The research is based on a systematic review of scientific literature, highlighting different methodologies for evaluating interlayer bonding, experimental tests, and international standards such as AASHTO, ASTM, and MTC regulations. A comparative analysis was conducted between samples obtained from the "Improvement of the Santa Maria - Santa Teresa - Hydroelectric Machu Picchu Bridge Road" project and laboratory simulations using the LOTTMAN test. The results demonstrate that the amount of tack coat significantly affects interlayer adhesion. Experimental tests confirmed that a tack coat application rate of 0.4 l/m² provides optimal indirect tensile strength (TSR) values, improving mechanical bonding between asphalt layers. Moreover, findings indicate discrepancies between laboratory simulations and real-world construction data, emphasizing the need for field verification to ensure adherence to project specifications. The study concludes that optimizing tack coat application techniques is crucial for enhancing pavement structural integrity. Future research should focus on refining non-destructive testing methods, such as the Falling Weight Deflectometer (FWD), to evaluate interlayer adhesion in situ. Establishing standardized adhesion evaluation protocols will contribute to more durable and cost-effective pavement infrastructure.

1. Introduction

The study by the National Institute of Roads has identified that at the international level, the drastic increase in the population has been increasing the construction of pavements, which represents an important positive impact on the development of the country, in order to meet part of the needs of the population and also favors socioeconomic growth; but they also have a negative impact on the environment, this because asphalt pavements release toxic gases in their preparation and placement; generating losses of material properties and reducing service life,(INVIAS, 2022)**.** At present, the development of each country depends mainly on road transport, which allows the generation of economic, social, cultural benefits, etc., in different cities of the territory. The latest studies indicate that billions of dollars are spent each year on road rehabilitation and maintenance; as well as irrecoverably lost man-hours, generating increased costs and unstable road conditions that endanger our comfort and safety, according to the Supervisory Body for Investment in Public Transport Infrastructure[1].

In 2012, the Ministry of Transport and Communications (MTC) prepared a report on Peru's roads, examining according to the National Road Network regime to assess road conditions. Their findings showed that of the 100% (26,017.17 km) of road, only 48% (12,444.93 km) is paved, 9% (2,421.23 km) planned, and 43% (11,150.91 km) unpaved. It is worth mentioning that the roads are in charge of the MTC, while the urban pavements are inspected by the Ministry of Housing, Construction and Sanitation (MVCS), it is estimated that between 65,000 and 130,000 kilometers of asphalt pavements are

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under the supervision of the municipal, district or provincial governments, however the Peruvian State has the responsibility for the conservation of 239,000 kilometers of neighborhood roads. according to the guidance of the MTC or the MVCS[3].

A study conducted in China by the School of Roads at Changan University aimed to examine the mechanical principles of interlayer bonding failure by analyzing the K-value in order to suggest a feasible parameter[4]. Their research took into account cutting, tensile, torsion tests to meet mechanical parameters. According to their research, increasing the traffic load, the bonding properties between layers even increase the load and durability. They commonly classify cut-off, start-up, and torsion tests to analyze influencing factors. Therefore, it is recommended to apply an adhesion layer to conditions of high surface texture, dry, clean and good compaction. However, it is necessary to deepen the mechanical analysis of the failure of the intermediate layer and the relationship between the various elements that have influence. Some et al.[5] indicate that asphalt pavement is composed of several layers, which is why it is essential to ensure the durability of the soil structure by joining interfaces. Layers that do not adhere can lead to early deterioration of the surface layers due to the poor distribution of mechanical loads that traffic exerts on the base layers. Adhesion depends on several factors such as the placement temperature and the use of asphalt emulsions to achieve a uniform structure. The results were based on the elaboration of graphs mainly of concrete resistance, using the principle of frequency-temperature superposition (FTSP), concluding that the increase in the size of the samples significantly increases both the shear strength and the shear stiffness and decreases the shear energies. Biglari et al.'s[6] paper focuses on examining the bond strength that occurs between a combination of sand and asphalt used as a coating, which was properly compacted using a roller (RCC). The sample under consideration consists of four different types of bonding layer, including the one that was modified using ground rubber (CMR), the 60/70 grade binder, the slow-setting cationic emulsion (CSS), and the fast-graded cationic emulsion (CRS). For the analysis, different proportions of these materials were used, these being 200, 400 and 600 g/m^2. The surface temperature used during the experiment was 60 °C, with the main objective of the study being to analyze the effect that temperature has on the adhesion strength. The report by Covey et al.[7], analyzed the performance of emulsions designed to reduce tracking and increase shear strength between layers (ISS). CSS-1H emulsions are the most commonly used slow-setting grades in Oregon, and therefore newly developed emulsions were compared to them. The analysis indicated that there is a positive correlation between the rheological tests and the ISS of the field cores. Using the results of simple rheological experiments, a linear equation was generated to predict the ISS in situ. The results showed that the texture of the pavement surface did not have a significant effect on the ISS, but environmental and traffic factors did affect the ISS to some extent. In conclusion, there is a need to generate unified guidelines on quality control and quality assurance (QC/QA) of the garter layer and construction practices.

Delbono et al.[8] explain that pavement is composed of several layers that can be built with different materials. Displacements between layers are a major cause of cracks, because if there is not adequate adhesion between layer joints, the layers become weakened, leading to early cracking and deformations more easily in fluid traffic due to the internal energy of the material. This can cause fatigue problems and cracks that spread from the surface to the inside of the pavement. The research focused on improving the cohesion between the different substrates using geosynthetic materials and asphalt emulsions, considering the placement point to avoid damaging the pavement surface. The results show that adhesion is positively or negatively influenced depending on the type of geosynthetic material and substrate used. It is concluded that these findings can contribute to improving the durability and resistance of the pavement. Chun et al.[9], in their article, aimed to analyze the impact of various adhesion situations between the layer in critical parts of the pavement, taking into account its performance and durability. For its analysis, the finite element technique (FEA) and large-scale field tests were used. The results showed that the pavement had the ability to accurately foresee the variation of the critical responses located between the junctions of the layer, in addition to an adequate adhesion that positively influences the asphalt deformation, which translates into good structural benefits in the performance of the pavement. In this context, Canestrari et al.[10], indicated the cohesion between layers of the asphalt pavement interfaces, where the evaluation of the effects, in terms of stress-strain distribution, produced by traffic loads on road infrastructures is recognized. The results of the experimental research are presented with a preliminary overview of the basic elements, test methods, and experimental investigations on layer-bonding. The first layer of pavement was installed without using interface treatment, while the others were laid in two different emulsion types. This study involved fourteen laboratories from 11 countries carrying out torsion or shear tests. The results of this analysis are presented in terms of accuracy and correlations with respect to parameters, which provides valuable information to adhesion tests between the different layers of asphalt pavements.

In this review, the focus is on different methods for evaluating interface bonding, which is the key to creating materials with exceptional mechanical properties. The researchers have conducted tests both on-site and, in the lab, to measure the performance of the bond between layers, giving them a broader perspective on the subject. Overall, the purpose of this study is to propose a standard interlaminar junction testing procedure that can be used in all industries. Due to the causes explained above, the following question arises in this study: How do the characteristics of the adhesion properties influence intermediate layers of asphalt pavement? This study was carried out because there is little research related to the adhesion properties between intermediate layers of asphalt pavements, which is why through a systematic review it is intended to collect information to establish bases for future studies and obtain more accurate data.

Based on this, samples and tests will be obtained from a project that is currently being carried out; generating at the same time a simulation of samples in the laboratory to visualize the components and behavior of pavements in our country. Adding to the systematic collection of data in the good pro of the study over time.

2. Materials and methods

2.1 Materials

The present research was carried out by comparing the samples of the project versus the simulation of samples carried out in the laboratory, related to the adhesion between the asphalt layers (LOTTMAN Method).

2.2 Methods

The present research aims to analyze the characterizations of the adhesion property in intermediate layers of asphalt pavement. The study is considerable; with an explanatory level methodology, since it was characterized by collecting information from two or more samples to observe and analyze the behavior it presents. An experimental design allows the evaluation of the causes and effects of the variables on another within a study. An experimental level methodology is used, which is why the data obtained from the project is developed and presented in comparison to the execution of data in the laboratory.

First stage: search for information

Initially, it seeks to collect data about the characteristics of the pavement, taking into account the adherent properties between intermediate layers of asphalt pavements for the feasibility of the objective.
To carry out the experimental work, manuals and regulations were used as support, such as: AASHTO STANDARDS, ASTM STANDARD, MATERIALS TESTING MANUAL (MTC).

Second stage: Development of the Laboratory Simulation Work:

To carry out the tests in the laboratory, the specifications and results obtained from the Technical File of the Project in question were taken as a basis, the execution sequence is detailed below:

League Irrigation

Bond Irrigation is performed for the necessary adhesion and to ensure that the new asphalt layer located on the existing structure acts together as a single system in the distribution of traffic loads to the pavement structure (monolithic behavior). Because of this, it is necessary to ensure good construction practices in order to ensure uniform bond irrigation with total coverage of the intervention area, ensuring adequate adhesion in the area. the interface and, in this way, the overall performance of the flooring. In **Table 1** we can see the application material for the laboratory work was:

Asphalt cement 40/50; 60/70; 85/100 on 120/150.
CSS-1h slow-breaking cationic emulsion diluted in water.
CRS-1 OR CRS-1h fast-breaking cationic emulsion.

Table 1. Inclusion and exclusion criteria

Asphalt Material	Guy	Quantity (l/m2)
Asphaltic Cement	40/50; 60/70; 80/100 or 12/150	
Cationic Slow Break Emulsion Diluted with	CSS-1 o CSS-1h	
Fast-breaking cationic emulsion	CRS-1 o CRS-1h	

Approach to the test to determine the adhesion of asphalt formed in two layers (Asphalt Pastes)

Enabling of Pastures by LOTTMAN Method: The molding of the pastures was carried out with the percentages determined by the Lottman method design of asphalt, approving the number of molded pastes that were 08 units, in order to make the simulation of league irrigation with the following rates: 01, 02, 03 and 0.4 l/m2.

Table 2. Dosage table Irrigation of the League

DESCRIPTION OF TESTS	Unit	(A)	(B)	(C)	(D)
1. Sample Number	No.	**1**	**2**	**3**	**4**
2. Dosage	l/m2	**0.1**	**0.1**	**0.2**	**0.2**
3. Asphalt Weight	Gr.	0.813	0.814	1.58	1.59
4. Area del Paston	cm2	**81.28**	**80.34**	**80.45**	**80.87**
5. Spreading Range	g / cm2	0.010	0.010	0.020	0.020
6. Spreading Range	Kg / m2	0.100	0.101	0.196	0.197
7. Spreading Range (6) / Grav. Specif. Pen 80 -100	L/m2	0.10	0.10	0.19	0.19
8. Temperature Corrected Range (6) x 1.010	L/ m2	0.10	0.10	0.20	0.20
9. Average Measured Spread Range	L/m2	**0.10**		**0.20**	
SPECIFICATION:		**0.1 - 0.4 l/m2**			

Table 3. Dosage table Irrigation of the League

DESCRIPTION OF TESTS	Unit	(A)	(B)	(C)	(D)
1. Sample Number	No.	**5**	**6**	**7**	**8**
2. Dosage	l/m2	**0.3**	**0.3**	**0.4**	**0.4**
3. Asphalt Weight	Gr.	2.40	2.45	3.20	3.25

Table 3. Dosage table Irrigation of the League (Continued)

DESCRIPTION OF TESTS	Unit	(A)	(B)	(C)	(D)
4. Area del Paston	cm2	**80.72**	**80.98**	**81.00**	**80.81**
5. Spreading Range	g / cm2	0.030	0.030	0.040	0.040
6. Spreading Range	Kg/m2	0.297	0.303	0.395	0.402
7. Spreading Range (6) / Grav. Specif. Pen 80 -100	L/m2	0.29	0.30	0.39	0.40
8. Temperature Corrected Range (6) x 1.010	L/ m2	0.30	0.30	0.40	0.40
9. Average Measured Spread Range	L/m2	**0.30**		**0.40**	
SPECIFICATION:		**0.1 - 0.4 l/m2**			

Application of Bond Irrigation for Adhesion Between Pastures

Fig. 1. Application of the ligator irrigation with 0.1 l/m2

Fig. 2. Adherence of the two pastes

Fig. 3. Application of the ligator irrigation with 0.2 l/m^2

Fig. 4. Placement of the dough for adhesion

Fig. 5. Application of the ligator irrigation with 0.3 l/m^2

Fig. 6. Placement of the dough for adhesion.

Fig. 7. Application of the ligator irrigation with 0.4 l/m^2

Fig. 8. Placement of the dough for adhesion.

The application of Bond Irrigation and the placement of the pads for adhesion comply with the technical standards ASTM D-2027 and AASHTO M-82.

Compaction test by Means of a concrete press taking into account the Mtc E - 513 standard

Fig. 9. Compaction Rate 0.1 l/m2 kgf. 30 KN

Fig. 10. Compaction Rate 0.2 l/m2 kgf. 30 KN

Fig. 11. Compaction Rate 0.3 l/m2 kgf. 30 KN

Fig. 12. Compaction Rate 0.4 l/m2 kgf. 30 KN

Fig. 13. Group of pastons enabled for the Lottman test

LOTTMAN method test on pastures conditioned with different league irrigation rates

This test method is used to evaluate the effects of saturation and accelerated conditioning in water with a freeze-thaw cycle of compacted asphalt mixtures.

This test method allows the visual evaluation of the detachment of the asphalt cement added in the asphalt mixture.

This method is carried out respecting the cycles and days of the test so that its results are not variable.

The Lottman test can only be performed when a final design is available.

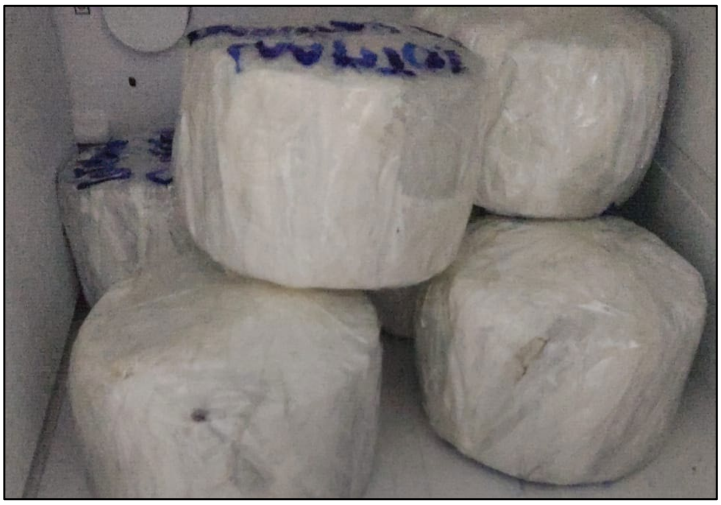

Fig. 14. Preparation of the pastes for the Lottman test for the freeze-thaw cycle

Fig. 15. Rice Test and Samples in the Bain-Marie to start with the Lottman rupture tests

Fig. 16. Lottman test of conditioned briquette breakages with different league irrigation rates.

Fig. 17. Asphalt pastones carried out by the Lottman test

The tests were prepared and comply with the following regulations:

- MTC E-22: RESISTANCE OF COMPACTED ASPHALT MIXTURES TO MOISTURE-INDUCED DAMAGE.
- AASHTO T 283: RESISTANCE OF COMPACTED ASPHALT MIXTURES TO MOISTURE - INDUCED DAMAGE.
- ASTM D4867/D4867M-22: STANDARD TEST METHOD FOR EFFECT OF MOISTURE ON ASPHALT MIXTURES.

3. Summary of data according to the project

The samples obtained were from the project: “IMPROVEMENT OF THE SANTA MARIA - SANTA TERESA - MACHU PICCHU HYDROELECTRIC BRIDGE” HIGHWAY

Table 4 shows that for the adhesion study, the analysis was carried out using the LOTTMAN test, obtaining positive and acceptable results for the project in execution. The Indirect Tensile Strength (TSR) ratio, whose value is obtained from the ratio between the Average Stress at Tension of the Conditioned Subgroup and the Unconditioned Subgroup, was 83.0%, thus complying with the Conserved Strength in accordance with MTC E-522, AASHTO T 283 and ASTM D 4867, minimum TSR = 80%.

Table 4
Study of the project in intervention

				SAMPLE DATA				
BITUMEN:	PEN 85/100	**ADDITIVE:**	0.5% QUIMIBOND 3000		**ASPAVING CONTENT:**		5.8	%
				DRY			WET	
Item	**N° Specimens**	**And.**	**1**	**2**	**3**	**7**	**8**	**9**
1	Diameter	Cm	10.087	10.144	10.122	10.097	10.055	10.121
2	Thickness	Cm	6.702	6.826	6.815	6.844	6.876	6.839
3	Briquette Weight in the Air	Gr.	**1237.7**	**1226.7**	**1238.7**	**1233.1**	**1227.2**	**1233.2**
4	Saturated Briquette Weight	Gr.	**1243.8**	**1229.8**	**1245.2**	**1237.7**	**1232.4**	**1237.6**
5	Briquette Weight in Water	Gr.	**702.1**	**691.5**	**704.2**	**699.6**	**694.9**	**700.2**
6	Briquette volume per offset = (4-5)	cc.	541.7	538.3	541.0	538.1	537.5	537.4
7	Specific Bulk Weight of Briquette = (3/6)	gr/cc.	2.285	2.279	2.290	2.292	2.283	2.295
8	Specific Gravity Maximo - Rice (ASTM D 2041)	gr/cc.	**2.459**	**2.459**	**2.459**	**2.459**	**2.459**	**2.459**
9	% of Voids = (8-7)x100/8 (ASTM D 3203)	%	**7.1**	**7.3**	**6.9**	**6.8**	**7.2**	**6.7**
10	Void Volume (9*6)/100	cc	38.4	39.5	37.3	36.7	38.5	35.9
				SUBJECT TO SATURATED CONDITION				
11	Saturated Briquette Weight	Gr.				**1257.8**	**1255.0**	**1256.5**
12	Briquette Weight in Water	Gr.				**717.7**	**715.3**	**718.3**
13	Briquette volume per offset = (11-12)	cc.				540.1	539.7	538.2
14	Absorption Water Volume = (11-3)	cc.				24.7	27.8	23.3
15	Saturation = 100*14/10	%				67.3	72.2	64.8
				Ambient Temperature Condition			**Freezing phase at -18°C for 16hFollowed by 24h in water at 60°C + 1h 25°C**	
16	Thickness	Cm				6.637	6.697	6.711
17	Saturated Briquette Weight	Gr.				**1244.6**	**1241.8**	**1242.0**
18	Briquette Weight in Water	Gr.				**687.4**	**687.1**	**688.5**
19	Briquette volume per offset = (17-18)	cc.				557.2	554.7	553.5
20	Absorption Water Volume = (17-3)	cc.				11.5	14.6	8.8
21	Saturation = 100*20/10	%				31.3	37.9	24.5
22	Swelling = 100*(19-6)/6	%				3.55	3.20	3.00
23	Indirect Tensile Strength	medical history.	**408**	**418**	**442**	**343**	**352**	**339**
24	**Dry Resistance = (2*23)/(PI*1*2)**	**kg/cm2**	3.8	3.8	4.1			
25	**Moisture Resistance = (2*23)/(PI*1*16)**	**kg/cm2**				3.3	3.3	3.2
				No Conditioned			**Conditioned**	
				3.9			**3.3**	
			TSR		**83.0%**			

Summary of data according to the laboratory simulation:

Table 5
Assimilated laboratory analysis study

PRACTICE	**And.**	**Irrigation of the League 0.1, l/m2**		**Irrigation of Liga, 0.2, l/m2**		**Irrigation of the Rubber Zone 0.3, l/m2**		**Irrigation of the Rubber Zone 0.4, l/m2**	
		DRY	WET	DRY	WET	DRY	WET	DRY	WET
		1	1	1	1	1	1	1	1
% of Voids = (8-7)×100/8 (ASTM D 3203)	%	7.5	7.2	6.9	6.5	7.7	7.8	7.9	7.3
Void Volume (9×6)/100	cc	44.4	43.2	40.9	38.5	46.9	47.2	48.4	44.1
Saturation = 100×14/10	%	--	**70.6**	--	**66.3**	--	**64.6**	--	**67.4**
Dry Resistance = (2×23)/(PI×1×2)	**kg/cm^2**	**2.8**	--	**2.9**	--	**3.0**	--	**3.1**	--
Moisture Resistance = (2×23)/(PI×1×16)	**kg/cm^2**	--	**1.9**	--	**2.0**	--	**2.1**	--	**2.4**
TSR		**67.72%**		**68.57%**		**72.57%**		**76.06%**	

Table 5 shows that by analyzing the tests by the LOTTMAN method of the samples tested in the laboratory, it is indicated that with a greater amount of bond irrigation, the percentage of the indirect tensile test result (TSR) is improved. Compared to the data obtained from the Technical File of the project in question, the results are negative, as they are outside acceptable parameters in accordance with MTC E-522, AASHTO T 283 and ASTM D 4867 Standards. This research thus demonstrates the difference between data obtained in the laboratory and the data that are actually reflected in the works.

4. Results

In the summary table, it has been shown that with a greater amount of bond irrigation, the results of the TSR (Relationship in Indirect Tensile Strength) are positively improved, since this test performs a diametrically shear stress on the asphalt paste, where it indicates that the aggregate and bitumen particles have good adhesion. Among the contact area with the bond irrigation, it was possible to visualize that there is adhesion between the two asphalt pastes and the most outstanding is the adhesion with greater bond irrigation, which in this case the optimal point was 0.4 l/m².

Table 6
Summary Lottman Trial with different of league irrigation

PRACTICE	And.	Irrigation of the League 0.1, l/m2		Irrigation of Liga, 0.2, l/m2		Irrigation of the Rubber Zone 0.3, l/m2		Irrigation of the Rubber Zone 0.4, l/m2	
		DRY	WET	DRY	WET	DRY	WET	DRY	WET
		1	1	1	1	1	1	1	1
% of Voids = (8-7)×100/8 (ASTM D 3203)	%	7.5	7.2	6.9	6.5	7.7	7.8	7.9	7.3
Void Volume (9×6)/100	cc	44.4	43.2	40.9	38.5	46.9	47.2	48.4	44.1
Saturation = 100×14/10	%	--	**70.6**	--	**66.3**	--	**64.6**	--	**67.4**
Dry Resistance = (2×23)/(PI×1×2)	**kg/cm^2**	**2.8**	--	**2.9**	--	**3.0**	--	**3.1**	--
Moisture Resistance = (2*23)/(PI×1×16)	**kg/cm^2**	--	**1.9**	--	**2.0**	--	**2.1**	--	**2.4**
TSR		**67.72%**		**68.57%**		**72.57%**		**76.06%**	

5. Discussion

In accordance with the general objective which is to determine the characterization of the adhesion property in asphalt pavement interlayers in the last 10 years, it is verified that the accurate characterization of the adhesion property becomes a necessity as concerns about failures between layers and materials increase, According to the authors, they explained that the properties will change according to the load capacity and durability, taking into account the pathologies of cracking, slippage, disunion and deformation. In his study, he suggests choosing the adhesion rate to apply it on surfaces with high, dry, clean textures and good compaction, however, it is necessary to deepen the analysis of the failure mechanism of the intermediate layer and the interaction between the different factors[4]. The study by Some et al.[5], indicates that the most important properties are asphalt, asphalt emulsions, asphalt emulsions, asphalt shear shear emulsion asphalt shear emulsion asphalt shear adhesion shear shear adhesion shear shear adhesion demonstrating that increasing sample sizes significantly depend on both shear strength and shear stiffness and decreases shear energies. According to the tests carried out and carried out in the laboratory, we could say that with a greater amount of league irrigation, the TSR values of asphalt grasses are improved, since the positive adhesion values are checked. Shear testing has become the predominant method for evaluating the bonding qualities between interlayers, regardless of whether normal stress is applied or not. Nonetheless, there has been a growing push towards the development of non-destructive testing techniques capable of field testing, which is expected to be a key area of development in the future. Across the range of non-destructive testing, the Drop in Weight Deflectometer (FWD) has become the most widely used tool for measuring the deflection of pavements. The popularity of FWD can be attributed to several advantages it offers, including a shortage of labor and cost requirements, rapid testing operation, and the ability to detect a greater number of points. Importantly, FWD has gained worldwide recognition as a standard test method[11].

6. Conclusion

In the last forty years systematic research has been carried out on the bonding property between layers, which is important due to the constant increase in traffic. To delve deeper into this property, this review focuses on its characterization in different areas, including mechanics, the influence factor, the experimental, which includes the simulation of laboratory tests and the results of the project in question. At present, the shear test is widely used to estimate the strength of the joint. One way to carry out this test is through the interlayer shear test, which can more closely simulate the realistic failure of the interlayer, as well as having a simple operation. Other test equipment has been developed based on different purposes and charging modes. A future trend is the development of non-destructive testing to evaluate the performance of the bond between layers. Most non-destructive methods rely on propagating waves with a frequency greater than 20 Hz on asphalt pavement, which can be done on site without causing damage. On the other hand, the most common device used for pavement deflection testing is the FWD test. Future work in this field will focus on improving the repeatability of test results as well as accuracy in the evaluation process of rigid pavement structures, which is a major concern. The bond between layers of a material can be influenced by multiple factors, such as the properties of the material itself, the construction conditions, and the type of samples used, among others. In the field, the influence of these factors can be more complex than in the laboratory. The coating rate has been the subject of numerous studies, this rate must meet the optimal performance and cost requirements. In some studies, it has been found that optimal performance can be achieved without adding a layer of adhesion. In addition, the curing time may not significantly affect the bonding property between layers. Therefore, the standardized evaluation of the bond between layers requires considering various influencing factors and using suitable test equipment.

To improve the durability and reliability of the bond, it is strongly recommended to carefully consider the application rate of the bonding layer and ensure that the surface is clean, dry, has sufficient friction, and is well compacted. In addition, in order to accurately evaluate and measure the bond strength, it is crucial to establish specific test methods and evaluation parameters that allow for a better characterization of the joining process in future projects. By doing so, optimal joint performance and long service life can be achieved. The test implemented in the laboratory execution has been able to indicate that the greater the amount of bond irrigation, the positive results are obtained in the results of the indirect tensile test (TSR), since this test performs a diametrically shear stress to the asphalt pastures, in which it is indicated that the particles of the aggregate and bitumen, correct adhesion is obtained.

According to the bond irrigation and the contact area between the asphalt pastures, it was possible to verify that the higher the value of the bond irrigation, the greater the adhesion, concluding that the optimal bond irrigation is 0.40 l/m². An evaluation is carried out with the results of the Lottman design test, prepared by laboratory simulation and the result obtained from the Technical File of the project, there is a difference since with these results it would not be complying with what is determined in the Technical File Section 423 asphalt concrete ("IMPROVEMENT OF THE SANTA MARIA - SANTA TERESA – GIDROELECTRICA MACHU PICCHU BRIDGE) ROAD, Resistance Retained in the AASHTO Indirect Tensile Test T 283 = 80 min. That is why it is recommended to carry out more in-depth studies on the works and projects today to obtain more realistic values. The contribution of this research has led to the study and understanding of the good adhesion properties in the intermediate layers of asphalt pavement, which is why through this research the performance of new analyses has arisen in order to obtain a more in-depth work that helps to highlight the data obtained in this study.

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