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Title	Theoretical design proposal for simulated hot asphalt mixture at a temperature below zero degrees Celsius
Item Type	info:eu-repo/semantics/article
Authors	Chávez, H.;Pezo, A.;Llerena, G.;Torres, V.
DOI	https://doi.org/10.1088/1757-899X/758/1/012059
Publisher	Institute of Physics Publishing
Journal	IOP Conference Series: Materials Science and Engineering
Rights	info:eu-repo/semantics/openAccess
Download date	2026-11-28 00:46:39
Item License	http://creativecommons.org/licenses/by-nc-sa/4.0/
Link to Item	http://hdl.handle.net/10757/651795

IOP Conference Series: Materials Science and Engineering

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To cite this article: H Chávez *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **758** 012059

View the article online for updates and enhancements.

This content was downloaded from IP address 190.237.122.103 on 27/04/2020 at 16:13

IOP Conf. Series: Materials Science and Engineering **758** (2020) 012059 doi:10.1088/1757-899X/758/1/012059

Theoretical design proposal for simulated hot asphalt mixture at a temperature below zero degrees Celsius

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Abstract. In the world there are adverse climates, climates that hinder the good construction and paving of roads, generating insecurity among the locals and visitors. This over time affects the economy of a country, as a road boosts tourism, transport and commerce. Therefore, a mixture was designed to mitigate a problem in the placement of hot asphalt mixture at temperatures below zero degrees Celsius. That is, a conventional mix design was proposed, but with different types of filler (lime, Portland cement type I and silica) tested with the Marshall and Lottman method which are governed according to the EG-2013 standards [1] and parameters established in the Asphalt Institute [2]. To find the optimum, it was tested with 5.0%, 5.5% 6.0% and 6.5% asphalt cement. Then with the results obtained a comparative analysis was performed. Finally, specimens without any additives were made, the specimens once prepared at 140°C were subjected to freezing, resulting in the three types of filler, that the hot asphalt mixture with incorporation of Portland cement type I to a 5, 90% of asphalt cement is the optimum since, subject to extreme temperatures below 0ºC they comply with the parameters required in the standards.

Keywords. Marshall methodology, quality tests (Lottman), filler percentage, combination of aggregates, optimum asphalt content (C.A) and EG-2013 (Manual of General Technical Specifications for Construction in Peru).

1. Introduction

A big problem in places where there are climates of temperature below zero, is the decrease of the productivity of the projects during the process of placing hot asphalt mixture, where the temperature can vary in a matter of minutes and remain below 0ºC during all the day, which represents a restriction for the placement of hot asphalt mixture (MAC) in cold climates that is stipulated in the normal EG-2013 [1],

According to the researcher Javier Reyes, who analyzed the variations in the temperature of asphalt mixing observed that the placement of a mixture at temperatures below zero results in segregation, micro fissures, undulating surfaces, tears and especially changes in mechanical and dynamic properties of the mixture [3], thus decreasing the life time of the asphalt folder.

All the development of the research was in the collection of information and laboratory tests that demonstrated the design of optimal hot asphalt mixture that meets the established parameters.

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2. Materials and Design

2.1. Materials

- **Selection of coarse and fine aggregates**

Figures 1 and 2 show the aggregates that have been used for the preparation of the asphalt mixture, these have also been washed and dried to perform the tests and are free of impurities to show their optimal behavior.



Figure 1. Crushed sand without humidity.



Figure 2. Thick Aggregate ¾" and Medium Aggregate 3/8" dried

- **Filler selection.**

The three types of filler (Portland cement type I, lime and silica) have been selected for research due to their physical and chemical characteristics in the hot asphalt mixture design. See figure 3.



Figure 3. The filler has been selected according to its composition, lime and portland cement type I for being oxidants and silicas for being mineral with properties similar to lime [1].

- **Asphalt Cement Selection (C.A)**

For the selection of asphalt cement it was verified that they can have an optimum performance and abrasion with the aggregates, therefore, in accordance with the parameters of the standards for the design, asphalt cement 85/100 was used. See figure 4.



Figure 4. Asphalt cement 85/100 was selected according to reference of Standard EG-2013 [1] and for the accessibility of getting on the market.

- **Marshall Methodology. -** It delimited the optimum content, stability, percentage of voids and resistance to compression of asphalt cement for a specific proportion of aggregates.

- **Lottman test. -** It determines the tensile strength of the specimens, measuring the loss of cohesion of a compacted mixture as a result of the effects of accelerated saturation in water.

2.2. Design

- The procedure consists in selecting the gravel aggregates at 48% (3/4" and 3/8"), sands (Crushed and Fine) at 50% and filler at 2%. This is placed in the oven at a temperature of 140°C.

- In figure 5 it can be seen that the outlet temperature of the asphalt mixture was taken from the oven. Also while the combined aggregates remain in the oven they are beaten evenly at a temperature of 140 ° C.

- Figure 6 shows the procedure of placing MAC (Hot Asphalt Mixture) in specimens.

- The specimens, as shown in Figure 7, have been placed freezing, this allows simulating the climates under 0 ° C to which they can be subjected during the placement of the asphalt folder.



Figure 5. Temperature verification.



Figure 6. MAC is placed left fresh from the oven in the Marshall test specimens, which are struck an average of 75 times around the mold.



Figure 7. The specimens are frozen for 24 hours. Simulating extreme climates where they can be placed [4]

For the Marshall and Lottman tests, the MAC is frozen to simulate cold climates (below 0ºC), this abrupt change in temperature so variant (from hot to cold) shows that this type of MAC can be applied since the tests have been frozen for more than 24 hours.

The freezing time of the MAC has been considered for the reason that it is desired to see the physical and chemical behavior of the design at temperatures below 0ºC, this generates a simulation in the MAC placement in the project [5].

3. Results and discussions

3.1. Results

In Table 01, Marshall's tests and the results obtained with the three types of filler are analyzed, only designs made with silica and cement comply with what is established according to the EG-2013 standard [6] and the asphalt institute.

Table 01. Analysis of MAC-2 by Marshall tests

Filler	Silica	Cement	Lime
%AC. Optimal (± 0.20)	5,8	5,9	6,0
% Vacuum with C.A.	78,2	81,6	87,6
Rigidity Index	3792	3840	3949
% of V.M.A	16,4	17,2	15,8
Stability	1371	1125	1385
Unit Weight kg / m3	2,383	2,39	2,419
% Air Vacuum	4,0	3,8	2,2
Flow (in.)	14,0	11,5	14,0

In Table 02 according to Lottman's tests and the results obtained with the three types of filler, only the designs made with cement and lime comply with what is established according to EG-2013 [1] and AASHTO T 283 standard [6].

Table 02. MAC-2 analysis by Lottman tests

Filler	Silica	Cement	Lime
Optimum% of C.A.	5,8	5,9	6,0
% Dry Vacuum	6,89	7,2	6,96
% Saturated Vacuum	6,73	7,3	7,2
Humidity Resistance (kg / cm2)	4,35	3,617	3,43
Dry Resistance (kg / cm2)	7,49	4,37	4,19
Retained Resistance (Adhesion)	58,08	82,75	81,72

3.2. Discussions

- In accordance with the parameters established by the asphalt institute and the EG-2013 standard [1] it is verified that of the materials used as filler in the tests, both silica and lime, do not meet certain restrictions such as lime in the percentage of vacuum with C.A. it has to be 87.6% and the limit according to the EG-2013 standard is 85%, so the percentage of air vacuum is 2.2% and the standard allows us at least 3.0%.

- Silica has had many variations, compared with other results obtained with cement and lime, silica in the different tests (5.0%, 5.5%, 6.0% and 6.5%) the optimum that is has C.A. it is 5.8%, however, in some tests they do not meet the parameters required by the standard, so the optimal percentage of asphalt cement does not only meet the retained resistance (adhesion) which results in 58.08 and the minimum according to AASHTO T 283 [6] is 80.00.

4. Conclusions

- According to the results obtained and the comparative analysis performed with the different types of fillers, it is obtained that the hot asphalt mixture subjected to temperatures below 0ºC complies with all the parameters established by the EG-2013 standards [1], AASHTO T 283 [6] and the asphalt institute so that a hot asphalt mixture can be placed under these conditions [2].
- The results of the other types of filler (lime and silica), which do not meet certain conditions can be studied for other types of research since, with the use of some additive, they may meet the parameters required for the placement of hot asphalt mixture subjected to temperatures below 0 ° C.
- The results obtained from tables 1 and 2 show that it is possible to place MAC at temperatures below 0ºC, complying with the standards of conventional designs, so that higher production would be obtained, although in EG-2013 standard [1] there are restrictions where it says us that the minimum temperature of placement is at 6ºC in ascent.
- From the results in table 01, it was obtained that the hot asphalt mixture design with lime incorporation does not comply with the parameters mentioned in the EG-2013 standard in the properties of percentage of air voids. Therefore, the result obtained of 2.20% of air voids will generate a greater range of exudation and in turn this may disrupt the structural response to ice and thaw due to the increase in its density.
- In Table 02, it has been verified that the Lottman tests carried out on the asphalt mixture with silica incorporation do not comply with the restriction parameters of ASHTO 283 [6], so that this mixture will cause problems of adhesion and premature wear.
- The asphalt mix, with the incorporation of Portland cement type I as a filler, meets all the parameters established in the EG-2013 standard [1], with the best asphalt cement content of 5.90% the best mechanical behavior of the mixture was achieved, in addition that the briquettes have suffered a freezing of -20ºC, the results were obtained: Stability (1125 kg), Flow (11.5 - 0.01 ”), Density (2,338 gr / cm³), Retained Resistance (82.7%), and Resistance to Compression (3.0 Mpa). (3.0 Mpa).

5. References

[1] Ministry of Transportation and Communications; 2013; Road Manual “general technical specifications for construction”; (EG-2013); Vol. 1; Peru; Pag-1282.

[2] Asphalt Institute (1982); Manual of Principles of Construction of Hot Asphalt Mix Pavements MS-22. Lexington; U.S.

[3] Oscar Javier Reyes Ortiza, Javier Fernando Camacho Tauta, Fredy Reyes Lizcanob; March 5, 2006; Influence of the temperature and energy level of compaction on the dynamic properties of an asphalt mixture; Faculty of Engineering Magazine No. 36. pp. 121-130; Vol. 36; Magazine Faculty of Engineering Universidad Antioquia; Colombia; Page-9.

[4] M.I. Yelitza Ayala del Toro, Dr. Horacio Delgado Alamilla, Dr. Paul Garnica Anguas; April 7, 2016; Effect of Temperature on the Evaluation of Fatigue in Binders Vol. 18; Asphalt; Road Infrastructure Magazine / LanammeUCR / ISSN: 2215-3705; Mexico; Page-8.

[5] M. Sc Ing Lucia del Pilar Saez ALvan, 2015, PT-21 Pavements. Selection of main articles - 4.a; Mechanical Behavior of Asphalt Mixtures at Low Temperatures in the Altitude Regions above 3500 meters; Vol. 04; institute of construction and management; Peru- Lima (ICG); Page 421.

[6] American Association of State Highway and Transportation Officials (AASHTO); 2014; AASHTO T 283.