UNIVERSIDAD CATÓLICA SANTO TORIBIO DE MOGROVEJO

FACULTAD DE INGENIERÍA

ESCUELA DE INGENIERÍA CIVIL AMBIENTAL

Revisión Sistemática sobre la Evaluación de las Propiedades Físicas y Mecánicas de Pavimentos adicionado Fibras naturales y sintéticas

TRABAJO DE INVESTIGACIÓN PARA OPTAR EL GRADO ACADÉMICO DE BACHILLER EN INGENIERÍA CIVIL AMBIENTAL

AUTOR

Jose Fernando Montenegro Valle

ASESOR

Ronald Esteban Villanueva Maguiña

https://orcid.org/0000-0002-3707-5503

Chiclayo, 2023

TIB

INFORME DE ORIGINALIDAD

24%	22%	15%	4%
INDICE DE SIMILITUD	FUENTES DE INTERNET	PUBLICACIONES	TRABAJOS DEL ESTUDIANTE

FUENTES PRIMARIAS

1	www.scielo.br Fuente de Internet	3%
2	ria.utn.edu.ar Fuente de Internet	3%
3	www.mdpi.com Fuente de Internet	1%
4	www.journaltocs.ac.uk Fuente de Internet	1%
5	Jan Gebauer, Pavel Sofer, Martin Jurek. "The System for Fatigue Crack Propagation Detection Based on Machine Vision", 2021 22nd International Carpathian Control Conference (ICCC), 2021 Publicación	1%
6	Submitted to University of New South Wales Trabajo del estudiante	1%
7	revistas.uees.edu.ec Fuente de Internet	1%

umpir.ump.edu.my

Index

Resumen

En el presente artículo se intentó recopilar de diferentes revistas indexadas, información sobre el comportamiento del pavimento flexible y rígido, el pavimento flexible que está compuesto por una emulsión asfáltica que puede ser en frío o en caliente y el pavimento rígido que es el concreto.

Se presentan resultados de investigaciones en diferentes países como Colombia, China, Chile entre otras, se observa que muchas veces las fibras sintéticas favorecen a las propiedades mecánicas del pavimento flexible, como el epoxi que favorece a soportar altas temperaturas y dar impermeabilidad, se demostró que el dióxido de carbono es menor cuando sí incorpora pavimento reciclado además se demostró que la fibra de acero dentro del pavimento rígido mejora la propiedad de la flexión pero no favorece a la compresión.

Palabras clave: Fibras naturales, fibras sintéticas, propiedades de los pavimentos rígidos, propiedades de los pavimentos flexibles, propiedades físicas y mecánicas de los pavimentos, Repositorio de Obra Civil.

Abstract

In this article we tried to collect from different indexed journals, information on the behavior of flexible and rigid pavement, flexible pavement that is composed of an asphalt emulsion that can be cold or hot and rigid pavement that is concrete.

Research results are presented in different countries such as Colombia, China, Chile among others, it is observed that synthetic fibers often favor the mechanical properties of flexible pavement, such as epoxy that favors to withstand high temperatures and give impermeability, it was shown that carbon dioxide is lower when it does incorporate recycled pavement in addition it was shown that the steel fiber inside the rigid pavement improves the property of bending but It does not favor compression.

Keywords: Natural fibers, synthetic fibers, properties of rigid pavements, properties of flexible pavements, physical and mechanical properties of pavements, Civil Works Repository.

Introduction.

(Chen, y otros, 2022), According to the technological advances of our time, it allows to modify the elements and materials chemically making alloys and combining materials, so the technology in concrete has evolved very fast. Different researchers seek to propose designs of easy mixtures with better results in mechanical and economic physical properties, (Bellili, Aziz, Achab, Ammine, & Hamid, 2022) The main objective of this data analysis is to have a clearer view of the influence of fiber on the construction of some natural fibers and pozzolanas used in concrete to be able to relate them to hot asphalt.

Natural fibers

The topic related to the natural fibers incorporated into flexible asphalt, are scarce, then we will describe some fibers used in construction.

It is always sought to see the relationship between fiber and cement or concrete and its influence on the quality of the concretes is related. (Cuetara & Howland, 2018) Pozzolanas and fibers of natural origin are frequently used for the manufacture of mortars and concretes for a long time, in the same way he points out, (Vargas, Cerna, & Cuellar, 2020), that concrete which is also known as concrete is characterized by being a mixture of cement (binding material) with coarse aggregate (stone) and fine aggregate (sand) these 3 elements added with water make up a typical or traditional concrete mixture, when you want a mixture with specific properties such as greater workability, greater initial strength, With resistance to sulfates, with high compressive strength among others, pozzolanas or additives are added.

Synthetic fibers

The synthetic macro fibers are a substitute in the reinforcement of pavements which provides a better resistance behavior in addition to controlling the size of cracks or fissures, the pavement increases its flexion and ultimate load on slabs (Pombo, Altamirano, Giaccio, & Zerbino, 2022).

Polypropylene and steel fibers in concrete exposed to high temperatures are observed that the greatest advantages in strength are with thin fibers and not with thick fibers, the reduction of strength and surface cracking for different reinforced concretes was analyzed. (Balázs & Lublóy, 2017).

Synthetic fibers have also been used in concrete that are exposed to salts or sewage, and have given good results, so researchers Migliorini, Guimaraes, & Ozorio, (2017) They elaborated a concrete with steel fibers for maritime containment blocks, their experiment was based on comparing a concrete with steel fibers and another without steel fibers, both exposed for two years to the conditions involved in sea waves: such as harmful salts and abrasion, from this research I conclude that its durability of concrete depends on its confinement in the highly alkaline environment, That's why he recommends using concrete with steel fibers in tetrapod blocks in strategic, but not submerged, areas. The author (Zhao, Zhu, & Zhang, 2021) He states that the influence of graphene nanoplatelets inside concrete can not only improve chloride binding inside the cement paste but can also prevent chlorides from entering from the outside.

There are also proposed models where they are used to accurately predict the total stress-strain response of cement-based compounds containing hybrid combinations of metallic and synthetic fibers. (Abbas, Hussain, & Khan, 2021).

Using the acoustic emission technique, cracking processes, and loss of their mechanical properties of concrete can also be analyzed, with the aim of evaluating the effect of high temperatures on the breaking behavior of high-strength concrete beams with and without fibers(Xargay, Folino, Nuñez, & Gomez, 2018).

Systematic literature reviews and systematic mapping studies.

It considered the publications that have tested, basic properties both in concrete or pavements, where they have compared and had a standard sample without fibers or pozzolanas, then the name of the magazines or publishers is shown, because they were also considered books for the concepts.

Keywords: Natural fibers, synthetic fibers, properties of rigid pavements, properties of flexible pavements, physical and mechanical properties of pavements, Civil Works Repository.

Data base: As database to extract the articles were the following: Redalyc Org, Scielo, Google Scholar, Proquest.

Search Process : As a search process, the keywords mentioned above were used and placed between quotation marks, another search process was to place the filetype command, which was placed after the content between quotation marks, the AND connector, ISSN and aca-demic publications were also used; thus obtaining an initial total of approximately 55 articles found, but at the time of making the individual analysis of the articles, the same web page reduced to a final total of only 18 articles, specifying duplicity in some of the 55 articles initially shown. Finally, the articles were sorted by language.

Table 1. Names of journals and sources from which the information was collected.

Magazine or Editorial	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
ASCE library					1	
Safety Journal	1					
Biointerface Research in Applied Chemistry			1			1
Revista Ingeniería de Construcción		1				1
Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology			1			
Journal of Renewable Materials,						1
Hormigón y Acero		1				
Revista Materia	2	3				
RILEM Bookseries						1
Anales Científicos				1		
Construction and Building Materials				1		
Journal of Testing and Evaluation					1	

Discussion and development

(Xiang & Xiao, 2020) The epoxy materials inside the pavements generate properties favorable to the resistance of high temperatures, they also improve the stability to the movement of the asphalt, because epoxy resins have a three-dimensional crosslinking network that favors stability.

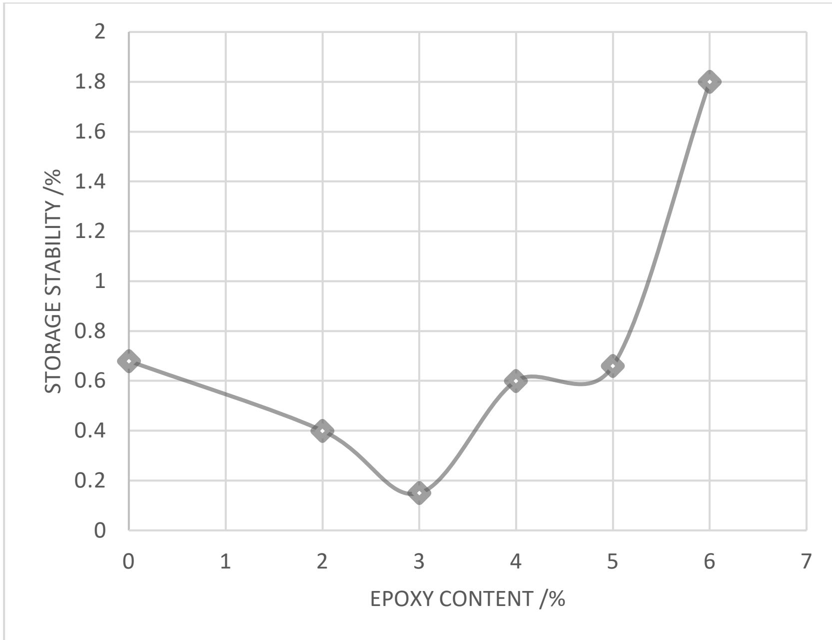


Figure 1. Storage stability of epoxy-emulsified asphalt with different epoxy contents

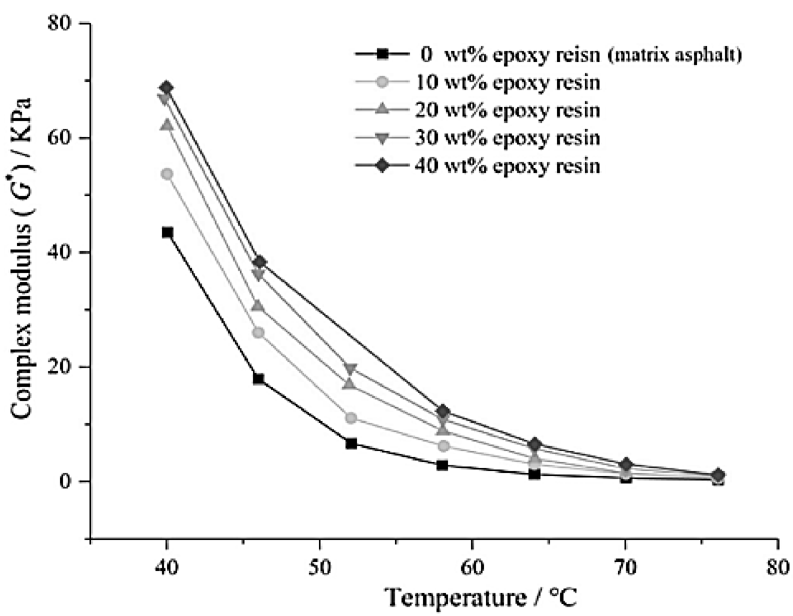


Figure 2. Complex module of epoxy emulsified asphalt

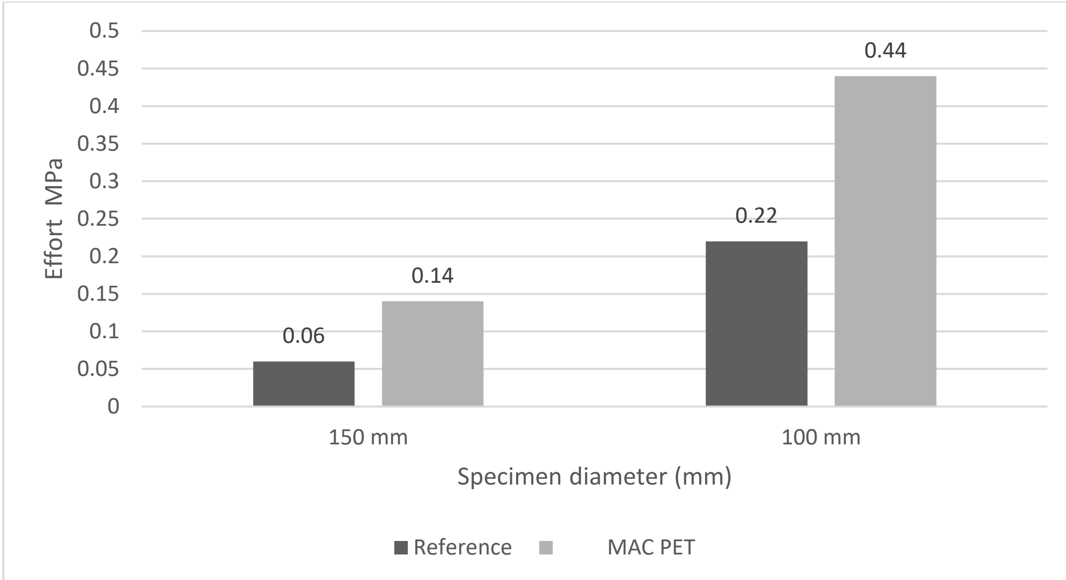
Table 2. Hot asphalt mixing, recycled pavement (Castro, Sabogal, & Fernández, 2022)

Hot Asphalt Mixing (AMF)	Recycled pavement content (%)	CO2 emission (pound/ton)
HMA1	0	164.5
HMA2	20	155.4
HMA3	20	130.5
HMA4	20	124.1
HMA5	20	117.5
HMA6	17	132.6
HMA7	0	150.3

(Delbono, 2019) To recover deteriorated concrete pavements, a reinforcement with geosynthetics was used. However, geosynthetic with concrete does not have adequate adhesion so a layer of conventional asphalt mixture modified with polymer as an adherent is proposed, good results were obtained.

Board 3. MAC PET adhesion with different mesh openings

Material	Interface load (kg)	Maximum strain load (mm)	maximum load deformación (MPa)	Work (kg.mm)
Reference	73.73	2.72	0.06	141.73
MAC PET 20x20 mm	139.64	3.88	0.11	402.94
MAC PET 30x30 mm	143.12	6.64	0.11	626.43
MAC PET 40x40 mm	169.40	5.05	0.14	511.85
MAC PET 60x60 mm	118.23	2.41	0.09	229.73
MAC PET 120x70 mm	111.09	2.92	0.09	232.90



Graph 3.Adhesion for cuts of different diameters of specimens

(Chávez, y otros, 2019) Rigid pavements made with steel fibers usually have 35% more favorable flexural strength and 5.99% more favorable to compressive strength Coma This is demonstrated in the following results for a concrete designed for a compressive strength of F'C = 350 kg / cm2.

Steel Fiber Reinforced Concrete (HRFA), conventional concrete (HC)

Board 4.Compressive Strength Test in Steel Fiber Reinforced Concrete (HRFA) and Conventional Concrete (HC)

Age of the sample	Concrete design ACI 544+(SHP+R)	+5 kg/cm^3	+10 kg/m^3	+20 kg/m^3	+30 kg/m^3	+40 kg/m^3
3	215.16	217.29	223.59	231.89	239.79	240.42
7	304.34	306.76	308.48	319.59	321.55	324.36
14	371.40	373.49	388.53	394.73	400.75	405.69
21	408.12	410.42	413.74	423.72	426.67	432.44
28	462.38	466.45	471.58	489.29	501.79	508.27

Board 5.Flexural wing strength test in Steel Fiber Reinforced Concrete (HRFA) and conventional concrete (HC)

Age of the sample	Concrete design ACI 544+(SHP+R)	+5 kg/cm^3	+10 kg/m^3	+20 kg/m^3	+30 kg/m^3	+40 kg/m^3
3	2.20	2.49	2.79	2.92	3.02	3.09
7	3.10	3.37	3.84	3.94	3.97	4.02
14	4.11	4.24	4.68	4.79	4.90	5.02
21	4.57	4.84	5.05	5.13	5.23	5.64
28	5.18	5.23	5.44	6.07	6.25	6.77

(Martinez, Caicedo, González, & Celis, 2018) In Colombia Experiment with recycled rubber grain added to asphalt emulsion mixtures, it is rescued that the breakage by hollowing is lower when 1% of recycled rubber grains are added.

Board 6. Fatigue carousel behaviour after 210,000 repetitions of 8.2 tonnes load

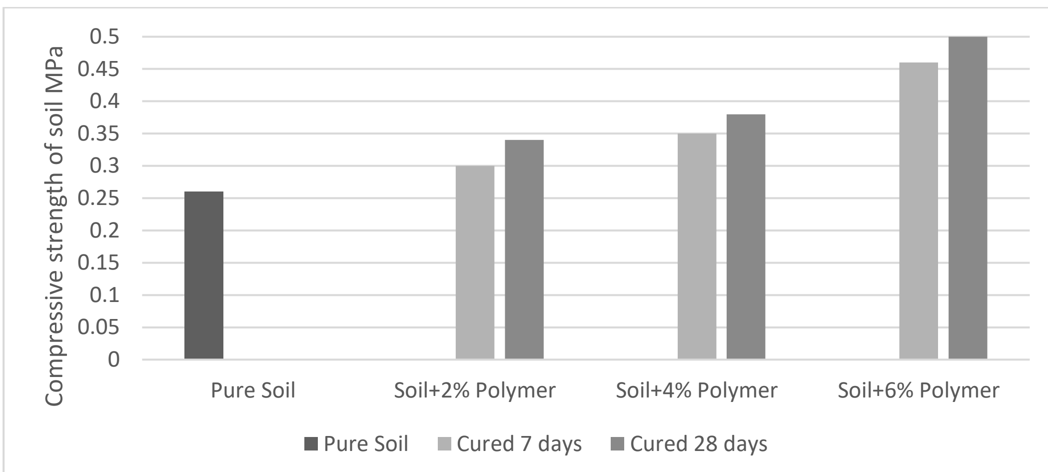
Design	MDC-2 + 0% Recycled Rubber Grain	MDC-2 + 1% Recycled Rubber Grain
Practice	Maximum values	
Ahuellamiento, mm	49.28	9.96
Deflection, 10 mm	254.1	160.8
Cracking density cm/m^2	921	127
Temperature recorded °C	48	45

(Herrera, Alonso, & Villegas, 2018) in Cuba, natural zeolites from the Tasajera deposit and raw wax from sugar cane were used to make warm or semi-hot asphalt mixtures.

(Barbosa, Marqués, & Guimaraes, 2018) not only natural or artificial fibers such as polymers to zero are added to the pavements, but also soils with a previous elaboration as is the case of calcined clay aggregates for pavements, this research was developed in the Amazon of Brazil as a result it was obtained that the soil has mineralogical characteristics suitable for the production

of calcined aggregates with a good mechanical behavior for the pavements, In the same way, it must always be verified that these floors are suitable for the requirements.
(Machado, Cavalcante, Alburqueque, & Ventas, 2017)

This floor with an added polymer in proportions ranging from 2% to 6%. A substantial increase in CBR and UCS figures was observed. The results revealed that the use of polymer association reduced plasticity, increased optimal moisture content, reduced dry apparent specific gravity, and expanded soil. The addition of a 6% polymeric association to the clayey-sandy-silty soil with considerable plasticity brought significant improvements to the geotechnical properties of the soil.



Graph 4. Simple compressive strength obtained for pure soil and for mixtures with polymer association

Conclusions

The different fibers, polymers and pozzolanas that was seen in this article give favorable results, for example, epoxy fibers increase the modulus of tangential elasticity G, with respect to temperature and increases the stability of energy storage by increasing the temperature this means that it supports higher temperatures.

On the other hand, you have a flexible hot pavement added recycled pavement, you get lower carbon dioxide emissions.

Concrete with synthetic fibers such as steel gives a favorable result to flexural strength however the compressive strength does not increase.

References

1. Abbas, Y., Hussain, L., & Khan, I. (2021). Constitutive Compressive Stress–Strain Behavior of Hybrid Steel-PVA High-Performance Fiber-Reinforced Concrete. *ASCE library*. doi:10.1061/(ASCE)MT.1943-5533.0004041

2. Balázs, G., & Lublóy, É. (2017). Post-heating strength of fiber-reinforced concretes. *ire Safety Journal, IL*, 100-106. doi:https://doi.org/10.1016/j.firesaf.2012.01.002.

3. Barbosa, V., Marqués, M., & Guimaraes, A. (2018). Caracterização mineralógica de um solo do acre visando à produção de agregados artificiales de argila calcinada para uso empavimentos. *Revista materia*, 50-80. doi: 10.7764/RDLC.17.2.330

4. Bellili, A., Aziz, A., Achab, M., Ammine, A., & Hamid, A. (2022). Effects of the variety and content of natural pozzolan coarse aggregate on the thermo-mechanical properties of concrete. *Biointerface Research in Applied Chemistry*, 5405-5415. doi:10.33263/BRIAC124.54055415

5. Castro, C., Sabogal, D., & Fernández, W. (2022). A review of emissions on pavement materials and sustainability rating systems. *Revista Ingeniería de Construcción, XXXVII*(2), 280-291. doi:10.7764/RIC.00033.21

6. Chávez, F., Yánez, A., Cabrera, D., Chipre, C., Montes, F., & Jorge, O. (2019). Determinación de cantidad óptima de Fibra de Acero para la elaboración de hormigón de cemento portland para losas de pavimentos rígidos. *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, 1-10. doi:10.18687/LACCEI2019.1.1.363

7. Chen, C., Li, H., Dauuleetbek, A., Shen, F., David, H., Milan, G., & Lorenzo, R. (2022). Properties and applications of bamboo fiber—A current-state-of-the art. *Journal of Renewable Materials*, 605-624. doi:10.32604/JRM.2022.018685

8. Cuetara, R., & Howland, J. (2018). Empleo de la metodología de superficies de respuesta para determinar el factor k de las puzolanas naturales y su influencia en la durabilidad de los hormigones. *Hormigón y Acero*. doi:10.1016/J.HYA.2018.06.002

9. Delbono, H. (2019). Restoration of pavements: Adhesion between layers with geosynthetic interposition of different mesh opening. *Revista Ingeniería de Construcción*, 307-320. doi:10.4067/S0718-50732019000300307

10. Herrera, R., Alonso, A., & Villegas, N. (2018). Evaluation of natural additives for warm asphalt mix. *Revista Materia*, 1-7. doi: 10.7764/RDLC.17.2.330

11. Machado, L., Cavalcante, E., Alburqueque, F., & Ventas, Á. (2017). Adição de uma associação polimérica a um solo argilo-arenoso com vistas à estabilização química de materiais para pavimentos. *Revista Materia*, 1-13. doi:10.1590/S1517-707620170003.0204

12. Martinez, G., Caicedo, B., González, D., & Celis, L. (2018). Trece años de continuo desarrollo con mezclas asfálticas modificadas con Grano de Caucho Reciclado en Bogotá: Logrando sostenibilidad en pavimentos. *Revista Ingeniería de Construcción*, 41-50.

13. Migliorini, A., Guimaraes, A., & Ozorio, B. (2017). Fibras de aço em blocos de concreto: estudo para utilização em ambiente marítimo. *Revista Materia*, *XVII*(2), 997-1008.

14. Pombo, R., Altamirano, M., Giaccio, G., & Zerbino, R. (2022). Design and Execution of Floors on Ground and Industrial Pavements with Fibre Reinforced Concrete. *RILEM Bookseries*, 640-651.

15. Vargas, V., Cerna, V., & Cuellar, C. (2020). Adherencia en el concreto reforzado con bambú. *Anales Científicos*, 381-392.

16. Xargay, H., Folino, P., Nuñez, N., & Gomez, M. (2018). Acoustic emission monitoring of high-strength concrete beams with and without fibers exposed to high temperature. *Revista Materia*, *XXII*(2), 23-28. doi:10.1590/S1517-707620180002.0410

17. Xiang, Q., & Xiao, F. (2020). Applications of epoxy materials in pavement engineering. *Construction and Building Materials*, 1-32. doi:https://doi.org/10.1016/j.conbuildmat.2019.117529

18. Zhao, R., Zhu, W., & Zhang, S. (2021). The effect of graphene nanoplatelets on chloride binding and chloride migration in cement paste. *Journal of Testing and Evaluation*, 50-55. doi:10.1520/JTE20200198