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Effect of Moisture Damage on Hot Asphalt Mixture: A Scientific Metric Analysis and Bibliometric Review

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Abstract

Asphalt concrete or a dense graded mixture is an acceptable additive used to improve the performance and longevity of asphalt road materials (DGM). The use of various recycled materials as fillers is one of many diverse strategies used to reduce the impact of moisture damage on the pavement, as well as to reduce cost, improve road efficiency, and reduce the harmful impact of solid waste by recycling it. Alkalinity, coarse surface roughness, fine particles preventing air gaps, increasing the bonding between asphalt slurry and aggregate, and improving moisture sensitivity are all characteristics of fillers.

It can be constructed so that it works well as a filler to increase the quality and durability of the pavement. It is essential to understand previous research pappers and investigations. The VOS Viewer was used to visualize the data in early tests. Keyword data was downloaded in Excel format from the Dimension, Web of Science, and Scopus websites. Lists these terms, authors, and researchers by country. With the help of the terms (hot asphalt), (asphalt sensitivity to moisture), (additives) and (wet damage), the researcher was able to conduct a study that was identical to his or her study.

Keywords: Hot asphalt, Asphalt sensitivity to moisture, Additives, Wet damage.

Introduction

Asphalt binders and mineral aggregate are the components of asphalt concrete. The aggregate skeleton is responsible for carrying the majority of the traffic load, and the binder serves as a glue to keep the aggregate skeleton together. Bitumen also functions as a viscoelastic

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adhesive. Temperature and load velocity have a big impact on the material's rheological characteristics. As a result of its outstanding cementing ability and waterproofness, it is primarily utilized for the pavement of roads and highways. A mixture of non-linear elasticity, linear elasticity, and viscous behavior is created by the interaction of the characteristics. The temperature and load factor of the mixture will affect the relative proportion of each operation[1]. The development of the asphalt blend with polymer and the use of numerous types of mineral filler improves street performance. Due to traffic, high temperatures, and environmental factors, flexible pavement exhibits a variety of problems (rutting caused by permanent deformation, fatigue& thermal crack) which are thought to be the most frequent failures on the pavement, and are among these downsides. Therefore, the hot asphalt mixture will be affected by these problems, and therefore the specialized designers must design an asphalt mixture that takes into account the environmental conditions that the road will suffer from to ensure good performance[2].

Throughout its service life, the asphalt paving mixture is typically exposed to a variety of harmful sorts of distress. A pavement that can withstand such strain for an extended period without suffering considerable degradation is said to be durable. According to this definition, all elements that cause deterioration would be considered to be part of the bituminous mixtures' durability. These elements include the volume of traffic, the climate, the construction process, and/or the use of subpar materials. These elements can lead to a variety of issues, including aging, fatigue, moisture damage, and permanent deformation. Due to the penetration of water through the pavement, asphalt mixtures suffer from moisture damage, which leads to a defect in the design of the mixture and thus It has the propensity to speed up the emergence of distress kinds represented(bleeding, raveling, rutting, and cracking) [3]. The purpose of studying the effect of moisture on hot asphalt mixture is to better understand how moisture affects the performance and durability of asphalt pavement. By understanding how moisture affects the properties of asphalt, researchers can develop more effective and durable asphalt mixtures that are better able to withstand the effects of moisture. This research can also help inform decisions about when and where to use different types of asphalt mixtures to maximize their performance and longevity.

1- Literature Review

Asphalt concrete mixtures' effectiveness and efficiency depend on several variables, including aggregate gradation, aggregate type, loading circumstances, the physical qualities of the binder & the mixture's volumetric properties [4]. Among these, the binder, which exhibits viscoelastic behavior, has a significant impact on many elements of how mixes behave[5]. In asphalt pavement, the increased loads on the axle, high temperatures, and moisture damage are among the most prominent damages that lead to distress. These adversities have a significant impact on asphalt pavements, including rutting, fatigue cracks, temperature cracks, and moisture damage[6]. The pavements deteriorate over time as a result of exposure to numerous environmental factors, such as changes in water sensitivity and traffic flow. Millions of many are spent each year on upkeep to prevent pavement rutting[7].

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Around the world, bituminous materials have been widely employed in the construction of highways. These hydrocarbons could be found in natural sources or come from the distillation of crude oil. The bituminous materials utilized in highway buildings are asphalts or tars. The bituminous materials, which range in color from dark brown to black, primarily consist of bitumen and also have high adhesive properties. Bituminous elements are the main component of HMA[2]. To attain the highest performance over the pavement's service life, mixture design in the lab is unavoidably required. One of the primary design considerations is the type of mortar, which is made up of bitumen, fine aggregate, and filler, to prevent fatigue cracking. The mortar is crucial in giving the mixture the cohesion, shear, and tensile strength needed to withstand traffic loading and temperature action. Another crucial element in preventing cracks caused by bending and shear stresses brought on by traffic loads is coarse aggregate[8].

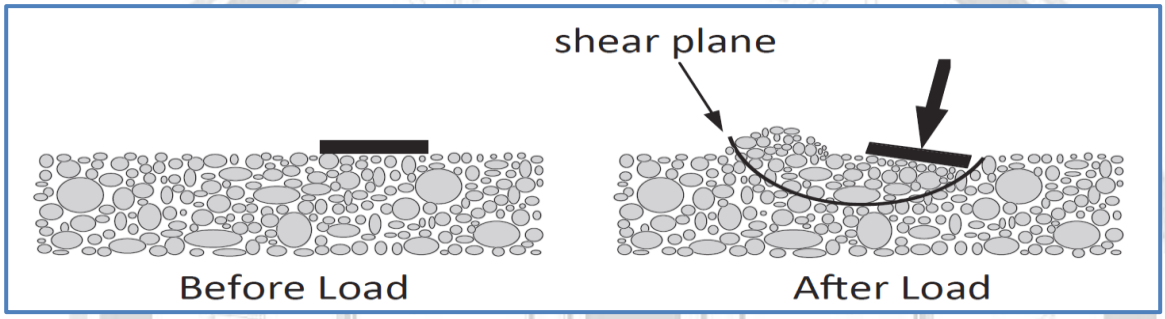

Figure (1) Shear Loading Behavior of Aggregate[9]

Mineral filler or dust is part of the aggregate in the asphalt mixture that passes through sieve No. 200. It is of great importance in constructing and performing asphalt pavements. The importance is illustrated by the following points (Increasing the stiffness of the asphalt, enhancing the resistance against damage, extending the asphalt binder, affecting the aging properties of the mixture..etc.)[10]. Previous research results showed that adding recycled materials and mineral fillers to the asphalt mixture improves the engineering properties of the mixture such as stability, water resistance, and crack resistance. The method of modifying bitumen with a polymer also increases the binding properties of the mixture and extends the life of the pavement[11].

[12]looked into the impact of mineral filler, such as hydrated lime on pavement deformation and moisture damage and proposed that mineral filler had mostly increased the mixture stiffness. In the majority of industrialized nations, polymer-modified asphalt (PMA) was first used in early 1970. Unmodified asphalt, which is acquired directly from oil refining, is obtained by mixing one or more additives onto it. The additions are chosen to enhance the characteristics of the unmodified asphalt, and different additives have varying effects on the asphalt's characteristics throughout a variety of temperatures. Asphalt is currently modified using a variety of additives and modification techniques, such as crumb rubber modifier (CRM) and styrene-butadiene-styrene [13].

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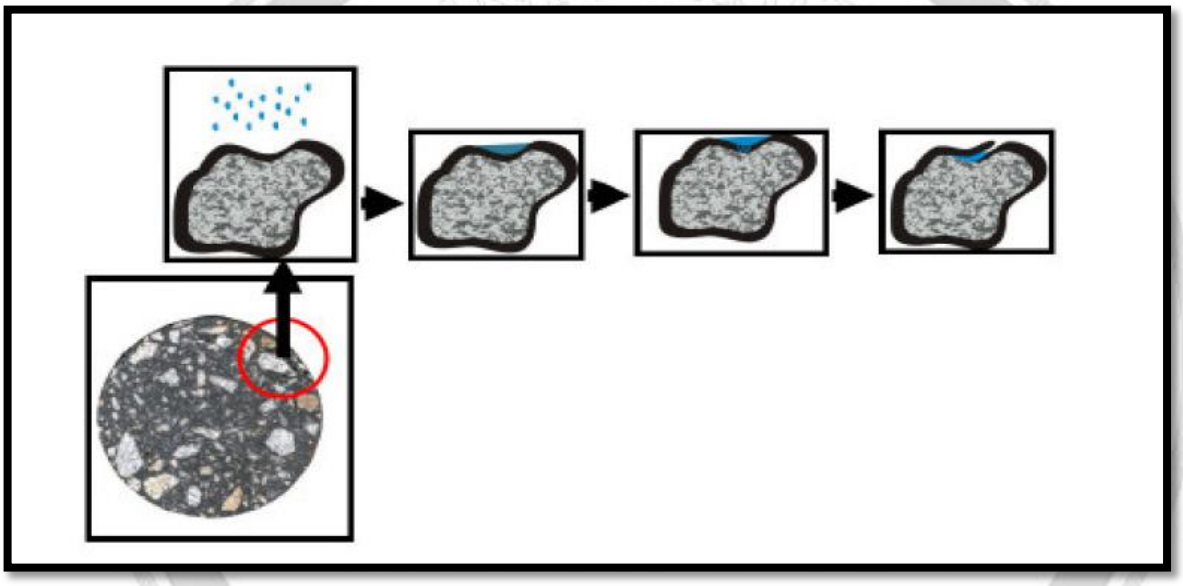
2- Factors Affecting Water Sensitivity

Several factors influence the resistance of HMA to water damage including which adhesive and cohesive failure (Separation occurs between the binder and the aggregate), mix design and construction (air voids, drainage, and permeability), environmental conditions that include (temperature, cold, rain, etc.) and traffic conditions.[14].

3- Mechanisms of Moisture Sensitivity

Is the most common cause of problems in HMA. Inter of moisture into the asphalt mixture can cause stripping; which weakens the asphalt binder and aggregate and causes aggregate stripped off [15].



Figure(2) Moisture Damage Mechanisms Illustration[16].

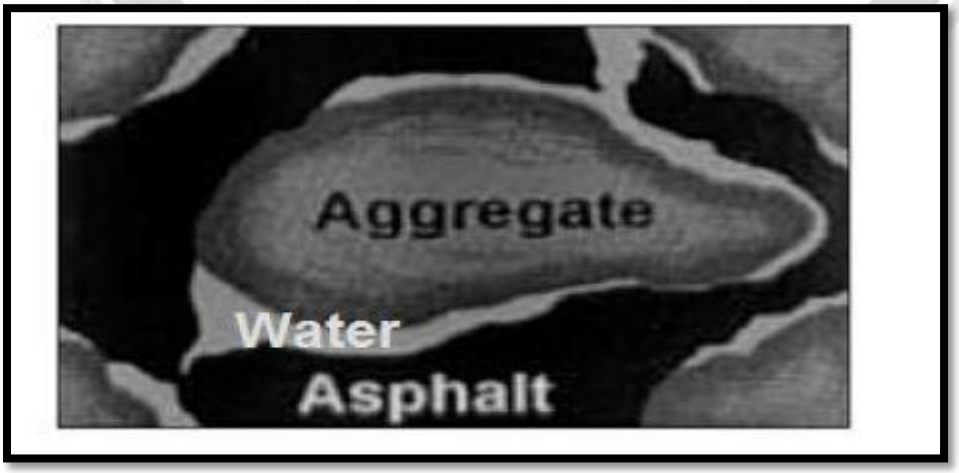


Figure (3) Water's Effect on Asphalt Mixture[17].

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Moisture damage can occur in several ways, the most prominent of which is the collection of rainwater for a long time without the presence of pipes to drain it, so it enters through the layers of the pavement and causes several damages, including stripping (separation of the asphalt bond from the aggregate granules) and other damages. Water can remain on the pavement even after the rain has ended, and therefore it needs a high temperature to completely remove it from the surface[18]. Many well-known mechanisms that can cause loss of adhesion or/and cohesion have been studied, and the most important of them (Displacement, Detachment, pore pressure, Spontaneous emulsification, Film rupture, Hydraulic scouring and Chemical disbanding).

4- Data Collection and Employed Tool

To facilitate scholarly and scientific research, The Web of Science, a platform of many databases for searching prior literature, was created. For several years, many searches for terms such as hot mix asphalt, asphalt moisture susceptibility, additives, and moisture damage were conducted using keywords and authors. All of these bibliometric techniques that present previous studies rely on the principle of the strong correlation between shared data. The co-citing paper or authors that appear in the same paper references are grouped into groups based on the intensity of the founder, nodes, and lines on the map, these nodes and lines represent the strength of interconnection between the elements annotated in the scholarly mapping (authors, countries, references & keywords)[19].

The scientific metric analysis is a statistical tool for determining the direction and rate of development in any field. The web of science website was chosen for the current investigation because it is a well-known source of bibliographic information and was recommended by many studies[20]. After removing all irrelevant documents, 142 publications, were obtained from the WOS. The graph shows that the number of publications grows each year exponentially[19].

Table (1) WOS Categories

Categories on the (Web of Science)	Record Count	% of 142
Civil Engineering	102	71.831
Materials Science Multidisciplinary	78	54.930
Construction Building Technology	76	54.930
Transportation Science Technology	12	8.451
Engineering Environmental	11	7.746
Materials Science Characterization Testing	10	7.042
Environmental Sciences	9	6.338
Engineering Multidisciplinary	7	4.930
Green sustainable Science composites	7	4.930
Materials Science composites	6	4.225
Energy fuels	4	2.817
Engineering chemical	4	2.817
Transportation	4	2.817

Chemistry Multidisciplinary	3	2.113
Engineering petroleum	3	2.113
Physics Applied	3	2.113
Multidisciplinary Sciences	2	1.408
Soil Science	2	1.408
Engineering Geological	1	0.704
Environmental studies	1	0.704
Mechanics	1	0.704
Nanoscience Nanotechnology	1	0.704
Public Environmental occupational health	1	0.704

5- Analytical Method

The visual maps were created with the help of the VOS viewer. The software, which primarily serves to improve link analysis, employs a uniform mapping and aggregating approach. Three different visuals can be produced by the VOS viewer: a network visualization, an overlay visualization, and a density visualization[21].

6.1. Country and Author Co-authorship

Table 2: Shows The Top 10 Contributions Made by Countries and Authors[20].

No	Country	Freq*	Authors	Freq*
1	USA	5	Akhtar, Mohammad Nishat	8
2	Malaysia	3	Hamedi , Gholam Hossein	8
3	Peoples r china	3	Kakar, Muhammad Rafiq	8
4	Switzerland	3	Bahia ,Hussain u,	6
5	Saudi Arabia	2	Hajj,e,y,	6
6	United Kingdom	1	Abbas, Ghadeer	5
7	Canada	1	Abu Bakar,Elmi	5
8	Iran	1	Ahmed,Waseem	5
9	Italy	1	Al-khafaji,Fatimah Fahem	5
10	Singapore	1	Al-mulali,Mohammed Zuhear	5

Note: * Freq= Frequency

Using the set of 2959 articles, in which authors and nations that contributed to the study of the moisture sensitivity of HMA were able to be identified.

148 authors have published at least five articles on the research topic. The strength of co-authorship ties with other authors is for each of the 148 authors. The total link strength is represented by nodes. Some of the 53 network elements are unrelated. The larger node of connected elements consists of eight elements arranged in two red and green groups and represents the heart of the author's research collaboration. The most strongly correlated authors (8) are Akhtar, Mohamed Nashat, Kakar, and Mohamed Rafeeq.

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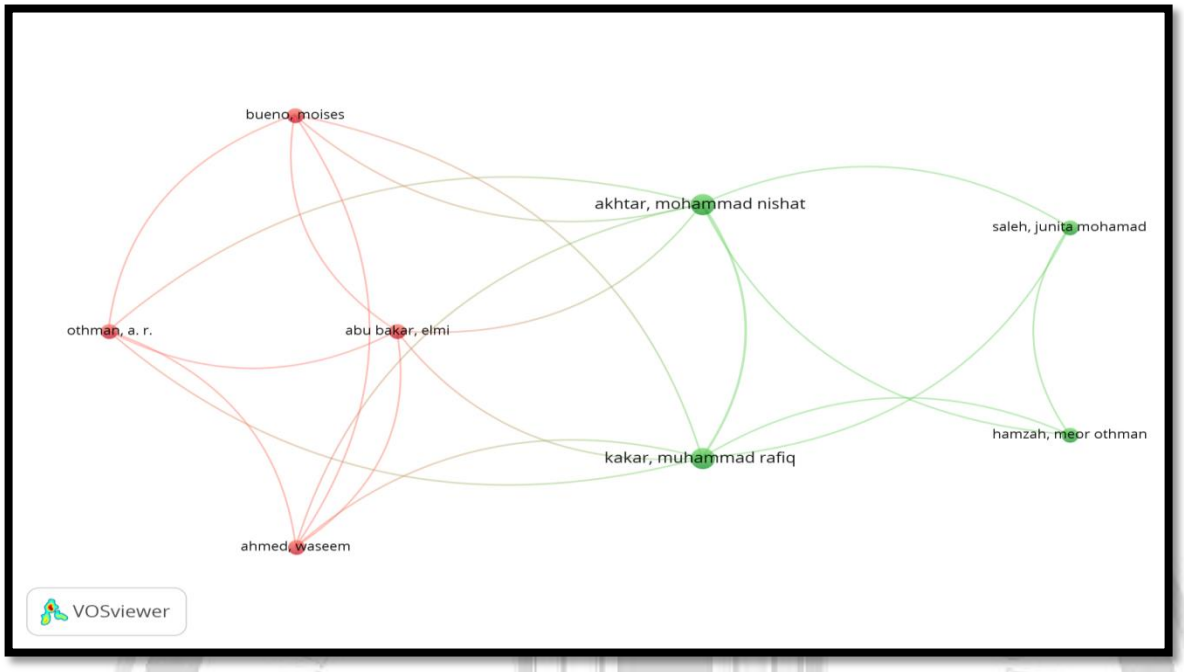

Figure(4) Co-authorship, Authors' Level

In terms of co-authorship in countries, only 17 countries meet the 17 document/state limit, and the strength of co-authorship links with other countries was calculated for all countries. The network includes countries with the highest total connectivity strength (Figure 5). The total link strength is represented by nodes. Our study revealed three clusters, each cluster having a leading state, having the largest node, the red cluster having three elements, the green cluster having two elements, and the blue cluster having one element. The United States leads research in this field of study and is linked to 17 other countries through a network of co-authorship.

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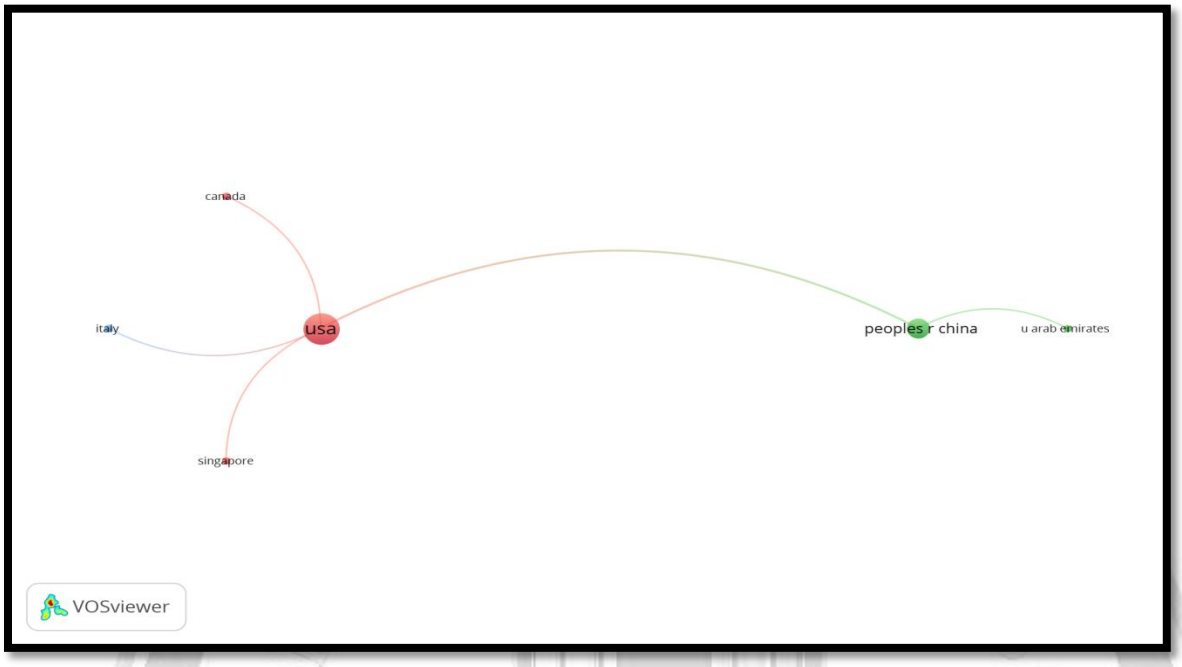

Figure(5) Co-authorship, Countries Level

6.2. Co-occurrence – Keyword Analysis

It is the bibliometric method for mapping the research field [22]. In general, to determine the top 10 keywords used in(the Moisture sensitivity of HMA). The minimum number of a keyword in most studies was chosen to be 2 as a 207 keyword boundary condition, 54 of which met the threshold. In this study, this analysis was used to map the topic's revolution trends related to hot mix asphalt. The total strength of links with other keywords is calculated through the 54 keywords (Figure 6) and (Figure 7), and the keywords that have the highest total correlation strength will be selected from Table (3) of the most co-author keywords.

Table(3) Most Co-occurred Author's Keywords

Id	Keyword	Occurrences	Total link strength
1	Moisture sensitivity	21	84
2	Moisture damage	13	54
3	Damage	9	52
4	hot mix asphalt	12	52
5	Performance	8	47
6	susceptibility	5	32
7	Surface free energy	6	31
8	Additives	5	30
9	Binders	4	28
10	Hot-mix asphalt	6	26

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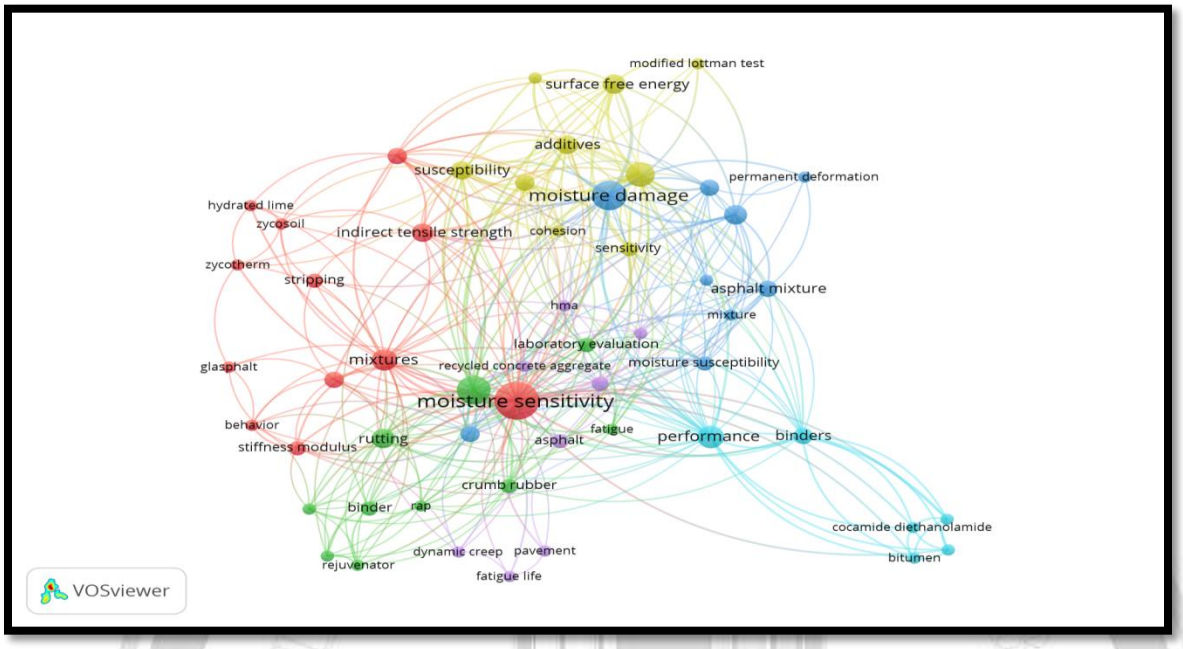
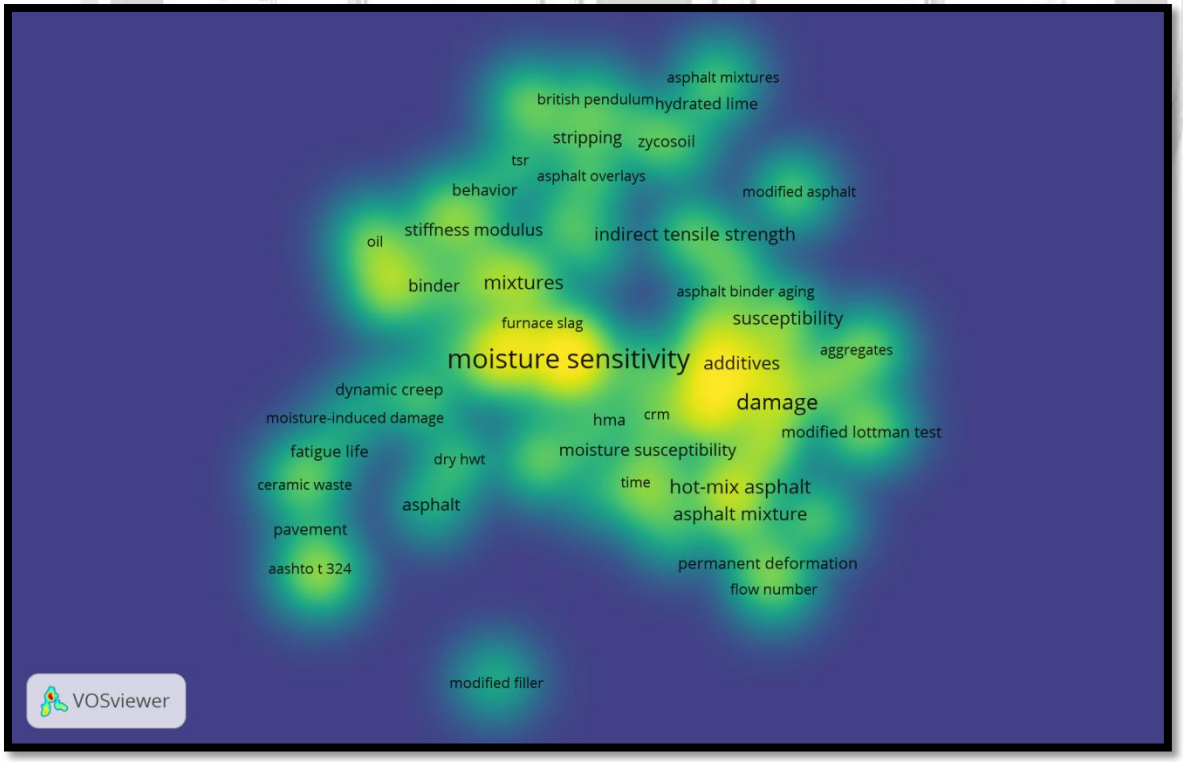
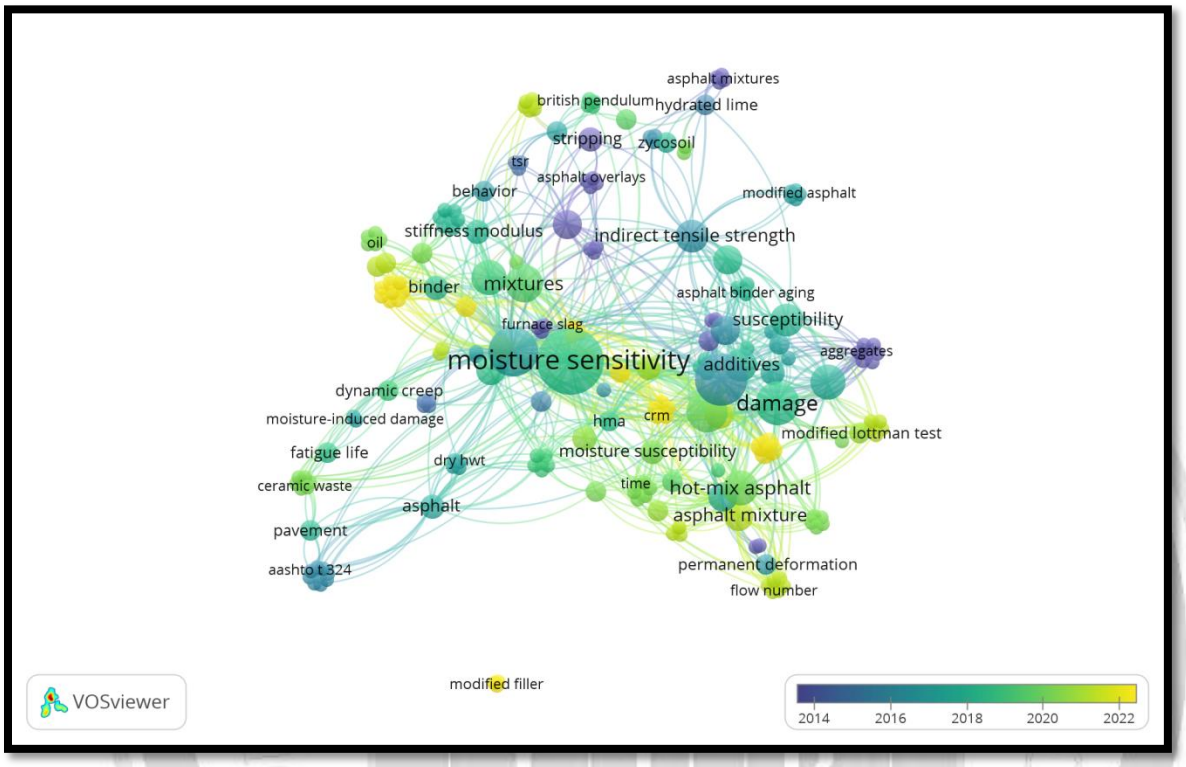


Figure(6) Keyword Co-occurrence Network Visualization



Figure(7) Visualization of Keyword Co-occurrence

The major keywords from 2016 to 2022 are (Moisture sensitivity, Moisture damage, hot mix asphalt, and damage), with purple covering in 2016 and yellow covering in 2022. It is worth noting that (Figure 8) includes 6 clusters, 516 total strengths, and 365 total links.



Figure(8) Co-occurrence Keyword Overlay Visualization with Average pub. year

6.3. Network of Citations

The citation study revealed carried out to recognize primary research (sources documents, countries, organizations, authors). recognizing document citations,and citation groups aid in the analysis of frequently cited documents to determine the crucial research domain [23], This section is concerned with determining clusters based on the scientists' and journals' most important citations. The clusters are labeled with the first author's last name and the title of the journal, and the phrases that were looked up are taken out of the document's title, abstract, and keywords[23].

6.3.1. Document as a Citation Unit

The bare minimum of document citations was set at 50. The most extensive set of linked items contains 97 citations. There are 34 clusters, according to the analysis. Figure 9 depicts the top citation clusters labeled by the first author's surname, each cluster represents a citation burst for the year represented by a specific group of researchers focused on the topic under consideration, the greatest number of citations for the keyword "Moisture sensitivity" was first observed in 2010, received the most citations for their study of the cohesive and adhesive

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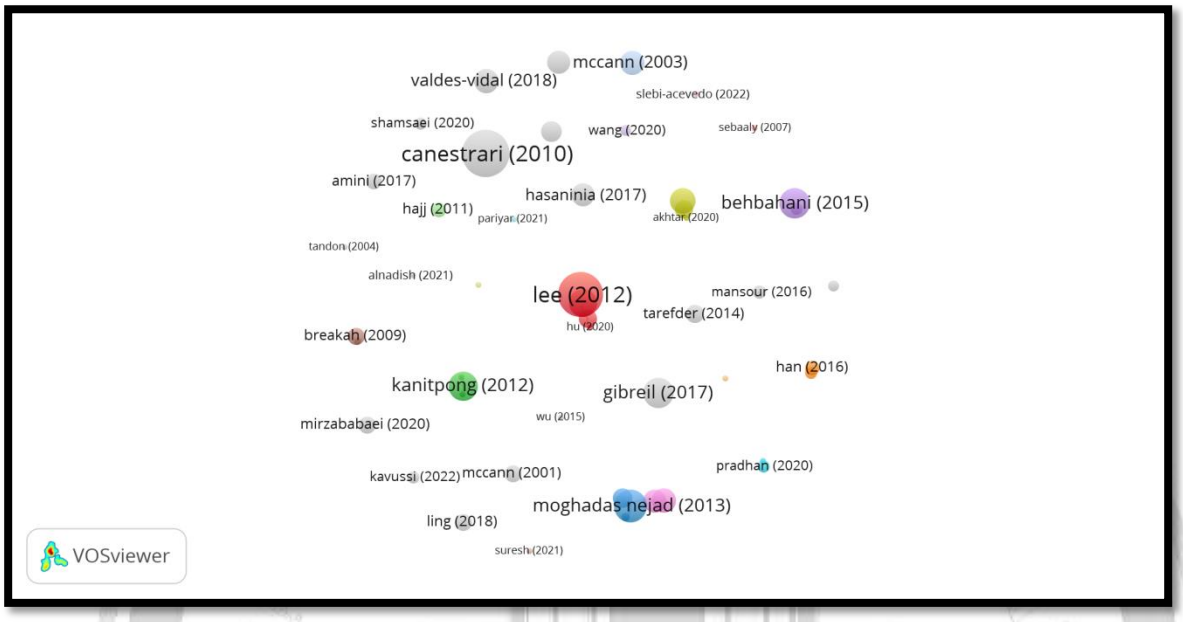
qualities of moisture-damaged asphalt-aggregate systems. The second largest citation cluster is associated with[20].



Figure(9) Citation Network – Document

6.3.2 Source as a Citation Analysis Unit

Based on the source of the citation, a scientific metric analysis was performed. Drawing on the title of the journal, from which a particular article is quoted. Only 29 of the 142 sources disclosed links between them. There seem to be a total of 22 groups and 10 links. Figure 10 depicts the source groups that received the most citations, the largest circles appear in (Proceedings of the International Forum on Energy and Environment 2015, and the Journal of Building Materials) is the largest choice of research topic in second place (Journal of Materials in Civil Engineering). These circles appear in the most prominent figure in Research topic and how fast it is growing.

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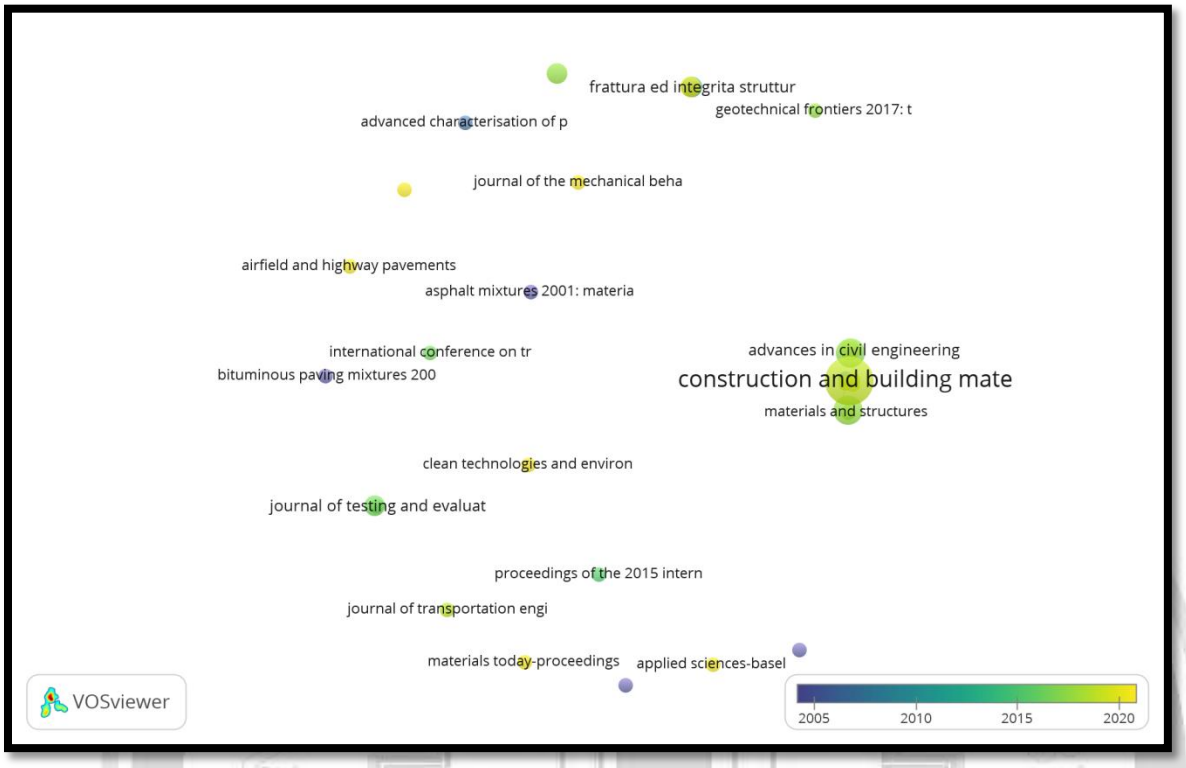

Figure (10) Citation Network – Source

6.3.2. Organization as a Unit of Citation Analysis

As a source For each of the 77 organizations, the overall strength of the citation relationships with other organizations will be determined. The organization with the highest overall link strength Which is(Univ Guilan with citations of 158 and total link strength of 9, and Amirkabir Univ Technol with citations of 86 and total link strength of 7)will be selected.

Table(4)Most organization

NO	Organization	Documents	Citations	Total link strength
1	Univ Guilan	7	158	9
2	Amirkabir Univ. Technol.	3	86	7
3	Empa	1	15	6
4	Univ Sains Malaysia	2	16	6
5	Iran Univ. Sci. & Technol.	4	79	5
6	Nanyang Technol. Univ	1	16	5
7	Univ. Wisconsin	3	127	5
8	China Changjiang Construct	1	36	4
9	Suleyman Demirel Univ.	2	0	4
10	Tongji Univ.	1	36	4

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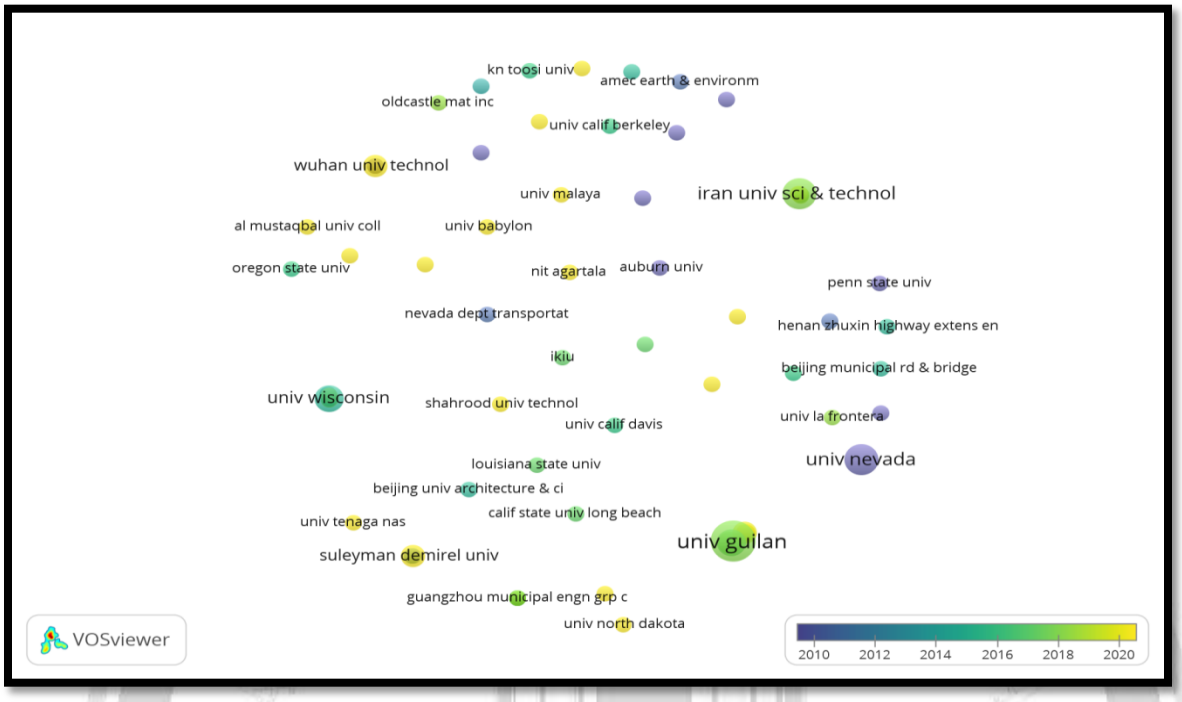

.Figure(11) Citation- Network – Organization

6.4. Network of Co-citations

One of the methods in scientific metric studies is the co-citation analysis of authors. It is the frequency with which 2 items, are cited in the latter literature at the same time. Analysis can help in understanding how specialist development works.

6.4.1 Cited Reference as a Co-citation Analysis Unit

Only 141 of the 1230 sources that were evaluated met the required criteria. Based on the evaluated data,(Figure 12) depicts the network, which consists of 5 clusters, 141 items, and 2454 links. The network's nodes represent cited references as a co-citation in the database, while the links represent the relationship between nodes. The larger the node, the more frequent the co-citations which indicate how frequently two specific documents have been used as a form of reference to base new research. The review papers (Kakar mr 2016&2015) are interestingly found in the network center.

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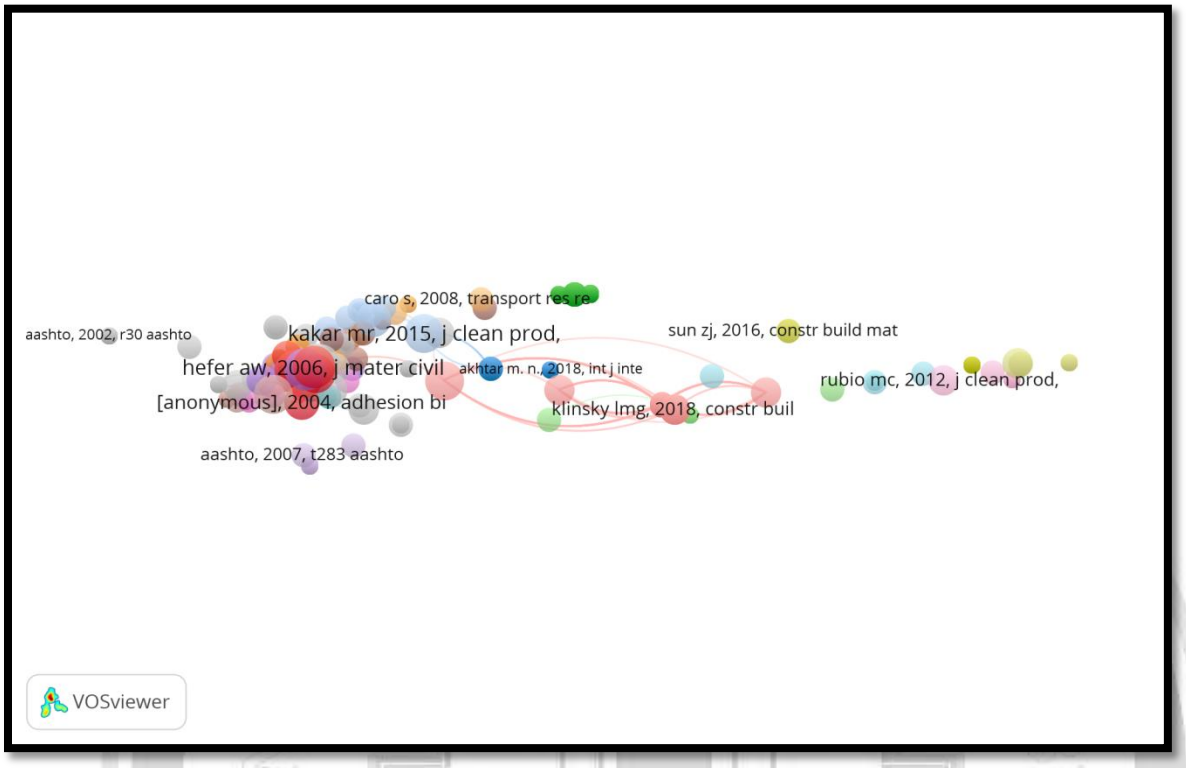

Figure (12) CO - Citation network - Cited Reference Level

6.4.2 Source as a Co-citation Analysis Unit

This subsection's co-citation analysis is based on the publication's source. As shown in Figure 13, the VOS viewer generated a network consisting of eight major clusters and 9765 links, each cluster represents a major journal, that has published articles on moisture sensitivity in hot mix asphalt and similar subjects in the pavement materials domain. The label for each significant cluster describes the journal title that has received the most co-citations. It is worth noting that the minimum number of citations for the cited references was set at 20 only 126 of the 665 sources meet the criteria.

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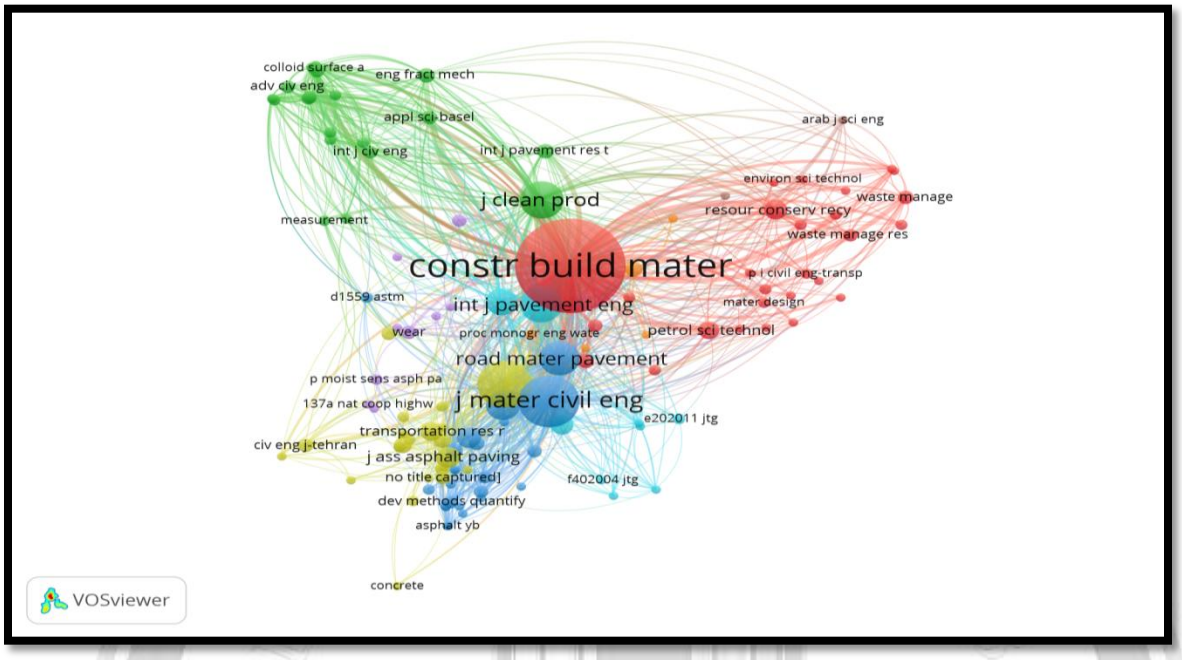

Figure(13) CO - Citation Network - Source Level

6.4.3 Author as a Co-citation Analysis Unit

In this analysis, the cited references must have a minimum of 20 citations. Only 211 of 773 sources meet the criteria. Figure 14 depicts 211 items, 7 clusters, 3350 links, and 7567 total link strength. ASTM and AASHTO were the most co-cited authors, as shown in (Figure14).

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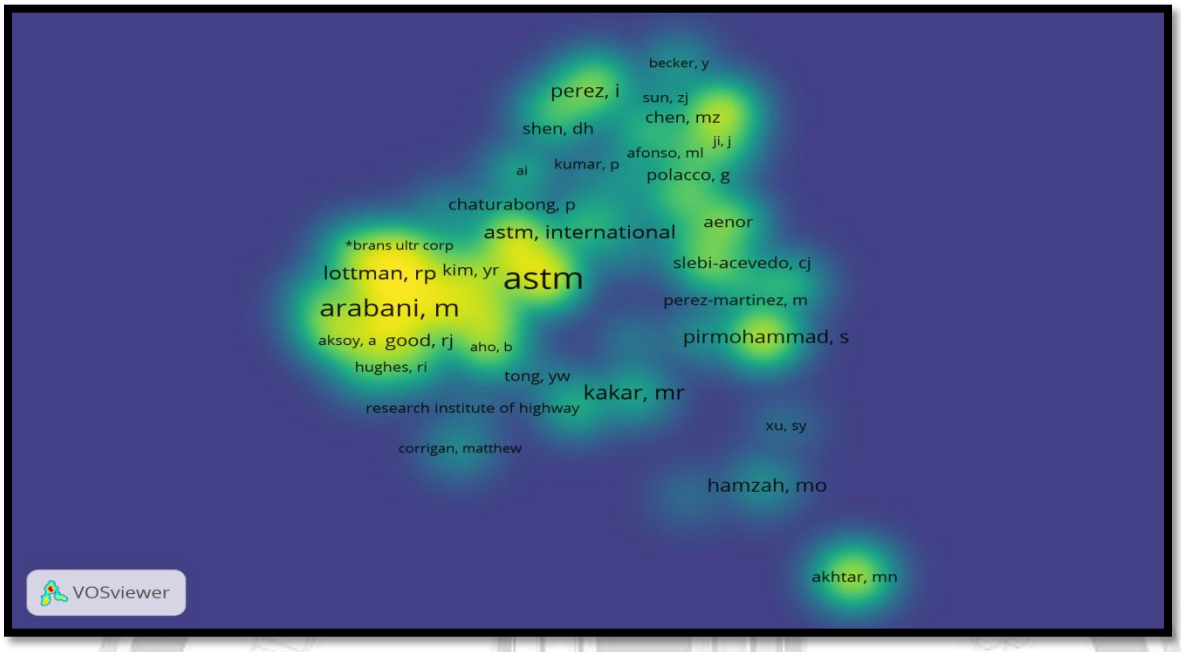

Figure (14) CO - Citation Network - Author Level

6- Summary

1- A review of the literature on investigations for flexible pavement using VOS viewer software yielded the following significant finding . According to the findings, the majority of the co-occurring keywords were(Moisture sensitivity for HMA, Moisture Sensitivity, damage, hot mix asphalt, Performance) and other keywords. The citation burst analysis can be used to estimate the scope of Moisture damage research. It is also mentioned that the source of the most citations a publication has received about the keyword " Moisture sensitivity ". The most important nations in the subject of this study have also been identified, particularly the United States, China, and other countries that have greater influence in publishing than other nations.

2- Asphalt concrete or a dense graded mixture is an acceptable additive used to improve the performance and longevity of asphalt road materials (DGM). The use of various recycled materials as fillers is one of many diverse strategies used to reduce the impact of moisture damage on the pavement, as well as to reduce cost, improve road efficiency, and reduce the harmful impact of solid waste by recycling it.

3- Reviewing relevant literature (from 2010 to 2022) that highlighted the harmfulness of moisture to pavement materials was reviewed, and they were studied and analyzed within the current study by reviewing recent authors, countries, and journals that shed light on pavement materials and solutions to reduce moisture sensitivity.

4- Researchers and designers should give importance to new issues. Since the discovery of the problem, moisture damage has long been a source of concern for flexible pavement researchers. Many studies and research have been conducted by researchers to find the

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causes that lead to pavement damage due to moisture, as well as find solutions to address these problems before they escalate.

5- To increase the effectiveness and durability of road bitumen materials, mixes such as bituminous concrete or a dense graded mix are suitable (DGM). One of many different methods used to reduce the cost and increase the efficiency of roads is the use of various recycled materials as fillers. Fillers have the following properties: alkalinity, rough surface roughness, finer particles that prevent the occurrence of air spaces, greater binding between asphalt mortar and aggregates, and improved moisture.

References:

[1] G. A. Huber, *Methods to achieve rut-resistant durable pavements*. Transportation Research Board,1999.

[2] E. R. Al-Gurah and B. H. Al-Humeidawi, "Assessment of performance of hot mix asphalt contained various types of mineral fillers and newly polymer modified bitumen.",2021.

[3] Z. I. ABED, "Superpave Mineral Aggregate Properties as Related.",2006.

[4] M. AMERI, D. MIRZAIYAN, and A. AMINI, "Rutting resistance and fatigue behavior of gilsonite-modified asphalt binders," *J. Mater. Civ. Eng.*, vol. 30, p. 4018292,2021.

[5] A. Amini, H. Ziari, S. A. Saadatjoo, N. S. Hashemifar, and A. Goli, "Rutting resistance, fatigue properties and temperature susceptibility of nano clay modified asphalt rubber binder," *Constr. Build. Mater.*, vol. 267, p. 120946,2021.

[6] H. Ziari, M. Aliha, A. Moniri, and Y. Saghafi, "Crack resistance of hot mix asphalt containing different percentages of reclaimed asphalt pavement and glass fiber," *Constr. Build. Mater.*, vol. 230, p. 117015,2020.

[7] G. Shafabakhsh, M. Sadeghnejad, and Y. Sajed, "Case study of rutting performance of HMA modified with waste rubber powder," *Case Stud. Constr. Mater.*, vol. 1, pp. 69–76,2014.

[8] C. . Communications *et al.*, "Children, adolescents, and the media," *Pediatrics*, vol. 132, no. 5, pp. 958–961,2013.

[9] A. I. J. A. Institute, "MS-2 asphalt mix design methods." Lexington Kentucky, USA,2014.

[10] L.-X. Yan *et al.*, "MicroRNA miR-21 overexpression in human breast cancer is associated with advanced clinical stage, lymph node metastasis, and patient poor prognosis," *Rna*, vol. 14, no. 11, pp. 2348–2360,2008.

[11] B. H. Al-Humeidawi, "Utilization of waste plastic and recycle concrete aggregate in the production of hot mix asphalt," *Al-Qadisiyah J. Eng. Sci.*, vol. 7, no. 4, pp. 322–330,2014.

[12] L. N. Mohammad, C. Abadie, R. Gokmen, and A. J. Puppala, "Mechanistic evaluation of hydrated lime in hot-mix asphalt mixtures," *Transp. Res. Rec.*, vol. 1723, no. 1, pp. 26–36,2000.

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[13] N. S. Mashaan, A. H. Ali, M. R. Karim, and M. Abdelaziz, "A review on using crumb rubber in the reinforcement of asphalt pavement," *Sci. World J.,2014*.

[14] J. Martin, L. A. Cooley Jr, and M. Hainin, "Production and construction issues for moisture sensitivity of hot-mix asphalt pavements," in *Transportation Research Board National Seminar*, San Diego, California,2003.

[15] I. Pinto, Y. Kim, and H. Ban, "Moisture sensitivity of hot mix asphalt (HMA," in *mixtures in Nebraska: phase II*, Nebraska Transportation Center,2009.

[16] Y.-R. Kim and J. S. Lutif, "Material Selection and Design Considerations for Moisture Damage of Asphalt Pavement.",2006.

[17] J. D'Angelo and R. M. Anderson, "Material production, mix design, and pavement design effects on moisture damage," in *Moisture Sensitivity of Asphalt Pavements: A National Seminar, Transportation Research Board of the National Academies*, Washington, DC,2003.

[18] H. A. Omar, N. I. M. Yusoff, M. Mubaraki, and H. Ceylan, "Effects of moisture damage on asphalt mixtures," *J. Traffic Transp. Eng. (English Ed.*, vol. 7, no. 5, pp. 600–628,2020.

[19] D. M. Cretu and F. Morandau, "Bullying and cyberbullying: a bibliometric analysis of three decades of research in education," *Educ. Rev.*, pp. 1–34,2022.

[20] S. Das and H. Zubaidi, "Last Forty Years of ITE Journal Articles: A Scientometric Overview," *ITE J. Online Exclus.*, [Online]. Available: https://www,2021.

[21] "Subgrade Stabilization of Railway Track : Literature Scientometric Analysis," vol. 31, no. 1, 2023.

[22] A. Lis, "Keywords co-occurrence analysis of research on sustainable enterprise and sustainable organization," *J. Corp. Responsib. Leadersh.*, vol. 5, no. 2, pp. 47–66,2018.

[23] A. Alnedawi, S. Ullah, A. Azam, E. Mousa, I. Obaid, and A. Yosri, "Integrated and holistic knowledge map of resilient modulus studies for pavement materials: A scientometric analysis and bibliometric review of research frontiers and prospects," *Transp. Geotech.*, vol. 100711,2021.

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تأثير أضرار الرطوبة على خليط الأسفلت الساخن: تحليل متري علمي ومراجعة ببليومترية

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الخلاصة

الخرسانة الاسفلتية أو الخليط الكثيف المتدرج هي مواد مضافة مقبولة تستخدم لتحسين أداء وطول عمر مواد الطرق الاسفلتية (DGM). يعد استخدام العديد من المواد المعاد تدويرها كمواد مالئة واحدة من العديد من الاستراتيجيات المتنوعة المستخدمة لتقليل تأثير أضرار الرطوبة على الرصيف ، وكذلك لتقليل التكلفة وتحسين كفاءة الطريق وتقليل التأثير الضار للنفايات الصلبة عن طريق إعادة تدويرها. تعتبر القلوية ، وخشونة السطح الخشنة ، والجسيمات الدقيقة التي تمنع فجوات الهواء ، وزيادة الترابط بين ملاط الإسفلت والركام ، وتحسين حساسية الرطوبة وكلها تعد من خصائص مواد الحشو.

يمكن تشييده بحيث يعمل بشكل جيد كمادة مالئة لزيادة جودة ومتانة الرصيف. من الضروري فهم الأبحاث والتحقيقات السابقة. تم استخدام عارض VOS لتصور البيانات في الاختبارات المبكرة. تم تنزيل بيانات الكلمات الرئيسية بتنسيق الاكسل من مواقع (Dimension و Web of Science و Scopus). يسرد هذه المصطلحات والمؤلفين والباحثين حسب الدولة. بمساعدة مصطلحات (الإسفلت الساخن) و (حساسية الإسفلت للرطوبة) و (المواد المضافة) و (التلف الرطب) تمكن الباحث من إجراء دراسة مماثلة لدراسته.

الكلمات الدالة: الإسفلت الساخن، حساسية الإسفلت للرطوبة، المواد المضافة، الأضرار الرطبة.