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Sustainable concrete pavements for low volume roads-Scientometric analysis of the literature

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Abstract: Developing countries like India invest huge amounts of money for the construction and maintenance of different roads which includes all types of roads. In this research paper a critical review of literature on sustainable pavements for low volume roads was made using sustainable materials for paving Ultra-thin white topping concrete overlays sustainable new pavements like Pervious concrete pavements, Roller compacted concrete pavements, Cell filled concrete pavements, Self-Compacting Concrete (SCC) Pavement and additional discussion on energy harvesting pavements done. Ultra-thin white topping concrete overlay has better-proven performance but interface bond strength is very critical to resist shear stresses which cause debonding of composite concrete layers. The porous cement or bituminous concrete helps to recharge the groundwater reducing the heat islands and makes nature eco-friendly but on the other hand clogging effect can retain the water in the pavement and causes failure of the pavement. Roller compacted concrete pavement, Self-Compacting Concrete (SCC) Pavement and cell-filled concrete pavements are good in terms of performance disadvantages are less. The Indian standard code should be developed to implement energy harvesting pavements that help to produce electrical energy which meets the need of society. Further Scientometric analysis of sustainable concrete pavements for low volume roads done using VOS viewer software and the database of research work from Dimensions software. From the research gap in keyword occurrences on this topic, it is observed that rice husk ash, recycled aggregate, aluminum dross and fatigue, modulus of elasticity has a wide gap indicating further research on the combination of these key words make sustainable concrete pavements further discussed regarding high impact research papers published, similarly countries were discussed in detail.

Keywords: Sustainable materials, low volume roads, Ultra-thin white topping concrete overlay, Pervious concrete pavement, Roller compacted concrete pavement, Cell-filled concrete pavement, Self-compacting concrete pavement, Energy Harvesting pavement, Scientometric analysis.

1. Introduction

India is a developing country in which Expressways and Highways and low-volume roads are being built rapidly for meeting the transportation demand of passengers and goods. The low-volume roads have their importance as the country is agriculturally based. Even the urban streets with the low volume of traffic the pavements should be designed to perform long-term keeping in view of sustainability. In general, there are two types of pavements which are bituminous concrete and cement concrete pavements but the bituminous pavements have short term failures within their design period which include cracking, rutting formation of potholes, etc causing the passengers lot of discomfort and the vehicles need many time repairs and a lot of discomfort to the passengers. The concrete pavements when compared with bituminous concrete pavements even though have an initial cost high the life cycle cost of the concrete pavements is less when compared with the other. The concrete pavements with the inclusion of sustainable materials replacement in cement which are by-products of many industries which include fly ash from thermal power plants, Ground granulated blast furnace slag from the steel plant, silica fume from aluminum metal industries, rice husk ash from rice mills in rural areas have proven performance in terms of strength, durability and further reducing the carbon dioxide emissions into the atmosphere. The pavement designs should meet sustainability criteria which include long-term performance, improving the mechanical, durability properties, and reducing carbon dioxide emissions protecting the environment, and helping human beings. Global challenges are now to meet Sustainability, Environment friendly, protecting climate reducing heat island, Energy harvesting, and Groundwater recharge. Construction of these types of pavements helps society and further makes pavement sustainable. This paper discusses the sustainable concrete pavements that can be executed as overlays and new pavement which include Ultra-Thin White topping concrete Overlays, Porous cement, and bituminous concrete pavements, Roller compacted concrete pavement, Cell filled concrete pavement, and Energy harvesting Pavement Surface technologies. Nowadays even the main function of the pavement is changing in terms of specific requirements. Hence this research paper literature discusses different types of sustainable pavement for low volumes discussing their merits and demerits leading to a proper conclusion.

2. Literature Review

2.1 Ultra Thin White topping-Cement Concrete Overlay

The bituminous concrete pavements will have different types of failures such as potholes, cracking etc, within a short period of design life period. To improve the life of the pavement traditional bituminous concrete overlay is not a long-lasting solution. Ultra-thin white topping is a cement concrete overlay with a thickness of 100 mm can which can be laid over the bituminous pavement with surface failures which is one of the best options. This can be laid on the existing pavement after milling the existing pavement to a minimum depth of 25mm so that the remaining depth of the pavement should be 75mm. The bond between the two composite concrete layers plays a key role in the performance of the pavement. The contraction joints of the concrete overlays are cut in a closer manner of about 0.6 m to 1.2 m with a thickness of 3mm extending up to one-third of the depth of the concrete overlay. There is no chance for one axle to fall on a single panel due to which most of the load coming on the panel which make the pavement set into compression. The temperature stresses were not considered significant as the thickness of the pavement is very thin and shorter contraction joint spacings reducing the length of the panel size [1]. For low-volume roads, the maximum axle load that comes on the pavement surface is taken as 10.2Tonnes. The corner stress will be critical for the design of these concrete overlays. The wheel path movement of the vehicles along the contraction joints should be avoided to reduce corner crack failures.

In the year 1991, Thin and Ultra-Thin white topping has laid on distressed asphalt pavements which need to bond with the existing pavement. These concrete overlays of 800 million number were constructed in North America. Ultra- Thin White topping in various forms was used in parking areas, low-volume streets, etc, projects completed in India[2].The first in New Delhi (Central Road Research Institute Campus), at Ghaziabad and Mahul road Mumbai in the recent period between the years 2004 and 2010. The projects had shown good to excellent performance so far, indicating that the rehabilitation strategy can stand up to the Indian climate and traffic conditions. The most important point is to notice that these pavements are constructed with high-performance concrete. Further number of projects in rural areas have been implemented and performing successfully in India. The concrete mix should be of M45 grade with a maximum water-cement ratio of 0.4. The cement content shouldn't exceed 565Kg/m^3. The Supplementary cementitious materials such as fly ash, GGBS, and silica fume were successfully used across the projects nations wide [3]. The usage of these mineral admixtures in hot weather conditions is highly encouraged. The addition these mineral admixtures have the following advantages ease of placement, compaction without segregation, less abrasion and permeability, long-term mechanical parameters, density, toughness, volume stability, and bond strength improvement [4]. The finite element analysis performed on this concept observed that the existing bituminous pavement surface will act as the base and with good strength, it improves the performance of Ultra-thin and Thin white topping. Further, the bond between these concrete layers is very much important in terms of long-term performance. The shorter the distance between the contraction joints better the life of these concrete overlays. The interface bond strength between the Ultra-thin white topping and bituminous concrete layer is very much important which will shift the neutral axis into the bituminous concrete layer making the UTW concrete layer get into compression. The temperature and moisture conditions have a significant effect on the bond strength. Because of the traffic load repetitions, the shear stresses develop at the interface between the composite concrete layers. For the long-term performance of the UTW concrete overlay, the shear stress developed should be less than the bond strength. The texture of the two layers will have a significant effect on the performance of the concrete overlay. From the study conducted it is observed that groove interface technique treatment technique varying from parallel to inclined angle at 45degrees improves the shear strength bond. Based on the results of interface shear strength tests, the range of bond strength of UTW-HMA was found to be 0.22–1.29 MPa [5]. There is an optimum panel size for which critical stresses will be least and improves the long-term performance of the pavement. Quaternary blended sustainable concrete mixes for Ultra-thin white topping concrete overlay performance have met the requirements as a conventional concrete mix [6].

Figure 1 Ultra-Thin White topping concrete overlay with shorter Panel size

2.2 Porous /Pervious Concrete Pavements

For a new pavement in the rural areas, urban parking areas, highway shoulders the concept of porous concrete pavements which have proven performance has come into the picture. This pavement helps to recharge the groundwater table avoiding the runoff of rainwater over the surface of the pavement, helps to reduce the urban heat islands and it is environment friendly. On the other hand, the bituminous concrete pavements emit more heat at mid-day. The concrete mix design of the porous concrete pavement includes the cement concrete with less or no fines. The pavement surface will be skid-resistant and further with less noise. These pavements are widely used in Japan, the USA, and Europe due to their performances in water permeating, water draining, and water-retaining. A good study has been conducted on pervious concrete pavement and understood that voids percentage in the concrete mix is between 15 and 25% [7]. As the percentage of air voids increases the strength of the hardened concrete decreases. The water-cement ratio of these pervious concrete mixes can be between 0.28 and 0.4 to sufficient coat the cement over the surface[8]. The aggregate to cement ratio is between 4:1 to 6:1. Typically the volume of the aggregates is 50% - 65% when compared with conventional concrete which has 60% -75%. The aggregates of size 9.5 mm -2.36 mm have been used to increase the strength properties [9]. The aggregate physical characteristic such as shape and size play an important role in the strength and durability parameters of pervious concrete pavement. Even the type of aggregate plays an important role aggregate such as limestone avoided and dolomite can be used to improve strength parameters and further enhancing porosity [10]. Figure 2 shows pervious concrete pavement with water pouring on the surface.

Figure 2. Porous concrete pavement surface and water pouring on surface

The usage of supplementary cementitious materials in the cement is limited up to a certain extent as the strength of the pervious concrete mix decreases when compared with the conventional concrete mix. Retardation admixtures can be used in the mix to ease the mix placement in the site without harshness. Pervious concrete mix design and proportioning hypothesis based on the excess paste theory was developed [11]. The cement paste volume required to provide sufficient coating was determined by dividing it with the surface area of the spherical aggregates. The traditional method of calculating mix proportions for pervious concrete based on the absolute volume method has been done. The aggregate density content varied in the range of 1400–1800 kg/m3 with an aggregate to cement ratio of 4:1–12:1.[12]. The curing of pervious concrete pavement shows no change in the improvement of flexural strength of concrete. The compressive strength of pervious concrete pavement at 7 days is about 70-90% of the 28 days.[13].

The combination of latex and fiber showed superior resistance against abrasion conducted using the three different methods control, loaded wheel abrasion test, and surface abrasion tests [14]. For porosities of 15%, 20%, and 25%, the compressive strength magnitudes were in the range of 38–44, 29–35, and 15–22 MPa, respectively. An increase in 10% of porosity will reduce compressive strength by 50% [15]. The permeability of these pervious concrete mixes should be around 0.1 cm/sec to 2 cm /sec. The fatigue performance of the pervious concrete pavement using micro silica with the addition of polymers and observed to receive 2 million cycles before failure.[14].In the case of porous concrete pavement, Discrete element modelling has to be done rather than finite element modelling as it has more number of pores continuity is missing. It is observed that higher the porosity the compressive strength of pervious concrete compressive strength is reducing.[16].

2.3 Pervious Bituminous concrete pavements

Pervious bituminous concrete pavements can be laid which helps to recharge the ground water without surface runoff causing urban inundations because of heavy rainfall in the case of storms.

Further helps to reduce heat island effect and helps to growth of plants making the environment Sustainable. These types of pervious bituminous concrete are being constructed with USA, Singapore, China, Japan, and Europe even on the highways as open-graded friction courses. These bituminous concrete mixes need a porosity of 16% to 25%. Further, the noise in these bituminous concrete mixes will be less as the percentage of air voids is high. In the aggregate gradation, the coarse aggregate presence will be more when compared with fine aggregate which reduces the surface area of the pavement mix which on the other hand needs modified bitumen to meet the required stability of the bituminous concrete mix. In general, modified binders are used like styrene butadiene styrene modified bitumen or rubber bitumen and 0.3% cellulose fibers to improve the durability and anti-stripping property of the mix [17]. The permeable bituminous concrete mix is prepared with a binder content of 4.5% to 6% as the surface area is less and meets the strength requirement. To evaluate the parameter dynamic stability at high temperature of the bituminous concrete mix wheel tracking test used. The rutting dynamic stability reached 5000 times/mm exceeding the result 3000 times/mm when high viscous bitumen is used when the test was conducted according to the standard [18]. The fatigue performance in submerged water has a negative impact on fatigue performance and crack resistance as a greater number of pores are present [19]. The permeability coefficient should reach 0.4 to 0.5cm/second which can meet the demand during heavy rains. The thickness of the bituminous concrete layer should be between 40 mm to 50 mm in a single layer. The ASTM 7064-04 suggested a minimum permeability coefficient of 100 mm/day. In the long-term performance, these gaps graded bituminous concrete mix the problems of clogging, ageing of binder, stripping of aggregate, ravelling, and spalling which causes the shortened life of these pavements when compared with dense bituminous concrete mixes. To avoid the clogging problem some people have preferred a vehicle that emits water at high pressure as jet to remove the contaminants which are responsible for clogging in the maintenance process of the pavement which increases the cost. The pervious bituminous concrete pavement is effective in water permeation noise reduction, skid-resistant. But further studies on the performance of these pavements are to be studied in the case of low volume roads as clay content in the subgrade soil layer affects the performance with water permeation into the bottom layer. The other most important if water is in contact with the bituminous concrete mix with contamination clogging effect there will be a chance of stripping of aggregate which causes the failure of the pavement.[20],[21],[22].

2.4 Roller Compacted Concrete pavements

The Roller compacted concrete pavement is a type of pavement in which concrete mix with zero slump is used and compacted by a roller preferred in the case of low volume roads. The concrete mix from the plant is brought in dumpers and laid on the bottom layer, spread and compacted. The roller-compacted concrete mix in the site can attain higher strength when compared with the conventional concrete, mix. The maximum size of the aggregate in the concrete mix will be 19 mm and the concrete mix is heterogeneously mix in the concrete plant and it looks like damped gravel. Further, the RCC mix is laid in the site with the thickness of 254mm and laid by an asphalt paving machine [23]. The concrete mix used in the RCC is a dry mix that has a low water-cement ratio but the same cement content as in the case of conventional concrete mix. There will be no usage of dowel bars in the construction of RCC pavement. More over these pavements don't need manpower for finishing as in the case of conventional concrete pavement. In recent times this RCC pavement is being constructed in city internal roads and highways [24]. The usage of supplementary cementitious materials in the cement content of the concrete mix is encouraged as they provide lubrication during the compaction. The materials such as fly ash provide increased placement time and workability. To decrease the thermal cracking the usage of supplementary cementitious materials is highly encouraged. The concrete mix proportioning for Roller compacted concrete is according to ACI211.3R, ACI 207.5R or IRC SP 68-2005 guidelines [25]. The fiber reinforced concrete is performing better manner when compared with conventional concrete in the case of RCC Pavements. The replacement of fly ash in aggregate has resulted in better strength improvement of the mixtures at all ages compared to which can be used in RCC pavements. The replacement of RAP in coarse aggregate can improve the properties of the concrete mix for RCC pavements. The RAP replaced concrete mixes further observed to have higher fatigue resistance. The ground granulated blast furnace slag replaced in the concrete mix with Manufactured sand has low initial strength but in the long-term performance is very good improving the mechanical and durability properties. Further, these mixes have good abrasion resistance with the increase in age [26]. The incorporation of rubber in the RCCP pavement will make it ductile but reduces the strength properties. The roller-compacted concrete pavements which can be preferred in low volume roads like local streets, rural roads, highway intersections, and Airport service areas. The reason for preferring the roller compacted concrete is regarding the mechanical properties, durability, and its economic performance. This can be preferred in the heavy haul roads, port facilities, and parking areas, etc. Because of its good mechanical properties this was used in dams and pavements. The disadvantages of RCC pavements are to achieve smooth and even surface other failures to be observed are raveling and cracks are other things to be observed in this pavement [27].

2.5 Cell filled concrete Pavement

Cell-filled concrete pavements are a very promising technology of road construction in the case of low-volume roads [28]. The South African cell-filled concrete pavement consists of compacting subbase, stretching the cell under tension and filling with aggregates, and carrying out grouting with cement sand mortar. But later they have identified that this technology is not working better. Further in our country, the cells were placed with concrete materials over different subbases for research [29]. A polyethylene white sheet of 200µm is generally used of size 150 mm x 150 mm and with a depth of 100 mm or 150 mm. Recycled polyethylene sheets black in colour can be used in this cell fill concrete pavements. The sub-base can be prepared with a soil-cement combination and as a natural aggregate is getting. The unconfined compressive strength and durability experiments should be conducted for the soil cement mix to check the suitability for utilizing the mix for the subbase. The unconfined compressive strength of soil-cement should be minimum of 2.8 MPa to meet heavy requirements. A minimum compressive strength of 30MPa is needed for cell-filled concrete pavement. d) Cell compacted concrete pavements in which plastic strips are placed and concrete of grade M30 with zero slumps is placed into these cells and compaction is done. This is a long-lasting pavement technology that creates employment for the public on rural roads. Figure 3 shows cell-filled concrete pavements and concrete laying. The structural evaluation of conditioned pavements using FWD indicate that the effective modulus of the cell-filled layer depends on the strength of the base course layer. Comparison of the cost of cell-filled pavements considered in this study with those of pavements designed as flexible and rigid pavements suggests that cell-filled pavements are cost-effective. If recycled plastic can be used for the formwork, the problem of disposing of used high-density polyethylene sheets can be mitigated to a great extent. Rut depths for these pavements after 1500 passes of a loaded truck were less than 2 mm.[30]

Figure 3. Laying of Cell filled concrete Pavement

2.6 Self Compacted Concrete pavements

Self-Compacting Concrete (SCC) is a special type of concrete, which does not require any other external vibration to attain the strength by eliminating the voids. In comparison viewpoint, SCC requires a high dosage of powder content as contrasted to conventional vibrated concrete. The quantity and size of coarse aggregate along with low water-powder ratio are considered to be limited characteristics to achieve the self-compatibility in SCC. For achieving better rheological properties of SCC and without having segregation and bleeding during transporting and placing, use a higher dosage of fine aggregate. For maintaining the mix to be cohesive use higher powder content or use of chemical admixture. Some of the advantages of SCC are lower noise at the worksite, reduction in labour, thinner cross-sections of concrete structural elements is possible, better bonding with reinforcement, and also improves surface finish. SCC improves the filling capacity at congested reinforcement sections. One of the ill effects of SCC is its cost, which is related to chemical admixture and high quantity of Portland cement. The SCC is, therefore, another option considering these properties for rigid pavement of village road noting the fact that a dense compacted concrete in line and level is a prime requirement for village road [31]. The replacement of cement with GGBS in SCC mixtures had shown better results of concrete like workability, mechanical strength, drying shrinkage, and abrasion resistance to which can be used in SCC pavements [32].

2.7 Energy Harvesting Pavement Surfaces

The recent year's concentration on the shortage of global energy shortage and environmental pollution and climatic change. In the case of bituminous concrete pavements lot of solar energy is absorbed and accumulated thermal energy lies in the pavement. The dynamic load on the pavement surface generates mechanical energy as the vehicle axle repetitions are there [33]. Piezo-Electric pavement technology will incubate the piezoelectric materials and further converts mechanical pavement loads on the pavement surface to electrical energy. Extensive laboratory studies have been conducted on this concept and Patented [34]. Photovoltaic pavement technology uses solar panels as construction for the pavement surface other than using conventional concrete mixes which converts solar energy to electrical energy. This concept was used in the bicycle lane with a 10 mm thick glass panel on the pavement surface underneath having crystalline silicon solar panels used. Structurally engineered solar panels were used for Solar Roadway [35]. Thermoelectric Pavement technology uses a thermoelectric module used in bituminous concrete pavements which can convert heat absorbed by the pavement to electrical energy. The difference in the temperature between the thermoelectric modules will be used to generate voltage. The temperature difference between subgrade and pavement is taken for efficient generation of power with the use of high thermal conducting materials [36]. The traditional way of pavements is nowadays advancing in its multi-functionality meeting the sustainability in different ways such as noise reduction, reducing heat island effect, etc. for example the rubber asphalt content can reduce the noise and light-colored concrete pavement reduces the pavement temperature.

3. Scientometric Analysis-Methodology

The Scientometric analysis is the quantitative study of publications to infer the research trends and progress in any discipline. The quantification of literature review has been done on the concept of Sustainable pavements for low volume roads. The database of research documents was taken from Dimensions [37]. VOSviewer software was used in Scientometric analysis and creating maps based on network data, visualizing and exploring maps based on any type of network data [38]. This software helps to know keyword occurrences, Citation-Country, Citation-Institution, Citation- Journal, Author - Co-Authorship analysis. This software gives a network of items of these terms' keywords, Countries, Journal, Institutions which will be indicated by circles and different colors. The Size and Label of the item are large indicates its prominence in research, similarly all items in one cluster that belong to one color have a close relationship. Further blue color has a low impact whereas yellow has a high impact on research. The following figure 4 shows the number of research papers published year-wise. Figure 5 Shows different categories of publications made between the selected period 2010 and 2021.

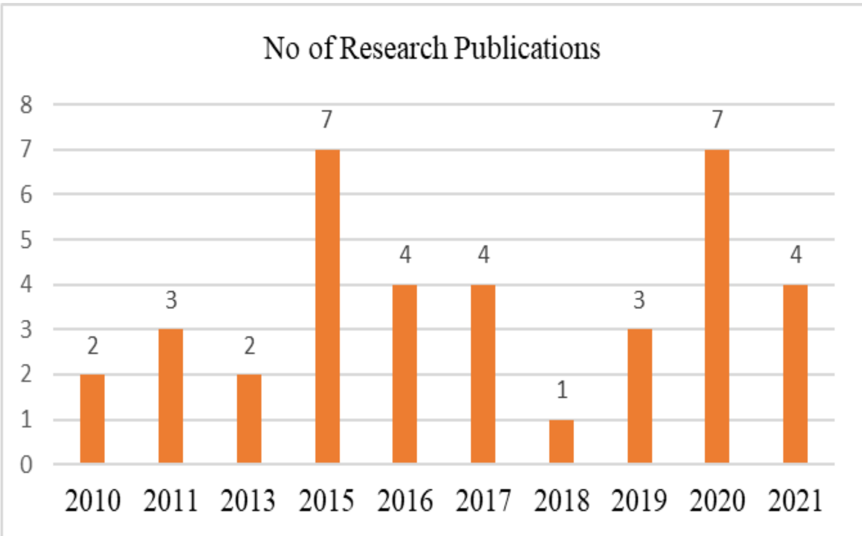

Figure 4 Research publications made year-wise.

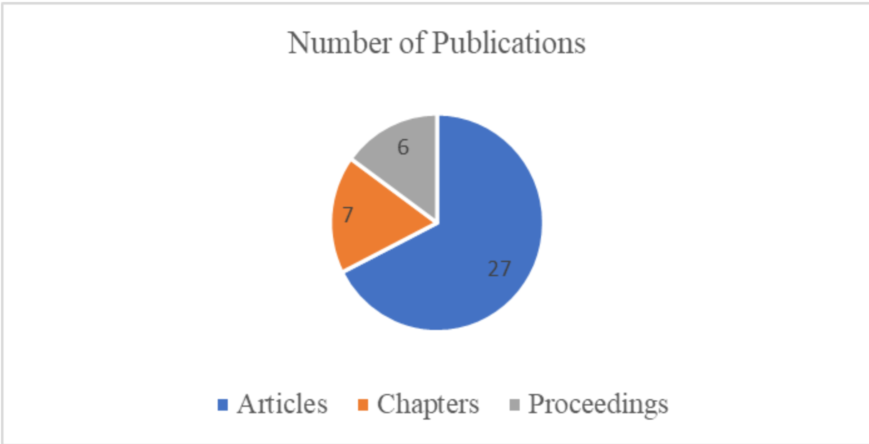

Figure 5 Category-wise Number of research publications made

3.1 Keyword-Occurrence analysis

The number of keyword occurrences taking as three 160 keywords out of 1555 has met the threshold. The keywords with a greater number of citations are pervious concrete pavement, mechanical properties, hot mix asphalt, resilient modulus, recycled aggregate. The closely related keywords are rice husk ash, concrete, replacement, aluminum dross, flexural strength, bottom ash, mechanical properties. The other set of closely related keywords are resilient modulus, modulus of elasticity, fatigue, damage analysis, low volume roads, recycled concrete aggregate. There is a wide gap between these terms which are low volume roads, recycled aggregate, resilient modulus, and concrete replacement, flexural strength, and mechanical properties. Later It is observed from the analysis that the word recycled aggregate which belongs to cluster number 2, which has 6 links, cluster strength of 119, number of publications as 7 have 150 citations. The following figures 6,7and 8 show Keyword occurrences Network, overlay, and density visualization.

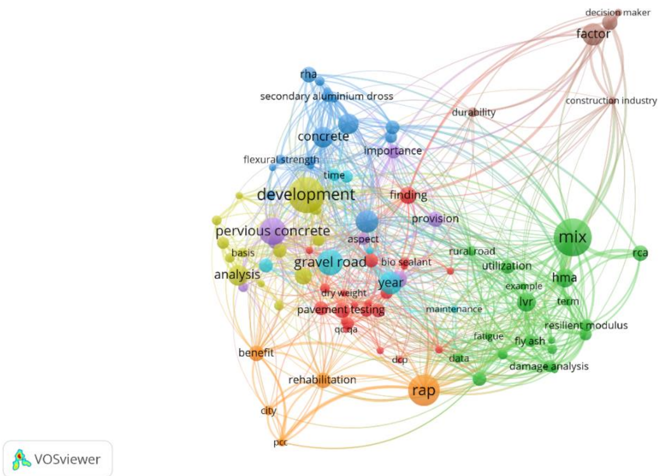

Figure 6 Keyword Occurrences Network Visualization

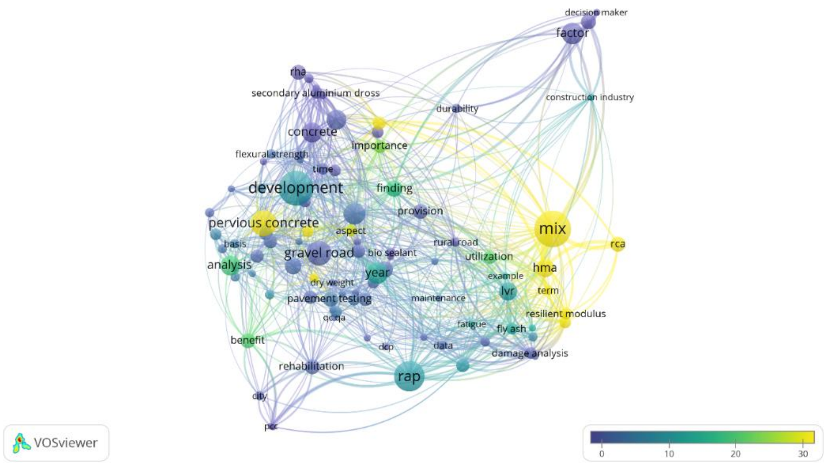

Figure 7 Keyword Occurrences - Overlay Visualization with Average Citations

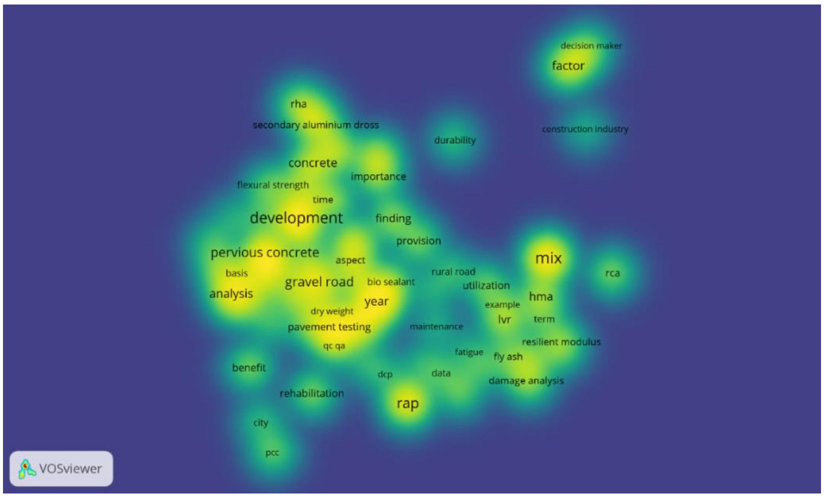

Figure 8 Keyword Occurrences Density Visualization

3.2 Citation-Institution Analysis along with sources

The consideration of citations and Institutions as one, nineteen number of Institutions met threshold out of thirty-five. Further, the Michigan State University, Indian Institute of Technology Kharagpur, and Indian Institute of Hyderabad have the Average citations as follows 150,129 and 15.5 Citations. More Publications were made by the University of Illinois Urbana Champaign with an average of number 50 in the year 2016.

3.3 Citation-Country Analysis

The consideration of a number of countries and a minimum number of citations as one, 12 countries met the threshold out of 17. The countries USA and India have produced a greater number of publications relatively with 11 and 7 respectively. Considering the overlay visualization, it was observed that India and the USA have average citations of 22.86 and 17.82

4. Discussion

Sustainable concrete pavement is the need for low volume roads which should have durability in terms of long-term performance economical and environment friendly. Sustainable concrete pavements or concrete overlays like Ultra-thin white topping, Porous concrete pavement, Roller compacted concrete, Cell filled concrete pavement and Energy harvesting pavement have proven performance across the world. The Sustainable cement concrete overlay on the existing bituminous pavement is called Ultra-thin white topping for low volume roads which have proven performance but the critical stress in these concrete overlays is corner stress. The interface bond strength is critical as shear stresses develop in terms of debonding at the composite concrete layers take place. Porous cement concrete pavements which are preferred in the low volume roads like urban parking areas, rural roads, and highway shoulders helps to recharge the groundwater table and improve nature with green trees and bushes protecting the environment and reducing heat islands. These concrete pavements are skid-resistant and have less noise. The mix design has lees or no fine with a certain extent of supplementary cementitious replacement is permitted. Similarly, Pervious asphalt concrete pavements have come into the picture with different countries like the USA, Singapore, China, Japan, and Europe. These pervious concrete pavements have similar problems of clogging due to which water penetration will not happen and need regular maintenance which increases the cost. The roller-compacted concrete which needs zero slump concrete mix more strength in the field when compared with conventional concrete pavement. The use of supplementary cementitious materials in the concrete mix along with polypropylene fibers to arrest the cracks that develop in the concrete pavement. Energy Harvesting Pavements can become alternative energy sources the bituminous concrete pavements will absorb a lot of heat from sun rays which have thermal energy in them. Piezoelectric materials placed in the pavements can convert mechanical energy in the form of load repetitions into electric energy. Photo-voltaic pavements use 10 mm thick glass plates placed on crystalline solar panels placed which can be used for bicycle lanes. Thermo-electric pavement utilizes the heat difference in temperature between thermoelectric modules to generate voltage. These pavements help to produce the energy needed for society.

5. Conclusions

1. In the case of Ultra-thin white topping concrete overlay as the panel size is less most of the concrete overlay will be under compression. The performance of this pavement is good across the world but the following points to observed. The other critical points that need to be considered is to avoid the wheel path of the vehicles over joints which causes the failure of the pavement in terms of corner cracks. The interface bond strength is very critical at the interface of the composite concrete layers which causes the debonding of these layers. Even the existing bituminous concrete pavement should perform as a strong base layer for durability.

2. The porosity in the case of pervious cement concrete pavements helps to recharge the groundwater water table. The pervious concrete pavement helps to reduce the heat island and is environmentally friendly. The fatigue performance of the pavement with micro silica and polypropylene fibers is observed to receive 2 million cycles before failure. The design of pervious concrete mix is very much important as is observed that a 10% increase in the porosity reduces 50% of the compressive strength. There is the necessity to develop a standard code for uniform practice in the field in the Indian conditions. Further studies to be carried out on the performance pervious bituminous or cement concrete pavements to be studied in the case of low volume road as clay content in the subgrade soil layer affects the performance with water permeation into the bottom layer. The other most important if water is in contact with the bituminous concrete mix with contamination clogging effect there will be a chance of stripping of aggregate which leads to failure of the pavement.

3. Replacement of Recycled asphalt pavement material in coarse aggregate can be used in the concrete mix to attain the strength for better abrasion resistance and fatigue resistance. The roller-compacted concrete has an uneven rough surface only skilled labour is required to lay in a proper manner.

4.Cell-filled concrete is very much preferred for low-volume roads in which recycled polyethylene sheets are stretched and placed concrete over that and compacted. These pavements help the concrete to have less tensile stresses as the polyethylene sheets take care of that. This technology can be preferred in the low volume roads and create local people employed in the form of stitching polyethylene sheets and laying. Rut depths for these pavements after 1500 passes of a loaded truck were less than 2 mm which should be observed as good for the life of the pavement. Self-compacted concrete pavement is better option where self-compaction takes place and density of the concrete mix in the pavement of takes place. But it needs the usage of chemical admixture which increases the cost of the concrete pavement. The reduction of cement content with materials like ground granulated blast furnace slag not only reduces the cost but on the other hand improves mechanical and durability properties of the concrete mix.

5. Indian conditions should be considered for new types of pavements like energy harvesting for low-volume roads. Further, the evaluation of performance of these pavements update to with research and field investigations should be done for the development of standards like codes for a new type of pavements like energy harvesting pavements.

6. From the Scientometric analysis of keyword occurrences using VOSviewer software Dimensions database on the topic of sustainable concrete pavements for low volume roads it is observed that rice husk ash, concrete replacement, aluminum dross, recycled aggregate, flexural strength, bottom ash, and mechanical properties closely related. The other set of closely related words are resilient modulus, fatigue, damage analysis, low volume roads, and recycled aggregate. There is a wide gap between these sets of keywords which the further research can be carried out with high impact for low volume roads.

7. In a Quantitative manner Transportation research board and Construction and building materials journals have published more papers. The institution University of Illinois Urbana Champaign has produced an average 50 number of publications. Considering the overlay visualization, it was observed that India and the USA have average citations of 22.86 and 17.82

8. From the literature it is observed that usage of sustainable concrete materials in the above-said pavements has the better improvement of mechanical properties, improved abrasion resistance, makes the pavement economic and environment friendly reducing the carbon dioxide gases into the atmosphere. Further from Scientometric analysis, it is observed materials like rusk ash, aluminum dross replacement, recycled aggregate bottom ash are one set of sustainable materials used but the strength and resilient modulus of these materials to be tested and bring into practice in the field makes the pavement sustainable. Considering the above precautions in each type of sustainable concrete pavement these can be constructed for low volume roads which will durable and eco-friendly.

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