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A Study of Porous Asphalt Pavement as Rainwater Harvesting System

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A B S T R A C T

Porous asphalt pavements allow for land development plans that are more thoughtful, harmonious with natural processes, and sustainable. They conserve water, reduce runoff, promote infiltration which cleanses storm water, replenish aquifers, and protect streams. With proper design and installation, porous asphalt pavements can provide a cost-effective solution for storm water management in an environmentally friendly way. Porous asphalt pavements with stone reservoirs are a multifunctional low impact development technology, which integrates ecological and environmental goals for a site with land development goals, reducing the net environmental impact for a project. Not only do they provide a strong pavement surface for parking, walkways, trails, and roads; they are designed to manage and treat storm water runoff. With proper design and installation, porous asphalt pavements can provide a cost-effective solution for storm water management in an environmentally friendly way. Mineral aggregate constitutes approximately 96% of porous asphalt by weight. The mineral aggregate for porous parking lot is made up of higher percentage of coarse aggregate compared to fine aggregate. Flat and elongated aggregate particles tend to break during mixing, compaction and under traffic loading. Since interlocking of each coarse aggregate particle in porous asphalt is critical, only good quality aggregate with high abrasion value, crushing value was chosen.The open structure of porous asphalt exposes a large surface area to the effects of air and water, which accelerates the oxidation rate and affects the coating properties of the binder. These factors may influence the adhesive strength of the binder-aggregate and lead to cohesive failure within the binder film, contributing to aggregate stripping and moisture damage. The addition of fillers in asphalt mixtures has been identified to stiffen the asphalt binder and improve mixture strength. .

Keywords: Porous Asphalt, Hydrated Lime, Recharge, Replenish, Stone Reservoir.

1. Introduction

Unlike conventional pavements, porous asphalt pavements are typically built over an un-compacted subgrade to maximize infiltration through the soil. Above the un-compacted subgrade is a geotextile fabric, which prevents the migration of fines from the subgrade into the stone recharge bed while still allowing for water to pass through. The next layer is a stone reservoir consisting of uniformly graded, clean crushed stone with 40% voids serving as a structural layer and to temporarily store water as it infiltrates into the soil below. Then, to stabilize the surface for paving, a thin (about 1-inch thick) layer of clean, smaller, single-size crushed stones are often placed on top; this is called the stabilizing course or choker course. The last layer consists of one or more layers of open-graded asphalt mixes with interconnected voids, allowing water to flow through the pavement into the stone reservoir. These open-graded asphalt layers consist of asphalt binder, stone aggregates, and other additives. By excluding fines, the open-graded mixture allows for more air voids (typically between 16% and 22% voids).

Porous pavements are an available storm water management technique which can be used on parking lots and low volume roadways in order to reduce both storm water runoff volume and pollution. In addition, ground water recharge is enhanced. Porous asphalt pavements can provide cost-effective, attractive, and long-lived solutions to parking lots, as well as providing storm water management systems that promote infiltration, improve water quality, and eliminate the need for a detention basin. The key to a successful porous asphalt surface is an underlying, open-graded stone bed that gives surface water a destination. Also, cost reductions result due to elimination of curbs, drains, and small sized storm sewers. Porous asphalt pavements consist of a relatively thin course of open graded asphalt mix over a deep base of large size crushed stones. Water can be stored in the crushed stone base until it can percolate into the sub-base or drain laterally.

2. Objectives of Study

1. To construct a sample road of porous asphalt pavement & conducting the required tests of strength & porosity.
2. To enhance the properties of porous asphalt pavement by using admixtures if required.
3. To compare the strength of ordinary asphalt pavement & porous asphalt pavement.

3. Literature Review

3.1 Ductility test for bitumen

Hussain et. al., 2017 described that, ductility is the property of bitumen that permits it to undergo great deformation or elongation. The bitumen sample is heated and poured in the mould assembly placed on a plate. These samples with mould are cooled in the air and then in water bath at 27 °C temperature. The excess bitumen is cut and the surface is leveled using a hot knife. Then the mould with assembly containing sample is kept in water bath of the ductility machine for about 90 minutes. The distance up to the point of breaking of thread is the ductility value which is reported in cm. A minimum ductility value of 75 cm has been specified by the BIS.

3.2 Composition of porous asphalt pavement

Joon Pankaj, 2017 added that Porous asphalt is produced and placed using the same methods as conventional asphalt concrete; it differs in that fine (small) aggregates are omitted from the asphalt mixture. The remaining large, single-sized aggregate particles leave open voids that give the material its porosity and permeability. To ensure pavement strength, fiber may be added to the mix or a polymer-modified asphalt binder may be used. Generally, porous asphalt pavements are designed with a subsurface reservoir that holds water that passes through the pavement, allowing it to evaporate and/or percolate slowly into the surround soils.

Yadu Jeet, 2016 expressed Permeable pavement can be constructed using pervious concrete, paving stones, porous asphalt or concrete or plastic-based pavers. However, here porous concrete is considered for the construction as it is easily available throughout. Pervious concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through. Pervious concrete is made using large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. Pervious concrete is a unique and innovative means to manage storm water.

A pervious concrete mixture contains little or no sand, creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly.

Shukry, 2018Porous asphalt has been used widely due to its ability to allow rainwater to drain quickly from the pavement surface through its pore structure. Given this ability, porous asphalt is utilized in wearing courses with approximately 50 mm thickness and placed over the impermeable asphalt surface as a possible solution for road safety improvements in wet conditions and for the reduction of traffic noise. Porous asphalt is designed with open-graded aggregate gradations that consist of a large proportion of coarse aggregates with a limited amount of fine aggregates to create larger quantities of interconnected voids of more than 18%, to allow water to penetrate through the voids. The life of a porous surface is expected to be shorter than that of a conventional asphalt surface because of the deterioration by runoff, air infiltration, subsequent stripping and oxidation, and hardening of the binder. On the other hand, the open gradation and high air-void content lead the porous asphalt mixture to poor durability due to less stone-on-stone contact caused by the inappropriate gradation and low density in porous asphalt mixture, which results in a lower performance than normal dense-grade mixture. Moreover, the open structure that facilitates water drainage exposes the pores of porous asphalt to air, water, and clogging materials that erode the binder film and eventually affects the strength of the binder aggregate bonding.

3.3 Properties of porous asphalt pavement

Patil V. et. al., 2018, added Porous asphalt is an innovative road surfacing technology which allows water into the asphalt mixes beyond its continuous air voids, several studies are quantified high removal rates of total suspended solids, metals, oils, and grease, as well as moderate removal for phosphorus, from using porous asphalt pavement. Porous asphalt pavements with stone reservoirs are a multifunctional, low impact development technology that ecological and environmental goals for a site with land development goals, reducing the net environmental impact for a project. Not only do they provide a strong pavement surface for parking, walkways, rails and roadways, they are designed to manage and treat storm water runoff. With proper design and installation, porous asphalt pavements can provide a cost storm water management in an environmentally friendly way.

Cahill et al. 2004, A typical porous pavement has an open graded surface over an underlying stone recharge bed. The water drains through the porous asphalt and into the stone bed, then, slowly, infiltrates into the,soil. If contaminants were on the surface at the time of the storm, they are swept along with the rainfall through the stone bed. From there they infiltrate into the sub-base so that they are subjected to the natural processes that cleanse water.

Khilari et. al., 2017, Porous paving systems consist of a porous asphalt or concrete surface course placed over a bed of uniformly graded broken stone. The broken stone bed is placed on an un-compacted earthen subgrade and is used to temporarily store the runoff that moves vertically through the porous asphalt or concrete into the bed. The high rate of infiltration through the porous paving is achieved through the elimination of the finer aggregates that are typically used in conventional paving. The remaining aggregates are bound together with an asphalt or Portland cement binder.

Khandal & Mishra, 2014, The porous asphalt pavement which can be used for parking lot or low-trafficked roads/streets works like this. The top 75 mm asphalt layer is specially designed to make it porous. Rainwater goes through it rapidly without any ponding. The water is then stored in an underlying open-graded stone bed, which is about 225 mm thick. From there, water percolates slowly into the underlying soil. The porous parking lot or street can be integrated with a roof rainwater harvesting system in the buildings adjacent to it by diverting the roof water to the stone bed. Recently, the Jaipur Development Authority has constructed the first ever porous asphalt parking lot in India.

Abdullah et. al. 1998, Porous asphalt pavement is more efficient than conventional pavements in terms of retaining pollutants, improving the quality of water and runoff while maintaining infiltration. Porous asphalt pavement reduces land consumption by reducing the need for traditional storm-water management structures. However, on the other hand, the priority objectives which are minimizing increased flooding and pollution risks while increasing performance efficiency and enhancing local environmental quality-of-life is achieved.

3.4 Strength & effectiveness of porous asphalt pavement

Shukry, 2018, The presence of filler can positively affect the overall mixture performance including strength, stability, workability, resilient modulus, resistance to moisture, resistance to permanent deformation, and aging characteristics. The indirect tensile strength test showed that the said strength of the asphalt mixture increases as the filler content rises. This higher tensile strength implies that mixtures with filler are capable of withstanding larger tensile stress before failure. Another study revealed that the results for resilient modulus also indicated that mixtures with filler show higher resilient modulus values, which leads to stiffer mixtures with superior load spread capacity and greater resistance to fatigue cracking and permanent deformation.

3.5 Application of porous asphalt pavement

Al-Jumaili Hasan, 2016, The application of porous asphalt is to provide skid resistance, especially in the wet season, which is markedly better than that of dense graded asphalt. The potential of aquaplaning, much reduced at normal driving speeds, and together with improved visibility, may be important benefit for using this type of mix. Porous asphalt is a type of mixture that consists of relative coarse aggregates bound together by a mixture of sand, filler and bitumen hereafter called mortar. After laying and compaction this results in a structure with a relative large amount of interconnected voids. Compared with dense asphalt concrete, the porous asphalt concrete has a very open structure with void contents around 20 %. Improvements primarily included the use of modified asphalt binders and fibres. The modified binders and fibres alleviated some of the problems that were encountered with open-graded friction courses in the United.

Boudreau et. al., 2009, Porous asphalt can also greatly increase safety by reducing aquaplaning and skidding accidents. It accomplishes this increase in safety not only by reducing the amount of water layering the surface, but by dissipating hydraulic pressure through its pores. Reducing the amount of water impounded on the road's surface also reduces the amount of vehicle spray and glare. On high-speed roads vehicle spray and glare can severely limit driver visibility thus decreasing their perception time in emergencies. By decreasing the spray and glare, drivers can feel more comfortable driving in adverse conditions because of the additional visibility.

3.6 The Study of Porous Asphalt Pavement

Chavanpatil & Chokakkar, 2018 stated that the performance of porous asphalt pavements is similar to that of other asphalt pavements. And, like other asphalt pavements, they can be designed for many situations. Common applications of Porous Asphalt Pavements are parking lots, side-walks, pathways, shoulders, drains, noise barriers, friction course for highway pavements, permeable sub base under the conventional flexible or rigid pavements and low volume roads.

The project model consists the size of glass box is 2'x1'x 2'2" (LxBxH) which includes the all of materials that are used. The bottom surface is un-compacted subgrade which is soil including in glass box at height 4 inches. The slope is provided as 1:10 and non-woven geotextile sheet is provided over a slope. After that un-compacted subgrade above surface consists the stone reservoir that is river stones which are in sizes 2 to 3 inches in between at height 10 inches. After that above surface contains rail road ballast in sizes 2 to 2.5 inches in between at height 4 inches. Next surface contains chocker coarse or filter coarse in sizes 0.5 inches at height 2 inches. Then next layer consist the porous asphalt pavement containing thickness 4 inches. In between all layers the geotextile knitted sheet is provided. The bottom part consists the gutter at the centre of model which is in 12''x 4''x 4'' as per our model and above that gutter the mesh is provided including knitted geotextile sheet in size.

Results:

1) Porous pavement is a sound choice on economics alone. A porous asphalt pavement surface costs approximately the same as conventional asphalt. Because porous pavement is designed to "fit into" the topography of a site, there is generally less earthwork.
2) Design, maintenance and water quality control aspects relevant to the practitioner were out lined for permeable and porous pavement system.
3) The development of a combined geothermal heating and cooling, water treatment and recycling pavements system is promising.

Khilari et. al., 2017,As the drainage properties of the normal bitumen porous asphalt is greater than that of crumb rubber porous asphalt this concludes that the voids in normal porous asphalt are filled by the crumb rubber particles which increases the strength of the specimen. The reduction in drainage is not much significant as compared to the increase in strength. Hence, the use of crumb rubber is recommended for increasing the strength of the porous asphalt pavements. The overall properties of porous asphalt are improved by the use of crumb rubber. The crumb rubber porous asphalt can be used as an alternative for conventional porous asphalt in areas where the traffic load is low or moderate. The other implementations of porous asphalt can be for recreational purposes, internal roads in town planning, parking lots etc.

3.7 Porous asphalt pavement mix design guidelines

Kiran Kumar et. al., 2014, Porous asphalt pavements offer developers and planners a new tool in their toolbox for managing storm water. These pavements allow water to drain through the pavement surface into a stone recharge bed and infiltrate into the soils below the pavement. With the proper design and installation, porous asphalt can provide cost-effective, attractive pavements with a life span of more than twenty years and at the same time provide storm-water management systems that promote infiltration, improve water quality, and many times eliminate the need for detention basin.

Material:

The aggregates used in the porous asphalt mix consisted of crushed angular granite stone with maximum size not exceeding 19 mm. Granite stone was chosen as coarse aggregate as it is a common higher quality aggregate available in the vicinity of Bangalore. Crumb Rubber Modified Bitumen (CRMB-60) was used throughout the study for the preparation of the porous asphalt mix.

Results:

The test results of various experiments conducted on Porous Asphalt Specimens for determining optimum binder content, namely: - Air Void content, Cantabro Abrasion, Ageing Potential and Drain Down Potential were obtained. Three performance tests were conducted which included Permeability, Moisture Susceptibility and Marshall Stability. the following concluding remarks may be derived:-

1) The aggregate gradation consists of 100 percent of 19 mm down sized aggregates but requires less than 15 % of the aggregate fraction passing 4.75 mm, so that the compacted mix becomes permeable and provide adequate permeability.
2) In order that the stone-on-stone contact condition is achieved in Porous Asphalt pavements, it demands the use of modified binders such as Polymer modified Bitumen or Crumb Rubber modified Bitumen.
3) For the Porous Asphalt to be permeable, air voids content of 18 percent and above is necessary.
4) The abrasion loss of the un-aged Porous Asphalt can be reduced significantly by increasing the percentage binder content or by using a modified binder such as the Crumb Rubber modified Bitumen due to improved flexibility.

load capacity. Permeable asphalt consists of asphalt binder and coarse stone aggregate, with a little fine aggregate. These have enough void space (normally designed for up to 30% voids) to allow speedy percolation of water and look like exposed aggregate concrete. Permeable pavement is economic and environmental friendly system.

4. Construction Methodology of Porous Asphalt Pavement

To determine the suitability of a project for permeable pavement, the key factors specific to the project should be considered. Based on their importance in overall decision making, these factors can be divided into primary, secondary, and other considerations which may impact the decision to use permeable pavements for a particular project. Primary considerations (i.e., fatal flaws or major design challenges) are those that would have an overriding influence on the decision to move forward with the project. Secondary considerations are those that have a lesser influence and usually are taken into account as part of the design process when there are no overriding considerations. These factors may diminish the performance or acceptability of permeable pavement or may require additional design provisions (and associated costs) to avoid risks. Other considerations may have some influence on the decision to include permeable pavements for a particular project. The primary considerations should generally be weighted the highest to reflect their importance in moving forward with the project, while secondary and other considerations are useful to prioritize between sites and inform design, but are not generally fatal flaws.

Typical guidelines for construction procedures for porous pavement include:

- Plan to construct the porous pavement as late as possible in the construction schedule.
- Protect site area from excessive heavy equipment running on the subgrade, compacting soil, and reducing permeability.
- Excavate the subgrade soil using equipment with oversized tires or tracks to minimize compaction to soil.
- As soon as the bed has been excavated to the final grade, the fabric filter should be placed with an overlap of a minimum of 16 inches. Use the excess fabric (at least 4 feet) to fold over the stone bed to temporarily protect it from sediment.
- Place the aggregate stone recharge bed carefully to avoid damaging the fabric. The aggregate should be dumped at the edge of the bed and placed in layers of 8 to 12 inches using tracked equipment and compacted with a single pass of a light roller or vibratory plate compactor.
- When using a stabilizer course, it is important that the aggregate be sized properly to interlock with the aggregate in the recharge bed. The stabilizer course should be placed at a thickness of about 1 inch. Some larger stones from the stone reservoir should be visible at the surface.
- The porous asphalt should be placed in 1- to 4-inch-thick lifts following state or national guidelines for the construction of open-graded asphalt mixes. (Track pavers are recommended)
- The porous asphalt should be compacted with two to four passes of a 10-ton static roller.
- Restrict traffic for at least 24 hours after final rolling.

5. Testing Method of Porous Asphalt Pavement

Porous asphalt (PA) is an innovative road surfacing technology which allows water to percolate into the PA pavement. The inter-connected voids inside the PA allowed water to infiltrate through the pavement and is usually laid on an impervious compacted base course.

Impervious surfaces, such as roadways, roof tops and parking lots resulting storm water runoff and deliver dirt and debris directly into the stream. In turn, the existing impervious surfaces caused ponding water which translates few hours of heavy rain into flash floods.

Based on the laboratory results from the mixes prepared using the modified gradation, the adopted gradation should fulfil the following criteria for storm water management purposes :

• Air Voids : Minimum air voids of 16% to 22 % (or greater) is acceptable to assure good permeability of the mix. The volume by dimension must be determined when computing the air voids of PA.

• Binder Content : Adequate binder content is important for durability of the mix. For MSA 9.5mm, 5.75% minimum by weight of total mix of binder content is required. For larger MSA mixes, lower minimum asphalt content is acceptable.

• Draindown : Generally, 0.3 percent maximum of draindown is permitted to quantify optimum amount of binder that suitable for mixing, transportation and laying process.

6. Materials and Methods

Mineral aggregate constitutes approximately 96% of porous asphalt by weight. The mineral aggregate for porous parking lot is made up of higher percentage of coarse aggregate compared to fine aggregate. Flat and elongated aggregate particles tend to break during mixing, compaction and under traffic loading. Since interlocking of each coarse aggregate particle in porous asphalt is critical, only good quality aggregate with high abrasion value, crushing value was chosen.

Aggregate type trap metal supplied by Sunil Patil, Gadhinglaj was used in this study. The aggregates were sieved, washed and dried into selected size fractions according to proposed gradation. Instead of being applied for PA, the aggregates were also set up for other layers in the PA parking lot system.

6.1 PA sample preparation

Two types of PA samples were prepared, namely cylindrical and slab. The cylindrical samples were prepared according to the Marshall method. The samples were used to determine the DBC and performance evaluation. The slab compactor was used to produce rectangular slab that was placed inside the WFS's body to simulate the uppermost layer of porous parking lot layers.

6.2 Mixing and compaction

Prior to the mixing process, the electrically heated vertical paddle mixer was first set to the required mixing temperature. The oven dried aggregates were fed into the mixture container and mixed dry for 30 seconds to ensure uniformity and homogeneity of the aggregate blend. Subsequently, the exact quantity of bitumen was poured onto the aggregate blended and the mixing was continued until the aggregate were uniformly coated with bitumen. The entire mixing process took approximately 2 minutes to accomplish. Next, the loose hot mix was placed onto a clean tray and conditioned in an oven at the compaction temperature (153°C) for 2 hours as recommended by Asphalt Institute. After conditioning, the hot mix was transferred onto the hot Marshall moulds via a metal chute. Once the compaction temperature was reached, specimen was subjected to 50 blows per face. The compacted samples were allowed to cool at room temperature overnight and extruded for further testing except for those subjected to permeability test.

7. Test Results of Porous Pavement

7.1 Selection of porous asphalt gradation

In most porous asphalt pavements for rain water harvesting management, a 9.5 mm MSA is used for the surface layer. However, it is reported that larger MSA mixes have been utilised for the same objective. A new generation of mix designs used 12.5 and 16 mm MSA instead of 9.5 mm. New mix specifications are producing mixtures with higher level of air voids, larger pore sizes and longer durability. The larger aggregate size was proposed since it resulted in higher air voids which are less susceptible to clogging and allowed rapid water percolation.

With proper design, porous asphalt which has larger open space between interlocking aggregate skeleton provides more air voids, thus enable shorter duration for water to percolate through the porous pavement. However, the drainage function only can be attained by the prevalence of interconnected air voids. Sufficient connected air voids in porous asphalt mixtures is vital to ensure the water can permeate through the air voids to achieve the drainage function. Other factors affecting air voids include bitumen content, aggregate shape and aggregate gradation.

7.2 Binder drainage

One of the common set back related to porous asphalt mix is drainage of binder from the aggregate due to excessive bitumen content used during mixing or low viscosity of bitumen content. Bitumen content used must be just enough to prevent excessive binder drainage occurring during mixing process, transporting and laying. The coarser the aggregate gradation, the drain down probability of asphalt bitumen during mixture design and field production is greater. Binder drain down causes binder content variations in an asphalt mix. Ravelling easily took place in areas deficient in bitumen content meanwhile too much bitumen content causes permeability loss. This result of this study should comply to requirements for drain-down, which is 0.3% maximum drain-down. The mixes were prepared at 155°C and tested at 10°C higher than the mixing temperature. The binder drainage test results are shown in Table 7.3 and correspond to the upper limit of the DBC. The results showed that more binder drainage took place as the binder content increase.

The results show that the retain binder is linearly correlated to the mixed binder content at lower bitumen contents. However, at binder contents exceeding 4.5%, the relationship diverge from the linear line but the amount of retained binder continues to increase until 5.5% binder content, beyond which point the amount of retained binder reduces. The binder drainage test was carried out to determine the maximum permissible binder content for specimen. For design purposes, the upper limit of the DBC adopted the target binder content which is 0.3% less than the optimum mixed binder content.

7.3 Abrasion resistance

To determine the minimum permissible abrasion loss, the relationship between abrasion loss and temperature has been established. A power model relationship to correlate permitted abrasion loss at various temperatures was established

The specimen abrasion loss decreases from 61.1% to 10.6% when the binder content increases from 3% to 5%. The test results indicate that at lower range of bitumen content, the mixes are more prone to disintegration. At higher binder content, more cohesion is established between the aggregate particles, thus reducing mix disintegration. Generally, the resistance of disintegration is assessed in term of its abrasion loss. The result shows that the aggregate particles disintegration gradually as the binder content increases also more binder content shows less abrasion loss percentages, since there is more binder to strongly bind the aggregate particles together. By adopting 16 % abrasion loss, the lower limit of the DBC is set at 4.1%. Therefore, the DBC of the PA mix tested ranges from 4.1% to 5.2%.

8. Comparison of Ordinary & Porous Mix

While special features such as the underlying stone bed are more expensive than conventional construction, these costs are more than offset by the elimination of many elements of standard storm-water management systems. On those jobs where unit costs have been compared, a porous asphalt pavement is generally the less-expensive option.

NAPA also says the cost advantage is even more dramatic when the value of land that might have been used for a detention basin or other storm-water management features is considered.

Porous asphalt will also save you money because it eliminates the need to put in a storm-water management solution such as a retention pond. The land that is normally slated for the retention pond can be developed and used as a profitable asset that adds value to the property.

There are a few key design and maintenance factors to consider in order to ensure optimum pollutant removal and longevity of porous asphalt pavements:

- Placement in areas with highly permeable soils; if underlying soil is damp, microbiological decomposition of pollutants may be impeded
- Existence of organic material in soil
- Vacuum sweeping on a quarterly schedule
- Use in low-density parking areas
- Restrictions on use by heavy vehicles
- Limited use of de-icing chemicals
- Inspection and enforcement of specifications during construction
- Pretreatment of runoff to paved area

9. Conclusion

The conclusions of the study are:

- Unlike conventional pavements, porous asphalt pavements are typically built over an un-compacted sub-grade to maximize infiltration through the soil.
- Pervious paving systems are paved areas that produce less storm water runoff than areas paved with conventional paving. The reduction in storm water runoff is achieved primarily through the infiltration of a greater portion of the rain falling on the area than would occur with conventional paving.
- With proper design, porous asphalt which has larger open space between interlocking aggregate skeleton provides more air voids, thus enable shorter duration for water to percolate through the porous pavement.
- The result shows that the aggregate particles disintegration gradually as the binder content increases also more binder content shows less abrasion loss percentages, since there is more binder to strongly bind the aggregate particles together.
- The results show that the retain binder is linearly correlated to the mixed binder content at lower bitumen contents. However, at binder contents exceeding 4.5%, the relationship diverge from the linear line but the amount of retained binder continues to increase until 5.5% binder content, beyond which point the amount of retained binder reduces.
- Hydrated lime is the most commonly used additive in asphalt mixtures. It is known as an active filler that provides good adhesive bonding at the binder–aggregate interface, which effectively controls water sensitivity and resists stripping.

REFERENCES

Abdullah W.S., Obaidat, M.T., Abu-Sa'da, N. M. (1998) "Influence of aggregate type and gradation on voids of asphalt concrete pavements" Journal of Materials in Civil Engineering", Volume 10, No.2, page no. 122 - 131.

Al-Jumaili Hasan (2016) "Laboratory evaluation of modified porous asphalt mixtures" Applied Research Journal, Volume 2, Issue 3, page no. 104 -117.

Aravind S., Joshi A., Aparajith S. (2018) "Construction of porous asphalt pavement using Graphene" International Journal of Recent Trends in Engineering & Research" Volume 4, Issue 4, Page no. 482 – 486.

Hussain Abed, T. Madhava Chary, Mohammed Nadeem (2017) "Construction of porous drain asphalt pavement" International Journal of Research, Volume 4, Issue 5, page no. 802-810.

Joon Pankaj (2017)"Permeable pavement system" International Journal of Engineering Sciences and Management, page no. 35- 43.

Khandal P.S., Mishra M. (2014) "A Revolutionary Technique of Rainwater Harvesting Integrated into the Design of Buildings and Parking Lots' Water Digest Magazine, March-April 2014, New Delhi, India.

Khilari Vikas, Kolhe Deepak, Babar Omkar, Patil Kiran (2017) "Improvement in characteristics of porous asphalt using crumb rubber" International Journal of Advance Research in Science and Engineering, Volume 6, Issue 4, Page no. 327 - 332.

Kiran kumar B. V., Manjunatha S. Shiv Prasad N. (2014) " Porous asphalt pavement A mix design guidelines" International Journal of Engineering Science Invention Research & Development, Volume 1, Issue 3, page no. 105 - 112.

Patil V., Patil P., Patil J., Patil M., Sawant K., Patil S. P. (2018) “A research paper on porous asphalt pavement” International Journal of trend in scientific research and development, Volume 6, Issue 2, Page no.2026 - 2031.

Shukry N. A. M., Hassan N. A., Abdullah M. E. (2018) “Effect of various filler types on the properties of porous asphalt mixture” IOP Conf. Series: Materials Science and Engineering, Page no. 1-12.

Tiwari Nitin, Powar A., Lokhande D., Karole A. (2017) “Design of pervious pavement for the light load bearing parking” International Journal of Engineering Sciences and Research Technology, Volume 6, Issue 4, page no. 792 - 795.

Yadu Jeet (2016) “ Permeable pavement & its application – A case study” Imperial Journal of Interdisciplinary Research, Volume 2, Issue 7, page no. 1367-1369.

Hamzah, M. O., Z. F. M. Jaafar, and F. Ahmad. "Laboratory simulation of porous asphalt parking lot system and mix design for storm water management." Journal of Engineering Science and Technology 8, no. 2 (2013): 217-232.

Chavanpatil, G. N., and S. S. Chokakkar. "The Study of Porous Asphalt Pavement with Emphasis in Road Construction Design." Int. Research Journal of Engineering and Technology 5 (2018): 623-24.