International Journal For Technological Research In Engineering
Volume 9, Issue 10, June-2022 *ISSN (Online): 2347 - 4718*

STUDY ON FRAME DESIGN OF HIGHWAY PAVEMENT MAINTENANCE TO ENHANCE THE DURABILITY THROUGH FOAMED BITUMEN

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Abstract: The proper operation of a civilization depends greatly on transportation innovations, notably road infrastructure. In order to guarantee safe and uninterrupted traffic, as well as good traffic management, and the delivery of key services to users, road maintenance is needed. As a consequence, it is vital that the road network, especially the carriageways, be maintained in great operational condition. The purpose of pavement management is to better distribute resources in order to maintain the desired road condition. There are a variety of pavement management approaches that may be applied. It is therefore feasible to offer a meaningful appraisal of their development until comprehensive and sophisticated models for the prediction of residual deformations are established. Materials that have been treated with foamed bitumen are able to endure prolonged exposure to adverse weather conditions. The asphalt has not been removed completely from the material that is inert. In the areas where road repair is taking place, it is possible to follow the flow of the cold-treated material immediately after condensation. Therefore, there will be as minimal limitations on movement as is practicable while carrying out fieldwork. It only takes a little amount of water to generate foamed bitumen, which results in reduced prices for the binding agent as well as the transmission infrastructure. Since it is less costly to manufacture, it also results in lower costs for the foamed bitumen itself. The use of foamed bitumen in the construction of roads receives further support from environmental concerns.

Keywords: Pavement Maintenance, Foamed Bitumen, Transportation Innovations, Road Network

I. INTRODUCTION

Throughout history, roads and pavements have been improved to accommodate the movement of people and the goods they generate. The qualities of the pavements are the most important for determining how to operate a vehicle in a given situation. Some of the factors that have historically worried individuals who drive and move in cities include speed, safety, comfort, and quality. These specifications are now considered essential.

Pavements have evolved over the last several decades, thanks to research that has brought new materials (like Asphalt), new standard sizes, and new specifications for the surface features. The vital contact surface with vehicle has surface qualities that allow for increased quality, speed, and comfort without compromising the safety of mobile vehicles and the people within them.

Essentially non-volatile, asphalt (bitumen) is characterized as a viscous liquid or solid that is soluble in trichloroethylene, is non-volatile, and softens gradually when heated. It's a dark brown or black substance with insulating and adhering qualities. From the refining process of crude oil, and as a natural resource or component of bitumen, which coexists with mineral components in the ground; In a wide variety of civil engineering applications (road construction, building construction, insulation dams and reservoirs, varnish production, etc.), asphalt is commonly used as a sealant or adhesive, and it is obtained either from natural resources (natural asphalt) or as a fractional distillation of crude oil derived (oil asphalt). Oil bitumen is the most extensively used for a variety of reasons, the most important of which is the high cost and difficulty of obtaining natural asphalt. It is primarily used as a binder between graded aggregates in the creation of road surfaces.

As a result, each new pavement is necessarily subjected to the disastrous effects of external variables, such as traffic and weather, as soon as it is delivered.

For this reason, there has been a long-term effort to develop adequate tools and measuring systems for surface inspection and measurement. A few decades ago, there was an effort to create new measuring tools for highways, but this has since faded. Because of the rapid advancements in technology over the last three decades, academic institutions were able to experiment with new ways to measure and record surface properties.

Pavement degradation results in residual deformations, which are caused by the soil's failure-deformability, according to design principles. Although asphalt layers may be permanently deformed, this is not a lifelong deformity. In general, the dynamic stress on the road, deteriorated quality of the layers' materials, and the impact of climate are to blame for the permanent deformation. Deterioration of surface qualities and convenience for road users are both a direct result. So, in order to decrease the risk of occurrence, particularly in the initial service intervals, it is required to examine the behavior of the elements impacting the structural condition of the pavement. Providing the residual deformation is a need for this inquiry.

II. RESTORATION OF PAVEMENTS

On one hand, recovery of lesions on the road surface, timing, and extent are determined by indicators of measuring the properties of the road surface and the results of surface inspections, while traffic volumes, climate conditions, available resources (people, equipment), and materials, in

particular f, are taken into account when determining what methods to use.
With the help of the Pavement Management System, the developer may plan out the details of how and when the motorway's pavement will be rehabilitated (PMS). It is through the employment of a Pavement Management System's tools and processes that a sufficient level of service for road surface care may be achieved. The "Network Layer" and "Project Level" of a PMS are two distinct layers of operation.
In order to execute the conservation measures established by management of maintenance organizations, the management at the network level is planned to be implemented. As a result, the PMS provides information on pavement restoration and new pavement construction at this level. The goal is to maximize the return on invested cash for all of the highway's pavements. Maintenance program are compared to find the most cost-effective strategy, with the goal of determining which program is more cost-effective in a certain time period. All the relevant data (roads, materials, climatic conditions, work expenses, traffic volumes, etc.) and the construction of models predicting the performance of pavements are necessary for a PMS to operate properly and efficiently. According to this Directive, it is necessary to gather road data in order to effectively manage the maintenance and implementation of relevant analytical models/prediction models for predicting the progression of road surface damage.
Pavement Condition Rating, PCR
The procedure is based on a thorough examination of the vehicle for any signs of damage. All symptoms of wear are graded on a scale from 0 (no damage) to a maximum of 5 or 10 (severe damage) (corresponding to a part with high wear). The status of the road is determined by the aggregate of all damage produced, which runs from 0 (no harm) to 100 (complete damage) (considerable damage). To get the PCR index, take the algebraic total and remove 100 from it.
The PSI relates the functional status of the road with the quality of driving. In the context of the AASHO road experiment, this is the outcome of the experience gained and is based on objective measurements of specific physical road surface metrics such as camber variation, cracks (% cracked surface), tread depth, and the surface area ratio with nearby repairs. The index ranges from 0 (for poor driving quality) to 5 (great driving quality) (excellent ride quality). For new roads in the US, a PSI of 4.2-4.7 is required, with the quality of the road playing a role in this range. The index value falls with time. Pavement restoration should be addressed if the value is more than 2.5. In order to be deemed in bad condition, a road surface must have an index value more than 2.0.
If you have a flexible pavement, you can calculate PSI using the following equation: PSI = 1,38 RD2 + 5,03 log 1 (SV+C+P) + 1,38 RD2 - 0,01 (C+P) 0,5 where SV is average camber to both the wheel tracks, RD is the average groove depth (a in) measured in both the wheel tracks with 4 ft long rods, C is the percentage of cracked surface (along cracks) and P is the percentage of patches. Only 5% of the PSI value is due to the effect of other variables, such as surface deterioration, which is reflected by the average slope value (SV). The flatness of the surface is expressed by the SV. The grooves, for example, have a very long-term impact on the road's functioning index because of their relationship with these in situ data.

Interventions for pavement maintenance
Road surface degradation may be repaired using a variety of maintenance methods. Road surface repair is a kind of technical maintenance that aims to improve the condition of the road. The kind, amount, and severity of the damage, as well as the skill, the available materials, etc., all have a role in the procedure that is used. If a certain method isn't acceptable for the situation, other options are used instead. It is important to remember that each maintenance activity is a collection of procedures that may be used for a certain kind of wear. Simply said, any degradation of the pavement necessitates the necessary maintenance to fix it. Furthermore, determining the root cause of degradation is critical to determining the most appropriate maintenance-treatment for damage. Maintenance operations have been undertaken throughout the last several years, as shown in Table 1.

Table 1: shows the main maintenance operations implemented in recent years.

Code	MAINTENANCE OPERATIONS
1	No interference.
2	Local spreading hot or cold mix, preceded by adhesive
3	Local consolidation without squaring and laying of hot or cold asphalt mix preceded by adhesive
4	Local consolidation with squaring and spreading hot or cold asphalt mix, preceded by adhesive.
5	Local consolidation without squaring and laying of hot or cold asphalt mix, preceded by adhesive and then Leveling layer of 4-5 cm.
6	Local consolidation with squaring and spreading hot or cold asphalt mix, preceded by adhesive and then Leveling layer 4-5 cm
7	Local spreading of hot or cold mix, preceded by adhesive and then Leveling layer 4-5 cm.

Interventions for pavement maintenance
The following paragraphs include interventions for pavement maintenance, depending on the type of problem.

Interventions for cracks maintenance
Pavement surface crack types may be caused by a wide range of factors. Prematurely sealing the fracture or fissures is often more accurate and effective than waiting until the damage has already occurred. A local rearrangement of the afflicted region may be necessary in other situations as well. An asphalt-modified thick substance is used in all circumstances of sealing or filling cracks. There should be an ASTM 1190 or BS 2499 standard for modified bitumen (elastomer). When using the new, heat-resistant modified asphalt to seal cracks, you'll need specialised equipment, such as an elastomer asphalt machine that can reach temperatures of up to 200° C and a burner powered by propane that can eject hot air rather than flame to heat and fix the crack before the modified asphalt is applied.

It is recommended to remove all of the bituminous layers and some of the foundation soil in order to reduce the level of the aquifer, as well as to rebuild all the layers with new acceptable materials, when alligator-type fractures form in a limited region. Large alligator cracks can only be repaired by adding an extra bituminous layer of the same thickness as the road's current condition. Before putting new carpet, level the layer screed if the cracked carpet cannot be removed. Cracks between paving lanes or spreading in the shrinkage or helical cracks should be treated in the same way as reflection and helical cracks.

After a thorough cleaning, it is advised that cracks in the track ends be filled with an appropriate modified asphalt. Filling is done with either cold or hot asphalt when it is raining. Cold sludge evaluation formula III or IV, cast if the precipitate is less than 25 mm, else use hot asphalt. For reflection cracks with less than 3 mm of opening space and a limited area, modified asphalt is used to seal or fill. If the aperture is less than 3 mm in diameter, asphalt coating may be used to maintain it. Cracks bigger than 3-5 mm in diameter are opened using a special cutter, cleaned with compressed air, dried, and heated to a certain burner temperature before being filled with hot air.
There must be sufficient vibratory or roller compaction. When the carrying capacity of the subsoil is reduced seasonally, the repair is done as in the reflection cracks while adjusting the water table (drainage works). In all other circumstances, it is necessary to reinforce the road by adding a fresh layer of asphalt. Maintaining transverse cracks is the same as maintaining longitudinal cracks.

Interventions for deformations maintenance
Road surface deformations or distortions are typical deteriorations that show up as unevenness in the pavement. Deformations may be repaired by filling them with hot or cold asphalt mix, which removes and replaces the afflicted region entirely. Ruts are repaired by injecting hot or cold asphalt into the groove. A 0.25 to 0.50 lt. /m2 cationic emulsion is used to spray a slurry-rating formula II or III prior to applying an adhesive coating. In order to repair the asphalt mixture, the particular asphalt layer must be removed and replaced with another appropriate asphalt layer.

Depending on the mat's thickness, the strip may be removed by grinding it down to 40-50 mm. A cationic emulsion adhesive covering of about 0.25 - 0.35 l / m 2 is necessary prior to laying. In order to create wide grooves, the surface must be milled to between 20 and 50 millimetres or according to the layer thickness, and the new carpet set on top of the hot asphalt mixture. It's necessary to apply a Slurry-III sealant carpet or a plain bitumen coating to any surfaces that are only going to see milling maintenance going forward. Using a specific equipment, the carpet may be broken and scraped together with a portion of the substrate if the road is 40 to 50 mm thick and has a loose aggregate foundation (3a). Finally, shape and roll the mixture after adding a little quantity of bitumen emulsion (fragments, aggregates, base and binder).
Depending on the extent of local subsidence, either hot asphalt or cold carpet with a manure mix is used to maintain the area. After spraying, an adhesive coating of 0.25 to 0.5/m2 lit cationic emulsion is maintained with a suitable hot asphalt in the event that the settling depth is higher than 25 mm.
Concentration of asphalt ensures that the previous surface is not visible. It is possible to use cold slurry class III asphaltic sealant in one, two, or three layers in areas where the maximum immersion depth is less than 20-30 mm. To avoid tooth formation, heated asphalt might be utilised in certain situations.

As a last step, a steam roller concentration of 6-8 tonnes is adequate. Local bulges must be maintained in the same way as alligator cracks for local services.

Interventions of weathering maintenance
The cold asphalt mix type Slurry seal-grade II or III or surface coatings are used to repair damage detachment aggregates. An extra asphalt layer was considered when the road conditions were really poor. Temporary or long-term maintenance is available for potholes. Temporary might become a simple cleaning puddle that is filled with appropriate hot or cold asphalt. Finally, proper calendaring is required to make sure that the lateral layer material is healthy and that the walls and surface are well cleaned, before filling it in with the appropriate hot or cold asphalt.

Interventions tread grinding maintenance
- Dispersing and fine hot rolling or hot air blasting are the most common methods for repairing asphalt leaks in a specific area. During the year's warmest days, hot aggregates are a good choice for dispersion. If a significant amount of asphalt formation is predicted, particularly under severe loads, it is advised that it be removed and replaced with fresh asphalt during the whole shift. The following strategies are used to maintain and restore skid resistance on roads using grinding aggregates:
- Laying of a new carpet suitable hot asphalt with hard aggregates.
- Laying porous mat.
- Method of Pre-anointed chip.
- Construction of cold Slip-minute Slurry type carpet.
- Chipseal (single or dual layer).
- Construction of hot carpet.
- Scraping the surface with a special cutter.
- In all the above methods except the last, necessary prerequisite is the use of suitable hard aggregates, not limestone.

Application of stabilization with foamed bitumen
For a long time, cement has been used to improve and maintain road surfaces. Several effective studies have lately been carried out to study the function of lime in stabilizing the subsurface with a high degree of flexibility. This study has resulted in hundreds of kilometres of lime and fly ash mixes being stabilized. Cracks have recently appeared on pavements stabilized using cement / lime and fly ash mixtures.

Cementitious pavement's fracture sensitivity is blamed on vehicle loads and a weak substrate carrier, according to this theory. Congestion wears a stiffly linked highway at a higher rate than in flexible pavements because of a force connection, according to the accelerated loading of the test equipment. To put it another way, a 20% overload indicates that rigid linings wear nine times as many times as granular ones (i.e., 1.24 = 2.1 for the flexible ones, and 1212 = 8.9 for the rigid ones).
For foamed bitumen stabilized roads, fatigue ratio measurement is important in estimating pavement life. The bituminous binder is now thought to provide improved fatigue resistance. The quantitative ratios of fatigue are being measured by the TTD employing bending beams. Stabilizing bitumen was examined in order to take use of the asphalt's flexibility in the fatigue characteristics of the stabilized lining's base carrier.

When foamed bitumen is added (instead of cement), this cold-treated material becomes very long-lasting. The quality of storage depends on the water content. If the water content of the cold-treated material is kept close to the ideal value, it can be kept for a long time. It is possible to compensate for moisture losses that may occur during homogenization of cold-treated material in a mixing plant by adding additional water.

Foamed bitumen-treated material can withstand long periods of exposure to harsh weather conditions. The asphalt has not been wiped away from the inert substance. In road restoration locations, the movement of the cold-treated material may be traced immediately after condensation. Field work may thus be done with the fewest possible restrictions on mobility. Small quantities of water are all that are needed to make the foamed bitumen, which results in lower costs for both the binding agent and transmission infrastructure since it is less expensive to manufacture. Foamed bitumen's use in road building is also supported by environmental considerations.

III. MODERN TECHNIQUES

Below we will refer to some of the modern techniques of construction and pavement maintenance products and the respective companies that produce them.

Ratchet

Roads may be repaired using the Ratchet technique in an incredibly short amount of time, regardless of the weather conditions. This technology was developed in the United States and can be used in any weather circumstances. The ratchet was used for 15 years to maintain the roads in the United States, which fulfilled the tightest quality and durability criteria in the globe. Alligator rips, which cause potholes, may be prevented by using modern technology and high-quality materials, which minimize unevenness, bumps, and difficulties with asphalt surface.

Road Tech

This new ROAD TECH technology is a game-changer. ROAD TECH 2000 is a non-pathogenic stabilizing product based on a microorganism. As a result, the ROAD TECH 2000 is eco-friendly in both conception and execution. All varieties of clay may be used, and it provides great road stability and dust suppression with no special equipment needed. It can also minimize the cost of creating small roads and maintaining existing ones. Besides being more stable and requiring less resources to maintain, it may also minimise erosion dramatically. When compared to other goods, ROAD TECH 2000 reduces the cost of living while also enhancing local traffic safety. All forms of stability and dust suppression applications may benefit from this technology.

Road TECH 2000 is a combination of bacteria that use clay grains and natural microbes that use clay. To prevent the clay from rehydrating, a polymer is created between each individual grain of the clay. ROAD TECH 2000 technology has demonstrated throughout the years that maintenance expenses are significantly reduced. ROAD TECH 2000 has the effect of extending the useful life of roads.

Gilsonite

The gilsonite is a natural hydrocarbon that modifies the asphalt so that some of it does not "soften" the asphalt and deform at high ambient temperatures, increasing resistance to low temperatures (while retaining its elasticity).

Fig. 1: Type of Gilsonite

- General Characteristics of Gilsonite.
- Natural hydrocarbon.
- Fine solid.
- Not carcinogenic.
- Fully compatible with the asphalt. High asphalt content.
- High nitrogen content (3%).
- Essentially no sulfur (0.3%).
- 99% pure in its natural state (Woods et al, 2012)
- Nontoxic Key Advantages of Gilsonite asphalt.
- Radical increase in strength of the asphalt and thus the apron.
- Substantial reduction of wear and destruction of the apron.
- Reducing the temperature effects of the environment on the tarmac without distortion.
- Fold increase in resistance to water corrosion.
- Significant increase in heavy traffic resistance capacity (softening asphalt) without distortion.

Street Print

The Street Print is a durable pavement solution that combines the flexibility of asphalt with the cement strength of the Street Print. With greater results and lesser upkeep, the Street Print is the most durable and beautiful option now available on the market. Specifically created for use on asphalt and pavement, the Street Print Standard Formula is an acrylic polymerized data coating that is completely coloured and entirely polymerized. Good adhesion, flexibility and scratch resistance; colour stability; chemical and abrasion resistance. The Street Print Standard Formula was developed to fulfil the high demands of street print applications by combining the most critical aspects.

Fig. 2: Image of street print

Trends for smart monitoring of pavements
Stratified bearings and asphalt layers are particularly vulnerable to collapse if the geological infrastructure of contemporary roadways isn't regularly monitored. There should be just one cause of any problems: inelastic shift traffic.

The difficulty is twofold when it comes to assuring the long-term functioning of road surfaces. Two things are necessary for a meaningful road condition assessment: first, a thorough examination of the road's behaviour, and second, an in-depth analysis of that behaviour. It's necessary to identify an educated approach for monitoring and measuring the road surface attributes in order to enhance both the original design and the maintenance management of roads. Individual characteristics are evaluated throughout time in order to determine the advancement of road behaviour in relation to other aspects of it. It's important to be able to forecast changes in roadway features so that essential steps or precautions may be taken to avoid predictable pavement problems from occurring. A road safety policy may be implemented in each phase of operation, ensuring the long-term viability of performance.

Non-destructive high-tech (NDT) testing systems, such as geophysical equipment, are used to monitor and record the aforementioned properties. Non-destructive testing makes it possible to acquire a large number of data points quickly and reliably without causing any damage to the road's surface. As a result of the high average speed, it is unnecessary to close the road and avoid obstructing oncoming vehicles.

When evaluating the roadway's load-bearing capability as part of the construction review, it is necessary to do a visual check for indications of wear and tear. The damage may be structural in nature, but it may not be connected to the pavement's viability and is thus operational. While the visual inspection is a helpful tool in the grade assessment of pavement, it cannot be used as a replacement or substitute for high-tech control and recording systems. This is due to the fact that a visual assessment can only tell you how the road's surface looks. While there may be unnoticed flaws in lower layers, the wear is already at an advanced level when the upper layers show up on the road surface with cracks that run from bottom to top.
To monitor pavement systems in real-time and continuously, Micro-Electromechanical Systems (MEMS) were developed. In order to create MEMS, microfabrication methods are used to create micro sensors. These sensors are able to detect changes in the pavement's surface as well as its general surroundings.

There are three major topologies used in civilian infrastructures for wireless systems, including starter, peer-to-peer, and multi-tier (Lynch and Loh, 2006). These systems are built to interact with a certain server.

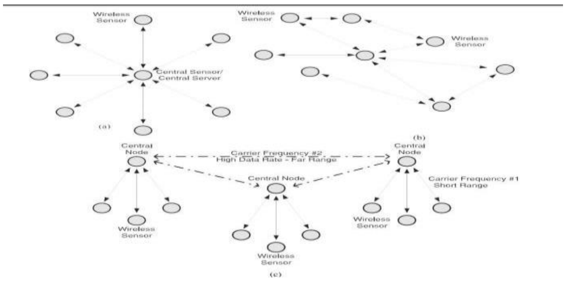

Fig. 3: Wireless network topologies: (a) star; (b) peer-to-peer; (c) multi-tier network topologies (Lynch and Loh, 2006).

Another option is Radio Frequency Identification, which utilizes radio waves to identify items and store data on tags. A reader and a tag make up a radio frequency identification system, which may be further separated into active sensor systems and passive sensor systems.

A high-speed profilometer known as the Laser Profiler (LP) may be used to assess transverse deformation. It's one of the most highly sophisticated and commonly utilized systems around. High-speed recordings are made by the LP to document the road's dispersion. An accelerometer and one or more sensors (laser) are utilized to record the vertical distance traversed. A beam with electronic sensors serves as the foundation of the high-speed profilometer. In a vehicle with a suitable form, the beam may be changed.
The LP counts and records during vehicle movement the following parameters:

- The vertical displacement of the beam from the road surface.
- The vertical acceleration of the beam.
- The time and distance recorded the two aforementioned parameters (via the speedometer)

IV. CONCLUSIONS

The proper running of a civilization relies heavily on transportation developments, particularly road infrastructure. In order to provide safe and uninterrupted traffic, as well as effective traffic management, and the supply of vital services to users, road maintenance is essential. As a result, it is critical that the road network, particularly the carriageways, be kept in excellent working order. The goal of pavement management is to better allocate resources in order to maintain the desired road condition. There are a number of pavement management methods that may be employed. Artificial intelligence has been employed in pavement management systems in recent years to determine the best possible road management solution. For complicated situations, standard optimization approaches seem inefficient.

Permanent deformation is required to keep residual deformation from spreading and causing difficulties, as well as to properly handle any problems that may arise as a result of this. As a result of this necessity, mechanical prediction models have been developed, but their applicability in international literature is restricted. This is mostly because mechanics are understood differently throughout the world, and as a result, worldwide recognition of endorsements is required for standards development.

Laboratory testing on real-world material samples are used to calibrate the parameters for further study of permanent deformation. Aside from expanding the number of trial plots and paving materials and extending the forecast time for the supply growth may be accomplished. It is thus possible to provide a meaningful evaluation of their evolution until elaborate and advanced models for the prediction of residual deformations are developed.

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