Volume-04
Issue-06
June-2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com[UGC Listed Journal]

Experimental Study on Cause of Asphalt Pavement Deterioration and Its Maintenance

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ARTICLE DETAILS

Article History
Published Online: 10 June 2019

Keywords
Asphalt, pavement, deterioration, maintenance, deformation, interventions.

ABSTRACT

The pavements have developed in recent decades, as studies have introduced new materials in their construction, such as types of asphalt, new standardising and new requirements for the surface characteristics. The surface characteristics, specifically the critical contact surface with motor vehicle tires, is able to provide higher quality, speed and travel comfort without compromising the integrity of mobile vehicles and their traveler.

The pavement, as a construction element, is linked with the road transport systems in a complex way, since essentially the supporting structure, which is responsible for the movement of vehicles. Modern technology has improved the stability, quality and safety of the road surface using new materials and construction techniques.

The provision of permanent deformation is necessary both during the design phase and construction and during the operation phase of a pavement. It explores the impact of factors affecting development and can provide valuable information on the performance of road against traffic loads. This permits the better management of the road network.

The study informs the types of deterioration found in asphalt pavements, as well as a number of types of maintenance, along with new ideas and suggested solution.

1. Introduction

Over the centuries, the roads and its pavements have evolved to be capable to meet the needs of humans to move themselves and the products they create. The asphalt pavement is the surface on which the mobility of traffic and people takes place, and the main features of these are the most important for how to make a move for a particular vehicle. Speed of vehicle, safety and comfort of people, quality etc. are some of the parameters that traditionally have preoccupied people who drive and move in the cities. Nowadays these parameters are a requirement. The pavements have improved in recent decades, as studies have introduced new materials in their construction (eg. Asphalt), new standardising and new requirements for the surface features. The surface features, namely the critical contact surface with vehicle tires, is able to deliver higher quality, speed and travel comfort without compromising the integrity of mobile vehicles and their passengers. The asphalt (bitumen) is defined as a viscous liquid or solid, consisting of hydrocarbons and their derivatives, which is soluble in trichloroethylene, is essentially non-volatile and softens gradually when it is heated. Its color is black or brown and has insulating and adhesive features. It is obtained by refining of crude oil and is also found as a natural reserve or as a component of natural bitumen, which coexists with mineral materials. The asphalt is generally used as a sealant or adhesive material in a wide range of applications which are subject mainly of civil engineering (road construction, building construction, construction of dams and reservoirs, varnishes production etc.) and is picked either from natural resources (natural asphalt) or as derived fractional distillation of crude oil (oil asphalt). The most widely spread is the oil bitumen mainly for economic reasons since collecting the natural asphalt is quite expensive and difficult. Its main use is in the manufacture of road surfaces, as a binder between the graded aggregate for its production.

Asphalt

Asphalt is the residue of the distillation of crude oil after further distillation under pressure. The preparation of the crude oil contains a number of distillation processes, and if necessary further processes including the mixing and oxidation processes. The refining of crude oil starts with atmospheric fractional distillation to separate the gas oil, kerosene, naphtha, gasoline, gas oil and residue that forms a complex fraction of higher molecular weight. The residue was then passed through a second distillation, wherein the distillation column is now prevailing temperatures 350 ° C - 400 ° C and vacuum conditions (10 - 100 mmHg). So we get different types of paving asphalt, they can be used both in roads and in airport projects. The residue of the second distillation may be further modified by blending processes or either oxidation or emulsifying the production of bitumen of different properties and cohesion.

Asphalt Gaps

By asphalt gaps we refer to the air sacs located between the coated asphalt aggregates a compressed asphalt. Spaces are divided into the following categories: the gaps between the aggregate (VMA: Voids in the Mineral Aggregate), the gaps which are filled with asphalt (VFA: Voids Filled with Asphalt) and the compressed asphalt gaps that are inflated (PAV: Percentage of Air Voids). The percentage of gaps between the aggregate (VMA) is the available space between the aggregates that receives the active volume of the contained asphalt (i.e., the total volume of the bitumen, reduced by the volume which is absorbed by the aggregates) and the volume of voids air necessary for the asphalt. The higher the value the more VMA space between aggregates to extract the bitumen. Through the VFA is determined whether a sufficient proportion gaps filled with asphalt and indirectly determine the necessary amount of bitumen in the mix. The appropriate percentage of VFA helps prevent weakness of the mixture due to the thin coating of aggregates with asphalt. The percentage of air gaps will depend largely on the concentration method of the asphalt mix during the laying and the gradation of aggregate in the mix. The final percentage of air gaps is associated with the behavior of the pavement. Low percentage of air gaps results in the wheel tracking appearance as the asphalt cannot enter and fill the aggregate, resulting in observed declines in the wheel tracks upon the enforcement of traffic loads. Higher percentages of air gaps allow air entering the asphalt causing oxidation of the bitumen and thus premature aging of the mixture by reducing the resistance to permanent deformation. The volumetric composition of asphalt and the characteristics of the materials that make up the asphalt determine the stiffness measure.

2. Deformation and Its Types

Permanent deformation

Ensuring comfort and safety of a road user is the main concern for the design of pavements. A road constructed in order to secure the transfer of traffic loads to the subsoil and avoid damage creativity, critical for its functionality. So, proper planning, proper construction and proper management are three key components that contribute to the good operation and the prolongation of its life. Defining the factors which determine the bearing capacity of an asphalt pavement, and the study of the structural stress of requiring particular attention in order to achieve the possibility of transferring the traffic loads for which it was designed. The determination of the critical position of an asphalt pavement is the first step to assess the behavior and structural situation over the imposed loads

Type of Residual Deformation

Wheel tracking

One type of residual deformation is the wheel tracking. The wheel tracking due to permanent deformation of some or all of the pavement layers or subsoil and is caused by the relative movement of the material due to the traffic load. This form of the residual deformation is associated with the transverse distribution (profile) of the road surface (Loizos, 2008). The wheel tracking gradually grows under the influence of repeated loadings and typically depicted in the form of deformations along the wheel tracks, accompanied by small rearrangements at the ends. Two causes that contribute to wheel tracking is the compression and shear deformation (Sousa et al., 1991). Its appearance may occur at various times during the life of a pavement. According to a research done by the AASHO Road Test (American Association of State Highway and Transportation Officials, the shear deformation is crucial in the wheel tracking mechanism with condensation (ie reducing the volume and thus increase the density) have secondary role. Eisenmann and Chilmer (1987), illustrated the effect of the number of times the wheel passes to the surface profile of a plate of the laboratory. the specific authors came to the following conclusion

In the initial phase, the compression due to the traffic load is the primary growth mechanism of residual deformation. After the initial stage but the bulk of the compression due to the traffic conditions has been completed, further wheel tracking caused by the shear deformation. Therefore, the shear deformation is considered the main cause of wheel tracking growth in most of the life of a pavement.

Hofstra and Klomp (1972) found that the deformation of asphalt layers was greater in loading enforcement surface and gradually reduced depending on the depth. This is because the wheel tracking is a permanent deformation and thus increasing the depth increases the resistance and shear stresses are reduced. Also, Uge and van de Loo (1974) concluded that a further increase of the asphalt layer thickness beyond a limit does not entail a further increase of deformation within them. The above show that for materials having normal stiffness, the wheel tracking limited to asphalt layers (Sousa et al., 1991). Asphalt with low shear strength, essential for resistance to repetitive loads of traffic, have intense display wheel tracking problem. The problem is more acute especially during the summer months, as high temperatures are observed on the roadway

Lack of Smoothness

The lack of smoothness along the surface of a road is another form of residual deformation. Typically, Ullidtz (1998) investigating the effect of the absence of normality in a roadway, explaining how this is a result of fluctuations in extended length. These variations are related to the thickness of the layers, the elastic modulus, the asphalt content of the dynamic stress etc. The lack of smoothness represents an estimate of the variation of the residual deformation along the roadway.

Specifically, as a lack of smoothness is defined all along the road deviations from the true flat surface, with characteristic dimensions that affect the dynamic behavior of the vehicles, the dynamic loadings of road surfaces and ride quality. The longitudinal lack smoothness described by the undulations of the road surface. Great waves length is due primarily to the underlying layers, while small ripples length associated with the surface layer.

Any initial lack of normality, which may be due to manufacturing errors or material quality and equipment failure, usually intensifies with the passage of time. The downgrade was due to factors affecting permanent deformation, such as traffic loads and environmental conditions. The absence of normality seriously impacts the comfort of the users of a road and vehicle maintenance costs. Moreover, greater lack of normality involves more numerous and large changes of the vertical forces, and also created lateral forces between the tire and the road surface .

Measure of asphalt stiffness

The stiffness of the asphalt measure is calculated by the following fundamental equation : $Sm=(p/e)T,t$ where

p- positive trend

e - reduced distortion

t - Charging time

T - asphalt temperature

The stiffness is a measure of the asphalt resistance to deformation in imposing load. High price of stiffness measure on asphalt layers leads to relief of the underlying base layer and subbase while there is also a phenomenon of early occurrence of cracks in the repeated loading of such asphalt. so the increase in charging time, and the temperature increase, impact negatively on measure of rigidity, resulting in a reduction of the price, often with adverse effects on the roadway, if the changes are not taken into account.

3. Structural strength of the pavement

As structural strength is defined the ability of the pavement to bring loads of traffic and transfer them reduced to the ground. When the roadway is given in circulation, factors such as traffic volume and the axial extension of traffic passes, as well as the environment, reduce the carrying capacity of the pavement resulting in the appearance of damage. The traffic load cause stresses in the pavement, resulting in cracks, grooves, slides, etc. Environmental factors such as temperature changes also cause tensile stress and aging of the bituminous material, resulting in failure of cracking. As structural strength (efficiency) of a road surface is defined the remaining life expressed in either equivalent crossings, either in years, taking into account their respective future traffic volumes the design or the time of the pavement life, provided by the design.

Audits of structural strength are made with special schemes of nondestructive measurements and by spot checks. The spot non-destructive measurements with specific systems consist of impact force (static or dynamic) to the road surface and measuring the sinking, which occurred in all layers including the subsoil. The total immersion is the resultant of dips of the individual layers.

The measurement systems of structural strength of the road divided into two main categories, depending on the resistance measurement methodology, ie how to impose the load on the pavement and the measurement recording methodology

Restoration of pavements

The management at the network level is designed to implement conservation strategies decided by management of maintenance organizations and relate to the whole motorway. So, at this level, the PMS gives information about extended service plans, rehabilitation or construction of new pavements. The aim is to optimize the return on invested capital for all the pavement of the highway. The decisions taken by management, based on the comparison of alternative strategies maintenance programs, with the ultimate aim of identifying the maintenance program, which will have the greatest benefit / cost ratio, in a certain time period analyzed. A prerequisite for the proper and efficient functioning of a PMS is being powered with all the necessary data (roads, materials, climatic conditions, work costs, traffic volumes, etc.) and development of models predicting the behavior of pavements. So the collection of road data, as provided in this Directive, an operating condition of a PMS for the rational management of the maintenance and execution of appropriate analytical models / prediction models of the evolution of damage to road surfaces

Management of Pavements

The Pavement Management is a process that helps in making decisions concerning the maintenance of the road network at an adequate level of service, functionality and security with the least cost to the technical services and for users. To satisfy these requirements are necessary correct and sufficient information to take the decisions on the principles of engineering and management. The problem of Pavement Management lies in the large number and variety of parameters and the difficulty of establishing correlations between them.

Generally, the Pavement Management consists of three elements: pavement life cycle: includes information on the construction of pavements, the change in their status over time and how these processes can be affected by various forms of maintenance or reconstruction. Costs related to the pavement life cycle: it includes the cost of initial construction, maintenance costs, determining the remaining final value and to determine the cost of users. Management systems Pavements: include all systems for determining the timing for road maintenance at a satisfactory level of service at minimum cost.

4. Structure of pavement management systems

The Pavement Management includes two decision levels, the macroscopic strategic planning at the network level and scheduling maintenance activities and rehabilitation at the project level. At a network level pavement management system provides general inference information over the network and addresses the following: The size of the network, the current road conditions, the extent of damage and the history of wear and tampering. The current assets of the pavement as travel times and traffic accidents. The annual budgeted maintenance costs and available resources. The regular decisions and optimal resource allocation to maintenance works. The quality of road infrastructure strategy: control and intervention levels. Identify parts with similar features. Defining the characteristics of road surfaces to be measured, the measurement methods, the required equipment and the prescribed measuring frequency. Forecasts for future needs and costs of interventions

Pavement Condition Index, PCI

The Pavement Condition Index enables the assessment of the condition of the roadway based on damage observed on the surface and has been endorsed by the ASTM standards for evaluating the condition of pavements airports. It provides a subjective basis for determining maintenance needs and priorities assessment. The indicator does not measure the structural failure of the pavement or provide immediate assessment of flatness or slip. The index takes into account 16 species damages for flexible pavements and its value ranges from 0 (unacceptable situation) to 100 (excellent condition). Extracting Road Conditions Index is a specific mathematical algorithm based on the percentage of the area and the level of severity of any damage and weighting factors for each type and wear severity level.

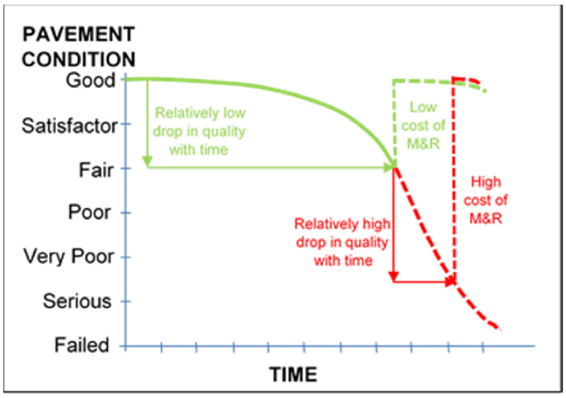

Figure 1 : pavement condition curve based on index PCI

Roughness Index for Driving Expenditure, RIDE aims to link the vehicle operating costs by state of the road in terms of flatness. The index measures the vertical acceleration of the vehicle due to road surface irregularities on the basis of analysis of frequency of road profile. The index can be measured using a suitable accelerometer mounted in a moving vehicle. The index is measured in mm / sec2 and takes values between 150 (approximately) on roads without incident and 1500 (approximately) on roads with significant abnormalities.

Pavement Condition Rating, PCR

The method is based on recording and scoring of all damages that occur to the road. The rating of all wear takes values from 0 (no damage) to a maximum value of 5 or 10 (corresponding to a portion with high wear). The algebraic sum of scoring all damage dealt, represents the state of the road surface and ranges from 0 (perfect condition without damage) to 100 (significant damage). The PCR index is calculated by subtracting the value of the algebraic sum of the value of 100 (Toivonen 2007),

Present Serviceability Index, PSI connects the functional state of the road driving quality. This is the result of the experience obtained in the context of road experiment AASHO and based on objective measurements of certain physical parameters of the road surface as the variation of camber, the cracks (percentage cracked surface), the tread depth and the surface area ratio with local repairs. The index takes values from 0 (unacceptable driving quality) to 5 (excellent ride quality). In the US, the PSI value for new roadways must have a value between 4.2 to 4.7, depending on the quality. The index value gradually decreases with time. (Toivonen 2007), The value of 2.5 is usually considered as a warning level for rehabilitation of pavement. When the index value is less than 2.0, the road surface is considered in poor condition and requires immediate restoration. (Toivonen 2007),

PSI indicator may be calculated for flexible pavements by the equation : PSI = 5,03 - log (1 + SV) - 1,38 RD2 - 0,01 (C + P) 0,5 where SV is the average fluctuation value camber to both the wheel tracks, RD is the average groove depth (a in) measured in both the wheel tracks with 4 ft long rod, C is the percentage of cracked surface (along cracks in ft / 1000 ft2) and P is the percentage of the patches (ft2 / 1000 ft2). The flatness is expressed by the average slope value (SV), contributes very substantially to the PSI value (approximately 95%), while only 5% related to the influence of other factors such as the surface damage. Very patient, for example, the contribution of the grooves as a result of association of this functionality index situ observations on roads.

Table 1: MAINTENANCE OPERATIONS

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.
8	Local consolidation with squaring and spreading hot or cold mix,

5. Interventions for pavement maintenance

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

Interventions for cracks maintenance

The types of surface crack of the pavement and vary due to various causes. In many cases simple early filling of the crack or cracks are more correct and efficient maintenance. In other cases, it is necessary local reorganization of the area affected. The sealing / filling of cracks in all cases is a thick material that is specific modified asphalt. The modified bitumen (elastomeric) should fulfill the requirements of specification ASTM 1190 or BS 2499. For the implementation of the modified asphalt to seal cracks requires the use of special hardware, such as (a) heating the elastomer asphalt machine capable of heating up and 200 ° C and capable of supplying the hot asphalt material over the crack and (b) a burner (propane) which ejects superheated air (not flame) for heating and fixing the crack before the diffusion of the modified asphalt.

For alligator type cracks when they appear in a small area, the full removal of all bituminous layers is suggested, and layers with unbound inert and part of the foundation soil; these are the appropriate measures for reducing the level of the aquifer and the reconstruction of all the layers' new suitable materials. When the extent of alligator type crack is large, treatment is only restoring the carpet, ie an additional bituminous layer similar state of the road thick. If the fractured carpet cannot be removed, leveling the layer screed is recommended, before laying the new carpet.

Interventions for deformations maintenance

Deformations or distortions of the road surface are, in general, those deteriorations that characterize the pavement as non-planar. Generally, the maintenance of deformations may consist of simply filling them with hot or cold asphalt mix to the complete removal of the affected area and replacing it with new material. Rutting wheel tracks, the maintenance is done by filling the groove with a suitable hot or cold asphalt Slurry-rating formula II or III, after being sprayed adhesive coating with a cationic emulsion in an amount of 0.25 up 0,5 lt / m 2. If the deformation of the asphalt mix is high, certainly requires the removal of the particular asphalt layer and then the re-laying thereof with another suitable asphalt.

The removal of the strip is made by milling to a depth 40-50 mm, or depending on the thickness of the mat to be dismantled. Before laying required adhesive coating with cationic emulsion in amounts of about 0,25-0,35 lt / m 2. For widthwise grooves requires milling of the surface to a depth of 20-50 mm or analog of the layer thickness and the new carpet laying by hot asphalt mix, after having sprayed adhesive coating with a cationic emulsion. If the maintenance decides to proceed only with milling, then the surface must be sealed with sealant carpet of type rating Slurry- III or simple bitumen coating. When the road surface is composed of a single layer of asphalt 40-50 mm thickness and the basis of loose aggregates (3a) the maintenance can be done by breaking the carpet with a special machine, the scraping thereof and part of the base, the addition of a small amount or bitumen emulsion and finally forming and rolling the mixture (fragments, aggregates base and binder) .

In local subsidence maintenance takes place either by the hot asphalt laying or laying cold carpet of Slurry formula depending on the depth of immersion. When the depth of the settling is greater than 25 mm is maintained with a suitable hot asphalt after sprayed adhesive coating with a cationic emulsion in an amount of 0.25 up 0,5 lt / m.

The asphalt is laid and suitably concentrated, so as not to create contoured to the old surface. When the maximum immersion depth of less than 20-30 mm, local precipitation filled with cold asphalt sealer formula Slurry-grade III in one, two or three layers as the area previously cleaned and sprayed with adhesive. In other cases, the hot asphalt is used which suitably cast so as not to create tooth.

Interventions of weathering maintenance

Repairing damage detachment aggregates is done by laying the cold asphalt mix type Slurry seal-grade II or III or with surface coats. When road conditions are very bad and examined the case of additional asphalt layer. For potholes maintenance can be temporary or permanent. When temporary becomes simple cleaning puddle and filled with suitable hot or cold asphalt or ready packaged cold asphalt. When maintenance is definitively cutting and squaring puddle so as to have a healthy lateral layer material, thorough cleaning, spraying the walls and the surface with a cationic emulsion, filling it with a suitable hot or cold asphalt and finally appropriate calendaring.

Interventions tread grinding maintenance

Local asphalt emergence usually restored by dispersion and fine aggregate hot rolling, or hot air jets. If dispersion hot aggregates are recommended to work the hottest days of the year. When the emergence of asphalt is to a great extent and especially when it is severe, it is recommended to be dismantled across the layer and restored with new asphalt. When the road surface presents grinding aggregate maintenance and restoration of Slip resistant capacity of this is done with the following methods:

- 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.

6. Conclusions

The transportation projects and particularly road infrastructure is very essential to the proper functioning of a society. The road maintenance is important both to ensure the safe and unimpeded traffic and the other for efficient traffic management and provide the necessary services to users. For this reason, the roads and especially roadways should be in good condition to allow proper operation of the road network. The pavement management through complex decision-making processes undertakes to maintain the desired state of the roadway with better resource allocation. The pavement management systems are tools used in pavement management. In recent years the pavement management systems use artificial intelligence technologies for finding the optimal solution for road management. This is because classical optimization methods seem inefficient to complex problems.

The limitation and the proper handling of potential problems caused by the development and dissemination of residual deformations makes it imperative provision of permanent deformation. This need led to the development of mechanical prediction models, in which however the international literature responding is limited. This is due mainly because there are different views on the mechanics and thus the development of standards must be based on internationally accepted endorsements.

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