THE USE OF FIBER IN ASPHALT PAVEMENT

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Abstract - Roads, today, are one of the important factors of communication and transfer of passengers and loads and of main issues of day that is discussed about. Different conferences are held about roads. On the surface of busy roads, cement and bitumen is used so that in case of load-apply to them the may afoul some changes that will bring about horizontal stretching tensions on the surface layer that if the amount of these stresses go beyond the materials stretching endurance ,it will form cracks.

Keywords - Asphalt, Fibers, Steel Fibers, Asphalt Pavement.

I. INTRODUCTION

Using fibers, is one of the important approaches to control and decrease the width of the cracks resulting from direct stretch.

Using thin and short threads that distribute accidentally in every direction of asphalt is a suitable way to make an isotropic condition and a system which can monotonously cause increasing softness to all direction and retain tensile strength. This thin thread is called Fiber, and is of different types and forms with various usages. Such as polymeric and steel fiber, glass and etc.

II. TYPES OF CRACKS IN ASPHALTS PAVEMENT:

A. Mosaic Cracks(Crocodile cracking- Alligator cracking)

This kind of track resembles the hide of a crocodile, that's why it is named alligator cracking. This ruin appears with cracking some or whole of the surface of asphalt layer in the shape of relatively small polygons, which can be expanded in amount by load-apply.

So much fatigue and deforming is due to load-apply to the surface that causes mosaic cracks, and is usually created in making basis and under-basis layers that lack enough compacting and/or in soils with high deforming and low resistance.

B. Edge Cracks

This kind of cracks are formed in parallel to the length axis of roads and in little distance from the surface. This kind of cracks may have longitudinal cracks in addition to transverse ones which usually intersects one or some longitudinaltrack and ends in the surface.

Lack of sustainability and shear resistance of soil or surfacesideway materials can cause this kind of crack which absence of density in the dug spot and close transportations causes lateral deformation of soil and appearance of cracks as the result.

C. Thermal Contraction Tracks

This kind of track is formed as the result of changes in the volume and shrinkage of the surface due to temperature drop, which is usuallylongitudinal and sometimes forms in the shape of a set of big and interconnected cracks. The difference between this kind of track and mosaic tracks is the bigger upright parts and sharper corners of track in contraction tracks. Using hard bitumen in particular climates causes contraction tracks.

D. Falling between two line -cracks

That of longitudinal seams between the road lines fall into this category, which are formed due to asynchronous asphalting of the surface of adjoining lines. Thus, the upright seams are opened and water can easily penetrate and ruin most parts. Moreover, this ruin is seen in sideway lines and asphalt shoulder of roads.

E. Reflective Cracks

These tracks in the asphalt coating surface and in the site of those cracks that were in the surface of the old pavements, which results from vertical and horizontal layers under the asphalt coating.

F. Slippage (crescent) Cracks

These cracks form inthe direction of vehicles movement as the result of applying horizontal forces (braking) on the upper asphalt surface which is formed due to lack of adhesiveness between the upper asphalt layer and its underneath layer.

III. EFFECTS OF VARIOUS ADDITIVES/MODIFIERS ON ASPHALT MIXTURE

Main benefits of additives are:

1) Reducing costs
2) Reducing asphalt thickness
3) Reducing everyday repairments and prolonging

upgrading asphalt paving
4) Rise in allowed pressure of asphalt
5) Using new industrial products in run and production
6) Using lesions of industries and hygienic of the environment

Types of Modifiers:
1) Fillers
2) Extenders
3) Fibers
4) Oxidants and Anti-oxidants
5) Hydrocarbons
6) Anti strips
7) Polymers

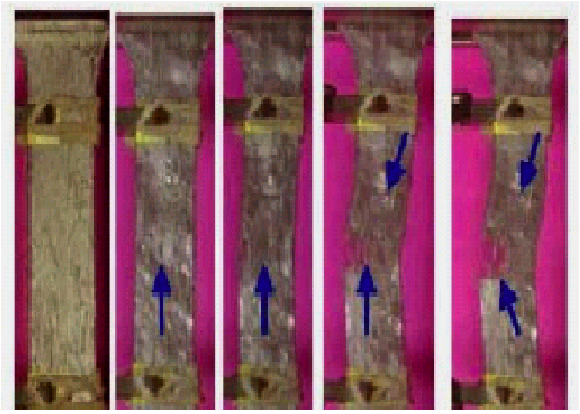


Fig. 1 procedure of stress in cracks

IV. FIBER ASPHALT PAVEMENTS

Producing Fiber Asphalt Pavement:
Higher amount of aspect ratio (1/d), causes aggregation and engagement of fibers. In order to give a fine mixture, maximum aspect ratio number limits to 100.
Physical Properties of Materials:
Asphalt V – 0.35
Soil V – 0.32
Loading frequency 5HZ, in the temperature of 20C
Stiffness factor of compacted macadam asphalt mixture 3.1(pa)*10^9
Stiffness factor of rolled asphalt mixture 3.5(pa)*10^9
Fatigue factor
Stiffness factor of compacted macadam asphalt mixture (or bitumen 100)
8) LogNf=-9.38-(4.16LogEr)
9) LogNf=-9.38-(4.16LogEr)
Er tensile strain in substrate asphalt layer under common wheel loading
Nf design life (total loading of standard equivalent ax)

V. BENEFITS OF FIBER ASPHALT

-Resistant against surface lamination, abrasion, and weathering
-Highly resistant against fatigue stresses
-Greatly resistant against shocks
-Excellent elasticity (high capacity in relative deformation)
-High load bearability after being cracked
-highly resistant against stretching, bending, and cutting
-Plenty of stamina

Flexibility of fiber asphalt, just like properties of plastic materials, prevents the asphalt from sudden raptures. Since steel fiber scatter three-dimensionally or better to say multi-dimensionally through the body of asphalt. In case of crack formation,in any of directions, the fiber creates some connections and therefore prevents the cracks expanding. Therefore, fibers actively engage in limiting the width of cracks and help in forming plenty of micro-cracks, and increase the capacity utilization as the result.it is seen especially in inhibited slabs, such as asphalt pavement in which friction causes expansion and contraction.It is worth noting that,the performance of steel fibers and improvement of asphalt mechanical properties depends largely on quality of fiber mixture layout, quantity of fiber, form of fiber, the aspect ratio (1/d), and etc.

VI. APPLICATIONS OF FIBER IN ASPHALT PAVEMENT

In road and runway construction
A runway suitable for landing airplanes should be fine, staminal, and shock absorber in order to be ready to confront any kind of weather condition and shock. Therefore, using asphalt fiber in constructing runways could be useful. In patterning roads and highways with high traffic loading, replacement of fibers could be very economical, because it causes reducing asphalt thickness, reducing the width of those cracks resulting from shrinkage, and controlling the width of expansion and contraction cracks. It also increases pavement strength against fatigue, reduces destructive factors of atmosphere, reduces lifeless loading in bridges, decks, and wharves due to decreased thickness of the slab,prevents deformation, and also reduces heat stress and resistance against corrosion and exhaustion.

VII. STEEL FIBER

Steel fiber is of best and most consuming fibers, which has drawn attention of most designers to itself because of favorable elasticity strength and fixing ability supply in the body of asphalt. Because steel fiber is neither produced in nor imported to Iran, most engineers and consultants don't have the knowledge or know little of this technology. It is also very expensive because of problems in buying it, such as currency, porting costs, customs duties, and etc. Therefore, it is not economical.to solve this problem, the Building and Housing Research Center has

invented a kind of wavy steel fiber out of internal wires.

Steel fibers scatter accidentally through every direction of asphalt. Cracks resulting from direct stretching can be controlled by steel fibers, because the fiber can act like a communication bridge once the asphalt cracks, and transfers the tensile strength, and then integrates the asphalt pavement. That is why the number of cracks increase, but the length, width, and depth of cracks extremely decrease.

A. Steel Fiber Properties

Shape of fiber

One of the effective parameters in the quality of fiber asphalt is its shape. For example, specific bending strength can be acquired by comparing 1.5 percent of plain fibers. This approximately saves consumption of fiber up to 50 percent consumption of fiber.

Also, the area under the loading curve, deformation of crooked fiber will be much more, which means more energy absorption.

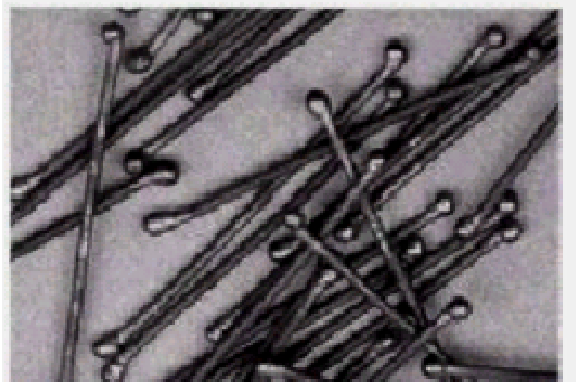


Fig. 2 Shape of steel fiber

TABLE 1. Influence of Steel Fiber on Asphalt and Fiber Bond

Shape of fiber	Diameter	Length	Fiberstrength	Average Pull-outload
Simple and direct	0.3	variable	1205	4.17
Indented and direct	0.5	30	955	8.1
crotchety	0.4	40	1355	4.93
Tiny flexural	0.35	30	1295	5.25
Coarse flexural	0.4	25	1615	13.4
Long tail	0.3*0.4	14.5	510	7.27

B. Aspect ratio of fiber

Aspect ratio or the ratio of length of fiber to its diameter, is considered as one of the important parameters in fiber performance. When fiber is added to the asphalt mixture, if the length of asphalt is less than the critical length of LC, the fiber will be pulled out of the mixture due to losing unity. And if the length of fiber is more than the critical length, the fiber will get to the threshold of flowingand ruptures. And if the fiber length is equal to the critical length, the tensile stress of fiber (σ f), and shear strength (τ) resulting from equivalency of forces will be as follows:

1. σ f/τ =2 .Lc/d

As the above equation shows, fiber's resistant tension, and its resistance, has direct connection to aspect ratio; therefore, we should pay attention that increasing the aspect ratio, decreases the efficiency and drifting of fibers as well as the quality of asphalt.

2. Fiber layout

Fiber layout in the axis of crack is very important in force transferring, and fibers perpendicular to the surface of cracks are of more usages. Of course, the substitute for fiber in asphalt as totally accidental, which should be distributed in two dimensions of length and width and in parallel to the horizontal axis, that is in direction of applied elasticity tensions in road pavements and airports.

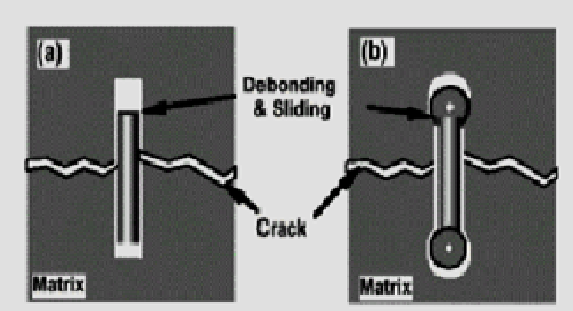


Fig. 3 Fiber layout in asphalt

1) Elasticity modulus of fiber

In load bearing mixtures, the more the modulus of elasticity, the more is the tension borne by the mixture. This is possible when there is unity between the fiber and asphalt. It is worth noting that, the more the modulus elasticity of fiber is, the more the cutting load capacity will be. (figure4)

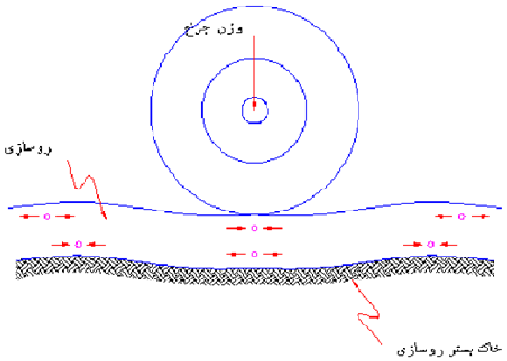


Fig. 4

C. Static Strength of Steel Fiber

Compression Strength

Because of compressibility of asphalt and access to

specific compression strength is possible through changing the mix design, using fiber is not good for this property. However, it is worth noting that steel fiber increase the compression strength of asphalt.

Elasticity Strength
Considering the weakness of asphalt in elasticity, if steel fiber lays constantly in direction of tensile stress, the tensile stress of asphalt increase; whereas, the asphalt fiber accidentally lay in asphalt. However, the specific amount of decrease in strength depends on shape, type, size, and other properties of fiber.

Bending Strength
Steel fiber has a remarkable effect on bending strength.
Elasticity strength, of asphalt materials under the temperature of 20c in the loading time of 50 milliseconds (90km/hr speed) is about 21-35kg/cm^2

Shear Strength
Steel fiber has a remarkable effect on shear strength.
Fatigue Strength

Steel fiber has a remarkable effect on fatigue strength. Asphalt and road fatigue remarkably decreases due to moisture harms. Thick layers of asphalt in stress control condition, and the
Thin layers in strain control condition under high temperature, the thin layer increases in size, and decrease fatigue life. However, tensile condition of constant strain increases in continuation of loading. We have less fatigue life with high temperature.

Dynamic Strength
Steel fiber has a remarkable effect on dynamic strength of asphalt.
Abrasion Strength
Steel fiber has a remarkable effect on abrasion strength of asphalt.

VIII. GEOGRIDS

Geogrid is a material with large holes so-called apertures.
These apertures vary from 1 to 10cm (based on the longitudinal and transverse arrangement of the ribs).

Types of georgrids
1. Tensarcrop
2. Tenaxcrop
3. Paragrids
4. Tiragrids
5. Fortral
6. Maxtrex
7. Stratagrid
8. Othergrids

Among all types of geogrids, 5 kind of them are available in Iran. These are made in Germany and are produced in two types namely Fortrac and Hatelit. The first one is used in soil reinforcement, while the second is used in asphalt reinforcement. Both kind of named geogrids are knitted by twisted fiber, and connects to a joint, and a poly vinyl chloride (P.V.C) coating or bitumen materials are given in the end. Typical applications of geogrids in Iran are reinforcing asphalt pavement of steel bridges such as Nasr, Kalej, and Sadr, in which Hatelit Were used. Fortrac geogrids were used in building the retaining walls of Tehran Exhibition's park.

IX. REINFORCEMENT OF ROAD'S BASE LAYER WITH ASPHALT PAVEMENT

Studies show that, if we want to use geogrids in the base layer, we should put it in the middle of the base layer. However, there are several graphs in this area, by which we can calculate the reinforced thickness by having the unreinforced thickness of the levee layer. Of course, these graphs are not available for all types of geogrids.

X. REINFORCEMENT OF ROAD'S BASE LAYER WITHOUT ASPHALT PAVEMENT

The major application of geogrids is in reinforcement of fine and compacted soil in building chip roads without asphalt pavement. Some benefits of this example of soil reinforcement are increasing load strength of the base levee, better load distribution in soil, and controlling cracking in soil. (When the difference of layers before and after reinforcement is much more, compared to the running and installing costs of geogrids, it's better to use geogrids instead.)

-Benefits of geogrids:
1) Decreasing the thickness of levee layer in roads
2) Increasing life time and lasting of asphalt and levee in front of loading and environmental factors

-Applications of geogrids
- Under sand materials in uncovered roads
- Under basalt in rail way structure
- Under overhead materials in soil structures
- Reinforcement of levees or dams
- Repairing ruins in gable roof
- As Gabion in the structure of walls
- As Gabion in erosion control structures
- As Gabion in the sides of bridges
- As fixed connection for the surface of retaining walls
- As reinforced asphalt in road paving
- As concrete reinforcer in most case
- To reinforce cracked stones
- To reinforce cracked concrete
- Land fill to reinforce vertical and lateral development
- Land fill to reinforce the coating as coating reinforcer
- Land fill as three-dimensional to increase load capacity
- As three dimensional for levees on fine soils
- For stability of rock sludge aggregator as reinforcer

CONCLUSIONS

Based on all the content, we can conclude that using fiber in asphalt pavement will decrease the costs. In order to meet the needs of our country in economy and occupation, manufacturing fiber asphalt producing factories could be very beneficial. Moreover, using fiber will increase the useful life and lasting of asphalt and levee in front of loading and environmental factors in long term and saves costs.

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