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Determination of the Suitable Dimension of the Cracks for Sealing in Preventive Maintenance

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Abstract: Pavements life will be increased by timely maintenance and the expenses will be decreased effectively by choosing the optimum time for repairing and preventive maintenance, usually, pavement life parameter is used as an optimum time for repairing. The cracks dimensions, as a measurable parameter in pavement level, can also help us choosing the repairing and preventive maintenance time. In this research, the procedure expense of preventive maintenance and repairing is considered as a measure of choosing tine for sealing cracks. If it is not possible to seal the cracks, this expenses should be equal wilt the expanses of operating and repairing the pavement using the relations of the cracks progression and calculated expenses of maintenance and repairing operations unit in pavement unit, a relation has been proposed for determining the cracks dimensions to be soiled.

Key words: Crack sealant, preventive maintenance, operating expenses, repairing pavement, pavement management system

INTRODUCTION

The condition of our roads and highways greatly contributes to the overall vitality of the Iranian economy. By improving ride quality, extending pavement life and ensuring safety, effective pavement preventive maintenance programs will help to allow people and goods to move safely and insure that our road network remains in good condition (Haas, 2001).

Many pavement agencies are now focusing on maintaining the overall value of their roadway assets and are striving to make better-informed decisions on how they allocate funding to minimize the deterioration of their assets. This new form of management referred to as Asset Management has clearly identified the benefits of strong pavement preventive maintenance programs compared to the commonly used worst-first repair approach.

Pavement maintenance and rehabilitation needs studies frequently indicate that current funding levels are not sufficient to maintain the road system at an optimal level of service. Iranian Municipalities indicates that Iran is facing a massive infrastructure. These funding shortfalls are considerable and a significant increase in funding is not likely. A strong pavement preventive maintenance program offers an opportunity to help close the gap between pavement maintenance needs and optimal pavement condition to better serve the traveling public.

Pavement Management System (PMS) is used to optimize the Pavement maintenance and reconstruction management this management technical, because of the restful interests, is used rising the preventive maintenance is one of the effective actions in pavement management system, although, perhaps, the pavement design life is continuing to live, but the pavements need maintenance during operating them and it is very important to choose the maintenance time the preventive maintenance consists of the repairing operations such as, Sealing cracks, sealing, micro surfacing and hot overlay the effects of the pavement preventive maintenance operations on the pavement performance in several stops are shown during its life.

During pavement life, the cracks caused by preventive maintenance are the thermal and Fatigue cracks on the loading, are sealed. If the cracks on the asphalt are not sealed on time, the surface waters penetration decreases the resistance of the base and sub-base layers and this causes deformation of the pavements. Sealing cracks is performed to keep the structure capacity of the pavement and prevent the water penetration and destruction.

The need to improve the design and performance of pavements is paramount to insuring the viability of our national infrastructure. Comprehensive monitoring of pavement performance through programs such as application of steel slag asphalt for preventive

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maintenance flexible pavement project has identified design, material mix design and construction and maintenance improvements to extend the life of our infrastructure. This has been accomplished through a better understanding of pavement design, material mix design, rehabilitation and maintenance methods and applications. Advancements in pavement material technology, as well as pavement design methods, use of waste material through research and development activities have made significant contributions to building longer lasting pavements with lower service costs and environmental impact.

With the increasing use and awareness of pavement management systems and environmental impact evaluation, it is important to strengthen the material components of these waste materials and particularly the preventive maintenance component (Potgicter, 2004).

Various preventive maintenance treatments are employed by highway agencies to restore pavement condition and retard future deterioration (Fig. 1). For specific climate conditions and traffic levels, the performance of the restored pavement will depend not only on the type of maintenance treatment, but also on the existing pavement condition when these treatments are applied. Crack sealing is the placement of specialized materials into working cracks by the cut and seal method. This method consists of cutting the desired reservoir shape at the working crack in the existing asphalt surface, cleaning the cut surfaces and placing the specified materials into the cavity. The cutting is performed with either a random crack saw or a crack router. This treatment is usually performed on working cracks and sometimes done in conjunction with an Asphalt Crack Filling treatment for non-working cracks. Sealing cracks and

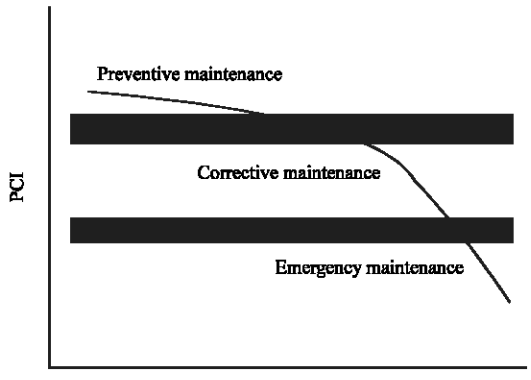

Fig. 1: Pavement changes index in relation to time (Khabiri, 2006)

open construction joints in the flexible pavement surface is done to prevent water from entering the pavement structure.

The existing pavement should be relatively new with a good base and cross section. On a flexible base, the HMA surface should be two to four years old and on a composite pavement (with underlying concrete), one to two years old. The visible surface distress may include: fairly straight open longitudinal and transverse cracks with slight secondary cracking and slight raveling at the crack face and no patching or very few patches in excellent condition.

Sealing cracks in pavements with an asphalt surface is a preventive maintenance activity performed by most highway agencies. Arrange of materials and methods are in use within Iran for this purpose. The choice of a specific material/methods on the country manager understands of the historical performance. Of various materials, pavement type, regional conditions and availability of operating funds.

Crack sealing can have many benefits including substantial life cycle cost savings, improved customer service and better system wide performance. Crack sealing may also affect the pavement in many ways such as tracking of sealing material by tire action, reduced skid resistance and a rougher pavement. Crack sealing is beneficial if pavement life is increased while maintaining serviceability. The primary concern is to in vest gate and document the effectiveness of crack sealing with respect.

- Economic benefits
- Maintaining and/or improving serviceability
- Extending pavement life

Reviewing scientific sources: Maintenance plays an essential and integral part in the life of a pavement. Throughout the past several decades, preventive maintenance has presented a series of challenges to pavement engineers, highway planners and others involved in the construction and management of public infrastructure at all levels of government. This study discuss about design shoulder of road that it is an important element in PPM. In PPM need understand performance of pavement and shoulder structure under load, therefore this paper noticed to pavement analysis.

According to the earlier study, it is necessary to consider some subjects such as performing the sealants, the relation between sealing cracks and the pavement management and the cracks effects in preventive maintenance. Rajgapoul and others have given some researches about the records of the pavement cracks

sealing in USA so that it is shown that sealing cracks operations are progressing about 30% in this country (Rajagopal and Minkarah, 2003).

In South Africa photometer provided the used sealing cracks procedure in which moreover examining the subject, the sealing cracks procedure has been examined in two.

Cases the cracks of which small dimensions from down to up and the cracks of which large dimensions from up to down progress, an other research has been done by asphalt and tar institute of Iran about the cracks sealing effects in pavement preventive maintenance. In this research, amalgamation of sealing cracks in pavement management system was examined based on the different situations characteristic of PCI. Another researcher has made research about the effects of sealing cracks on the pavement life, in this research, two roads were selected and principal soiling crack has been done for one of them and another was considered as a witness sample. The downward trend of the road quality has been shown as a model by drawing pavement situation against time.

Coordinated application of the preventive maintenance and pavement management system: The preventive maintenance, one of the specific procedures for repairing and maintenance of the pavement, is of the parts of pavement management system. In pavement management system, the different kinds of the pavements situations are specified with the pavement changes index. As per, the index, How to apply the sealing cracks will be considered in pavement management system and the procedure will be determined (Iran Bitumen and Asphalt Association, 2006).

Pavement current maintenance in a very good situation (index PCI between 75 and 95): Mostly, sealing cracks is used in PCI changes and also it is used to repair the small cracks. These cracks are usually less than 3 mm, if cracking happens slightly; initially observing the sealing cracks will prevent the water penetration in to the lower layers of the pavement.

Pavement preventive maintenance in a good situation (Index PCI between 60 and 75): The purpose of the preventive maintenance is to increase the purpose of the preventive maintenance is to increase the life of the pavement and decelerate the pavement situation index reduction rate. In this case, sealing cracks and preventive maintenance are ordinary and the crack width is 6.5 mm. Of course, firstly, it is recommended that also, the cracks with a width more than 3.2 mm are sealed and it was proposed that these operation s are performed in spring or autumn seasons.

Specific maintenance of pavement in a middle situation (PCI between 50 and 60): In this case, much destruction happens for the pavements and it affects the sub-layers and the preventive maintenance will be useless for the pavements. so the sealing cracks will be used to prevent any deformation in the pavements before beginning the main re construction operations. the cracks (alligator, reflective, length, crass) can be sealed with the different intensity levels (low, middle, high). The sealing cracks will increase the road life by the main reconstruction operations.

Reconstruction of pavement, pavement in a destructive situation (PCI between 25 and 50): In this case, the pavement needs over layer. Before performing, the sealing can be begun to prevent the water penetrating in the lower layers and the reflective cracks will be made in some points. This kind of sealing should be done inside the cracks and the sealing materials should not contact with over layers, so that un smoothness does not happen when compaction of over layer is made, According to the technical recommendations, the sealing materials should be placed 6.5 mm in a distance upper that the cracks. In these sealing, the widest crack should be prioritized.

Application of break mechanic concepts in pavement: Three kinds of breaks happen in asphalt concrete layer, such as separation skied, tear). The general law of break can also be used for analyzing the development of the pavement cracks, so that the development speed of the cracks can also be calculated by the experimental PARIS law (Yoder *et al*., 1975):

$$\frac{dc}{dn} = AK^n \quad (1)$$

Where:

$\frac{dc}{dn}$ = The crack length develop month in a lauding cycle.

N, A = Parameters of material and these parameters deepened on the tension resistance of break energy and the materials elastically hardness.

Because of repeated lauding, the cracks progress and then the materials under the loads are separated from each other. In this case the special tension stress exceeds and it causes the materials flow or the invisible minute cracks happen. These minute cracks make large cracks.

Both of cracks happen in mix asphalt concrete. Relation (1) is used to calculate the cracks length progress.

Economical comparing the sealing cracks: In order to determine the Suitable dimensions of cracks, it is necessary to analyze economically when sealing cracks. Some points should be considered: the expenses of sealing cracks and increasing degree of pavement life, the expenses of next repairing procedures, in case, the sealing cracks are performed, in case, the Sealing cracks are performed and pavement life decrease (Huang, 1993).

The expenses of timely pavement life decrease, (preventive Maintenance): The expenses of the sealing cracks of which length is X_1, in first Step, consist of:

- Expenses for preparing the materials
- Expenses for preparing the equipment
- Expenses of performing and human resources so that if X_1 (m) of sealing cracks is meant, total expenses will be:

$$Cost_{1,n} = E.\ X_1 \tag{2}$$

Where:

E = Sum of aforementioned there expenses are for cracks length unit.
X_1 = Crack first length.

Since this expense happens for N, repetition of standard loading axis, the expense of each loading in this axis will be:

$$Cost_{1,n} = \frac{E.X_1}{N} \tag{3}$$

The expenses of timely unsealing cracks of pavement:
Operating expenses: These expenses are caused by the damages inflicting the vehicles, because of unsmooth roads or delays happen for the passengers (raising the fuel expenses and wasting time of passengers)

$$Cost_{2,1} = L.\ X_2 \tag{4}$$

Where:

X_2 = The second length of crack is increased from X_1 to X_2 by lack of sealing cracks,
L = Expenses of damages inflicted to the vehicles for every axis because of Sealing cracks.

Expenses of final repairing: These expenses, which have been changed because of crack progression and Destruction intensity of the crack length parameters x2 and repairing unit Expense (f), are similar to the first sealing ones.

$$Cost_{2,2} = \frac{F.x_2}{N} \tag{5}$$

And total expense:

$$Cost_{2,n} = Cost_{2,1} + Cost_{2,2} = \frac{F.x_2}{N} + Lx_2 \tag{6}$$

Since the crack length is increased from X_1 to X_2 and the Relation of increasing crack length con is calculated with PARIS (1) law:

$$dc = Ak^n.dN \tag{7}$$

$$x_2 = x_1 + A\int_0^N .k^N.dN \tag{8}$$

With placing the relations (8 and 7) the final relation.

$$Cost_{t.n} = (\frac{F}{N} + L).(x_1 + A\int_0^N k^n.dN) \tag{9}$$

And since it is intended to determine the first length of crack X_1 for determination the time of repairing and preventive maintenance (sealing), so the expenses are considered equally.

$$Cost_{1,n} = Cost_{2,n} \tag{10}$$

$$\frac{Ex_1}{N} = (\frac{F}{N} + L).(x_1 + A\int_0^N k^n.dN) \tag{11}$$

$$x_1 = (\frac{F + LN}{E - (F + LN)}).A.\int_0^N K^n dn \tag{12}$$

If (a) is the expenses ratio of repairing and the first maintenance (preventive) To the expenses ratio of repairing and second maintenance (without Repairing and preventive maintenance).

$$\alpha = \frac{E}{F + L.N} \tag{13}$$

$$x_1 = \frac{A}{1-\alpha}.\frac{k^N}{Ln\ k} - 1 \tag{14}$$

So that the parameters of this relation have been given in the previous relations, so, the first length of crack x for sealing and preventive maintenance depends on some parameters such as the quantity of loading (n),

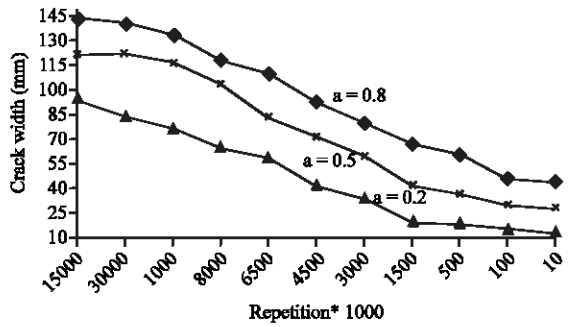

Fig. 2: The diagram of the crack suitable length changes for sealing in relation to the quantity of loading repetition (A = 2, K = 1.5) (Khabiri, 2006)

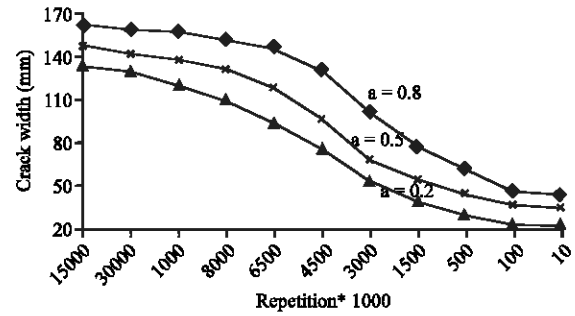

Fig. 3: The diagram of the crack suitable length changes for sealing in relation to the quantity of loading repetition (A = 3, K = 2.0) (Khabiri, 2006)

the ratio of repairing and preventive maintenance expenses depends on the expenses of lack of performing operations of repairing and preventive maintenance (a) and technical specifications of the materials (A, K).

Figure 2 and 3 show the diagram of the crack first length changes for different values (a) and factors A and K.

CONCLUSIONS

The preventive maintenance affects lengthening the pavement life so that determining suitable time of the pavement maintenance was emphasized in many researches, if the sealing cracks time is not chasing correctly, it will be possible to raise the expenses of repairing and preventive maintenance. so, in this research, a relation was proposed to determine the suitable length of the cracks in pavement unit for sealing cracks, after general reviewing the preventive maintenance concepts for its relation with pavement management and cracks mechanical concepts. The results are as follows:

- The more quantity of passage path axis, the less length of crack which is chosen for sealing the cracks.
- Increasing the expense ratio of the preventive maintenance to the final maintenance expense the suitable length of crack will increase for choosing the time of sealing crack in surface unit.

Following these researches, opened width and depth of the cracks can be considered instead of the crack volume dimensions crack length performing some experiment will be effective in choosing factors A and K for the asphalt materials and in making the results of this paper applicable.

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