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Polishing Mechanism and Its Numerical Modeling for Flexible Pavement

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Abstract: Pavement polishing is one of the distress types exhibited with asphalt pavement, which is caused by repeated sliding contact wear on the pavement wear course. In this paper, pavement polishing mechanisms are discussed first. Then a finite element procedure to predict pavement polishing is developed. A modified Archard's wear law is used to calculate geometric change based on contact pressure and relative slip between two bodies. The material loss due to polishing is realized through the geometric change. The thickness loss is also used together with deformation to calculate the polishing configuration due to surface ablation. The polished configuration will be adaptively remeshed for the next simulation time step. Thus the mechanical behavior due to pavement polishing can be reasonably captured. Representative simulations were provided to demonstrate the effectiveness of the proposed pavement polishing model, which include parametric study on material hardness and wheel slip rate. Further developments on pavement polishing modeling are also discussed in this paper.

Key words: *Archard's wear law; Finite element; Pavement polishing; Relative slip; Remeshing.*

Introduction

Pavement polishing represents damage to pavement surface, which usually involves progressively loss of pavement surface material due to relative motion between road surface and contacting tires. The progressive wear of pavement surface has been one of the negative factors impacting pavement structural life cycles, worsening normal operation condition, and degrading pavement mechanical performance. Therefore, pavement polishing has a negative economic consequence. During the past few decades, great effort has been made in understanding different pavement distress mechanisms. A few papers were devoted to understanding pavement polishing [1, 2], which focused on experimental study. Relatively little effort has been devoted to developing a simulation tool to predict the pavement polishing rate, which is the focal point of this paper.

The wearing course is placed on the top of asphalt pavement, which serves as a protection layer for the underneath of pavement. It resists traffic abrasive wear and in some cases serves as an impervious layer to protect the base, subbase, and subgrade. In most flexible asphalt pavements, the hardness of wear course is generally lower than that of aggregates. Pavement polishing is considered one of the distress types for asphalt pavement surface, which is caused by repeated sliding contact wear. Pavement polishing is usually triggered due to relative motion between tire/wheel and pavement surface. Overly polishing will create a smooth slippery pavement surface, resulting from tire polishing the sharp edges of the coarse aggregate. It has been observed that different aggregates generally have different hardness and exhibit distinct polishing rate. Polished aggregates will have the asphalt binder coating removed and become smooth. The consequence of serious polishing is to reduce the pavement surface skid resistance. Polished aggregates, as a form of surface distress, appear when the skid resistance values are low or have dropped significantly from previous ratings. It can be a serious surface distress for highway pavements. High polished pavement surfaces can be repaired by the application of a layer of wearing course on the top aggregate or replacement of the wearing course. To mitigate the risk of fast pavement polishing, strong pavement surface materials have to be used to slow down the polishing process and extend the working life of pavement materials.

In contrast to general engineering mechanics problems, pavement polishing seems challenging and difficult to be understood and modeled because of the complex wear environment, which generally includes dynamic loads, rolling and sliding motions, thermal frictional contact, wear debris recirculation, chemical reactions at the contact surface, geometric and material nonlinearity, changing material properties close to the surface, etc. Pavement polishing along with asphalt binder aging fatigue, creep, and fracture toughness cause progressive degradation of materials with time and lead to material failure as time advances. With increasing environmental condition severity, pavement polishing rates may increase dramatically.

During a pavement polishing process, the amount of material being removed is quite small. Thus the polishing process is not always easily detected in practice. Based on a literature survey, it is evident that a majority of past research efforts has been focused on experimental approaches to understand wear. Compared to the extensive effort exerted on understanding pavement distress mechanisms, very little work has been done on numerical modeling of pavement polishing. There is no commercial finite element (FE) code that can be directly used to simulate polishing or wear, even though contact mechanics formulations have been well developed and implemented in commercial finite element codes. Finite element modeling of wear has been attempted in the past [3, 4]. In a conventional finite element simulation, geometric changes due to surface ablation from wear have been neglected in contact simulations. Wear simulations have to be completed by integrating a wear law to calculate the geometric change. Podra, et al. [3] is one

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of the few researchers to apply the finite element software ANSYS to predict the contact stress for wear estimate, which is one of the major input parameters for sliding wear laws. His representative examples were conical spinning contact and pin-on-disc rubbing contact problems. Hegadekatte, et al. [4] developed a post-processor that interfaces with ABAQUS. The wear simulation tool works in a loop and performs a series of static FE-simulations with updated surface geometries to get a realistic contact pressure distribution on the contacting surfaces. After every wear step, the geometry is re-meshed to correct the deformed mesh due to wear and ensure a fairly uniform mesh for further simulation. The evolution of the contact surfaces wear for sheet metal forming and bulk forming operations were also addressed in literature [6]. The purpose of this paper is to explore a finite element procedure that can be used to simulate pavement polishing due to finite sliding and frictional contact from vehicle tires or wheels.

The remainder of this paper is organized as follows. Pavement polishing mechanism is discussed in section 2. In section 3, the finite element procedures for polishing simulation are presented. Numerical implementation is discussed in section 4. Numerical simulations of pavement polishing are given in section 5. Conclusion and future work are contained in section 6.

Pavement Polishing Mechanism

Pavement polishing is classified as a type of surface distresses, which is related to fatigue, loss of binding, traffic abrasion, aggregate degradation, and binder aging. All these effects can accelerate the surface polishing. Surface polishing is somewhat related to surface roughness. Pavement roughness is an expression of irregularities in the pavement surface that adversely affect a vehicle's ride quality. Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle operating costs, fuel consumption, and maintenance costs.

Mechanism of pavement polishing can be classified as abrasion, adhesive wear, or surface fatigue. Pavement abrasion is induced by vehicle tires, which forces hard particles against and moving along the pavement surface (see Fig. 1). The abradant usually has sharp angular edges to produce cutting or shearing action on the pavement. Abrasive wear can be defined as wear in which hard asperities on one body, moving across a softer body under some load, penetrate, cut, and plough the material from the surface of the softer body, leaving a groove. These hard asperities may be embedded in the contact interface. Pavement polishing is somehow related to adhesive wear, which is a progressive loss of material from pavement surface in relative motion between tire and pavement and is initiated by localized bonding between these surfaces. Whenever two solids experience relative motion, the friction force that tends to resist this motion occurs due to adhesion between the two surfaces. In adhesive wear, bonding between contacting surface features eventually results in fracturing of the material from one or both of the interacting surfaces. If the bond to one surface is stronger than the bond to the other, transfer of material may occur. If surface features are fractured from both surfaces, wear debris is produced. Subsequently the wear debris will become abrasive and the mechanism of material removal becomes abrasion. Surface fatigue will accelerate the pavement polishing process. After tremendous cyclic stress produced by repeated rolling or sliding on a pavement surface, microfracture will occur at the pavement surface. Binder removal would occur by subsurface cracking. Fatigue wear occurs when surface and subsurface cyclic shear stress or strain in the softer material exceeds the fatigue limit for that material. Under these repeated or cyclic loading conditions, subsurface delamination and cracking can occur, eventually leading to the release of particles. Fatigue damage can range from small areas of pitting not apparent on virtual inspection to macroscopic pits several millimeters in diameters to large areas of delamination. Fatigue wear is believed to be related to damage mechanics. Therefore some relationship between fatigue wear and damage mechanics should be investigated in the future.

Overall, polishing wear is unintentional progressive removal of material from a surface by the action of rubbing from other solids under such conditions that material is removed without visible scratching, fracture, or plastic deformation of the surface. Surfaces that have been subjected to polishing wear are usually smoothed or brightened, but this smoothing or brightening requires material removal and it can cause a loss of serviceability in some parts. Geometry can be changed enough to make a part un-usable. Atoms or molecules are individually removed from the surfaces by the rubbing counterfaces, which have been widely accepted in the field of wear research.

In summary, pavement polishing can occur through several mechanisms: adhesion, abrasion, and fatigue. They can generally occur simultaneously, although the relative contributions of each of these wear mechanisms differ in the interface.

Finite Element Procedures for Pavement Polishing

As emphasized early, pavement polishing is a slow mechanical process. So far, there is no routine procedure being established in the computational mechanics community. It is hoped to establish a procedure within finite element framework that can be used for future model further development. The computational framework contains the following major components: wear law for pavement polishing, polishing configuration, adaptive remeshing, and thermal frictional contact.

Wear Law for Polishing Prediction

In the field of wear research for materials, the oldest wear law was proposed by Archard in 1953 [5]. It has been widely used and cited in the field of tribology and still considered as the most popular wear law. The Archard wear law was given by:

$$W_{wear} = K_w \frac{\sigma_c S}{H} \tag{1}$$

where, W_{wear} represents wear rate, which can be volume/time or thickness; K_w is the so-called dimensionless wear coefficient, which is related to the materials' surface roughness in contact and can be related to the friction coefficient; H is the material hardness (MPa) of the softer body in the contact couple; S is the relative sliding distance between two contact bodies; and σ_c is the normal

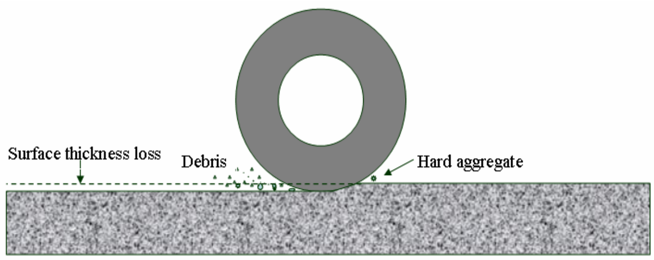

Fig. 1. Polishing Pavement Material Removal with a Tire or Wheel.

contact stress induced by the contact interaction. The original Archard's wear law can be classified as a phenomenological model for sliding wear. It assumes the critical parameters in sliding wear are the contact stress field and the relative slip between the contact surfaces. The equation exhibits a linear relationship between wear volume and relative sliding distance should the normal contact pressure be kept constant. Despite the fact that a completely different mechanism is associated with abrasive wear, one can apply the same constitutive equation as Eq. (1). The only change is the abrasive wear coefficient that physically represents a value that depends upon the average of the roughness.

Wear in general depends upon the properties of the material surface, the surface roughness, the sliding distance, the sliding velocity, the surface temperature, and contact stress. It is evident that no available wear model has contained all these effects in a single wear law. Also the surface roughness will change during the contact interaction process as well as the contact stress. Therefore, some further research efforts should be exerted in developing comprehensive wear model in the future. Enormous experimental work had been done to verify the validity of Archard's wear law and received a lot of critical comments. Many experimental investigations of wear confirm the validity of Archard's law significantly underestimates the wear when contact pressure exceeds the yield stress of the materials [6]. This means Archard's wear law has to be modified under the plastic condition.

Understanding Wear Coefficient, Toughness, and Skid Resistance

Wear coefficient appears in Archard's wear law, which is related to the surface toughness and skid resistance. Wear coefficient is also the material loss rate between two bodies. So far no formulations have been developed to reflect the relationship among them. A common test used to characterize toughness and abrasion resistance is the Los Angeles (LA) abrasion test. Aggregate toughness is its resistance to abrasion and degradation. Toughness of aggregate can be measured as the mass percent loss of material during the LA Abrasion test. Aggregate toughness is somewhat related to the skid resistance of aggregates.

The skid resistance of aggregates is the polishing resistance of the aggregate. Skid resistance depends on a pavement surface's microtexture, which refers to the small-scale texture of the pavement aggregate component and controls contact frictional behavior between tire and pavement surface [2]. Generally it increases in the first two years after construction as the asphalt binder coating the top layer of aggregate is worn away by traffic, then decreases over the remaining pavement life as aggregates become more polished. Aggregates used for the top wearing course for pavement better possess some resistance to polishing. Skid resistance can be measured using a locked-wheel skid tester, which basically employs a test wheel that is locked up as it is rolling and skidded along the tested surface. Skid resistance is generally quantified using some form of friction measurement such as a friction factor f and skid number SN as given by:

$$SN = 100f = 100\frac{F}{L} \tag{2}$$

where, F is the frictional resistance to motion in plane of interface and L is load perpendicular to interface. Polishing phenomena occurs because two bodies slide against each other. For pavement polishing, there is another concept named slip rate, which should be introduced to indicate the relative motion intensity. For tire/wheel braking, the slip rate is defined by:

$$\text{Slip rate} = \left(1 - \frac{\omega R}{V_x}\right) \times 100\% \tag{3}$$

where, ω denotes angular velocity, R is rolling radius, and V is traveling velocity at the tire or wheel center. It indicates there is relative motion between tire and pavement if slip rate is not zero. A nonzero slip rate between tire and pavement implies that pavement polishing will occur. This also applies to the slip rate equation for tire traction case, which is given by:

$$\text{Slip rate} = \left(1 - \frac{V_x}{\omega R}\right) \times 100\% \tag{4}$$

Update Polishing Configuration

As addressed earlier, pavement polishing is the outcome of two/three bodies sliding-contact interaction, which must be cast in a large deformation framework and take updated Lagragian regime. Fig. 2 shows the finite deformation of two bodies contacting and sliding against each other along the surfaces, which will lead to material loss from the surface of the softer body. Contact conditions have to be formulated with respect to the current configuration. Once the contact solution is obtained, then proceed to the next step wear calculation. For a purely large deformation without considering polishing, the current configuration can be updated as follows:

$$\mathbf{X}_{t_{n+1}} = \mathbf{X}_{t_n} + \mathbf{u}_{t_{n+1}} = \mathbf{X}_{t_n} + \Delta\mathbf{u} \tag{5}$$

where, $\mathbf{X}_{t_n}$ represents the initial configuration, $\mathbf{u}_{t_{n+1}}$ is the total displacement, and $\Delta\mathbf{u}$ is the incremental displacement. In order to visualize the progress of wear, the displacement due to wear at each of the nodes is added to the corresponding elastic displacement at the end of each wear step to get the total displacement. The corresponding coordinates of the surface node concerned due to wear will be calculated as follows:

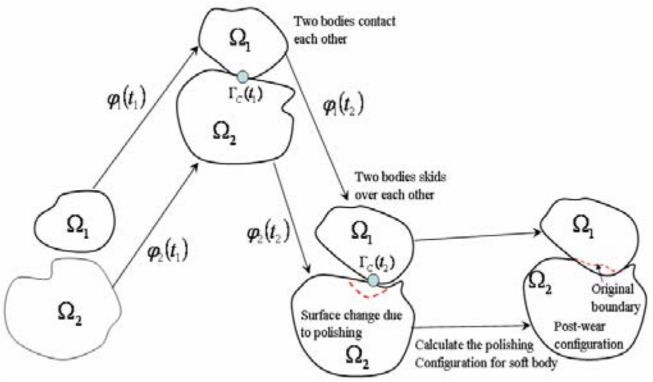

Fig. 2. Scheme for Polishing Configuration.

$$\mathbf{X}_{t_{n+1}}(\Gamma)=\mathbf{X}_{t_0}(\Gamma)+\mathbf{u}_{t_{n+1}}(\Gamma)+\Delta W\mathbf{n}_i \tag{6}$$

The current configuration including wear can be obtained by combine Eqs. (1) and (2). ΔW is the thickness loss in the normal direction of the wear surface and $\mathbf{n}_i$ is the normal vector at the surface nodes where wear are concerned.

The calculation of the inward surface normal vector at the contact surface nodes is a little complex. The reason is that one surface node connects with several elements and the surface is not smooth when using efficient linear interpolation functions. Linear shape functions will lead to C^0 continuity for displacement; the first derivative is not continuous at the surface nodes. The surface normal vector at each of the surface nodes is calculated by performing the following vector cross product:

$$\mathbf{n}=\boldsymbol{\varepsilon}:(\mathbf{r}\otimes\mathbf{r}) \tag{7}$$

where, $\mathbf{n}$ is the corresponding inward or outward surface normal, $\mathbf{r}$ is the vectors formed by connecting the concerned surface node and its neighboring nodes, and $\boldsymbol{\varepsilon}$ is the permutation symbol. The average unit normal vector from the above computed normal vectors is determined as follows:

$$\mathbf{n}_i=\frac{1}{\left\|\sum_{k=1}^{Node} n_k\right\|}\left[\sum_{k=1}^{Node} n_k\right] \tag{8}$$

Remeshing the Polishing Configuration

After the update polishing configuration is obtained, polishing configuration should be remeshed for next step simulation. On the wearing surfaces, the evolution of the faces and the corresponding normals are tracked by a surface-evolution algorithm. In particular, the wearing surfaces move in the post wear configuration with a normal velocity equal the wear rate, which is implemented by modifying the nodal coordinates based on the application of wear law calculation at the concerned surface nodes. In order to prevent degeneracies for finite elements adjacent to the wearing surfaces when the thickness of the layer removed by wear becomes comparable to the element thickness, the mesh is frequently needed to be modified for accommodating the surface wear.

The surface nodes are translated in the direction of the inward surface normal, depending on the amount of wear at that node. But in this way, limitations will occur by the surface element height, which means that surface elements have to be meshed in such a way that they have enough height to accommodate the entire sliding distance that is planned to be simulated; otherwise, at later wear simulation some FE will degenerate. Also it can give negative determinant of the Jacobian and lead to a termination of the simulation. But such a strategy for meshing will affect the accuracy of the FE results. It is not affordable to have a coarse mesh in the contact region unless the accuracy of the results can be compromised. In order to achieve the highest possible accuracy in the FE results and at the same time accommodate the wear on the surface for the entire planned sliding distance, to the model must be remeshed at the end of each wear step. The remeshing of the model allows for the correction of the deformed mesh at the surface (due to polishing) by shifting the nodes at the interior of the model proportional to the amount of wear at the surface nodes. ABAQUS has the capability to remesh the polishing configuration based on several methodologies [7].

Numerical Implementation

Pavement polishing simulation has been proved to be computationally very expensive because of surface ablation is a lengthy mechanical process. Real time simulation seems impossible in the near future. The strategy is to fully utilize the limited cycle simulations to predict the long term wear. Based on this goal, an automated wear calculation and remeshing for wear simulation was developed. Fig. 3 is the flow chart which contains the major procedures for polishing simulation. The polishing simulation procedures were implemented based on the available features already set up in the commercial finite element code ABAQUS, such as solver, postprocessing capabilities, etc. The technical part is on developing user subroutines to modify the surface node coordinates based on the pavement surface wear law.

Once the finite element model of the initial geometry has been generated, the program can run for any specified number of wear

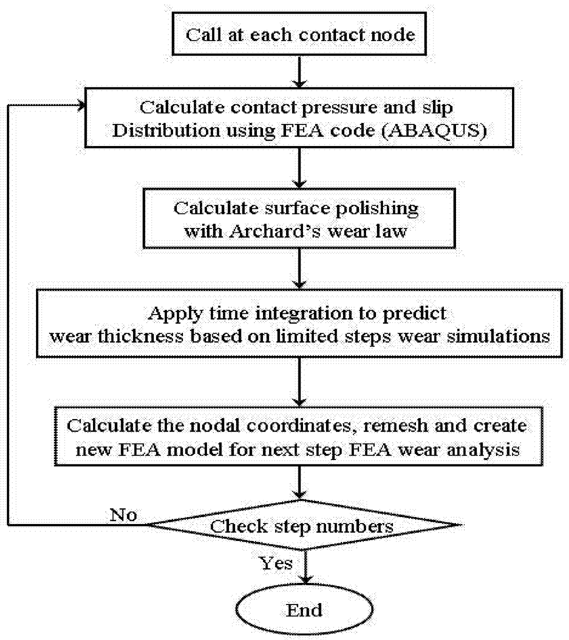

Fig. 3. Flow Chart for the Calculation of Polishing Configuration.

Table 1. Model Parameters for Pavement Polishing Simulation.

Elastic Modulus (MPa)	Poisson's Ratio	Pavement Hardness (MPa)	Wear Coefficient	Frictional Coefficient
1000	0.35	500	1.0E-04	0.2

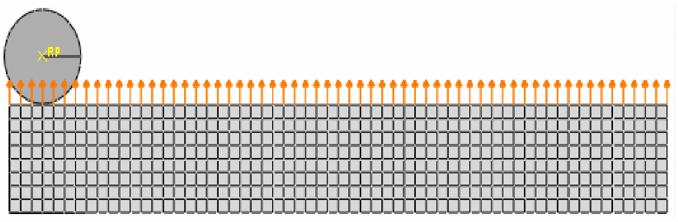

Fig. 4. Finite Element Model for Pavement Polishing Due to Fully Locked Wheel.

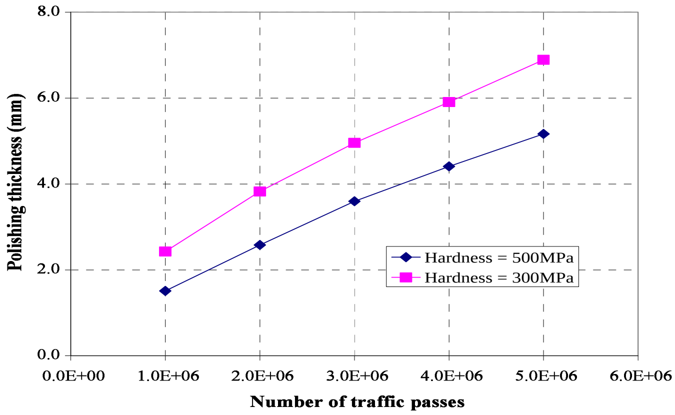

Fig. 5. Polishing Thickness Versus Number of Traffic Passes for Different Material Hardness**.**

cycles to predict the corresponding worn surface profiles and the evolution of surface and surface contact variables. The simulation tool consists of an interaction between a special-purpose Fortran program and ABAQUS, whereby the FE model is incrementally updated as described below. The wear thickness in the normal direction of the surface is calculated based on the local contact pressure and local slip distance of the each step FE simulation. The initial parameters required for the wear simulation include contact geometry, material mechanical properties, contact interaction properties, wear coefficient, and material hardness, which are defined within the FE model.

As mentioned earlier, material loss occurs extremely slowly and the computational time will be a challenging issue. Even though there has been effort to develop an efficient framework for wear simulation, it will be very difficult to simulate the entire sliding wear process with the current computer CPU speed at this moment. It might be practical to simulate the sliding contact process a number of steps and update the surface at each simulation step as realistic as possible. The strategy is to fully utilize the current computer capabilities and divide the wear simulation into a limited number N steps of finite element analyses (such 10 steps), which represents a long time. From step to step, it's assumed ΔK wear increments will be linearly added to all the previous steps. At each contact surface node, the incremental wear thickness can be approximately calculated by:

$$\Delta W = K_w \frac{\sigma_C}{H} S \times \Delta K \qquad (9)$$

The choice of a suitable value for ΔK is important for both the stability of the simulation and the resulting computational time. The larger the size of the wear step, the larger error will be generated and vice versa, owing to the considerable change in the contact area and thus the stress field. On the other hand, a smaller wear step will greatly increase the number of contact simulations, which forms the bottleneck as far as the computation time is concerned. Due to the fact that generally only small amount of material is removed, this might not be a serious issue on the choice of ΔK. Thus the total accumulated wear thickness can be given as follows:

$$W_{t_{n+1}} = W_{t_n} + \Delta W \qquad (10)$$

One of the foremost things that should be born in mind about the framework is that it aims to give key procedures that should be taken for general sliding wear simulation. Due to the amount of material loss due to wear is generally small, nearly all available wear simulations adopted the same procedure that applied the wear law in so-called post-processing [4]. Actually, the geometry due to wear was not modified in the wear process analysis. In this paper, the geometry of the part with soft hardness is modified based on the wear law and contact interaction.

Numerical Examples

In this section, two simple pavement polishing examples were created to demonstrate the effectiveness of the polishing modeling procedures. The focal point is to verify whether the wear simulation approach can correctly remove material from pavement surface by modifying the surface coordinates. The accuracy of the stresses and other state variable is not a concern in this paper.

Prediction of Polishing for Different Material Hardness

The first example is a three dimensional problem, which consists of a rigid cylinder wheel and deformable pavement (see Fig. 4). The horizontal extent of the pavement is 6.0m in the rolling direction, the width of the foundation is 1.2m, and the depth is 0.6m. In Fig. 4, the polishing direction (arrow direction) is defined in the original configuration of pavement part. The boundary conditions for pavement part model are fixed at the both ends and the bottom. A vertical point load is applied at the wheel center. The wheel is sliding on the top of pavement surface by applying a traveling velocity at the wheel center. Therefore it is fully locked and the corresponding slip rate is 100%. Frictional contact property between roller and top surface is defined as tangential behavior governing by frictional coefficient. In order to easily see the surface material loss, it's assumed that the softer flexible pavement only deforms elastically and, therefore, no geometric change appears due to permanent deformation in this model. The updated configurations are caused only by wear. Therefore any wear thickness loss can be easily visualized and verified.

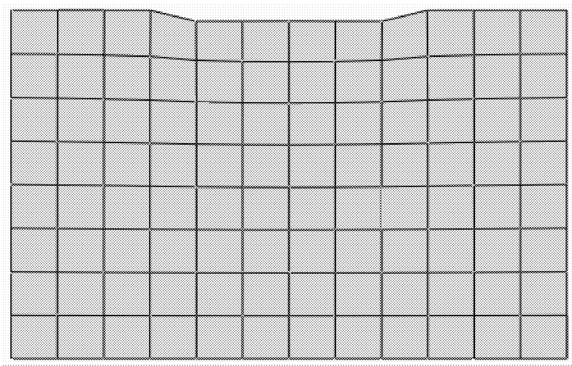

Fig. 6. Geometric Change after 1 Million Traffic Passes.

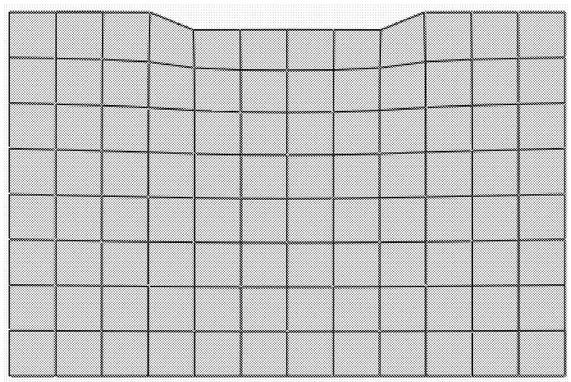

Fig. 7. Geometric Change after 2 Million Traffic Passes.

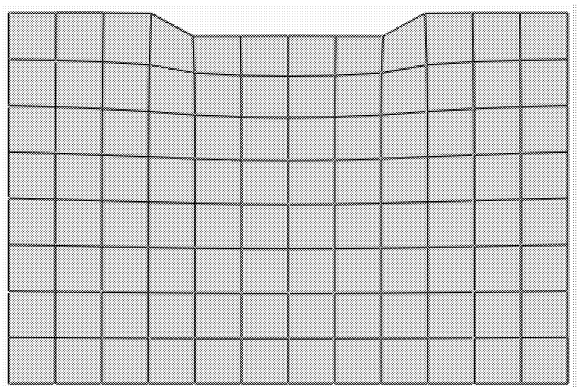

Fig. 8. Geometric Change after 3 Million Traffic Passes.

Fig. 5 shows the relationship between polishing thickness versus the number of traffic passes for different material hardness. For the same kind of loading condition wheel, the polishing thickness is linearly increasing with the number of traffic passes. Also it shows the bigger material hardness, the pavement polishing rate is relatively smaller. This agrees well with engineering knowledge on pavement materials. Figs.6 to 10 show the geometric change after surface polishing. Since the pavement part deforms elastically, no permanent deformation stays with the polished and deformed configurations. All elastic deformation can be easily recovered after completely unloading. The change of pavement profile after polishing can be easily seen from these intermediate configurations, which are completely unloaded and have no permanent deformations. Figs.6 to 10 also show the remesh is well executed after each wear simulation. These polishing configurations clearly demonstrate that deep groove will be formed in the traveling direction. Figs.11 and 12 are the contours of the logarithmic strain after unloading, which is induced by the surface ablation. These two figures clearly show residual stress will be created in the pavement due to pavement polishing. The residual stresses usually increase with the increasing pavement polishing and accelerate pavement distress.

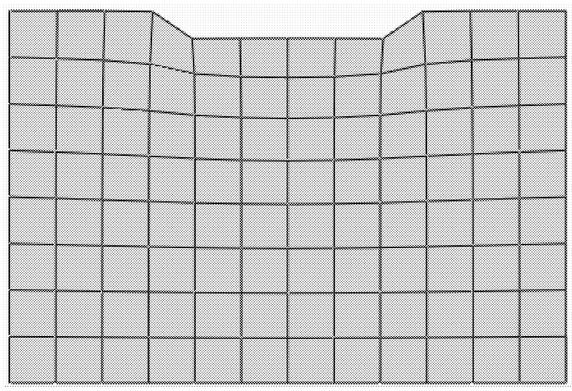

Fig. 9. Geometric Change after 4 Million Traffic Passes.

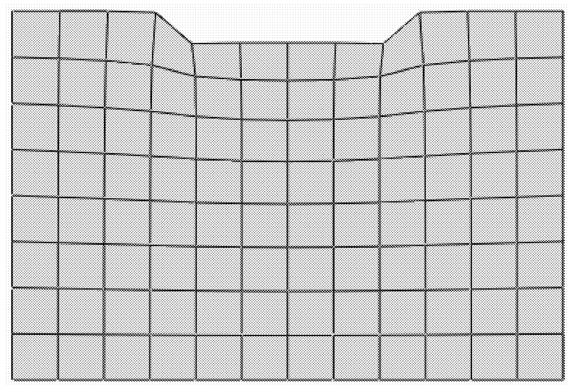

Fig. 10. Geometric Change after 5 Million Traffic Passes.

Polishing Prediction for Different Slip Rates

This model is modified based on the first example and model parameters are same as those used in the first example. The motion of roller is assumed to be sliding and rubbing against the top surface of the flexible body to generate polishing. Also the wheel is rotated with an angular velocity of 2*rpm* and 4*rpm*, which correspond to two different simulation cases. The corresponding slip rates are 65% and 30%, which are calculated using Eq. (3) for braking condition. For the same traveling velocity, a higher angular velocity wheel means more contact rubbing with pavement surface and produces higher polishing of pavement than those of lower angular velocity case and fully locked wheel case. Fig. 13 clearly verifies this well agreed result. Fig. 14 shows the frictional energy dissipation for different wheel/pavement interaction cases. Higher angular velocity leads to the higher frictional energy dissipation than the other two cases. This also agrees well with the generally accepted notion that frictional energy dissipation can be used as an important parameter to correlate wear or polishing. This should be included in the future polishing model development.

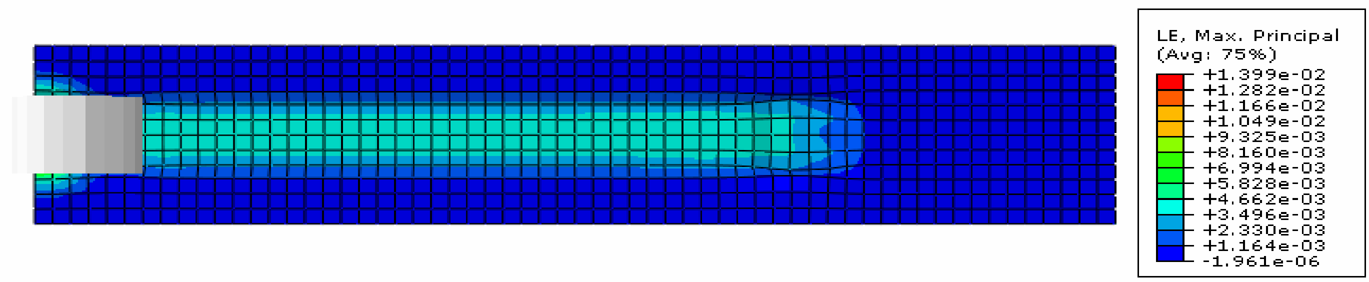

Fig. 11. Maximum Logarithmic Strain after Completely Unloading.

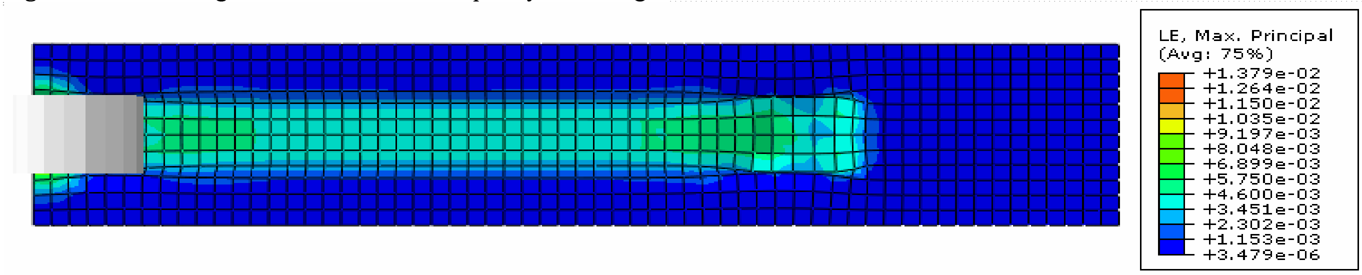

Fig. 12. Maximum Logarithmic Strain after Completely Unloading.

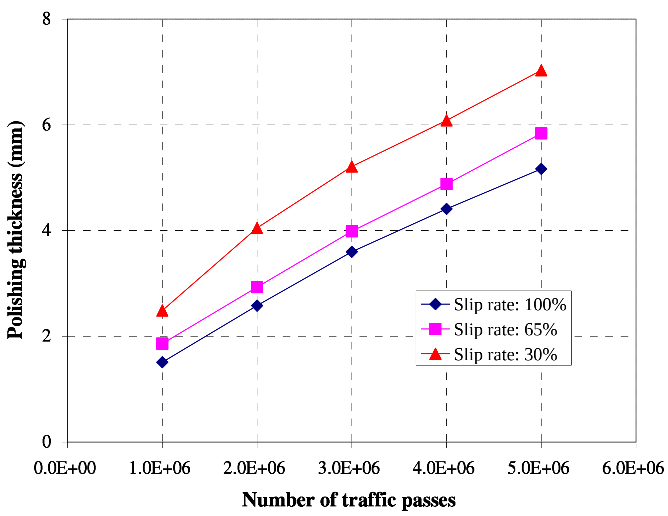

Fig. 13. Polishing Thickness Versus Number of Traffic Passes for Different Slip Rate.

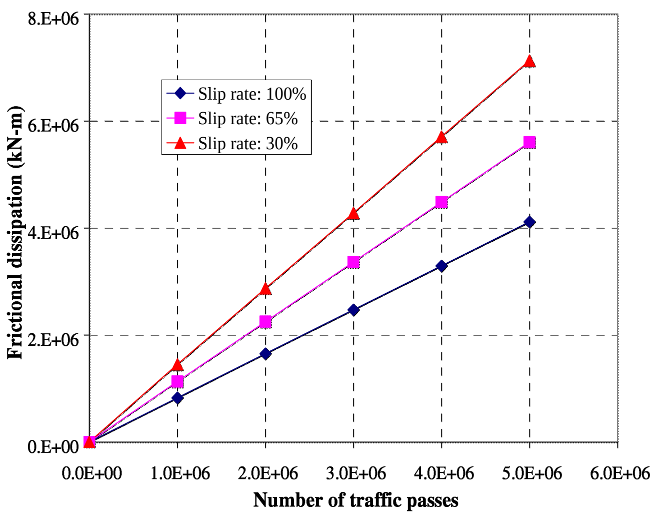

Fig. 14. Frictional Energy Dissipation Versus Number of Traffic Passes.

Conclusion and Future Work

In this paper, physical mechanisms to triggering pavement polishing were discussed first. Then a finite element procedure to simulate sliding wear was introduced. A modified Archard's wear law was employed to estimate the pavement polishing based on contact pressure and relative slip between the pavement and vehicle. The thickness loss was then used together with deformation to update the intermediate configuration due to polishing. The polishing configuration was adaptively remeshed for the next simulation time step. Thus the dynamic characteristics of interaction can be better captured. Representative simulations were provided to demonstrate the effectiveness of the proposed models, which include parametric study on asphalt layer's hardness and the relative slip rates in braking condition. The numerical examples demonstrate that the surface ablation due to wear can be predicted. As emphasized, numerical modeling of progressive wear is less advanced compared with the development of qualitative testing approaches. Pavement surface material loss is predictable, but the real time simulation seems extremely challenging in the near future. This represents a recent effort to tackle this issue.

A lot of efforts need to be done in the future, especially on the development of robust wear law and computer algorithm. For pavement polishing phenomena, a suitable wear law accounting for elastoplasticity should be developed in the near future. This can be achieved by developing a plasticity-dependent hardness model, which will be the next paper. Also tests should be done to obtain the pavement polishing model parameters that are needed to validate the polishing model. To be able to estimate pavement polishing will considerably improve the design of pavement structure and will have a significant impact on the maintenance and rehabilitation of pavement structure.

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