

## **FINITE ELEMENT ANALYSIS OF THIN FILM DEFORMATION IN ASPHALT MIXES USING GRADIENT ELASTICITY**

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### **ABSTRACT**

Asphaltic materials consist of asphalt binder, particles, and air voids. The wide range of distribution of particles, and the several order of magnitude differences in the stiffness between the constituents cause a wide range of stress and strain distribution within the microstructure. Micromechanics analysis has been used to study the relationship between individual material properties, their interaction within the microstructure, and consequently, the overall asphalt mix macroscopic properties. The FE with different constitutive models has been used to analyze the asphalt mix microstructure (e.g. Masad et al. 2001). This approach has been found, however, to be limited in capturing the details of the microstructure in a representative volume element (RVE). It requires very high number of elements in order to capture all sizes of particles and asphalt film present in the mix.

Strain gradient theories or nonlocal theories have been implemented in different

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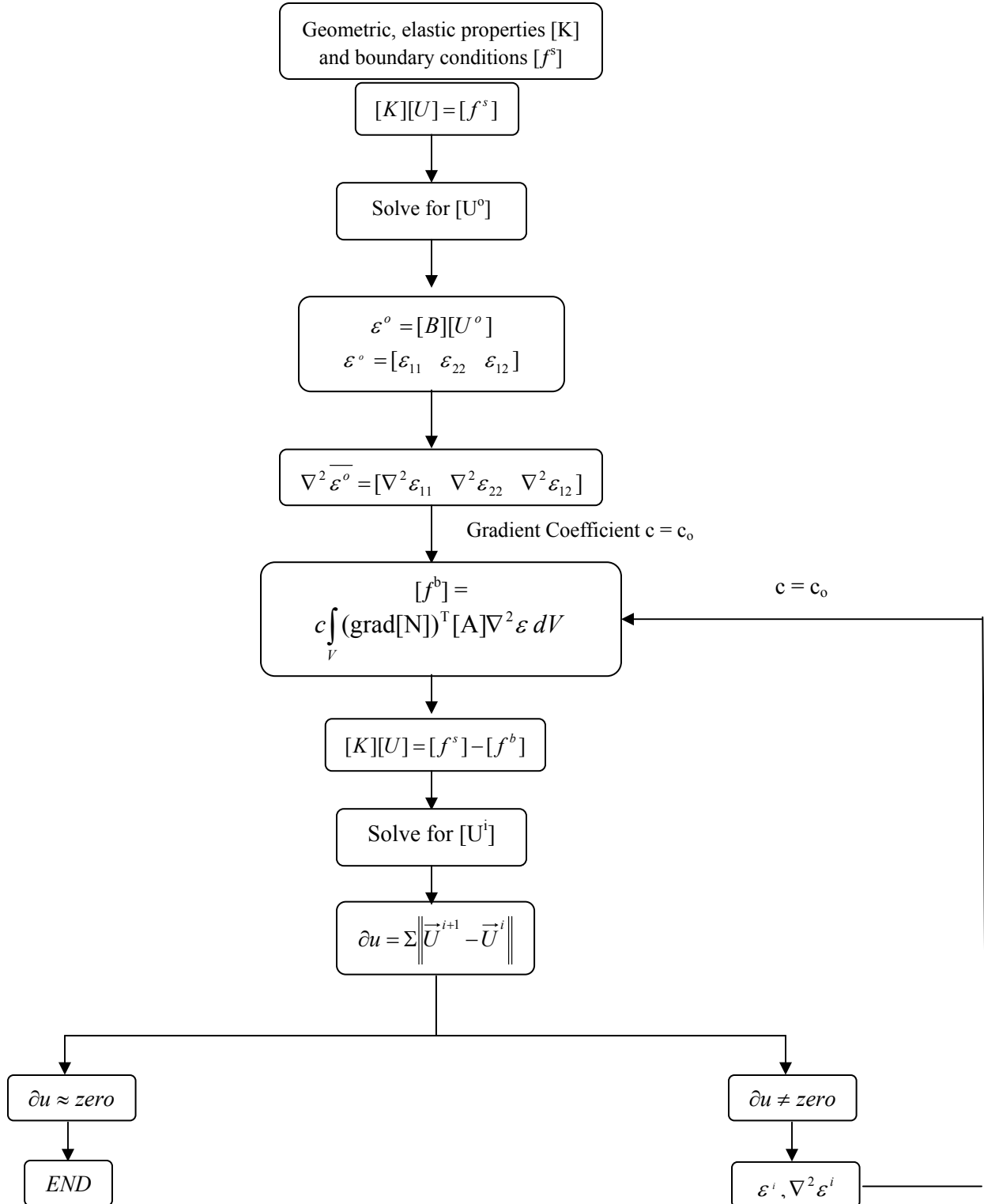
constitutive models to overcome some of the limitations of FE modeling (e.g. Aifantis 1984 & 1987 and Zbib 1992). A strain gradient theory is usually employed in order to introduce an internal length scale to the standard equations of continuum mechanics. Therefore, it is believed that using a strain gradient theory in the analysis of asphalt mix microstructure will assist in capturing the difference between mixes due to different particle and asphalt film size distributions. It also reduces the influence of the FE mesh resolution on the results.

In this study, strain gradient theory was used to capture the influence of film thickness on particle contacts. A finite element formulation of strain gradient elasticity model was implemented in the commercial package ABAQUS according to the algorithm shown in the figure below. The new finite element formulation was used to analyze idealized geometries of asphalt film between particles, and microstructure images of asphalt mixes. The results showed that gradient elasticity allows capturing the influence of binder film thickness and particle size on strain distribution. The use of strain gradient theory has also the added advantage of significantly reducing the influence of the finite element model resolution on the microscopic and macroscopic response of asphalt mixes.

Microscopic images of asphalt mixes with different particle size distribution were analyzed to calculate the strain gradient coefficient by evaluating the change in the average strain using a moving-window. In addition, the microstructure distribution was quantified using the change in percent of particles within a moving window, and the two

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point autocorrelation function. The strain gradient coefficients were related to these microstructure distribution functions.



## REFERENCES

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