Application of Asymptotic Expansion Homogenization for Vascularized Poroelastic Brain Tissue

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Abstract—Brain oedema formation after ischaemia-reperfusion has been previously modelled by assuming that the blood vessels distribution in the brain as homogeneous. However, the blood vessels in the brain have variety of sizes and this assumption should be reconsidered. One of the ways to improve this assumption is by taking into account the microstructure of the blood vessels and their distribution by formulating the model using asymptotic expansion homogenization (AEH) technique. In this paper, AEH of the vascularized poroelastic model is carried out to obtain a set of new homogenized macroscale governing equations and their associated microscale cell problems. An example of solving the microscale cell problems using a simple cubic geometry with embedded 6-branch cylinders representing brain tissue and capillaries is shown to obtain four important tensors L,Q,K, and G, which will be used to solve the homogenized macroscale equations on a larger brain geometry. This method will be extended in the future to include statistically accurate capillary distribution of brain tissue.

Index Terms—asymptotic expansion homogenization, vascularized poroelastic material, brain tissue, poroelastic theory, cell problems