Contribution ID: **485** Type: **Poster Presentation**

Stress concentration in the local load sharing fiber bundle model

Thursday, 25 May 2023 15:30 (1h 30m)

Material failure and fracture growth are phenomena that without a doubt have significant impact on industry and society alike. They dictate how long structures will last and what loads they can withstand, critical topics to consider in any engineering project. While some analytical formulations have shown partial success in describing and predicting material failure, numerical studies of Fiber Bundle Models (FBM) and Random Fuse Models (RFM) have given many interesting results, and are still frequently used in research today [1]. The fiber bundle model represents materials as a system of Hookian springs that break when critically stressed. A 2D fiber bundle is similar in structure to a cross section of a pours material, and while many explore flow through capillary fibers [2-4], others study the mechanical strength [5-6]. Global Load Sharing (GLS) is a type of fiber bundle where all the fibers in the bundle carry the same amount of load. This is similar to what would happen if a perfectly rigid material is stressed. However, if a material is flexible, the load will be focused more locally. In such a situation, Local Load Sharing (LLS) is more appropriate. To give some physical intuition of these extremes of GLS and LLS, consider eating a cake with a spoon. The cake is flexible and breaks locally around where the spoon is pushed through the cake. Compare this to what might happen if you use the spoon to try to take a piece out of a brittle cracker. There would be no spoon shaped hole in the cracker, because the stress from the spoon would not remain local, but be distributed globally. LLS has properties similar to that of a soft materials where as GLS is more similar to hard materials. Keep in mind however that soft/hard is different from elastic/brittle and that both GLS and LLS are capable of behaving elastically and brittley. The way LLS distributes load onto fibers is by grouping adjacent broken fibers in to groups called clusters. The fibers on the perimeter of each cluster are then given the load that would have been carried by the broken fibers in the cluster. This behavior leads to crack growth, as large clusters are more likely to grow even larger because their perimeters are stressed as a function of cluster size. This study explores a new way to distribute the load in the bundle that further elaborates on the idea of crack propagation. Our method, first suggested by Kjellstadli [7], is closely related to LLS but uses a non-uniform load distribution over the perimeter of clusters. LLS already has a mechanism for crack enhancement, but our method targets fibers individually as opposed to entire perimeters. We let fibers with fewer neighbours take on more load than fibers with more neighbours. Our implementation is a generalized model that contains LLS as a limit. When tuning the model away from LLS, the model produces clusters that are more solid, as opposed to the more fractal clusters commonly seen in LLS.

Participation

In-Person

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Session Classification: Poster

Track Classification: (MS12) Advances in computational and experimental poromechanics