Differences between PFT and continuum damage models

(reference Lemaitre, Bazant and Oh)

1. ~~PFT has its foundations laid on Griffith’s postulate which is based on thermodynamics arguments whereas continuum damage models (CDMs) are phenomenologically driven and the damage criterions are motivated based on micromechanics of the material.~~
2. ~~There is no rational basis for the choice of the damage tensor in CDM and there is no notion of width of the damage field. In this respect, PFT is unique due to the presence of regularization parameter $\ell$ and from the notion of $\Gamma$-convergence it has been shown that as $\ell \to 0$ the width of the damage zone shrinks to 0.~~
3. ~~In the absence of the regularization parameter, the solution obtained using CDM like many other fracture mechanics tools is dependent on the discretization size unlike PFT.~~
4. ~~PFT is derived from rigorous mathematical tools of variational calculus which guarantees uniqueness of the solution unlike CDM, which from 2~~~~nd~~ ~~law of thermodynamic can be shown to violate uniqueness.~~
5. ~~The evolution of damage in PFT is a consequence of the variational formalism and no separate evolution equations for the damage variable is required. Further, the criterion for crack initiation and propagation also arise naturally from the variational formalism.~~
6. ~~In the case of CDM a micromechanically driven damage criterion is postulated in a manner similar to that of a yield criterion in plasticity and an ad-hoc evolution law for the damage variable is also proposed.~~
7. ~~The damage criterion in CDM has ideas borrowed from plasticity theory where a damage locus and an evolution law for the damage variable is proposed similar to that of a yield locus and an evolution law for the plastic strain rate.~~

In standard local damage models, there is a local damage criterion such maximum stress criterion and damage in these models can get concentrated into bands of zero thickness. Further, the results depend on the mesh and based on mesh size one could get spurious failure modes. Further, these models can give non-unique solutions when softening occurs which can be shown from 2nd law of thermodynamics.

Differences between PFT and non-local damage models

(reference Cabot and Bazant (1987), Peerlings et al (1996))

What are non-local damage models?

The non-local damage model (NLDM) basically means that the stress or strain at a point not only depends on just the strain at the point but also strains or stress in a neighborhood.

How does damage occur?

1. Damage is a function of a history variable $Y$, and $Y$ satisfies a damage criterion akin to that of a yield condition in plasticity such as

$Y = \epsilon\_{eq}$

1. A evolution law based on the experimental details (ad-hoc) for the damage variable in terms of $Y$ is proposed.
2. The non-local term is introduced in $\epsilon\_{eq}$ by replacing it with an average term on a domain $\Omega$.
3. The average $\epsilon\_{eq}$ is developed using a weight function which decays over a length scale $\ell\_c$.

What are the advantages of NLDMS?

1. The introduction of the length scale $\ell\_c$ makes the method mesh independent.
2. The width of the damage field is controlled by $\ell\_c$.
3. These models are able to show size effects in fracture.

What are the disadvantages of NLDMS?

1. Damage initiation and growth is ad-hoc and depend on the specific constitutive model.
2. Damage initiation is hard to predict.

What are the disadvantages of gradient based NLDMS? (Peerlings et al.(1996), Pham et al, 2011)

These models the non local aspect comes from the dependence of the stress on gradients of equivalent strain or total strain. They don’t have a rigorous mathematical foundation as PFT although both the gradient and the PFT contain a gradient term related to the damage field. Further, PFT is based on Griffith’s postulate which is well acknowledged in the fracture mechanics community.