Extended scale effect analysis required for structural size and shape variation

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The scaling theory for quasi-brittle or brittle failures of structural elements has been developed in numerous papers and synthesized in booka, cf. Bazant et al [1, 2]. The analysis was limited to geometrically similar structures of different sizes D. Then the nominal stress value, defined as maximal local or averaged stress at failure decreases with growing size D. In the recent paper by Bazant [3] the review of different scaling forms dependent on strength and fracture parameters was presented. However, the analysis was limited to dependence of the nominal failure stress on the size parameter D, preserving fixed geometric shape parameters and material structure. In a real design or redesign process there is a need to vary both shape and size parameters , also connecting joints to structural or supporting elements. In the case of beam or plate structures the designer selects in-plane shape of an element, varying thickness and connection to adjacent element or support to foundation. All these parameters affect the limit load value, post critical response and also the size effect. There are two important parameters to be specified from the analysis:

1.Specification of limit state of a structural element, corresponding to the maximal load factor $\lambda_f P_0$, and of corresponding nominal stress value σ_f , relating them to varying shape parameters. This task belongs to problems of *sensitivity analysis* of limit loads with respect to shape and size parameters.

2.Specification of post-critical response and of related nominal softening modulus, including its sensitivity to geometric parameters. In fact, the analysis of post-critical response is important in view of interaction with adjacent or supporting elements. In the case of local failure of the element a dynamic mode is usually activated with the released energy transferred into the kinetic energy and activating dynamic motion of cooperating elements.

The present work illustrates determination of limit state with the related failure stress, and post-critical modulus values for the following cases;

1. Analysis of delamination process in a bi-layer plate system, with specification of limit load and its dependence on plate length and thickness, cf. Mróz et al. [4,5].The critical stress and post-critical modulus values depend essentially on plate length and thickness.
2. Numerical analysis of failure of plane notched elements under compression and tension with specification of critical stress and its dependence on geometric parameters.

3. Numerical analysis of limit states in reinforced concrete beams for varying thickness and length, cf. Syroka-Korol et al [6].

There is close relation of the limit state analysis for rigid, perfectly plastic structures to that for elastic, semi-brittle structures. The failure mode in rigid-plastic structures generates instantaneously in the intact material, but in elastic semi-brittle materials the extensive damage is generated before the ultimate failure mode is formed. This damage affects the value of limit load and of the corresponding failure stress. The concept of process zone separating fully damaged and intact states is useful in specifying the failure stress dependence on geometric parameters. The evolution of process zone length in the progressive damage process is discussed in presentation.

References.

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