



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:

Development of new displacement-based methods for the computation of notch stress intensities of sharp V-notches

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SHORT ABSTRACT

Brittle fracture assessment of engineering components or structures containing sharp V-notches is an important and evolving research area in the field of notch fracture mechanics. A large number of brittle fracture criteria have been developed based on the notch stress intensity factor (NSIF). Therefore, a great deal of effort has been put forward to develop various analytical, experimental, and numerical methods for determining the NSIFs accurately. In the case of complex configurations with complex boundary conditions, many numerical methods, particularly finite element method (FEM) based methods, have been proposed over the years. Different stress-based, displacement-based and energy-based methods have been proposed in connection with the FEM. Many factors of the FEM and of the V-notches have a serious effect on the accuracy of the computed NSIFs. An important aspect of the finite element analysis of the sharp V-notch problems is the lack of special or singular notch tip elements to model the singularity at the notch tip. As a consequence, the current practice is to use the conventional (mostly the isoparametric quadrilateral element (Q8)) elements at the notch tip as well as in the rest of the analysis domain. Moreover, due to the presence of the rigid body terms in the displacement field, unlike the crack problems, the notch opening displacement (NOD) and notch sliding displacement (NSD) are rarely used for the calculation of the NSIFs. Indeed, due to the presence of these rigid body terms, very few displacement-based methods are currently available for the determination of the NSIFs. In the present investigation, two simple, rugged, and efficient finite element displacement-based methods are proposed, which utilize the NOD and NSD to compute the pure mode I, pure mode II and mixed mode (I/II) NSIFs of two-dimensional sharp V-notched configurations subjected to arbitrary in-plane loading. In the first method, certain special properties of the notch tip Q8 elements are investigated, and as a result, an optimum point on the notch tip element is identified for the first time where the displacements are found to be more accurate. Using the NOD and NSD at this point, the NSIFs are calculated. In the second method, the NSIFs are determined using a collocation method in which the NOD and NSD quantities at the recommended collocation nodes along the notch flanks have been employed such that the formulation neatly bypasses the rigid body displacement terms. Both the methods are used to determine the NSIFs of various pure mode I, pure mode II and mixed mode (I/II) benchmark problems, and the results are compared with the available reference solutions. The results obtained using the present methods show an excellent agreement with the published results. Further, the variation of the

computed NSIFs using both the proposed method with the notch angle is in accordance with the theoretical and previous predictions. Many factors of the NSIF extraction methods, such as varied formulations, field variables sampled, location/areas of the sampling points and number of sampling points, etc., are known to affect the accuracy of the NSIFs. Furthermore, the use of the conventional elements at the notch tip in all of these methods also greatly affects the accuracy of the solution. Considering the impact of the above factors on the accuracy, to date, no comprehensive comparison of the above methods exists. Another aim of the present investigation is to conduct a comparison of the various available stress, displacement, and energy-based methods, including the two proposed displacement-based methods in order to study their performance in terms of accuracy of the computed NSIFs and the number of sampling points considered. By comparing all the methods, conclusions of practical relevance have also been provided.

