where σ_{nom} is the nominal stress* in the absence of the crack, a is the crack half-width, and b is the plate half-width (see Figure 5-18, p. 280). This equation will be accurate within 10% if $a/b \le 0.4$. Note that the stress intensity factor K is directly proportional to the applied nominal stress and proportional to the square root of the crack width. The units of K are either MPa-m$^{0.5}$ or kpsi-in$^{0.5}$.

If the crack width a is not small compared to the plate width b, and/or if the geometry of the part is more complicated than the simple cracked plate shown in Figure 5-18, then an additional factor β is needed to calculate K.

$$K = \beta \sigma_{nom} \sqrt{\pi a} \tag{5.14b}$$

5

where β is a dimensionless quantity that depends on the part's geometry, the type of loading and the ratio a / b. Its value is also affected by the manner in which σ_{nom} is calculated. It is customary to use the gross stress for σ_{nom} calculated from the original section dimensions unreduced by the crack dimensions. Using the net stress would be more accurate but is less convenient to calculate, and the difference can be accounted for in the determination of the geometry factor β. Values of β for various geometries and loadings can be found in handbooks, some of which are noted in the bibliography at the end of this chapter. For example, the value of β for the center-cracked plate of Figure 5-15a (p. 274) is

$$\beta = \sqrt{\sec\left(\frac{\pi a}{2b}\right)} \tag{5.14c}$$

This asymptotically approaches 1 for small values of a / b and is ∞ for $a / b = 1$.

For example, if the crack is at the edge rather than in the center of the plate, as shown in Figure 5-19c, the factor $\beta = 1.12$:

$$K = 1.12 \sigma_{nom} \sqrt{\pi a} \qquad a << b \tag{5.14d}$$

This equation will be accurate within 10% if $a / b \le 0.13$. This equation is also accurate within 10% for a plate cracked on both edges if $a / b \le 0.6$, and for an edge-cracked plate in bending if $a / b \le 0.4$.

Fracture Toughness K_c

As long as the stress intensity factor K is below a critical value called the **fracture toughness** K_c† (which is a property of the material) the crack can be considered to be in a *stable mode* (if the load is static *and* the environment is noncorrosive), in a *slow-growth mode* (if the load is time-varying *and* the environment is noncorrosive), or in a *fast-growth* mode (if the environment is corrosive).[13] **When K reaches K_c**, by reason of an increase in the nominal stress or by growth of the crack width, ***the crack will propagate suddenly to failure***. The rate of this unstable crack propagation can be spec-

* The nominal stress for a fracture-mechanics analysis is calculated based on the gross cross-sectional area, without any reduction for the crack area. Note that this is different from the procedure used for calculation of nominal stress when using stress-concentration factors in a regular stress analysis. Then, the net cross section is used to find the nominal stress.

† More correctly called K_{Ic} where the I refers to mode I loading. Fracture toughness values for the other modes of loading are designated K_{IIc} and K_{IIIc}. Since we are discussing only mode I loading here, it is shortened to K_c.