Step III *Calculation of dimensions of cross-section*

The resultant tensile stress $\sigma_{max.}$ at the point *A* is given by,

$$\sigma_{max.} = \sigma_b + \sigma_t = \frac{2099.28 \times 10^3}{t^3} + \frac{2165.07}{t^2} \quad \text{(ii)}$$

Equating (i) and (ii),

$$\frac{2099.28 \times 10^3}{t^3} + \frac{2165.07}{t^2} = 57.14$$

or

$$t^3 - 37.89\,t - 36739.24 = 0$$

Solving the above cubic equation by trial and error method,

$$t = 33.65 \text{ mm} \cong 35 \text{ mm}$$

The dimensions of the cross-section are 35 × 70 mm

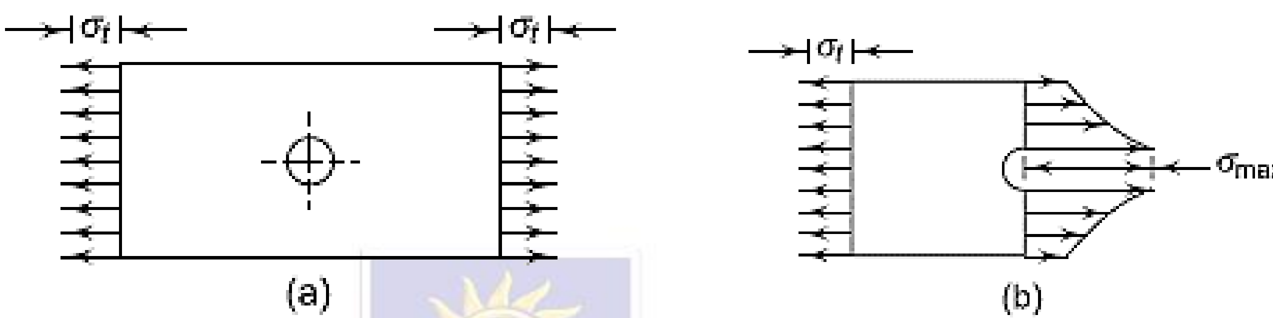
Lecture Machine Design - Design against Fluctuating Load

- STRESS CONCENTRATION
- In design of machine elements, the following three fundamental equations are used,

$$\sigma_t = \frac{P}{A}$$

$$\sigma_b = \frac{M_b y}{I}$$

$$\tau = \frac{M_t r}{J}$$



- The above equations are called elementary equations. These equations are based on a number of assumptions. One of the assumptions is that there are no discontinuities in the cross-section of the component. However, in practice, discontinuities and abrupt changes in cross-section are unavoidable due to certain features of the component such as oil holes and grooves, keyways and splines, screw threads and shoulders. Therefore, it cannot be assumed that the cross-section of the machine component is uniform. Under these circumstances, the ‘elementary’ equations do not give correct results. A plate with a small circular hole, subjected to tensile stress is shown in Fig. 5.1. The distribution of stresses near the hole can be observed by using the Photo-elasticity technique. In this method, an identical model of the plate is made of epoxy resin. The model is placed in a circular polariscope and loaded at the edges. It is observed that there is a sudden rise in the magnitude of stresses in the vicinity of the hole. The localized stresses in the neighbourhood of the hole are far greater than the stresses obtained by elementary equations.
- ***Stress concentration is defi ned as the localization of high stresses due to the irregularities present in the component and abrupt changes of the crosssection.***

- In order to consider the effect of stress concentration and fi nd out localized stresses, a factor called stress concentration factor is used. It is denoted by Kt and defi ned as,

$$K_t = \frac{\text{Highest value of actual stress near discontinuity}}{\text{Nominal stress obtained by elementary equations for minimum croos-section}}$$

or $$K_t = \frac{\sigma_{max.}}{\sigma_0} = \frac{\tau_{max.}}{\tau_0} \qquad (5.1)$$

where σ_0 and τ_o are stresses determined by elementary equations and $\sigma_{max.}$ and $\tau_{max.}$ are localized stresses at the discontinuities. The subscript t denotes the '*theoretical*' stress concentration factor. The magnitude of stress concentration factor depends upon the geometry of the component.

- The causes of stress concentration are as follows:
- (i) Variation in Properties of Materials In design of machine components, it is assumed that the material is homogeneous throughout the component. In practice, there is variation in material properties from one end to another due to the following factors:
- (a) internal cracks and fl aws like blow holes;
- (b) cavities in welds;
- (c) air holes in steel components; and
- (d) nonmetallic or foreign inclusions. These variations act as discontinuities in the component and cause stress concentration.
- (ii) Load Application Machine components are subjected to forces. These forces act either at a point or over a small area on the component. Since the area is small, the pressure at these points is excessive. This results in stress concentration. The examples of these load applications are as follows:
- (a) Contact between the meshing teeth of the driving and the driven gear
- (b) Contact between the cam and the follower
- (c) Contact between the balls and the races of ball bearing
- (d) Contact between the rail and the wheel
- (e) Contact between the crane hook and the chain In all these cases, the concentrated load is applied over a very small area resulting in stress concentration.
- (iii) Abrupt Changes in Section In order to mount gears, sprockets, pulleys and ball bearings on a transmission shaft, steps are cut on the shaft and shoulders are provided from assembly considerations. Although these features are essential, they create change of the cross-section of the shaft. This results in stress concentration at these cross-sections.
- (iv) Discontinuities in the Component Certain features of machine components such as oil holes or oil grooves, keyways and splines, and screw threads result in discontinuities in the cross-section of the component. There is stress concentration in the vicinity of these discontinuities.
- (v) Machining Scratches Machining scratches, stamp marks or inspection marks are surface irregularities, which cause stress concentration.

- REDUCTION OF STRESS CONCENTRATION

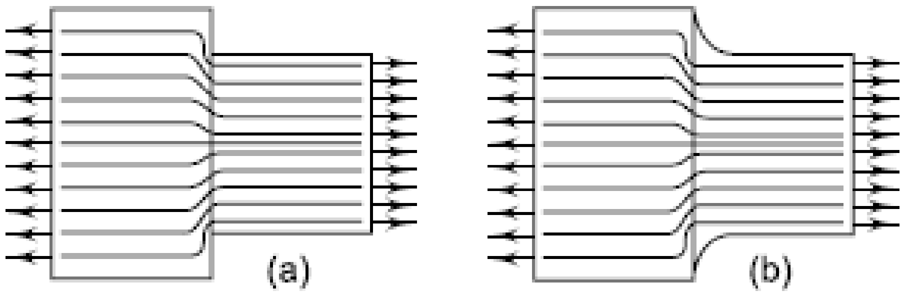


Fig. 5.8 *Force Flow Analogy: (a) Force Flow around Sharp Corner (b) Force Flow around Rounded Corner*

- In practice, reduction of stress concentration is achieved by the following methods:
- (i) Additional Notches and Holes in Tension Member
- ii) Fillet Radius, Undercutting and Notch for Member in Bending
- (iii) Drilling Additional Holes for Shaft
- (iv) Reduction of Stress Concentration in Threaded Members