las for the geometric properties *(A, I, Z)* of typical beam cross sections can be found in Appendix A and are also provided as *TKSolver* files on disk.

Curved Beams Many machine parts such as crane hooks, C-clamps, punch-press frames, etc., are loaded as beams, but are not straight. They have a radius of curvature. The first six assumptions listed above for straight beams still apply. If a beam has significant curvature, then the neutral axis will no longer be coincident with the centroidal axis and equations 4.11 do not directly apply. The neutral axis shifts toward the center of curvature by a distance e as shown in Figure 4-16.

$$e = r_c - \frac{A}{\int \frac{dA}{r}} \tag{4.12a}$$

where r_c is the radius of curvature of the centroidal axis of the curved beam, A is the cross-sectional area, and r is the radius from the beam's center of curvature to the differential area dA. Numerical evaluation of the integral can be done for complex shapes.*

The stress distribution across the section is no longer linear but is now hyperbolic, and it is greatest on the inner surface of a rectangular cross section as shown in Figure 4-16. The convention is to define a positive moment as one that tends to straighten the beam. This creates tension on the inside and compression on the outside surface from a positive applied moment and vice versa. For pure bending loads, the expressions for the maximum stresses at inner and outer surfaces of a curved beam now become:

* Expressions for this integral for many common cross-sectional shapes can be found in reference [4]. For example, for a rectangular cross section, $e = r_c - (r_o - r_i) / \text{LN}(r_o / r_i)$

$$\sigma_i = +\frac{M}{eA}\left(\frac{c_i}{r_i}\right) \tag{4.12b}$$

$$\sigma_o = -\frac{M}{eA}\left(\frac{c_o}{r_o}\right) \tag{4.12c}$$

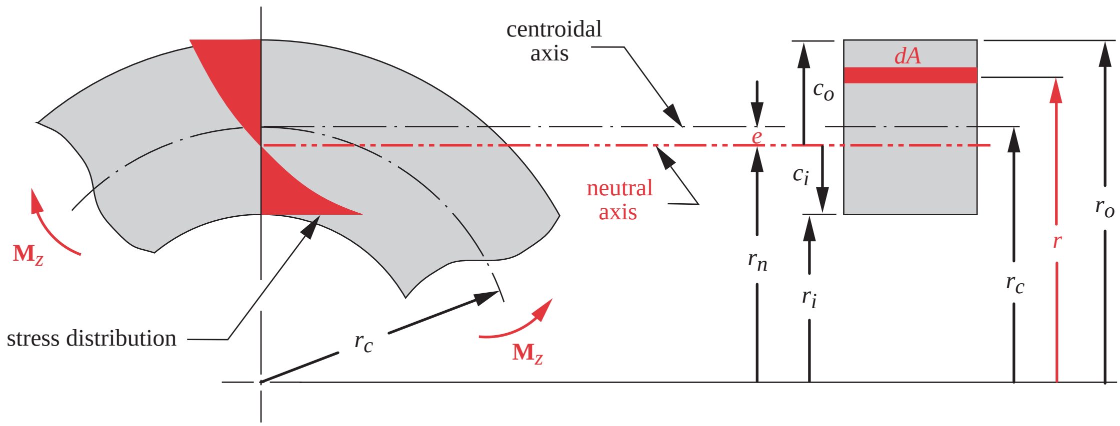

FIGURE 4-16

Segment of a Curved Beam in Pure Bending