Clearly, from the above Eq. 6.48, $\bar{\gamma}_i \mu_{X_i}$ should be on the failure surface; in particular, it may be at the most probable failure point. Thus, the required partial design factors are

$$\bar{\gamma}_i = \frac{x_i^*}{\mu_{X_i}} \tag{6.49}$$

Therefore, the determination of the required design factors is also a problem of determining the most probable failure point, x_i^* (see Section 6.2).

In the space of the reduced variates, the most probable failure point, from Eq. 6.16*a*, is

$$x_i'^* = -\alpha_i^* \beta$$

where

$$\alpha_i^* = \frac{\left(\dfrac{\partial g}{\partial X_i'}\right)_*}{\sqrt{\sum_i \left(\dfrac{\partial g}{\partial X_i'}\right)_*^2}}$$

From this we obtain the original variates as

$$x_i^* = \mu_{X_i} - \alpha_i^* \beta \sigma_{X_i} = \mu_{X_i}(1 - \alpha_i^* \beta \Omega_{X_i})$$

Therefore, the required design factors are

$$\gamma_i = 1 - \alpha_i^* \beta \Omega_{X_i} \tag{6.50}$$

In Eq. 6.50, the direction cosines, α_i^*, must be evaluated at the most probable failure point x_i^*. In general, the determination of x_i^* requires an iterative solution. For this purpose, the following simple algorithm may be used:

(1) Assume x_i^* and obtain

$$x_i'^* = \frac{x_i^* - \mu_{X_i}}{\sigma_{X_i}}$$

(2) Evaluate $(\partial g/\partial X_i')_*$ and α_i^*.
(3) Obtain $x_i^* = \mu_{X_i} - \alpha_i^* \beta \sigma_{X_i}$.
(4) Repeat Steps (1) through (3) until convergence is achieved.

The required design factors are then obtained with Eq. 6.50. Again, for nonnormal variates, μ_{X_i} and σ_{X_i} should be replaced by the equivalent normal $\mu_{X_i}^N$ and $\sigma_{X_i}^N$ of Eqs. 6.25 and 6.26 in the above algorithm.

Linear Performance Function For linear performance functions, the design factors, γ_i, are such that

$$a_o + \sum_i a_i \gamma_i \bar{x}_i = 0$$

In this case, the partial derivatives are independent of x_i, that is,

$$\frac{\partial g}{\partial X_i'} = a_i \sigma_{X_i}$$

The advantages of the multiple factor format of Eq. 6.47 are: (i) the individual factors, ϕ and γ_i, are relatively insensitive to changes in the design parameters (e.g., the load ratios between the various loads) and thus a given set of load and resistance factors should apply to a wide range of design conditions—a desirable attribute of a code provision; (ii) with the partial load and resistance factors, any other form of design factors, such as the safety factor, can be readily derived or evaluated (see Example 6.20).

6.4.2 Second-Moment Criteria

Even though a specific reliability-based design may be accomplished using the appropriate safety margin or safety factor, the design of a class of systems may require a more general form of design criteria. The most general and versatile form of criteria is to specify a design factor for each design variable. Consistent with practical situations, as described in Section 6.2.2, the necessary probability-based design criteria must often have to be developed also on the basis of the second-moment approach; that is, the required criteria have to be formulated on the basis of information for the first and second moments of the design variables.

In the space of the reduced variates, Section 6.3.2, designs at different levels of safety may be viewed as corresponding to satisfying different failure surfaces represented by varying distances to the origin, β, as shown in Fig. 6.13. Accordingly, the development of a design criterion is essentially tantamount to the determination of the design factors that will result in designs having failure surfaces that comply with a required safety index (i.e., the distance from the failure surface to the origin of the reduced variates satisfies some target value).

As indicated earlier, the most general design format is to apply a design factor on each of the basic design variables, known also as "partial factors." Without loss of generality, these factors may be applied to the respective mean values; thus,

$$g(\bar{\gamma}_1 \mu_{X_1}, \bar{\gamma}_2 \mu_{X_2}, \ldots, \bar{\gamma}_n \mu_{X_n}) = 0 \tag{6.48}$$

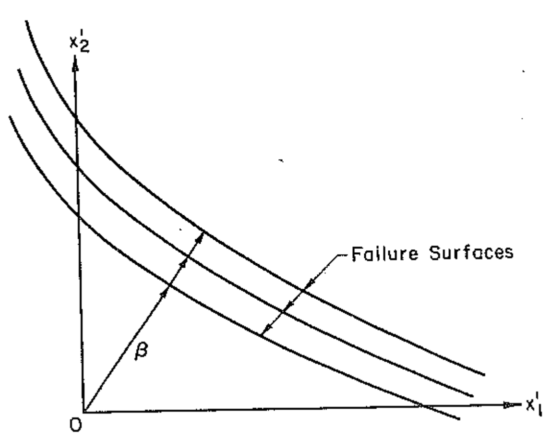

Figure 6.13 Designs corresponding to different failure surfaces.