

AS/NZS 1664.1
Supplement 1:1997

Aluminium structures

**Part 1: Limit state design—
Commentary**

**(Supplement 1 to
AS/NZS 1664.1:1997)**

AS/NZS 1664.1 Supp1:1997

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The Association of Consulting Engineers, Australia
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PREFACE

This Commentary was prepared by the Standards Australia/Standards New Zealand Committee BD/50, Aluminium Structures. It is intended to be read in conjunction with AS/NZS 1664.1, *Aluminium Structures*, Part 1: *Limit state design*, but it does not form an integral part of that Standard.

This Commentary is not intended to provide a general primer to probability-based limit state design (LSD) criteria. This is provided in Reference 2 and in the further references which are cross-referenced numerically in the text and listed at the end of this document.

The objective of this Commentary is to give an explanation of the reasons for the recommended capacity factors in AS/NZS 1664.1 and to provide background material to the requirements of that Standard.

The clause numbers and titles used in this Commentary are the same as those in AS/NZS 1664.1 except that they are prefixed by the letter C.

Gaps in the numerical sequence of this Commentary's clause numbering means that no explanation of or background to the missing clause(s) is necessary.

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SECTION C1 GENERAL

C1.4 REFERENCED DOCUMENTS The Standards listed in Clause 1.4 are subject to revision from time to time. A check should be made with Standards Australia or Standards New Zealand, as appropriate, as to the currency of any document referenced in the text.

SECTION C3 GENERAL DESIGN RULES

INTRODUCTION The general procedure of applying the limit state design (LSD) method for aluminium building structures consists of the following steps:

- (a) Determine the stress due to the factored loads, f , by conventional elastic structural analysis. The factored loads are the specified dead, live, wind, rain, snow or earthquake loads multiplied by the load factors given in Clause 2.4.
- (b) Compute the factored limit state stress ϕF_L from Clause 3.4 and verify that—

$$\phi F_L \geq f$$

Clause 3.4 gives the capacity factor ϕ and the limit state stress F_L for a variety of commonly encountered aluminium structural members and elements. The limit state stress F_L is dependent on the material properties and the member geometry. It reflects the ultimate load-carrying capacity of the member or element, be that yield, fracture, plastification, buckling or crippling. The limit state stresses in these LSD criteria are identical to those given in AS/NZS 1664.2 by setting the factors of safety equal to unity in the various formulas given in Clause 3.4 of AS/NZS 1664.2.

The capacity factor ϕ accounts for the uncertainties of determining the limit state stress. It is computed by the method of first-order second-moment probabilistic analysis presented in Reference 2 for a target reliability index of $\beta_T = 2.5$ for the yield limit state and $\beta_T = 3.0$ for the fracture limit state. Below is a detailed account presenting the background for each of the capacity factors used in Clause 3.4 of the LSD criteria.

Prior to this detailed account it will be instructive to discuss in a simple manner the basic concepts of probabilistic design. Failure is defined when the resistance, as characterized by a limit state, is less than or equal to the load effect on the structural element. The load effect in these LSD criteria for aluminium structures is characterized by the stress computed by elastic analysis from the forces acting on the structure. Both the resistance R and the load effect Q are random quantities (see Figure C1).

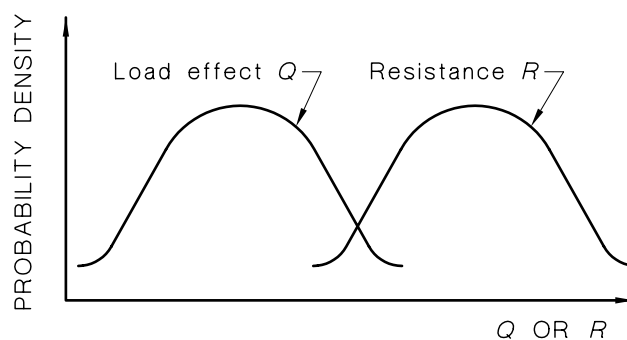


FIGURE C1 SCHEMATIC REPRESENTATION OF PROBABILITIES OF THE LOAD EFFECT AND THE RESISTANCE

Limit states are either ultimate or serviceability limit states. These LSD criteria pertain to the ultimate limit states of yield, fracture, plastification, buckling and crippling, although the serviceability limit states of deflection and the appearance of buckling are also features (see Section 4).

Failure is then not necessarily the total collapse of the member, but the reaching of a practically defined ultimate limit state. It occurs when $R < Q$. Alternatively, failure also is defined as in $\ln(R/Q) \leq 0$, as shown in Figure C2. The probability of exceeding a limit state is the shaded area. According to current practice, it is not necessary to define a desired probability of failure, but a 'reliability index' β is determined such that the 'target reliability index' β_T for a new code is approximately equal to the value of β inherent in the traditional specification for standard design situations (Ref. 2). This process of selecting a target reliability index is called 'code calibration'. It will be illustrated for the simple case of tension members.

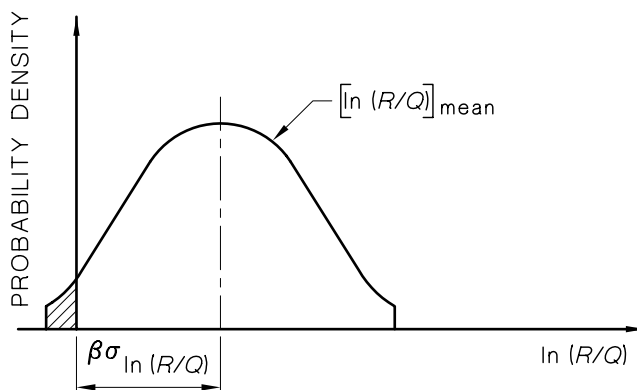


FIGURE C2 DEFINITION OF THE RELIABILITY INDEX β

According to first-order statistical derivations, the value of β from Figure C2 is expressed by the following formula:

$$\beta = \frac{\ln(\bar{R}/\bar{Q})}{\sqrt{V_R^2 + V_Q^2}} \quad \dots \text{C3(1)}$$

In this equation $\bar{R}$ and $\bar{Q}$ are the mean values of the resistance R and the load effects Q , respectively, and V_R and V_Q are the corresponding coefficients of variation.

The resistance of a tension member for the limit state of yielding is—

$$R = A F_{ty} \quad \dots \text{C3(2)}$$

and thus

$$\bar{R} = \bar{A} \bar{F}_{ty} \quad \dots \text{C3(3)}$$

and

$$V_R = \sqrt{V_A^2 + V_{F_{ty}}^2} \quad \dots \text{C3(4)}$$

The available data on dimensions and yield stress of aluminium structures were evaluated in Reference 3, and the following conservative estimates of the statistical properties were suggested:

$$\bar{F}_{ty} = 1.10 F_{ty}, \quad V_{F_{ty}} = 0.06, \quad \bar{A} = A_n, \quad V_A = 0.05$$