AUSTRALIAN STEEL INSTITUTE

AS 4100 DS02

Steel Structures – Lower tier analysis

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LOWER TIER ANALYSIS OF STEEL STRUCTURES

Introduction

AS 4100 provides designers with several tiers of methods of structural analysis. The more accurate computer methods of the higher tiers can be applied to a wide range of steel structures, including ones with complex geometry and unusual loadings. For these structures, the computer methods can provide accurate assessments of the member actions which are not possible by hand analysis, and can lead to more economic structures.

The lowest tier of AS 4100 also provides designers with simpler methods which can be used for virtually all practical structures, with the main exceptions being some extremely flexible structures which often fail serviceability criteria. The lowest tier is based on the traditional first-order methods of analysis, with some amplification of the computed bending moments in structures with significant instability effects.

In many cases, amplification of the first-order bending moments is not required. Examples include beams, tension members and triangulated structures with joint loads only, and many braced compression members with non-uniform bending moment distributions.

Determinate structures

Determinate structures are ones that have sufficient frictionless hinges (real or assumed) to allow the reactions and joint forces to be determined by equilibrium considerations alone. Examples are simply supported beams, articulated beams, three-pin portals, braced rectangular frames with simple beam to column connections, and triangulated structures with joint forces only.

First-order analysis. For this analysis, the second-order effects caused by the deflections are ignored.

Second-order effects. In certain cases, individual members of a determinate structure have to transmit both bending and compression actions, as in the case of eccentrically loaded compression members. For these members, an estimate of the second-order moments caused by the products of the compressions and the deflections may be made by using moment amplification (see Section 4 of AS 4100). Second-order moments may be significant in members with high compression and bending moment, and small in members with highly non-uniform moment distributions.

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Indeterminate Structures—First order analysis

Elastic analysis of statically indeterminate structures has formed a central part of the education of structural engineers for many years, with many different hand methods such as moment area, slope deflection, moment distribution, virtual work and others discussed in standard textbooks. However, the difficulty and high probability of error of these have rendered them unsuitable for the manual analysis of all but the simplest of structures. Instead, designers have often relied on available solutions in handbooks, despite their limited scope.

Plastic analysis

The method of plastic analysis avoids the analysis of an indeterminate structure since the plastic mechanism converts it into a determinate structure. This method relies on the structure having sufficient ductility to allow moment redistribution to take place from the elastic distribution to the plastic mechanism distribution. This ductility requirement effectively limits the application of plastic analysis to structures composed of compact sections (no premature local buckling) and with sufficient lateral bracing (to prevent premature lateral buckling).

Approximate analysis

An alternative manual method of analysis is provided by an approximate method which converts the structure into a statically determinate one by assuming the locations of a sufficient number of inflection points (of zero amount), which can then be analysed using equilibrium considerations alone. Such a method relies on a combination of the skill of the analyst in assessing the inflection point locations, and the ductility of the structure in allowing any moment redistribution to take place. This method is equivalent to the lower bound method of plastic analysis, and should therefore only be used for structures whose ductility is ensured by the use of compact sections and sufficient lateral bracing to prevent premature failure before the required redistribution can take place.

Computer methods of elastic analysis

The time consuming and error-prone nature of manual analysis for all but the simplest statically indeterminate structures has led to the widespread use of computer programs for the first-order elastic analysis of indeterminate structures. Computer methods will become more generally used as more engineers are trained in their use, and as computer hardware becomes more affordable and more powerful.

Second-order effects

Second-order moment effects may be caused in flexural frames by instability effects which result in additional moments $N^*\delta$ and $N^*\Delta$ arising from the products of axial compression forces N^* and the member and frame deflections δ and Δ. Second-order effects become more important in frames using high strength members, and in frames for which more advanced design techniques lead to lighter and more economical members.

Second-order effects may be significant when both the moments and compression forces are substantial. Second-order effects are small in the members of braced frames which have highly non-uniform moment distributions.

The determination of second-order moment effects by the method of moment amplification is discussed in the next limit states data sheet.