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Modelling of Steel Structures

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Abstract

This document gives guidance on the creation of computer models for steel structures with orthodox details and connections in order to produce safe, cost effective, real structures. It is primarily aimed at structural engineers using readily available analysis software. It highlights the importance of a qualitative understanding of structural response both during the creation of the analysis model and whilst appraising the analysis output. After a general introduction to the elastic, plastic and elastic-plastic analysis of two and three dimensional frames, separate chapters address the modeling of: Simple beam and column frames, Trusses and lattice girders, Portal frames, Curved, tapered and non-homogeneous members, Connections, Supports and Loads. It also provides guidance on simple checks to ensure the analysis is correct and an overview of member design for the less experienced designer. This document is limited to the modeling of general building and plant structures of normal proportions under static loading. Offshore structures, masts, bridges, shells and plates are not covered, nor is grillage analysis. The guide concentrates on first order analysis programs. Second order analysis is discussed, but both the analysis and the type of structure requiring second order analysis are outside the scope of this document. The fabrication industry reports increasing incidences of designs that are overly complex, resulting in expensive fabrication details and a loss of cost effectiveness. In some cases designs have been presented which do not represent reality.

Keywords: *Steel Structures, Buckling, Serviceability Checks.*

1. Introduction

Steel offers the various advantages to the construction Industry. The versatility of steel gives architects the freedom to achieve their most ambitious visions. Structural steel is an essential component of stadiums, shopping centers and commercial developments. Steel is also one of the most sustainable construction materials, building owners naturally value the flexibility of steel buildings and the value benefits they provide. Steel is ideal for modernization, reconfiguring, extending or adapting with minimal disruption.

The design of steel structures involves the planning of the structure for specific purposes, proportioning of members to carry loads in the most economical manner, and considerations for erection at site. First, the structure should serve the purpose for which it is intended and this is achieved by proper functional planning. Secondly it should have adequate strength to withstand direct and induced forces to which it may be subjected during its life span. An inadequate assessment of forces and their effects on the structure may lead to excessive deformation and its failure. Therefore, the design of the structures includes functional planning, acknowledge of the various forces, strength of materials and the design methods. In addition the structure should be economical and easy to erect.

An economical structure requires an efficient use of steel and skilled and unskilled labour. Although this objective can usually be accomplished by a design that requires a minimum amount of steel, savings can often be realized by using more steel if it results in a simpler structural form with less fabrication. In fact, as of today, materials accounts for one third or less of the cost of a typical steel structure, whereas labour costs can account for 60 per cent or more.

2. Restraint to Buckling

If a facility to restrain a member is provided, it is likely that the program considers the restraints effective in all load cases. In reality, this is unlikely. Consider a simply supported rafter subject to both gravity load and uplift load cases: all purlins provide restraint in the gravity load case, but only those with stays to the bottom flange do so in the uplift case. Two separate design runs may therefore be necessary to check both cases, with different restraint conditions. The nature of the restraint assumed by the module must be investigated. Some restraints (for example the bottom flange restraint of a portal rafter) restrain against buckling in the y-y direction and against lateral torsional buckling. Buckling about the x-x axis is not affected. The introduction of a restraint may assume by default an effective restraint against lateral torsional buckling, and buckling in both axes. Programs usually have the option to re-introduce the correct buckling length in the appropriate direction.

3. Serviceability Checks

Default deflection checks are likely to be included, which may need revision. In most general analysis and design software, beams and columns will be checked for deflection within their own length; only cantilevers will be checked at the tip. The structural designer may be tempted to use this facility when checking the sway of the frame, expecting that the deflection quoted for the column will be the deflection measured at the column top. The quoted deflection is likely to be that calculated within the length of the column.

It may be convenient to reclassify the columns as cantilevers in order to apply the correct checks, or in order to base the member design on the deflection of the column top. For manual checking, displacements at nodes will generally be quoted as global displacements, and not relative to particular elements in the model.

Caution must also be exercised when checking deflection of a series of elements connected longitudinally, for example in a truss chord. The quoted deflection may well be of an individual element between nodes; the actual joint deflections from the analysis output must be considered in order to check the overall deflection. Some programs have a facility to check the overall deflection by identifying the elements to consider as one single member.

The deflections resulting from the analysis will be based on the initial section properties, and whilst the design module may perform a pro-rata adjustment when calculating the deflection, a re-analysis with the chosen sections will be beneficial if the deflections are close to the allowable limit. This may be particularly significant in rigid frames, where re-sizing the elements will affect the distribution of moments and the deflection of the structure.

4. Effective Lengths

These will usually be given a default value in the x-x and y-y directions to be modified by the structural designer. The effective lengths assumed by the program will be based on the length of the element. Considering a truss for an example, the effective length of the top (compression boom) may be related to the node positions in one direction, and the purlin positions in the other. More importantly the bottom boom in reversal is likely to have an effective length between restraint positions, usually considerably more than the distance between nodes. The structural designer must therefore review and amend as necessary the effective lengths assumed by the program. The introduction of restraints within the length of an element requires a similar review of the revised effective lengths in each direction.

5. Minimum Weight

Many design programs have a minimum weight design option, which produces the lightest section satisfying code requirements. This is a useful option, and saves the trial design of different sections, and certainly there is no value in providing excessive capacity compared to the imposed forces and moment. However, it must be appreciated that a least weight solution is generally not the cheapest solution overall.

As a minimum weight solution is approached, fabrication costs increase dramatically, mainly due to the need for local stiffening at the connections. Fabrication costs also increase as standardization and repetition decrease. In addition to local stiffening, a least weight solution can lead to members which become increasingly impractical to connect, simply due to physical size. As a general guide, members with flanges too narrow for 20 mm bolts should be avoided. Connections to the webs of flanges. This can cause difficulty on site, due to the congestion in the connection area, in addition to the necessity to notch the members connected to the web. Section sizes should be rationalized where possible. In particular, the same steel section should be chosen for each element of a member (for example a truss chord).

6. Conclusions

Most common steelwork structures may be satisfactorily analyzed as two dimensional models. Exceptions include some plant structures and structures designed to span in two directions such as space trusses.

Two-dimensional modeling is generally recommended as:

- It is simpler than three-dimensional modeling.
- Model frames are generally duplicated in reality, giving economy in analysis and design effort, and rationalization and repetition in fabrication.
- Connections to out-of-plane members are nominal pins wherever possible, avoiding complex and stiffened connections.
- Most standard profiles are intended primarily for bending about one axis.

References

[1] Standing Committee On Structural Safety Tenth Report SET0 Ltd, 1994
[2] CIM steel Design for manufacture guidelines The Steel Construction Institute, 1995
[3] NERVI, P. L. Structures W. Dodge Corporation, 1956
[4] BROHN, D. M., COWAN, J. Teaching towards an improved understanding of structural behaviour The Structural Engineer, Vol. 55, No 1, 1977
[5] BROHN, D. M., COWAN, J. Discussion on the paper ‘Teaching towards an improved understanding of structural behavior, the Structural Engineer, Vol. 55, No 11, 1977