CHAPTER 4: DESIGN

4.1 DESIGN PRINCIPLES

The design process is guided by the following general principles:

- Steel sheds and garages should be designed by competent engineering practitioners to current Australian codes and standards using limit states design principles.
- Actions and action combinations should be in accordance with AS/NZS 1170 series.
- Design of cold formed steel components should be in accordance with AS/NZS 4600.
- Design of other steel components should be in accordance with AS 4100 or AS 1163.
- Sheds and garages should always be fit for the stated purpose(s) for which they are designed or offered for sale and be constructed from materials that are fit for the purpose for which they are intended as required by the NCC.
- Design details should be documented to a level that can reasonably ensure satisfactory construction to meet structural design objectives.
- Design assumptions and limitations such as site conditions, soil types, drainage, flood datum level, etc should be clearly explained in documentation.
- Any restrictions on future building use or alteration should be communicated in design documentation and reiterated in sales literature and training.
- The design process assumes the selection, installation and maintenance of appropriately durable materials for all buildings designed using this Design Guide.

4.2 SECTION AND MEMBER DESIGN

STRUCTURAL MEMBER DESIGN

Section properties

Member design relies heavily on the correct use of section properties and these values must be determined accurately before member design can be completed correctly. Steel building products suppliers can provide a detailed list of full section properties for their available sections. The designer needs to have good reason to vary from using these published section properties. The section properties from one manufacturer to another will vary for seemingly similar sections. These variances can be significant and designers should be careful to ensure equivalence when using section properties from one manufacturer when the end product is being purchased from another – especially when differences in section stiffeners are present.

Section properties should be calculated in accordance with AS/NZS 4600 Section 2 or AS 4100 as appropriate. The conventional method is to split the section into smaller simpler elements and sum the properties of each of these elements together in the appropriate manner. This method is known as the 'linear' or 'midline' method.

The most important consideration when using section properties in cold formed steel design is the appropriate use of either effective section properties or full section properties (gross section properties). Full section properties are those properties of the full unreduced section with no allowance made for localised buckling once the member is subjected to stresses due to design forces. The full section properties are greater than the effective section properties.

Full section properties are used for the determination of buckling moments or stresses. Effective section properties are used for the determination of section and member capacities, as specified in AS/NZS 4600. When determining the deflections in order to perform serviceability checks, it is recommended that a closer approximation to the actual effective section properties be used. This could be completed through using an iterative process. Alternatively, it is considered acceptable to use the average between the full and effective section properties to derive these deflections. This is recommended as the difference in the deflections when using the full and effective section properties can possibly be significant, whereas the difference in the bending moments and stresses is unlikely to be as this is more related to the relative stiffness of individual members.

Accurate effective section properties are required for a number of checks on member and section capacity. Effective section properties are the properties of a section under certain levels of stress. When a section is stressed certain elements in the section can suffer localised buckling and hence become ineffective in supporting the desired stresses. This does not constitute section failure but simply indicates that this part of the section is no longer effective in resisting loads and needs to be taken out of the full section properties creating the effective section properties. At a level of zero stress the effective section properties are equal to the full section properties.

It is common industry practice to use the effective section properties of the section at yield stress in the outer fibre of the section, but it is allowable to increase the effective section properties used if this is not the actual level of stress. These increased effective section properties would need to be calculated on an individual basis as interpolation between zero stress and yield stress in the outer fibre of the section is a very inaccurate method of determining effective section properties at varying stress levels. Calculation of effective section properties is complex and should be completed in accordance with AS/NZS 4600 Section 2 taking into account the effective widths of each element in the section. A good reference for this design procedure is the *Design of cold formed steel structures* by G.J. Hancock 4th edition, Australian Steel Institute, 2007.

There are a number of commercially available software packages that can be used to calculate section properties. However the user should ensure that they have adequate knowledge and understanding of the process used by the software, underlying assumptions and the results produced before using relying on such systems.

It is common industry practice to combine two C sections in a web to web (back to back) configuration in order to produce a single stronger I type section. In this case it is not acceptable to simply multiply the section properties of the single section by two, but instead the section properties should be recalculated as this is now a doubly symmetric section. The method of fixing the sections together will affect the section properties, and it should also be noted that the l/t ratio of the web does not increase. Hence an increase in the effective section properties cannot be attained through this method because both webs can still independently suffer localised buckling. It is also a requirement of AS/NZS 4600 that such built up structural assemblies comply with Section 4. This includes cover sheets and stiffeners used to increase section capacity.

Effective lengths of members

The design of structural members, for various forms of buckling, requires the determination of accurate effective length values for the members in question – the design of cold formed steel sections used in steel shed design is no different.

The determination of effective lengths normally involves the use of an effective length factor (k). This factor takes into account the influence of the end restraints of the member (or sections of the member) against rotation and translation. Information regarding the idealised theoretical k values can be found in Section C3.4E (Table C3.4) of the commentary of AS/NZS 4600.

The designer must adequately assess each member to determine the appropriate value of the effective length factor (k) and the resulting effective length of the member, for all three axes x, y and z (or the rotational/twisting axis). The designer should be able to justify the values used for each of these separate axes.

The determination of the effective lengths in a standard shed portal frame incorporating knee and apex braces can be quite complex and onerous. One method is the completion of an elastic buckling analysis.

The forces present within members also need to be considered when calculating the effective lengths of certain sections of the particular members. Hence effective lengths of members can vary depending on the member design check being performed and the load case applicable on the frame. It may not be appropriate to set the effective length values and use them for the entire member design for a range of applicable load cases. An example of this is the compressive load check performed on the column in a standard shed portal frame. Under uplift loading, the compressive section of the column is generally the short length from the knee brace connection point to the haunch point, hence the effective length for the compression check is this length multiplied by an appropriate value for k. A different situation applies when the lower section of the column is in compression, when the base fixity is an important consideration in determining the value of k.

As a guide, appropriate values for effective lengths are shown in Table 17.

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