Residential Applications of Cold-formed Structural Members in Australia

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SUMMARY

The design of steel framed houses in Australia is governed by a range of Australian Standards covering materials, structural design and performance and loading. The paper describes these standards and their applicability. Innovative building systems using high strength steel have recently been introduced into the residential construction market in Australia. A brief description of the members used in these systems is provided. The National Association of Steel Framed Housing (NASH) promotes the use of steel in homes and provides educational material to assist builders, suppliers, teachers and students.

1.0 Introduction

Steel framed housing construction had its beginnings in Australia in the 1940s because of a shortage of timber building materials. In 1982, the National Association of Steel-framed Housing (NASH) was formed to promote the use of steel in residential construction. Today, approximately 12% of new houses are constructed using steel framing, which translates to 40,000 homes per year.

Cold-formed light gauge steel sections are used in roof trusses, rafters, wall framing and floor systems. Until recently, most steel framed houses were manufactured from G500 cold-rolled steel (72.5 ksi yield point) in the thickness range 1.0 - 1.2 mm (0.04 - 0.05 in). The sections were normally fairly simple with plain unlipped and lipped channels predominating. Simple Z-sections were also used for rafter members in trusses. The G500 sections were most frequently welded although "tab-in-slot", bolting and self-drilling fasteners were commonly used. More recently, G550 cold-reduced steel (80 ksi yield point) in the thickness range 0.48 - 0.75 mm (0.02 - 0.03 in) has been used.. The thickness of these sections allows simpler connections but requires more complex shapes to overcome buckling and twisting problems. However, connection is easier with a variety of bolted screwed, and clinched systems being used. Nailing is also possible into the thinner sections of high strength steel.

This paper describes briefly the standards and specifications that cover the design of steel framed houses in Australia. A brief description of some of the more recent sections in the G550 material is also provided.

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2.0 Standards and Specifications

2.1 Materials

The majority of steel framed housing members and connections are constructed from steel to AS 1397-1993 Steel Sheet and Strip - Hot-Dipped Zinc-Coated or Aluminium/Zinc Coated. These steels typically have a designation of the form G550 where the G indicates that mechanical properties have been achieved by in-line heat treatment prior to hot dipping in zinc or aluminium/zinc. The numeral (eg 550) indicates the yield point in MPa. The two most common steels are G500 with a yield point of 500 MPa (72.5 ksi), a tensile strength of 520 MPa (75.4 ksi), and an elongation on a 50 mm (2 in) gauge length of 8 percent, and G550 with the yield and tensile strength of 550 MPa (80 ksi), and a minimum elongation of 2 percent on a 50 mm gauge length.

2.2 Design Standards

The Australian Standard AS 3623-1993 "Domestic Metal Framing" sets out the performance requirements, in terms of structural adequacy and serviceability, for the framing of buildings up to two storeys in height and roof pitches of up to 35 degrees. Alternative methods of assessing structural adequacy using either permissible stress or limit state design methods are provided in Sections 2 and 3 respectively. Section 4 sets out the minimum loads, load combinations and corresponding design criteria which shall be considered for serviceability requirements. In the case of floor systems, both static and dynamic serviceability requirements are given. The dynamic requirements are based on the work of Ohlsen (Ref. 4). Under the application of a static concentrated load anywhere on the floor, the floor deflection should not exceed 2.0 mm (0.08 in). Under the application of a unit impulse of 1.0 N-s anywhere on the floor, the maximum impact velocity is limited to a value which depends on the lowest natural frequency of the floor system and the modal damping which may be assumed to be 0.9% unless other values are proved to be more appropriate. The criteria were established from the response to floors that are already in use and found to be satisfactory. The computation of the floor response should take into account the joists, flooring boards and the interaction of joists and flooring boards in a grid system. The computation method is limited to floor systems with a frequency greater than 8 Hz.

Dead or live loads, snow loads and earthquake loads should be considered according to Australian Standards AS 1170.1, AS 1170.3 and AS 1170.4 respectively. The specified wind loads are in accordance with AS 4055 "Wind Loads for Housing", rather than the Wind Loading Standard AS 1170.2 which is used for general structural design.

Permissible stress design should be performed to Australian Standard AS 1538-1988 "Cold-Formed Steel Structures Code" which is explained in Hancock (Ref. 3). This standard is similar to the 1980 and 1986 editions of the AISI Specification for Cold-Formed Steel Structural Members. Limit states design will soon be performed to the joint Australian/New Zealand limit states design standard currently in draft form as DR 95246 (Ref. 5). This standard is very similar to the 1991 AISI-LRFD specification except that it permits the use of high strength steels described in Section 2.1 above. In the case of G550 steel less than 0.9 mm (0.035 in) thick, the yield stress and tensile strength are limited to 75% of 550 MPa.

As an alternative to calculation according to the appropriate Australian Standards, load testing of steel frames is permitted in Section 5.2 of AS 3623. The test loads shall be equal to the design loads for the relevant strength or serviceability requirements, multiplied by the appropriate factor given in Table 5.1 of the standard which is reproduced in Table 1 of this paper. The factors in the table allow for the number of units tested and the coefficient of variation of the structural characteristics. For example, for 3 tests and a coefficient of variation of 10%, the factor is 1.33. For cyclonic areas, a fatigue loading sequence involving 1000 cycles for roof and wall structures, and 10,000 cycles for cladding is given in Section 5.2.5 of AS 3623.

At the present time, a "Model Housing Performance Standard" is being developed by the Australian Building Codes Board as part of the Housing Code of Australia. This standard is a performance based standard similar to AS 3623 except that it applies to all materials and not just cold-formed steel. It applies to dwellings not exceeding 3 storeys. Performance levels are specified in relation to annual probability of occurrence. For a specific design, performance level is to be specified by the user. In general, 4 performance levels are available ranging from an annual probability of exceedance of 1/50 to 1/1000.

3.0 Innovative Building Systems

A new generation house framing system has been developed by BHP Building Products under the name SUPRAFRAME. The system consists of two major components, the wall framing called SUPRAFRAME and the roof framing called SUPRATRUSS. The wall framing system uses a lipped channel with a dovetail stiffener in the web for convenient connection of accessories. The stud sections are normally constructed from 0.6 mm galvanised G550 material. The frame sections are fastened together with the QUIKLOK clinching system.

The roof truss system uses a unique hollow flange chord member in G550 steel of thickness 0.6 mm. A section of the chord member is shown in Fig. 1. The closed sections are formed by clinching along the overlap sections along the web at 25 mm intervals. The three dimensional stiffness of the trusses was demonstrated in a three dimensional analysis accounting for torsion of the closed flanges of the chord sections (Ref. 1). The torsional stiffness of the chord sections was found to be a function of the clinching spacing and was proven by testing in a torsion testing machine (Ref. 2). An elevation of a complete truss is shown in Fig. 2. The web members consist of simple lipped channels and the tiling battens are a hat section, all in G550 steel. The web members are connected to the chords by bolting, and the tiling battens are either nailed or screwed to the tubular top flange of the chord shown in Fig. 1. The stiffener in the flange of the chord is deliberately eccentric to permit easy nailing and screwing of the tiling battens. The small tubular bottom flange permits the web members of the truss to be attached directly to the web of the chord members without interference.

4.0 Education and Training

The National Association of Steel Framed Housing (NASH) has produced education and training materials for construction of steel framed houses. The material consists of:

1. Trainers Syllabus and Assessment Manuals for Teachers

2. Training Resource Kit for students and suppliers

3. Training Videos for floor, wall and roof framing

Manufacturers also produce manuals for their products.

5.0 Conclusions

Design standards and specifications are available in Australia to provide steel framed houses which are both serviceable and have adequate strength. The standards are performance based and allow either testing or computation as a means of compliance. There is a recent trend towards the use of higher strength steel and thinner sections with 0.6 mm (0.023 in) thick steel of stress grade 550 MPa (80 ksi) being most common.

Innovative structural members and systems are being developed and marketed to take account of the reduced weight and ease of fixing of the thinner sections. Training materials are being developed and promoted by the National Association of Steel Framed Housing to assist in the acceptance of steel frames by house builders.

6.0 Acknowledgments

Permission to publish material on the SUPRAFRAME by Mr Cam Seccombe of BHP Building Products is appreciated.

7.0 References

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4. Ohlsen, "Floor Vibration - A Serviceability Problem", Proceedings, Australasian Structural Engineering Conference, Institution of Engineers, Australia, Sydney, September 1994.

5. Standards Australia/Standards New Zealand, "Cold-Formed Steel Structures" (Revision of AS 1538-1988), DR 95246, June 1995.

No of units to be tested	Coefficient of variation of structural characteristics					
	5%	**10%**	**15%**	**20%**	**25%**	**30%**
1	1.20	1.46	1.79	2.21	2.75	3.45
2	1.17	1.38	1.64	1.96	2.36	2.86
3	1.15	1.33	1.56	1.83	2.16	2.56
4	1.14	1.30	1.50	1.74	2.03	2.37
5	1.13	1.28	1.46	1.67	1.93	2.23
10	1.10	1.21	1.34	1.49	1.66	1.85
100	1.00	1.00	1.00	1.00	1.00	1.00

Table 1: Factors to Allow for Variability of Structural Units

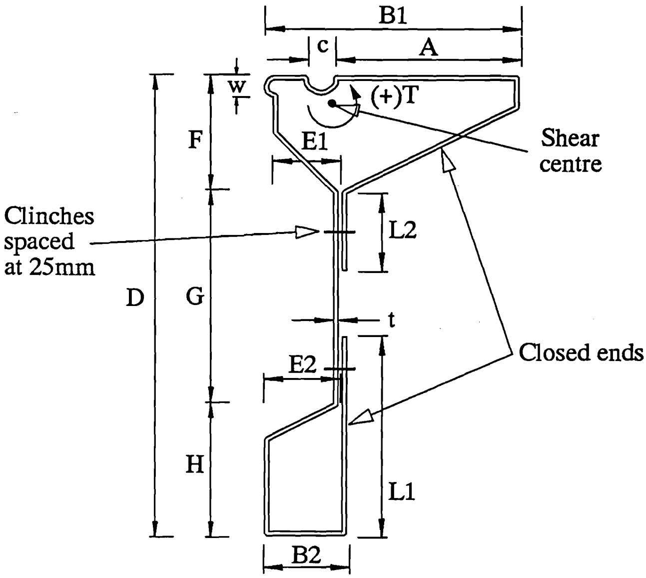

Fig. 1: SUPRATRUSS Chord Section

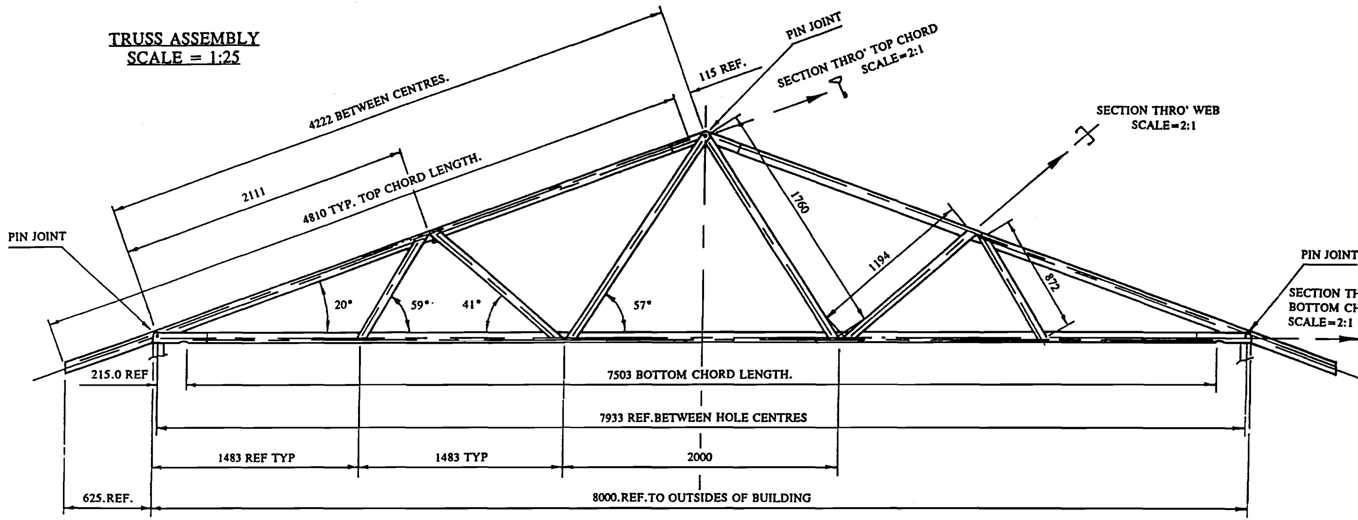

Fig. 2: SUPRATRUSS Elevation