Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 69 (1993)

Artikel: Australian performance standard for domestic metal framing
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DOI: https://doi.org/10.5169/seals-52550

Australian Performance Standard for Domestic Metal Framing

Normes de qualité australiennes pour des bâtiments à ossature métallique

Australische Güteanforderungen an Stahlskelettwohnbauten

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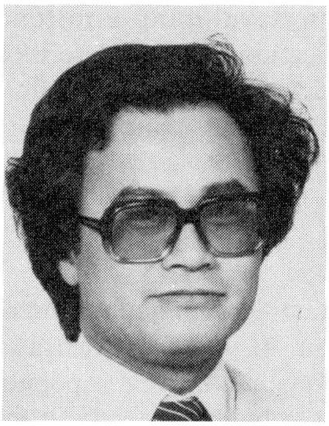

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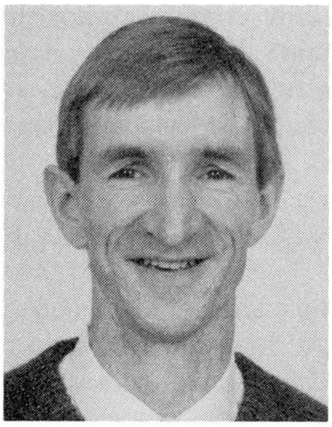

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SUMMARY

This paper presents the background of the serviceability requirements of the Australian Standard on Domestic Metal Framing. This is the first Australian structural performance standard to include serviceability as part of the mandatory requirements. The difficulties involved in drafting the serviceability requirements are discussed. Details of the requirements are given. These included serviceability performance under static loads, dynamic performance of floors and verification procedures.

RESUME

Cet article présente les données de base des exigences d'aptitude au service relatives aux normes de qualité australiennes pour des bâtiments à ossature métallique. Pour la première fois en Australie, l'aptitude au service a été prise en compte en tant qu'exigence obligatoire dans une norme qualitative sur les structures. Les auteurs rappellent les difficultés survenues au cours de l'étude préliminaire. Ils donnent les détails des dispositions correspondantes, qui tiennent compte de l'aptitude au service sous charge statique, du comportement dynamique des planchers et de méthodes de vérification.

ZUSAMMENFASSUNG

Der Beitrag schildert den Hintergrund für die Gebrauchstauglichkeitsanforderungen der australischen Norm für Stahlskelettwohnbauten. Damit wird erstmals in einer australischen Tragwerksnorm die Gebrauchstauglichkeit als bindende Anforderung aufgenommen. Die beim Entwurf aufgetretenen Schwierigkeiten und Einzelheiten der Bestimmungen werden geschildert. Diese beinhalten die Gebrauchstauglichkeit unter statischer Belastung, das dynamische Verhalten von Geschossdecken und Nachweisverfahren.

1. INTRODUCTION

The introduction of performance standards is part of Australian Standards policy of developing multi-part standards, with the first part being the performance requirements and subsequent parts being deemed-to-comply solutions. The Performance Standard for Domestic Metal Framing [1] is one of the first of this new generation of standards.

This paper presents the background of the structural serviceability requirements of this Standard. It is the first Australian Structural Standard to include serviceability as part of the mandatory requirements. Aspects of the Australian domestic metal framing industry are briefly outlined to explain the needs for a performance standard in this area and the reasons to make serviceability requirements mandatory. General aspects of performance standards and serviceability requirements are discussed. These include the needs of various users of the standard such as the industry, the owners and the building control authorities; and the difficulties in developing a rational serviceability specification. Details of the proposed serviceability specification are then described. These include static serviceability loads as well as serviceability limits for roof, wall and floor systems and the dynamic performance of floors. The problems of verification are also discussed.

2. AUSTRALIAN DOMESTIC METAL FRAMING INDUSTRIES

Most houses built in Australia are of framed construction, with timber framing dominating. Metal-framed construction, although it has been in existence for more than 30 years in Australia, constitutes only a small fraction of the houses built. It dominates the kit-home market and is popular for construction in remote areas where building materials are difficult to obtain. Recently, it has gained more popularity with the project builders.

Although the term 'metal framing' is used so that aluminium is not excluded from the Standard, at present all metal framed houses being built in Australia are made of cold-formed light-gauged steel. The steel components are the roof trusses, the wall frames and the floor joists. The components may be used separately with other traditional construction materials such as timber or brick or together in an all steel-framed house. A steel-framed house may have a metal or tiled roof, brick veneer or hardboard-clad external walls, and plasterboard on internal walls and ceilings. In a finished house it is difficult to identify the type of framing.

Almost all Australian metal framing is based on proprietary systems. Most systems have adopted different section shapes to suit their particular designs, since roll-formed steel framing component can be of almost any shape and dimension. A large number of innovative developments are currently taking place in Australia as the market share for metal framing increases. To assist in the development of cold-formed steel framing for domestic construction, a document titled 'Structural Performance Requirements for Domestic Steel Framing' [2] was produced by the authors for the industry as a forerunner of the Standard. The performance standard has been drafted at the request of the industry to create a fair competitive environment not only between different metal-framing systems but also between different construction materials eventually. Mandatory structural serviceability requirements are also the wish of the industry to ensure some degree of uniformity in performance between different competing steel framing systems.

3. STRUCTURAL SERVICEABILITY AND PERFORMANCE STANDARD

'A performance standard describes all the features that are required of a product but does not prescribe what to do to attain those features. It offers means of verification that the product will behave as intended. It allows the selection and the comparison of products for a particular purpose from the widest possible range, consistent with the need of the user' [3].

The drafting of the serviceability performance standard for the Australian domestic metal-framing industry has to take into account the needs of various interested parties other than the industry, such as the owners/occupiers and the building control authorities. Serviceability problems, in the perception of the occupiers, represent quality defects, although quality assurance and serviceability are two separate issues and should be dealt with separately. The users need a performance specification that is independent of the material of construction so that they can be assured of satisfactory performance regardless of their choice of material. The designers need clearly stated serviceability conditions that can be assessed preferably by computation or simple deemed-to-comply requirements. The building control authority needs performance criteria that are easily verifiable.

While general aspects of performance are easily identified, e.g. roofs should not sag and walls should not crack, etc., they are not easily quantified. Acceptable frequencies of exceeding serviceability limit states may vary through several orders of magnitude depending on the type of limit state considered, the variability of the human response to a serviceability condition and the cost associated with providing a certain level of serviceability. Another difficulty is to define structural serviceability conditions and to relate them to actual building performance. The behaviour of domestic construction is complex because of the system effects which are difficult to account for in design. Serviceability criteria should be developed based on cost-effectiveness concepts. A reliability model could be developed to include all sources of variability and uncertainty, particularly the variability in the people's responses to serviceability phenomena together with relative costs associated with providing certain levels of serviceability. From the model, the most cost-effective solution and the corresponding serviceability criteria can be derived. While the theoretical framework for such a model is available [4], its application requires considerable input data and is not yet available.

The Standard committees' immediate aim is to develop a serviceability performance specification which is:

- simple to use;
- based on well defined structural parameters that are measurable and computable;
- easily understood by the designers; and ideally
- independent of the construction materials

... The drafting committee has therefore adopted the following strategies:

- basing the requirements on the levels currently accepted for domestic construction in Australia as exemplified by existing construction; and
- limiting the requirements to those identifiable with specific aspects of performance and verifiable preferably with in-situ measurements.

4. FEATURES OF THE PROPOSED SERVICEABILITY SPECIFICATION

4.1 General

The proposed draft standard requirements are limited to structural serviceability performance. Both the load or the load combination and the serviceability limit appropriate for a specific serviceability condition are given together. The criteria given are intended to give satisfactory performance for most domestic construction because they are based on the performance of currently accepted construction. For specific situations, they may be varied if found inappropriate. An appendix to the Standard gives typical examples of these situations. The reasons for the performance requirements are also given in the appendix, while the standard proper refers only to specific requirements.

4.2 Static Performance

4.2.1 Performance under dead loads

Out-of-flatness deflections under dead loads are restricted to prevent objectionable sagging and possible damage to architectural finishes. The general limit is span/300 with different absolute limits for different components. This is applicable to roof battens, roof rafters, (with an absolute limit of 20 mm), ceiling joists (12 mm) and lintels (9 mm). Roof truss top chords are expected to have the same performance as roof rafters and bottom chords as ceiling joists. Better performance is expected of ceiling battens with a limit of span/600. Top plate deflection under dead load can only occur if there is no alignment of the roof trusses or rafters with the studs. For this situation, a limit of span/240 or 6 mm has been imposed for top plates in single or upper storeys and a limit of span/300 for lower storeys. For floors, the permanent gravity load consists of dead load and the sustained component of live load (set at 40% of the design live load). For this combination a static deflection limit of span/250 has been set for both floor joists and bearers.

All the above limits are based on the levels currently accepted for domestic construction using currently accepted design procedures [5].

4.2.2 Performance under live loads

Defection under live load has been used in this serviceability specification to control the stiffness of members to ensure adequate performance. Performance under two types of live loads has been specified. For a concentrated live load of 1.1 kN representing the weight of a person, a deflection limit of span/180 has been set for roof batten to prevent tile cracking due to a person walking on a roof. For roof trusses, a limit of span/270 has been used for deflection between truss panel points with an absolute value of 15 mm for maintenance purposes. For members in the lower storey of a two-storey construction, a deflection limit of span/200 has also been placed for the design live load of 1.5 kPa. This limit is applicable to top plates and lintels.

4.2.3 Performance under wind loads

A serviceability wind load has been specified by the Australian Wind Loading Standard corresponding to a wind speed which has a 5% chance of exceedance in any one year. For studs supporting flexible wall cladding, a deflection limit under wind of span/240 with a maximum of 12 mm has been set. For stiffer wall cladding such as ceramic tiles, a tighter limit of span/360 with a maximum of 8 mm has been imposed. No limit is placed on studs in a brick veneer construction. As the brick veneer skin is much stiffer than the wall frame, the serviceability wind pressure is not likely to be transferred to the stud wall. Traditionally other deflection limits have been placed on various other components but they have been deliberately omitted from this performance specification because no rational basis for them has been found.

4.3 Dynamic Performance

The specification for dynamic performance has been limited to floor systems. The standard has not yet placed a performance requirement for accidental impact loads on walls although the need for such a requirement has been discussed.

Dynamic performance of floors is a difficult problem. Parameters that affect dynamic performance and methods of measuring and specifying these parameters are still subject to considerable discussion, although progress has been made in the understanding of the problem [6]. Australian steel joist floors, for various practical reasons, are built over a fairly limited range of parameters. Joist spacings are either 450 or 600 mm, timber decking is either 19 or 22 mm thick. Over these ranges, satisfactory performance has been obtained for C-joist design using span/750 limit on deflection under a specified uniformly distributed live load of 1.5 kPa. For rectangular hollow sections, successful design has been obtained with span/500 as the dynamic performance criterion. These are however deemed-to-comply criteria. Effort has been made to relate the performance of these floors to dynamic parameters, the account of which is given in another paper at this colloquium [7].

At the time of writing this paper, the committee has not made up its mind over various available options for specifying dynamic performance:

(a) limiting acceleration induced by a foot fall;
(b) limiting peak velocity due to an impact load;
(c) limiting deflection due to a unit concentrated load; and
(d) maintaining the traditional method of limiting deflection under uniformly distributed load.

Option (c) is theoretically the weakest but it has been shown to work in practice. For any of the other three options to be used, a calibration exercise has to be carried out to relate the criteria to the currently acceptable floors.

4.4 Verification

The Standard provides two methods for the verification of a particular design for its serviceability performance: by computation or by testing.

For verification by computation, the load redistribution caused by the system effects may be taken into account. The Standard, however, offers little guidance on load redistribution except for the grid effects on concentrated and partial area loads.

For verification by testing, the Standard only provides guidance for prototype testing which is useful in developing new framing systems. Because of the complex system behaviour, testing is not only feasible but also often the most economical way to verify the serviceability performance of a steel frame subassembly or component.

5. CONCLUSION

The background and the main features of the structural serviceability requirements of the draft Australian Performance Standard for Domestic Metal Framing have been presented. Although the draft still has many shortcomings, it will fulfil the basic need of the metal framing industry of ensuring some degree of uniformity in the structural performance of steel framed houses.

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