Racking tests of nailed walls of timber and fibreboard

Autor(en): **Edlund, B.**

Objekttyp: **Article**

Zeitschrift: **IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht**

Band (Jahr): **11 (1980)**

PDF erstellt am: **21.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-11248

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

II

Racking Tests of Nailed Walls of Timber and Fibreboard

Essais de cisaillement de parois formées de panneaux d'aggloméré et de contre-plaqué cloués

Schubversuche an Wandelementen mit aufgenagelten Sperrholz- und Faserplatten

B. EDLUND
Associate Professor
Chalmers University of Technology
Göteborg, Sweden

SUMMARY

In the walls of modern timber houses there is a trend to utilize the shear stiffness of panels of e g fibreboard of plywood nailed to the timber frame. Such walls act as windbracing elements. This paper demonstrates the structural behaviour of such walls in in-plane shear and presents briefly two recent investigations in Sweden.

RESUME

Dans les maisons modernes en bois, on a tendance de plus en plus à utiliser la résistance au cisaillement des panneaux d'aggloméré et de contre-plaqué qui sont cloués sur l'ossature en bois. Ces panneaux sont utilisés principalement comme contreventements. Ce rapport décrit le comportement de tels éléments soumis à un effort tranchant dans leur plan; on présente encore brièvement les résultats de deux études effectuées récemment en Suède.

ZUSAMMENFASSUNG

Bei modernen Kleinhäusern aus Holz besteht die Tendenz, die Schubsteifigkeit von Scheiben aus Holzwerkstoffen, z.B. Holzfaserplatten oder Sperrholz, die am Holzskelett genagelt sind, auszunützen. Solche Scheiben wirken dann als Windverbände. In diesem Beitrag wird das Tragverhalten von solchen Wänden unter Schubbelastung anhand einiger neuerer schwedischer Untersuchungen kurz beschrieben.

1. INTRODUCTION

The stabilization of one or two storey timber houses against wind loading may be made by separate wind bracing. A modern trend is to utilize the structural action of nailed wall panels of e. g. fibreboard or plywood instead of diagonal bracing. The panels are mainly acting in shear. In the design of walls under in-plane horizontal wind-induced loading (racking load) both the strength and stiffness of the sheared wall as well as the properties of the nailed joint are of interest.

The aim of this paper is to give the main characteristics of the shear action of load carrying thin panels nailed to a timber frame wall (also called stud wall) and to present a test series of eleven walls under racking load carried out at Chalmers University of Technology, Division of Steel and Timber Structures, Göteborg. Two larger test series comprising both walls and simple connections carried out at the Swedish Forest Products Research Laboratory (STFI), Stockholm will also be mentioned.

One main problem for the designer is the selection of a suitable nail spacing. Another is the question of how to predict the stiffness and load carrying capacity of long gable walls (maybe 5 or 6 m) consisting of several wall elements joined together and which may contain window openings. A third question is to find a suitable method to secure the bottom windward corner of the wall against uplift.

2. SHEAR ACTION OF WALL ELEMENT

Study a timber stud wall with panels nailed to one or both sides of the wall. The panels are usually of fibreboard or plywood, but also other boards such as chipboard or gypsum board may be used. The external load is a horizontal load at the top of the wall, Fig 1. The nailed joints of the timber frame itself are so weak that the unclad timber frame will not be considered to take any shear, but will act as a mechanism. The board panels can be regarded as rigid in shear. The flexibility of the fasteners (nails or staples) between boards and studs is usually so large that fairly large deformations will take place in these joints. Unless the nail spacing is very small, failure will occur at the fasteners. In some cases for panels with small out-of-plane bending stiffness, buckling may occur and give rise to failure.

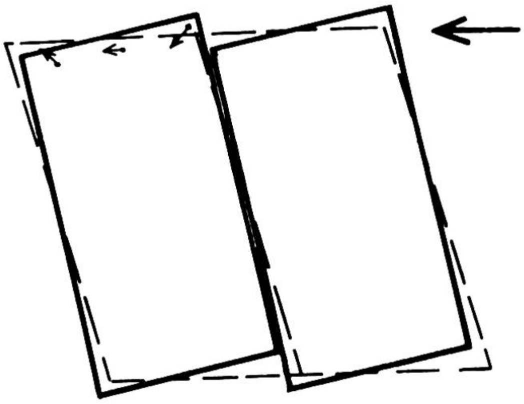


Fig.1 Wall element with two board panels loaded in shear. Schematic illustration of deformations. The small arrows show the deformation of the nails from board to timber frame.

The deformations of a typical two-panel wall in shear are shown in Fig 1. The mutual displacement between the two panels at their junction is clearly seen. If a longitudinal joint strip of plastic and paper is placed along this junction the shear stiffness of the wall will increase considerably.

3. TEST SERIES

3.1 General

A pilot test series of eleven full-size walls under racking load has been made at Chalmers University of Technology [5]. The walls had lengths from 2.40 m to 6.60 m and were composed of prefabricated wall elements having widths 1.20 m or 0.60 m. The elements had lumber framing to which a hardboard or a low density fibreboard skin was nailed. The aim was mainly to study the stiffness of walls with different length and different types of board material (both one-sided and two-sided cladding) *and* to find efficient and simple methods in order to secure the wall against uplift due to the shear load. Therefore it was important to achieve realistic edge conditions especially at the bottom sill.

At the STFI in Stockholm a larger test series has been carried out on 35 walls of which 11 had openings for windows |6|. The main aim of that series was to study the stiffness and strength of wall elements with different types of panels nailed to *one* side of the wall. The walls were of short and medium length 1.20, 1.80, 2.40, and 3.60 m. The stud spacing was 600 mm. The elements were loaded in a shear testing frame which provided the artificial support forces needed for equilibrium. This series may be regarded as pure shear tests of isolated wall elements. Therefore, studies concerning edge joints and the uplift problem are outside the STFI investigation |6|. The panel types in the STFI series are medium density hardboard, low density fibre board (asfaboard), chipboard, plywood, and gypsum board (the thicknesses are the same as in section 6).

The rest of this section (§§ 3.2 and 3.3) and section 4 will deal only with the series at Chalmers University.

3.2 Test specimens

As already mentioned, the basic building block for the walls tested at Chalmers is a prefabricated element in full height (2.40 m) and normally 1.20 m wide (in a few cases also 0.60 m width was used). The size of the lumber was 40x150 mm^2 and the spacing of the wall studs 600 mm, i. e. each normal element of width 1.20 m had three studs. Fibreboard was fastened to both sides of the timber frame - a 12 mm soft board (asfaboard) on one side and a 10 mm hardboard on the other. Staples were used as fasteners. One aim of the tests was to study the use of a more dense nailing (spacing 75 mm) than the usual minimum (100 mm). The elements were then joined together to the desired length by boards overlapping the neighbouring wall stud. These joints were also nailed with staples.

Nine walls were of size 2.40x2.40 m^2 (two elements joined together) and two walls were full-length gables 2.40x6.60 m^2. One of the latter had a hole for a window.

3.3 Testing arrangement and loading procedure

A special testing rig was built where the walls were tested in an upright position. The vertical load on top of the wall was simulated by a series of hydraulic jacks and the horizontal wind load by a larger jack (P in Fig 2). The elements were placed on a timber sill as used in practice. Different types of anchorage against uplift were tested. The type that proved to be best was a steel angle bolted to the element and the sill at A, see Fig 2.

For a discussion of different testing methods see |1|.

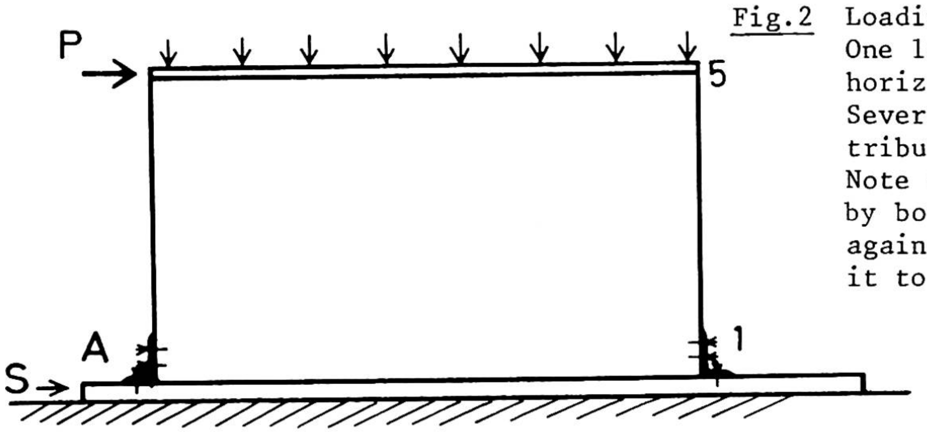


Fig.2 Loading arrangement. One large hydraulic jack for horizontal racking force P. Several small jacks for distributed vertical top load. Note steel angles attached by bolts to secure wall against uplift by anchoring it to the bottom sill (S).

The vertical load was applied with 2.15 kN on each jack (jack spacing 0.6 m) on a steel U-bar attached to the top of the wall. This load was then kept constant during the rest of each test. The friction between the jacks and the U-bar was practically eliminated by inserting Teflon discs. The horizontal load P was then applied with load levels of 2 kN, 4 kN, 6 kN etc up to 16 kN or to the maximum load if failure or excessive deformations occurred for $P < 16$ kN. The load P was kept constant on each load level during 5 minutes, then P was diminished to 0 and kept at zero level during 5 min. Readings of dial gauges (placed horizontally and vertically at the corners) were made after each 5 minutes interval.

Each of the 2.4 m wide walls was tested twice : (a) with only two nails attaching the wall to the sill (one nail at each end), (b) with one special steel angle bolted to wall and sill as shown in Fig 2. Details of the observations during loading are given in Ref. [5].

4. RESULTS OF WALL TESTS

As an example of experimental results the load-displacement curves for the upper unloaded corner of seven walls of width 2.4 m are shown in Fig 3. In this figure it is distinguished between the two cases a and b just mentioned. Normally test 'a' was made first, but for specimens 8 and 9 test b with the angle connection was made first.

The elements were in most cases loaded until some local failure occurred, usually at the fasteners. For the long element with opening,buckling of the board panel occurred near the opening which opened up the nailing row along the lower edge of the window opening.

From Fig 3 the effect of the angle (at A in Fig 2) is clearly seen. The effect of the board type is also apparent. For two walls (no 6 and no 7) the 12 mm low density fibreboard on one side of the element was replaced by 10 mm hardboard. In Fig 3 these two walls have the largest stiffness.

The horizontal displacement δ_5 is directly measured by the dial gauge. Therefore the slip that may occur along the bottom sill is included. If the horizontal displacement at the bottom corner 1 is subtracted and the result is divided by the wall height,a measure of the total wall shear, the angle γ , is obtained (translation removed). As there in many cases, however, is an uplift at the corner A the element will also rotate. By subtracting also this rotational angle θ from γ the shear strain of the isolated wall is obtained. This $\gamma_o = \gamma - \theta$ is called the "actual shear strain" by Sugiyama [4].

The discussion of shear action given in section 2 indicates that, given the shear capacity of a wall with one board panel, the load carrying capacity of a long wall with a series of board panels may be obtained by adding the shear capacity of each panel. This has also been confirmed by tests, c. f for example [4, Fig 10].

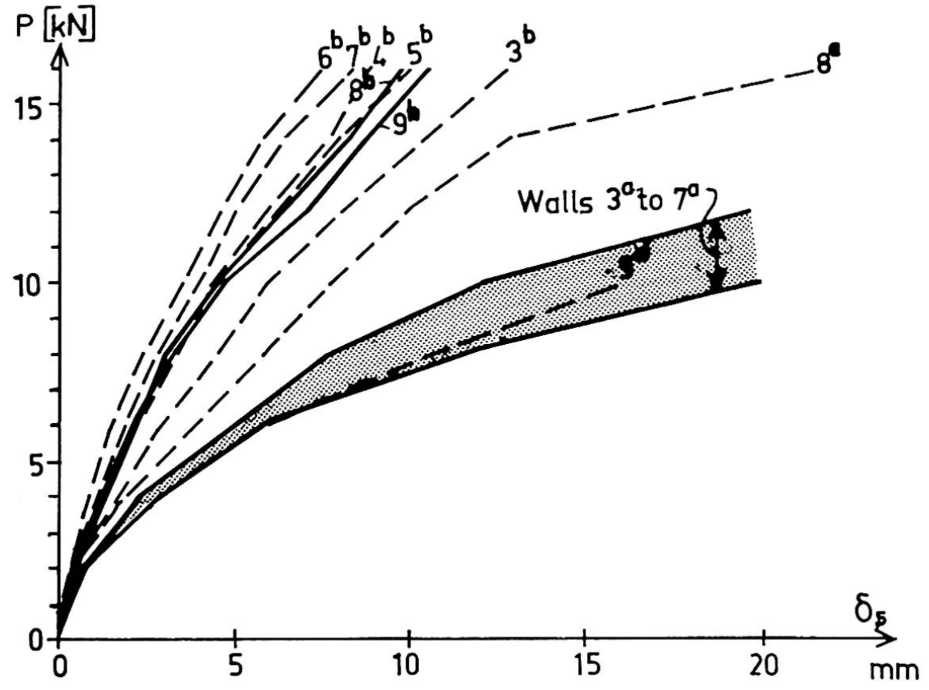


Fig.3 Load versus measured horizontal displacement at upper unloaded corner (point 5).
Walls 3 to 9 with length 2.4 m. Walls 6 and 7 have 10 mm hardboard on both sides. All the other walls have 10 mm hardboard on one side and 12 mm low density fibreboard on the other side.
Fully drawn curves —— first test
Dashed curves ---- second test
a no angle connections
b steel angle connections bolted at bottom corners

5. COMPUTATIONAL MODELS

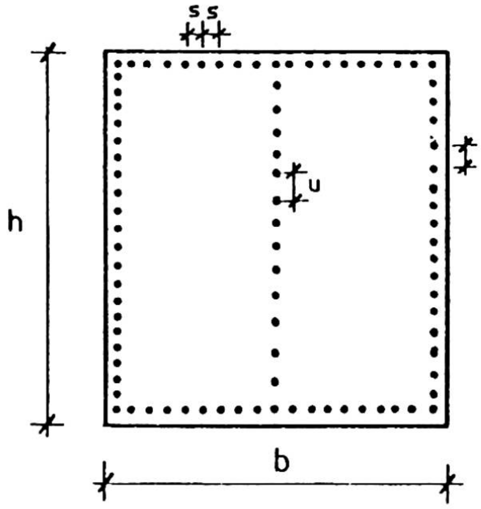
Simplified methods. - Assume that both the timber elements and the panels are rigid, i e only the deformation of the fasteners is considered. Further, study only the behaviour of an isolated wall element, i e the anchoring to the foundation is left out of the discussion. Then relatively simple formulas for the stiffness and strength of nailed elements under shear load may be derived, see for example Tuomi & McCutcheon [2] and Kortesmaa [3]. In a work under way at the STFI in Stockholm [6], *Bo Källsner* has obtained the following formula for the ultimate shear load P_u (assuming fastener failure) of a wall element with three studs. The geometric parameters are defined in Fig 4.

$$P_u = (k_h^2 + k_v^2)^{-1/2} \cdot nQ \tag{1}$$

(2a), where $k_h = 6n/(6n+2m+4/m+p-3+2/p)$

(2b) and $k_v = 3\alpha n/(3m+n+2/n)$.

Here Q is the load carrying capacity of one fastener in a test according to Fig 5 with $\varphi = 0^\circ$.
A wall consisting of N such elements will have the ultimate load $N \cdot P_u$.



$n = \frac{b}{s}$

$m = \frac{h}{t}$

$p = \frac{h}{u}$

$\alpha = h/b$

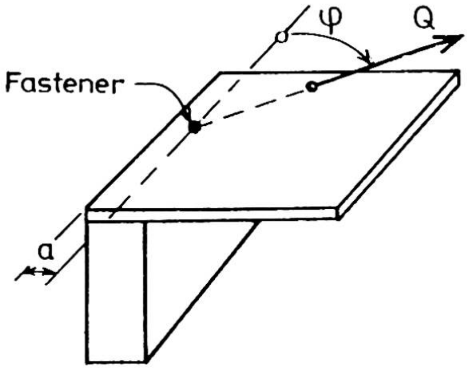


Fig.4 Definition of non-dimensional parameters n, m, and p for fastener spacing for a wall with three vertical studs.

Fig.5 Loading test of mechanical fastener joining panel and lumber.

FEM-method. – A more accurate computation will be made with the aid of a Finite Element program on a digital computer.

6. FASTENER CHARACTERISTICS

The load-deformation properties of a fastener joining board and lumber depend on a number of parameters such as panel material and thickness, fastener type and dimensions, edge distance a, angle of loading φ, Fig 5. In a systematic investigation at STFI, Stockholm [6], tests to failure were made on 700 simple joints with one fastener. The main parameters varied were (1) Edge distance a; (2) Angle φ between force direction and edge of panel ($-90^\circ < \varphi < 90^\circ$, where $\varphi < 0$ correspond to a compressive force Q); (3) Panel type : asfaboard 13 mm, medium density fibre board 12 mm, gypsum board 9 and 13 mm, plywood 8 mm, chipboard 12 mm; (4) Fastener type (nail, and for gypsum board nail or screw). The results are strength and stiffness of single fastener as functions of these parameters.

ACKNOWLEDGEMENT

This paper is based on research partially supported by the Swedish Council for Building Research - for the CTH-project grant no 780993-5.

REFERENCES

1. YANCEY,C.: The development of an improved test for evaluating the racking resistance of wall panels. NBS Building science series 91. Washington 1976.
2. TUOMI,R. - McCUTCHEON,W.: Racking Strength of Light-Frame Nailed Walls. ASCE Journal of the Structural Division 104 (1978), ST7 (July), p 1131-1140.
3. KORTESMAA,M.: Fibreboard and chipboard walls as windload bracing. (In Finnish). Rakennusteollisuus 1976, No 4, p 26-31.
4. SUGIYAMA,H.: On the racking stiffness of bearing walls of platform framing construction due to full-scale house test and ASTM racking test. Meeting of Int. Union of Forest Res. Organisations (IUFRO) Wood Engineering Group, Vancouver, Canada August 1978, Proceedings Paper 12, p 232-243.
5. BJÖRKLUND,G. - OLSSON,L. - ROSENDAHL,M.: Membrane action of windbracing wall elements of lumber and fibreboard — Experimental investigation of the stiffness of prefabricated wall elements with special reference to connections (In Swedish). M Sc Thesis, Chalmers University of Technology, Dept of Structural Engineering 1979. Unpublished.
6. KÄLLSNER,B.: Skivor som vindstabiliserande element vid träregelväggar (Panels as windbracing elements for timber stud walls. In Swedish). STFI-Report (To be published) Swedish Forest Products Research Laboratory, Stockholm.