JAMES COOK CYCLONE STRUCTURAL TESTING STATION

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SIMULATED WIND TESTS ON A HOUSE

Part 2 — Results

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SIMULATED WIND TESTS ON A HOUSE

Part 2 Results

G.N. Boughton*

SUMMARY

Loads in excess of those experienced in tropical cyclones were placed on a 40 year old timber framed duplex in a series of tests designed to trace

SIMULATED WIND TESTS ON A HOUSE

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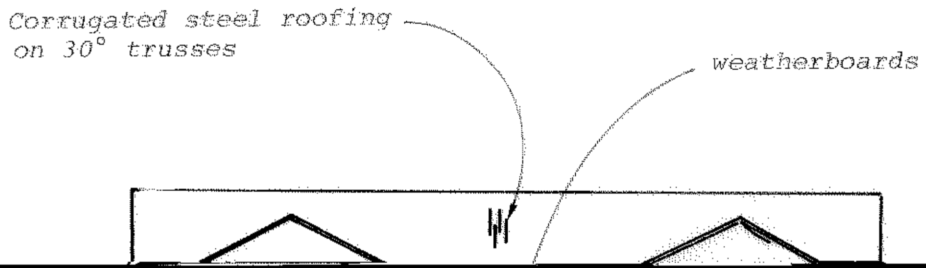
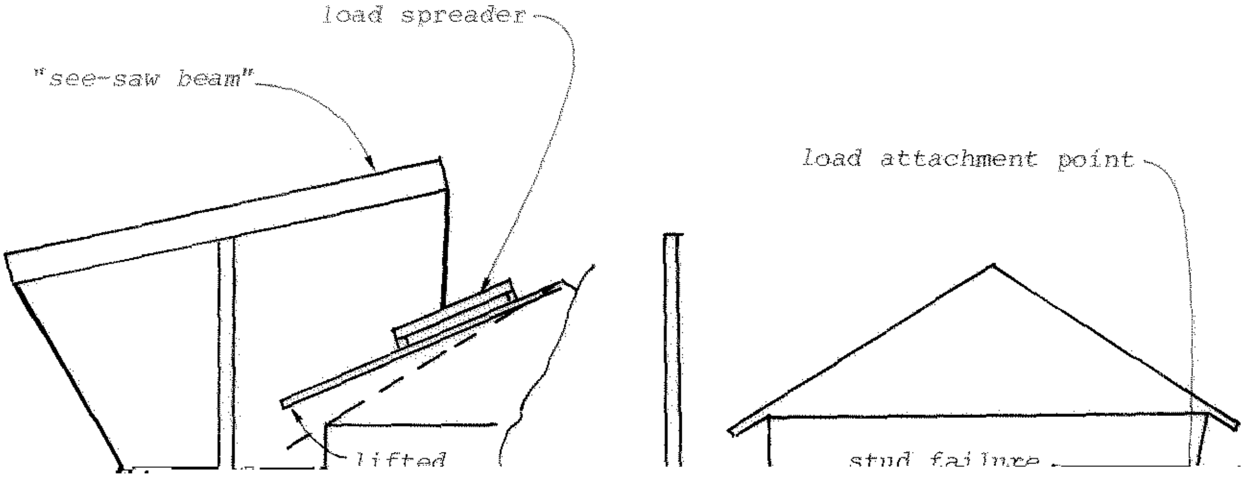
1. INTRODUCTION

In nearly all facets of industry, it is necessary to conduct tests on full taken over by the Queensland Housing Commission, fitted with internal walls, ceiling and wall linings, and converted to a duplex. Over its 40 year history, the house had been subjected to high wind loads from three major cyclones including cyclone 'Althea' which damaged many other buildings throughout Townsville. However, as all the sheets of roofing and weatherboards on the house were the originally installed items, the house appeared to suffer minimal damage in these three high wind events. A sketch of the home is shown in Figure 1, and some relevant structural details are summarised below.



Roof sheeting	Corrugated galvanised steel sheeting, nailed every second corrugation.
Roof structure	Bolted timber trusses at approximately 3


load spreader
"see-saw beam"
load attachment point
lifted
stud failure

3. EXPECTED WORKING LOADS - WIND TUNNEL TESTS

[redacted]

Load designation	Critical Wind Direction	Load (kN)	Net Average Pressure (kPa)
'AS code' lateral load on entire house (normal to Northern wall)	15°	57	1.04
'AS code' uplift on roof panels 9 and 10 (normal to roof)	60°	63	1.76

These 'AS code' loads can be compared with the maximum load experienced by [illegible]

4. UPLIFT ON ROOF - A STRENGTH TEST

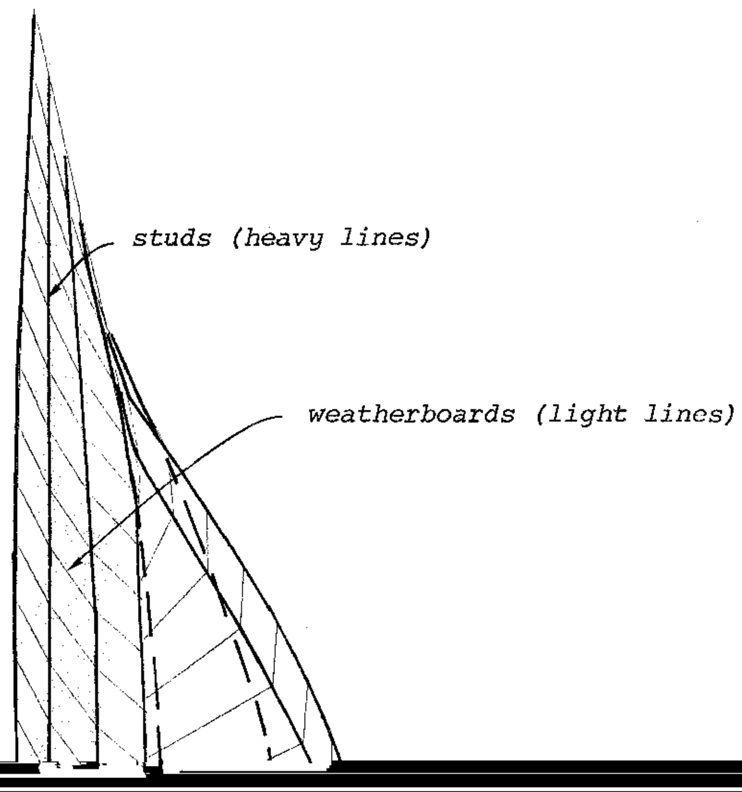
As extensive testing of roof sheeting has been performed by this station, and other testing organisations and manufacturing companies no attempt has been made to apply uplift loads to the roof sheeting itself. Rather, the uplift loads were applied to the purlins of a 25 m^2 area of the roof using the loading configuration shown in Figure 2(i). The load spreaders distributed the applied uplift to twelve point loads on the purlins giving an average area distribution of just over 2 m^2 per load point.

The total ultimate load attained was 60.6 kN, equivalent to an average

The actual mode of failure was by withdrawal of the nails securing the purlins to the top chord nailing blocks. Forty nails in twenty locations were affected. This gave the average resistance of each nail at failure as 1.52 kN compared with the allowable design resistance of 0.63 kN (Australian Standard, 1975), i.e. average failure load was 2.4 times

A series of tests on wall studs was performed to ascertain the degree of load sharing carried out between studs and other elements in walls, and to determine the factors that affect the in-situ strength of studs. In these

For the first three stud tests, in which the wall claddings, nogging and bracing were left intact, a theoretical finite element analysis of the timber


studs (heavy lines)
weatherboards (light lines)

The bending moments applied to the stud at failure are shown below and lead rather complex force transfer mechanism at or above the top plate level distributes load from the top of the studs to the bracing walls. This

	Test Result	'AS code'	'Althea'
Total lateral load on Northern wall (kN)	192	57	42
Load factor = ultimate load / [illegible]	[illegible]	3.37	4.57

[illegible]

7. LATERAL LOAD AT FLOOR LEVEL - A STRENGTH TEST

As indicated in Sections 5 and 6 of this report, all lateral loads on the building are eventually transferred to floor level either by studs directly to the bottom plate or by studs to roof structure bracing systems and then to the floor through walls parallel to the direction of the wind. Thus, all lateral load applied to the building must be transferred from the floor to the ground. In the case of the house reported in this work, this involved the transfer of force from the timber floor bearers through steel ant caps to timber piles, and then to the ground. As there was no effective shear connection between the house and the stumps, the transfer of this lateral force relied on friction between the bearers and the ant caps and between the ant caps and the stumps.

In this test, an 11.5 metre length of house with weight estimated at 140 kN was subjected to a lateral load applied at floor level as shown in Figure

As the lateral loads used in determining the current code design load and the 'Althea' load were for wind at 15°, the uplift used must also correspond to wind at 15°. At this angle, the mean uplift pressure coefficient on the southern side of the roof was 0.47 and the mean pressure coefficient on the northern side of the roof 0.1 downward (Holmes, 1981). This gives a net uplift on the 11.5 m section of the house tested of 18 kN under

However the current code design load factor for first slippage is lower than recommended (Department of Construction). Thus under the cyclic loading applied by a current code design high wind event, some slippage may have commenced and if the loading had persisted, a failure may have eventuated.

Timber framed houses that are built to modern specifications tend to have lighter frames and ceiling structures. Also, there are many cladding systems available for external walls that are considerably lighter than points along the Northern wall and loading was restricted to keep the house behaviour within elastic limits. Load was applied at the same point a

8.1 Lateral Load Resistance of 'Bracing Walls'

[illegible]

8.2 Lateral Load Distribution in Roof Structure

The point load applied to the house in the stiffness tests was located adjacent to an internal wall. From the above analyses, it was determined [illegible]

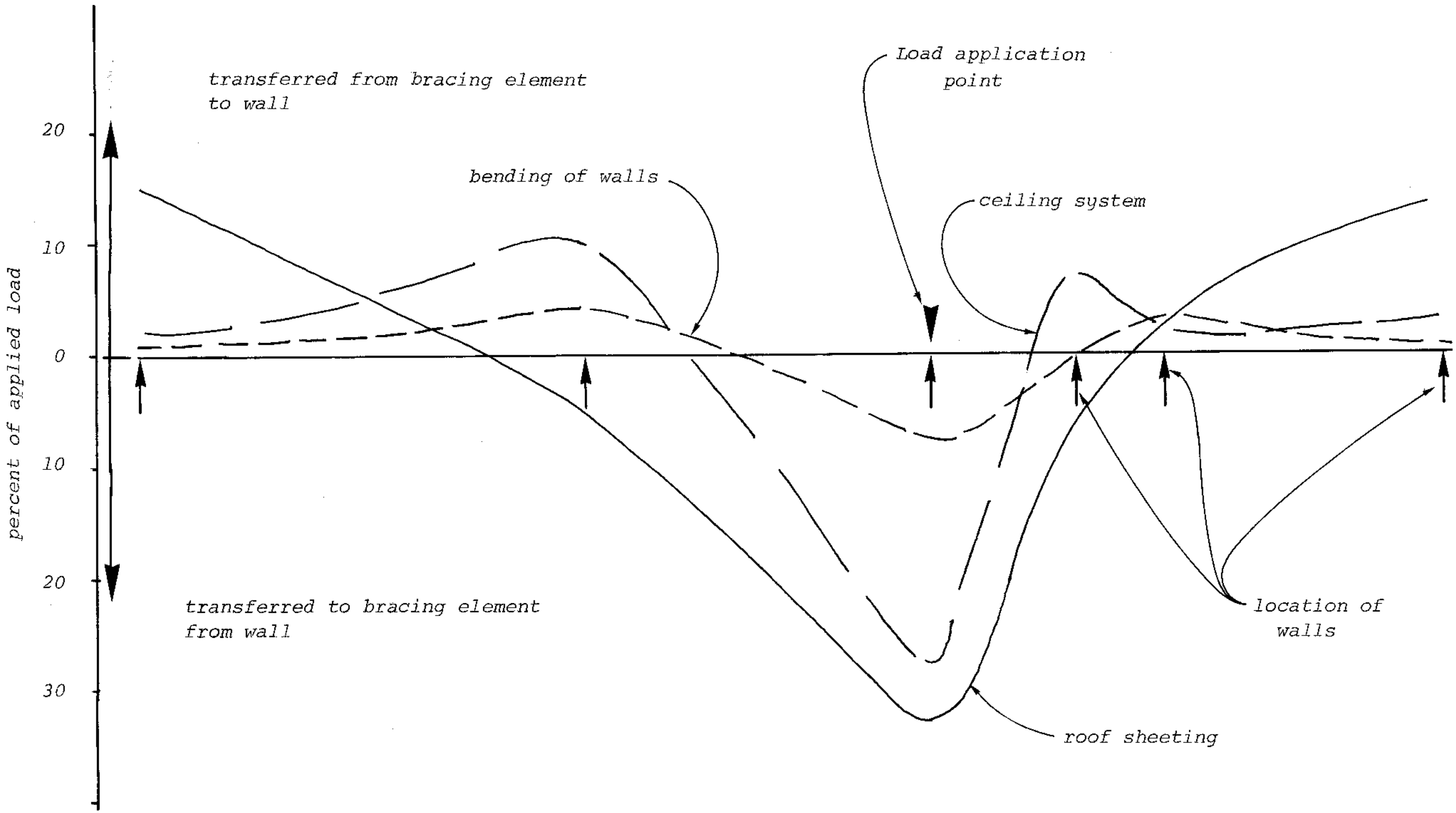


Figure 5. Percentage of applied load carried by lateral bracing elements.

in most modern building by-laws, it is recommended that the bending action mechanism used in load transfer, and it is planned to check this work in the next house tested.

The high percentage of load carried by the roof sheeting, and the large distances it can span make it a very useful lateral load carrying diaphragm.

9. RECOMMENDATIONS FOR FUTURE TESTING

The analysis of the test results has highlighted the need for improving testing procedures in future full scale house tests. Most of these stem from inadequacies in the measurement system used in the first full scale

10 CONCLUSIONS

This series of tests has demonstrated the viability of the house testing

[illegible]

10.2 Conclusions on the House Testing Project

The first series of tests has established the success of a portable house testing method to simulate high winds.

The results have highlighted the need for research into ceiling and roof sheeting diaphragm, and future testing will continue to stress [illegible]

4. BEST, R.J. and HOLMES, J.D. (1978) "Model Study of Wind Pressures [illegible]

5. BOUGHTON, G.N. and REARDON, G.F. (1982) "Simulated Wind Tests on a House - Part 1 Description". Technical Report 12, Cyclone

14. WALKER, G.R. and GONANO, D. (1981) "Investigation of Diaphragm Action of Ceilings - Progress Report 1". Technical Report No. 10, Cyclone Structural Testing Station, James Cook University of North Queensland.

15. WALKER, G.R., BOUGHTON, G.N. and GONANO, D. (1982) "Investigation of Diaphragm Action of Ceilings - Progress Report 2". Technical Report No. 15, Cyclone Structural Testing Station, James Cook

APPENDIX A - TEST RESULTS

A.1 Loading Arrangements

Figure A.1 shows a plan of the house showing the position of the loading frames and giving the location of the points of application of the loads [illegible]

Points A to E	*stud loads*
F to I	*top plate loads*
J and K	*bottom plate loads*
L and M	*uplift loads*

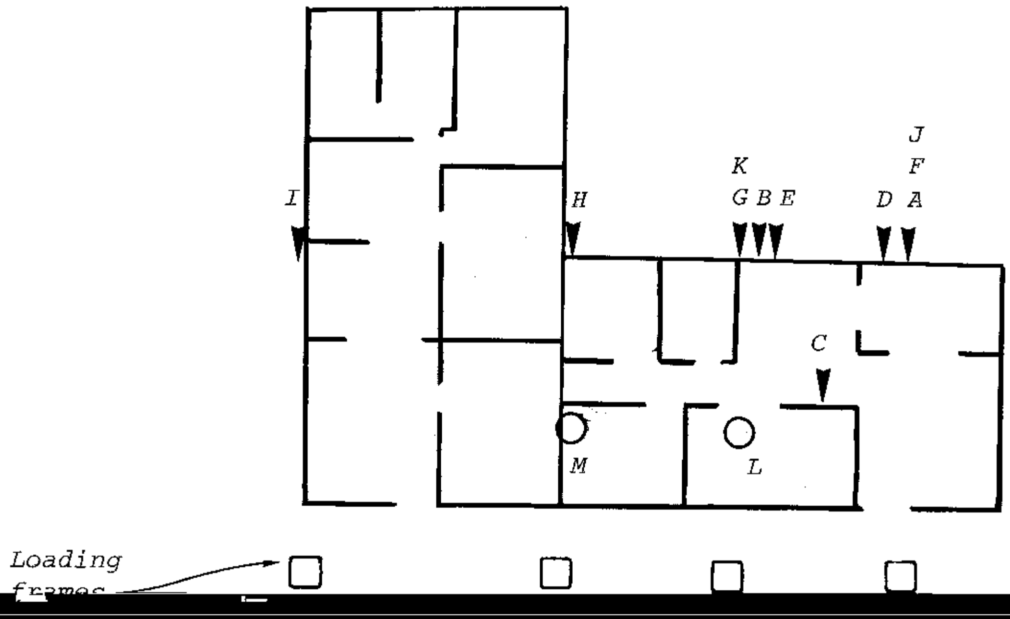
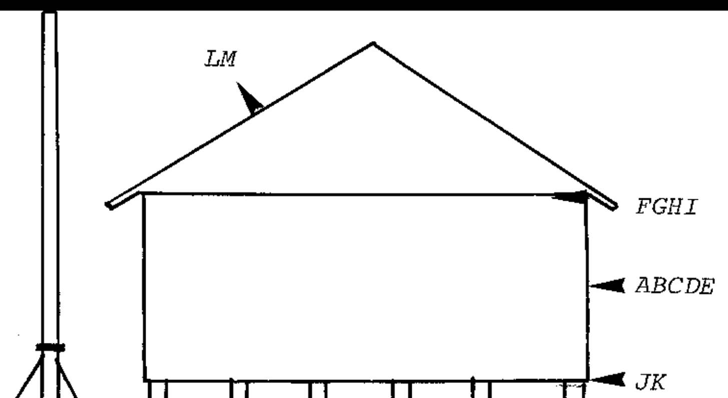


Figure A.1 Plan of house showing load points




Claddings
Load cell

Deflection gauges were positioned as shown in Figure A.4. The positions shown enabled the deflected shape of the stud to be found and also allowed the evaluation of the sideways distribution of load by the cladding and the noggings.

Test History

The load was applied in 1 kN increments and deflections measured at all gauges for each increment up to 14 kN, then the gauges were removed for their protection as failure appeared imminent. Loading continued until

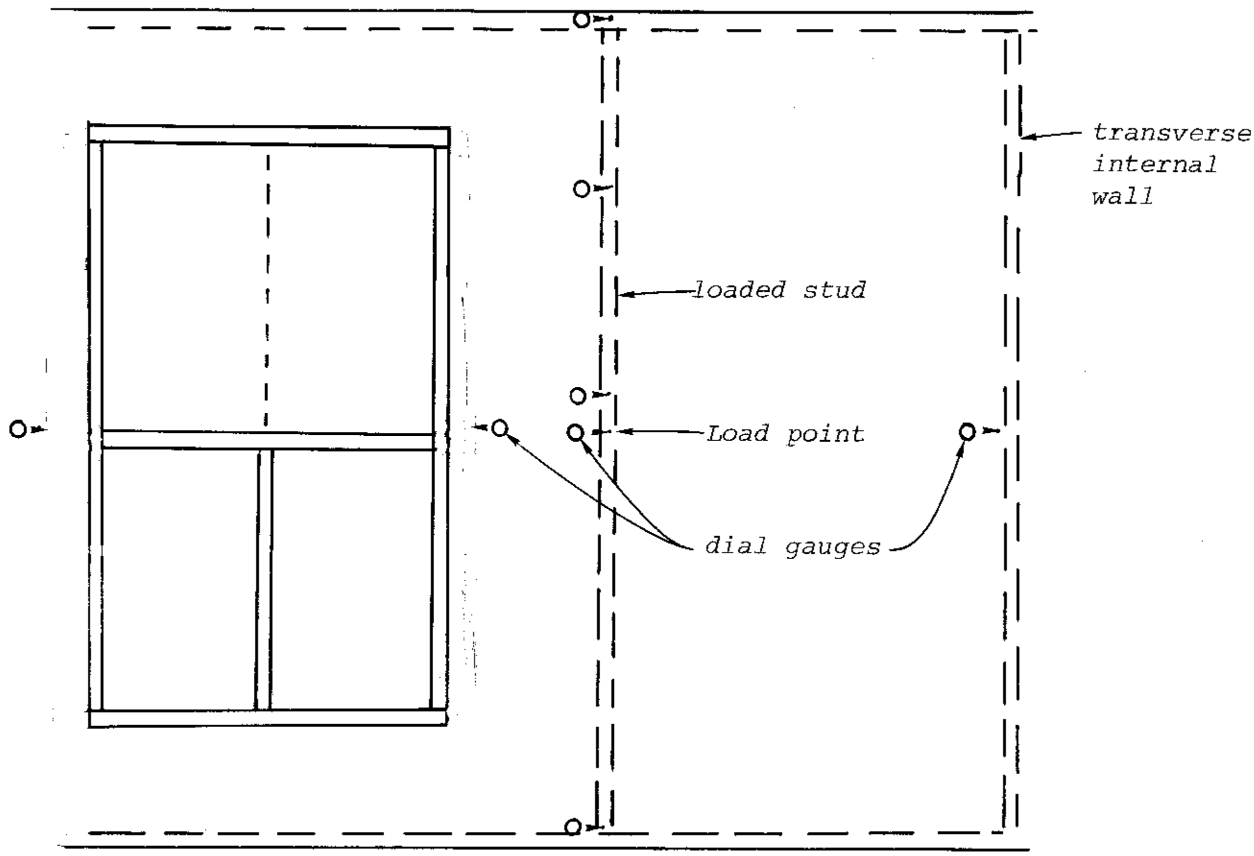


Figure A.4 Test configuration stud test

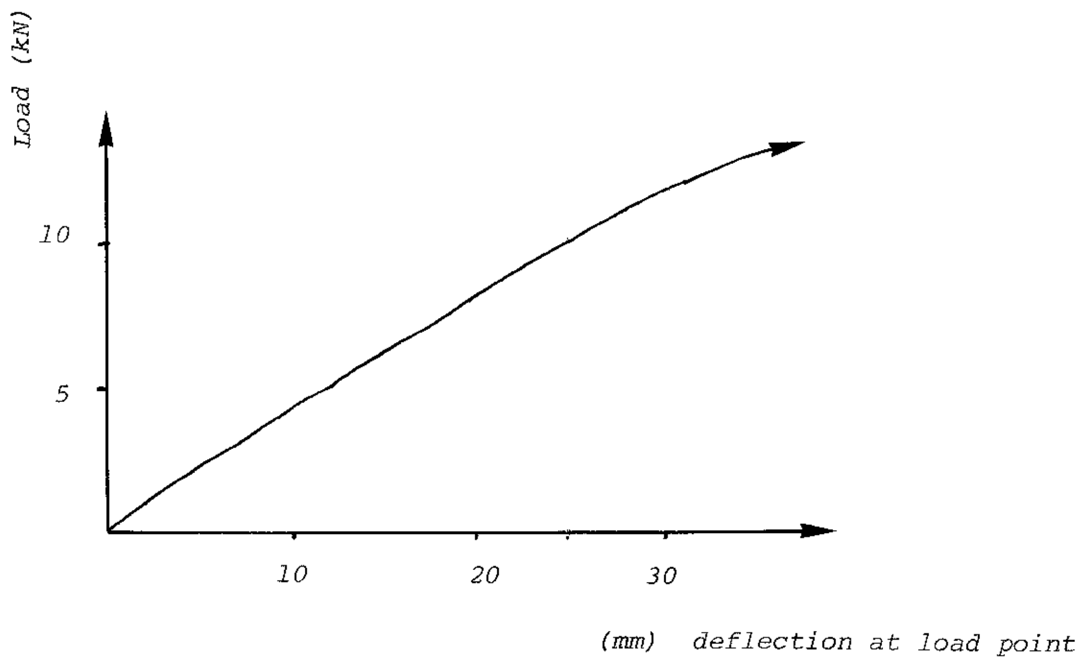


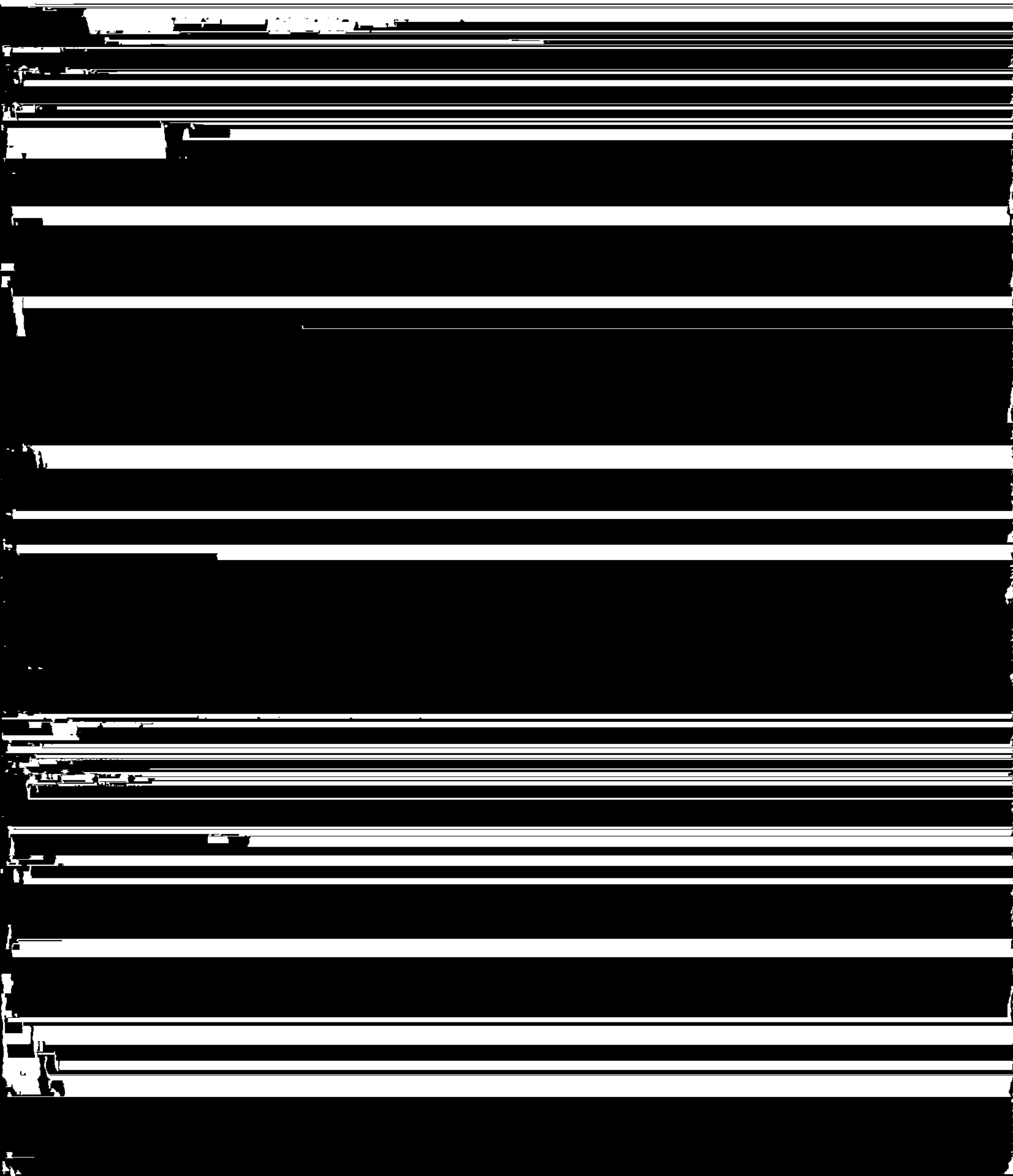
Figure A.5 Load-deflection curve for stud tests

Test History

[illegible]

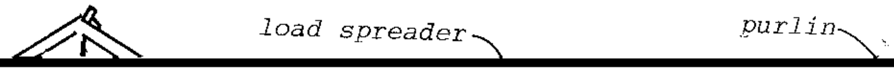
A.6 Stud Test 4

Geometry of Test



6.9 kN. At failure the stud was broken in flexure on both sides of the loading plate. At the failure load the two end driven nails securing the stud to top and bottom plates were still performing adequately although significant withdrawal had occurred, due to the deflected shape of the studs.

The loads sustained during the early part of this test, during which deflection readings were taken, are also subject to doubt. After the dial gauges were removed, a step increase in the load occurred, and the load at failure


load spreader
purlin

A.9 Floor Test

Geometry of Test

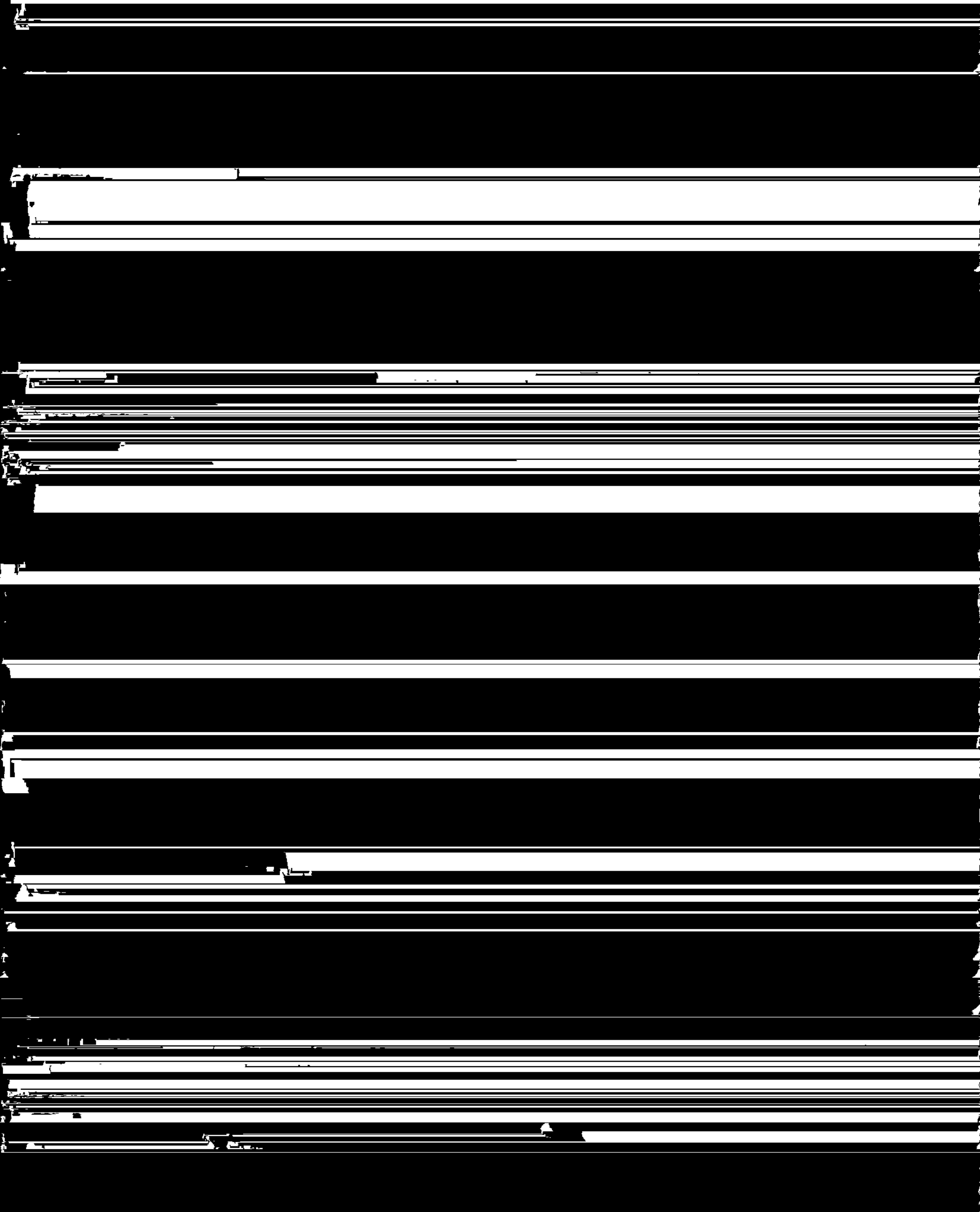
In this test, a lateral load was applied to the floor structure of the house

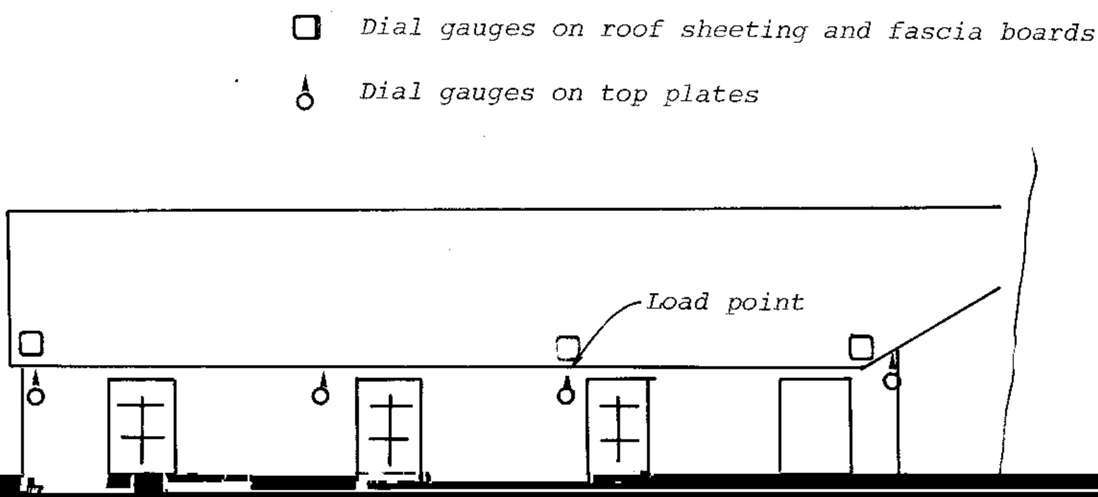
[illegible]

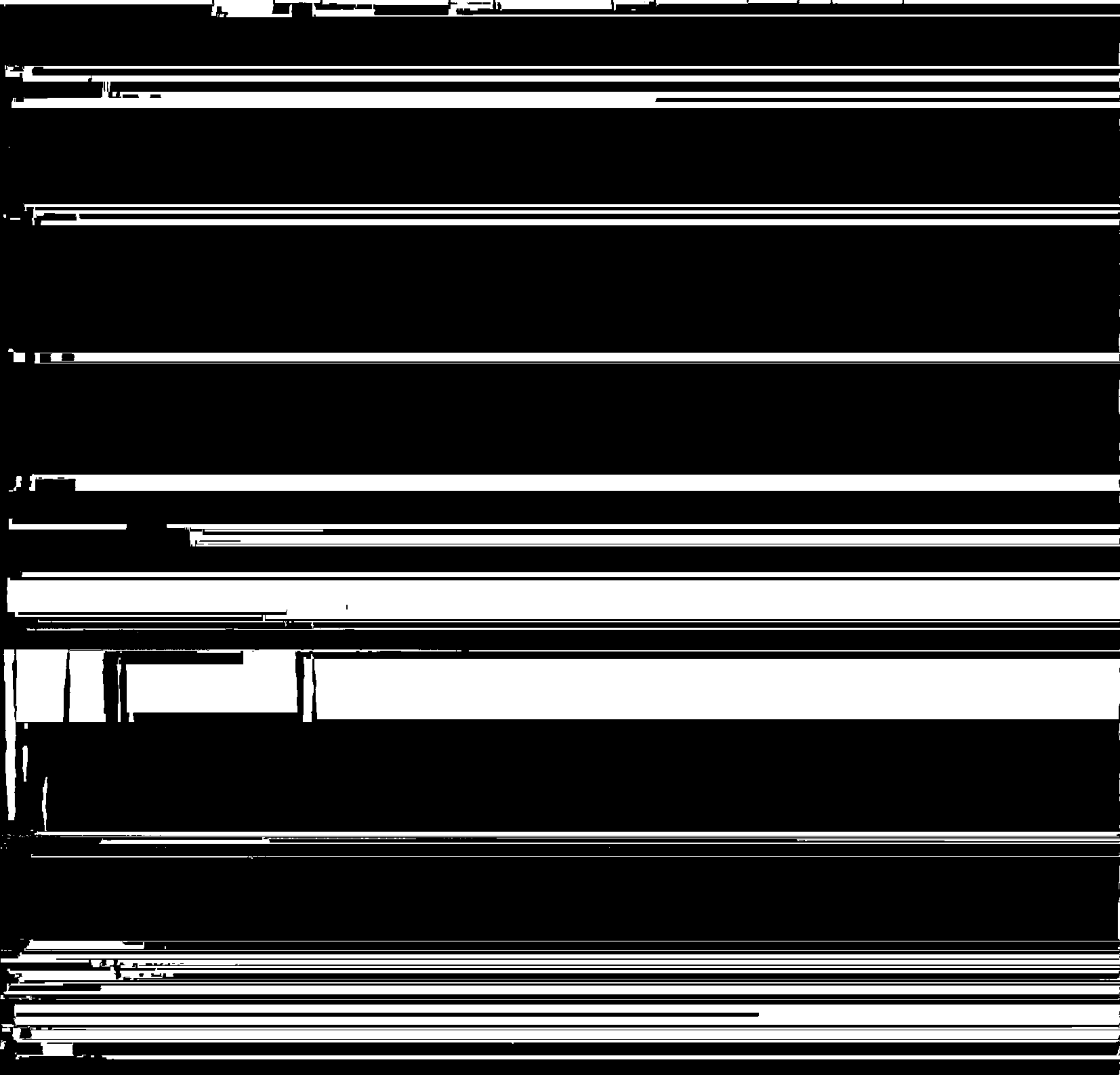
Test History

During the loading in each of the four tests, the top plate bent inwards quite noticeably and ceiling panels near the load point rotated in plane. [illegible]

A.12 Top Plate Tests 6 to 11




Dial gauges on roof sheeting and fascia boards
Dial gauges on top plates
Load point

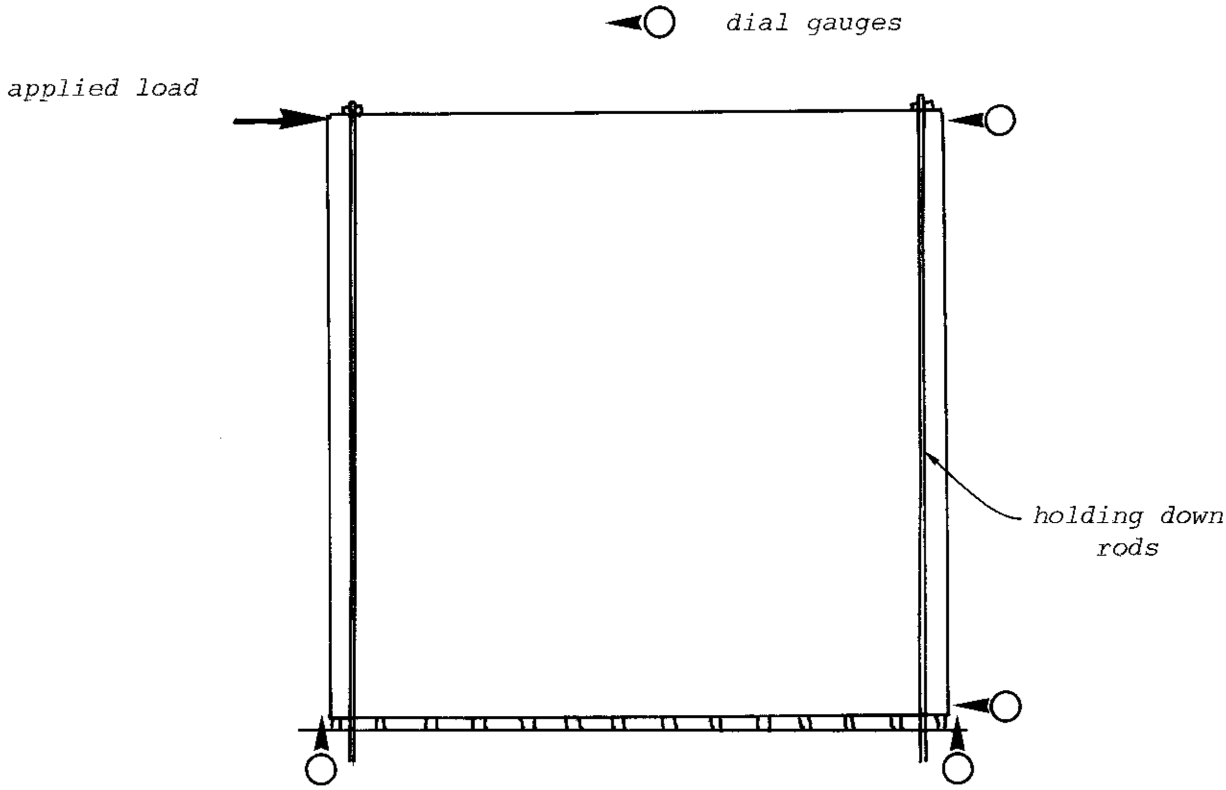


A.13 Top Plate Test 12

Test Geometry

This test was performed on the internal wall that was immediately adjacent

[illegible]


dial gauges
applied load
holding down rods