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SIMPLE METHODS TO RESIST JOIST ROLL-OVER FORCES

S. J. Thurston

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PREFACE

This is the first of two reports prepared for the research programme on house foundations undertaken by BRANZ. The second report is BRANZ Study Report SR 46 entitled "Design Loads For House Pile Foundations", currently in preparation.

ACKNOWLEDGEMENTS

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NOTES

This report is intended for researchers, structural engineers, architects, builders and other workers in the field of house foundations.

SIMPLE METHODS TO RESIST JOIST ROLL-OVER FORCES

BRANZ Study Report SR 45 S.J. Thurston

REFERENCE

Thurston S.J. 1992. Simple Methods To Resist Joist Roll-over Forces. Building Research Association of New Zealand. Study Report SR 45. Judgeford, New Zealand.

KEYWORDS

From Construction Industry Thesaurus - BRANZ Edition: Piles; Foundations; Bracing; Joists; Earthquake Loads; Wind Loads; Houses

ABSTRACT

The latest New Zealand non-specific design code for light timber frame houses defines the minimum required strength of the connection between joist and bearer/s at each braced pile or anchor pile. The connection is required to resist a horizontal force, totalling 12 kN, applied parallel to the bearer at the diaphragm level. These horizontal forces tend to roll joists over onto the bearer below. The potential cost in providing mechanisms to resist joist roll-over forces has caused some concern in the building industry. Consequently, some simple and cheap methods which satisfy the requirements of the code have been investigated. This report describes this work. A draft BRANZ Technical Recommendation is also presented which details recommended construction methods to resist joist roll-over action.

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1. INTRODUCTION

The latest New Zealand non-specific design code for light timber frame houses - NZS 3604: 1990 (SANZ, 1990a) dictates that the connection between joist and bearer/s at each braced pile or anchor pile is required to resist a horizontal force totalling 12 kN applied parallel to the bearer at floor level. Figure 4.10(c) in the code, depicting the design forces, is reproduced as Figure 1 of this report. If unresisted, the horizontal forces cause failure by rolling the joists over onto the bearer below. If the loads can be transferred through the joists to the bearer, they are then transferred to the pile via the bolted connection shown in Figure 1, and thus to the ground by a combination of pile and brace action.

The criterion for resisting joist roll-over actions is not in the previous version of the non-specific design code - NZS 3604:1984 (SANZ, 1984). There is some debate as to whether this is a realistic potential failure mechanism. Whilst such a failure mechanism is theoretically possible, no such failures have been observed in practice when New Zealand houses have been subjected to earthquakes or high wind loads. It has been argued that joist roll-over is prevented by mandatory blocking, partition wall stiffness, floor masses etc. For floors between storeys the code does not require specific joist roll-over forces to be resisted, instead relying on typical and specified construction details. The potential costs of providing proven mechanisms to resist specified joist roll-over forces, directly above the foundation level, has caused concern in the building industry. This project was initiated to develop and validate some simple and cheap methods so builders could satisfy the joist roll-over requirements of NZS 3604:1990. A draft BRANZ Technical Recommendation (Appendix B) details the recommended construction methods to resist joist roll-over actions. These methods can also be used for joist roll-over resistance above foundation bracing walls.

The connections detailed in this report will not satisfy NZS 3604:1990 strength requirements for the connection between joist and bearer for loads parallel to the joist, such as depicted in Figure 4.23 or described in clauses 4.7.7.2 or 4.7.7.3 of the Standard. If the pile is required to resist loads in this direction, the builder must provide this strength by other methods. Examples are provided in Appendix B.

2. TESTING DETAILS

2.1 Construction

Cyclic joist roll-over tests, simulating an earthquake, were performed on several different types of house foundation test specimens. Unless specifically identified later, all specimens were fabricated using 20 mm thick flooring grade particleboard sheet (1.5 m wide), with 200 x 50 mm Radiata Pine joists (1.5 m long) at 600 mm centres and a bearer (two 150 x 50 mm Radiata Pine sections nailed together to give a section 150 x 100 mm). Nailing between the blocking and particleboard sheeting was 60 x 2.8 mm diameter galvanised jolt head nails at 100 mm centres. This nail pattern is closer than normally used but was required to transfer the load from the sheet to the joists because of the small specimen size tested. All other nailing complied with NZS 3604:1990. At each end of the blocking there were two 100 x 3.75 mm diameter flat head horizontal nails connecting the joist to the blocking; at each joist there were two 100 x 3.75 mm skew nails between joist and bearer. There were no skew nails between blocking and bearer unless specifically detailed below. Except where noted, full joist depth blocking was used in all cases.

Using joists at 400 mm centres (instead of 600 mm) causes a higher aspect ratio of the blocking (thus the tendency to overturn is greater). However as the critical load transfer mechanism is shear at the base of the blocking, it is considered that details which satisfied the testing criteria would perform well in practice as long as the joist spacing divided by the joist height was not less than 2.

2.2 Test Set-up

The test set-up is shown in Figure 2. One test specimen used three rather than two joists (see Figure 3 and Photo 1). An actuator applied horizontal loading to the specimen through a steel angle section which was screwed to the particleboard flooring. The load was transferred through the joists (in "roll-over" mode) to the bearer, which was bolted to the strong floor.

Loading was applied using a 100 kN closed loop electro-hydraulic ram and was measured by means of a 100 kN load cell calibrated to Grade 1 accuracy. Linear potentiometers (accuracy 0.25%) measured horizontal displacement of the diaphragm and vertical uplift at the joists. Test load and displacement readings were recorded using an IBM compatible PC running a software package to record data in real-time mode.

The test was run under deflection control with diaphragm displacement of about 2 mm/second.

2.3 Test Programme

A single test was performed initially on each of eight different configurations (JOIST001 to JOIST008), using specimens constructed from timber air-dried to about 16% moisture content. Tests were done in August 1991. Four more test specimens of type JOIST008 were then fabricated from wet timber and allowed to dry for 4 months before testing (labelled Specimen 1 to Specimen 4). Testing was done in January 1992.

BRANZ has observed large scale tests on specimens with mandatory blocking along bracing lines and blocking at particleboard sheet edges. These specimens resisted about 1.7 times the joist roll-over forces of the small specimens described in this report. Because of this and other strength enhancing features present, but ignored, in a complete house constructed in accordance with NZS 3604:1990, it was considered that a single small specimen test giving a cyclic loading resistance of 15kN could reasonably be relied upon to give a lower 5 percentile strength of 12kN in a full house construction.

General details of tests JOIST001 to JOIST007 are shown in Figure 2, and those of JOIST008 in Figure 3. The specific restraints provided for each configuration to resist the joist roll-over forces are descibed below.

2.3.1 JOIST001 (See Figure 4)

Instead of normal blocking, which does not extend below joist level, a 300 x 50 mm blocking was nailed to the side of the bearer with ten 100 x 4 mm flat head (FH) nails at 50 mm centres. Two horizontal nails (joist/bearer per joist) and two skew nails (joist/bearer) were used. Particleboard was fastened to each joist using 2.8 x 60 mm bright jolt head (JH) nails at 150 mm centres. It was not nailed to the blocking. Because these nails pulled through the particleboard (edge failure) in this test, the nails were closed up to 100 mm in all subsequent tests to allow the required load to be transferred to the joists. Although this is closer than normal construction it was intended to simulate the load transfer provided by activated nails well away from the pile in full size specimens. In terms of joist roll-over resistance, the closer nailing should not significantly affect extrapolation from the test results to actual construction conditions.

2.3.2 JOIST002 (See Figure 5 and Photo 2)

Full depth blocking (200 x 50 mm) was used with 100 x 4 mm skew and horizontal nails between joist and blocking and joist and bearer. A 240 mm length of 100 x 1 mm perforated nail plate was nailed to both the blocking and bearer with 14, 3.15 x 30 mm pan head galvanised nails into each.

2.3.3 JOIST003 (See Figure 6 and Photo 2)

The same as JOIST002 except a 190 x 116 mm claw (hammer in) nail plate replaced the 250 x 100 x 1 mm nail plate. (The long direction of the claw nail plate ran parallel to the bearer.)

2.3.4 JOIST004 (See Figure 7 and Photo 3)

The same as JOIST003 except that the single claw nail plate was replaced with two 127 x 116 mm claw nail plates, located close to the ends of the blocking and both on the same side of the blocking. Teeth orientation was as per the previous test, i.e., wide side of teeth perpendicular to the grain. Only about 80% of the teeth were hammered cleanly into the timber, the rest being distorted and showing only partial penetration.

2.3.5 JOIST005 (See Figure 8 and Photo 3)

This construction was similar to JOIST001. However, the blocking depth was the same as the joist depth (200 mm) and only seven 100 x 4 mm FH nails at 75 mm spacing were used at the base. The blocking overlapped the bearer by 75 mm, leaving a 75 mm gap between blocking and flooring.

2.3.6 JOIST006 (See Figure 9 and Photo 4)

Blocking and bearer were joined by a 100 mm wide strip of 12 mm construction grade ply with 11, 30 x 2.8 mm galvanised plasterboard clouts at 50 mm centres between the ply and either blocking or bearer.

2.3.7 JOIST007 (See Figure 10 and Photo 4)

At each joist, a 350 x 50 mm long Radiata pine post was used to connect the joists to the bearer. The post was nailed to the side face of the bearer using eight 100 x 3.75 mm diameter FH nails in a square pattern. Nail spacing was selected to be the minimum necessary to conform with requirements of SANZ (1990b). Three horizontal nails linked the post to the joist, and the usual two skew nails were installed between bearer and joist.

2.3.8 JOIST008 (See Figure 3 and Photo 1)

This specimen was constructed using three joists, each separated by full depth blocking along the axis of the bearer. The usual nailing pattern applied, except three 100 x 3.75 mm diameter FH nails were installed on each side of the blocking (between blocking and bearer). The particleboard sheet was only 0.9 m wide and was 1.7 m long and extended 100 mm past the two end joists.

2.3.9 Specimen 1 to Specimen 4 (See Photo 5)

These four specimens were tested about 5 months later than the other test specimens. They were constructed from fully saturated timber and allowed to dry in a semi-covered exterior environment for 3 months, before being placed under cover for the last month. Rain was periodically driven beneath the shelter to wet the particleboard sheets, softening the top surface. This represented typical though not desirable construction practice.

The specimens were all constructed to a similar specification to JOIST008 except the particleboard sheet was 1.5 m wide and only 1.2 m long and two (rather than three) skew nails per blocking piece per side were used between blocking and bearer. At each end the sheet terminated at the centre of the joists (i.e., about 23 mm from the outside edge) and bright rather than galvanised nails were used. The nails were placed nominally 12 mm from the end edge (actual distance varied from 7 to14 mm, with average about 10 mm). This may have significantly affected test results (discussed later).

3. TEST RESULTS

The load versus deflection curves (hysteresis loops) generated during testing are presented in Appendix A. During some tests, computer problems caused small portions of data to be lost. The only practical effect of this has been that some loops have portions omitted rather than being one continuous line. A summary of the number of cycles to predetermined load levels is given in Table 1.

Five different construction methods were found to have the required 12 kN connection strength. This force can be converted to equivalent bracing units (BU) as defined in NZS 3604: 1990. It is useful to do this conversion for situations where the joists are located directly over concrete, masonry or sheet material foundation walls and it is required that maximum bracing is transmitted to the walls below. Using methods from Thurston (1992), the bracing ratings can be derived as 20 x 12 = 240 BU for wind, and 15 x 12 = 180 BU for earthquake. However, bracing values used in design must not exceed that of the foundations below the joists. Reputable published values only should be used.

3.1 General Description of Failure Mode

3.1.1 JOIST001 to JOIST008

Unless otherwise stated, failure mode refers to the joists pulling away from the blocking, as shown in Figure 11. This is called the standard failure mechanism. Nails tended to pull out near the top of the joist "C" (as shown in Figure 11), and the blocking pushed the base of joist "C" in the direction of the load. The outside skew nail heads were sometimes forced out of joist "C" at high loads: whereas joist "T" opened near the bottom and often lifted upwards from the bearer, pulling skew nails out of the bearer with the heads being pulled back against the joist.

3.1.2 Specimen 1 to Specimen 4

Although the same deformation mechanism as described above was seen, the failure in all these specimens occurred from the nails pulling out through the ends of the particleboard sheet (sometimes displacing a wedge of particleboard in front of the nail) and sometimes by the nail head being dragged completely through the sheet. Failure resulted from loading the nails directly away from the sheet edge. However, this is not considered to be a realistic loading condition: in practice the loading to the sheet in this direction will tend to be from compression of the adjacent sheet (see Figure 12). This confinement is expected to result in an increase in the nail pull-through failure load for the nail loaded perpendicular to the particleboard edge.

In no instance did the skew nailing between the blocking and bearer show significant distress.

3.2 Failure Modes for Different Specimens

3.2.1 JOIST001 Loads Resisted = 4 cycles to 16 kN and failure at about 18 kN

The standard failure mechanism occurred, except that the final load was limited by the jolt head (JH) nails either pulling through the particleboard (PB) or out of the joists. Joist T rotation was significantly less than joist C rotation. The ten 100 x 3.75 mm diameter flat head (FH) nails between blocking and bearer showed no sign of distress and the blocking remained relatively fixed with regard to the bearer. Due to a computer malfunction the latter portion of test data was lost. The loads noted above and in Table 1, and the plots in Appendix A, are for the first portion. Test notes indicate that four cycles at 16 kN were resisted before the nails pulled through the PB edges at about 18 kN.

Joist uplift measurements showed that both joists lifted about 7 mm with one joist settling about 1.5 mm. This indicates that partition walls preventing this uplift can contribute to resisting joist roll-over.

3.2.2 JOIST002 Peak Loads Resisted = 21.5 kN and -16.2 kN

The 240 x 100 x 1 mm nail plate connection appeared to be very stiff with no visible gaps opening between the blocking and joists until the ±12 kN cycle. Then, the standard failure mechanism started to develop. The nails did not pull through the PB to the same extent as JOIST001. It should be noted that there were more JH nails fastening the flooring to the joist in this test and the nails were galvanised. About 50% of the nail heads had started to pull through the PB - generally 3-5 mm at test completion. The skew nails were observed to be "working hard" (i.e., nails were working loose, deforming the local timber and distorting, thereby indicating that they had been loaded close to their ultimate capacity).

3.2.3 JOIST003 Peak Loads = 13.3 and -12.4 kN

At the first cycle to ±12 kN the only distress in the 119 x 116 mm claw nailplate appeared to be slight buckling undulations. However at further cycles to ±12 kN at one top corner of the plate the teeth started to pull out of the blocking, and continuation of this finally "unzipped" the connector and the load capacity of the joint dropped away. This joint was more flexible than JOIST002 which utilised the 200 x 100 mm nail plate.

3.2.4 JOIST004 Peak Loads = 17.8 and -16.9 kN

The 127 x 116 mm plates buckled and warped but the connection maintained its strength until the teeth on one plate pulled out.

3.2.5 JOIST005 Peak Loads = 11.4 and -10.2 kN

This 300 x 50 mm timber blocking connection was quite flexible and the standard failure mechanism developed early and limited the joint capacity. The seven nails between blocking and bearer showed no signs of distress, i.e., did not appear to be "working hard".

3.2.6 JOIST006 Peak Loads = 19.1 and -17.1 kN

The standard failure mechanism dominated in this joint with the ply/blocking and ply/bearer connection showing little sign of distress or relative movement.

3.2.7 JOIST007 Peak Loads = 10.0 and -10.3 kN

Although this joint (which utilised a pine post connection) was initially moderately stiff, beyond about 7 kN load (when the standard failure mechanism started to occur) the stiffness rapidly reduced. The eight 100 x 4 mm FH nails in a square pattern between post and bearer showed little sign of being "worked hard". It is suspected that the load was being non-uniformly resisted by the joists. If one joist resisted 6 kN and the average "radius" fitting the square nail pattern was 50 mm, the load/nail = 6 x 0.25/0.05 x 8 = 3.8 kN. Some distress should be expected. A stiffer detail may have been one post either side of the same joist. This would have contained and helped prevent the failure mechanism, shown in Figure 13.

3.2.8 JOIST008 Peak Loads = 31.8 and -31.2 kN

This construction, of three joists with full depth blocking along the axis of the bearer, was very stiff up to cyclic loads of ±15 kN. Exterior joists "rotated" as per the standard mechanism but the centre joist remained near vertical with the PB apparently "slipping" over this joist. At higher loads, large "sliding" movement (i.e., nail failure) between the centre joist and the PB took place (Figure 14). However, the final failure was nail pullout "unzipping" from one end of one external joist. The skew nails from blocking to bearer showed little sign of distress, with the blocking lifting slightly at alternate ends for each load direction.

It would appear that double blocking is more than twice as effective as single blocking in resisting joist roll-over forces. If a wider PB strip had been used (i.e., more nails from PB to joist) more load may have been resisted. Note that nailing PB to joist was at 100 mm centres.

The four specimens below were similar in construction to JOIST008. The main difference was that two rather than three skew nails were used each side of each blocking.

3.2.9 Specimen 1 Peak Loads = 17.8 and -18.8 kN

These particular joists were severely curved indicating high non-uniform drying strains. Without warning about six nails simultaneously pulled out of the ends of the particleboard sheet, at the peak load after the fourth cycle to 16 kN.

3.2.10 Specimen 2 Peak Loads = 21.5 and -20.6 kN

No edge nails had pulled pulled out of the ends of the particleboard sheet after four cycles to 16 mm. One nail pulled through at the first push to 20 kN and about four pulled through at the first peak pull to this load.

3.2.11 Specimen 3 Peak Loads = 15.8 and -20.6 kN

A cut edge of particleboard sheet was used at one end of the specimen and the nail edge distances were very small there. One was 7 mm, another 8 mm, and two were 10 mm. The nails pulled out through this end during the first cycle to 16 kN and the load in this direction could not be re-estabished. These results consequently were considered unrealistically low and were ignored. Most nails pulled out of the other end of the particleboard sheet at the peak pull load of 20.6 kN, after the four cycles to 16 kN.

3.2.12 Specimen 4 Peak Loads = ±20.9 kN

The nails progressively pulled out of the ends of the particleboard sheet during cycling to ±20 kN, until sudden failure occurred.

4. CONCLUSIONS

The New Zealand Standard for light timber framed construction not requiring specific design - NZS 3604:1990 (SANZ, 1990a) requires construction details at each anchor or braced pile to resist a joist "roll-over" force of 12 kN. Five practical methods of achieving this were tested successfully and the results presented. These results apply where the joist spacing divided by the joist height is not less than 2. For New Zealand use, the durability requirements of Section 2.2 of NZS 3604:1990 must be satisfied which may require hot dipped galvanising to SAA (1981) (rather than just zinc plating) of steel nail plates in damp situations.

The BRANZ recommended detail, to resist the 12 kN code specified joist roll-over force, is a double blocking system with eight skew nails (as used for Specimens 1 to 4 in the report). This detail can generally be made with offcut building materials (with consequent cost savings) and is easy to install on site.

Four other solutions have sufficient strength. These systems all use a single timber blocking fitted between joists and nailed with conventional nailing and strengthened as below:

(1) the blocking is deeper than the joist and is nailed horizontally to the bearer below (Figure 4);

(2) a 240 x 100 x 1 mm perforated galvanised steel nail plate was nailed to both the bearer and blocking (Figure 5);

(3) two 127 x 116 mm nail claw plates were used to join the blocking and bearer (Figure 7);

(4) the blocking and bearer were joined by a strip of 12 mm thick H3 treated plywood nailed to both with plasterboard clouts (Figure 9);

Solution (4) is the tidiest and the one that apparently has little operator dependency, but it does require ply to be available on-site.

The bracing strength of the joist roll-over connection may be required where there is a concrete or masonry foundation wall directly under the bearer or where sheet foundation cladding is connected to the bearer. In this instance the above systems are capable of providing a bracing of 240 BU for wind and 120 BU for earthquake. However, the bracing values used in design must not exceed that of the foundations below the joists. Only reputable published values for these should be used.

5. REFERENCES

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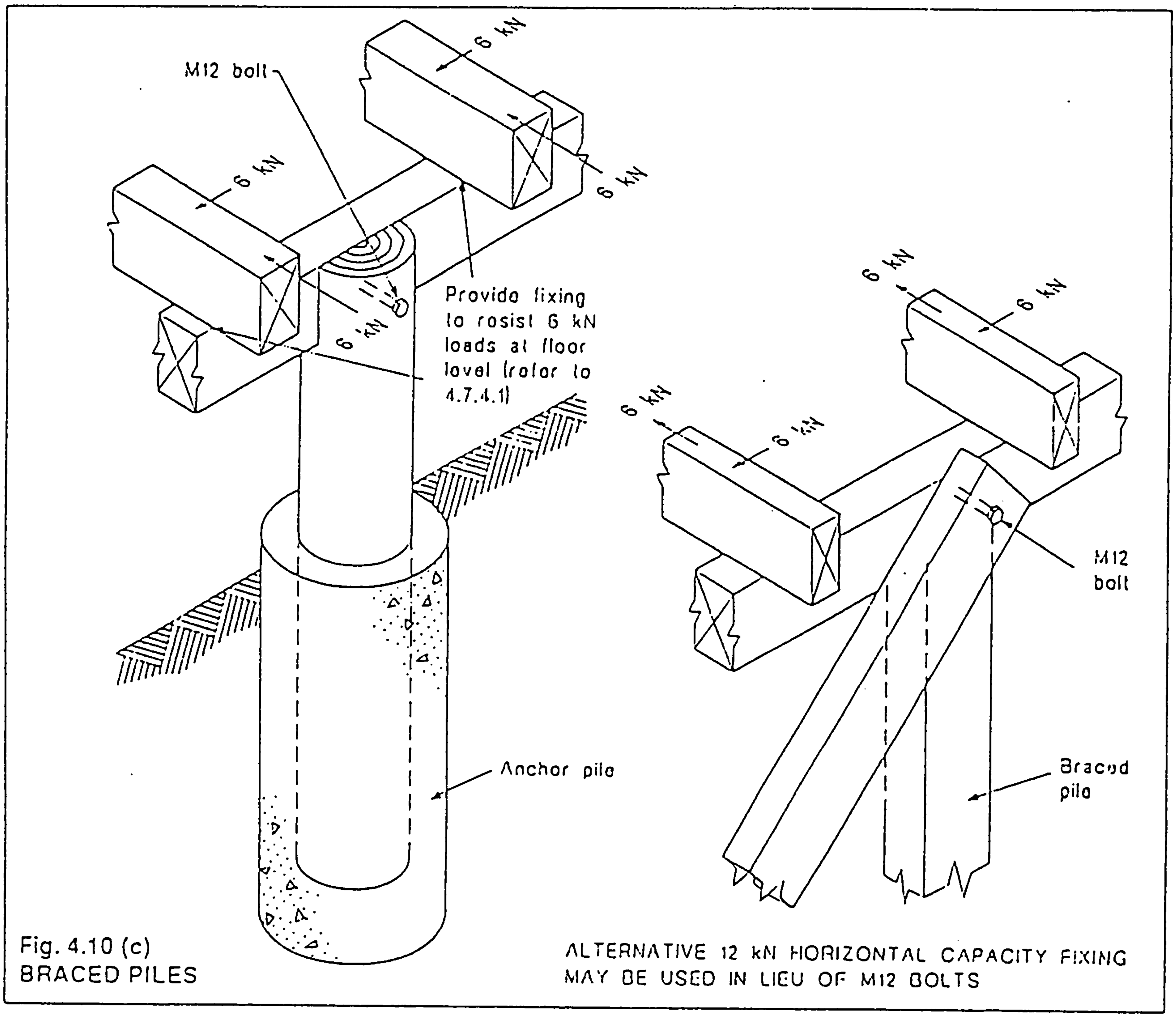


Fig. 4.10 (c)
BRACED PILES

FIGURE 1 EXTRACTS FROM NZS3604 : 1990 (SANZ, 1990)
(REPRODUCED WITH PERMISSION FROM SANZ)

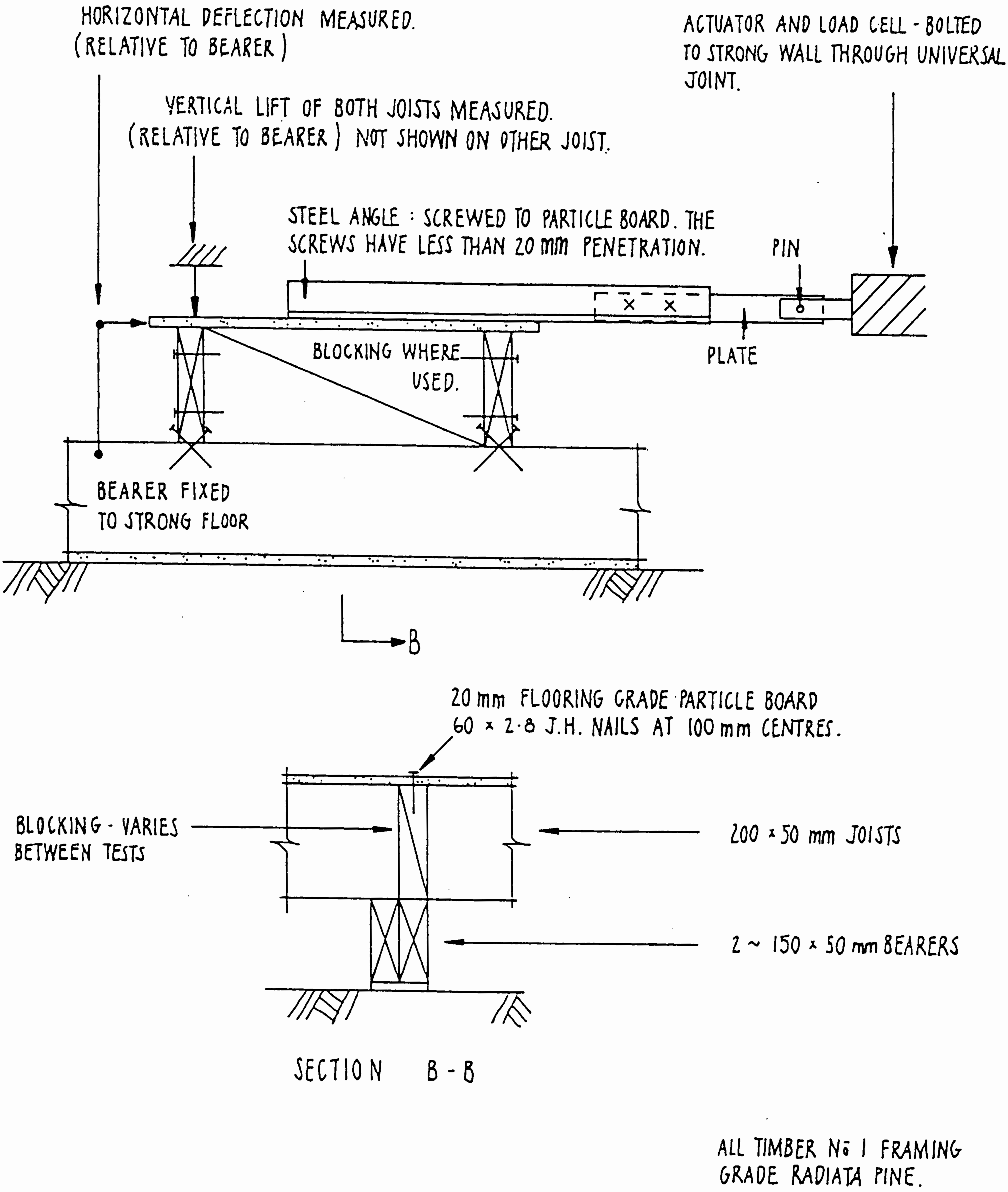


FIGURE 2 : TEST DETAILS FOR TESTS JOIST001 TO JOIST007

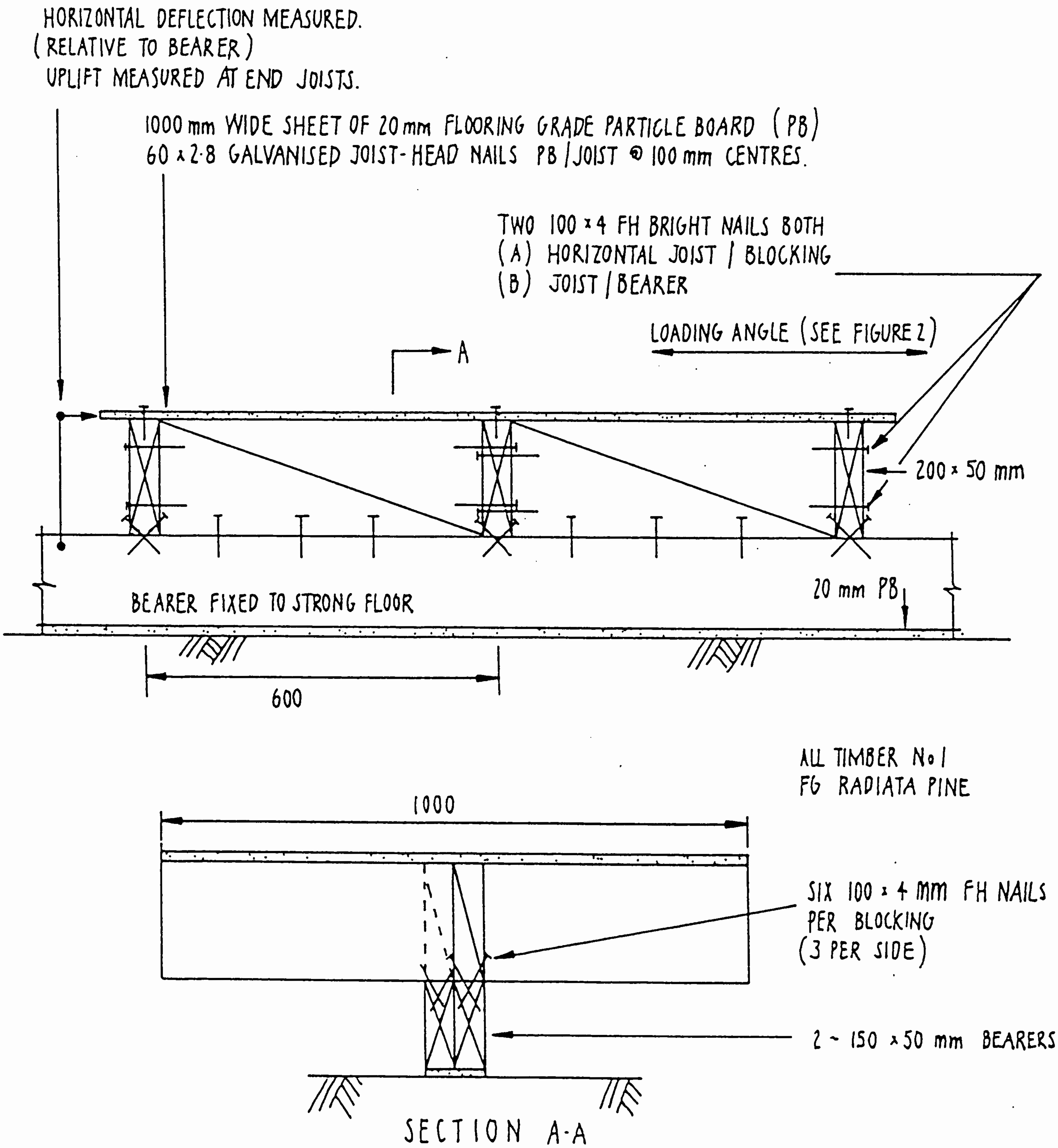


FIGURE 3 : TEST DETAILS FOR TEST JOIST008

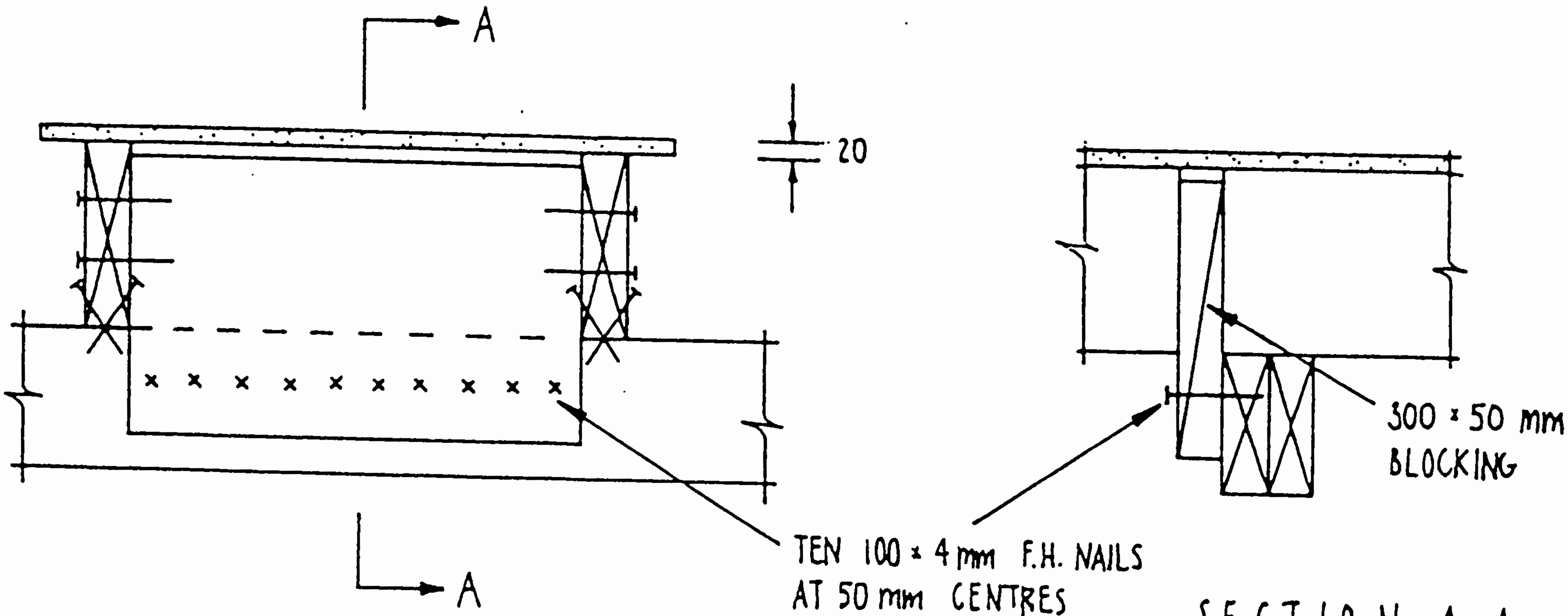
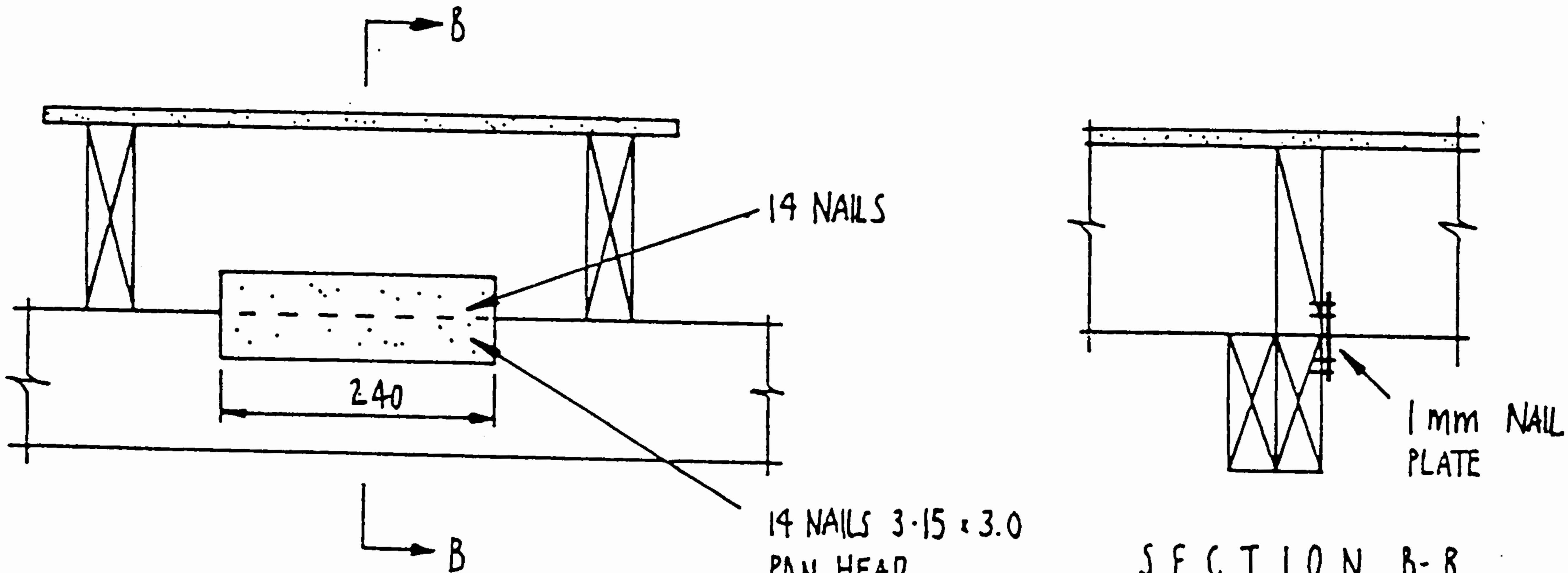


FIGURE 4 JOIST001

SECTION A-A
A'-A' SIMILAR



SECTION B-B
B'-B' AND B''-B'' SIMILAR

FIGURE 5 JOIST002

FIGURE 6 JOIST003 ~ AS FIGURE 5 BUT NAIL PLATE 196 × 116 mm

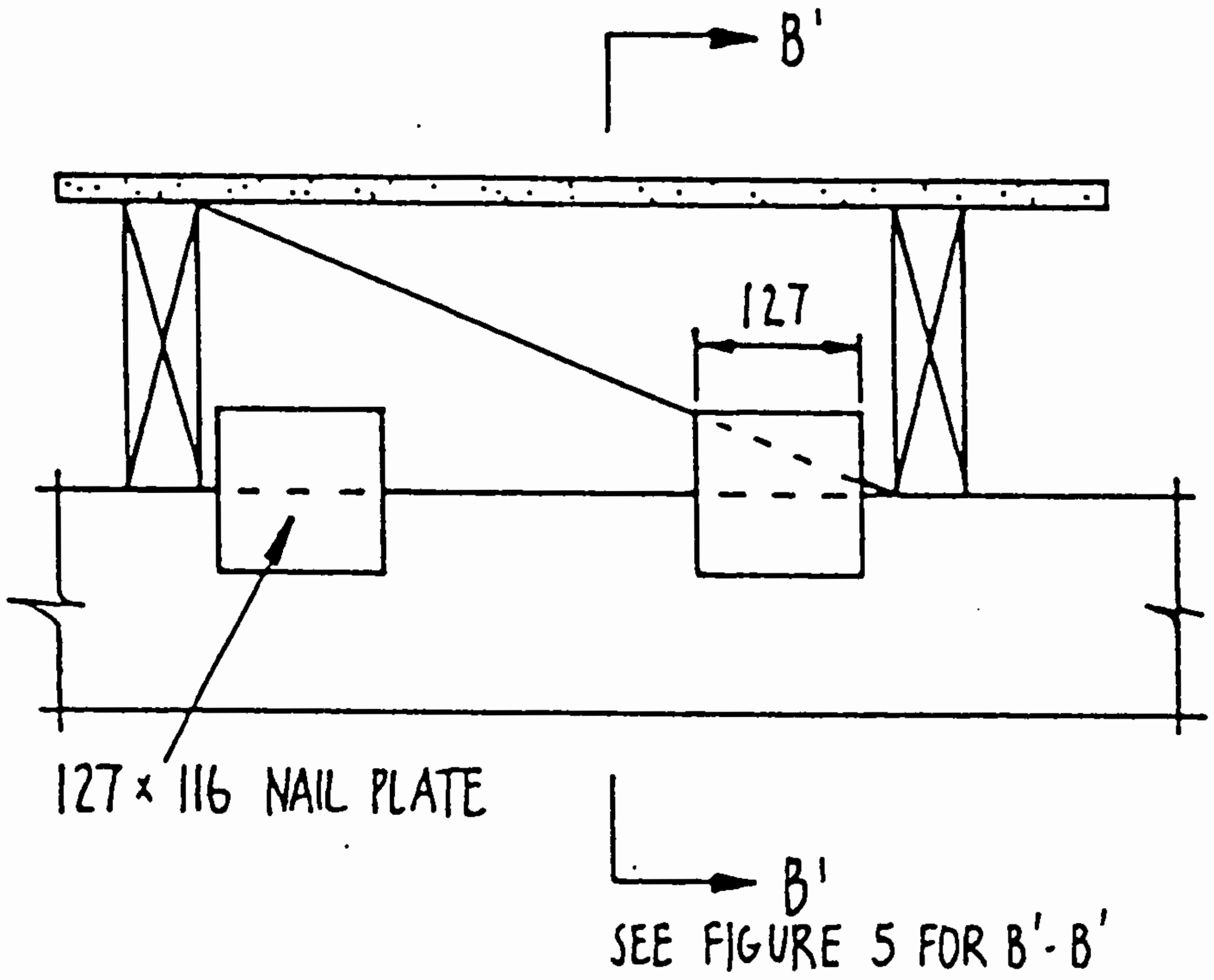


FIGURE 7 JOIST004

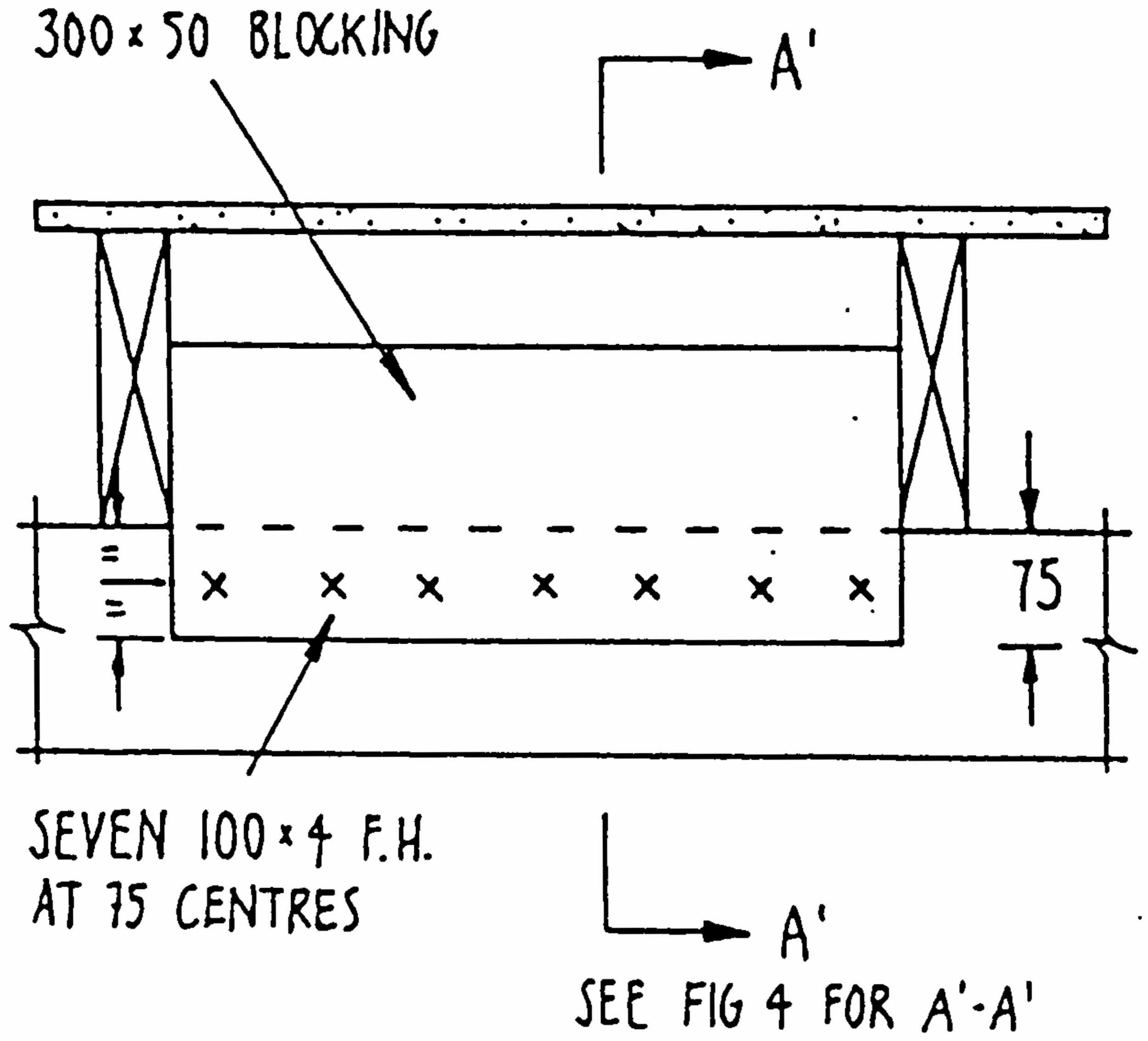


FIGURE 8 JOIST005

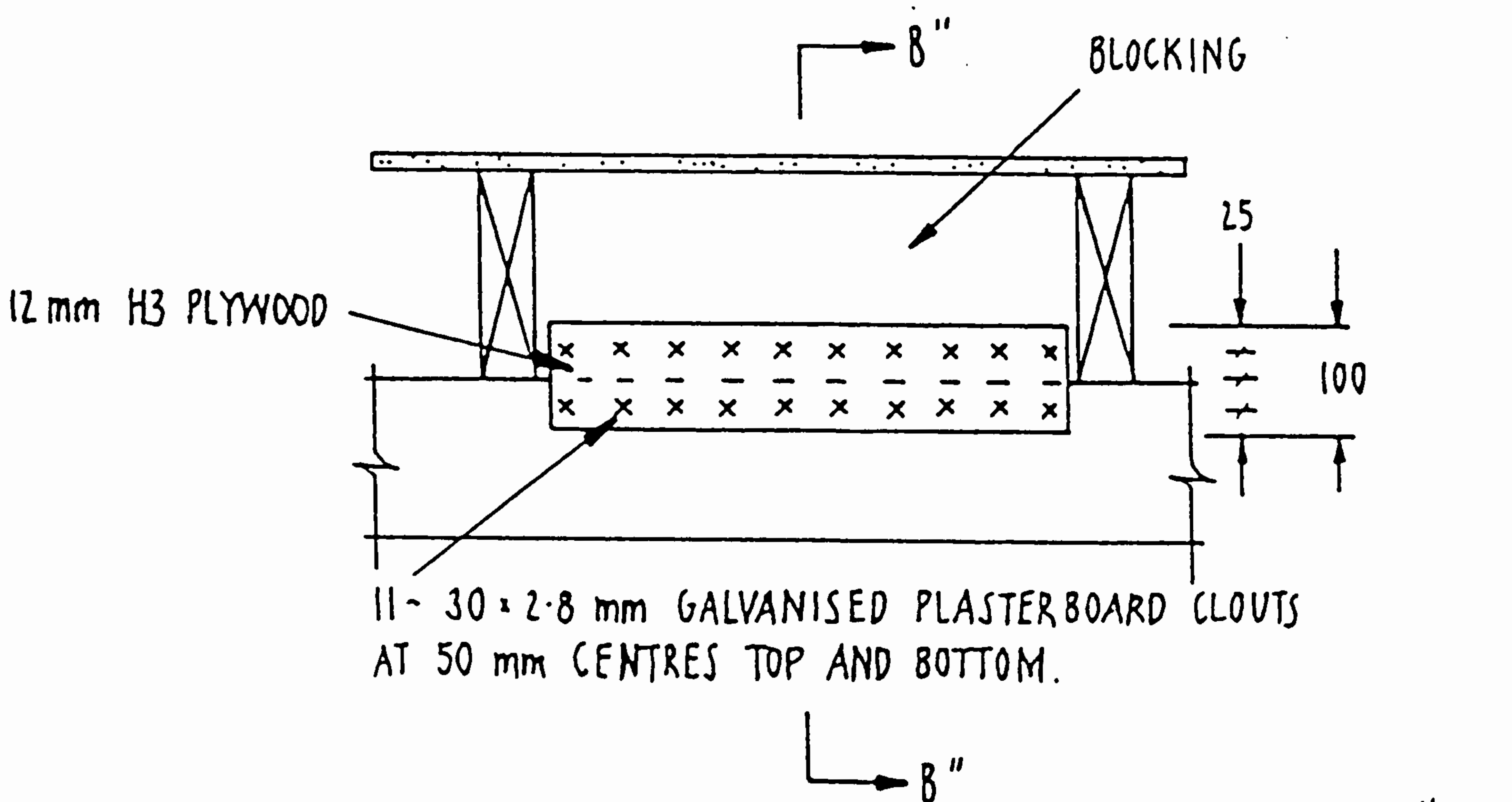


FIGURE 9 JOIST006 SEE FIGURE 5 FOR B''-B''

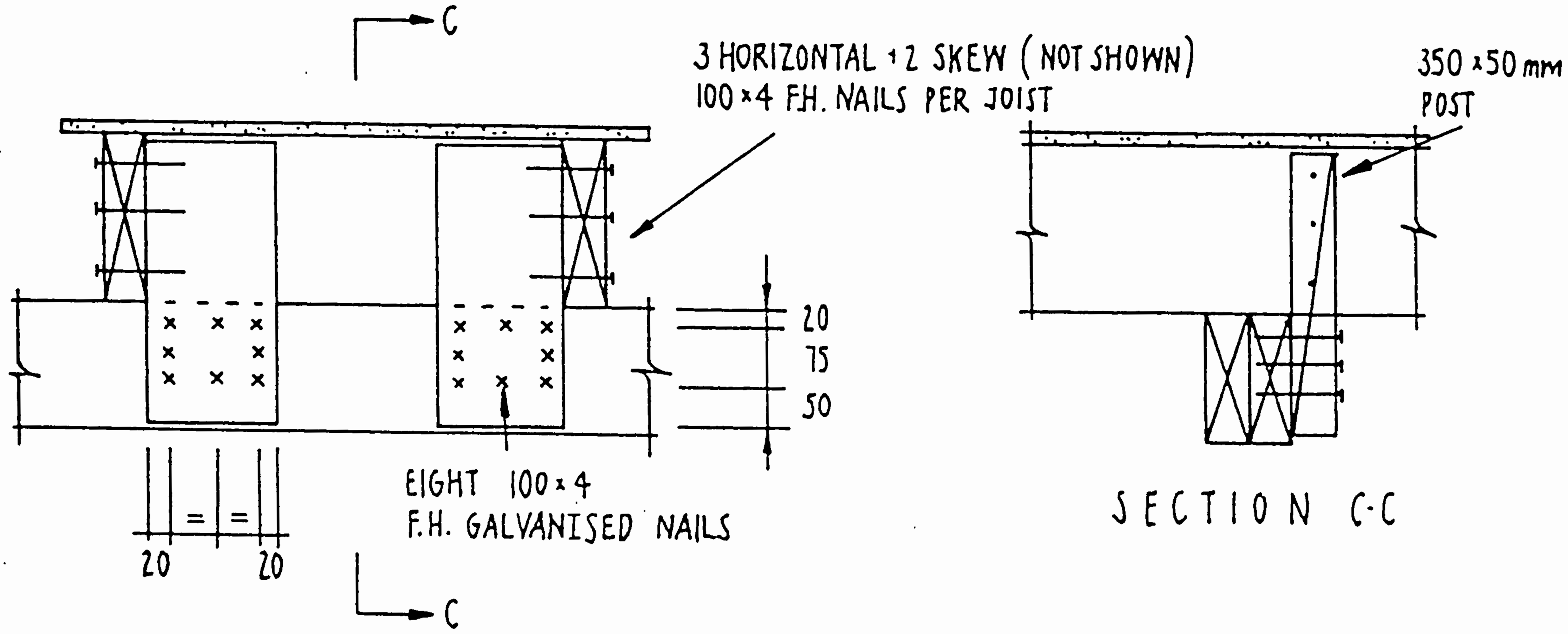


FIGURE 10 JOIST007

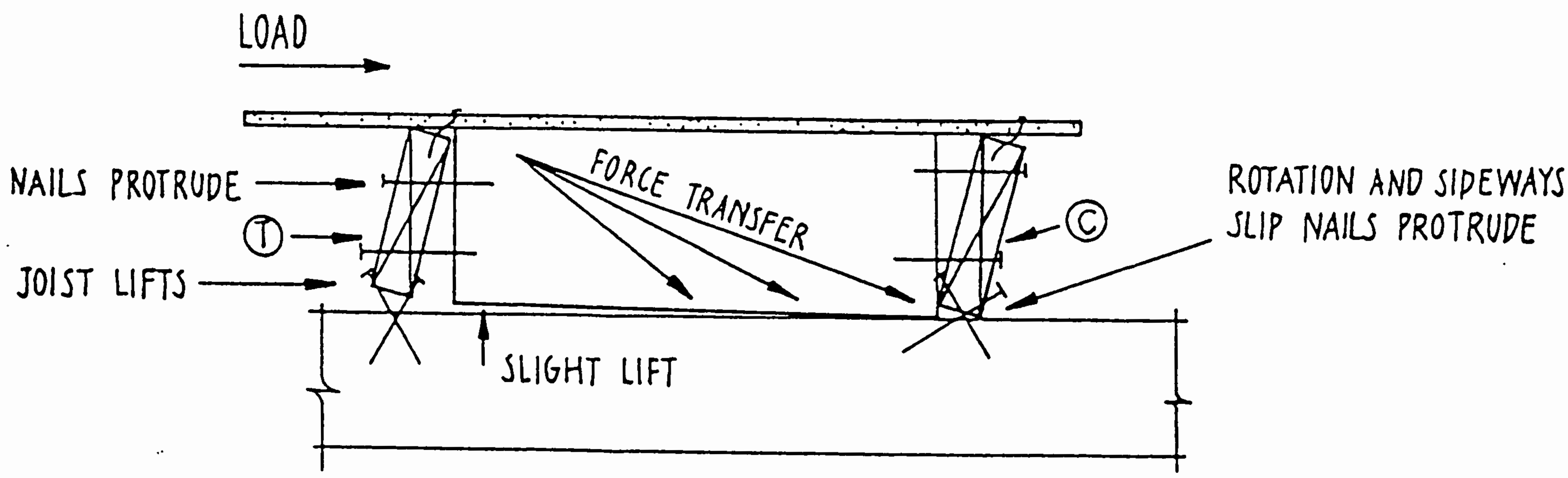
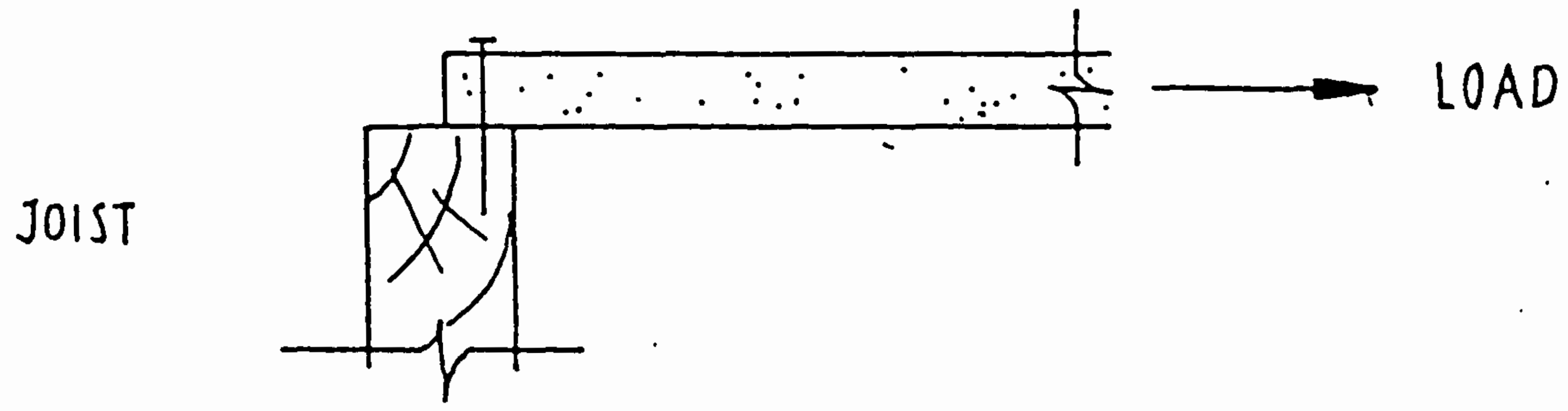
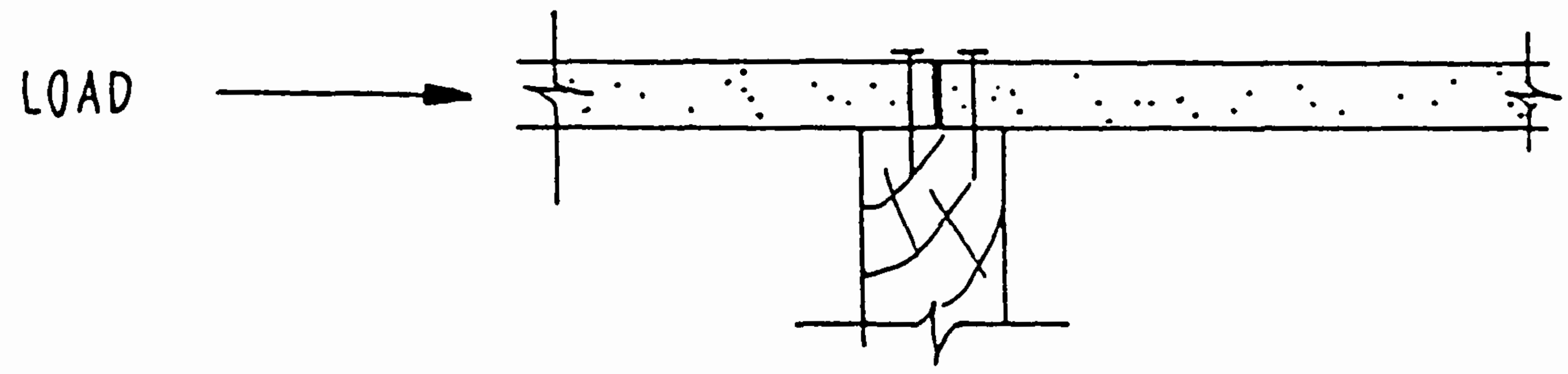


FIGURE 11 TYPICAL DEFORMATIONS



(A) LOAD ON TEST SPECIMEN



(B) LOAD IN REAL STRUCTURE

FIGURE 12 COMPARISON OF LOADING ON TEST SPECIMEN AND REAL STRUCTURE.

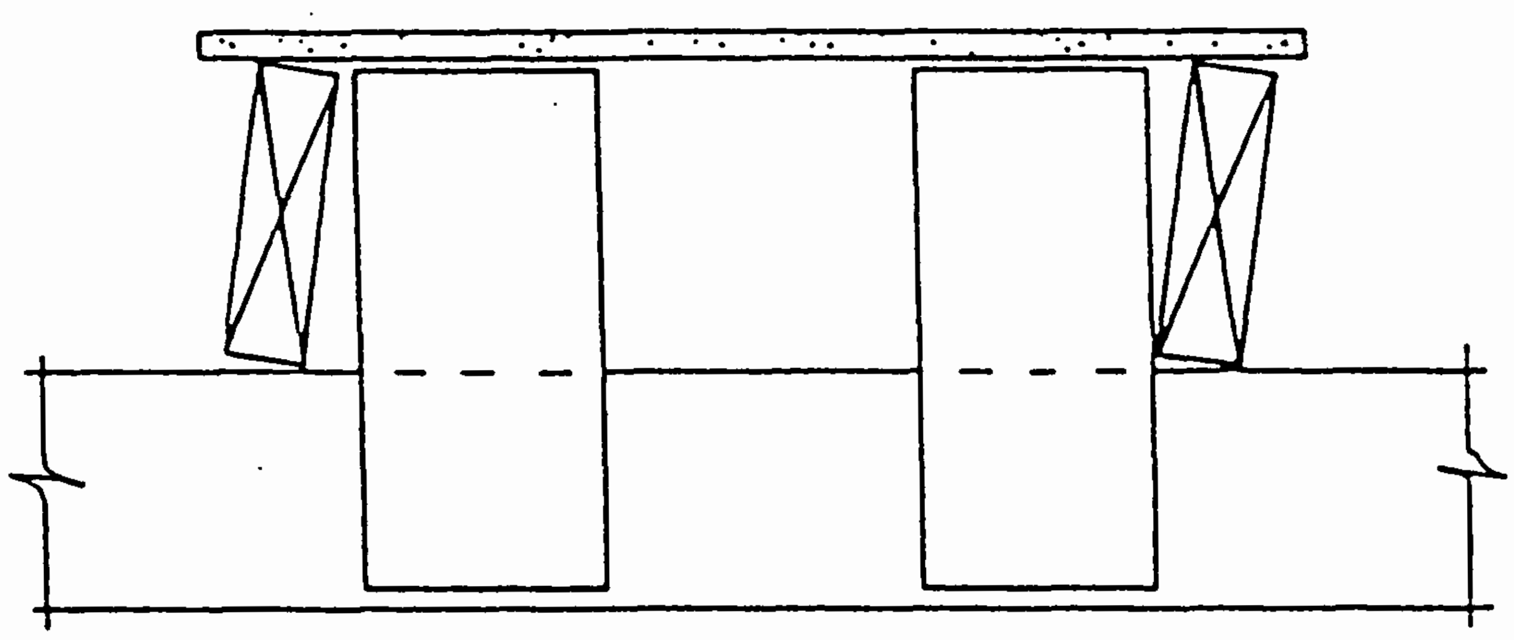


FIGURE 13 DEFORMATION JOIST007

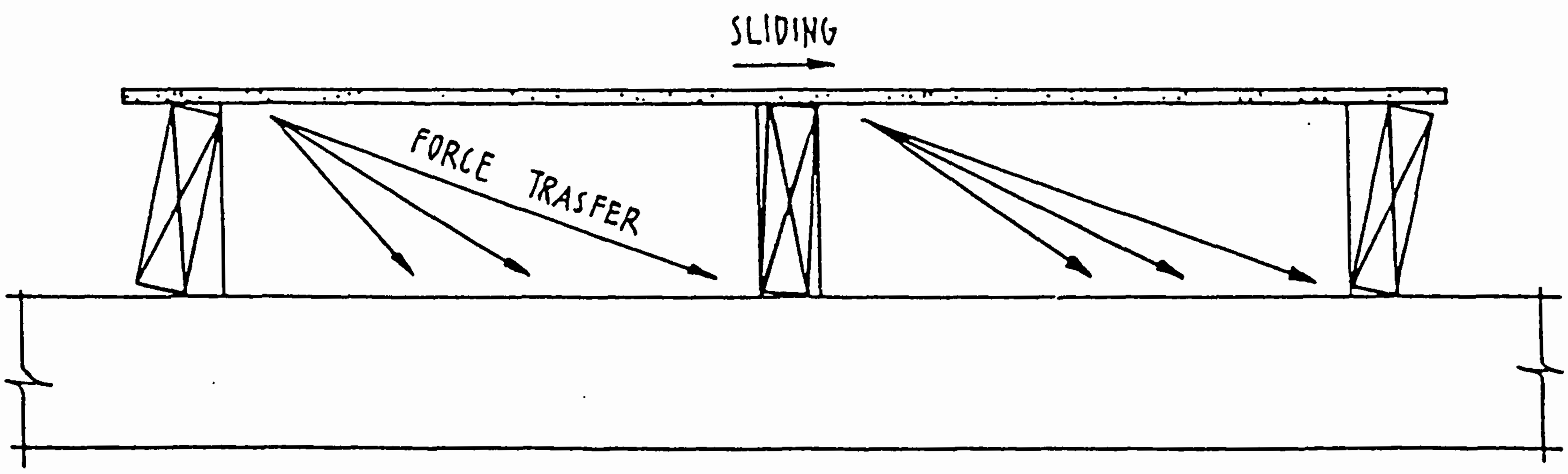
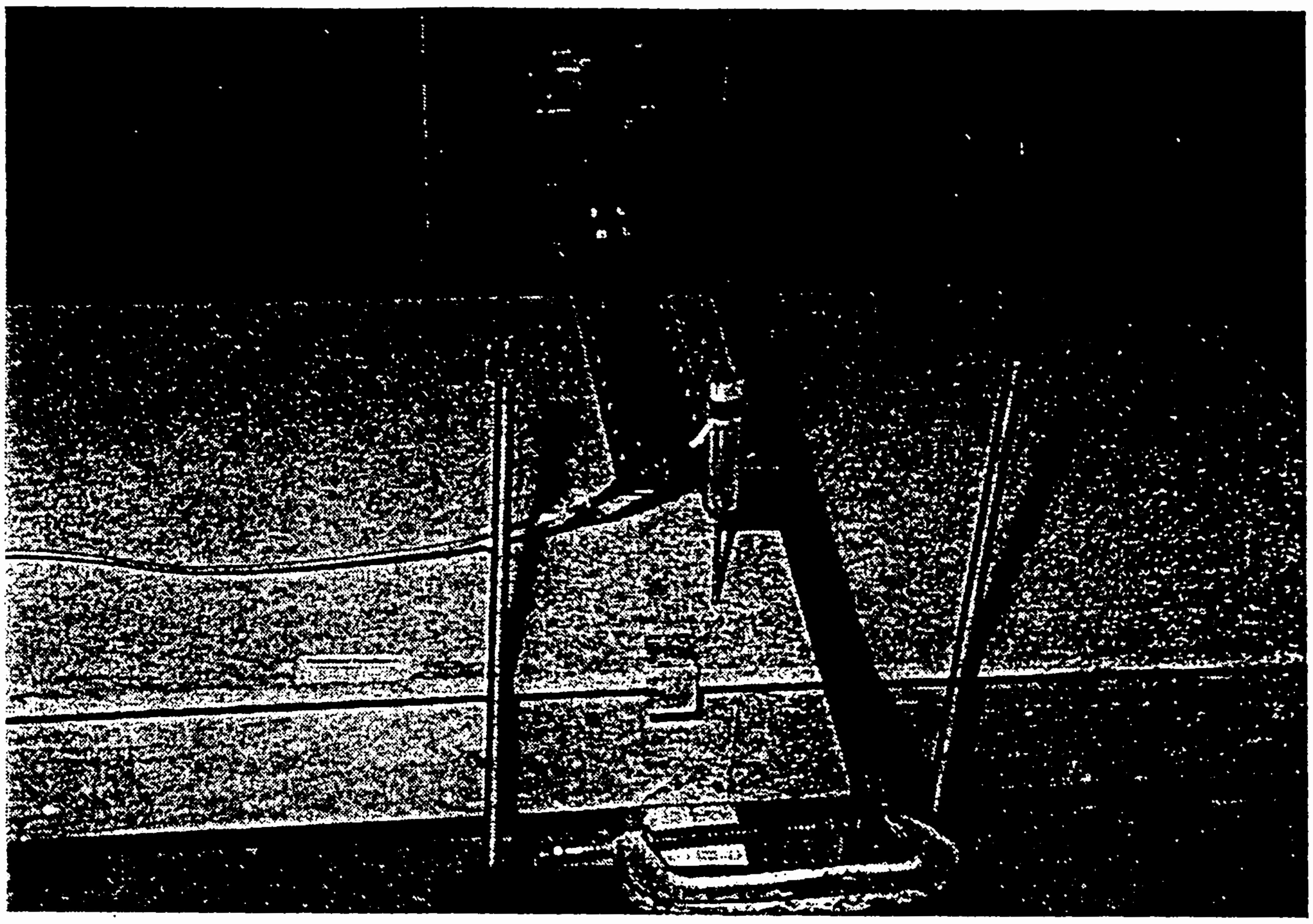


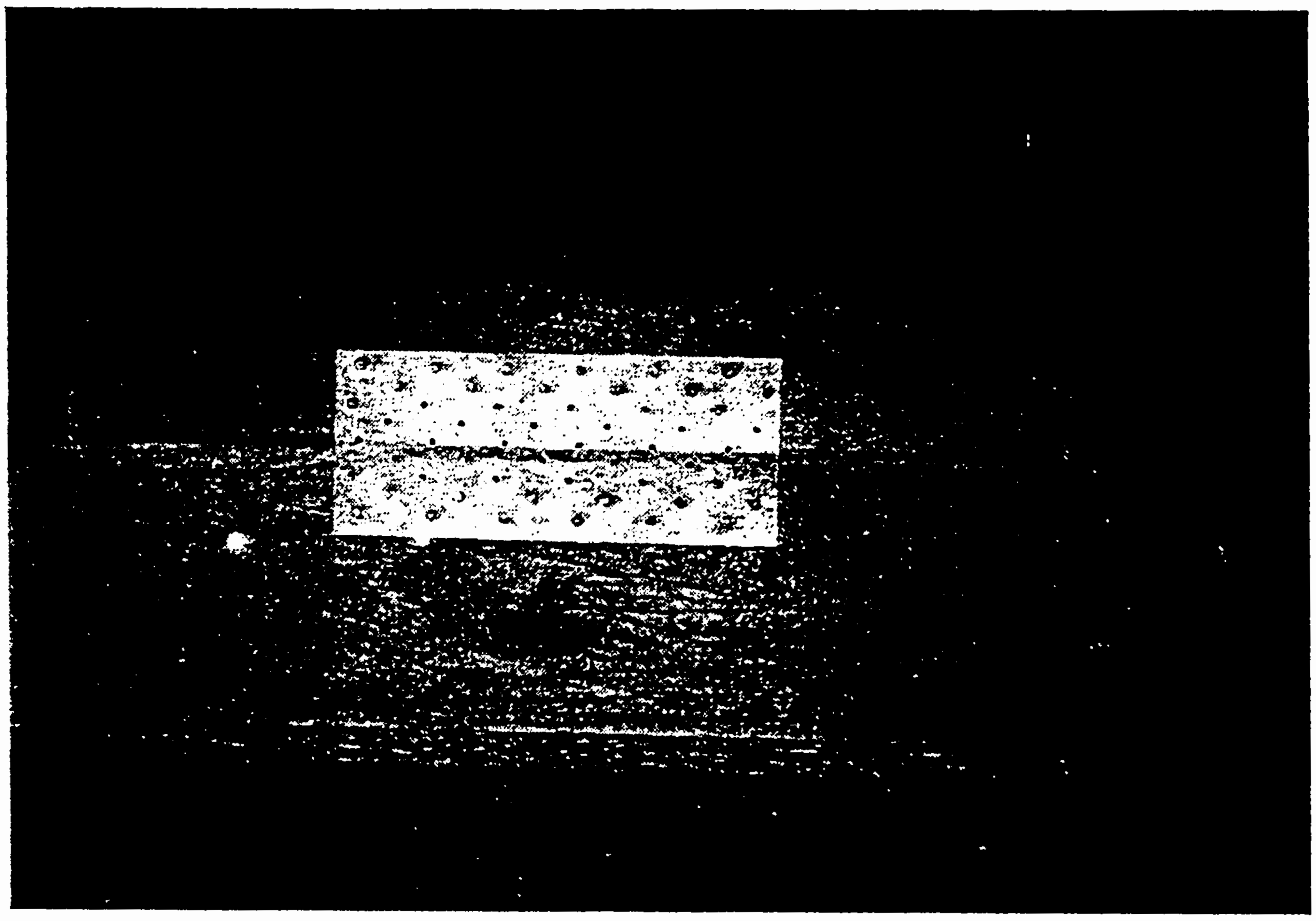
FIGURE 14 DEFORMATION JOIST008



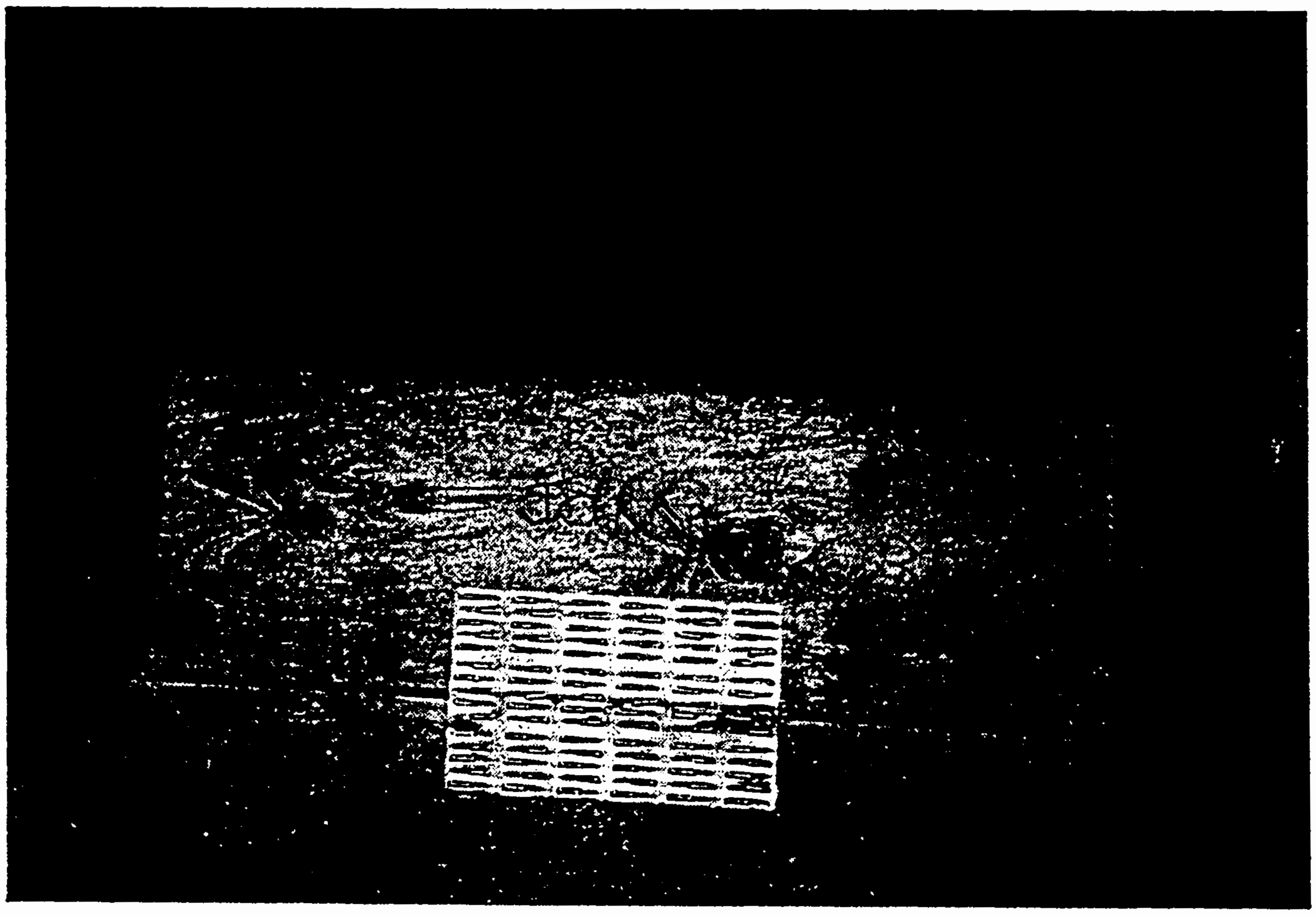
(a) Two joint systems

(b) Three joint system (JOIST008)

Photographs set 1. General test set-up

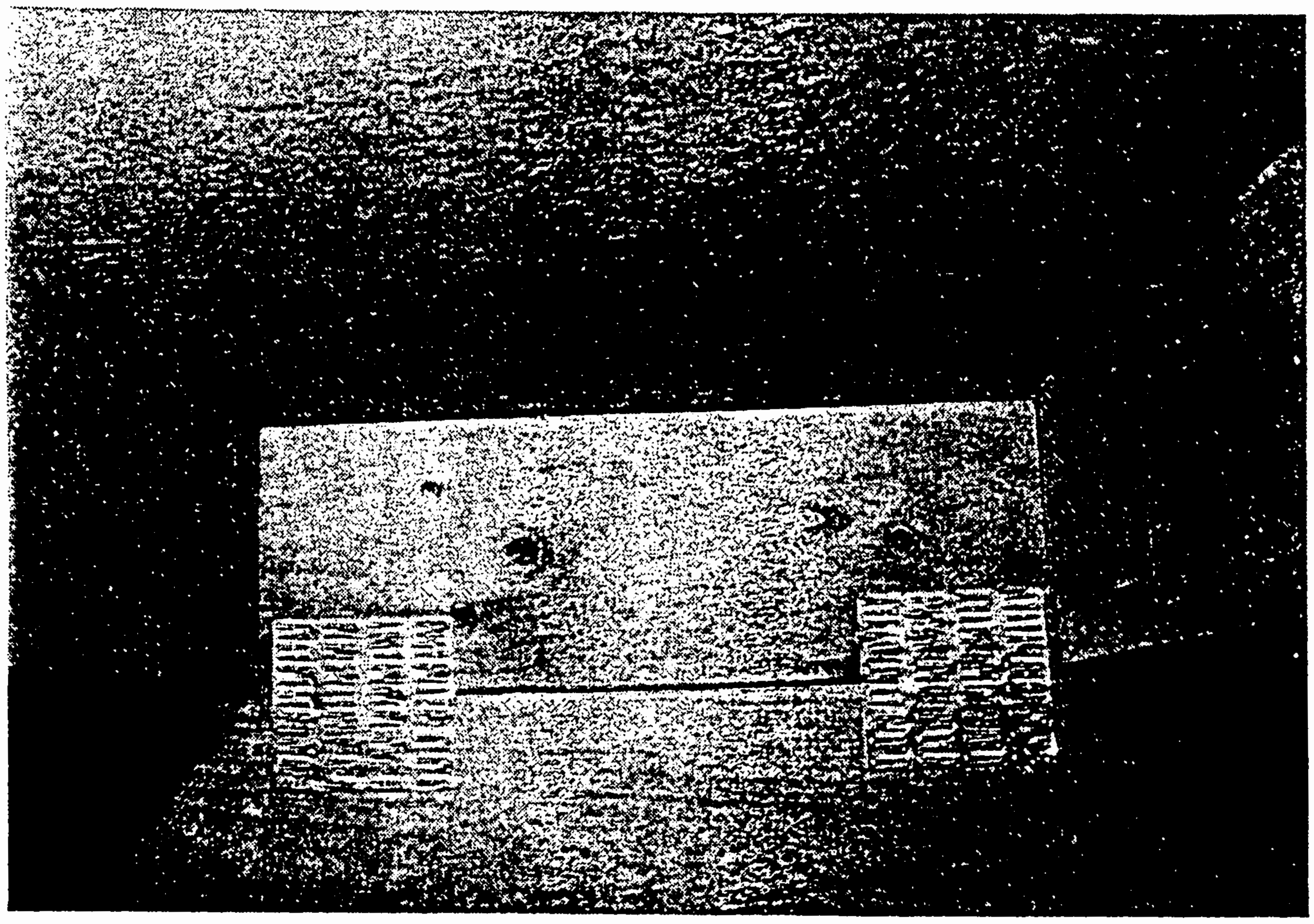


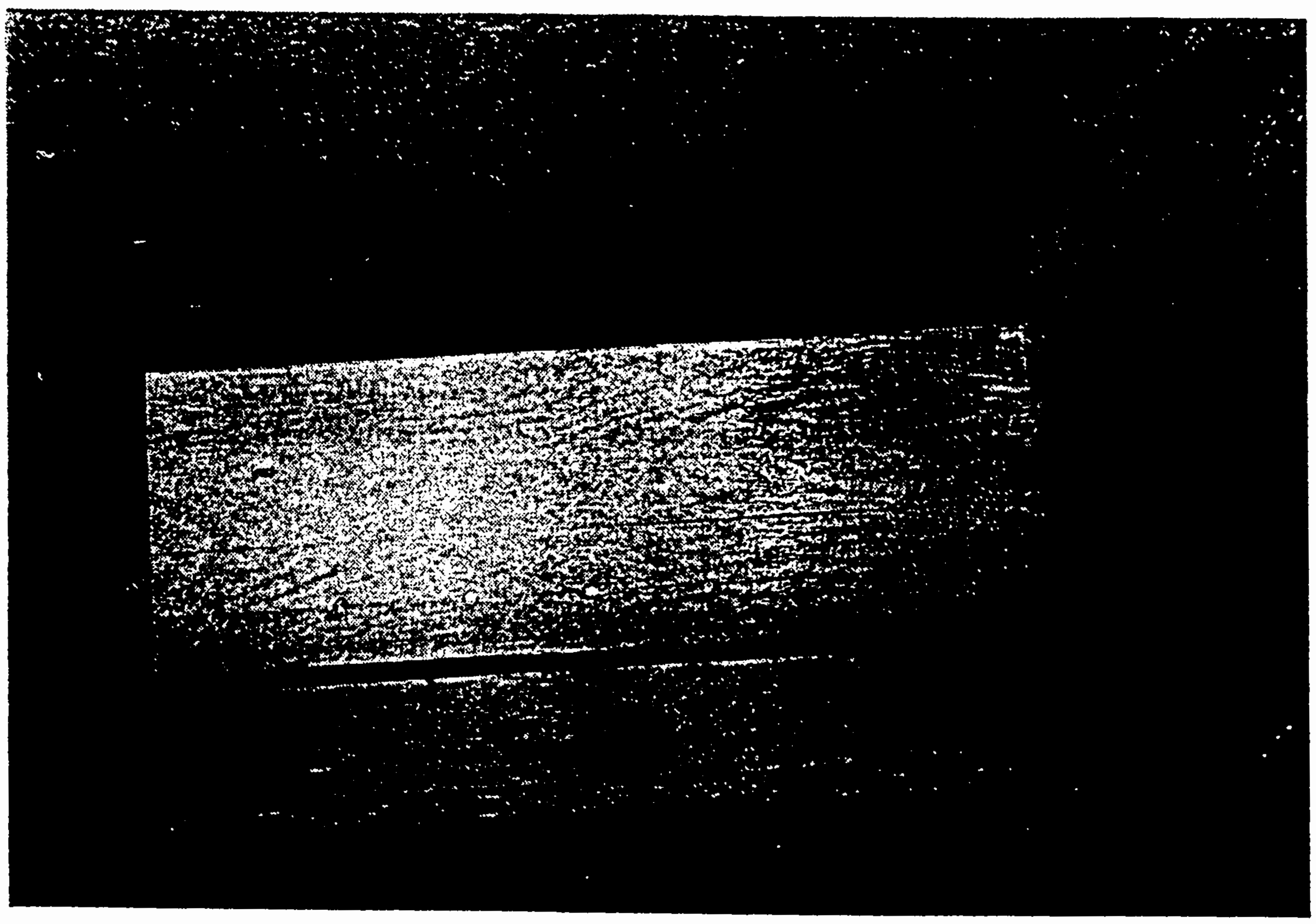
(a) JOIST002 Detail



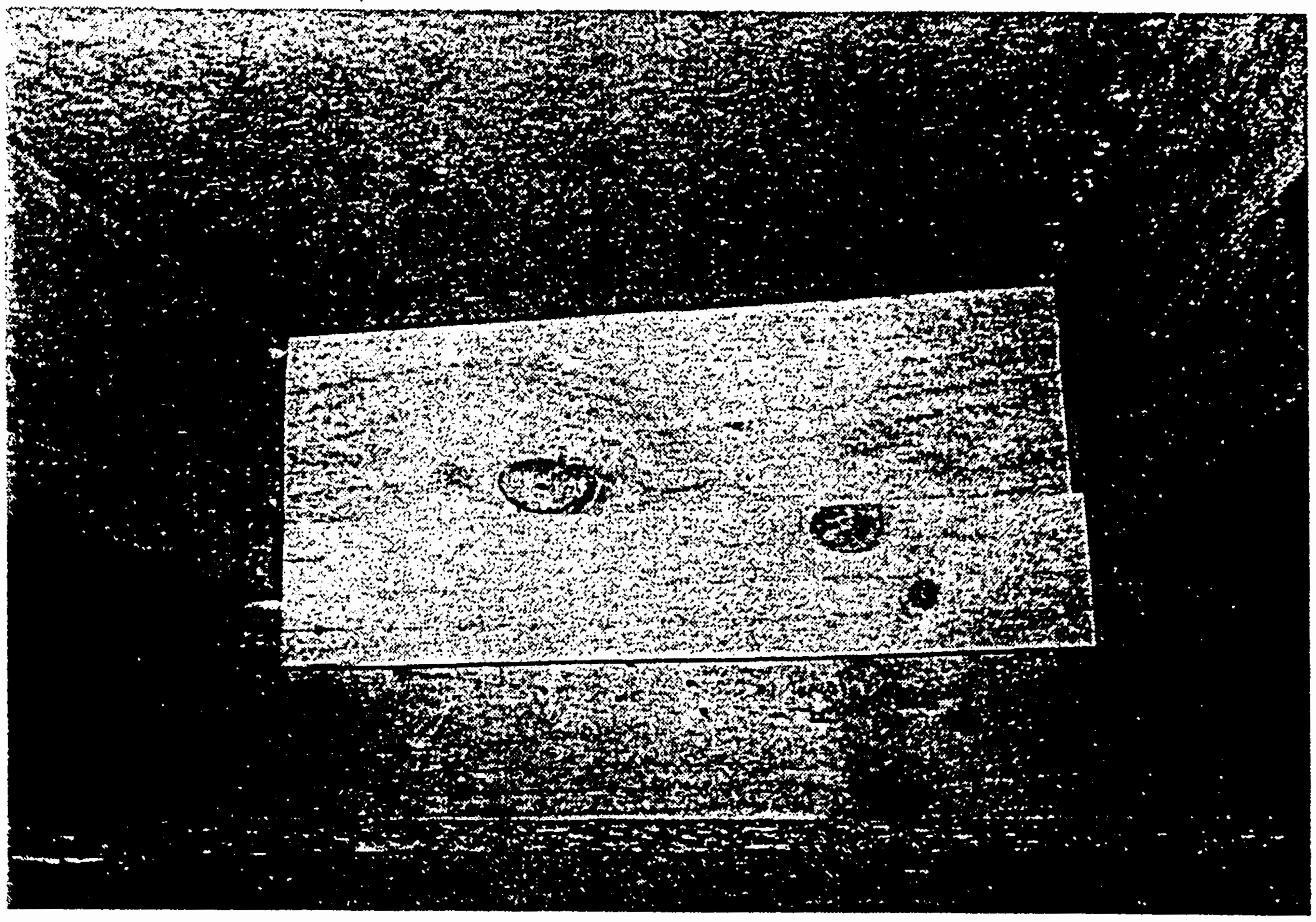
(b) JOIST003 Detail

Photographs set 2. Blocking connection detail (JOIST002-3)

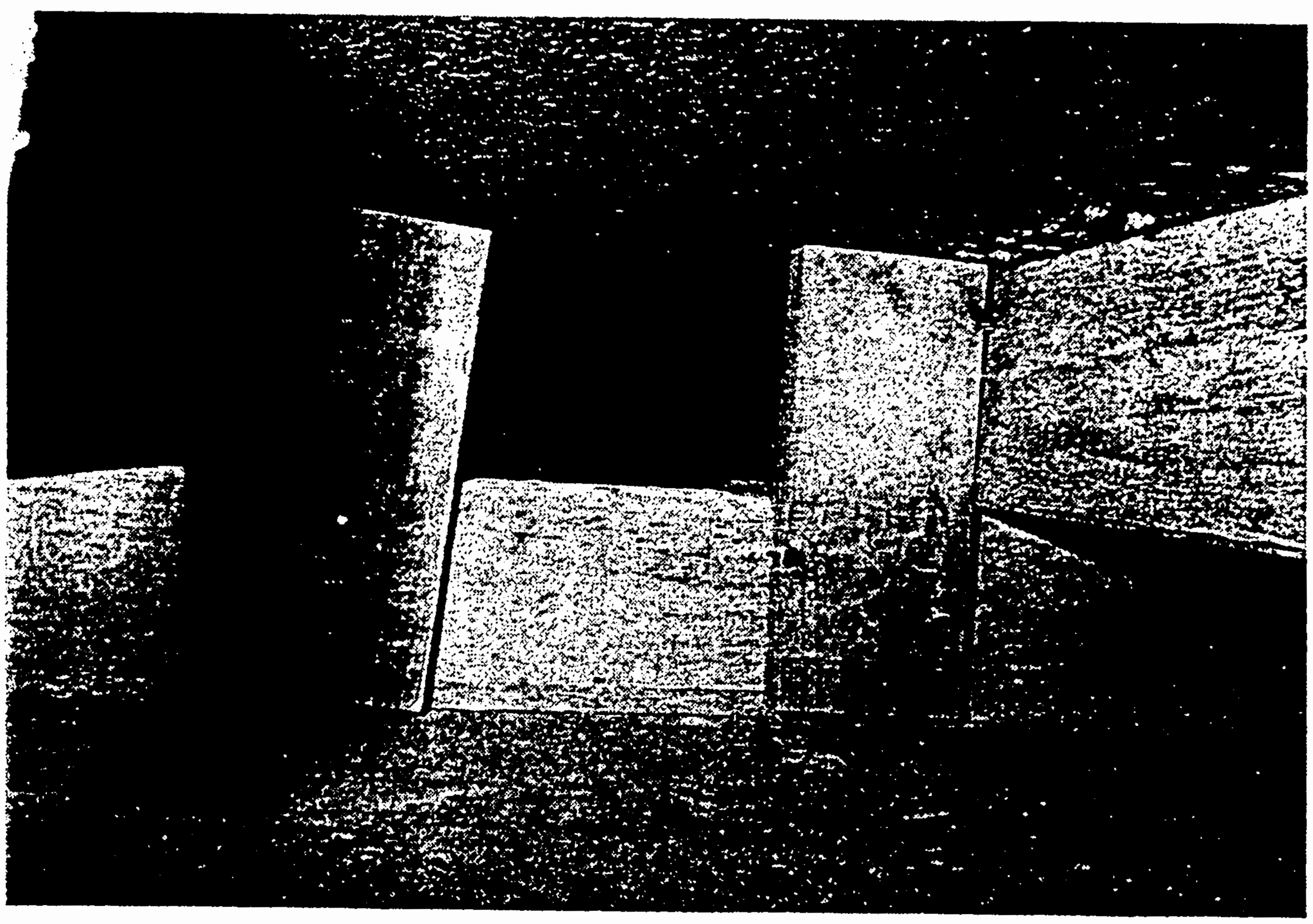

((a) JOIST004 Detail


(b) JOIST005 Detail

Photographs set 3. Blocking connection detail (JOIST004-5)

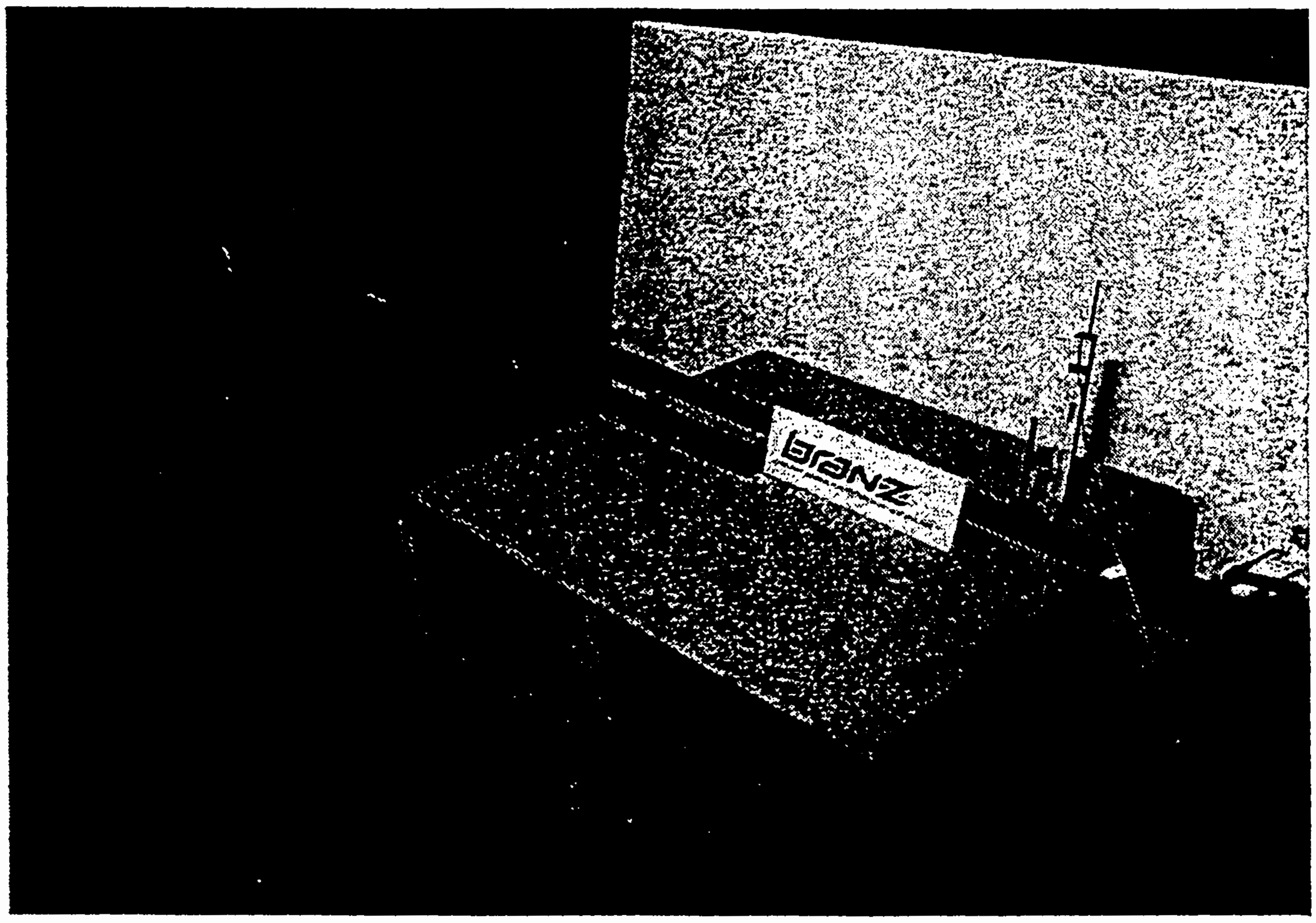


(a) JOIST006 Detail

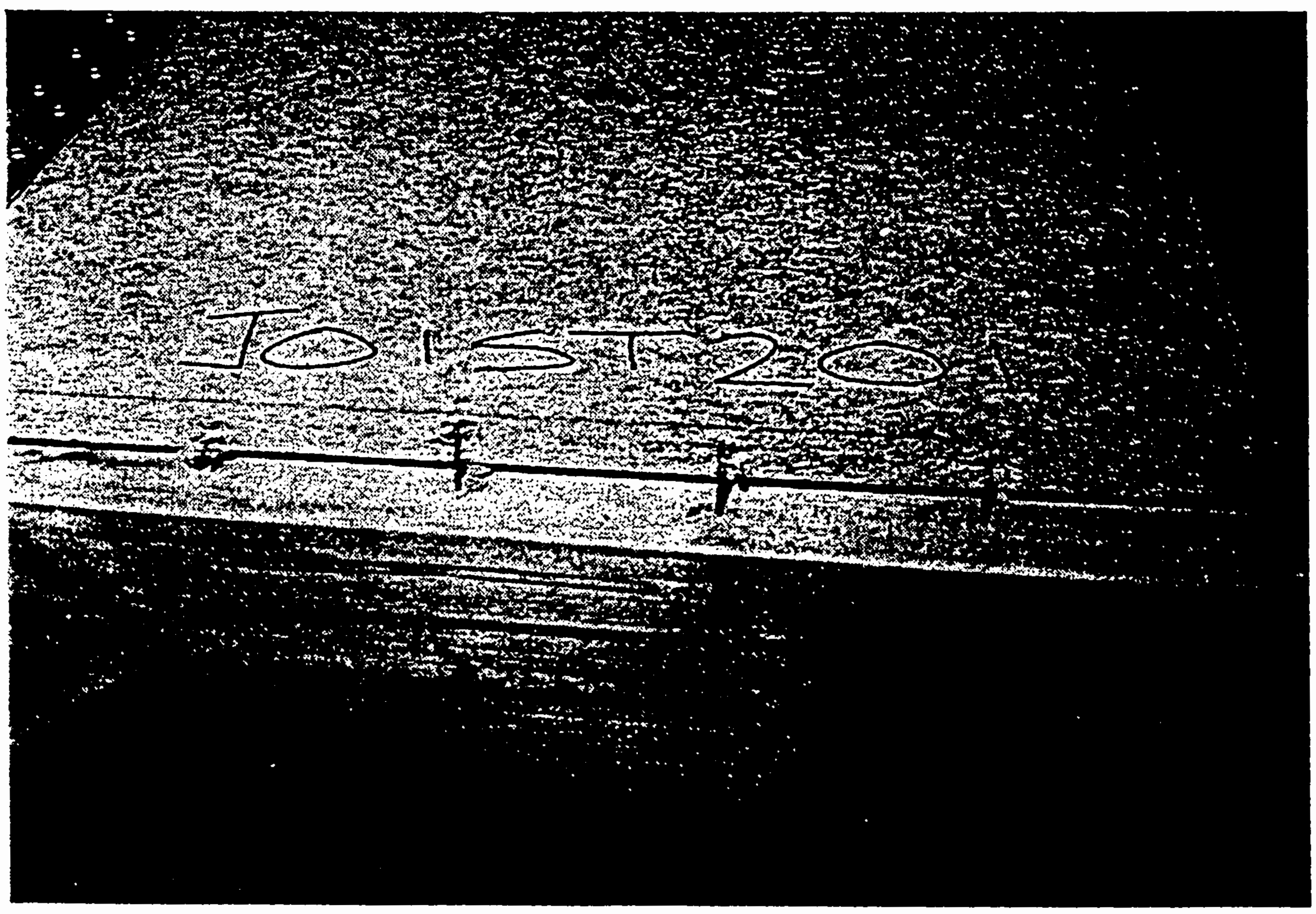


(b) JOIST007 Detail

Photographs set 4. Blocking connection detail (JOIST006-7)



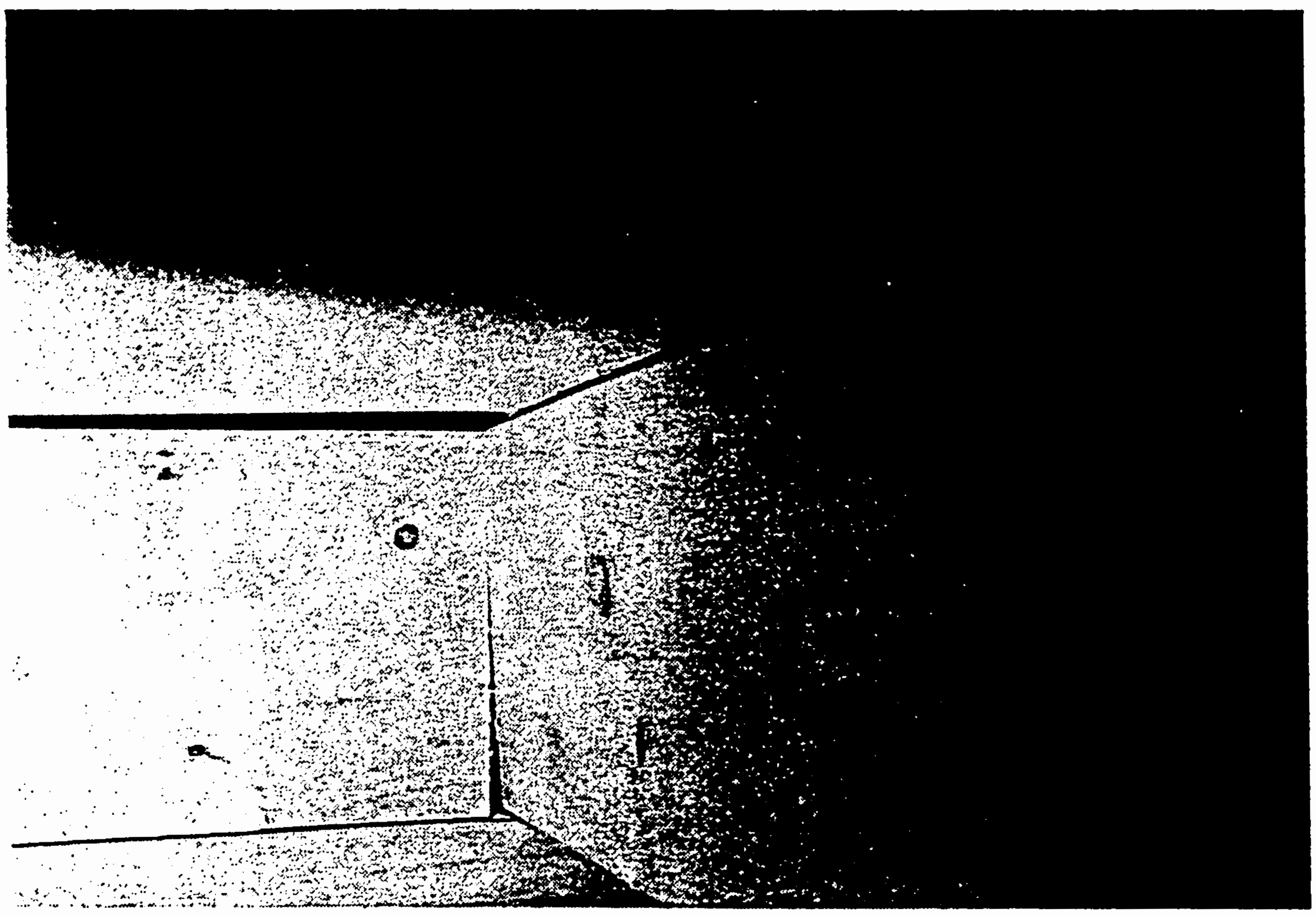
(a) General set-up



(b) Nails pulled though sheet ends

Photographs set 5. Details of specimens 1-4

(a) Blocking construction (note curved joists)



(b) Distortion at test completion (PB lifted and distortion joist / blocking)

Photographs set 6. Blocking details of specimens 1-4

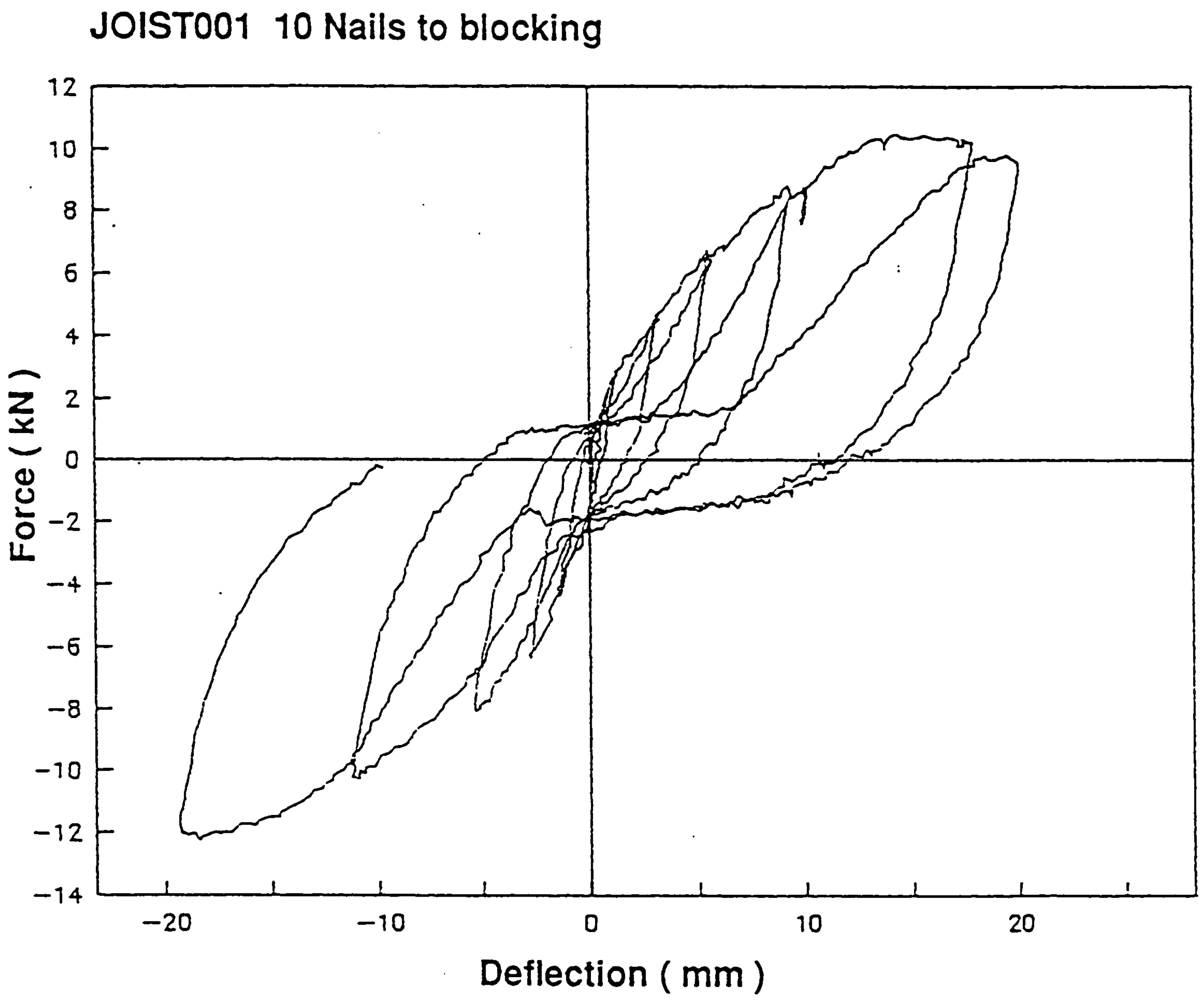
TABLE 1: RESISTED LOADS

Specimen Label	Number of Cycles at each Pre-Determined Load Level
JOIST001*	1 cycle to slightly more than ±4,6,8 and 10 kN and then 0.5 cycle to 12.2 kN.
JOIST002	1 cycle to ±2,4,6,8,10 kN, 4 cycles to ±12 kN and ±15 kN, 0.5 cycles 21.5 kN.
JOIST003	1 cycle to ±3,6,8,10 kN, 3.5 cycles to ±12 kN
JOIST004	1 cycle to ±2,4,6,8,10 kN, then 4 cycles to ±12 kN, 1 cycle to ±15 kN and 1 cycle to 17.8 and -16.9 kN
JOIST005	1 cycle to ±2,4,6,8,10 kN, then 1 cycle to 11.4 and -10.2 kN.
JOIST006	1 cycle to ±2,4,6,8,10 kN, then 4 cycles to ±12 kN, 2 cycles to 19.1 and -17.1 kN
JOIST007	1 cycle to ±2,4,6,8 kN and then 2 cycles to ±10 kN.
JOIST008	1 cycle to ±2,4,6,8,10,12 kN, then 4 cycles to ±16, 2 cycles to ±24 kN and 1 to ±30 kN.
Specimen 1	1 cycle to ±4,6,8,10,12,14 kN and 4 cycles to ±16 kN.
Specimen 2	1 cycle to ±4,8,12 kN, then 4 cycles to ±16 kN and 1 to ±20 kN.
Specimen 3	1 cycle to ±4,8,12 kN, then 4 cycles to 23 mm deflection when the load dropped from 16 kN to 10.3 kN. The load reached 16 kN in the other direction. 1 further cycle to -20 kN.
Specimen 4	1 cycle to ±4,8,12 kN then 4 to ±16.9 kN and 2.5 to 20 kN.

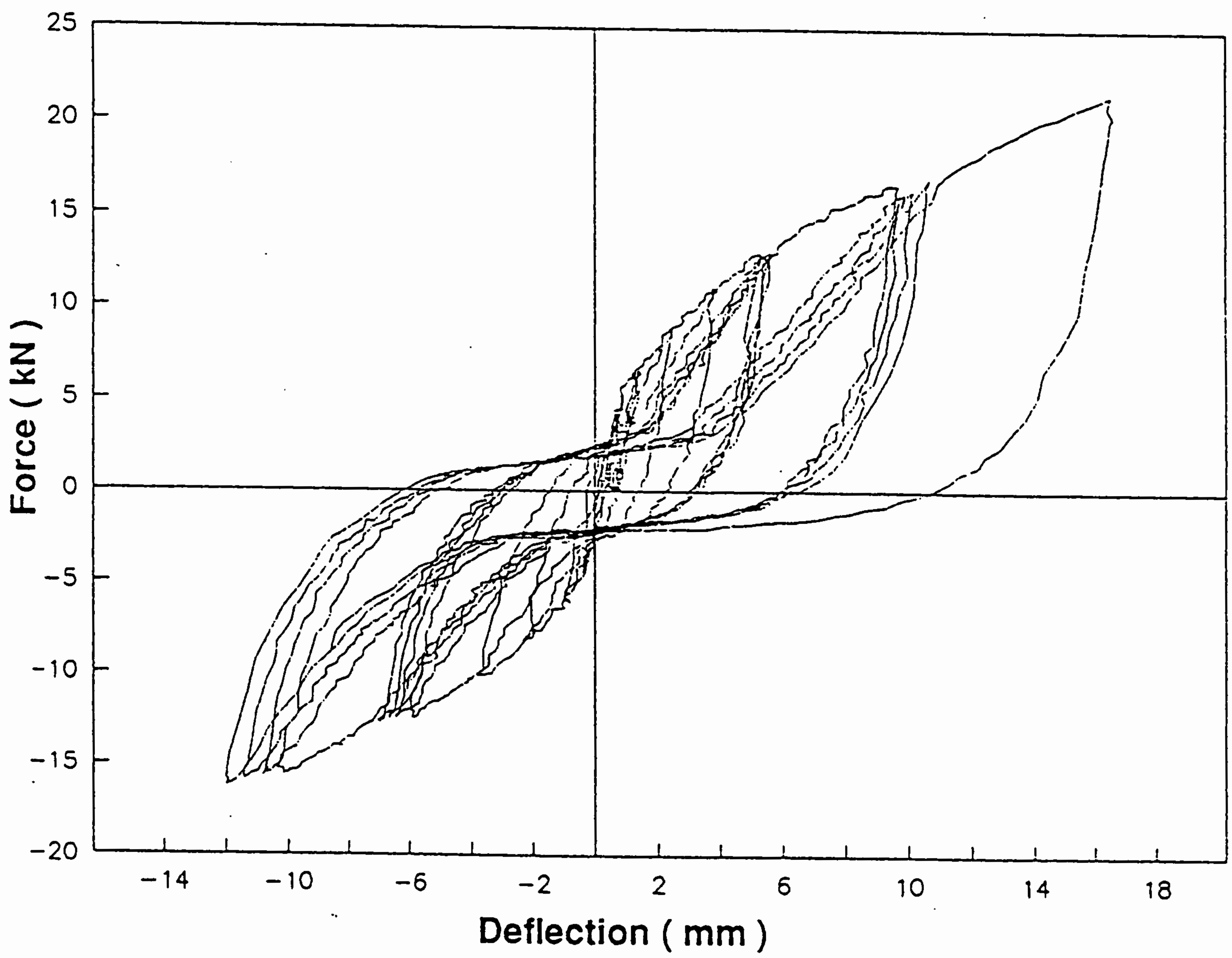
* Note, due to computer malfunction the latter portion of test data for this specimen was lost. However it was loaded to 4 cycles to 16 kN and then failed on the next cycle at about 18 kN using controls of the screen X-Y plot and digital actuator load display.

APPENDIX A

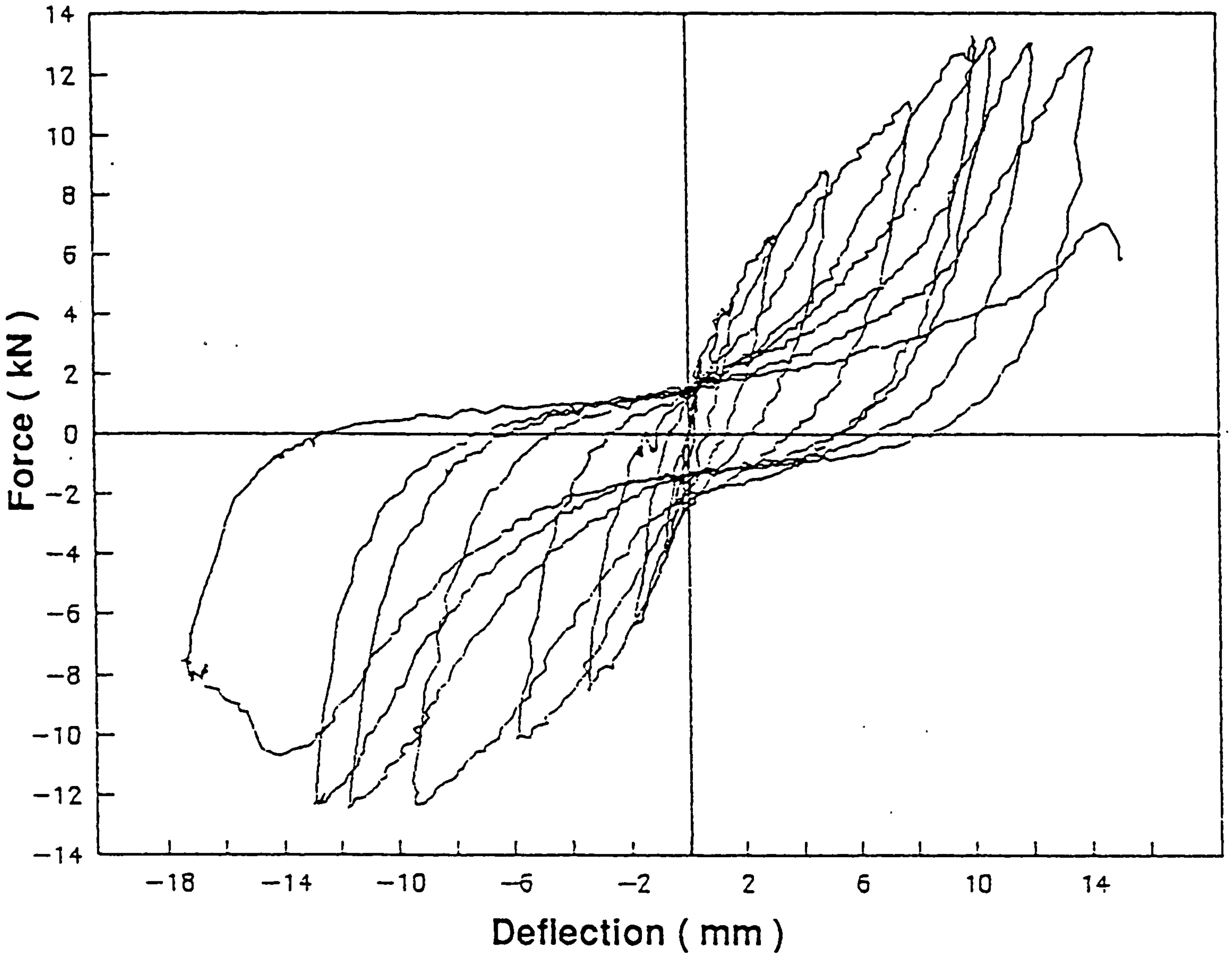
HYSTERESIS LOOPS GENERATED DURING TESTING



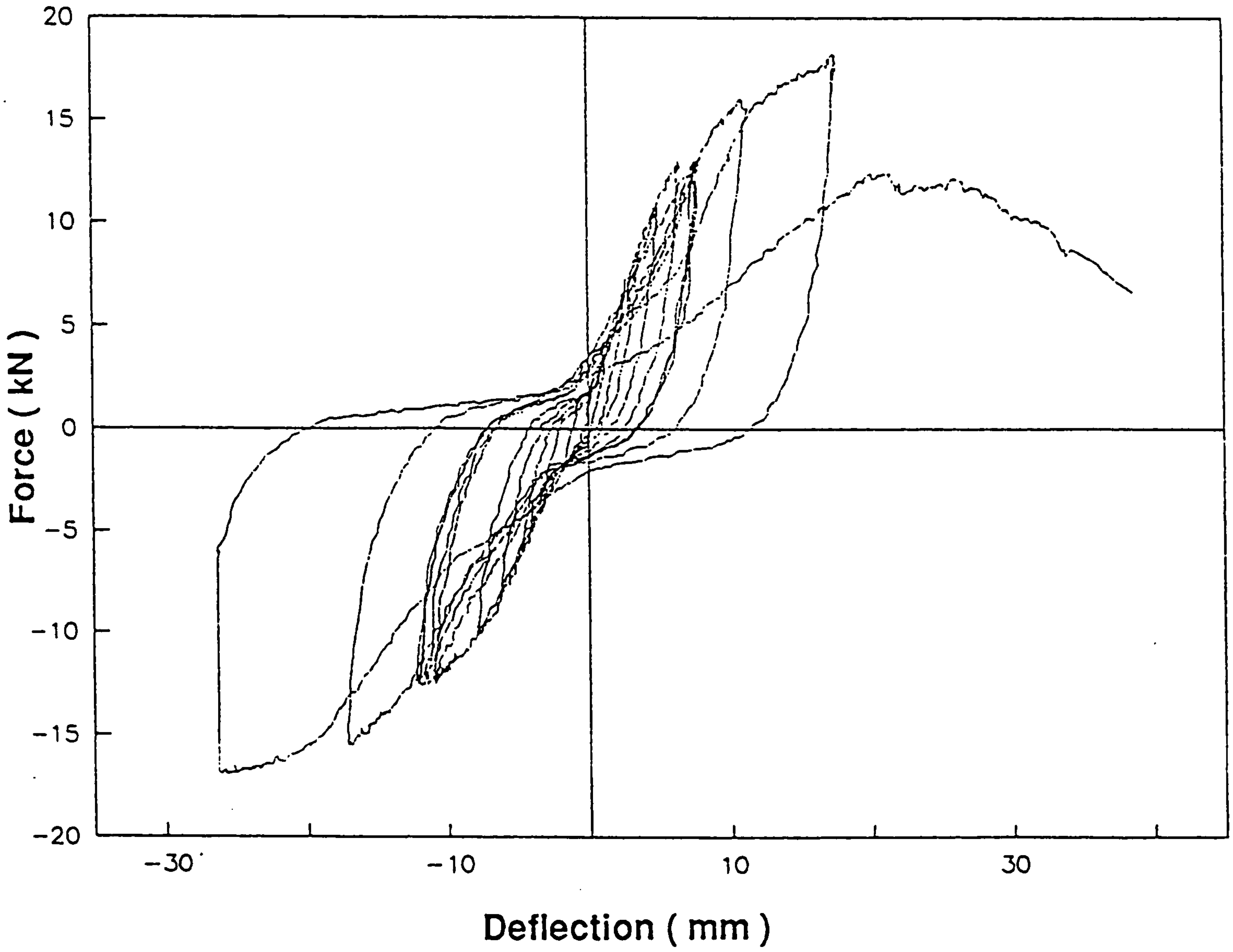
JOIST002 250mm Nail plate



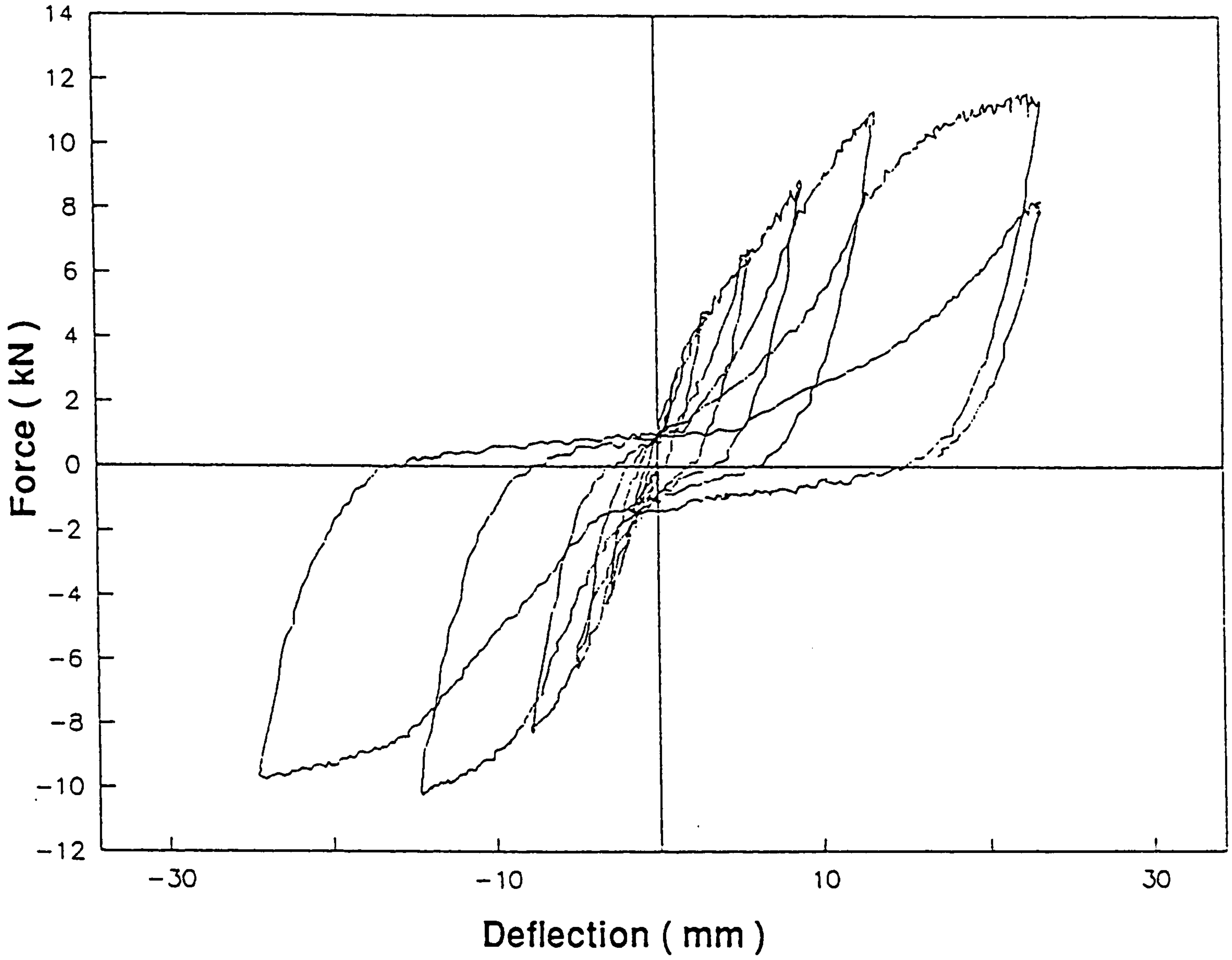
JOIST003 109 x 116 Claw steel plate



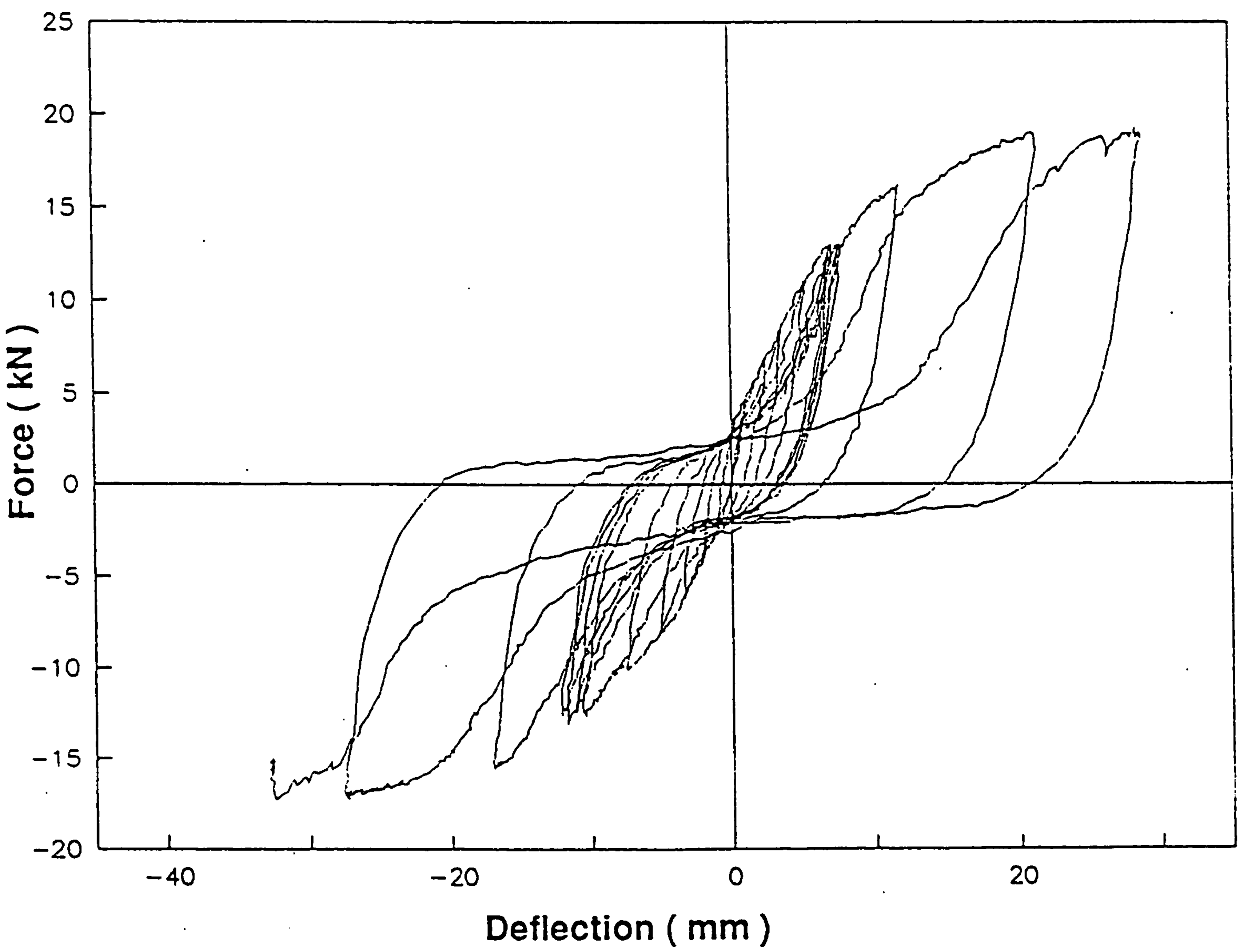
JOIST004 Two 127 x 116 Claw steel plates



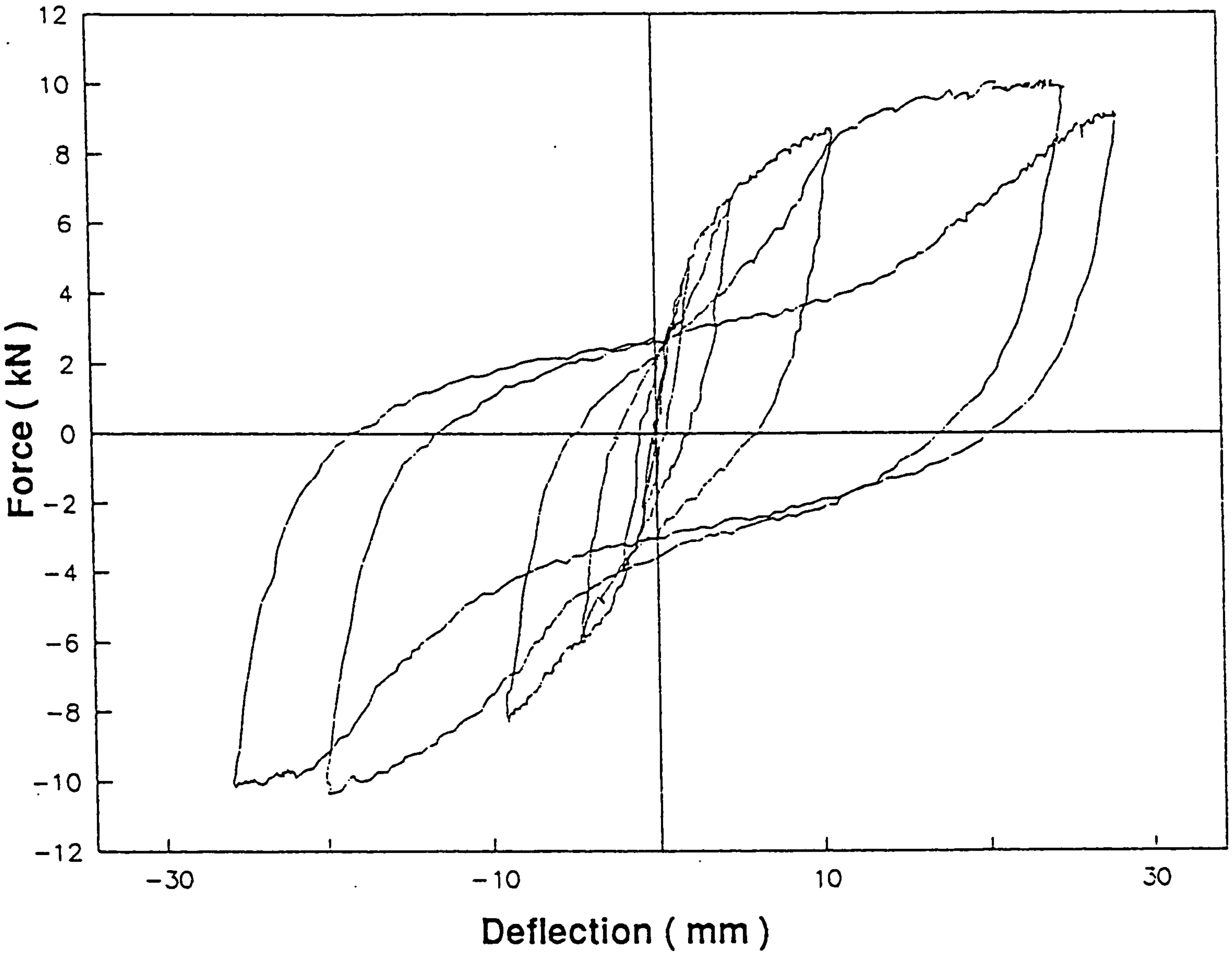
JOIST005 7 Nails to blocking



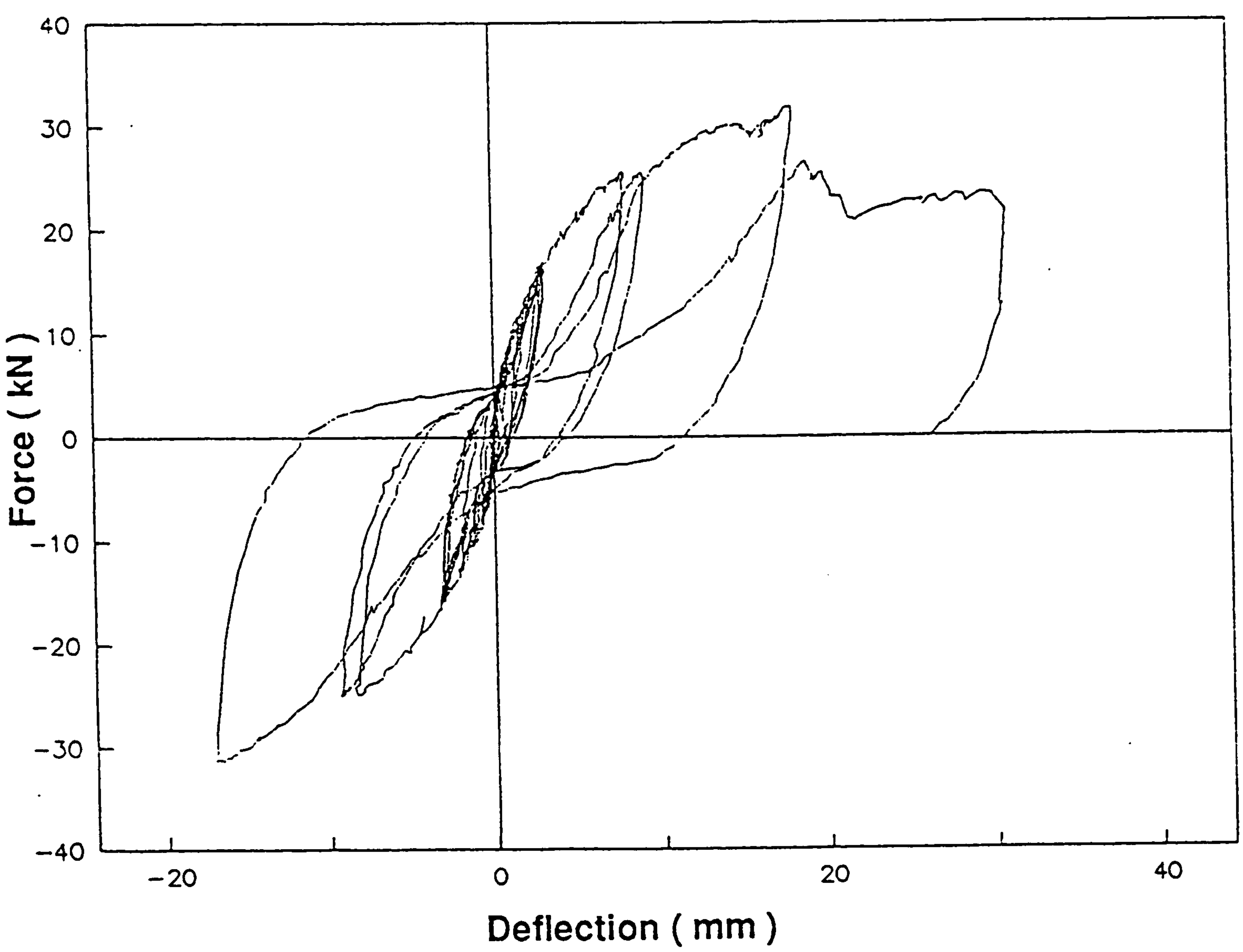
JOIST006 530 x 100 mm strip of 12 mm plywood



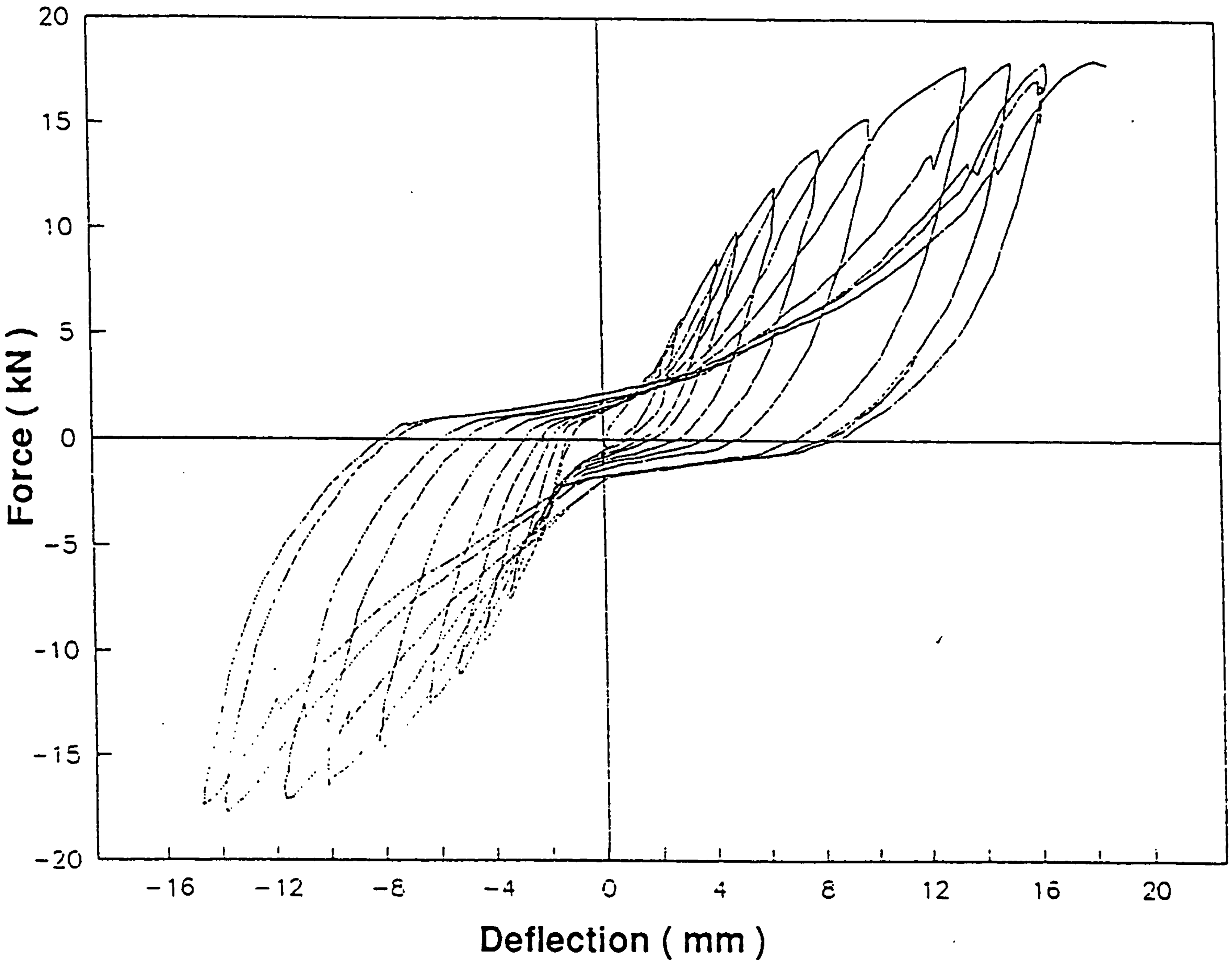
JOIST007 350 x 50 mm Post at each joist



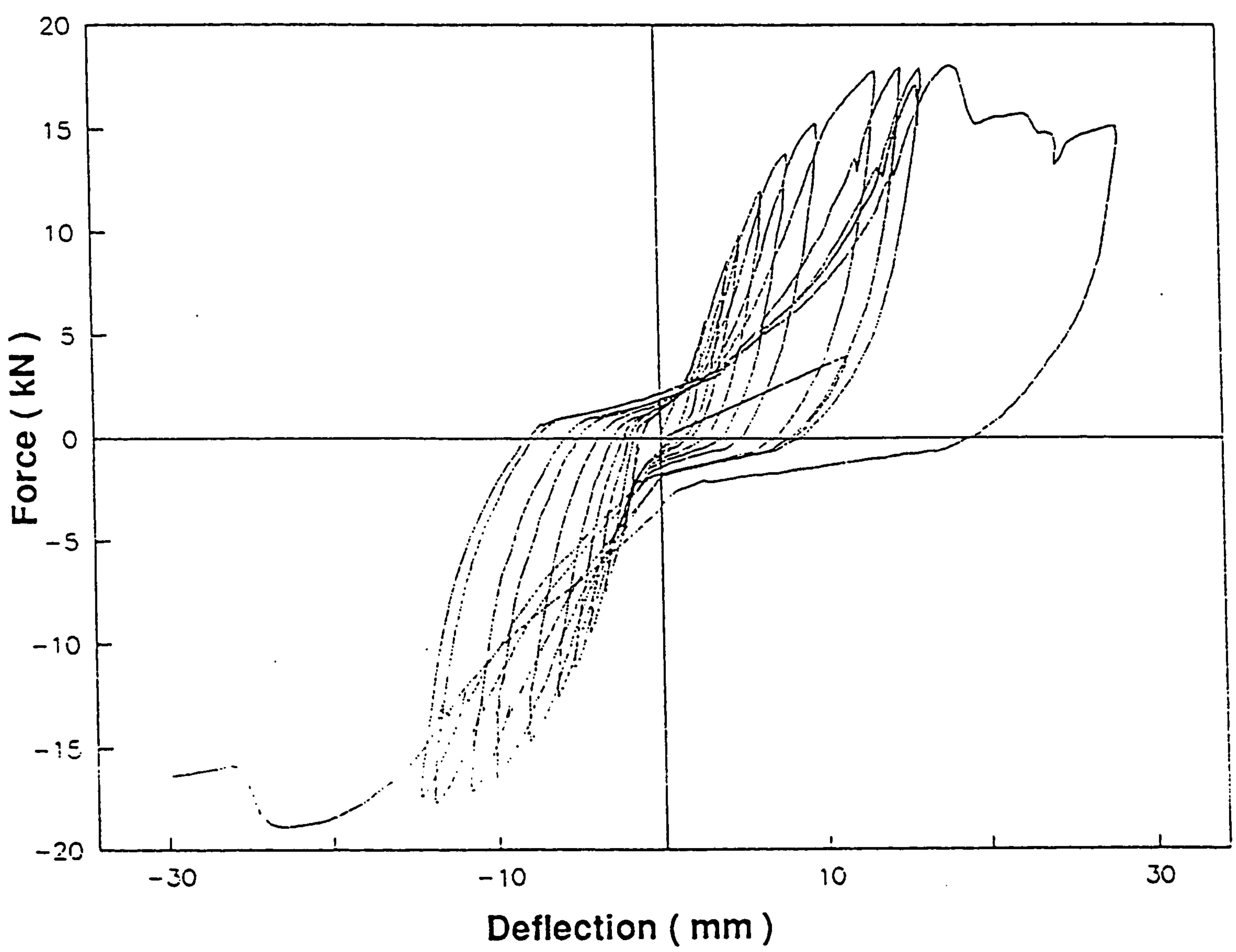
JOIST008 Blocking between two joists



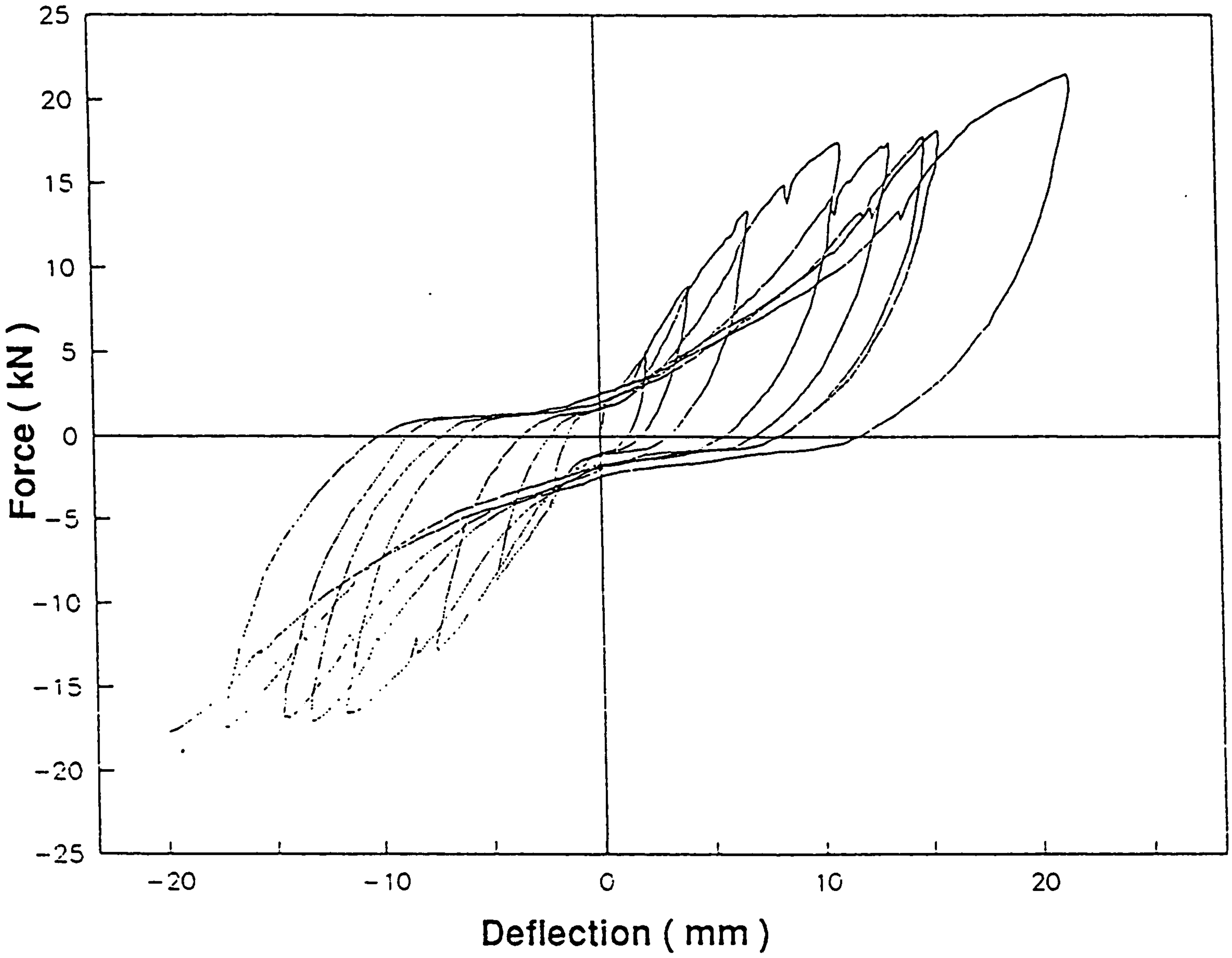
Joist roll-over test specimen 1



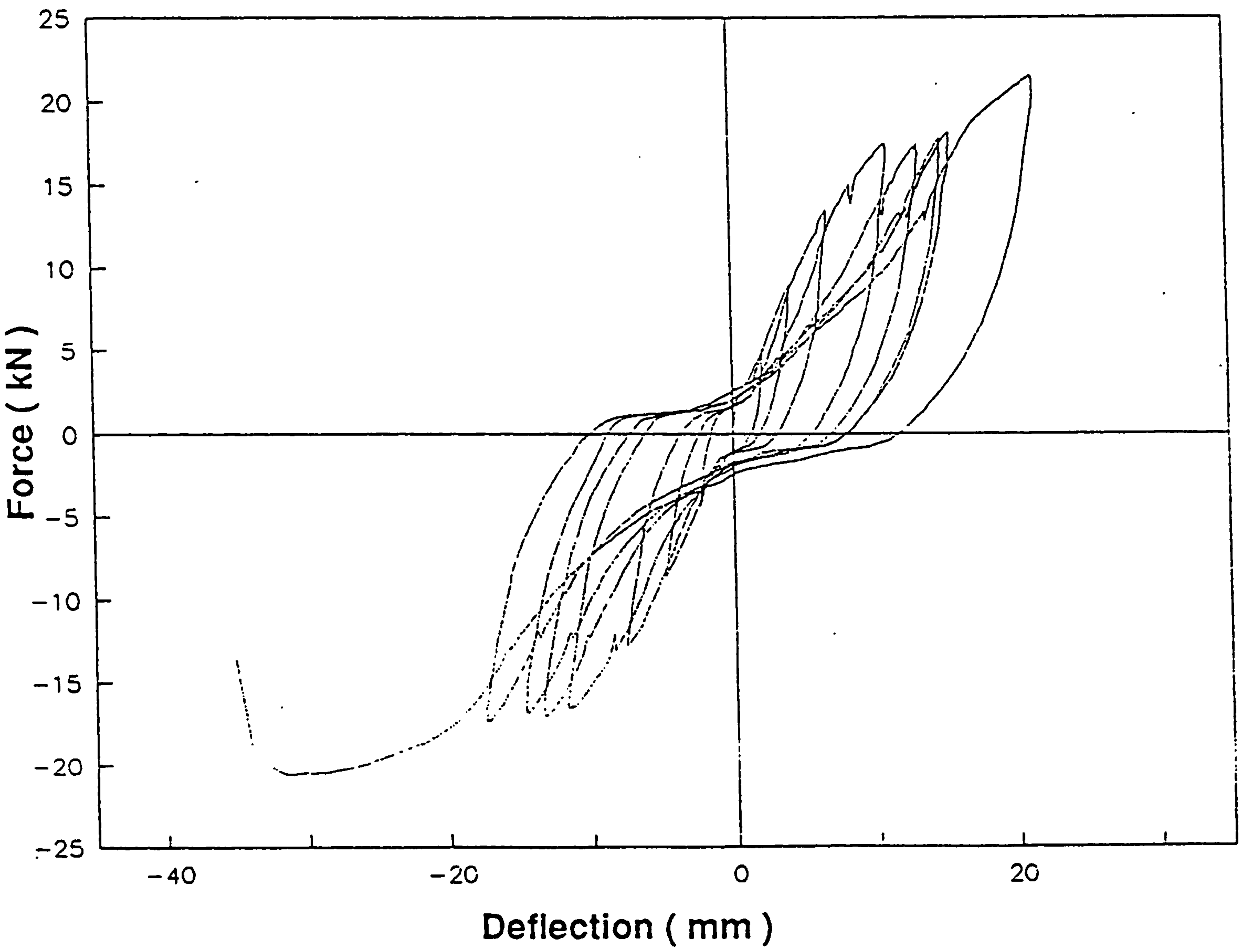
Joist roll-over test specimen 1



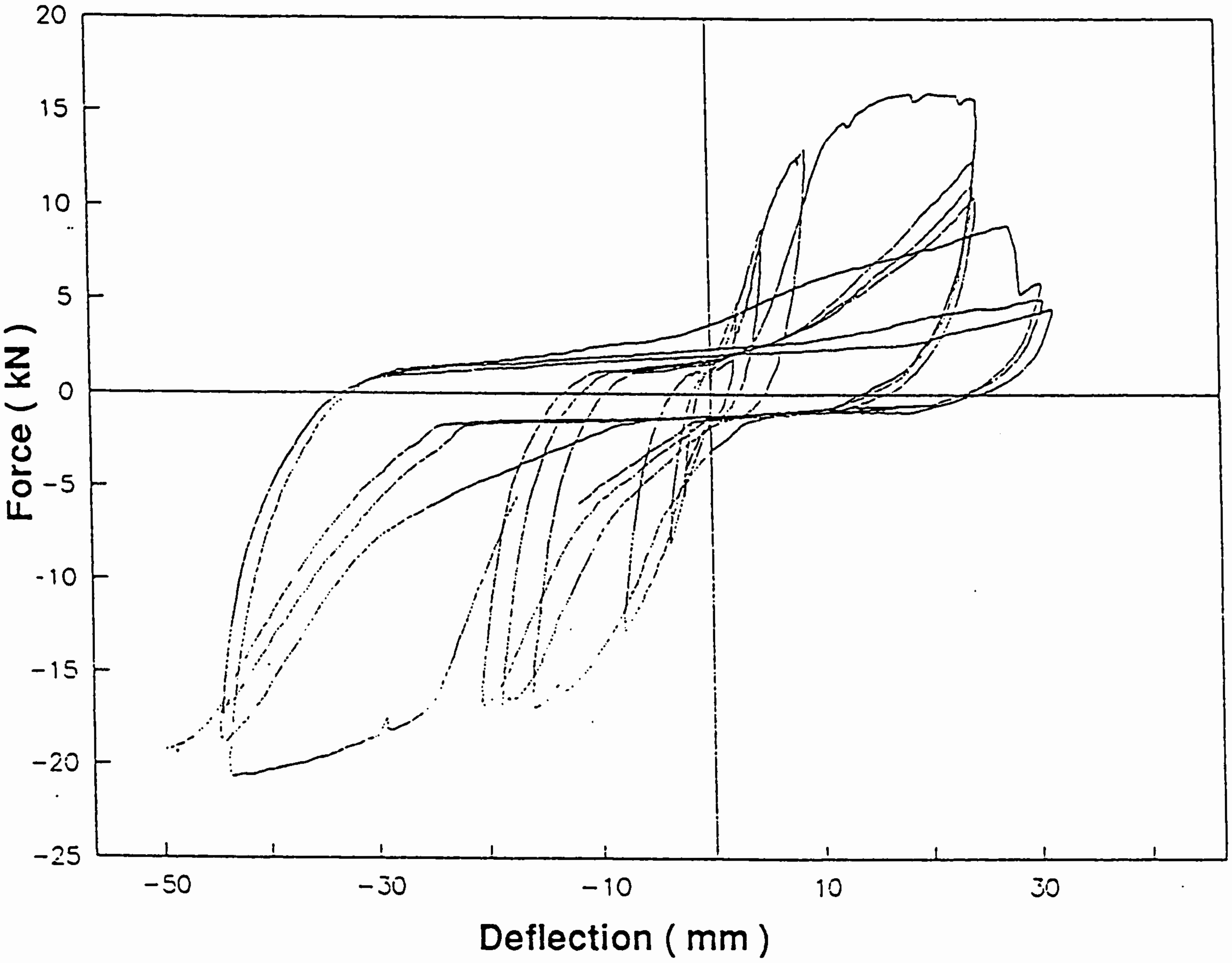
Joist roll-over test specimen 2



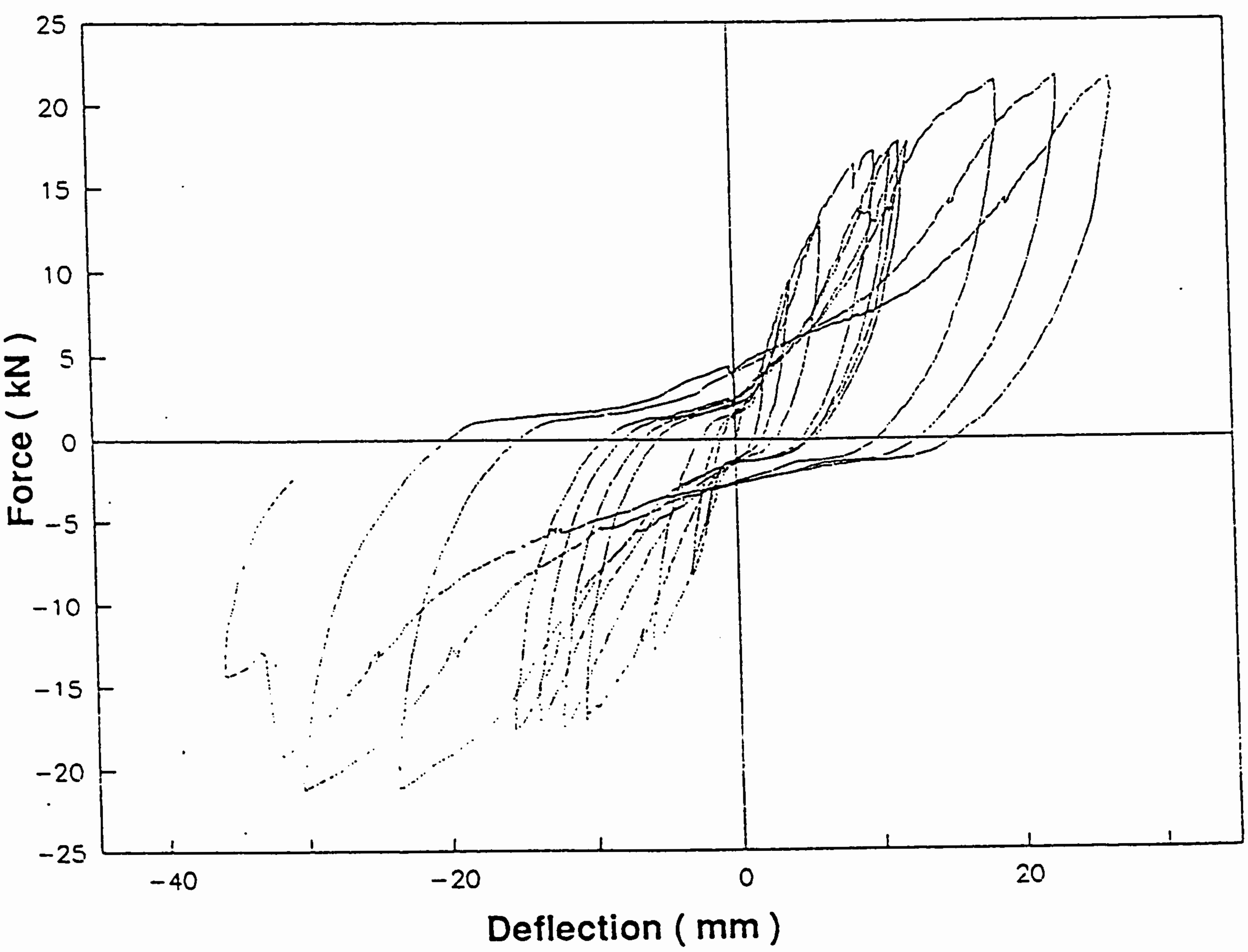
Joist roll-over test specimen 2



Joist roll-over test specimen 3



Joist roll-over test specimen 4



APPENDIX B

PROPOSED BRANZ TECHNICAL RECOMMENDATION

BUILDING CONSTRUCTION METHODS TO SATISFY NZS 3604: 1990 JOIST ROLL-OVER CRITERIA

S. J. Thurston

REFERENCE

Thurston S.J. 1992. Building Construction Methods To Satisfy NZS 3604:1990 Joist Roll-Over Criteria. Building Research Association of New Zealand Draft Technical Recommendation. Judgeford, New Zealand.

1. INTRODUCTION

The latest version of the New Zealand non-specific design code for light timber frame houses NZS 3604:1990 (SANZ, 1990) dictates that the connection between joists and bearers at each braced pile or anchor pile is required to resist a horizontal force totalling 12 kN applied parallel to the bearer at floor level. Figure 4.10(c) in the standard, depicting the design forces, is reproduced as Figure A1 of this Technical Recommendation. If unresisted, the horizontal forces tend to roll the joists over onto the bearer below. This draft BRANZ Technical Recommendation details the recommended construction methods to resist joist roll-over actions.

The connections detailed in this report will not satisfy NZS 3604:1990 strength requirements for the connection between joist and bearer for loads parallel to the joist such as depicted in Figure 4.23 or described in clauses 4.7.7.2 or 4.7.7.3 of the Standard. If the pile is required to resist loads in this direction, the builder must provide this strength by other methods. Some specific examples are discussed below.

Where an M12 bolt connects a brace to a bearer (see Figure A1) and there is no brace on the pile in the orthogonal direction, then any of the five systems shown below are adequate without additional strengthening. The 6 kN force at each joist which is parallel to the joist, need not be resisted. However, for an anchor pile, a steel brace or other detail must be provided to resist this 6 kN force per joist in the direction parallel to the joist.

This is similar to where a concrete or masonry foundation wall sits directly under the bearer, or where sheet foundation cladding is connected to the bearer. In this case the systems outlined below are capable of providing a bracing of 240 BU (Bracing Units) for wind and 120 BU for earthquake. However the bracing values used in design must not exceed that of the foundations below. Reputable published values only should be used.

2. SYSTEMS SATISFYING NZS 3604:1990

The systems which have sufficient strength (12 kN) to satisfy the relevent clauses of NZS 3604:1990 are described below and shown in Figure A2. To comply with this recommendation they must be used on the bearer passing over the applicable braced pile or anchor pile; the distance between the centre of the system used and the pile must not exceed 1.5 m. The blocking must be tight and cut from No 1 Framing Grade Radiata Pine or Standard Building Grade Douglas Fir. The methods can only be applied where the joist spacing divided by the joist height is not less than 2. Nailing and timber treatment (including ply) must comply with NZS 3604: 1990. In particular at each end of the blocking there must be two 100 x 3.75 mm horizontal nails connecting the joist to the blocking and at each joist there must be two 100 x 3.75 mm skew nails between joist and bearer. Full joist depth blocking is used in all instances except as discussed for System 1.

BRANZ has appraised several proprietory pile foundation connection systems and these are still considered to be suitable solutions. The systems outlined below are merely alternative methods of resisting the roll-over forces.

SYSTEM 1 Instead of normal blocking use a deep "blocking" nailed to the side of the bearer with ten 100 x 3.75 mm flat head nails at 50 mm centres. The depth of this blocking is 100 mm more than the depth of the joists. Thus, use 300 x 50 mm blocking with 200 mm deep joists.

SYSTEM 2 The blocking is connected to the bearer with a single 240 mm length of 100 x 1 mm (minimum size) of perforated nail plate symmetrically placed. Use 14 3.15 x 30 mm pan head galvanised nails in both bearer and blocking. The plates shall be hot dipped galvanised to SAA (1981) where required by the durability requirements of Section 2.2 of NZS 3604:1990.

SYSTEM 3 The blocking is connected to the bearer with two 127 x 116 mm (minimum size) claw steel nail plates located close to the ends of the blocking. Note that the orientation of the plate is such that the wide side of the plate teeth are perpendicular to the timber grain. This system is limited to subfloor spaces not exposed to the weather and where dampness and condensation does not normally occur. The durability requirement is specified in Section 2.2.3 of NZS 3604:1990.

SYSTEM 4 The blocking and bearer are joined with a 100 mm wide strip of 12 mm (minimum) thick H3 or better treated plywood with eleven 30 x 2.8 mm galvanised plasterboard clouts at equal spacing between both the ply and blocking and ply and bearer.

SYSTEM 5 Blocking is used between two adjacent joists. Four 100 x 3.75 mm skew flat head nails connect each length of blocking to the bearer.

3. REFERENCES

Standards Association of Australia. 1981. Galvanised Coatings. AS 1650. Sydney.

Standards Association of New Zealand. 1990. Code of Practice for Light Timber Frame Buildings Not Requiring Specific Design. NZS 3604. Wellington.

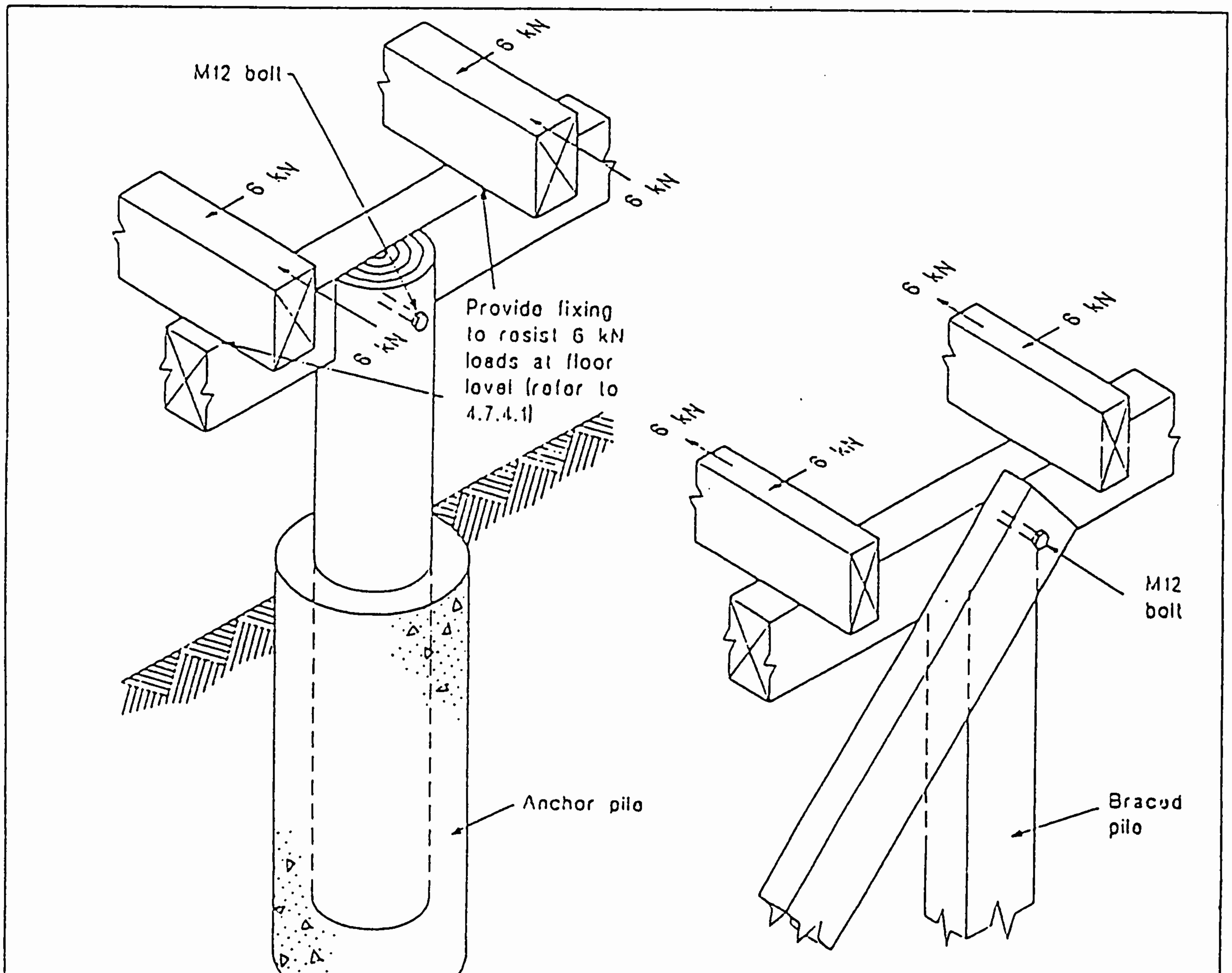


Fig. 4.10 (c)
BRACED PILES

FIGURE A1 EXTRACTS FROM NZS3604 : 1990 (SANZ, 1990)
(REPRODUCED WITH PERMISSION FROM SANZ)

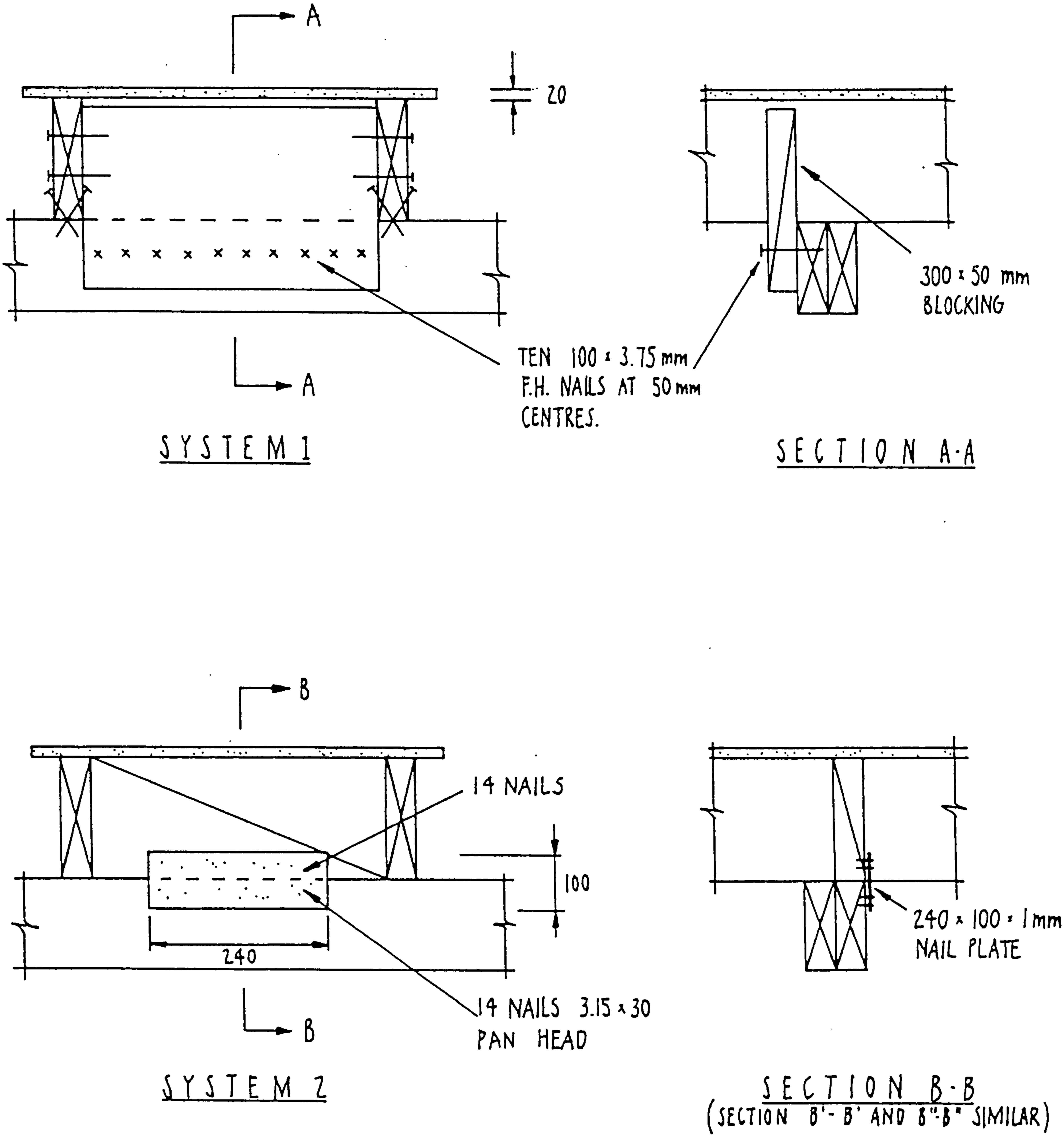
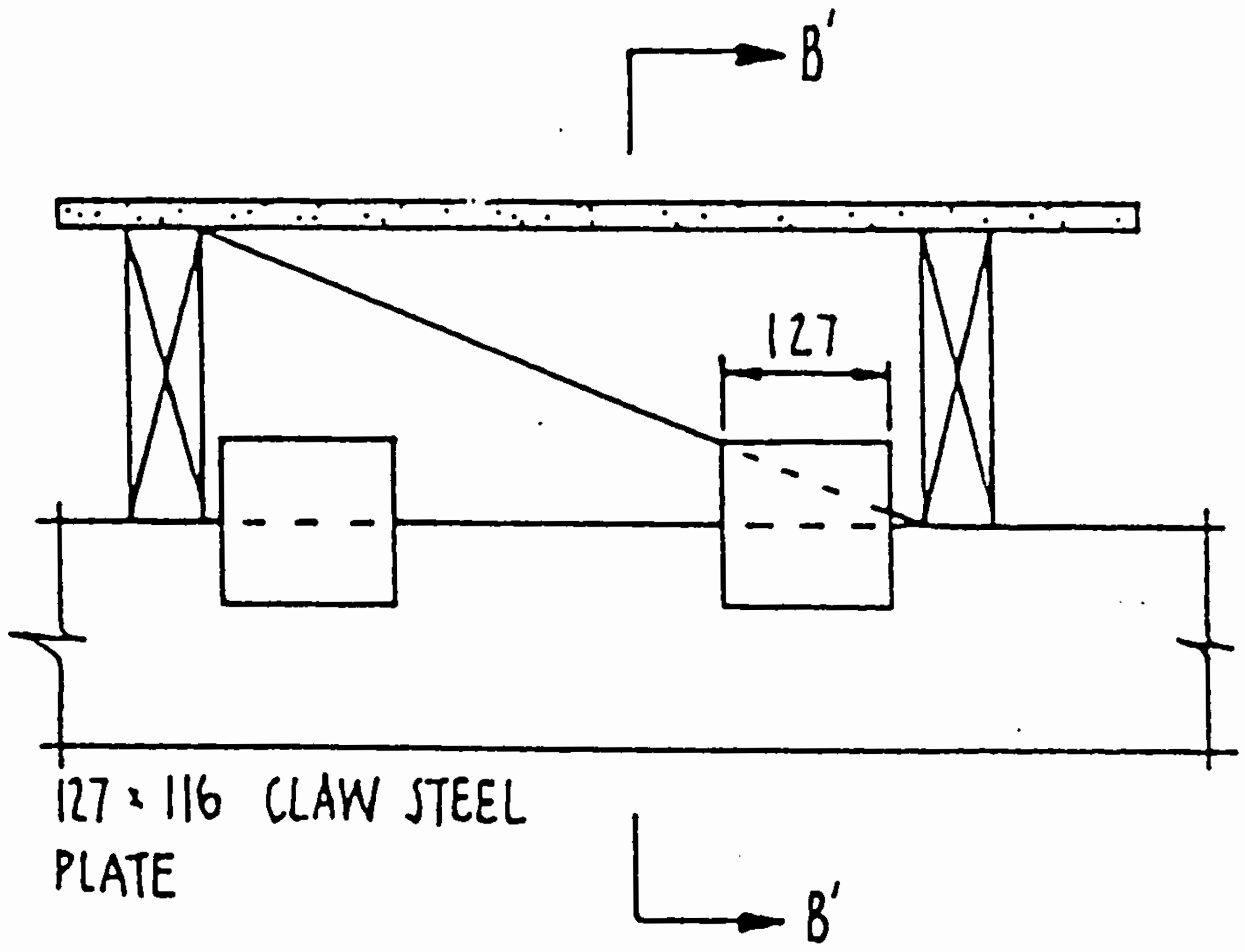
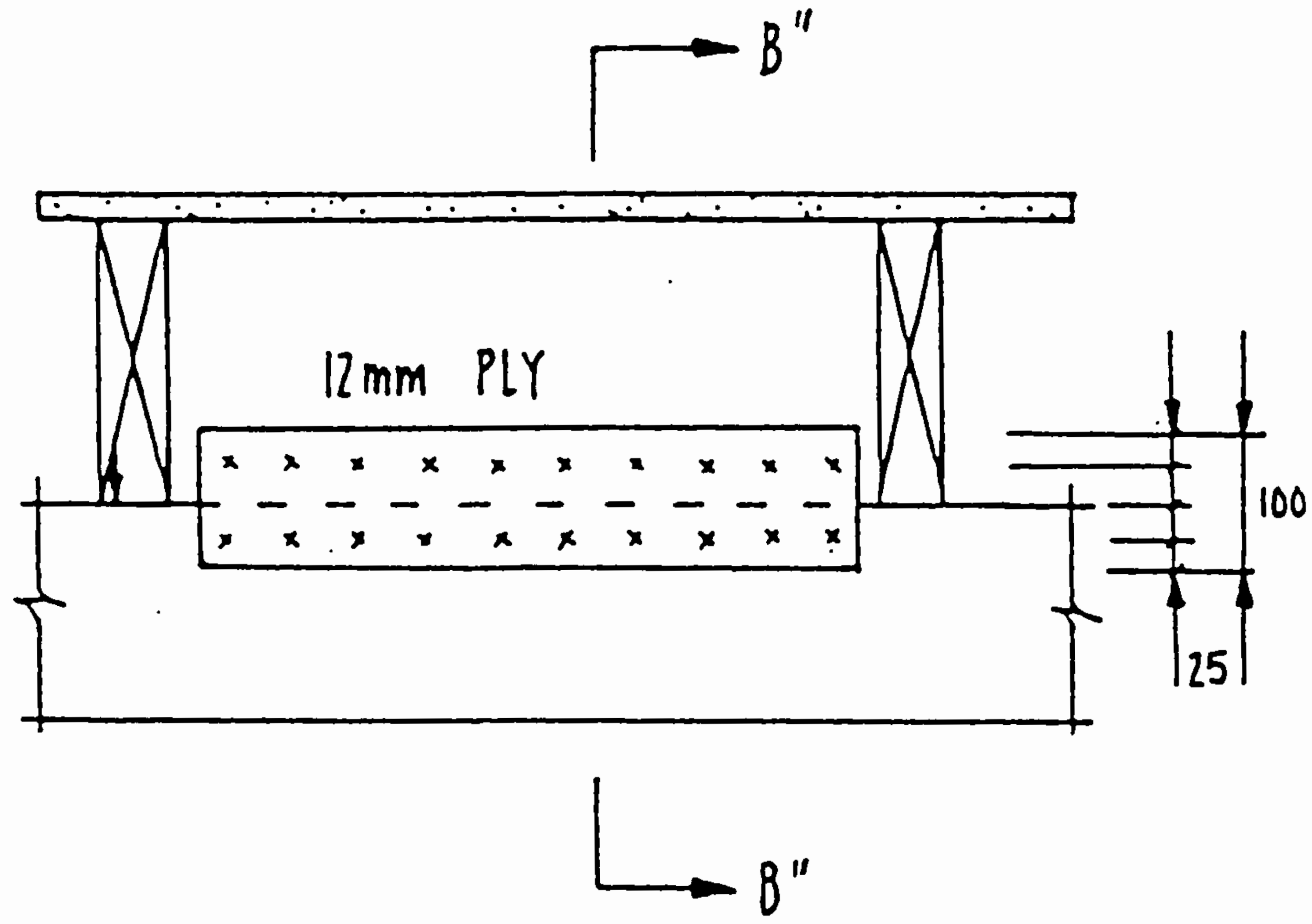


FIGURE A2 12KN CONNECTIONS TO PREVENT
JOIST "ROLL OVER"

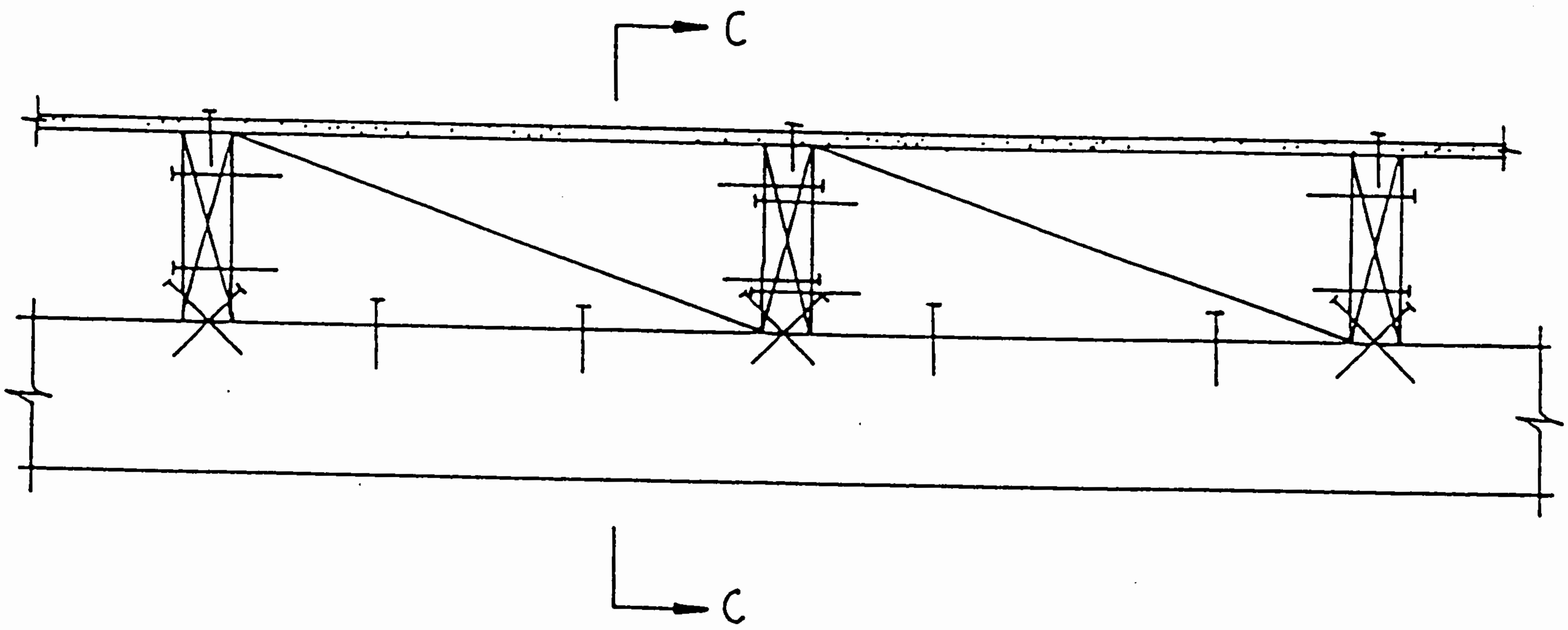


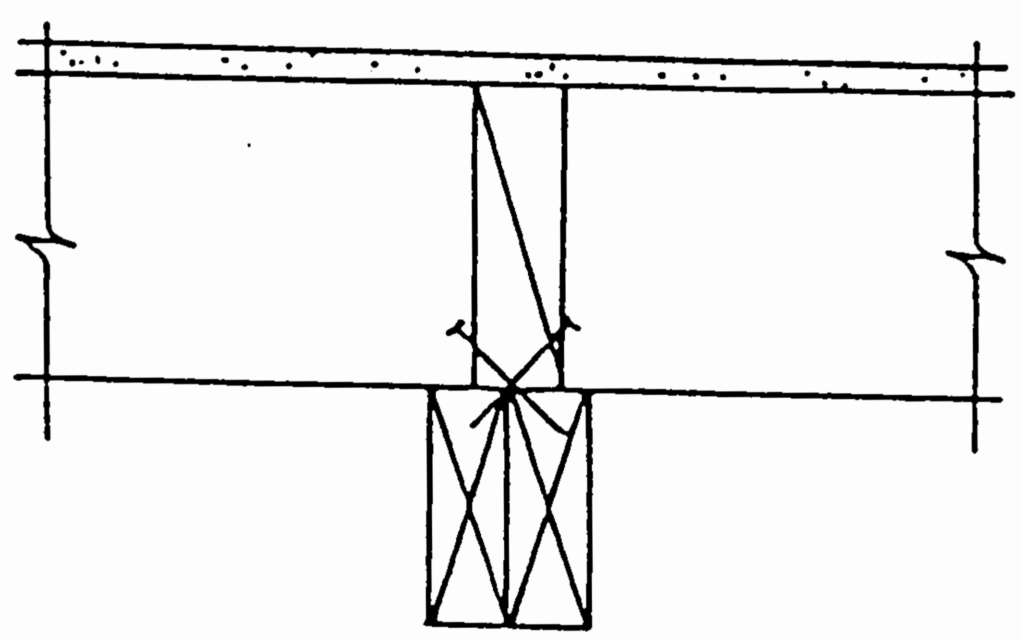
SYSTEM 3



ELEVEN No 30 x 2·8mm PLASTERBOARD CLOUTS AT EQUAL CENTRES. TOP AND BOTTOM

SYSTEM 4





FOUR 100 x 3.75 mm F.H. NAILS PER BLOCKING (IE 2 PER SIDE)

SECTION C-C

SYSTEM 5

FIGURE A2 CONTINUED

THE RESOURCE CENTRE FOR BUILDING EXCELLENCE

BRANZ MISSION

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the application of acquired knowledge,
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