Aug 20th, 12:00 AM - Aug 21st, 12:00 AM

Racking Performance of Plasterboard-Clad Steel Stud Walls

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Recommended Citation

Golledge, B.; Clayton, T.; and Reardon, G., "Racking Performance of Plasterboard-Clad Steel Stud Walls" (1992). *International Specialty Conference on Cold-Formed Steel Structures*. 3.
https://scholarsmine.mst.edu/isccss/11iccfss/11iccfss-session7/3

Eleventh International Specialty Conference on Cold-Formed Steel Structures
St. Louis, Missouri, U.S.A., October 20-21, 1992

RACKING PERFORMANCE

OF

PLASTERBOARD-CLAD STEEL STUD WALLS

SUMMARY

It is recognised that structural design efficiency in domestic and similar structures can be improved when the composite behaviour and contribution of all materials in the permanent structure can be fully recognised in the structural design of the frame. The ability to achieve this improvement is currently limited by the need to rely on empirical test results for standardised building elements when considering the composite behaviour of the entire structure. The existing test methodology for determining the shear strength of plasterboard lined steel stud walls leads to an excessively conservative design of the complete structure. Since the test configuration is for isolated test panels, the absence of continuity of the plasterboard lining around a set corner is not included in the test procedure.

A test program has been devised and carried out to explore the effect of the set corner on the performance of shear test panels. A dramatic improvement in both diaphragm shear strength and shear stiffness has been achieved in these tests supporting a proposal to amend the standard test methodology to include set corners.

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1.0 INTRODUCTION

Bracing against wind induced racking loads is required in all domestic buildings . There are many ways by which bracing can be provided in the frame. Generally membrane and diagonal bracing systems are used in timber framed construction . In steel framed houses both tension only and tension /compression bracing systems have been extensively used. Membrane bracing systems have not been widely used in steel building frames because of the cost penalty resulting from screw fixing over the more conventional practice of pneumatic nailing used in fixing membranes to timber frames. In bracing the lower storey of two storey constructions, the Australian design requirement approximately doubles the bracing in ground floor wall frames compared with the upper storey. Further, the window and door openings in the lower storey frame compete for the clear wall space required for diagonal bracing installation. Since the performance of diagonal bracing is dependent , amongst other variables, on the angle of installation, increasing this angle for higher bracing capacity also increases the clear wall space requirement. This problem may be alleviated if normally fixed plasterboard sheeting could be used to supplement bracing capacity, since plasterboard is a commonly used internal lining material with high shear strength and shear stiffness.

The procedure of using plasterboard to supplement bracing was advocated by Wolfe (1983) who conducted an extensive series of tests on plasterboard as a bracing medium, investigating such parameters as wall length, panel orientation and number of faces clad. Tarpy (1984) demonstrated that plasterboard can provide bracing for steel framed domestic buildings. Reardon (1988) showed that plasterboard lining with normal fixing can provide adequate bracing even though it was not designed to do so and that after the lining has been applied the diagonal braces have no effect on the bracing stiffness of the frame.

The above research into wall racking has been based on the American Standard tests ASTM E72-80 or ASTM E564-76, or international equivalents. These standards require a braced wall panel to be tested in isolation. (ie. no end wall or ceiling connection). The older E72-80 standard defines the size of wall and the constraints to be supplied by the reaction frame. The more liberal E564-76 allows different sizes of wall and recognises that the method of fixing the wall to foundations plays a significant role in its racking performance. These standards may be suitable for testing traditional diagonal bracing or wood based materials but it would appear that they do not provide an adequate test for plasterboard acting as a diaphragm.

Plasterboard has the advantage of being a nominally continuous lining around the four corners of a room. That is, when it is fixed to a frame the individual sheets that meet at a corner are joined together and sealed with a plaster compound that has significant shear strength. The capacity of the set corner to transfer forces to the transverse wall is not allowed for in the ASTM test method. This paper describes research conducted on the effect of set corners on the performance of plasterboard diaphragms.

2. SHEATHED BRACING WALLS

2.1 Performance

The performance of sheathed bracing walls is influenced by a number of factors. These include the mechanical properties of the sheathing material, the number of faces clad, the type, size and frequency of fasteners and the details used to hold the wall in place against sliding or overturning forces.

The type of framing does not normally have a big influence on the performance of bracing walls. Within the normal bounds of domestic construction the frequency of framing members does not have much influence either. (Tarpy 1984) If the joints between members have the capacity to transfer bending moments, the frame could contribute to the racking performance, but this is not significant. (Tarpy 1984)

The sheathing must have adequate shear strength and rigidity as well as sufficient bearing strength to transfer force to and from the frame via mechanical fasteners such as screws. The performance of the sheathing is usually directly proportional to its thickness. Sheathing on two faces of the wall can double its racking strength and stiffness, although sometimes the factor is less than 2 as the two faces may not share the racking forces evenly.

Adjacent boards of plaster or cement based sheathing are normally bonded together by a process called setting. This involves filling the gap between boards with a plaster cement, overlaying this with a binding tape , usually paper , and then applying finishing coats of plaster cement. Fig 1 illustrates the process. Setting is used for horizontal or vertical joints between sheets on the face of a wall and also at vertical corner joints.

Fasteners are a very important element in a bracing wall as they transfer forces from the frame to the diaphragm as well as from the diaphragm into the frame. The capacity of each fastener to transfer force depends on its diameter and its fixity to the frame. The fasteners around the perimeter of a bracing wall directly influence the bracing capacity, whereas those on internal studs have much less effect.

Details used to fix the walls to the floor, and thus prevent sliding or overturning, tend to affect the overall performance of the wall rather than the actual racking strength of the diaphragm. If these elements are not designed correctly, local buckling or crushing of the stud and/or track can occur at the point of attachment.

2.2 Application

Bracing performs different functions in different stages of construction. During erection of the frames, bracing is used to stabilise the structure and to allow plumbing of the frames. This is achieved using in-built frame bracing, strap or diaphragm, but may be supplemented by temporary bracing. Diaphragm bracing is usually installed on the external face of the external perimeter wall corners as shown in plan section, Fig 2.

The next stage of construction is usually the installation of the roof cladding. From this stage onward bracing is required to stabilise the building against wind load. While there is a strength requirement at this stage, the stiffness requirement is less important since slight movements of the structure within the elastic range will not give rise to any harmful damage . Since the external claddings and windows are not normally installed at this stage, it is not practical to install plasterboard linings. The required bracing effect must again be achieved using in-built frame bracing, supplemented by temporary bracing. After the lock-up stage has been reached, plasterboard linings are installed in the house. The stiffness of the bracing system now becomes important as door fitment and final wall finish detail is required and cracking of the wall surface, jamming of doors and windows from excessive frame movements would be unacceptable. Plasterboard is normally fixed to the inside face of external walls and both faces of internal walls. A feature of the lining process is the plasterboard usually abuts internal corners as shown in Fig 3.

3 TEST METHOD DEVELOPMENT

3.1 Shear Loading of Test Panels

It is conventional practice in Australia to test nominally two dimensional plasterboard wall panels to ASTM specifications E72 or E564-76, whereby a horizontal point load is applied to the top track. The point load represents the wind load on half of the external wall height plus the horizontal component of the wind load on the roof. Fig 4 shows the wind loading, wall and bracing wall reaction. If the ceiling plasterboard is fixed directly onto the bottom chords of roof trusses, and the cornice is installed, the roof system is effectively joined to the internal wall linings and a path is available for direct transfer of the horizontal component of roof wind loading as shown in Fig 5. Similarly there is a path for transferring lateral wind loads from external walls directly to bracing wall linings from the ceiling membrane by way of the cornice. The cornice and the cornice cemented connection to the ceiling and wall plasterboard lining has to remain serviceable under the action of the wind loads for load transfer between the ceiling and the wall membrane. In the event this connection fails the applied loading reverts to point loading on the bracing panel top track at the wind loaded wall junction as in standard testing methodology. It was decided the conventional method of point loading the shear panels should be used in this testing program since it simplifies the test set - up and would also make the test results independent of the type of material used for the ceiling membrane and the requirement for cornice installation.

3.2 Derivation of New Standard Test Samples

A typical house floor plan is shown in Fig.6, for all wall types. A - E specified in Fig's. 7 and 8.

3.2.1 External Walls

In brick veneer construction in Australia, the external brick cladding is fixed to the frame with metal wall ties. The ties are normally flexible, thus limiting shear transfer between the brick veneer and the wall frame. External cladding other than brick veneer may provide some racking capacity but this is not normally considered in design.

Plasterboard lined internal faces of external walls falls into two standard configuration. The first configuration has two set internal corners, as illustrated by Wall A in Fig. 7. The other Wall B has one set internal corner and one set external corner and this arrangement is normally found in L-shaped houses.

3.2.2 Internal Walls

Plasterboard lined internal walls have three standard configuration. Wall C in Fig. 8 is a standard internal partition wall, which has four internal set corners. Another configuration is a nib wall, as illustrated by Wall D, which has two internal and two external set corners. Finally, Wall E is an internal partition wall with three internal set corners and one external set corner.

3.2.3 Test Sample Selection

In the main test program, an external wall type and an internal wall type were selected from those described in Sections 3.2.1 and 3.2.2 respectively. It was decided that the external test panel should have overall dimensions of 2400 mm x 2400 mm (8 ft x 8 ft), be lined on one side and have two set internal corners, as shown in Fig 7, Wall A. The internal wall test panel chosen was of the same overall dimensions, clad on both sides incorporating four set internal corners as shown in Fig. 8 Wall C. The internal corners were formed using a 100 mm (4 inch) 10 mm (0.4 inch) thick plasterboard strip screwed onto the frame junction detail B of the standard wall junctions shown in Fig 9.

It was also decided that duplicate external and internal wall frames should be made without set corners, as controls for the test program.

All samples were plasterboard clad using TYPE 6 - 18 x 25mm (1 inch) long bugle head screws and wall board adhesive fixed in accordance with the manufacturer's specifications.

3.2.4 Frame Assembly

All stud and track sections used in the tests were 1.00 mm thick 75 x 35 mm C-chords, with a guaranteed minimum yield stress of 550 MPa (80 ksi). Studs were swaged at the ends, to fit into the plates. All the stud-to-track connections were made using one No 10 - 16 wafer head screw on each side. A typical frame assembly is shown in Fig 10,

3.3 Testing

Racking tests were carried out at two different locations in Australia. The first series of tests were carried out at BHP Sheet and Coil Products, Research and Technology Centre, Port Kembla, N.S.W. The second series was performed at James Cook Cyclone Testing Station, Townsville. Qld. Slightly different wall frames were tested at Townsville. These walls were 50 mm (2 inch) higher which meant there was insufficient edge distance left on the plasterboard for screw fixing to the top and bottom track. The fixing was actually made into the stud flange adjacent to the top and bottom track. The frames were also longer by 25 mm (1 inch) than the frames tested at Port Kembla so that the overall dimensions of the frames were 2450 mm high X 2425 mm wide. While these dimensional and consequential fastening differences were not intentional, the testing proceeded because it was agreed that the important consideration was the effect of set corners, not confirmation of a previous test result. This reasoning was further supported by the fact the actual test rigs and methods were slightly different since the Townsville and Port Kembla tests were carried out on vertical and horizontally mounted wall panels respectively, which could also account for slight variation in test result.

The first series of tests carried out at Port Kembla were with walls tested in a horizontal position in the test rig. These walls were 2400 mm (8 ft) wide x 2400 mm (8 ft) high and constructed from steel C-sections. The plasterboard was screwed to the top and bottom track at the stud junction, at each side of the sheathing joint at the centre of the panel and a total number of 14 screws vertically along each corner stud. The wall test set-up is shown in Fig. 11. The wall was prevented from sliding at the end of the bottom track. Overturning of the frame was prevented by a roller on the top track. Load was applied to the frame along the axis of the top track using a hydraulic ram. Displacements were only measured at gauges 1 and 4. The racking deflections were calculated by subtracting the deflection at 4 from the deflection at gauge 1. A summary of the strength test results is given in Table 1.

In the second series of tests carried out at Townsville, 2425mm (8 ft 1 in) long x 2450mm (8 ft 2 in)high steel framed walls were tested in the vertical position. The plasterboard was screwed to the stud at the top and bottom track junction, and at other places the same as the Port Kembla test panels. The racking force was applied by a hydraulic ram mounted on a braced column,refer photographs. A 20kN capacity force transducer was located between the ram and the wall to accurately measure the racking force. The force was applied through a 100mm long timber block that ensured that there were no extraneous stress concentrations in the steel members. The walls were prevented from overturning by an M12 anchor rod located at each end, adjacent to the stud. A bearing track was used on top of each rod to prevent local buckling of the top track section. Lateral bracing at the top of the walls was supplied by three members spaced at about 1000mm centres. They were pin fixed to both the wall and a support frame so that they were able to provide lateral restraint without attracting any of the racking force. Longitudinal translation of the wall was prevented by the M12 anchor rods and an extra horizontal reaction point at the end of the bottom track.

In plane displacements were measured at the locations shown in Fig.11 Gauge 1 measured the overall movement of the top track member. Gauge 2 measured any horizontal displacement of the wall. Gauges 3 and 4 measured the rigid body overturning of the wall, as would be caused by lifting of one and downwards deflection or crushing at the other. The net racking #r deflection can be calculated from the following simple formula:

$$\#r = \#1 - \#2 - H/L\,(\#3 - \#4)$$

where #1 etc is the displacement at gauge 1 etc, and H and L are the height and length of the wall.
The test procedure involved the application of the racking load in increments with the displacements being recorded at each interval. The shear strength results from this series of tests is shown in Table 2.

Further tests were carried out at Port Kembla on the strength of the screw fixed plasterboard connection on an Instron Universal Testing Machine and the shear capacity of the plasterboard set joint. Tests were carried out on samples shown in Fig. 12 and Fig. 13. on the screw connections and the set joint respectively. The strength results are shown in Tables 3 and 4 for screw connections and set joint shear capacity respectively. A graph of load versus deflection characteristics of the plasterboard connection failure is also shown in Fig. 14. This was obtained from the Instron Universal Testing Machine.

4.0 ANALYSIS OF TEST RESULTS AND MEMBRANE FORCE SYSTEMS

In all tests, the Townsville results are approximately 3 kN (0.67 kip) less than those from Port Kembla and this can be attributed to the differences in the test sample and to a lesser degree test method. A set corner increases the shear strength by approximately 5kN (1.12 kip) in all tests carried out on single sided panels and approximately 10kN (2.24) for all double sided walls which have two set corners at each end. The load capacity of a shear panel clad on one side approximately doubles when the other side is also clad. The mode of wall failure without set corners was by fastener failure along the top track whereas in walls with set corners, it was by membrane buckling accompanied by screws tearing in the plasterboard along the bottom track. The average screw connection strength of Type 6-18x25mm (1 inch) in 10 mm (0.4 inch) plasterboard is 0.47kN (0.105 kip) and the shear strength of a paper taped and set joint is 7.2 kN/m (0.49 kip/ft). The bugle head screw connection shear strength remains fixed at a constant value when the screw is tearing in the plasterboard.

Plasterboard wall panels clad on one side with 10 mm (0.4 in) plasterboard with and without set corners have been analysed and are summarised as follows..

4.1. Test Wall Without Set Corners

In the conventional test wall frame clad one side (Fig. 15) the applied loading P is mainly transferred into the plasterboard sheathing by the screws A1, A2, A3, A4 and A5 . The horizontal shear load in the plasterboard is mainly transferred into the bottom track by the screws C1, C2, C3, C4 and C5. The complementary shear forces are mainly transferred out of the membrane by the screw fixing in the frame corners AD and BC. The force in the bottom track is resisted by a stop at C. The maximum resultant shear force on the screw connections is at screw locations A1 , A5 , C1 and C5 in Fig 15. These screws resist both horizontal and vertical shear loading from the track and stud respectively. Since the failure of the connection fixing the plasterboard to the top track determines the test failure loading, the screw loading at A1 or A5 must form the basis for the design of these plasterboard shear membranes within the elastic range.

4.1.1 Force Analysis

An analysis was carried out on a wall frame tested in Port Kembla which was clad one side without set corners and the load at which visible screw connection movement occurred in the plasterboard at the top track was found to be 2.5 kN (0.56 kip). The assumed force distribution is shown in Fig. 15.

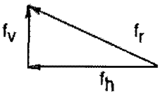
Average horizontal force f_h on the screw A5

Number of bugle head screws in the top track = 5
Maximum load/screw 2.5 kN/5 = 0.5 kN (0.11 kip)

Average vertical force f_v on the screw A5

No of bugle head screws in the stud = 14
Maximum load/screw 2.5 kN/14 = 0·178 kN (0.04 kip)

Resultant force f_r on the screw A5



force polygon

Maximum load f_r on the screw at A_5

$f_r = \sqrt{f_v^2 + f_h^2}$ = 0.53 kN (0.12 kip)

The average connection failure load from testing and shown in Table 3 was 0.47kN. (0.11 kip)

Three additional single tests were carried out using the same panel size but with different screw spacing in the track and stud and the load per fastener was calculated in the same way. The results are shown in Table 5.

The actual failure load of these shear panels is significantly higher than the loading in the design. This is because the connection can maintain its load carrying capacity whilst bearing failure of the plasterboard about the screw is occurring and the resulting movement of the membrane causes the screws at B1 and D13, Fig 15 in the top of the end studs to load and consequently increases the overall shear strength.

4.2 Wall With Set Corners

The wall test frame (Fig.16) is loaded in the conventional way but the distribution of forces in the system is substantially different. In addition to the forces shown in Fig. 15, a force P at A converts to a distributed loading onto the plasterboard set internal corner. If there is direct transfer of forces into the corner without settlement or crushing, differential sliding movement between the top track and the plasterboard will not occur hence the absence of arrows along the top and bottom track in the figure. The primary function of the screw fixing at this stage is to laterally restrain the sheathing against buckling. This mechanism also applies to the forces leaving the membrane at C, the position of the frame stop, in Fig 16. The vertical shear forces leave the bracing wall membrane at the corners BC and AD. The screws fixing the plasterboard to the end studs of the bracing panel transfer some of the shear force whilst the balance is distributed into the adjacent corner stud by way of the corner set and the plasterboard screw fixing.

4.2.1 Force Analysis

Failure of the test panel occurred by the plasterboard membrane buckling between C1 and C2 as shown in Fig. 17 and the failure can be explained in the following way. The section of plasterboard between screw positions C1 and C2 is in compression when the applied loading at A exceeds the horizontal shear the screws at C2, C3, C4 and C5 can resist without causing in plane sliding of the membrane relative to the bottom track. From the screw connection load / deflection graph, Fig. 14 movement begins at the onset of loading and so the membrane section between C1 and C2 load in compression since this movement is effectively restrained by the encasing effect of the framed corner at C. When the membrane between C1 and C2 reaches its critical buckling load, the screws at C2, C3, C4 and C5 have reached their critical tearing load. The critical failure load of the bracing panel is therefore equal to the membrane buckling load for screw spacing of 600 mm (2 ft) between C1 and C2 , the total tearing failure load of the screws in the bottom track and any additional restraint to the plasterboard provided by the screw fixing at corner D and other parts of the system. This additional shear capacity is reflected in the Port Kembla test results obtained from wall panels clad one and two sides without set corners, and results in force redistribution into the end wall studs when yielding of the plasterboard is occurring about the screws in the top and bottom track. The magnitude of this force P_{system} is dependent on the wall frame material and construction, especially the screw position and spacing along the end studs. The buckling capacity of the plasterboard $P_{buckling}$ is the difference in load capacity between walls with and without set corners for walls clad one side only and, half the difference for wall panels clad both sides. The approximate difference in load capacity for the addition of the set corner is 5kN (1.12 kip). The strength of the screw connection in plasterboard fixed with bugle head screws is 0 .47 kN/fastener, and the in-plane membrane movement at the onset of buckling is resisted by a force $P_{tearing}$ which results from screw fixing C2, C3, C4 and C5 in the bottom track.

The applied load $P = P_{buckling} + P_{tearing} + P_{system}$ ------------ 1

The total resisting load provided by the 4 screws = $P_{tearing}$= 4 x0.47 kN (0.11 kip) = 1.9 kN (0.43 kip)

The panel test failure load P was 10 kN (2.24 kip) and substituting in equation 1

$$\begin{aligned} P_{system} &= 10 - 5 - 1.9 \\ &= 3.1 \text{ kN } (0.7 \text{ kip}) \end{aligned}$$

The racking capacity of the plasterboard membrane is mainly dependent on the shear strength of the horizontal set which bonds adjacent sheets. The bond comprises screw fixing the plasterboard each side of the joint at each stud followed by setting, which cements the butt joint together using paper tape and a special cementing plaster - refer Fig 1. The screw fixing each side of the butt joint can transfer a maximum shear load of 5 x 0.47kN = 2.35 kN (0.53 kip). Where five is the number of screws along one side of the joint. The test failure load was 10 kN so the actual setting process was responsible for transferring the shear load across the joint and as such should be considered in the overall design of these types of bracing panels.

The vertical shear in the membrane is transferred into the end studs of the wall panel and adjacent corner studs by means of plasterboard fixing screws and the corner set. The load transferred into the corner is equal to the reaction load and this is 10kN (2.24 kip), and assuming the load is evenly distributed about the plasterboard corner by means of the set, the maximum shear in the set is 5 kN (1.12 kip). The average loading on the screws vertically along the corner studs = 10kN/28 = 0.357 kN (0.08 kip), where 28 is the total number of screws in a corner and 10 kN is the reaction loading on the wall panel.

Additional bracing strength can be gained in conventional plasterboard clad wall panels by simply increasing the number of screws around the perimeter. In the new bracing panels a number of parameters affect the performance and the following describes the mix of these variables which will tend to maximise the racking strength of the standard test panel.

The set joint strength at the wall centre is the load limit of the membrane and this is 7.2 kN/m x 2.4 metre = 17.28 kN (3.88 kip). The number of screws required vertically along each corner = 17.28 kN/0.47kN = 38, this means an additional 10 screws is required at each corner. The approximate screw spacing in the top and bottom track which will tend to maximise the load carrying capacity of plasterboard can be determined using equation 1 with P_{system} = 3.1 kN (0.7 kip) for Port Kembla tests.

$$P_{max} = P_{buckling} + P_{tearing} + P_{system}$$

Let the required screw spacing be X mm and since the buckling load is proportional to k / X^2, where k is a constant, and from the test results the buckling load is 5kN and the screw spacing is 600mm then ;

$$k = 600^2 * 5 = 1.8 \times 10^6 \text{ kN mm}^2.$$

The maximum buckling load $P_{buckling} = 1.8 \times 10^6 / X^2$ kN

The maximum tearing load $P_{tearing} = (L/X) * 0.47$ kN

L = length of the wall panel = 2400mm (8 ft)
0.47 = the plasterboard connection failure load kN

$$P_{max} = 17.28 \text{ kN} = 1.8 \times 10^6 / X^2 + (2400/X) * 0.47 + 3.1$$

Solving for X gives the design spacing of 402 mm (1.31 ft).

The number of screws required in the track = 2400 / 402 = 6 screws, hence 6 screws are required and the average spacing is 400mm (1.31 ft). This analysis assumes bearing failure of the plasterboard at the set corner does not occur and a buckling relationship exists like the one proposed. The buckling relationship will vary with the plasterboard type and thickness.

4.3 Test Panel Shear Stiffness

The shear stiffness is determined from the load - deflection curves.

A reference load in the elastic range of the load - deflection of one third ultimate is recommended by ASTM and that load and corresponding deflection were used in the calculation. The results are shown in Table 6.

The results suggest set corners significantly increase the stiffness of racking panels.

The results however are not conclusive since they offer no explanation as to why the stiffness of the test frame doesn't double after addition of cladding to the other side of the panel and why the magnitude of the stiffness differed so greatly between test locations. Further review of the stiffness measurement methodology is required to assess its suitability in the bracing test.

CONCLUSIONS

The strength test of wall frames, clad one side with set corners show an average increase of 5 kN (1.12 kip) over those tested without set corners. With cladding attached to both sides, the shear strength of walls with set corners increased by 10 kN (2.24 kip) over those without corners. The plasterboard set joint at the centre of the wall can take a shear load of 7.2 kN/m (0.49 kip/ft) which can set a limit on racking design capacity of plasterboard membranes.

The test on the plasterboard screw connection gave a failure load of 0·47 kN and this result generally supports the proposed design philosophy for wall frames without set corners loaded within the elastic limit.

Further testing is required on panels with set corners to establish the plasterboard edge bearing capacity and confirm the membrane buckling relationship with screw spacing in the track for different types and thicknesses of plasterboard. The various end conditions required to transfer loads from the membrane need additional investigation, especially in the areas of window and door openings.

The current ASTM test methods are suitable for evaluating any form of bracing wall where the principal means of load transfer between the frame and bracing element is via the fasteners or fixings, this includes diagonal frame bracing and external diaphragm bracing such as plywood. However it has been shown that it is more appropriate, and indeed there is considerable advantage to be gained out of incorporating the effects of set corners when testing plasterboard clad walls.

ACKNOWLEDGMENT

The authors are extremely grateful for the support given to this project by Research & Technology, Port Kembla, Lysaght Building Industries, Chullora and the James Cook Cyclone Structural Testing Station, Townsville and the comments of Professor Gregory Hancock. We also thank the staff at Lysaght Building Industries especially Mrs Emily Ede, Mr Geoff Roach, Mr Santan Pathmanandavel, Mr Campbell Seccombe and Mr Graeme Stark from Research and Technology for their tireless application and support given in the formulation of this report.

Appendix Notation

f_h = Horizontal force (kN)

f_r = Resultant force (kN)

f_v = Vertical force

H = Height of wall (m)

L = Length of wall (m)

P = Racking Load (kN)

r = Net racking deflection (mm)

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Appendix - Current Test Methods

Previously the racking capacity of walls clad with plasterboard has been evaluated using test methods E72-80 and E564. The E72-80 test specifies that the plasterboard be fixed to an 8 ft. by 8 ft. timber frame consisting of 2" x 4" plates and 2" x 4" studs at 16" centres with double studs at either end. The bottom track is bolted to the floor and a racking load is applied to the top track. The frame is prevented from overturning by rollers on the top track. Rollers are also used to prevent lateral movement of the frame. As this test method specifies the construction of the wall frame it is not a valid test for a complete wall however it may be of some use for testing and comparing cladding materials.

E564-76 is designed to evaluate the racking capacity of a complete wall frame under actual load conditions. This test method specifies that the frame to be tested is constructed using the same materials as would be used in actual building construction. The fixing of the cladding, bracing and hold down detail must be the same as that which will be used in actual building construction. A minimum wall size of 8 ft. high x 8 ft. wide is specified, however the wall may be wider or higher than this. Load is applied to the test wall along the axis of the top edge of the frame. The wall may be restrained from overturning and lateral displacement with rollers which do not restrict in plane displacement. The test method assumes that the strength and stiffness of the test wall is proportional to it's length, allowing results to be extrapolated to longer walls.

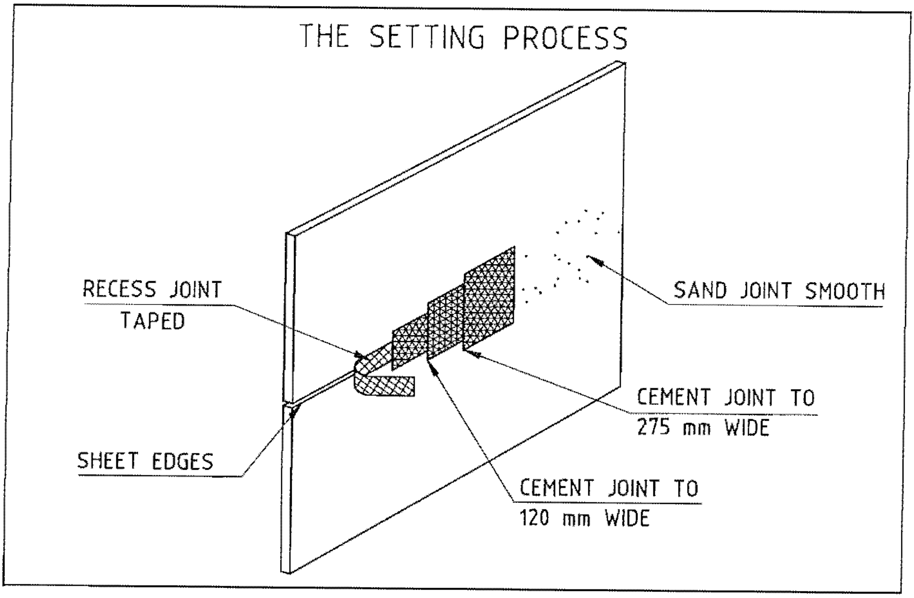
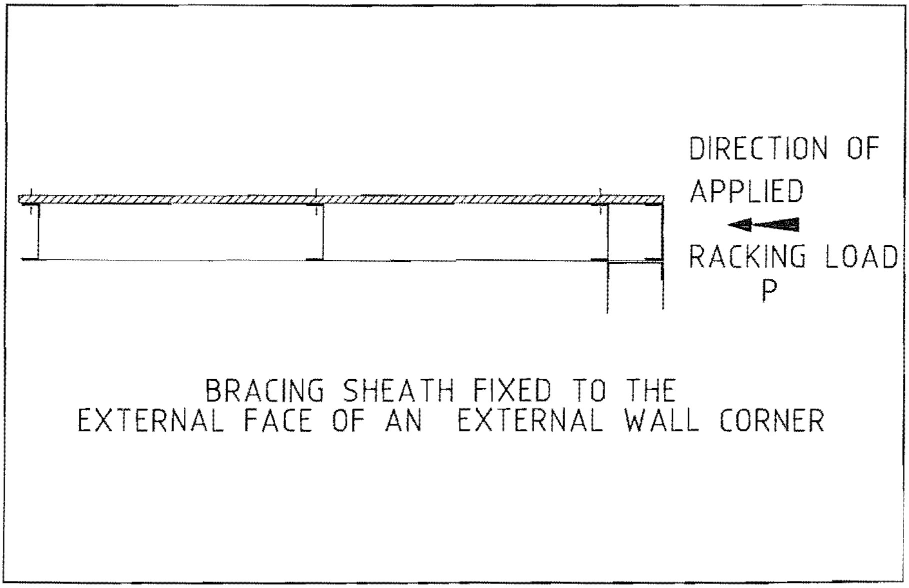


Figure 1



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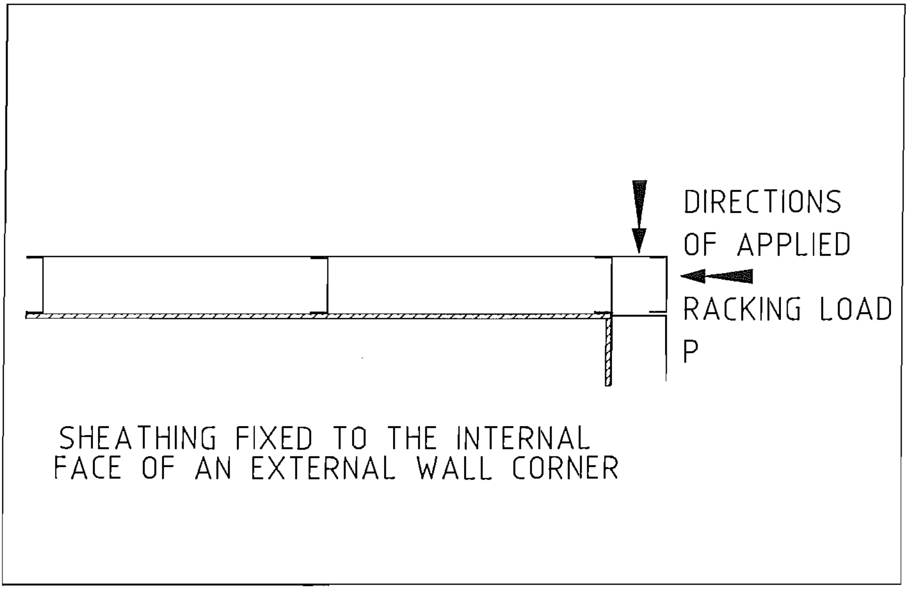

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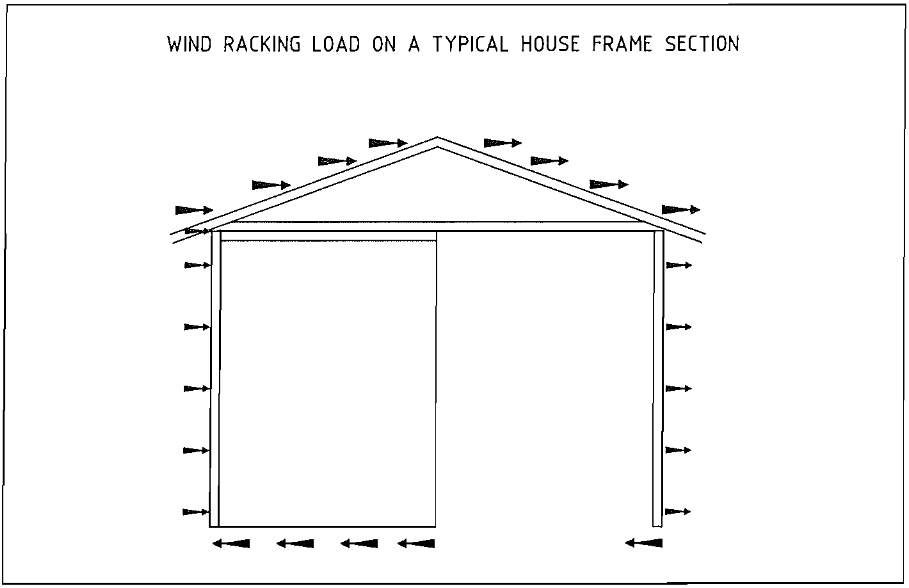

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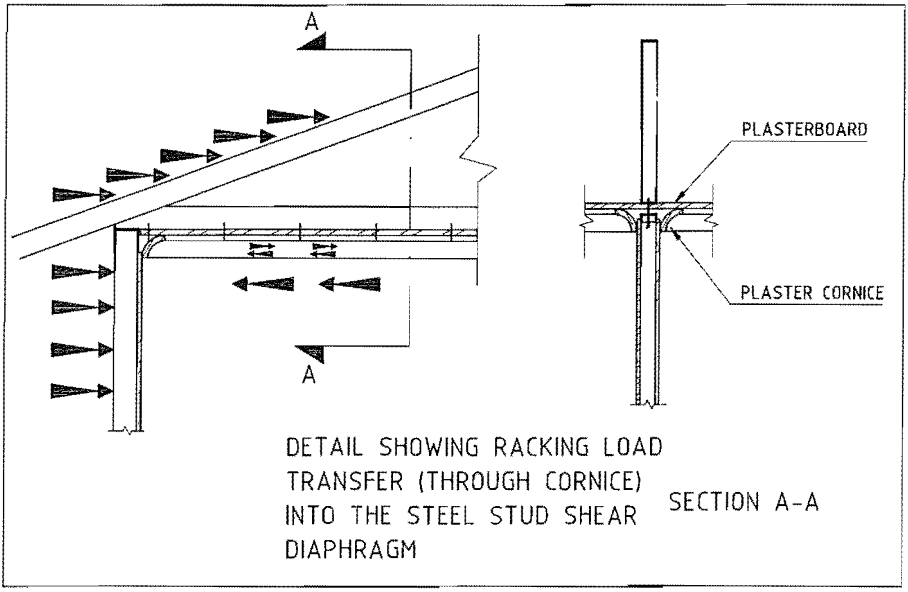

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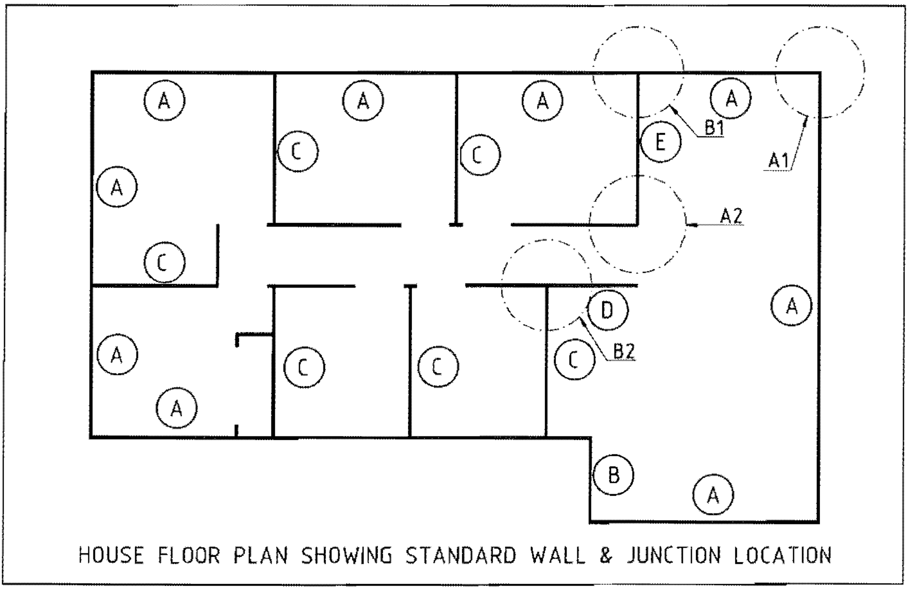

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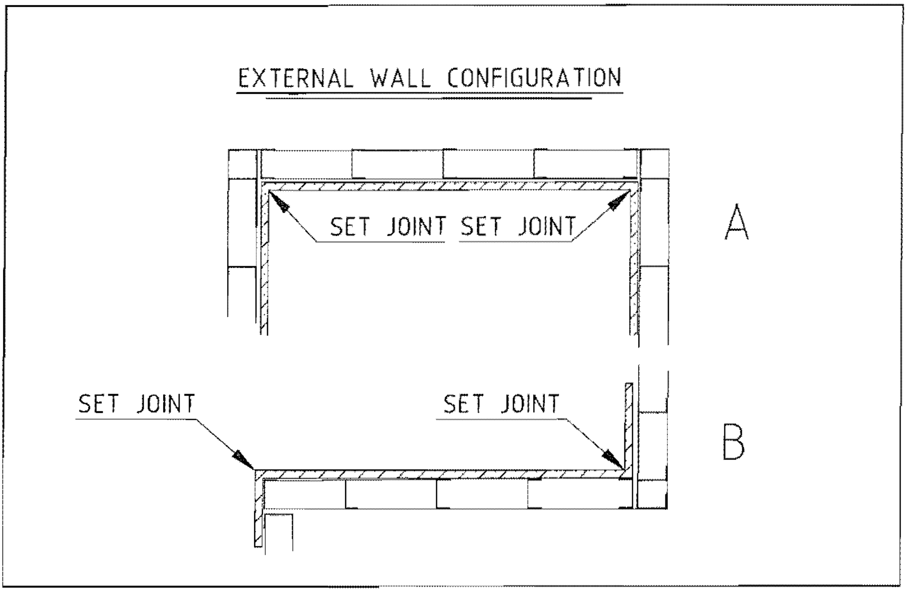

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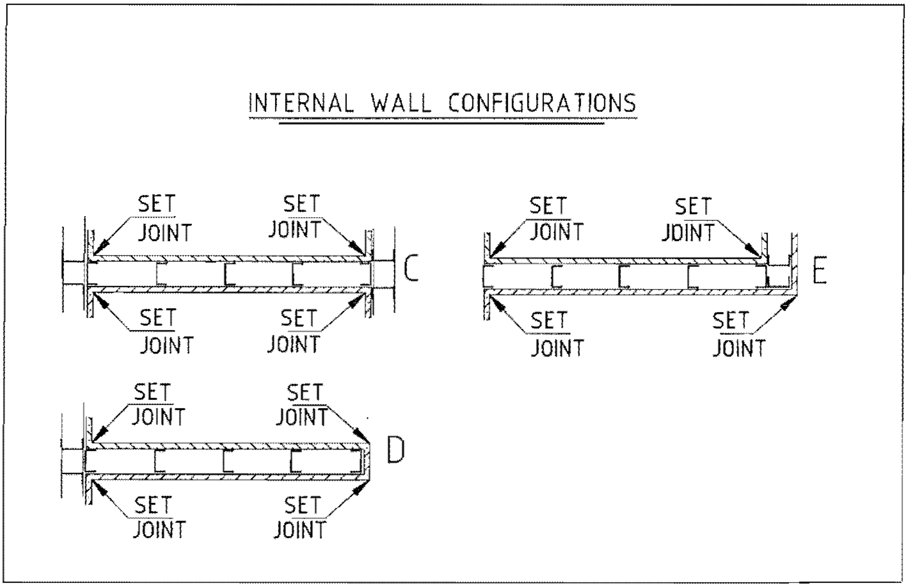

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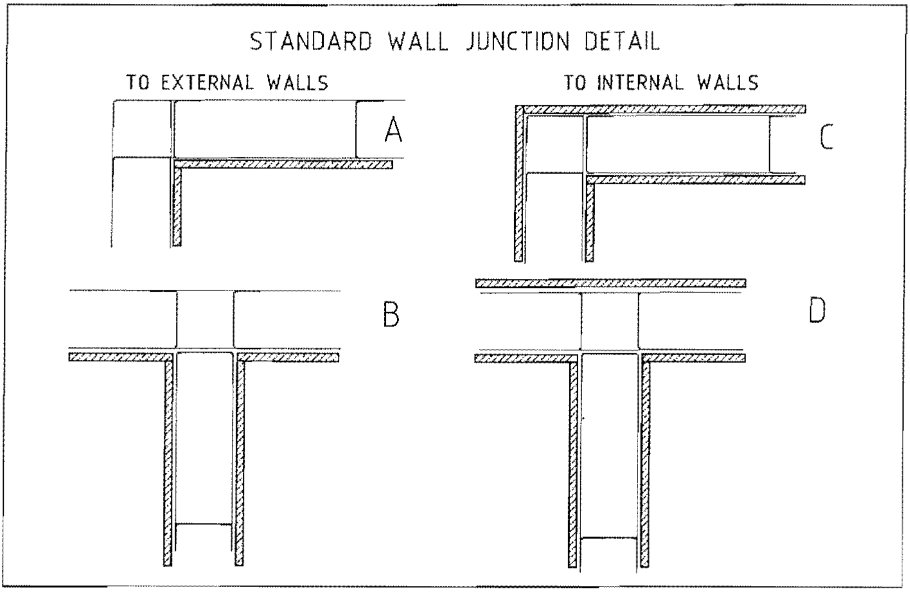

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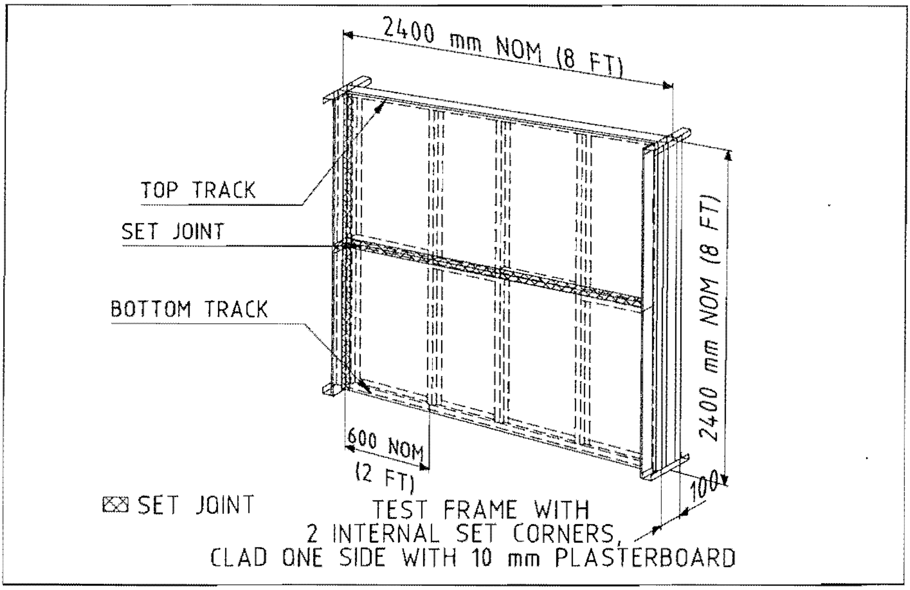

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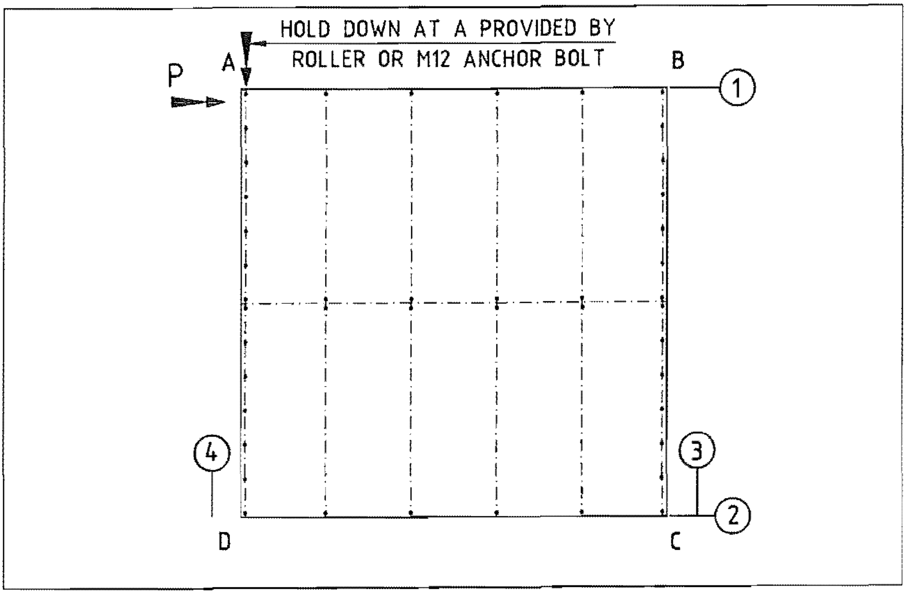
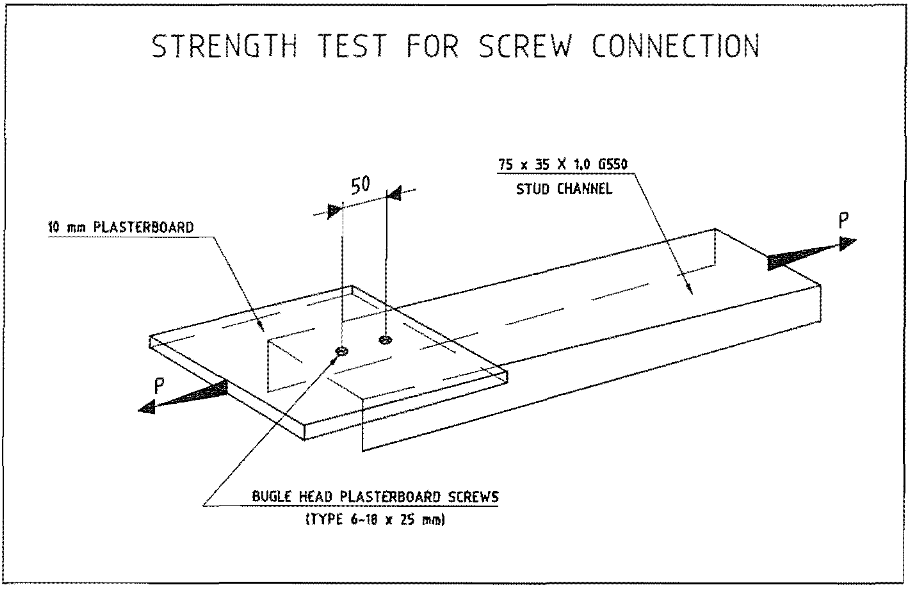


Figure 11



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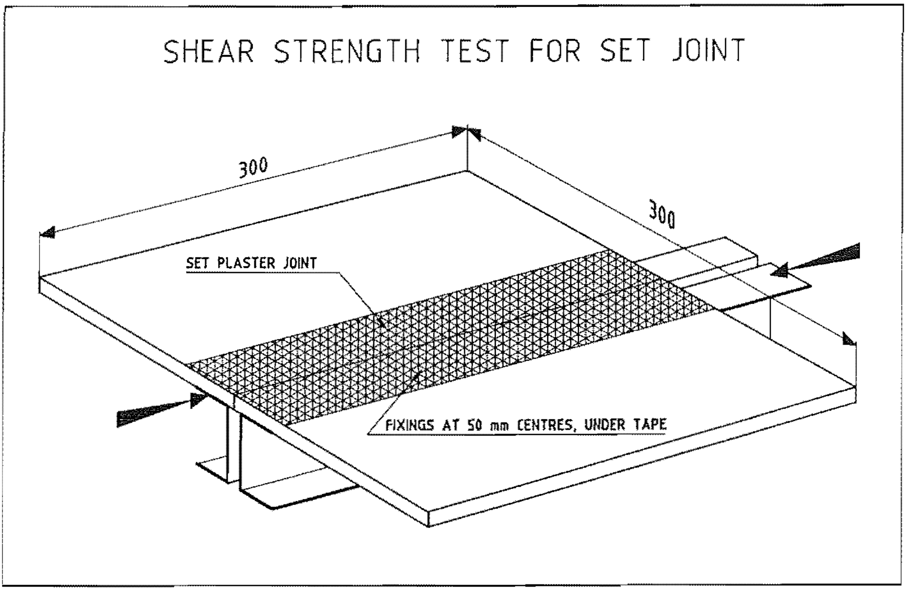

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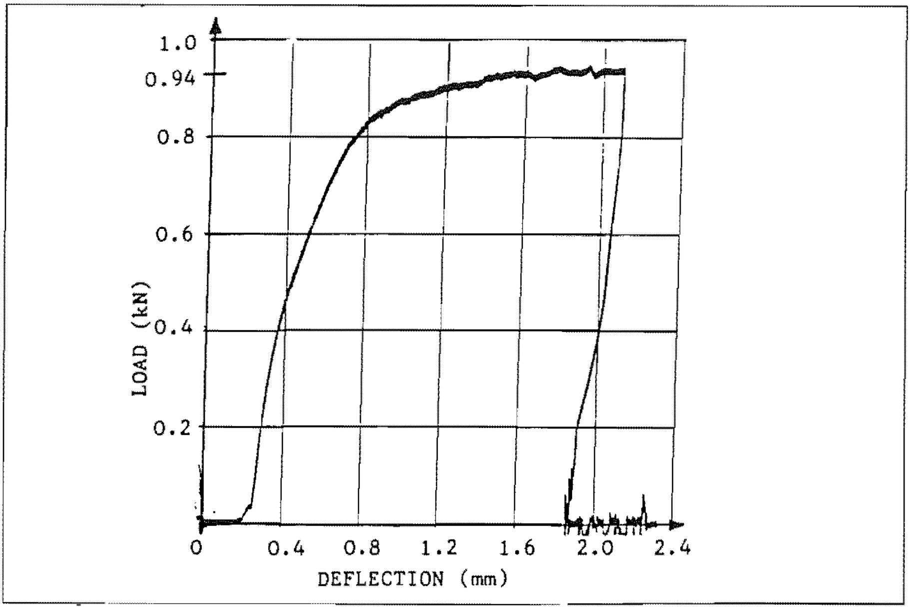


Figure 14

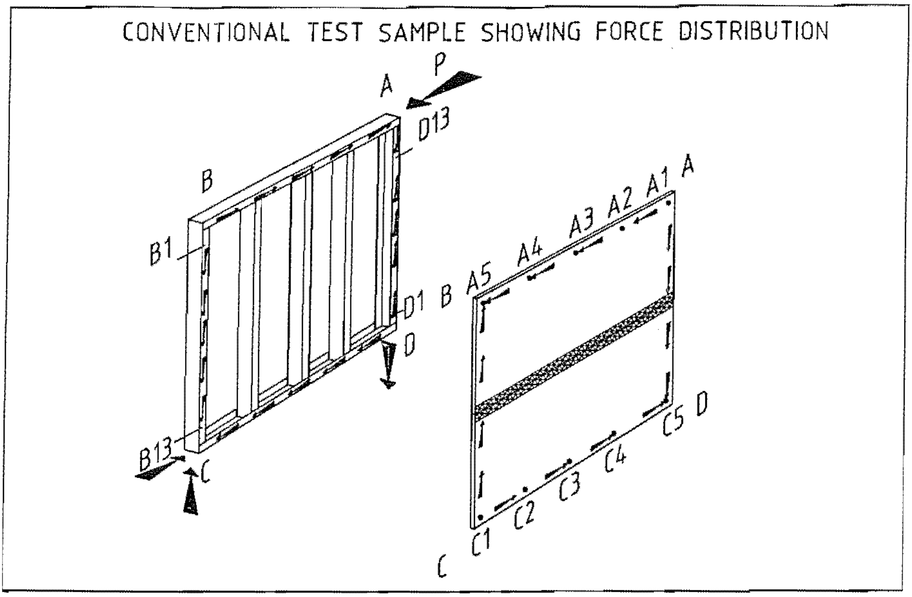


Figure 15

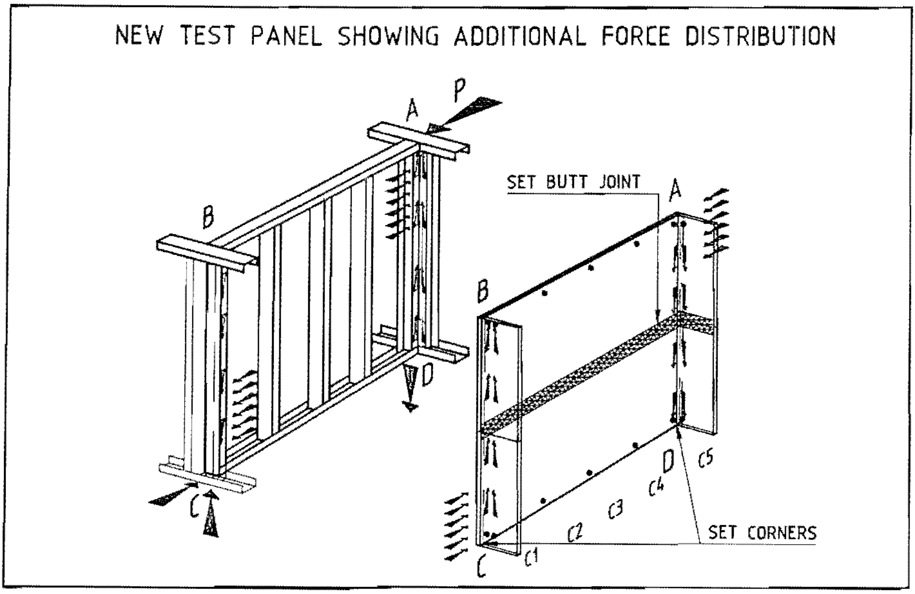


Figure 16

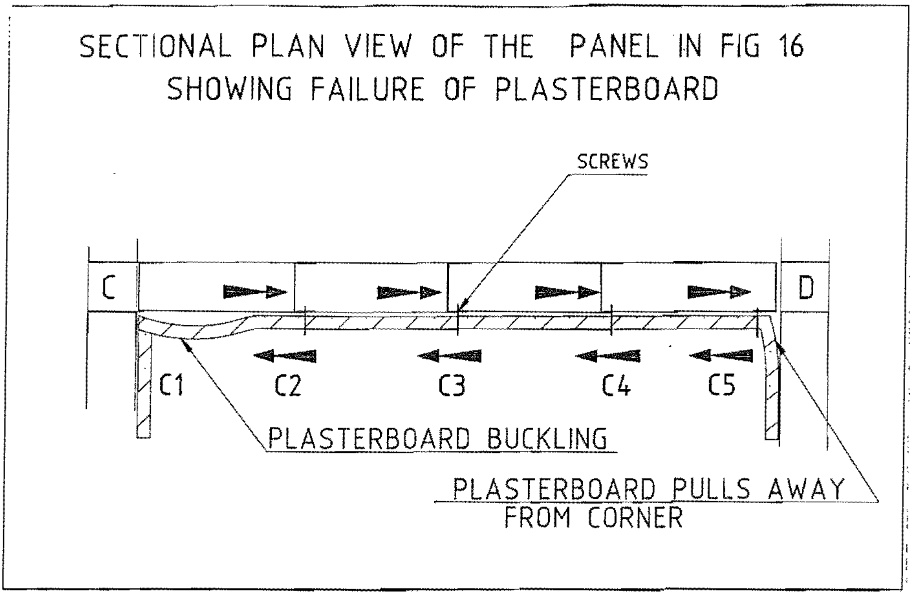
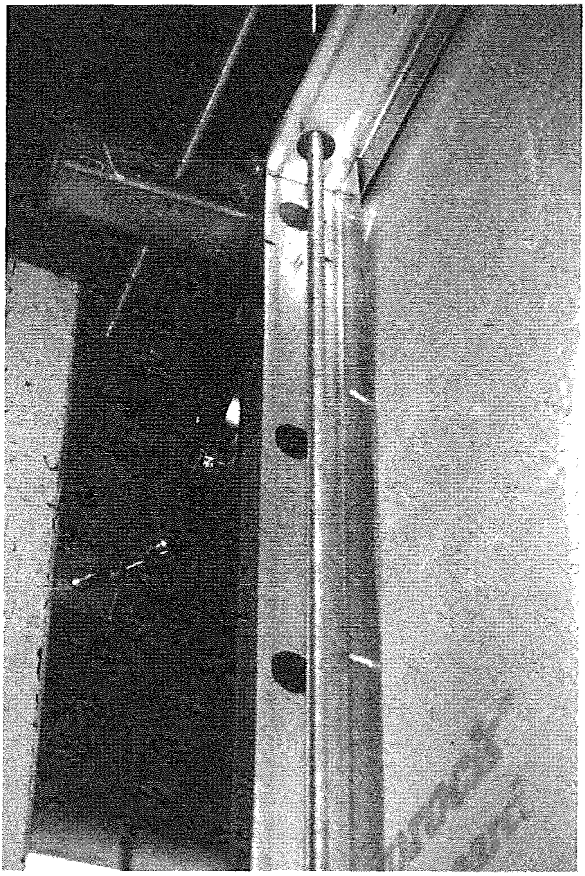
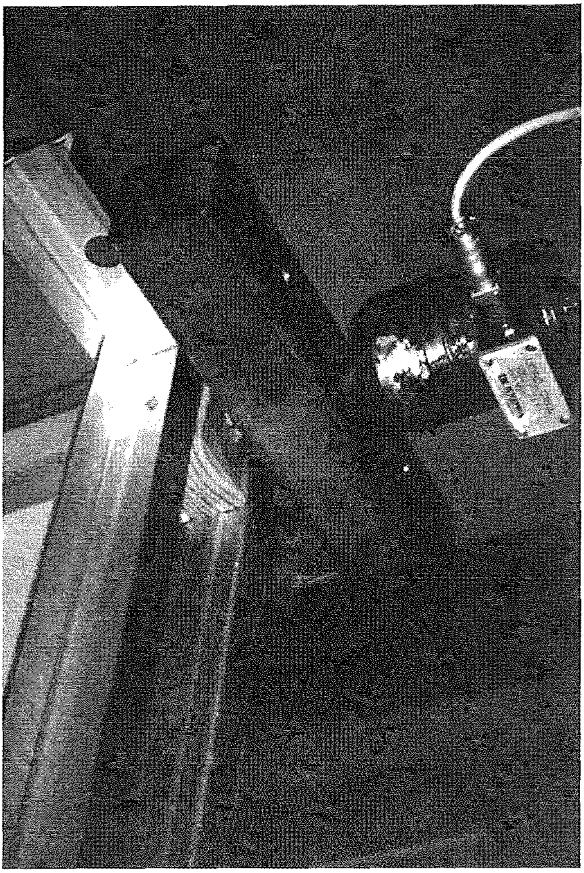

SECTIONAL PLAN VIEW OF THE PANEL IN FIG 16
SHOWING FAILURE OF PLASTERBOARD
SCREWS
C
D
C1
C2
C3
C4
C5
PLASTERBOARD BUCKLING
PLASTERBOARD PULLS AWAY FROM CORNER

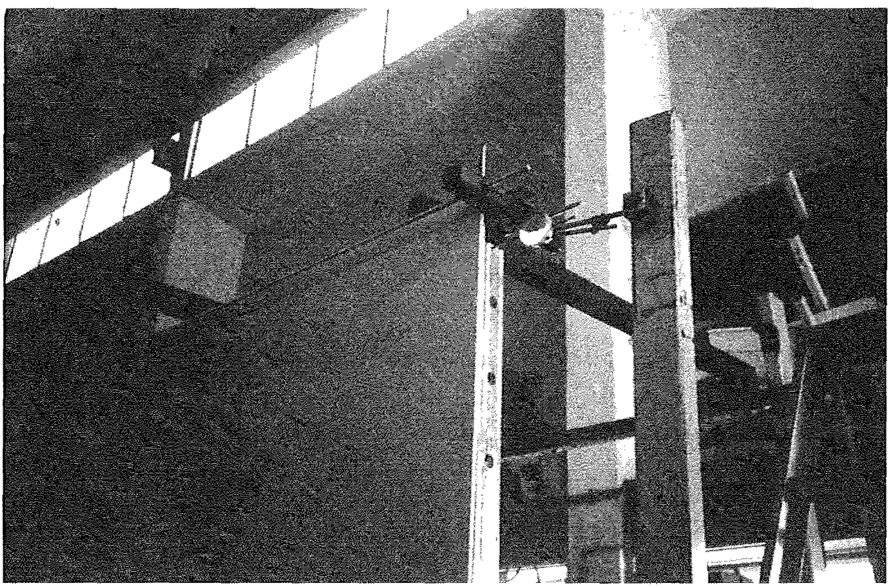
Figure 17



Photograph 1 - showing M12 tie bar at Townsville.



Photograph 2 - showing load application.



Photograph 3 - showing wall panel ready for test.

Table 1.

PORT KEMBLA - TEST RESULTS

NOMINAL WIDTH m (ft)	SIDES CLAD	CORNERS SET	MAXIMUM LOAD kN (lbf)	COMMENTS
2.4 (8)	1	2	10.0 (2248)	Failure due to the plasterboard buckling out of plane and tearing around the screws along the bottom plate.
2.4 (8)	1	0	4.5 (1012)	Screws starting to tear in plasterboard along top plate at 2.5 kN (562 lbf). Failure due to screws tearing in the plasterboard along the top plate and studs.
2.4 (8)	2	4	18.5 (4159)	Failure due to the plasterboard buckling out of plane and tearing around the screws along the bottom plate on both sides of the wall.
2.4 (8)	2	0	8.5 (1911)	Failure due to screws tearing in the plasterboard along the top plate.

Table 2.

TOWNSVILLE - TEST RESULTS

NOMINAL WIDTH m (ft)	SIDES CLAD	CORNERS SET	MAXIMUM LOAD kN (lbf)	COMMENTS
2.4 (8)	1	2	7.1 (1596)	Failure due to plasterboard buckling out of plane and tearing over screws
2.4 (8)	1	0	1.5 (337)	Failure due to screws tearing in plasterboard along the top plate and down the studs
2.4 (8)	2	4	14.6 (3282)	Failure due to plasterboard buckling out of plane and tearing over screws. Studs crushing at support.
2.4 (8)	2	0	5.0 (1124)	Failure due to screws tearing in plasterboard along the top plate and down the studs.

Table 3

SHEAR STRENGTH OF THE PLASTERBOARD - SCREW CONNECTION

TEST NUMBER	1	2	3	4	5	6	7	8	9	10
FAILURE LOAD kN (lbf)	0.50 (112.4)	0.44 (98.9)	0.53 (119.1)	0.45 (101.2)	0.49 (110.2)	0.46 (103.4)	0.53 (119.1)	0.43 (96.7)	0.44 (98.9)	0.46 (103.4)

Table 4

SHEAR STRENGTH OF TAPED JOINT ON PLASTERBOARD

TEST SAMPLE	LOAD kN/m (lbf/ft)
Joint using perforated paper tape.	7.2 (493)
Joint using fibreglass tape.	5.9 (404)

Table 5

MAXIMUM LOAD ON SCREW A5 AT ONSET OF PLASTERBOARD TEARING

TEST NUMBER	SCREW SPACING ALONG TOP AND BOTTOM TRACK mm (ft)	TOTAL NUMBER OF SCREWS	SCREW SPACING ALONG EACH END STUD mm (ft)	TOTAL NUMBER OF SCREWS	MAXIMUM LOAD ON SCREW A5 kN (lbf)
1	600 (2)	5	200 (.67)	*14	0.53 (119)
2	300 (1)	9	600 (2)	* 6	0.50 (112)
3	600 (2)	5	600 (2)	* 6	0.65 (146)
4	200 (.67)	13	200 (.67)	*14	0.47 (106)

figures include both screws either side of the central set joint

Table 6

RACKING STIFFNESS

NOMINAL WIDTH m (ft)	SIDES CLAD	CORNERS SET	RACKING STIFFNESS kN/mm (lbf/in)			
			B.H.P. PORT KEMBLA	% INCREASE DUE TO SET CORNERS	C.T.S. TOWNS-VILLE	% INCREASE DUE TO SET CORNERS
2.4 (8)	1	2	0.95 (5.42)	38	2.10 (11.99)	126
2.4 (8)	1	0	0.69 (3.94)		0.93 (5.30)	
2.4 (8)	2	4	1.00 (5.71)	47	10.82 (61.78)	548
2.4 (8)	2	0	0.68 (3.88)		1.67 (9.54)	