G.J. Edgell, C.A. Fudge

Sumitomo Metal Mining Siporex Co., Ltd, Research and Development Center, Japan

Testing of reinforced AAC walls under lateral and racking loads

ABSTRACT: Reinforced AAC panels in the UK have been used in past, but these tended to be acting as roof units and to a limited extent floor units, with walling elements occasionally used horizontally as fire walls or thinner vertical elements for partitions. In more recent times, their use in housing has been explored as a series of vertical storey height, solid wall elements (each element being 600 mm wide) to form the outer fabric of construction. In this form of construction a thickness of 200 mm will act as the main load-bearing component of the structure as well as making a significant contribution to the overall thermal performance of the building.

The vertical load resistance can be determined using the European Standard EN 12602. However, little data existed in the UK to enable the design of the walls to resist horizontal lateral load and resistance to racking. This paper reports on some preliminary tests to determine the vertical and horizontal spanning capacity of walls made with large elements. These tests were on storey height walls or 1 m high walls each 2.4 m long for the determination of their vertical and horizontal spanning capacity respectively. The walls were built off a slip plane to ensure as little friction at the base as possible, loads were applied using air bags. The racking tests followed the principles of EN 594 which applies to timber structures. The modes of failure in the flexural tests were as expected although the results were quite variable. In the racking tests localised failure occurred at the point of applying the racking load in half of the tests although the results were not so low as to be discounted. Further tests are needed to establish the variability to be expected and to eliminate the localised failure in the racking tests.

1. Introduction

Storey height units in reinforced AAC have been available for some time in the UK and from time to time they have been used as walling elements in housing. However although standard test methods for their compressive strength when loaded vertically are available there are no specific tests for resistance to out of plane load either by vertical or horizontal spanning and none for in plane lateral (racking) loads. This paper presents the results of some preliminary tests which were carried out to investigate the suitability of the test methods and to derive some preliminary data.

2. Test specimens

The test specimens for the horizontal spanning tests consisted of four number 1 m high panels each 600 mm wide and 200 mm thick and these were joined on their vertical sides with thin joint (nominally 3 mm) mortar complying with EN 998-2. The AAC had a nominal compressive strength of 3 N/mm^2. The panels were built off a slip plane to ensure there was as little friction at the base as possible.

The test specimens for both the vertically spanning and racking actions were similar to those above but were 2.4 m high. Those for the racking action were built off a bed of class M3 mortar in order to represent a realistic base condition without a slip plane. For the out of plane loading the intention of using the slip plane was to aim to achieve a flexural value that might be used for design purposes. For the racking load the slip plane was excluded to avoid a premature sliding failure. All of the walls were tested after curing for 7 days.

3. Loading arrangement

The loads for the out of plane loading tests were applied using air bags reacted against a reaction structure. The racking load was applied by a horizontal jack and the vertical loads by a series of vertical jacks with rollers fixed to the ends of each to permit in-plane movement of the test panel. The location of strain gauges, deflection transducers, the specimen format and loading system are shown in figure 1.

4. Loading procedure

The 1 m high wall was loaded in increments of 1 kN/m^2 and strain gauge and transducers were recorded up to failure. The 2.4 wall loaded out of plane was loaded in increments of 0.2 kN/m^2.

Vertical loads of 0 kN and 1 kN were applied by each of the vertical jacks to each of three panels subjected to racking; these were loaded to failure using the racking load. The procedure followed that for timber framed panels e.g. an initial racking load of 3 kN is applied to the panel. This is retained for 1 minute and then released. The panel is allowed to recover for five minutes and the racking load is then applied until failure occurs.

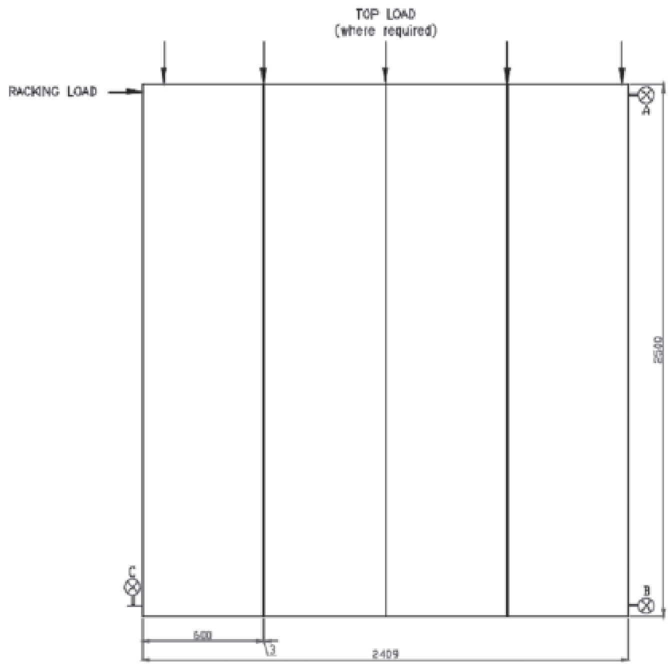

Fig. 1. Detail and Dimensions for Racking Tests.

5. Test results

The test results in terms of load to failure are given in Tables 1-3.

Table 1

SUMMARY OF THE FAILURE LOADS OF THE HORIZONTAL SPANNING WALLS.

Wallette No.	Load at Failure (kPa)	Mode of Failure
1	5.1	Failed at first vertical joint – mortar to block failure
2	6.6	Failed to the left of the centre joint through the block
3	8.0	Failed at centre – block failure

Table 2

SUMMARY OF THE FAILURE LOADS OF THE VERTICAL SPANNING WALLS.

Wallette No.	Load at Failure (kPa)	Mode of Failure
1	4.2	
2	6.0	Failed horizontally across the wall at mid height
3	3.3	

6. Discussion

6.1. Horizontally spanning panels

The results of the loads at failure are quite variable. In test one failure was at the mortar joint at the left hand side of the panel, in the latter two it was by the unit failing close to the centre of the panel (see figures 2 and 3). The loads at failure indicate that at the failure in panel 1 the bending moment across the joint was 2.4 kN-m whereas the maximum in the panel at mid span was 3.7 kN-m. In panels 2 and 3 the maximum bending moment was 4.8 kN-m and 5.8 kN-m respectively. Consequently in panel 1 the first joint resisted less than half the moment that was carried by the central joint before failure of the block close to the central joint in subsequent tests. The deflections indicate that in panel 1 the displacement was quite asymmetrical with the left hand panel displacing far less than the right hand or naturally the centre panels. All of the panels were very stiff with maximum deflections at failure no more than approximately span/1200 and deflections at working load much less (see figures 4-6). The relative stiffness of the left hand side of panel 1 and relatively low failure moment is obviously a matter of concern. Clearly three specimens is insufficient to derive a statistically meaningful lower bound bending capacity and with the data we have we would be forced to conclude a low characteristic or representative lower bound. Naturally the joint in question in panel 1 may have been in some way unusual or deflective, alternatively perhaps some low load cycling might have helped with 'bedding in' and made the deflected profile more symmetrical and the failure load to be nearer to that of the remaining two panels.

Table 3

SUMMARY OF THE FAILURE LOADS OF THE WALLS TESTED FOR RACKING RESISTANCE.

Wall No.	Vertical Load (kN/m)	Load at Failure (kN)	Mode of Failure
1		60	Localised failure at top of wall at load position
2	0	121	Localised failure at top of wall at load position
3		124	Diagonal failure through wall
4		98	Localised failure at top of wall at load position
5	2.1	110	Diagonal failure through wall
6		66	Diagonal failure through wall

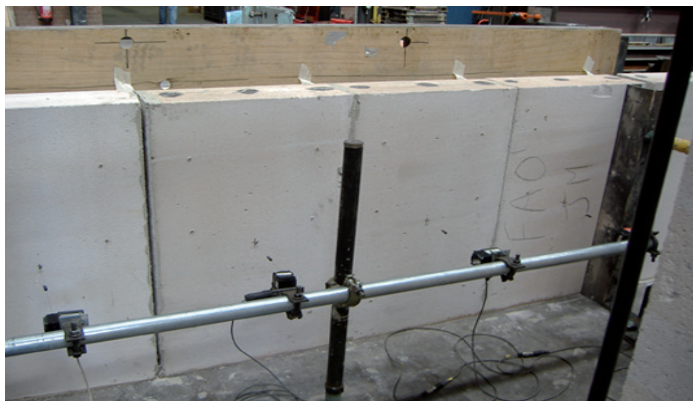

Fig. 2. General View of Test Arrangement and Failure of Wall 1 under Horizontal Spanning Test.

Fig. 3. Failure of Wall 3 under Horizontal Spanning, Note the Unit Failure and not Mortar Joint Failure.

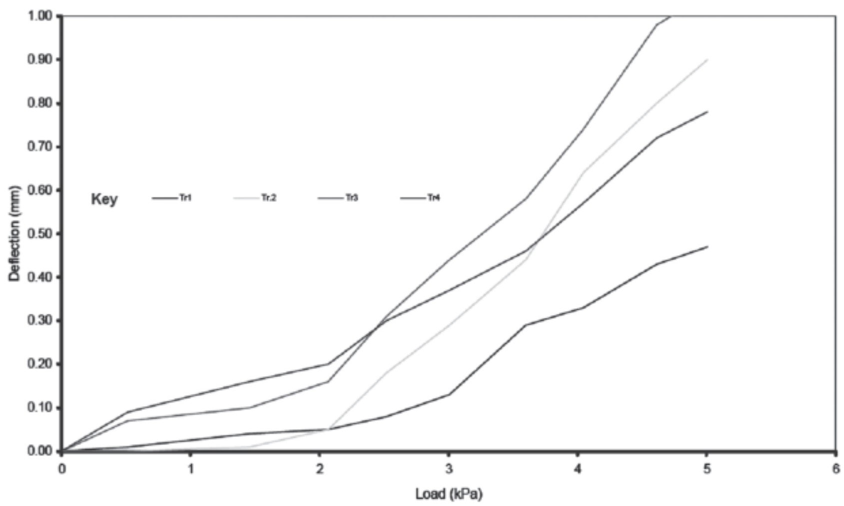

Fig. 4. Load Versus Deflection for Horizontal Spanning Panel, Test 1.

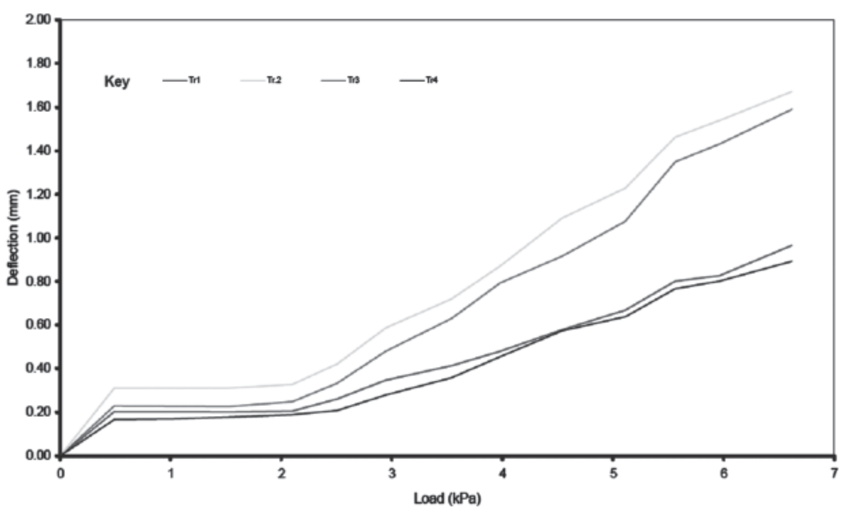

Fig. 5. Load Versus Deflection for Horizontal Spanning Panel, Test 2.

6.2. Vertically spanning panels

In the case of the vertically spanning panels there was again considerable variability in the results. The panels failed in a similar way i.e. an approximately horizontal crack near to mid span. The load deflection curves of each panel in the wall were very similar, an example is shown in figure 7. In this case the strains in panel 2 which gave the highest result were very varied across the face of the panel, in panel 3 the strains in each part of the panel increased in the same way with applied load. The spans involved are similar to those in the horizontal spanning tests and consequently the failure loads and moments associated with them are similar for both directions of spanning. Clearly the variability in these panel results requires some further investigation and further testing is needed before the test could be recommended as a standard approach.

6.3. Racking tests

The results from these tests are given in Table 3. The key fact here seems to be that it is quite possible to generate good racking resistance either with or without pre-compression on the wall. However whether pre-compressed or not there were some low results. Studying the deflection data shows that there is no clear correlation between the mode of deflection and the failure modes. So for example in the walls with pre-compression all of the walls failed following a whole wall rotation, i.e. clockwise rotation of the wall in the rig. However in wall 4 there was local crushing below the applied racking load but wall 6 which failed by diagonal cracking gave the lowest result. Consequently the results may suggest that when eliminating local failure, which should be the next objective in the test method development, the variability of the results may not be reduced to an acceptable level.

7. Conclusions

All of the test methods require some further development to try to reduce the variability in the results. For the horizontal spanning test some bedding-in cyclic loading might be helpful and for the racking test a larger loading plate and higher pre-compressions should be considered. The bending capacity of the panels was similar when either vertical or horizontal and the differing strain behaviours in the 1.2 m x 600 mm elements used to make up the test specimens seems to suggest that some joints are more effective than others in ensuring proper plate like behaviour. Further testing is required to investigate some of these points further and to provide a more statistically meaningful database.

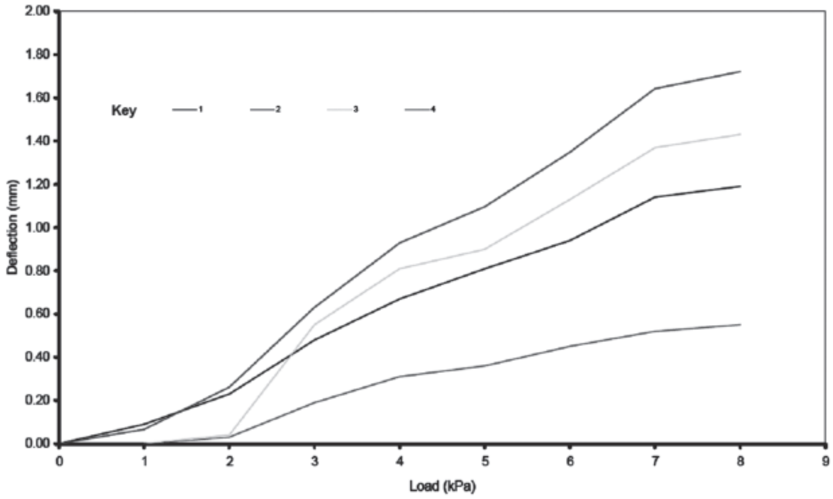

Fig. 6. Load Versus Deflection for Horizontal Spanning Panel, Test 3.

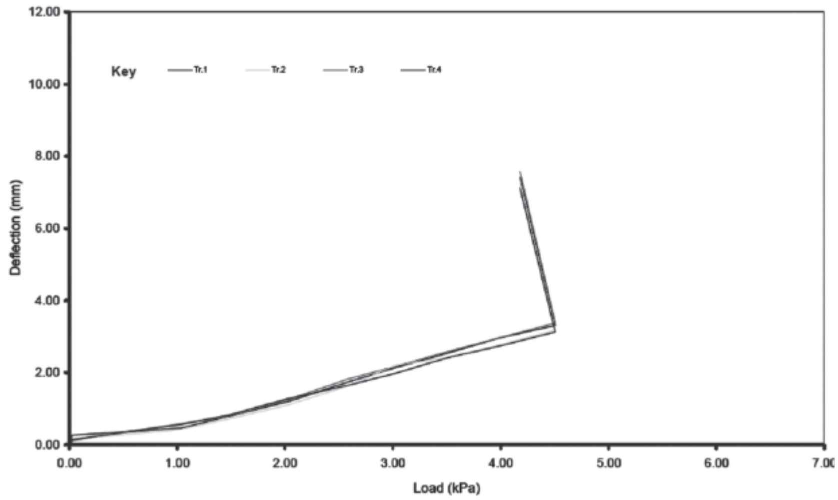

Fig. 7. Load Versus Deflection for Vertical Spanning Panel, Test 1.

References

[1] British Standards Institution. Prefabricated reinforced components of aerated concrete, BS EN 12602: 2008.

[2] British Standards Institution. Timber Structures – Test Methods. Racking Strength and Stiffness of Timber Frame Wall Panels, BSEN 594-1996.