Project	Client
Fish Net and Bottle Building System	AGRÉMENT SOUTH AFRICA
Discipline	
Structural Testing	Dr Walter Burdzik

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Revision

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1. General

1.1. Background

Prof Walter Burdzik was requested by Agrément to evaluate the structural strength of the building system for wind loading on gable walls, hard and soft body impact loads and loading on fixings.

Photograph 1: The test specimen with the wind load brackets attached.

1.2. General

The testing was based on the principles as laid down by Agrément South Africa, Performance Criteria: building and walling systems.

1.3. Building System

A complete house was constructed on the Agrément test site.

Photograph 1: The building system consists of cold drink bottles that have been filled with sand. The bottles are stacked and the wall covered with a fish net that is then plastered.

Photograph 2: Photograph of the bottles used to build the wall

2. Wind Loading on Gable wall

2.1. Agrément Criteria

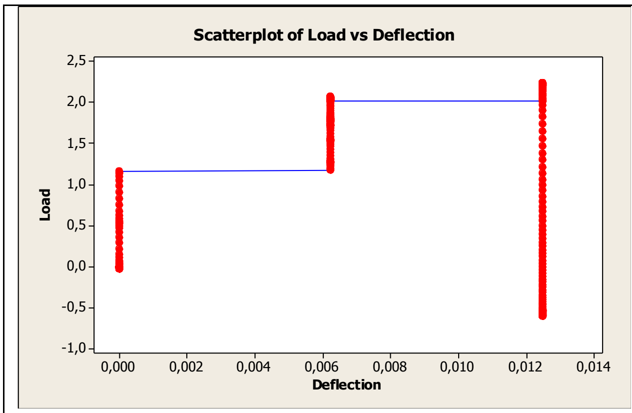
Summary of ultimate design wind pressure coefficients

Component	Cpe +Cpi	Ultimate design pressures
Wind uplift on roof	-0,8 - (+0,8) = -1,6	0,77 kPa upwards
Outward pressure on doors and windows	-0,6 - (+0,8) = -1,4	0,67 kPa outwards
Inward pressure on doors and windows	+0,9 - (-0,3) = +1,2	0,58 kPa inwards
Outward pressure on all walls	-0,6 - (+0,8) = -1,4	0,67 kPa outwards
Inward pressure on all walls	+0,7 - (-0,3) = +1,0	0,48 kPa inwards
Horizontal pressure on the side of a building (This is the pressure that causes racking)	+0,7 - (-0,3) = +1,0	0,48 kPa inwards or outwards
Local effects on eaves overhangs	-1,2 - (+0,9) = -2,1	1,01 kPa upwards

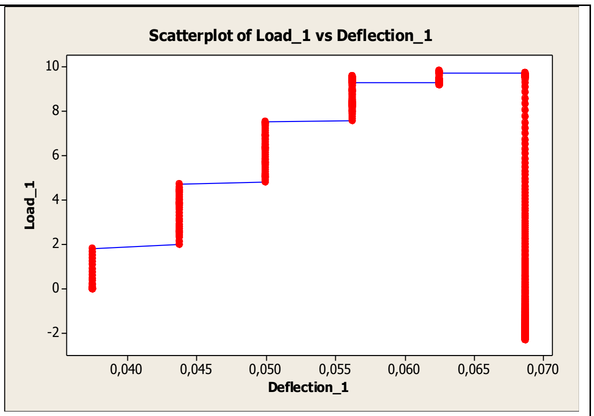
The Ultimate or failure loading has been increased to ascertain at what load the wall will fail so that a better idea can be formed about the safety of the building

2.2. Test Results

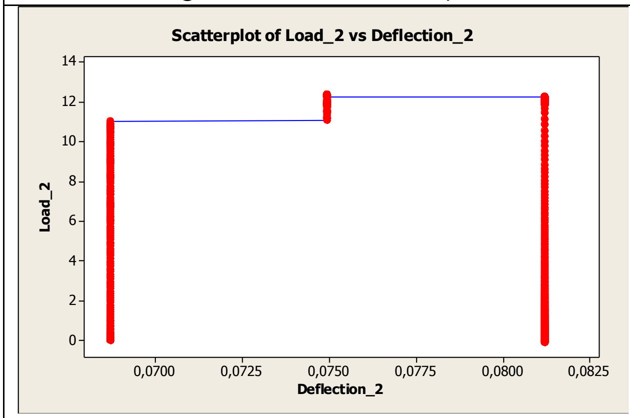
The ultimate load on the gable wall is 13 kN with an expected failure load in the region of 16,5 kN. The residual deflection after the second service wind load cycle was less than 0,5 mm which is substantially less than 25% of the wall thickness



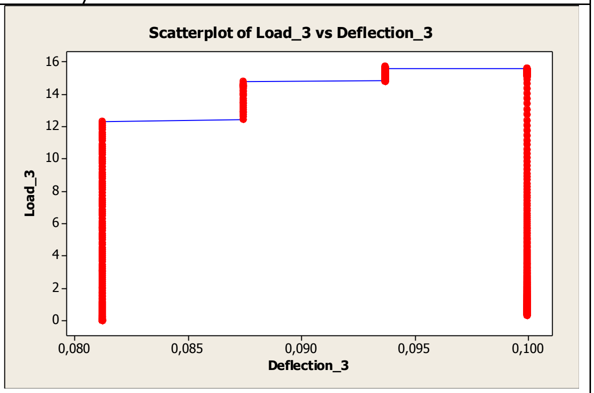
Initial Loading of 2,1 kN second cycle



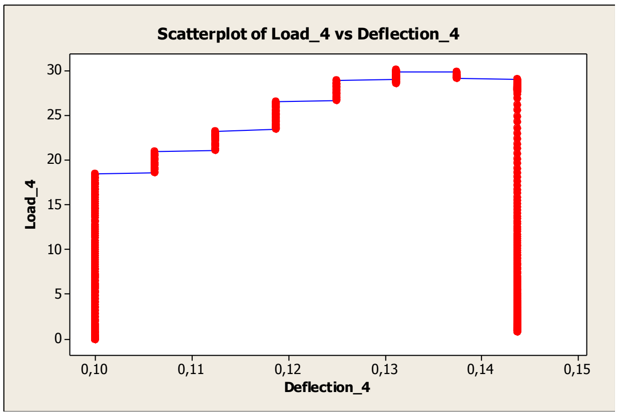
First Cycle of service load



Second Cycle of service load



Ultimate Load on the wall, i.e. 1,3 times service load



Estimated failure load on the wall.

Criteria

The deflection under the second cycle of full service load shall not exceed the deflection under the first cycle of full service load by more than 10 %.

The deflection under the second cycle of full service load shall be no greater than 25 % of the finished thickness of the wall.

The wall passed the service loading condition and ultimate load as well as any expected failure load. The system was so stiff that it was very difficult to measure the deflection at the top of the wall.

System Passed the expected failure wind load on the gable wall.

3. Wind Uplift on Roof Fixings

3.1. Agrément Criteria

An ultimate design uplift pressure of 0,77 kPa is used to determine the force on the roof fixing between the wall and the roof truss. The truss spacing is assumed to be 1,2 m. Loading is then applied to the truss as close as possible to the wall. The Service load is taken as 2,6 kN, which allows for a slight overhang and the ultimate load is taken as 3,6 kN. The failure load is used to determine the safety of the fixing against wind load and should be substantially more than the ultimate load. The difference between the ultimate load and the failure load depends on the variability of the strength of the fixings.

3.2. Test Results

The roof-uplift loading was undertaken by jacking against the roof truss at the wall support. The service load was set at 2,6 kN which then represents the load on a 1,2 m wide section of the roof at the wall. The load was applied with the deflection after the first application being 0,1 mm. The ultimate load of 4,0 kN was exceeded and a failure load of 12.0 kN was carried by the holding down detail without any sign of failure.

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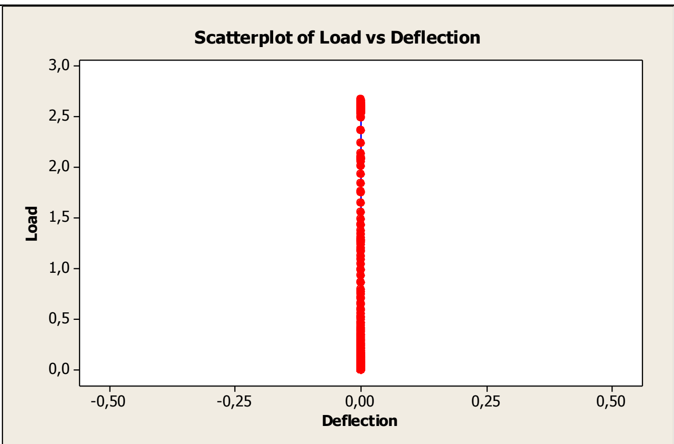
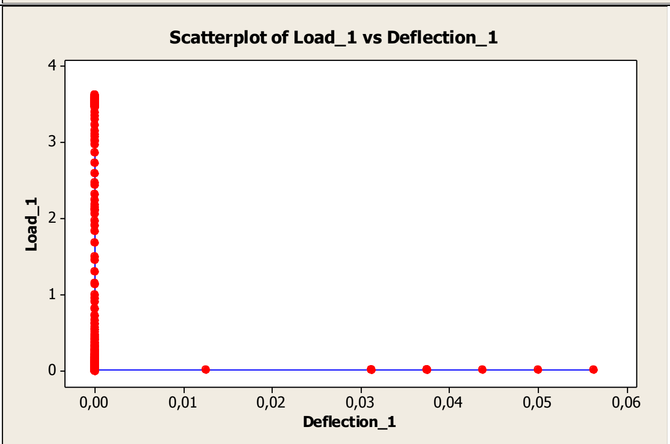
Photograph 5: Loading on a roof truss.

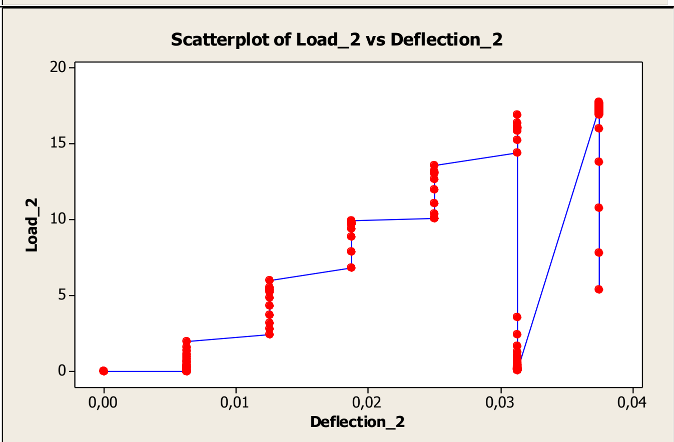


This show the loading cycle for service load of over 2.6 kN. The deflection is so small that it could not be measured.



This shows the ultimate wind load condition with a residual deflection of less than 0,06 mm.

Once again the roof was so stiff that the measurement of deflection was difficult.



The load was increased to 17 kN, which is in excess of 6,5 times the service load

System passed the ultimate roof wind load.

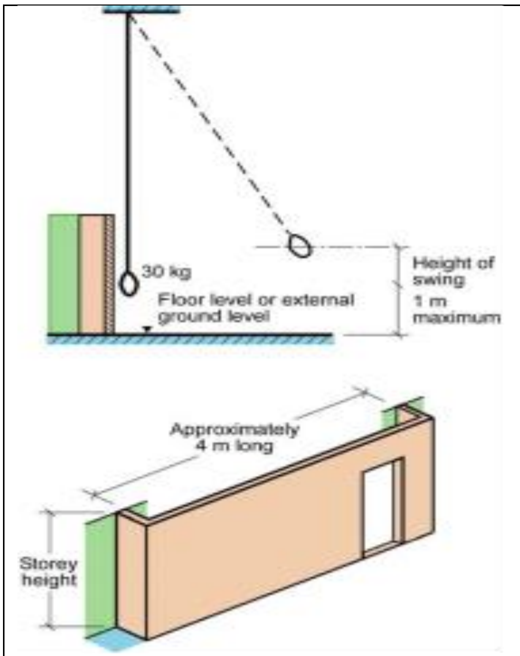
4. Revised Soft Body Impact Test

4.1. Agrément Criteria

Criteria for resistance of walls to impact damage by soft-body impact

Height of swing of sandbag Energy equivalents of impacts (in brackets)				
Type of wall	• Internal walls other than those mentioned in column on the right • External walls at ground floor level (impact from "inside") • External walls at first floor and higher levels (impact from "outside") - in cases where this test is considered necessary		• Internal walls around lift shafts, stairwells, escape routes; loadbearing internal walls • External walls at first floor and higher levels (impact from "inside") • External walls at ground floor level (impact from "outside")	
	Without causing appreciable cracking or permanent deformation	Without causing collapse	Without causing appreciable cracking or permanent deformation	Without causing collapse
Masonry or heavyweight construction	600 mm (176 J)	1 400 mm (412 J)	900 mm (265 J)	1 800 mm (530 J)
Lightweight construction	450 mm (132 J) (framing) 300 mm (88 J) (cladding)	900 mm (265 J) 900 mm (265 J)	900 mm (265 J) 900 mm (265 J)	1400 mm (412 J) 1400 mm (412 J)

Table 2: Loading Conditions for Soft Body Impact Testing

	After the two blows from the lower height, a wall must not be permanently deformed or displaced by more than 1/600th of its height. In addition, any cracks formed must not be wider than 0,5 mm and their aggregate length must not exceed 300 mm. After the higher height, from which two blows must not cause collapse of a wall (safety criterion).

4.2. Test Results

The wall panel showed no cracking even after the third strike by the bag,

The bottle wall passed the soft body impact test.

5. Hard Body Impact Test

5.1. Agrément Criteria

The resistance of the wall to damage by the impact must be as follows:

- the wall surface must not be punctured nor must it be indented or locally displaced by more than 3 mm after two blows by the steel tool from the heights given in the criteria
- there must also be no readily visible cracks (ie wider than 0,25 mm) and their aggregate length must not exceed 300 mm.

Criteria for the resistance of wall surfaces to impact damage by steel tool apparatus (hard-body impact)

Type of wall, whether of masonry, heavyweight or lightweight construction	• Internal walls other than those mentioned in column on the right • External walls at ground floor level (impact from "inside") • External walls at first floor and higher levels (impact from "outside") - in cases where this test is considered necessary	• Internal walls around lift shafts, stairwells, escape routes; loadbearing internal walls • External walls at first floor and higher levels (impact from "inside") • External walls at ground floor level (impact from "outside")
Height of swing of tool, the impact of which must cause no appreciable cracking or deformation of the wall Approximate energy equivalents of impacts (in brackets)	250 mm (5,3 J)	375 mm (7,9 J)

Table 3: Loading Criteria for Hard Body Impact Testing

5.2. Test Results

The panel passed all the criteria for the hard body impact loading with slight damage to the steel sheathing, the indentation being less than 3 mm after two blows by the chisel point. See Photograph 7.

	Photograph 7: This shows the damage to the outer skin of the wall after three strikes with the chisel point. The indentation was less than 3 mm

The revised panel passed the hard body impact test.

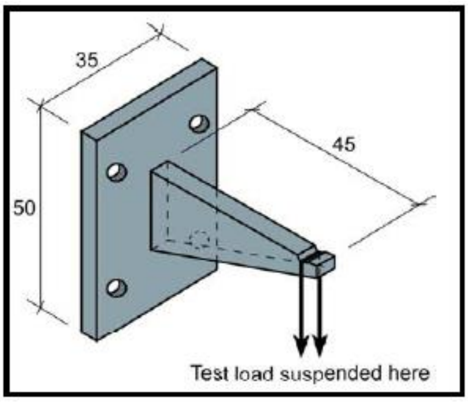
6. Attachment of Fittings to Walls

6.1. Agrément Criteria

Criteria for the attachment of fittings to walls

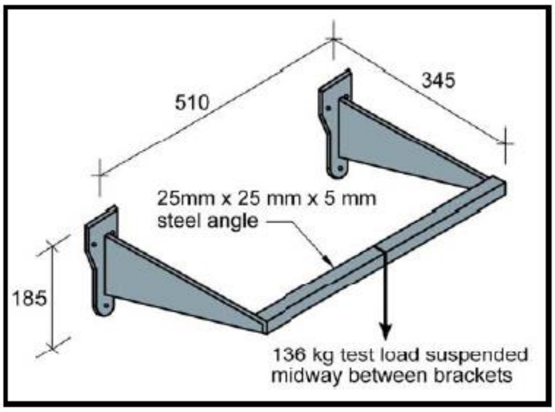
The walls of buildings are often required to support loads that are imposed on them by fittings that are directly attached to them and which carry loads found in everyday use. The fittings are classified as:

- Lightweight or mediumweight fittings (examples of lightweight fittings are hat and coat hooks, towel rails, etc.)
- Mediumweight fittings are fittings with single arms from which objects or appliances are suspended, (for example a nominal 9 kg fire extinguisher).
- Heavyweight fittings These include heavy sanitaryware (eg wash-hand basins) or other fittings or brackets from which appliances are suspended (eg fire-hose reels). The possibility of a person standing on such a fitting is also taken into account.
- Shelving: single shelves as well as tiers of shelves are considered in this category.



Light and Medium-weight Fittings

A test fitting, fabricated from steel as illustrated, is fixed to the wall with four screws or such other suitable fixing devices as may be used in practice. An initial test load of 2,3 kg is suspended at the position shown for one minute and the load is thereafter increased in 2,3 kg increments at one minute intervals until failure or maximum loads of 11,5 kg (lightweight fittings) or 23 kg (mediumweight fittings) are attained.



Heavy-weight Fitting

A test fitting, fabricated from steel as illustrated, which simulates a pair of wash-hand basin brackets, is fixed to the wall with screws or such other suitable fixing devices as may be used in practice. The test fitting is located about midway between the end of the wall and the door opening. A test load of 136 kg is suspended at the positions shown on the steel angle for five minutes. This test is carried out only once for a particular wall.

6.2. Light and medium weight fittings

The revised panel was able to withstand the light and medium weight fittings using Fischer plugs with the coach screws. See Photograph

Photograph: This shows the length of screws that were used as it opened in the plaster and not the bottle

Photograph 9: This photograph shows the panel successfully supporting the medium-weight fitting load, using Fischer Plugs with the hammer-in screws.

The bottle wall passed the light and medium fitting load.

6.3. Heavy-weight Fittings

The revised panel supported the heavy fitting load and maintained a mass load of 136 kg.

Photograph 10: This shows the bottle wall supporting the heavy fixing load

Note that the same fixings and hammer-in screws were used for the heavy fitting support.

The wall passed the heavy fitting load.

7. Door Slamming

Test for resistance to door slamming

The test to determine the resistance of walls to door slamming is not carried out as a routine test, but only when other factors indicate that it may be useful.

For this test a wall specimen similar to that used for sandbag impact tests is required with a door frame fitted in the opening as is done in practice. A door with a mass of 25 kg is hung in the door frame. The door is slammed from a position of 60° open, with a force of 150 N applied at the handle position in the direction of closure, such force being applied until the door makes contact with the frame. Slamming of the door is repeated 10 times. Special attention is given to those cases where heavier doors are specified for use in the building or walling system.

Walls with built-in door frames fitted with doors must show no signs of damage or loosening or detachment of the frame from the wall after the above test has been carried out.

The door-slamming test was done and the panel system passed the test.

8. Summary

The following structural tests were carried out on the building system. For ease of viewing the tests are presented in a tabular format.

Test Procedure	Outcome of the Test
Gable Wall Wind Loading	**Passed** the test for wind loads on the gable walls.
Wind Loading Roof Fixing	**Passed** the test for roof wind loading.
Soft Body Impact	**The system passed** the soft body impact test, without cracking. However, there was no penetration through the wall.
Hard Body Impact	**The system passed** the test with light damage and an indentation of less than 3 mm
Light- and medium-weight fittings	**The system passed** the test by carrying the 30 kg mass load for 15 minutes
Heavy-weight Fittings	**The system passed** the test by being able to carry the required mass weight of 136 kg
Door Slamming	**The system passed** the door slamming test as the frame became loose

Structural Evaluation

The building system passed all the Agrément structural criteria. This building system had a very solid feel to it.

There is no structural reason why this building system could not be given an Agrément certificate.