

Product: Stacker Packers

Document Reference: Load Testing of Stacker Packers

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Section A | Background:

The information contained within this document has been extracted and or interpreted from work carried out on behalf of Brilliant Ideas Ltd by the [HCC County Highways Laboratory](#) and the [TWI Limited](#).

Product:

Stacker Packers are a levelling shim solution specifically designed for levelling precast concrete units. Their integral inbuilt dowels allow the shims to interlock horizontally and vertically, forming a safe and stable structure.

Manufactured from virgin High Impact Polystyrene (HIPS), complete with UV stabilisers, Stacker Packers have a high compressive strength. The addition of UV stabilisers overcomes the yellowing and brittleness associated with prolonged exposure to UV rays of unmodified HIPS.

Testing:

In the last six months we have carried out compression tests with shim stack heights ranging from 25mm to 100mm and we used two companies for this work: The HCC County Highways Laboratory and TWI Limited.

HCC County Highways Laboratory carried out simple compression tests and the TWI Limited carried out compression tests whereby the stress / strain relationship was analysed and recorded during the test.

The tests and results are summarised within the following pages.

Section B | The HCC County Highways Laboratory Tests:

Compression load test carried out by the HCC County Highways Laboratory



County Highways Laboratory
 Stockbridge Road, Micheldever Station, Hampshire SO21 3BB
 Telephone: 01962 774502
 Fax: 01962 795042



Test	Laboratory Cube Number	Stack Size	Date Tested	Description
1	E 1000 A1	50mm	19/11/2021	Compression test to the point of failure
2	E 1000 B1	50mm	19/11/2021	85% of load from Test 1
3	E-1000 C1	50mm	19/11/2021	62.5% of load from Test 1
4	E 1001 A1	60mm	03/12/2021	Whichever is the lesser value of: Test 1 or Failure
5	E 1001 A2	60mm	03/12/2021	Value from Test 3
6	E 1001 B1	80mm	03/12/2021	Whichever is the lesser value of: Test 1 or Failure
7	E 1001 B2	80mm	03/12/2021	Value from Test 3
8	E 1001 C1	100mm	03/12/2021	Whichever is the lesser value of: Test 1 or Failure
9	E 1001 C2	100mm	03/12/2021	Value from Test 3

Table 1: Summary of tests which were carried out



Figure 1: Photo of Test 4 | 60mm stack height under 230kN Load



Figure 2: Photo of Test 5 | 60mm stack height under 143.8kN Load



Figure 3: Photo of Test 6 | 80mm stack height under 230kN Load



Figure 4: Photo of Test 7 | 80mm stack height under 143.8kN Load



Figure 5: Photo of Test 8 | 100mm stack height under 230kN Load

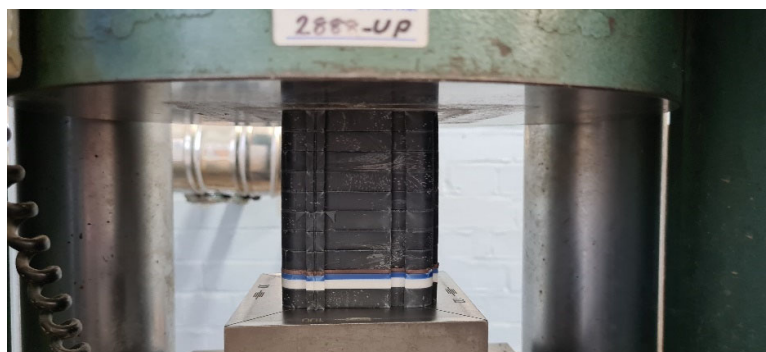


Figure 6: Photo of Test 9 | 100mm stack height under 143.8kN Load

Results:

Test	Laboratory Cube Number	Stack Size	Date Tested	Shim Mass (g)	Dimensions Before Test (mm)			Load Applied (kN)	Dimensions Post Test (mm)			Load Applied (N/mm ²)
					X	Y	Z		X	Y	Z	
1	E 1000 A1	50mm	19/11/2021	223	70.97	70.98	49.67	230.0	72.59	73.64	46.75	46.94
2	E 1000 B1	50mm	19/11/2021	224	70.86	70.82	49.50	195.5	71.51	71.48	48.18	39.90
3	E 1000 C1	50mm	19/11/2021	224	70.82	70.84	49.42	143.8	70.90	70.89	49.23	29.35
4	E 1001 A1	60mm	03/12/2021	272	70.83	70.77	59.71	230.0	73.01	73.35	55.49	46.94
5	E 1001 A2	60mm	03/12/2021	273	70.96	70.95	59.67	143.8	71.12	71.23	59.18	29.35
6	E 1001 B1	80mm	03/12/2021	362	70.81	70.87	79.25	230.0	73.01	73.35	71.03	46.94
7	E 1001 B2	80mm	03/12/2021	362	70.87	70.89	79.21	143.8	71.08	71.15	78.25	29.35
8	E 1001 C1	100mm	03/12/2021	452	70.84	70.79	99.02	230.0	73.01	73.35	85.38	46.94
9	E 1001 C2	100mm	03/12/2021	452	70.90	70.87	98.99	143.8	71.12	71.07	97.62	29.35

Table 2: Summary of results

Test	Laboratory Cube Number	Stack Size	Date Tested	Shim Mass (g)	Shim Stack Depth Pre Test (mm)	Load Applied (kN)	Shim Stack Depth Post Test (mm)	Deformation
3	E 1000 C1	50mm	19/11/2021	224	49.42	143.8	49.23	0.38%
5	E 1001 A2	60mm	03/12/2021	273	59.67	143.8	59.18	0.82%
7	E 1001 B2	80mm	03/12/2021	362	79.21	143.8	78.25	1.21%
9	E 1001 C2	100mm	03/12/2021	452	98.99	143.8	97.62	1.38%

Table 3: Summary of post-test vertical deformation - Tests 3 / 5 / 7 / 9

Dimensions:

Dimensions were recorded at our own workshop prior to sending to the HCC Highways Authority Laboratory and upon receipt (post-test). The method on which the shim stacks were measured was utilising a Digital Vernier Calliper and the shim stacks were clamped using a G-Clamp up to a point at which no gaps were visible between the inter shim contact points.

For clarity the tests carried out by the TWI Limited which are summarised within Section C of this report it should be noted that all the dimensions were recorded at their own laboratory.

Contact / Load Transfer Area:

The compression load is based on full 70mm x 70mm (4900mm²) contact / load transfer area, but due to the interlocking dowels the contact / load transfer area is actually 4361mm² hence the values (N/mm²) shown in Table 2 are deemed conservative.

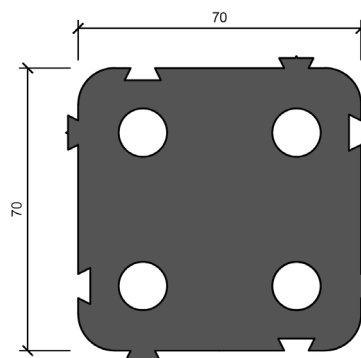


Figure 7: Plan view of 70mm x 70mm stacker packer showing voided location where the interlocking dowels are located (Contact / Load Transfer Area = 4361mm²)

Section C | TWI Laboratory Tests:

The TWI Limited were instructed to carry out further tests whereby the stress / strain relationship was recorded during several tests. The full report is available upon request and all load displacement graphs are given in APPENDIX A (Page 10).

Test No.	Shim Type	Shim Height (number)	Test Information
1	Stacker Packer	50mm (7shims)	Constant displacement rate up to 230kN
2	Stacker Packer	50mm (7shims)	Constant displacement rate up to 143.8kN
3	Stacker Packer	50mm (7shims)	Constant displacement rate up to 0.5% of stack height
4	Stacker Packer	25mm (3shims)	Constant displacement rate up to 143.8kN

Table 4: Summary of tests which were carried out



Figure 7: Photo of TWI Test 4 | Pre-Test

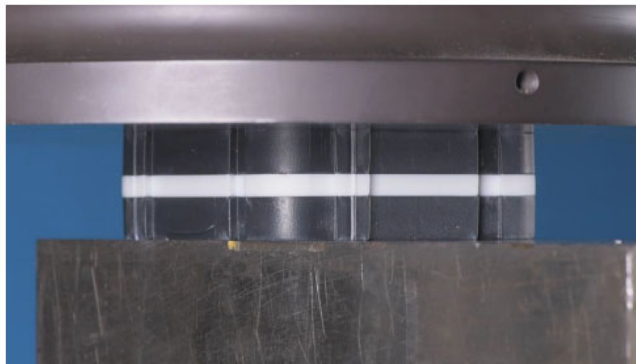


Figure 8: Photo of TWI Test 4 | under 143.8kN Load

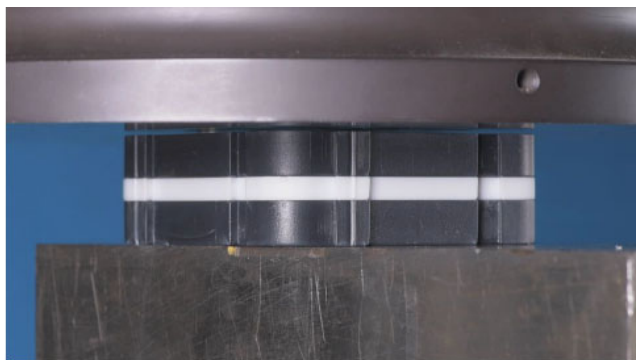


Figure 9: Photo of TWI Test 4 | Post-test (load removed)

Results:

The results of all tests are summarised below and within the following tables.

Test 1

Demonstrated that 230kN is beyond the capability of the Stacker packer and deformation was permanent with clear permanent deformation on all shims.

Test 2

Although to the human eye the shim stack looked undamaged, post-test measurement showed a very small loss in individual shim thickness and an increase in the width measurement, this value was deemed to represent negligible deformation. The pre and post-test measured values are shown below in Table 6.

Test 3

Showed no damage on any of the shims at a displacement equal to 0.5% of the measured pre-test height of 49.01mm but the load was not representative of loads that would be seen in normal use, and so it was decided to use three shims from this test, numbers 1, 2 and 7 to provide a nominal 25mm stack height for Test 4.

Test 4

Showed no visible damage and the load displacement graph showed no deviations, unlike those obtained from Test 2 had at around the 100-130kN. Upon unloading and a 4 hour relaxation period, the sample has almost returned to the pre-test geometry as shown in Table 8 and indicated that 143.8kN had caused negligible or no lasting damage.

Test 5

This test has largely been removed from this report and was based on another system which utilises the same material, but due to the increased amount of voids, this system has a lower contact / load transfer area of circa 3428mm² which is circa 21% less than the Stacker Packer System (4361mm²). These voids are only visible when you turn the shims upside down. Due to this reduced area the results were representative of this and report concludes that a 50mm shim stack showed serious deformation at 100kN with permanent deformation occurring at 85kN. These test results are available to view at our offices.

Test No.	Observations
1	Achieved load Damage to all shims
2	Achieved load Slight dimensional change in shims
3	Achieved displacement value No damage or dimensional change
4	Achieved load Very slight short term dimensional change

Table 5: Summary of results

Note: Based on the outputs the following Tables only focusses on Test 2 and Test 4 (143.8kN Load)

Shim	Width (mm)	Width (mm)	Width (mm)	Width (mm)	Thickness (mm)	Thickness (mm)	Thickness (mm)	Thickness (mm)
ID	A	B	A	B	A	B	A	B
	Pre-Test		Post-Test		Pre Test		Post Test	
1	70.83	71.07	71.02	71.08	9.36	9.33	9.36	9.27
2	71.01	71.12	71.26	71.21	4.69	4.69	4.69	4.69
3	71.18	71.06	71.33	71.34	2.80	2.79	2.75	2.76
4	71.48	71.44	71.56	71.50	2.08	2.08	2.06	2.08
5	70.85	70.90	71.17	71.04	9.23	9.21	9.22	9.20
6	70.72	70.84	71.01	71.09	9.48	9.50	9.48	9.47
7	70.97	70.94	71.05	71.04	9.58	9.50	9.50	9.45

Table 6: Measurements of shims pre and post-test used for Test 2

Description	Width (mm)		Thickness (mm)	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Average Width	71.03		71.19	
Total Thickness (Shims 1 to 7)			47.22	47.10
Total Thickness Average			47.16	
Post-Test Deformation Average	+0.23%		-0.36%	

Table 7: Summary of average dimensions and post-test deformation - Test 2

Shim	Width (mm)	Width (mm)	Width (mm)	Width (mm)	Thickness (mm)	Thickness (mm)	Thickness (mm)	Thickness (mm)
ID	A	B	A	B	A	B	A	B
	Pre-Test		Post-Test		Pre Test		Post Test	
1	71.07	71.02	71.05	71.04	9.68	9.67	9.68	9.66
2	71.12	71.08	71.17	71.16	4.62	4.61	4.60	4.60
7	71.04	71.02	71.05	71.06	9.65	9.70	9.69	9.63

Table 8: Measurements of shims pre and post-test used for Test 4

Description	Pre-Test		Post-Test	
	Pre-Test	Post-Test	Pre Test	Post Test
Average Width	71.06		71.09	
Total Thickness (Shims 1 / 2 / 7)			23.95	23.98
Total Thickness Average			23.97	
Post-Test Deformation Average	+0.04%		-0.02%	

Table 9: Summary of average dimensions and post-test deformation - Test 4

Section D | Conclusion:

Based on the TWI Limited report the stacker packer shims appear to be able to take 143.8kN without any discernible dimensional change being observed if a 25mm stack height is used. In the event of a 50mm stack height being used with a seven shim assembly, there is a slight dimensional change probably caused by the amount of interfacial contacts or any variance in the parallel between the two mating faces on the shims.

The tests carried out does not account for any longer term creeping that may take place.

For Test 1 and Test 2 containing 7 shims both appear to follow a similar load displacement behaviour and appear to move out of the elastic deformation zone at a point around 130kN.

When considering the 50mm stack height from both the HCC County Highways Laboratory and the TWI Limited the post-test vertical deformation was recorded at -0.38% and -0.36% respectively.

To this end we recommend for shim stacks up to 50mm stack height the Stacker Packer compressive strength value should be taken as:

30N/mm² (under factored loads)

- This is based average plan area of 70mm x 70mm (4900mm²).
- The actual net load contact area is 4361mm² which would return a higher compressive value.
- For stack heights greater than 50mm then this value would reduce (refer to Table 3).
- Should this value not be sufficient then we recommend clipping together additional shims to provide a larger contact / load transfer area.

APPENDIX A

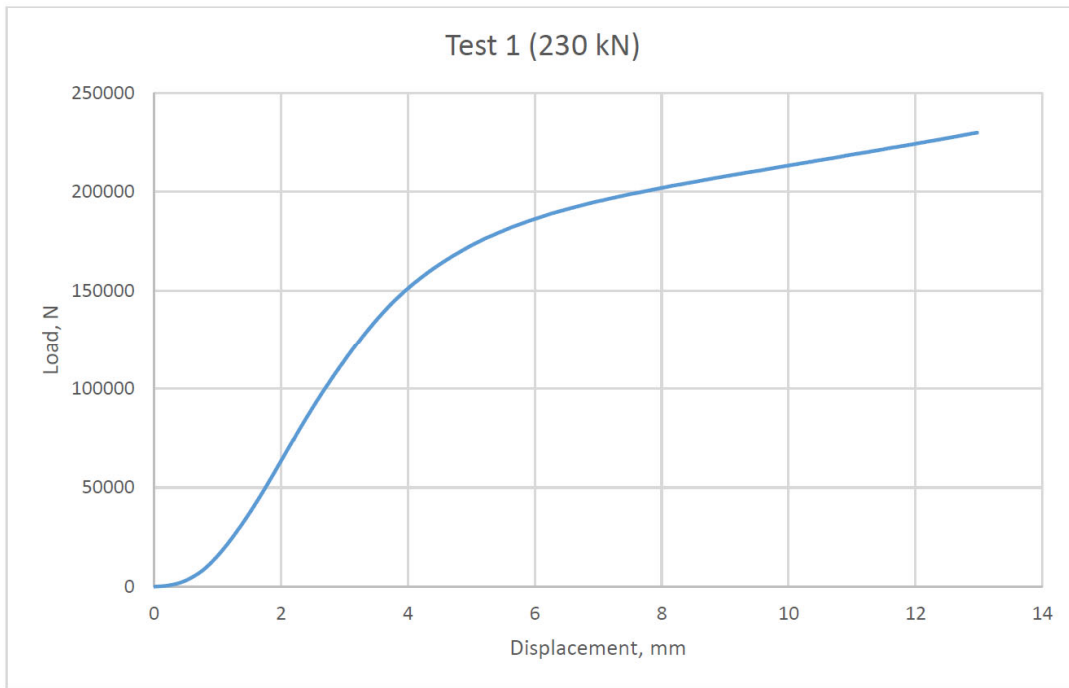


Figure A1: Test 1 - Load displacement graph

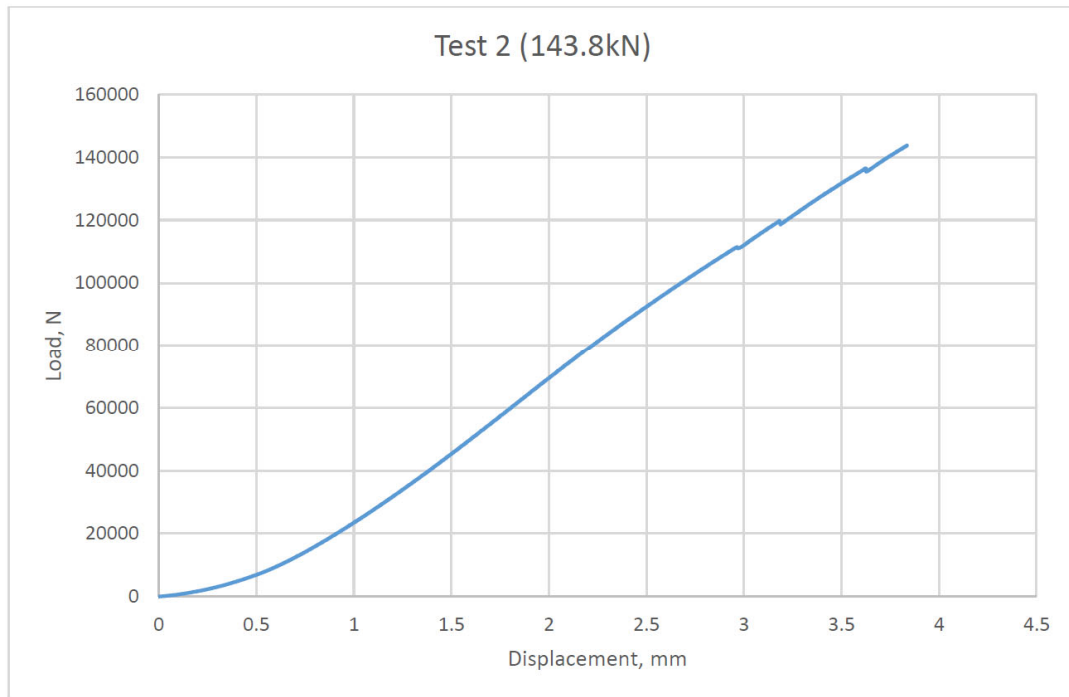


Figure A2: Test 2 - Load displacement graph

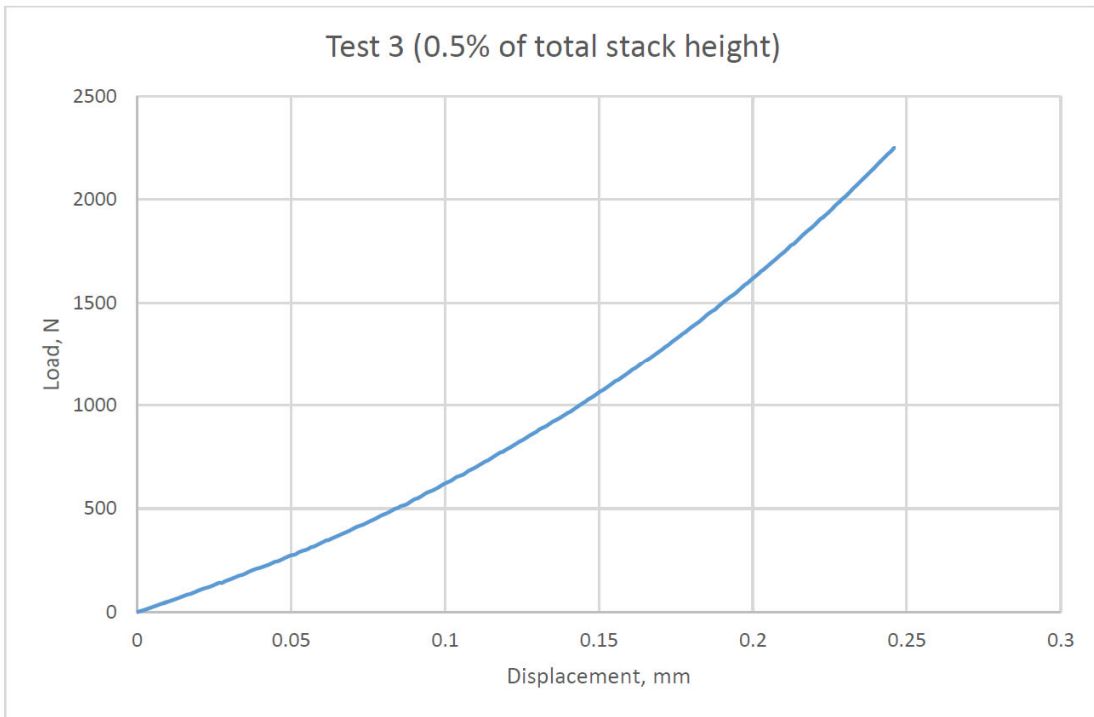


Figure A3: Test 3 - Load displacement graph

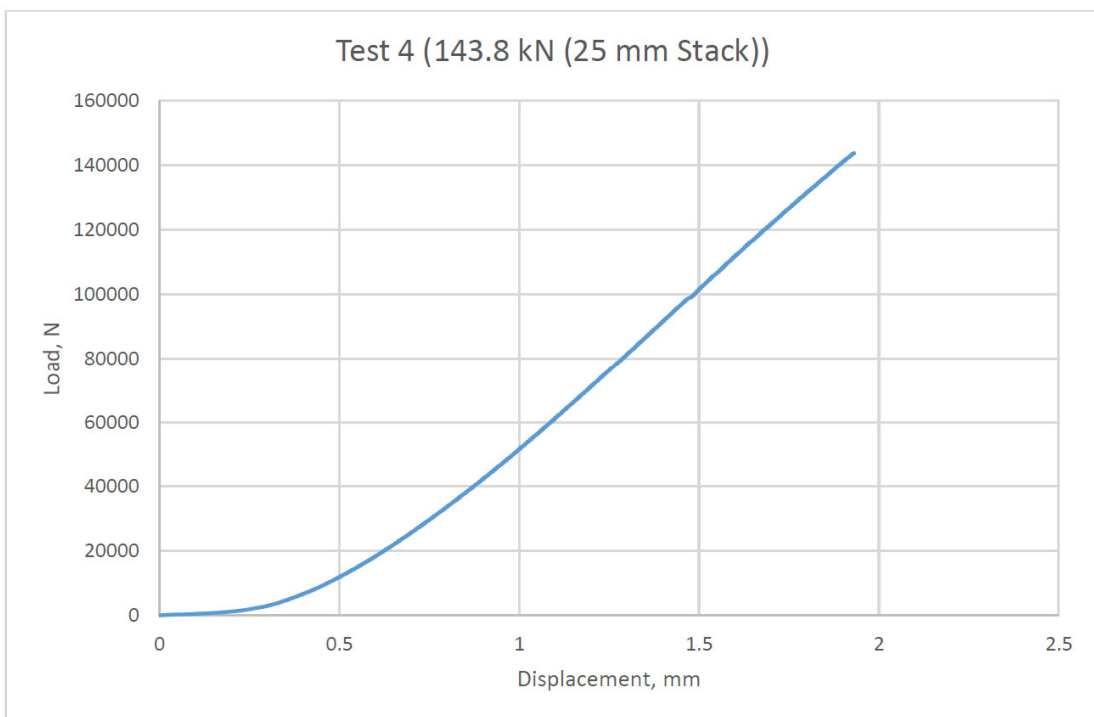


Figure A4: Test 4 - Load displacement graph