STRUCTURES TEST REPORT

ST14322-001-01

ROCKCOTE RESENE INTEGRA FLOOR PANELS – DEFLECTION/CRACK LIMIT ASSESSMENT

CLIENT
Rockcote Resene Limited
5 Venture Place,
Middleton,
Christchurch,
New Zealand

All tests and procedures reported herein, unless indicated, have been performed in accordance with the BRANZ ISO9001 Certification

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1. BACKGROUND AND OBJECTIVE

The Client (Rockcote Resene) had previously undertaken testing with BRANZ to determine the bending strength and point load resistance of their 75mm thick Lightweight Concrete Integra floor panels. The results of this test may be observed in test report ST11534-001-01 dated 24th June 2019 [1]. The testing in that report only considered the Ultimate Limit State (ULS) capacities of the panels. The Client has received the following question from an Engineer looking to use their product:

"The AAC panels we proposed to use are supported on timber floor joists, which the deflection control is Span/400. My understanding is the AAC panel will be placed perpendicular to the joists. My question is what deflection limit we should use, higher than L/400 to avoid cracking or L/400 is sufficient?"

Based on this question, the Client is looking to understand the Serviceability Limit State (SLS) of the panels and to determine what deflection limits should be put in place to minimise the presence of cracking under load. Report ST11534-001-01 [1] finds that flexural cracking was observed on the top surface of the panels near the central support but does not identify the deflection of the panel when this observation was made. Referring to the data files from this series of tests, it is not possible to ascertain any relationship between load/displacement and crack development.

The expected outcome of this report is to provide a deflection limit (Span/XXX) for the panel and to confirm or advise otherwise the suggested serviceability limit state criteria, similar to what is provided in Table C1 of AS/NZS 1170.0 [2].

2. DESCRIPTION OF SPECIMEN

2.1 Product description

The 75mm thick INTEGRA lightweight concrete flooring system consists of 75mm thick panels that are 1800mm long and 600mm wide. The panels have a tongue and groove edge and are reinforced with two layers of reinforcing mesh. The mesh bar spacings are 130mm in both directions and the bars are 5mm diameter. The mesh layers are orientated so that the longitudinal bars are located respectively 25mm below the upper and lower faces of the panels.

The panels are laid in a staggered bond pattern over timber or steel joists and are fixed down with 14g x 100mm long galvanised INTEGRA screws in the body of the panels and 14g by 150mm long galvanised INTEGRA screws at the ends of the panels. The screws have a countersunk head and are installed with the top of the screw flush with the upper surface of the panel.

With reference to the product literature, supporting joists may be placed at 360mm, 400mm, 450mm and 600mm centres.

2.2 Specimen construction

Each specimen consisted of a frame constructed from 90 x 45 SG8 Radiata Pine dry framing timber to simulate the support joists of the INTEGRA panel. The joist spacing was varied to suit the configuration being tested at the time. The longitudinal members of the frame were spaced such that the panel was able to span between joists without any support provided by the longitudinal members. Fixing of the panel to the timber frame was as per the Client's installation recommendations and as noted in section 2.1. Typical test setup may be observed in Figure 1.

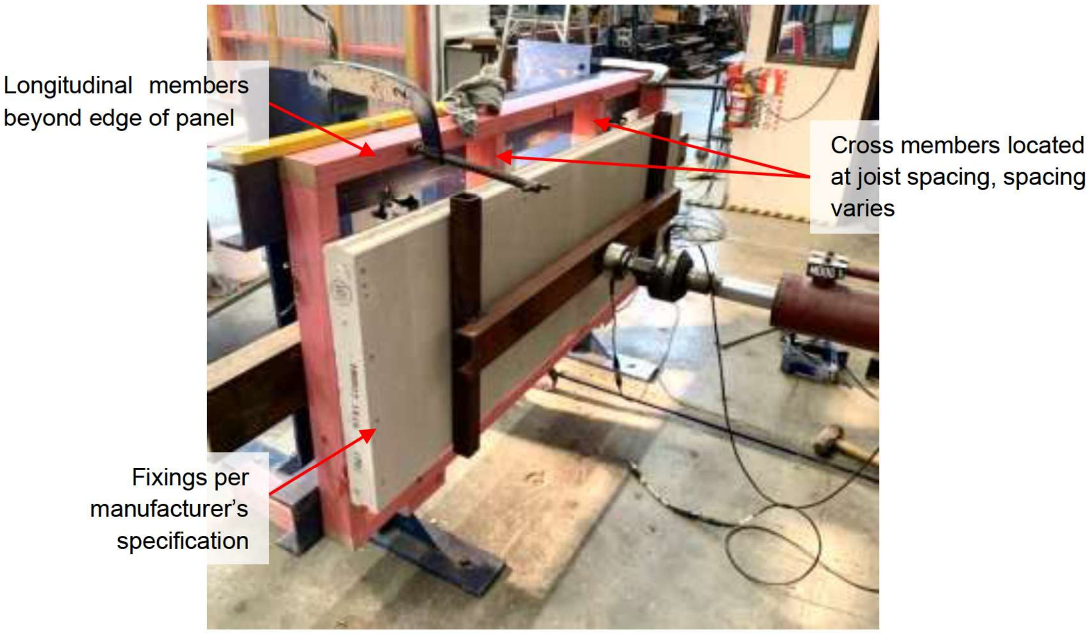

Figure 1 – Specimen Construction

Table 1 provides a summary of specimens constructed for each joist spacing.

Table 1 - No. of Specimens Constructed

Joist Spacing (mm)	No. of Specimens Constructed
600	5
450	2
360	1

Prior to testing, it was expected that the 600mm joist spacing would provide the governing criteria. The tests of the 450mm and 360mm joist spacing were to verify any conclusions from the 600mm spacing tests.

3. DESCRIPTION OF TEST

3.1 Date and location of test

Tests were carried out in September 2021 in the Structures Test Laboratory at BRANZ, Judgeford, New Zealand.

3.2 Test set-up

Refer to Figure 2Figure 1 for the typical setup during testing. The test specimen, complete with joist frame was supported vertically. This orientation was chosen to suit the position of the loading actuator. The frame was clamped to a reaction frame which is subsequently bolted to the strong floor. The load from the actuator was distributed to 2 No. 50mm square hollow sections (SHS) using as spreader beam, to apply a line load to the test panel at the centre of the panel's span between adjacent joists. Potentiometers were located on the unloaded side of the panel, aligned with the loading SHSs. A potentiometer was located on either edge of the panel to identify any twisting/uneven loading and deflection.

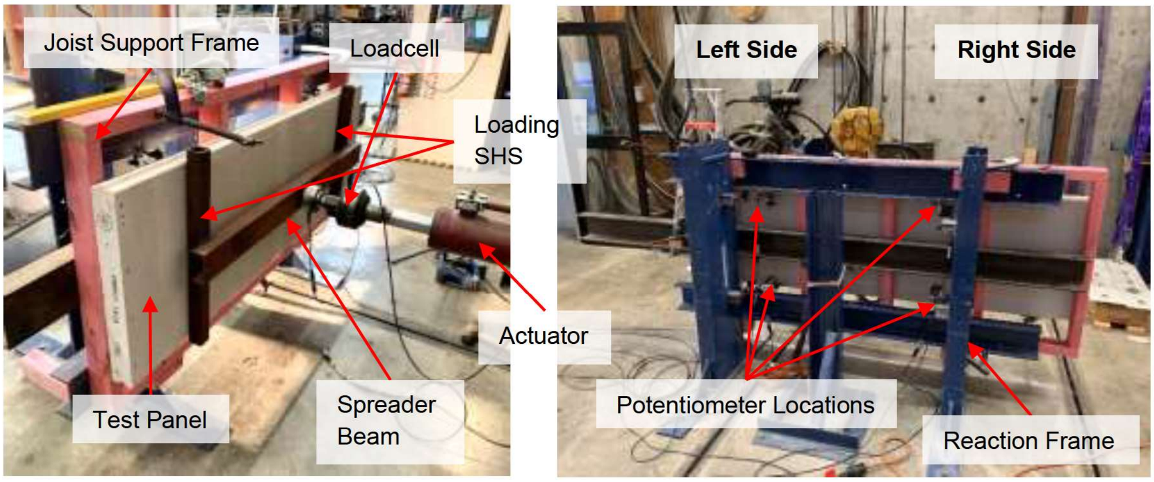

Figure 2 - Typical Test Setup

3.3 Test procedure

The following deflection limits were selected for testing:

Span/600
Span/500
Span/400
Span/300
Span/250

These are the typical deflection limits used in AS/NZS 1170.0 [2] Table C1. For the proposed joist spacings covered by the product literature, this equates to the following deflections at the midspan between joists.

Table 2 - Serviceability Limit Criteria

Serviceability Criteria	Joist Centres			
	360mm	400mm	450mm	600mm
Span/600	0.60mm	0.67mm	0.75mm	1.00mm
Span/500	0.72mm	0.80mm	0.90mm	1.20mm
Span/400	0.90mm	1.00mm	1.13mm	1.50mm
Span/300	1.20mm	1.33mm	1.50mm	2.00mm
Span/250	1.44mm	1.60mm	1.80mm	2.40mm

The actuator was operated in a displacement control mode. This allowed the panels to be loaded until the potentiometers read the panel deflection of the appropriate Serviceability Criteria under assessment. The displacement was then held, and the panels were inspected for any signs of cracking. Where possible, the crack widths were measured and recorded. Panel deflection was then increased to the next serviceability criteria and observations recorded.

4. OBSERVATIONS

This test was a qualitative assessment of the INTEGRA flooring panel and relied upon the observations made by the BRANZ Engineers during testing. The surface texture of the panels often made for difficult inspection of the panel for the development of cracks. These difficulties should be considered when reading the observation and recommendation sections of this report and to err on the conservative side where possible.

During testing it was noted that often the panels were not loaded evenly, resulting in some potentiometers showing slightly larger deflections than others. Refer to Figure 3 for a typical potentiometer reading screen. When an "average" result is referred to in this report, this is calculated based on the average of the displacement on panel side considered, e.g. 1.33mm (right side) and 1.29mm (Left Side) in the case of Figure 3 below.

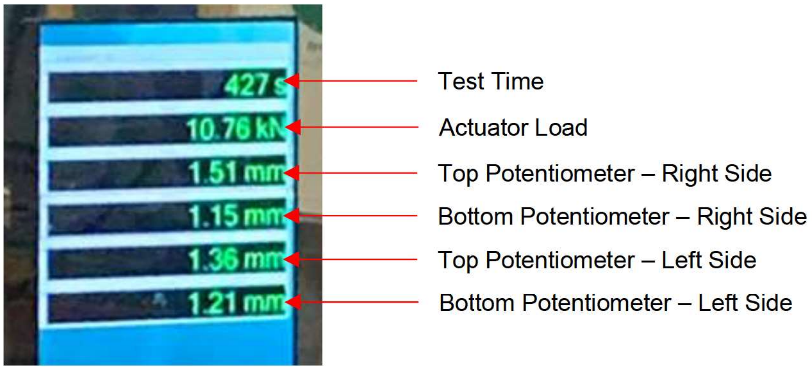

Figure 3 - Typical Potentiometer Reading Screen

4.1 600mm Joist Spacing Tests – Alternate Bays Loaded

Since this was the largest panel span in the technical literature it was also the largest displacement criteria as per Table 2. To achieve the worst-case sagging moment, alternate bays were loaded as per Figure 4.

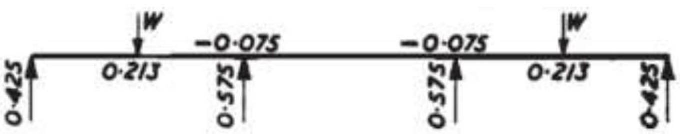

Figure 4 - 600mm Spacing Load Configuration

Three replicate tests were completed with 600mm joist spacing and alternate bays loaded. Although 'popping' and creaking sounds were heard as the panels were loaded, cracks were not easily observed until the panels achieved a displacement of ~1.2mm (Span/500). These were hairline cracks and unmeasurable, Figure **5**.

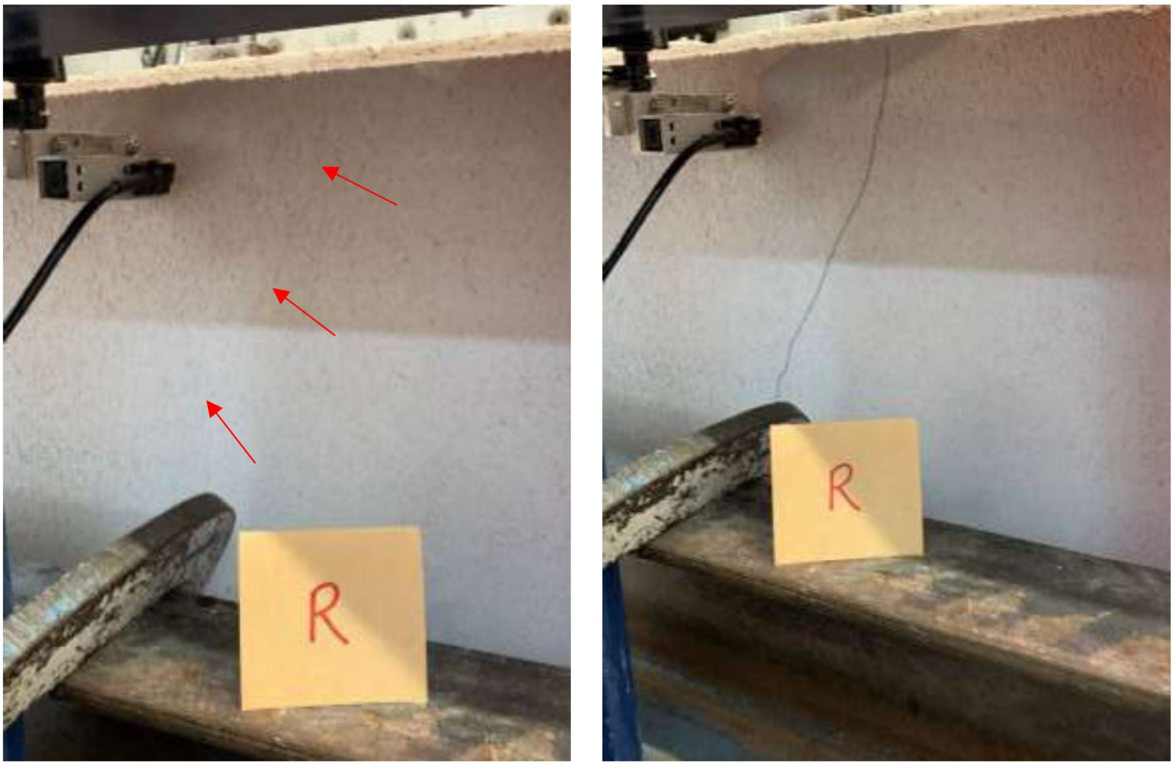

Figure 5 **- 600mm span typical hairline crack observation. Right photo same crack marked with pencil.**

Once the deflections had increased to at least 1.5mm (Span/400), with an average deflection of 1.81mm (Span/330) recorded, crack widths of approximately 0.15mm were observed, Figure 6.

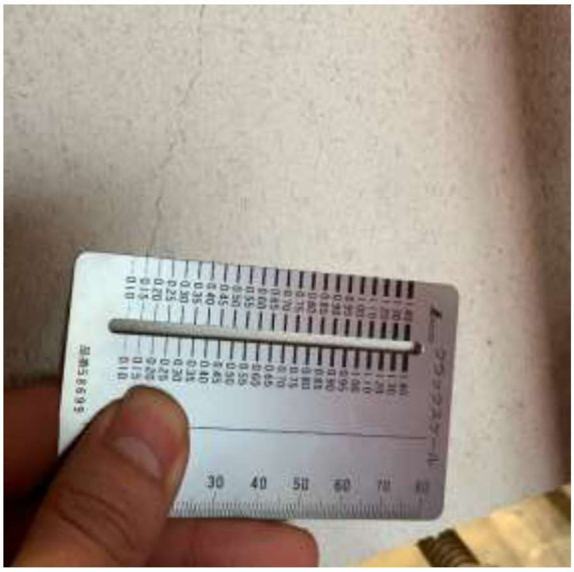

Figure 6 - Typical Crack Widths Observed in 600mm Span Specimen

It is worth noting that once the span deflections had achieved 2.4mm and load removed, all cracks closed and were no longer visible. There was however a permanent set in the panels of as much as 1mm once the load had been removed.

4.2 600mm Joist Spacing Tests – Adjacent Bays Loaded

From the tests above, it was observed that cracking to the midspan of the panel was noted when 1.5mm of displacement was achieved. To understand at what deflection limit the panels would crack over a joist, two specimens were tested with adjacent bays loaded. This would generate the largest hogging moment over the intermediate support as per Figure 7.

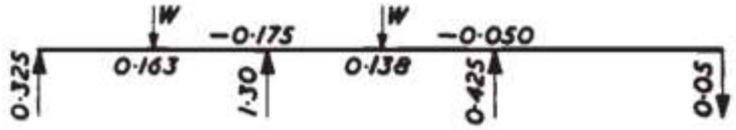

Figure 7 - Adjacent Bay 600mm Spacing Load Configuration

Cracking over the intermediate support was not observed until all potentiometers indicated a displacement of approximately 2.0mm (Span/300) at the midspan. The crack width was noted as <0.1mm. This arrangement is deemed to be less onerous than the configuration discussed in Section 4.1.

4.3 450mm Joist Spacing Tests – Alternate Bays Loaded

Tests were repeated on two panels with joists located at 450mm centres. To achieve the worst-case sagging moment, alternate bays were loaded as per Figure 8.

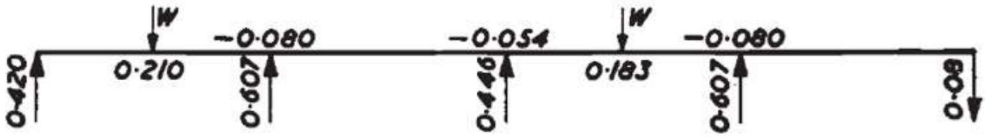

Figure 8 - 450mm Spacing Load Configuration

No cracking to the panels was observed until *all* potentiometers read at least 1.125mm (Span/400), with an average displacement of 1.76mm (Span/255). At this time, the crack widths were recorded as less than 0.1mm.

The tests confirmed that the assessment of the 600mm test panels would provide the most onerous serviceability criteria.

4.4 360mm Joist Spacing Tests – Alternate Bays Loaded

A single test on the 360mm joist spacing configuration was completed to confirm or otherwise that the observations made on the 600mm joist spacing were the most onerous serviceability criteria. Similarly, an alternatively loaded bay configuration was adopted, refer Figure 9.

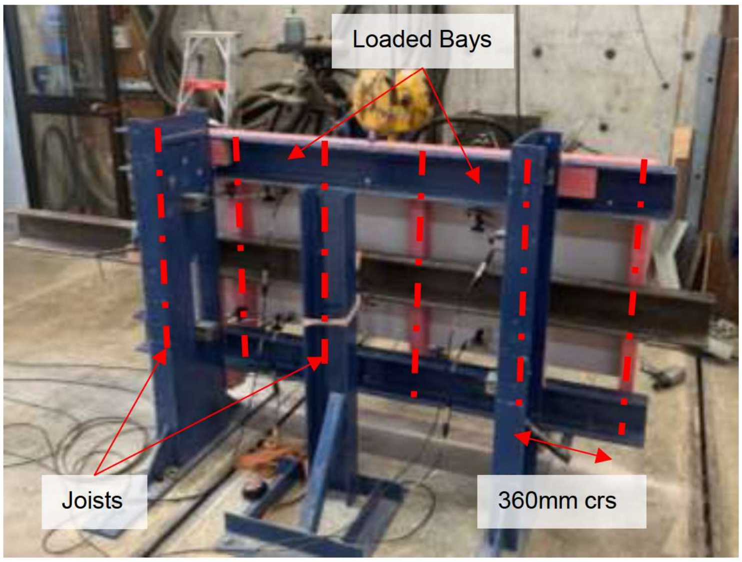

Figure 9 - 360mm Spacing Load Configuration

No cracks were observed until the displacement readings on *all* potentiometers read 1.44mm (Span/250) and the average displacement on the right loaded bay showing cracking was 1.86mm (Span/194). The cracks observed at this deflection limit were recorded as having a crack width no greater than 0.1mm. Once the load had been removed, the cracks had closed and were not longer observable. A maximum permanent set of 0.70mm was recorded.

This test provided further support to the finding that the tests conducted with joists located at 600mm centres provides the most onerous serviceability criteria.

5. RESULTS

AS/NZS 1170.0 [2] Table C1 provides the following suggestions for floor and floor support serviceability criteria. The relevant extract is provided in Figure 10 below.

TABLE C1

SUGGESTED SERVICEABILITY LIMIT STATE CRITERIA

Element	Phenomenon controlled	Serviceability parameter	Applied action	Element response (see Notes 1 and 2)
Normal floor systems	Noticeable sag	Mid-span deflection	G and $\psi_l Q$	Span/400
Specialist floor systems	Noticeable sag	Mid-span deflection	G and $\psi_l Q$	Span/600

Figure 10 - Extract of Table C1 from AS/NZS 1170.0

It is from this table that it is understood that the Engineer had obtained the Span/400 criteria. It is worth noting that the phenomenon controlled for this element response is 'Noticeable Sag'. This has not been assessed as part of this test. Instead, the propagation of cracks has been the phenomenon controlled as requested in the original query.

Table 3 - Summary of Observations

Test Setup	Deflection				
	Span/600	Span/500	Span/400	Span/300	Span/250
600mm Alternate Bays Loaded	No Cracks Identified	No Cracks Identified	<0.15mm	<0.2mm	Not measured
600mm Adjacent Bays Loaded	No Cracks Identified	No Cracks Identified	No Cracks Identified	Hairline	<0.1mm
450mm Alternate Bays Loaded	No Cracks Identified	No Cracks Identified	<0.1mm	<0.2mm	Not measured
360mm Alternate Bays Loaded	No Cracks Identified	No Cracks Identified	No Cracks Identified	No Cracks Identified	<0.1mm

Table 3 provides a summary of the observed crack widths during the tests.

Based on the observations made from the sample of tests outlined above, it is possible to conclude that to avoid cracking of the panels that is visible to the human eye, Span/600 is an appropriate Serviceability Limit State Criteria to adopt as per AS/NZS 1170.0 [2] Table C1. However, if cracking is permitted (up to approx. 0.15mm crack width), Span/400 would be a suitable criterion to adopt for the INTEGRA flooring system. It is worth noting that each panel was loaded to achieve a deflection of Span/250 or more and once the load had been removed, although a permanent deformation in the panel remained, the cracks had closed and were longer identifiable.

6. REFERENCES

[1] BRANZ, 24/06/2019. ST11534-001-01, Determination of the Bending Strength and Point Load Resistance of 75mm thick Rockcote Resene Integra Floor Panels

[2] AS/NZS 1170: 2002 "Structural design actions; Part 0 General principles, Part 1 Permanent, imposed and other actions, Part 2 Wind actions". Standards Australia, Sydney, Australia.