SINCLAIR KNIGHT MERZ

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Teg Tab The Labor Saver

TEG TAB

REPORT ON SEISMIC CAPACITY TESTING AND DESIGN

- Rev 2
- 03 August 2006

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1. Introduction

Sinclair Knight Merz was commissioned by Conacc Ltd to investigate the seismic load capacity of their Teg Tab product. Teg Tabs act as spacer blocks at the riveted connections between the perimeter trimming angles and ceiling runner tees used in suspended ceiling systems with rebated tiles (anticipated configuration illustrated in Figure 1 below).

The New Zealand and Australian standard governing cold formed steel structures stipulates that the capacity of riveted connections must be determined by physical testing for this configuration, where the steel materials are not in direct contact at the point of fastening (refer AS/NZS 4600:1996, Section 5.5.2.3).

This report is intended to fulfil the test reporting requirements of AS/NZS 4600:1996, Section 6, providing information on the method of loading, test results, and resulting design capacity for the riveted Teg Tab connection detail. The Teg Tab system was found to perform adequately for use in perimeter-fixed suspended ceilings as a method for providing seismic restraint, subject to the load capacities and limitations contained in this report.

Figure 1: Anticipated Teg Tab detail for perimeter fixed ceilings with rebated tiles

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2. Testing methodology & conditions of testing

Testing was undertaken at USG's Australasian manufacturing plant in Penrose, Auckland on 6th April 2006. Eighteen direct tensile tests of the Teg Tab connection were undertaken using USG's on-site tensile test rig, with a manually operated hydraulic jack, bench mounted vice grip, and calibrated load cell (refer Figure 2). Deflection of the perimeter angle in the direction of load application was measured using a dial strain gauge, mounted approx 50mm from the main tee, on the opposite side to the screw fixing into timber. Test materials and configuration were as shown in Sketch SK01 in Appendix C.

Figure 2: Photograph of Teg Tab tensile test set-up.

Test component properties were as follows:

Ceiling grid main tees:

- Tests 1, 2, 4: USG DONN DX30D main tee, 38mm deep web, 24mm flange width, 0.30 BMT
- Test 3: USG DONN DXT30D main tee, 38mm deep web, 15mm flange width, 0.30 BMT

Fixings:

- Rivet between main tee and perimeter angle: 3.2mm (⅛") diameter, blind rivet, Aluminium (alloy 5056). Minimum edge distance 5mm (0.2").
- Screw fixings between perimeter angle and timber wall framing: No. 8 gauge (4.17mm/0.16" diameter), R/head steel screws, 51mm (2") long, 20mm (¾") minimum edge distance. Single screws installed no more than 50mm (2") away from centreline of main tees (refer note below).

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Other components:

- Perimeter angle: USG DONN MT45 perimeter angle, 21x19mm angle legs, 0.45mm BMT
- Timber to represent wall framing: radiata pine, 90x45mm (nominal 100x50, or 4"x2").
- Wall linings between timber and perimeter angle: none

Tensile load was applied to the main tee in 2kg increments until the first buckling or deflection was observed, and then in 1kg increments until failure occurred. Five of the eighteen tests excluded the Teg Tab, to act as a control. Test results were recorded on the test methodology sheets attached in Appendix C.

Note: when relying on perimeter fixings for seismic restraint of suspended ceilings, it is essential that the perimeter trim angles are securely fixed along a horizontal line of solid framing, with fixings at regular centres as specified in the manufacturer's seismic design specifications (Refer Figure 3 below). In order to withstand tension force around a perimeter fixed ceiling, screw fixings through perimeter trim into wall framing must be installed as close as practical to the ceiling tee centrelines. These perimeter angle fixings at tee locations must be designed to withstand the seismic tension loads imposed by the ceiling, with fastener spacings in accordance with applicable codes and/or manufacturer's guidelines. For a wall to act as a restraining element the studs must be capable of carrying the applicable line-load reactions imposed by the ceiling in a design level earthquake, and their own seismic face load.

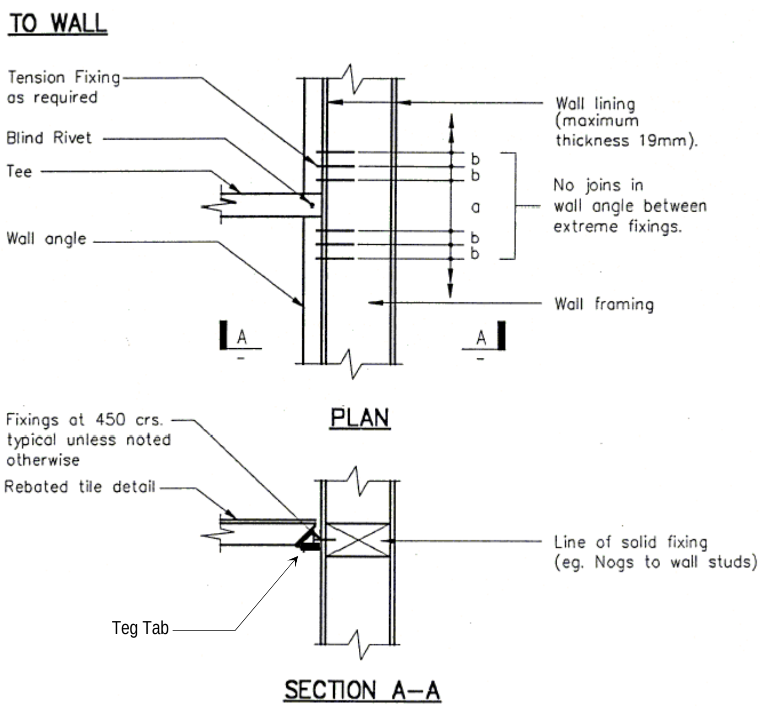

Figure 3: diagram to show perimeter angle fixings to wall framing

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3. Test results & ultimate strength

Test results are summarised in Figure 3 below (refer to Appendix A for imperial measurements):

Items tested	Deflection at failure (mm)	Recorded failure loads (kg)	Typical failure mode
Control Test (no Teg Tab, DX30D)	1.4, 2.0,1.5,1.5*	65, 59, 66, 70, 69	Rivet shear failure
24mm Teg Tab with DX30D	1.6, 1.4, 1.8, 1.7, 1.7	55, 50, 60, 51, 55	Rivet shear failure
15mm Teg Tab with DXT30D	1.4, 1.7, 1.1, 1.9, 1.6	49, 57, 50, 60, 51	Rivet bending & pullout
24mm Teg Tab with DX30D**	2.6, 1.3, 2.3	52, 46, 48	Rivet bending & pullout

* Deflection not recorded for third test out of five

** Timber framing 600mm long for these tests only, 300mm for others.

Figure 4: Key results from eighteen tensile tests.

The ultimate design capacity of the overall connection may be evaluated from test data using AS/NZS4600:1996 "Cold-formed steel structures", Section 6.2.2.7 (refer to Appendix B for details). The minimum failure load is divided by a statistical 'safety' factor to account for the variability of structural units, yielding the following ultimate limit state design capacities:

Perimeter angle connection with no Teg Tab (control test): ϕN_t = 40kg (≈390 Newtons).

Perimeter angle connection with 15mm or 24mm Teb Tab: ϕN_t = 29.5kg (≈290 Newtons).

Note that the connection between the main tee and perimeter angle retains approximately 75% of its strength when a Teg Tab is installed, compared with tests where the riveted steel members are in direct contact.

Engineer's Note: the ultimate limit state design capacity is to be compared with factored ultimate limit state loads (e.g. 1.2 x Dead Load & 1.5 x Live load). Ultimate limit state is defined in AS/NZS4600:1996 as a limit state of collapse or loss of structural integrity. Recommended working load capacity is ⅔ of ultimate limit state capacity.

4. Suspended ceiling design & code compliance

Perimeter trim is permitted to carry vertical and horizontal forces from the ceiling in Australia & New Zealand, provided it is designed and detailed correctly (refer AS/NZS 2785, Section 1.3.23). Many ceiling design codes anticipate that the perimeter trim will be fixed along two adjacent walls, and free to allow differential movement along the opposite two walls. The isolation gap along the non-fixed edges must be sufficient to accommodate the expected movement from seismic forces, thermal expansion etc.

Design forces on the Teg Tab connections around a perimeter-fixed ceiling during an earthquake must be evaluated by a suitably qualified engineer. Design loads for a given ceiling will vary depending on factors such as:

1) the height and flexibility of the overall building where the ceiling is installed,
2) the position (level) of the ceiling within the building,
3) the level of earthquake hazard in the geographical region where the ceiling is installed,
4) the importance level and occupancy of the building (e.g. ceilings in hospitals with post-disaster functions and public buildings containing crowds would require higher seismic capacity than commercial offices),
5) the weight of the ceiling tiles, ceiling grid system, and insulation material or building services that rest on the ceiling and affect its seismic mass (heavier ceilings require much stronger seismic restraints),
6) the flexibility and ductility of the ceiling and it's fixing/connection details (stiffer ceilings will attract larger seismic loads, brittle ceiling restraints require larger safety factors), and
7) the consequence of failure, which is influenced by such factors as the height of the suspended ceiling above floor level, the weight of ceiling tiles, whether ceiling damage will prevent continuing operation of evacuation and life safety systems such as exit lights and fire sprinklers, and the potential for ceiling tiles or other objects (such as services in the ceiling plenum) to fall onto building occupants below.

It is the responsibility of the ceiling designer to ensure that ceilings are designed in accordance with all standards and codes as appropriate for their jurisdiction (refer to Appendix A for suspended ceiling design in California). A selection of relevant codes is given below (subject to future revisions and amendments, list not exhaustive):

Australia & New Zealand

- AS/NZS 2875:2000, Suspended Ceilings - Design & Installation
- AS/NZS 4600:1996, Cold-formed Steel Structures
- AS/NZS 2946:1991, Suspended ceilings, recessed luminaries & air diffusers
- AS/NZS 1170.5:2004, Structural Design Actions - Earthquake Actions NZ

5. Assumptions and limitations

- Reliance on this test data for establishing the performance of any connection configuration, materials or fixings is entirely at the risk and discretion of the ceiling designer.
- This report is intended to fulfil the test reporting requirements of AS/NZS 4600:1996, Section 6, providing information on the method of loading, test results, and resulting design capacity for the riveted Teg Tab connection detail. Compliance of the Teg Tab connection detail with any other applicable codes is to be determined by the ceiling designer and is outside the scope of this report.
- Evaluation of design capacity is intended to prevent ultimate limit state failure of the assembly in a design level earthquake. Damage to ceiling services from earthquake movement, cracking or deformation of architectural finishes, or any other consequent damages that might arise from earthquake movement are not considered.
- Design of suspended ceilings to comply with all applicable standards, codes, and manufacturers guidelines is the responsibility of the ceiling designer.
- Detailing of the perimeter joints for perimeter-fixed ceilings to allow for thermal movement, relief of air pressures, and fire is the responsibility of the ceiling designer and outside the scope of this report.
- Product testing was undertaken with the ceiling main tee member perpendicular to the perimeter trim. Angled fixings are outside the scope of this report.
- It is assumed that Teg Tab spacers will be placed between a ceiling runner (tee) and a steel perimeter angle with a single rivet connection, with minimum edge distance of 5mm or 1.5 times the fixing diameter, and as close to the centre of the Teg Tab as possible.
- It is assumed that the adjacent wall and roof structure has adequate capacity to withstand seismic forces (i.e. consideration of timber framing or other supporting structures is excluded from this report). If there is any doubt over the adequacy of the wall framing then the structure should be assessed by a structural engineer prior to installation.
- A co-efficient of variability of 15% has been assumed for the connection assembly, as prescribed by AS/NZS4600:1996, C6.2.2.3 for connections and assemblies. The 'safety factor' of k_t = 1.46 is also based on the number of units tested for each configuration (e.g. 5).

Appendix A Suspended ceilings in California

In certain situations, suspended ceilings may be restrained by perimeter fixing without the need for bracing systems to the structure above. The Californian D.S.A's Interpretation of Regulations IR 25-2 "Metal Suspension Systems for Lay-in Panel Ceilings", Section 1.6 states that "suspended acoustical ceiling systems with a ceiling area of 144 square feet or less, and fire rated suspended acoustical ceiling systems with a ceiling area of 96 square feet or less, surrounded by walls which connect directly to the structure above, do not require bracing assemblies when attached to two adjacent walls."

These DSA regulations only strictly apply for certain buildings, designers must confirm the applicability of this guideline to their specific design situation. Using perimeter trim to carry vertical and horizontal forces from the ceiling may require DSA approval for use in some Californian buildings (IR 25-2, Section 1.2), and may be difficult to obtain.

It is the responsibility of the ceiling designer to ensure that ceilings are designed in accordance with all standards and codes as appropriate for their jurisdiction.

A.1 Test Results in Imperial Units

Test results taken from Section 3 are summarised in imperial units in Figure 5 below:

Items tested	Deflection at failure (mils = 0.001 inches)	Recorded failure loads (lb)	Typical failure mode
Control Test (no Teg Tab, DX30D)	55, 79, 59, 59*	143, 130, 145, 154, 152	Rivet shear failure
24mm Teg Tab with DX30D	63, 55, 71, 67, 67	121, 110, 132, 112, 121	Rivet shear failure
15mm Teg Tab with DXT30D	55, 67, 43, 75, 63	108, 126, 110, 132, 112	Rivet bending & pullout
24mm Teg Tab with DX30D**	102, 51, 91	115, 101, 106	Rivet bending & pullout

* Deflection not recorded for third test out of five

** Timber framing 24" long for these tests only, 12" for others.

Figure 5: Key results from eighteen tensile tests.

Perimeter angle connection with no Teg Tab (control test): ϕN_t = 88lb

Perimeter angle connection with 15mm or 24mm Teb Tab: ϕN_t = 65lb

Engineer's Note: the ultimate limit state design capacity is to be compared with factored ultimate limit state loads (e.g. 1.2 x Dead Load & 1.5 x Live load). Ultimate limit state is defined in AS/NZS4600:1996 as a limit state of collapse or loss of structural integrity. Recommended working load capacity is ⅔ of ultimate limit state capacity.

Appendix B Strength Calculations

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Client:	Conacc Limited	Project No.	AB01728
Project Name:	Teg Tab Seismic Capacity Investigation	Calc Series	Teg Tab
Calcs Title:	Test result analysis	Page	1
		By	KMS
		Date	20/07/06

1) TEST RESULTS

Failure loads in kilograms (kg)

No Teg Tab	*With Teg Tab*			
TEST 1	**TEST 2**	**TEST 3**	**TEST 4**	**T2, T3, T4**
65	55	49	52	
59	50	57	46	
66	60	50	48	
70	51	60		
69	55	51		

2) ANALYSIS OF RESULTS:

	No Teg Tab	*With Teg Tab*				
	TEST 1	**TEST 2**	**TEST 3**	**TEST 4**	**T2, T3, T4**	
NUMBER OR TESTS, n	5	5	5	3	13	no.
MINIMUM FAILURE LOAD, min (kg)	59	50	49	46	46	kg
AVERAGE FAILURE LOAD (kg)	66	54	53	49	53	kg
STD DEV (kg)	4.3	4.0	4.8	3.1	4.4	kg
SAMPLE CO-EFFICIENT OF VARIATION	6.6%	7.3%	9.0%	6.3%	8.4%	…standard deviation/mean
CODE PRESCRIBED COV	15%	15%	15%	15%	15%	...As per AS/NZS 4600 Supp1:1998 (refer notes below)
COV, k_{sc} FACTOR	1.46	1.46	1.46	1.56	1.34	...AS/NZS 4600:1996 (Table 6.2.2, refer below)
ULTIMATE CAPACITY (kg) = min/k_{sc}	40.4	34.2	33.6	29.5	34.3	...AS/NZS 4600:1996 (6.2.2) & NZS 3404:1997 (17.5.2)

3) CODE INFORMATION:

AS/NZS4600, TABLE 6.2.2, k_{sc}

No units	**Co-efficient of variation**					
	5%	10%	**15%**	20%	25%	30%
1	1.2	1.46	**1.79**	2.21	2.75	3.45
2	1.17	1.38	**1.64**	1.96	2.36	2.86
3	1.15	1.33	**1.56**	1.83	2.16	2.56
4	1.15	1.3	**1.5**	1.74	2.03	2.37
5	1.13	1.28	**1.46**	1.67	1.93	2.23
10	1.1	1.21	**1.34**	1.49	1.66	1.85
100	1	1	**1**	1	1	1

Co-efficient of variation prescribed in AS/NZS4600:

Co-efficient of variation for structural characteristics k_{sc} =

10% *(for strength of members, AS/NZS4600, C6.2.2.3)*

15% *(for strength of connections and assemblies, AS/NZS4600, C6.2.2.3)*

5% *(for stiffness of members, AS/NZS4600, C6.2.2.3)*

10% *(for stiffness of connections and assemblies, AS/NZS4600, C6.2.2.3)*

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Appendix C Test Methodology

INSTRUCTIONS:	Photocopy this blank form and complete for each test (18 tests in total).			
TEST SET-UP:	**Teg Tab installed?**	**Rivet**	**Main tee**	**Test number (circle)**
Test 1	✗ (control test)	3.2mm Al (5056)	DX30D (24mm)	1 2 3 4 5
Test 2	✓ (24mm wide)	3.2mm Al (5056)	DX30D (24mm)	1 2 3 4 5
Test 3	✓ (15mm wide)	3.2mm Al (5056)	DXT30D (15mm)	1 2 3 4 5
Test 4	✓ (24mm wide)	3.2mm Al (5056)	DX30D (24mm)	1 2 3

** For Test 4 only, use test configuration shown in sketch SK02 (longer timber).*

FOR ALL TESTS:		
SET-UP	Tick to confirm test set-up and materials are as per Sketch SK01	
	Record length of test specimen at start (distance between vice jaws)	mm
APPLY DEFORMING LOAD	Apply load in 2kg increments until first visible deformation or buckling occurs. Record deformation load:	kg
	Record length of test specimen (distance between vice jaws)	mm
	Describe buckling (take photographs):	
APPLY FAILURE LOAD	Apply load in 1kg increments until pull-out or tearing failure occurs. Record below:	
	Circle all failure mechanism(s) observed: Identify primary reason for failure with an asterix (*)	A) Tearing of perimeter angle B) Tearing of main tee flange C) Tilting and buckling of steel, releasing rivet D) Bending and pullout of rivet E) Rivet shear failure F) Pull-out of timber screws (if so, repeat test) G) Other. Please describe: ______________________________ ____
	Record length of test specimen just before failure	mm
	Record failure load to nearest 0.5kg	kg
	Take photographs, minimum 2 (record photograph numbers):	

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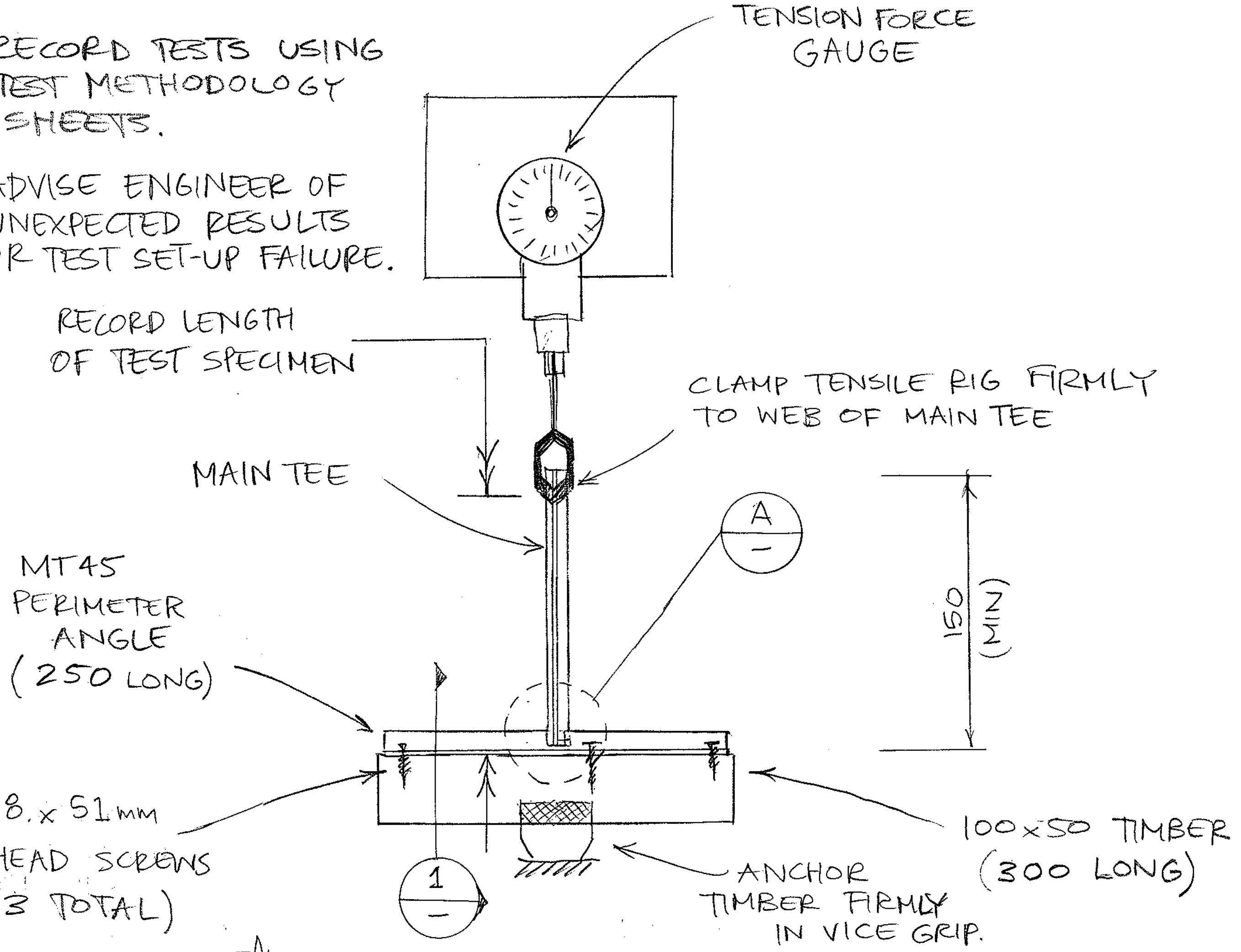
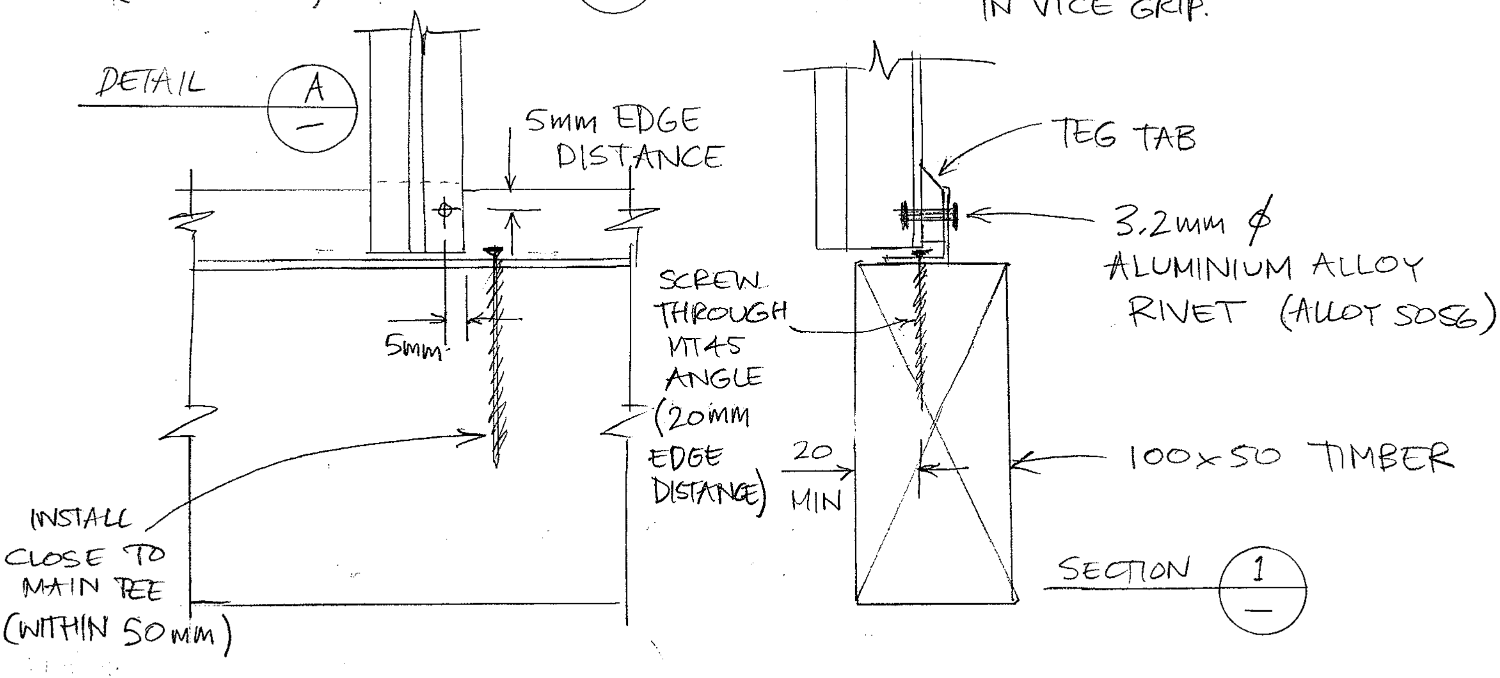
Job No.	AB01728
Calc. Series	TT
Client	CONACC LTD
Page	SKETCH 01
Job Name	TEG TAB SEISMIC INVESTIGATION
By	BJD
Calcs Title	TEST SETUP FOR STRENGTH ASSESSMENT
Date	20/03/06

TEST 1-3

NOTES:

1) TEST COMPONENTS VARY. REFER TO TEST METHODOLOGY
2) RECORD TESTS USING TEST METHODOLOGY SHEETS.
3) ADVISE ENGINEER OF UNEXPECTED RESULTS OR TEST SET-UP FAILURE.





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Job No. AB01728
Calc. Series TT
Client CONACC LTD
Page SKETCH 0
Job Name TEG TAB SEISMIC INVESTIGATION
By BJD
Calcs Title TEST SETUP FOR STRENGTH ASSESSMENT
Date 20/03/06

TEST 4

NOTES:

1) TEST COMPONENTS VARY. REFER TO TEST METHODOLOGY
2) RECORD TESTS USING TEST METHODOLOGY SHEETS.
3) ADVISE ENGINEER OF UNEXPECTED RESULTS OR TEST SET-UP FAILURE.