Seismic Hanging and Bracing

A Heads-Up – the playing field is being shaken up

FPA NEW ZEALAND

Christchurch 2010/2011

- Sprinkler Systems generally held up well
  - Except for:
    - Tanks
    - Where other services took out sprinklers
      - Racks, ceilings, wind-braces
- NZS4541 is basically sound
  - But some of Christchurch's performance
    - By good luck and not management

Wellington July 2013

- One high profile sprinkler "failure"
  - An air-conditioning unit was not restrained
    - NZS4219
  - Took out a sprinkler dropper
    - High profile site
    - Modern/new
    - Large Business Interruption costs
- Greater emphasis on Building Services seismic design
  - Sprinklers coming under greater scrutiny

NZS4219/NZS4541

- NZS4219 excludes sprinkler pipework
  - Some engineers now stating NZS4541 flawed
  - Some engineers believe “flaws” were “inadvertent”
- NZS4541 requires 1g design unless otherwise specified
  - NZS1170.5 may require loadings as high as 3.6g
  - Will result in beefier (and more expensive) braces
- NZS4219 is very specific about concrete fasteners

What does this mean?

1. Expect various parties to look at your bracing
   – More than “FPIS”
2. Expect “FPIS” to be trained up on seismic bracing
   – Most inspections on “gut” feel
3. Expect parties to ask for seismic design calculations
   – Aon shortly to publish a Technical Note on this

NZS4541 is Clear

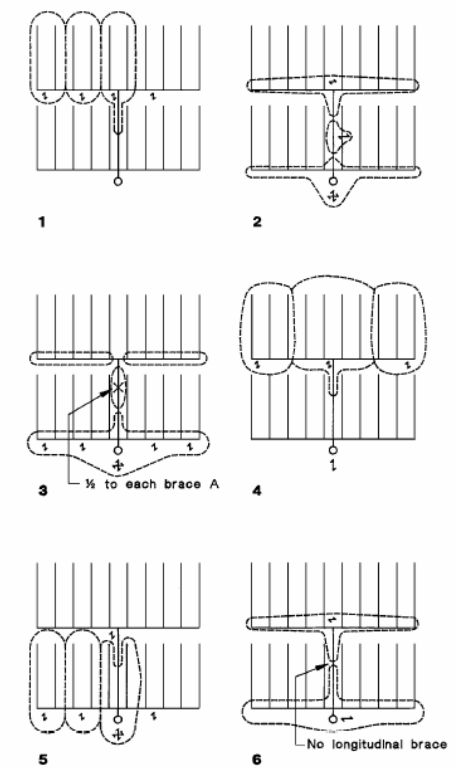
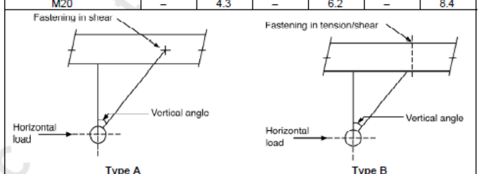


Table 4.7 – Horizontal load capacity of typical connections

Fastening type	Horizontal load capacity					
	Vertical angle 30°		Vertical angle 45°		Vertical angle 60°	
	Type A (kN)	Type B (kN)	Type A (kN)	Type B (kN)	Type A (kN)	Type B (kN)
Masonry anchors						
M6	1.7	1.3	2.4	2.0	2.9	2.6
M8	3.0	2.0	4.2	2.9	5.2	3.8
M10	4.4	2.9	6.2	4.3	7.6	5.5
M12	6.8	4.3	9.5	6.3	11.7	8.7
M16	12.0	5.7	17.0	8.7	20.9	12.3
Bolts to steel						
M6	1.7	1.9	2.4	2.6	2.9	3.0
M8	3.0	3.5	4.2	4.6	5.2	5.4
M10	4.7	5.5	6.7	7.3	8.1	8.5
M12	6.8	7.9	9.5	10.5	11.7	12.3
M16	12.0	14.4	17.0	19.1	20.9	22.0
Bolts to BP 450 purlins						
M6	1.7	–	2.4	–	2.9	–
M8	2.9	–	4.1	–	5.0	–
M10	3.6	–	5.1	–	6.2	–
M12	4.3	–	6.1	–	7.4	–
M16	5.7	–	8.1	–	9.9	–
Bolts to timber						
M12	2.1	–	3.3	–	4.4	–
M16	2.9	–	4.8	–	7.1	–
M20	3.7	–	6.4	–	10.0	–
Coach screws to timber						
M8	–	0.75	–	0.95	–	1.1
M10	–	1.3	–	1.8	–	2.2
M12	–	1.8	–	2.6	–	3.4
M16	–	3.0	–	4.2	–	5.6
M20	–	4.3	–	6.2	–	8.4



NOTE –
(1) Bolted shear (type A) connections to timber as
(2) Tension/shear (type B) connections to timber a
diameter and have a minimum thread length 6
(3) The loads for timber connections are for dry tin

.6 – Allowable horizontal loads of typic

Brace length for $l/r = 200$ (m)	Allowable horizont 30° angle from vertical (kN)	45° angl from ver (kN		
(tension only)	0.23	0.3		
0.50	1.0	1.4		
0.60	1.4	2.0		
0.80	2.5	3.5		
1.00	3.9	5.5		
1.7	2.5	3.5		
2.2	3.9	5.5		
2.8	5.0	7.1		
3.2	5.7	8.1		
4.0	8.1	11.5		
5.1	10.4	14.7		
0.35	3.0	4.2		
0.46	5.0	7.0		
0.58	6.2	8.8		
0.96	1.7	2.5	3.0	3.5
1.1	3.4	4.9	6.0	6.9
1.5	4.7	6.7	8.2	9.4

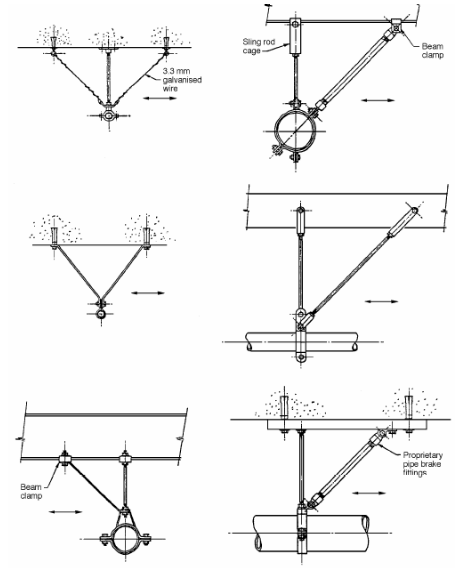
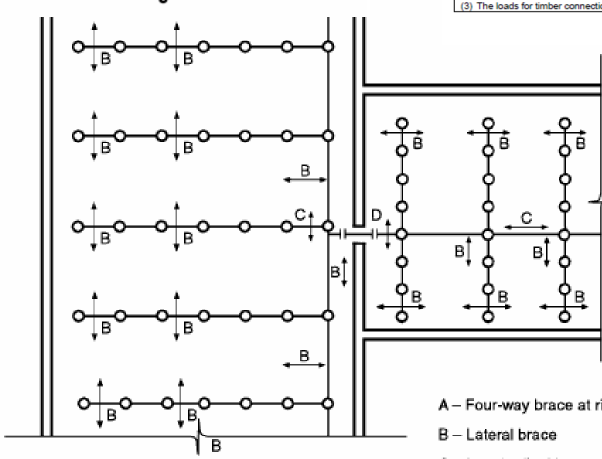


Table 4.5 – Weight calculations

Pipe size (nominal diameter) (mm)	Weight including water (W_p) (kg/m)	Material
25	3.05	BS 1387 medium screwed and socketted tube
32	4.19	
40	5.03	
50	7.37	
65	10.3	
80	13.7	
100	21.1	
150	38.8	
200	62.6	BS 3600 tube

NOTE – For a seismic acceleration of 1.0 g the required restraining force F_p is given by:
(1) $F_p = W_p \times 0.00981 \times L_p$ (kN)
(2) where L_p = length of pipe under restraint.



A – Four-way brace at riser
B – Lateral brace
C – Longitudinal brace
D – Couplings at wall penetration

What to Do?

1. Establish required design loading
   1. Tender stage?
   2. Before designing?
   3. Specified?
2. Design to it!
   1. Clamp to structure; or
   2. Carry out the calculations – not rocket science
   3. Design/select bracing – not a fitter decision!
   4. Show bracing on drawings
   5. Correctly select fasteners

Crimes

- Long threaded rods
- Bent base plates
- Inadequate longitudinal braces
  - One per run?
- Inadequate fasteners into concrete
- Un-braced flexible couplings
- Inadequate flexibility

Cracked concrete

What is it, why do we care?

What does it mean to fasteners?

What to do?

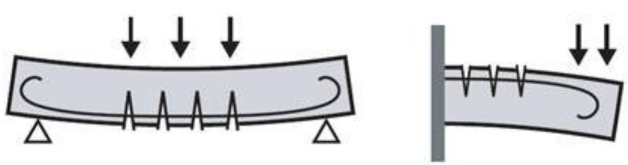
When to assume cracked concrete?

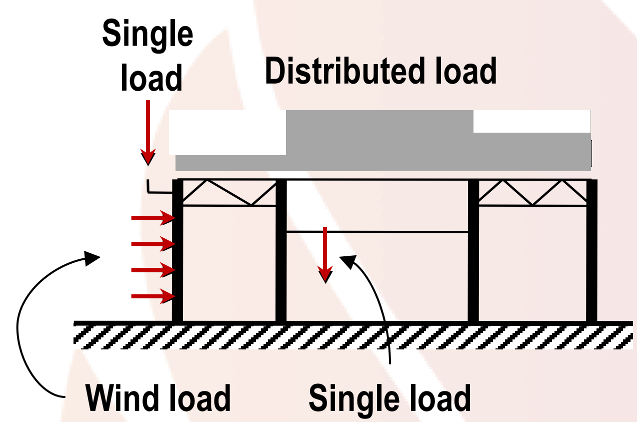
- Determining whether concrete is “cracked”

If a concrete member section is in tension, then the concrete can be considered to be cracked. Cracking is a normal condition with reinforced concrete members.

Locating a tension zone can be quite simple for a beam or cantilever…

… though can be fairly complex for real structure load scenarios





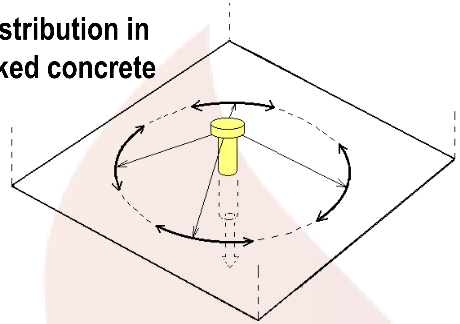
“Installation of mechanical anchors at the underside of the beam/slab shall be based on tests on cracked concrete.”

State of California Office of Statewide Health Planning and Development

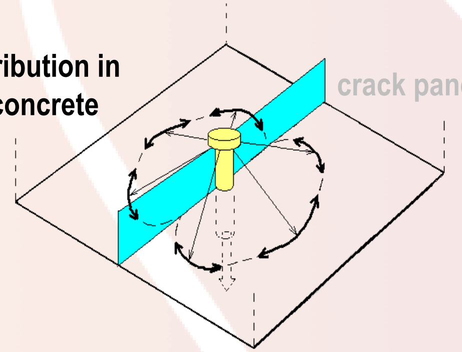
When to assume cracked concrete?

Cracked concrete affect on anchor performance

Anchorages in non-cracked concrete
show a stress distribution axially symmetric to the anchor axis. Equilibrium is provided by this circular ring of stresses.



Anchorages in cracked concrete
Show a stress distribution that is redistributed within the concrete, thus reducing the area to transmit tensile forces into the concrete



What does this mean to fasteners?

The fasteners capacity is de-rated dependant on its design – expansion vs screwed

By how much depends on code/design used for the job e.g. NZBC B1 would require sprinkler pipework in an IL3/4 building in Wgtn/Chch to be designed for up to 3.6g.

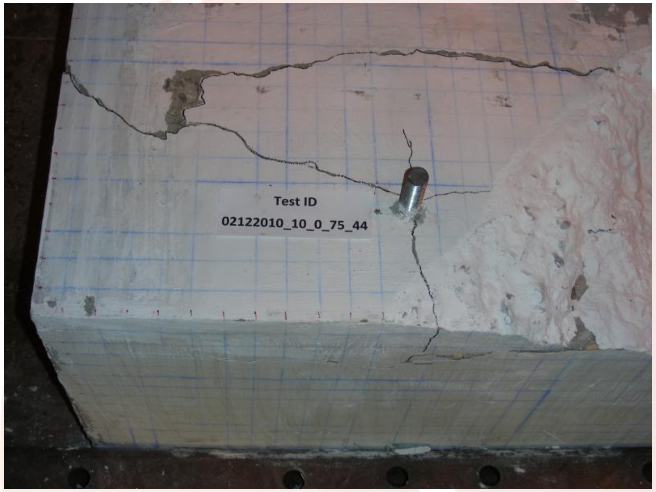
HST M10					
uncracked concrete kN	cracked concrete kN	seismic C1	seismic C2	Diff	C2
13.4	7.5	5.3	2.2	56%	16%

What to do?

Refer to Aon Technical note **TN-14-14**

Information on suitable fasteners can be sourced from the following:

- Hilti engineering for earthquake applications
- Powers Seismic Approved Fixings
- Ramset Engineering Bulletin EB04013 dated 25 November 2013
- Other suppliers may come onto the market
    - Ask them about cracked concrete



Ceilings

Summary

- Christchurch and Wellington Events
  - Have shaken up the construction industry
  - The world has changed
  - Our standards must lift
    - Even if not warranted