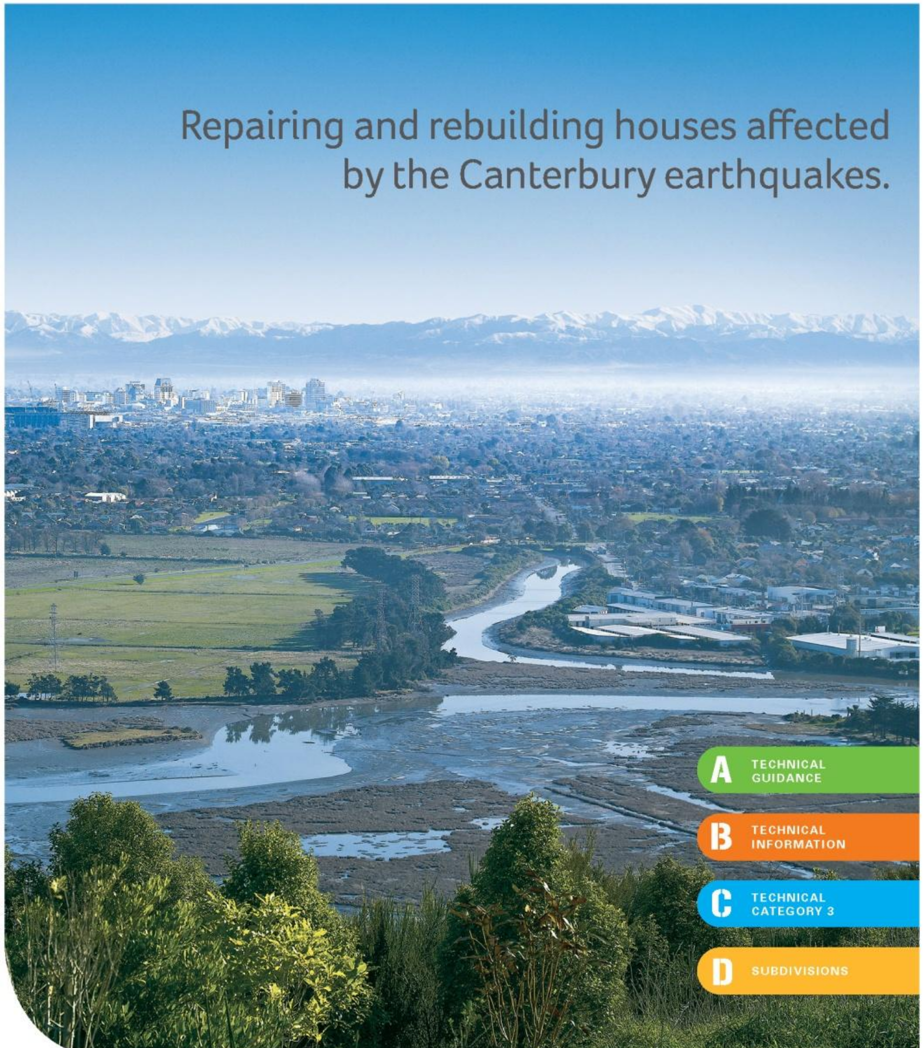
GUIDANCE

Repairing and rebuilding houses affected by the Canterbury earthquakes.



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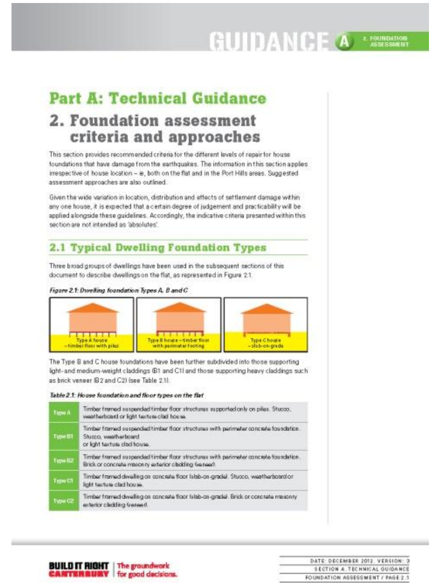


Part A: Technical Guidance

2. Foundation assessment criteria and approaches

This section provides recommended criteria for the different levels of repair for house foundations that have damage from the earthquakes. The information in this section applies irrespective of house location – ie, both on the flat and in the Port Hills areas. Suggested assessment approaches are also outlined.

Given the wide variation in location, distribution and effects of settlement damage within any one house, it is expected that a certain degree of judgement and practicability will be applied alongside these guidelines. Accordingly, the indicative criteria presented within this section are not intended as 'absolutes'.

2.1 Typical Dwelling Foundation Types

Three broad groups of dwellings have been used in the subsequent sections of this document to describe dwellings on the flat, as represented in Figure 2.1.

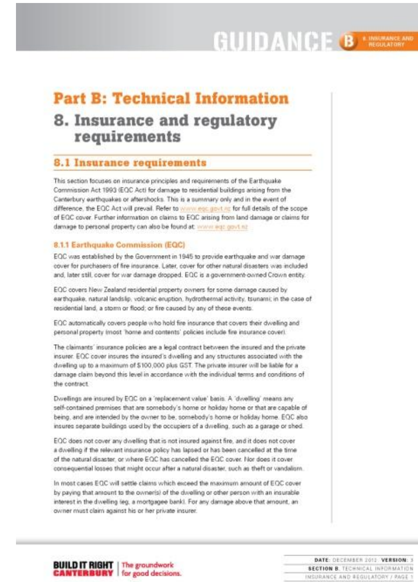
Figure 2.1: Dwelling foundation Types A, B and C

Type A house – timber floor with piles | Type B house – timber floor with perimeter footing | Type C house – slab-on-grade

The Type B and C house foundations have been further subdivided into those supporting light- and medium-weight claddings (B1 and C1) and those supporting heavy claddings such as brick veneer (B2 and C2) (see Table 2.1).

Table 2.1: House foundation and floor types on the flat

Type A	Timber framed suspended timber floor structures supported only on piles. Stucco, weatherboard or light texture clad house.
Type B1	Timber framed suspended timber floor structures with perimeter concrete foundation. Stucco, weatherboard or light texture clad house.
Type B2	Timber framed suspended timber floor structures with perimeter concrete foundation. Brick or concrete masonry exterior cladding (veneer).
Type C1	Timber framed dwelling on concrete floor (slab-on-grade). Stucco, weatherboard or light texture clad house.
Type C2	Timber framed dwelling on concrete floor (slab-on-grade). Brick or concrete masonry exterior cladding (veneer).



Part B: Technical Information

8. Insurance and regulatory requirements

8.1 Insurance requirements

This section focuses on insurance principles and requirements of the Earthquake Commission Act 1993 (EQC Act) for damage to residential buildings arising from the Canterbury earthquakes or aftershocks. This is a summary only and in the event of difference, the EQC Act will prevail. Refer to www.eqc.govt.nz for full details of the scope of EQC cover. Further information on claims to EQC arising from land damage or claims for damage to personal property can also be found at: www.eqc.govt.nz

8.1.1 Earthquake Commission (EQC)

EQC was established by the Government in 1945 to provide earthquake and war damage cover for purchasers of fire insurance. Later, cover for other natural disasters was included and, later still, cover for war damage dropped. EQC is a government-owned Crown entity.

EQC covers New Zealand residential property owners for some damage caused by earthquake, natural landslip, volcanic eruption, hydrothermal activity, tsunami; in the case of residential land, a storm or flood; or fire caused by any of these events.

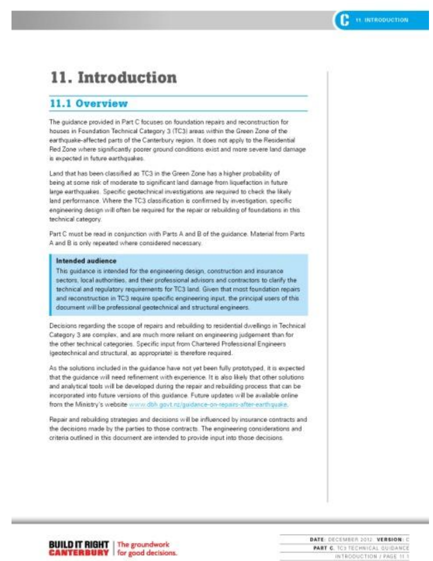
EQC automatically covers people who hold fire insurance that covers their dwelling and personal property (most 'home and contents' policies include fire insurance cover).

The claimants' insurance policies are a legal contract between the insured and the private insurer. EQC cover insures the insured's dwelling and any structures associated with the dwelling up to a maximum of $100,000 plus GST. The private insurer will be liable for a damage claim beyond this level in accordance with the individual terms and conditions of the contract.

Dwellings are insured by EQC on a 'replacement value' basis. A 'dwelling' means any self-contained premises that are somebody's home or holiday home or that are capable of being, and are intended by the owner to be, somebody's home or holiday home. EQC also insures separate buildings used by the occupiers of a dwelling, such as a garage or shed.

EQC does not cover any dwelling that is not insured against fire, and it does not cover a dwelling if the relevant insurance policy has lapsed or has been cancelled at the time of the natural disaster, or where EQC has cancelled the EQC cover. Nor does it cover consequential losses that might occur after a natural disaster, such as theft or vandalism.

In most cases EQC will settle claims which exceed the maximum amount of EQC cover by paying that amount to the owner(s) of the dwelling or other person with an insurable interest in the dwelling (eg, a mortgagee bank). For any damage above that amount, an owner must claim against his or her private insurer.



11. Introduction

11.1 Overview

The guidance provided in Part C focuses on foundation repairs and reconstruction for houses in Foundation Technical Category 3 (TC3) areas within the Green Zone of the earthquake-affected parts of the Canterbury region. It does not apply to the Residential Red Zone where significantly poorer ground conditions exist and more severe land damage is expected in future earthquakes.

Land that has been classified as TC3 in the Green Zone has a higher probability of being at some risk of moderate to significant land damage from liquefaction in future large earthquakes. Specific geotechnical investigations are required to check the likely land performance. Where the TC3 classification is confirmed by investigation, specific engineering design will often be required for the repair or rebuilding of foundations in this technical category.

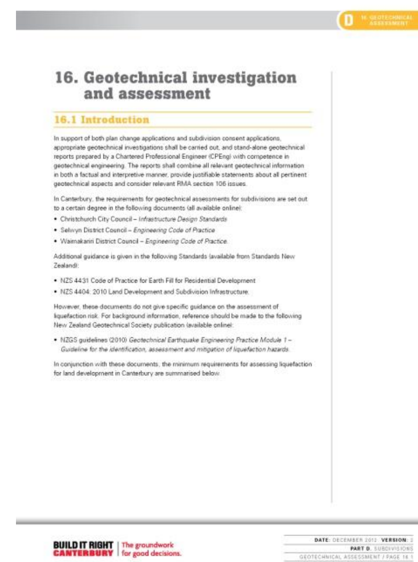
Part C must be read in conjunction with Parts A and B of the guidance. Material from Parts A and B is only repeated where considered necessary.

Intended audience
This guidance is intended for the engineering design, construction and insurance sectors, local authorities, and their professional advisors and contractors to clarify the technical and regulatory requirements for TC3 land. Given that most foundation repairs and reconstruction in TC3 require specific engineering input, the principal users of this document will be professional geotechnical and structural engineers.

Decisions regarding the scope of repairs and rebuilding to residential dwellings in Technical Category 3 are complex, and are much more reliant on engineering judgement than for the other technical categories. Specific input from Chartered Professional Engineers (geotechnical and structural, as appropriate) is therefore required.

As the solutions included in the guidance have not yet been fully prototyped, it is expected that the guidance will need refinement with experience. It is also likely that other solutions and analytical tools will be developed during the repair and rebuilding process that can be incorporated into future versions of this guidance. Future updates will be available online from the Ministry's website www.dbh.govt.nz/guidance-on-repairs-after-earthquake.

Repair and rebuilding strategies and decisions will be influenced by insurance contracts and the decisions made by the parties to those contracts. The engineering considerations and criteria outlined in this document are intended to provide input into those decisions.



16. Geotechnical investigation and assessment

16.1 Introduction

In support of both plan change applications and subdivision consent applications, appropriate geotechnical investigations shall be carried out, and stand-alone geotechnical reports prepared by a Chartered Professional Engineer (CPEng) with competence in geotechnical engineering. The reports shall combine all relevant geotechnical information in both a factual and interpretive manner, provide justifiable statements about all pertinent geotechnical aspects and consider relevant RMA section 106 issues.

In Canterbury, the requirements for geotechnical assessments for subdivisions are set out to a certain degree in the following documents (all available online):

- Christchurch City Council – *Infrastructure Design Standards*
- Selwyn District Council – *Engineering Code of Practice*
- Waimakariri District Council – *Engineering Code of Practice*.

Additional guidance is given in the following Standards (available from Standards New Zealand):

- NZS 4431 Code of Practice for Earth Fill for Residential Development
- NZS 4404: 2010 Land Development and Subdivision Infrastructure.

However, these documents do not give specific guidance on the assessment of liquefaction risk. For background information, reference should be made to the following New Zealand Geotechnical Society publication (available online):

- NZGS guidelines (2010) *Geotechnical Earthquake Engineering Practice Module 1 – Guideline for the identification, assessment and mitigation of liquefaction hazards.*

In conjunction with these documents, the minimum requirements for assessing liquefaction for land development in Canterbury are summarised below.

What are the main clarifications that might affect your work?

- Three technical areas:
  - ‘Structural’
  - ‘Geotechnical’
  - ‘Consent Processes’

Also:

- Numerous editorial and layout changes

“STRUCTURAL”

Cracks

- Document has been amended to correct inconsistencies related to cracks in slabs and foundation walls
  - Cracks up to 5mm wide – no engineer involvement
  - Cracks more than 5mm wide – guidelines cover repair
  - Type B foundation - 5mm crack criteria in table 2.3 now recognised as too conservative

“STRUCTURAL”

Table 7.1 – Wall Damage

- Additional guidance and clarification where damage has occurred to wall linings or framing.
  - Diagonal cracks < 50mm long – refix panels
  - Diagonal cracks > 50mm long – replace panel
  - Wall ‘drumminess’ to be dealt with
  - Wall ‘junctions’ include sheet joins

Table 7.2 – Claddings

- Now included to help designers with light/medium/heavy (rebuild) decisions

Table 7.1: Summary of actions relating to repair/replacement of plasterboard lining

Extent of wall damage evident	Repair/replacement action	Review of bracing requirement	Building consent/ compliance basis	Comments
1. Minor cracking at sheet joints (< 0.5 mm) (Note a). No signs of movement at skirting board.	Scraping out old stopping (taking care not to damage paper facing), re-stopping and repainting. Check for 'drumminess' of sheets (Note c).	Not required	Schedule 1(a) and 1(ah) exemption • Applies to bracing and non-bracing elements	Cosmetic repairs
2. Moderate cracking at sheet joints (> 0.5 mm) (Note b). Minor movement of perimeter sheet fixings or movement of sheets evident at skirting board.	Refixing of sheets adjacent to existing fixings and re-stopping of joints. When sheet edges are too damaged to allow re-fixing, replacing affected sheet(s) with comparable component or assembly (eg, standard or enhanced plasterboard (as applicable)), fixed as a bracing element (Note d), checking and making good any damaged framing connections where reasonably practicable. Check for 'drumminess' of sheets (Note c).	Not required	Schedule 1(a) and 1(ah) • Repairs in accordance with this guidance document	Superficial and localised repairs Note: where panels are replaced, compliance with other clauses of the Building Code (eg, B2, E3) must be achieved (Note f).

UPDATE:
December 2012

Table 7.2: Summary cladding weight chart for rebuilds in properties classified as TC1, TC2 or TC3

Technical Category	Foundation type	Wall cladding Maximum recommended weights		Roof cladding Maximum recommended weight
		The following cladding weights are default listings only, which may be varied by specific engineering design		
TC1	NZS 3604 Type C [1]	H		H
	NZS 3604 Type A [1]	M		H
	NZS 3604 Type B [1]	H		H
TC2	NZS 3604 Type A	M		L
	NZS 3604 Type B (enhanced)	Single storey M		L
		Two storey M		L
	Concrete Raft (Simple floor layout) Refer to section 5.3	Options	Single storey	
		1	H	H
		2 (300 mm)	H	H
		3	H	H
		4	H	H
		Options	Two storey	
		1	M	L
		2 (300 mm)	M	H
		2 (400 mm)	H	H
		3	H	L
		4	M	L
TC2 / TC3	Hybrid	Timber floor	M	L
		Concrete floor	Single storey H	H
			Two storey M	L
TC3	Deep Piles	Concrete raft Options 2,4 modified	H	H
	Site Ground Improvement	For use with all TC2 foundation options and cladding weights		
	Surface Structures (Simple floor layout) Refer to section 15.4	Type 1, 2	M	L
		Type 3	Single storey M	L
			Two storey M	L

(1) Refer to section 2.1 for descriptions of house foundation types.

“GEOTECHNICAL”

Investigations

- Clarification around investigation depths
- Energy rating of SPT equipment
- DPT and SWS not for primary data

Liquefaction Settlement Calculations

- For comparison with TC2/TC3 limit indices (only), calculations may be limited to the upper 10m of soil profile
- Liquefaction characteristics still need to be assessed and considered over full depth of investigation
- Expanded methodology from subdivision section (Part D) now incorporated in Part C

"GEOTECHNICAL"

Static Bearing Calculations

- Clarification around specific calculations for static bearing – if you have less than '200 kPa' or '300 kPa', all is not lost.

Multi Helix Piles

- All helixes must be within the dense founding layer, not within liquefiable layers or intermediate stiff layers

Ground Improvement Methods Type 1 & 2

- Expansion of scope beyond 10m limit on liquefiable depth – can now use surface crust options (densified or cement stabilised) in conjunction with surface structures type 1 or 2 (i.e. lightweight house on timber subfloor)

13.2 Single or isolated house site investigation

The geotechnical investigation process in TC3 should broadly follow the subdivision investigation requirements set out in Part D, under the guidance of a CPEng geotechnical engineer or suitably experienced PEngGeol. engineering geologist.

Where practical at least two deep investigation points (CPTs, boreholes with SPTs, etc) should be undertaken to enable site characterisation to 10–15 m depth. This might be achieved in conjunction with nearby existing deeper information where it is feasible on or immediately adjacent to the site.

Given the relative cost of CPT data it is considered best practice to push CPTs to refusal, however where there are very deep deposits (for example in excess of 20 m) of penetrable materials some judgement is required regarding the usefulness of the deeper information. It must be recognised also that early termination of CPT investigation depths may result in loss of potentially useful information regarding possible pile founding depths, ground improvement options, overall site settlements and general site characterisation. Conversely, while a minimum target depth of 15 m is recommended (and early termination at this depth is not encouraged), if CPTs refuse at between 10 m and 15 m depth the cost of a physical borehole to gain additional information may not always warranted in the first instance, in all cases.

It is recognised that CPT data is generally superior to SPT data in determining liquefaction susceptibility, and therefore CPTs will normally be carried out in preference to SPTs. However where ground conditions dictate the need for SPTs it is important that equipment is used that has been properly energy rated so that an appropriate energy ratio can be used to correct SPT 'N' values. CPT equipment should be calibrated, and procedures carried out, to ASTM D5778-12.

In many cases only a single location will be initially feasible (due to access considerations and other constraints) or in some cases where CPT testing is hampered by gravel layers, a single borehole with SPT testing may be appropriate, augmented by shallower investigations. It will then be up to the judgement of the CPEng Geotechnical Engineer or PEngGeol whether these may be supplemented by further additional shallow investigations, geophysical testing and/or if further deep investigation points are necessary (either during the initial investigation phase, or possibly post-demolition where this occurs).

Groundwater measurements during the investigations should also be undertaken. Liquefaction assessments should be carried out following the guidelines in section 13.5, as well as further analyses appropriate to the particular foundation or ground remediation solutions being considered for the site.

In addition to the above deep investigations, shallow testing (in accordance with TC2 requirements) can be used to supplement the deep investigations as required.

13.5 Liquefaction assessment

In addition to standard geotechnical characterisation, the site data should be analysed using recognised methods to determine liquefaction susceptibility and in particular likely ground deformations under design serviceability limit state (SLS) and ultimate limit state (ULS) ground motions.

13.5.1 Liquefaction analysis methodologies (minimum requirements)

Recognised standard liquefaction analysis methods outlined below, and repeated in Part D, shall be used in conjunction with specified input ground motions and, where appropriate, observations of land damage from recent seismic events. As discussed in section 12, it is recognised that the calculation of liquefaction-induced settlements is an inexact process. For the purposes of calculating consistent 'index numbers' to compare with nominal 'limits' set out in these guidance documents, a consistent methodology will need to be adopted by all users. It must still be recognised however that engineering judgement is required in considering the 'sensibility' of analysis results, and therefore these methodologies should only be applied by those with a strong background in geotechnical engineering.

For the purposes of this document, calculations of liquefaction potential (triggering) should be carried out using the methods of Idriss & Boulanger 2008, as outlined in the publication "Soil Liquefaction During Earthquakes" – EERI monograph MNO12. Only data obtained directly from CPT, SPT or seismic shear wave velocity measurements shall be used in carrying out liquefaction assessments. Where primary data has been obtained for the site using these methods, *and site access constrains the further use of these primary methods*, supplementary infill data can be considered from Swedish Weight Sounding or DPT using recognised correlations. For fines corrections where soil samples have not been retrieved and tested the method of Robertson and Wride (1998) should be used. For the calculation of post-liquefaction induced settlements, the method of Zhang et al (2002) is to be used. It should be noted that this does not imply that these methodologies are mandated for applications outside the scope of this document.

Ground input motions

Ground input motions for SLS and ULS liquefaction analysis are provided in Appendix C2. In summary, for deep soft soil (Class D) sites they are:

- SLS 0.13g
- ULS 0.35g

These figures are the result of extensive probabilistic modelling by GNS Science and observations of land and building damage caused during the Canterbury earthquake sequence and are recommended for use for liquefaction analyses on the flat land of Christchurch by the Ministry as of April 2012.

3.4.1 Shallow subsurface investigation for TC1 and TC2

(Text removed for clarity)

- For foundation options 1–4 in section 5 of this document, Scala blows per 100 mm shall be minimum 2 blows (ie, 50 mm per blow) for ground deemed to have 200 kPa geotechnical ultimate bearing capacity. For other foundation types (eg, in TC1), 300 kPa will need to be confirmed in accordance with NZS 3604.

Note that the '300 kPa' and '200 kPa' values discussed above are only 'index' values for use in conjunction with NZS: 3604 or this document. The actual geotechnical ultimate bearing capacity for a particular foundation for design purposes, when estimated from scala penetrometer test results is subject to modifications that depend on the soil type, foundation geometry and water table depth. (Furthermore, scala penetrometer testing as a means of determining bearing capacities is only appropriate for residential structures particularly those within NZS: 3604). Where the specified '200 kPa' or '300 kPa' criteria are not met on a site, a specific engineering design calculation should be carried out to determine the actual static loads being applied to the foundations. In many cases this will allow the use of Options 1 to 4 on ground with less than '200 kPa' geotechnical ultimate, or for the appropriate resizing of other foundation footing dimensions without the need to excavate down to depths where 200 kPa or 300 kPa soils are located. Due regard must be taken of soil type, foundation geometry and water table depth in carrying out these calculations. 150 kPa geotechnical ultimate (raw) should however be considered as the lower limit of acceptable soil strength, in the absence of specialist geotechnical advice. Due regard must always be given to other potential issues, for example peat deposits, non-engineered fill etc.

Shallow subsurface investigations can be carried out by a soils technician or other suitably trained and supervised person. In TC2 this needs to be under the guidance of a CPEng qualified engineer.

13.6 Technical Category TC3 confirmation

If damage to the land or foundations is less than implied by the TC3 categorisation, then the deep geotechnical investigation and liquefaction analysis undertaken by a CPEng. geotechnical engineer or suitably qualified PEngGeol. engineering geologist may indicate that the site has TC2 rather than TC3 performance characteristics for that particular site. As part of this determination, liquefaction characteristics need to be assessed over the full depth of the soil profile investigated. However, when comparing calculated settlement values to the index values in Table 3.1 in Part A, calculations can be limited to the upper 10 m of the soil profile (this does not in any way imply that potential issues do not need to be considered below 10 m depth, this is simply a calculated 'index' number for comparison to the index values in Table 3.1 in Part A). Specific design based on the deep geotechnical investigation and TC2 solutions signed off by a suitably qualified CPEng. geotechnical engineer can then be undertaken.

15.2.3 Pile types and options

The following pile types are considered the most suitable types for residential construction in TC3. Typical sizes and indicative capacities for these pile types are given in Table 15.3.

Screw piles

Screw piles consist typically of one or more steel plate helixes welded to a steel tube. The pile is screwed into the ground and then the tube is filled with concrete. Torque measurements are used to identify penetration into the target bearing stratum. These piles have the advantage that almost all of the load is transferred to end bearing on the steel helixes embedded into the target bearing stratum, with minimal side resistance along the shaft. With liquefaction of overlying materials, there will be little down-drag. For this reason, multi-helix piles must not have helixes within the liquefiable deposits, or any deposits above the bearing stratum that are underlain with liquefiable deposits. The concrete filled steel tube stems are very ductile providing good ability to cope with global lateral movement.

Design of these piles for axial capacity is usually by proprietary methods, and these should be supported by documentary evidence such as field load tests of relevant sized piles in local conditions.

15.3.4 Specification, construction and verification issues

Specific requirements for each of the options which provide adequate solutions are set out in this section. These methods are generally currently applicable to sites where the depth of liquefiable materials is limited to 10 m below the ground surface. However, for the deep treatment options (ie, deep soil mixed columns, jet grouted columns, stone columns and LMG columns) if the liquefiable deposits extend beyond this limit, the methods are still applicable as long as the depth of treatment extends to at least 8 m and then additionally to the depth beyond which calculated ULS settlements under the zone of treatment are less than 100 mm, and calculated SLS settlement are less than 50 mm.

Alternatively, where the depth of liquefiable materials exceeds 10 m, shallow method Types 1 and 2 can still be used under the following circumstances:

- where treatment extends to 2 m outside the foundation line, AND
- where in-situ methods are used then a geogrid should be installed at a depth of 0.5 m (noting that the excavate and replace options already include a geogrid at the base); AND
- where a Type 1 or Type 2 timber floor surface structure (only) is constructed.

Detailed model specifications/method statements for these methods are included in Appendix C4.

“CONSENT PROCESSES”

Canterbury Geotechnical Database

- Reminder that geotechnical data is available on the database, but also of your obligation to upload data as a condition of use for the database.
- Required to upload geotechnical data at building consent stage in any case.

Format of Supporting Information for Building Consents

- Electronic template has been developed between Cera and the BCAs.
- Summarises geotechnical information, and building information.
- Will streamline consent processing.

GUIDANCE

Repairing and rebuilding houses affected by the Canterbury earthquakes.

A TECHNICAL GUIDANCE

B TECHNICAL INFORMATION

C TECHNICAL CATEGORY 3

D SUBDIVISIONS

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