Determination 2014/011

Regarding the refusal to accept a proposed alternative method for assessing site subsoil classes to establish Building Code compliance at 181-185 Victoria Street, Wellington

1. The matter to be determined

1.1 This is a determination under Part 3 of the Building Act 2004[1] ('the Act') made under due authorisation by me, John Gardiner, Manager Determinations and Assurance, Ministry of Business, Innovation and Employment ('the Ministry'), for and on behalf of the Chief Executive of the Ministry.

1.2 The parties to this determination are

- Body Corporate 88863, comprising the owners of 54 apartments at 181-185 Victoria Street, Wellington ("the applicants"), acting through an agent
- Wellington City Council, carrying out its duties and functions as a territorial authority ("the authority").

1.3 I have included GNS Science as a person with an interest in the matter.

1.4 The application for determination arises from the applicants' plan to carry out earthquake strengthening on their existing building. In initial discussions with the authority, they proposed using a new method for interpolating between the site subsoil classes described in NZS 1170.5:2004[2] as part of their means of establishing compliance with the Building Code. However, the authority advised that it would not accept this method as a proposed alternative solution[3].

1.5 I consider the matter to be determined[4] is the exercise of the authority's power of decision in respect of a proposed building consent.

1.6 In making my decision I have considered the submissions by the parties, the report of the independent expert commissioned by the Ministry to advise on this dispute ("the expert") and the other evidence in this matter.

1.7 The relevant verification method and standards are described in Appendix B.

[1] The Building Act, Building Code, Compliance Documents, past determinations and guidance documents issued by the Ministry are all available at www.dbh.govt.nz or by contacting the Ministry on 0800 242 243.
[2] NZS 1170.5:2004 Structural design actions – Part 5: Earthquake actions – New Zealand. The Verification Method B1/VM1 cites NZS 1170.5:2004 as a means of complying with Building Code Clause B1 Structure.
[3] An alternative solution is a design (of all or part of a building) that complies with one or more requirements of the Building Code, but does not follow the solutions provided by the Compliance Documents
[4] Under sections 177(1)(b) and 177(2)(a) of the Act

2. The existing building and its site

2.1 The apartments belonging to the applicants are in a ten storey building on the corner of Victoria and Ghuznee Streets. The building has retail units on the ground floor, some office space on level 1, parking on levels 1 to 4, and the apartments on level 5 and above.

2.2 The building was originally constructed in about 1970 and is founded on reinforced concrete piles. According to reports prepared for the applicants by a firm of engineering consultants ("the engineering consultants") in 2011 and 2012, it is located about 350m southwest of the original Wellington foreshore (540m southwest of the current Wellington foreshore).

2.3 In these reports, the engineering consultants said that bedrock at the site was estimated to be about 50m deep and likely to be overlain with alluvium variably composed of weathered gravel and sand deposits with silt layers. The firm also noted that the Wellington fault[5] was about 1.6km to the northwest.

3. Submissions

3.1 On 15 August 2013 I received an application for determination that included copies of:

- a report to the applicant from the engineering consultants, 'Seismic Subsoil Class Review'(12 January 2011), assessing the subsoil class at the site
- a further report from the engineering consultants, "Desk Top Geotechnical Seismic Assessment (20 April 2012), prepared to allow a structural engineer to conduct an initial assessment of the building's seismic stability
- an April 2011 conference paper by a principal scientist of GNS Science's Hazards Group[6] ("the McVerry paper") proposing an alternative method for assessing site subsoil classes that involves interpolating between these classes
- the authority's email of 21 June 2013 to the agent for the applicant advising that it would not accept the method proposed in the McVerry paper as an alternative solution for complying with the Building Code.

3.2 Each of these items is described further below. The authority did not make a submission in response to the application and neither the authority nor the applicant requested a hearing.

3.3 The engineering consultants' January 2011 report said the site period was uncertain because of the uncertainty in the depth to rock. The firm's assessment was that it was likely to be 0.5s to 0.75s and could not be reliably concluded to be less than 0.6s. Therefore, the engineering consultants recommended assuming a subsoil class of D[7] based on the information that was currently available.

3.4 The engineering consultants also noted that NZS 1170.5 defined subsoil class as a step function, with a step at the site period of 0.6s between Class C and Class D. It said research was in progress to consider the possibility of a linear or other alternative function but the conclusions of this were some way off.

[5] This fault is included in Table 3.6 of NZS1160.5:2004 as a major fault requiring near fault factors when assessing structural design actions.
[6] 'Site-effect terms as continuous functions of site period and Vs30', GH McVerry of GNS Science, Proceedings of the Ninth Pacific Conference on Earthquake Engineering, April 2011, Auckland, New Zealand.
[7] Class D deep or soft soil site >0.6s, as defined in NZS 1170.5: 2004

3.5 The engineering consultants' April 2012 report noted that this research was now complete and referenced the McVerry paper. It said:

> The option is now available to assess the site response on the basis of a period of 0.75s (upper end of expected period). Confirmation of [the authority's] acceptance of this as an alternative solution should be sought.

3.6 The McVerry paper was presented at the 2011 conference of the New Zealand Society for Earthquake Engineers Inc. and is discussed further in Appendix A (the expert's report). This paper proposed replacing the spectral shape factors currently in NZS 1170.5 with new site-effect terms that were a continuous function of site period over the range 0.25s to 1.5s. The paper said this would potentially eliminate the large 'jump' in structural design requirements for buildings on the boundary between Class C (shallow soil) and Class D (deep or soft soil).

3.7 The authority's email of 21 June 2013 followed discussions with the applicants' agent regarding proposed earthquake strengthening work for the building and use of the method proposed in the McVerry paper. The authority said:

> … from the information you have provided the site response would need to be based on site subsoil Class D. However, this classification can be countered if you provide information from a qualified geotechnical engineer who can justify to Council a lesser soil classification, if they determine that this is warranted.
>
> [The authority] will not accept interpolation between subsoil class C and D as an alternative solution.

3.8 Further material from the applicant

3.8.1 On 1 November 2013, the agent for the applicant sent me a copy of a further report by the engineering consultants, 'Investigation of Seismic Sub Soil Class' (25 September 2013), with the comment:

> It is noted C boundary .60s – we at .64s – narrowly drop to D.
> The interpolation for our particular site could therefore be suitably applied.

3.8.2 This report, prepared after drilling a 52m deep borehole and conducting standard penetration tests, concluded:

> A natural period of the site has been calculated based on 50m to rock and shear wave velocities estimated from correlation with SPT. This assessed period is greater than 0.6 seconds implying subsoil class D.
>
> A natural period of the site of 0.64 seconds has been calculated based on 50m to rock and shear wave velocities estimated from correlation with SPT.
>
> Based on the above assessment, the seismic subsoil category is considered to be 'Class D – Deep Soil' for the site in accordance with NZS 1170.5:2004 Section 3.1.3.

3.8.3 It is my view that even though a classification of Class D has been confirmed for the site subsoil, the matter remains determinable.

3.9 A draft determination was issued to the parties and GNS for comment on 12 December 2013.

3.10 The authority accepted the draft without further comment in a response received on 10 February 2014.

3.11 A letter from GNS, received on 10 February 2014, stated that GNS does not agree with the recommendation in the expert's report that the method should not be accepted as an alternative solution. GNS also noted that it was in discussions with the Ministry with a view to setting up a working group to address the use of elastic site hazard spectra based on site period as an alternative to the site-class spectra of NZS 1170.5.

3.12 The applicants responded by email on 14 February 2014, noting that as the site was placed just outside the .60s at .64s, the applicants maintained the view that interpolation 'should be allowed'.

4. The expert's report

4.1 General

4.1.1 As stated in paragraph 1.6, I commissioned an independent expert who is a Charted Professional Engineer with expertise in geotechnical engineering to review the McVerry paper and to provide advice on whether the proposed method could be used to establish compliance with the Building Code.

4.1.2 I received the expert's final report on 31 October 2013 and sent copies to the parties and GNS Science on 1 November 2013. The expert's report is discussed in more detail in Appendix A.

4.1.3 In summary, the expert considers that the method proposed in the McVerry paper is rational and could eliminate some of the large 'steps' the current method creates between different site soil classes – and the corresponding jumps in structural design requirements.

4.1.4 However, the expert does not recommend adopting it as an alternative solution for establishing compliance with the Building Code at present, because he considers that:

- the analysis is mostly based on estimates rather than actual measurements of site period
- it ignores other site specific factors and may cause its own anomalies
- it should not be adopted without a more comprehensive review of the seismic hazard spectra and procedures in NZS1170.

4.2 Responses to the expert's report

4.2.1 On 19 November I received a response to the expert's report from GNS Science, which I circulated to the parties.

4.2.2 The response from GNS Science

- disagreed with the expert's view that the proposed method of interpolating elastic site spectra for horizontal loading between site subsoil Class C and Class D should not be accepted as an alternative to NZS 1170.5, and did not agree its implementation should be deferred until after a thorough review of the hazard spectra and other site effect issues
- said that 'this confused issues that relate as much to the determination of the NZS1170.5 spectra as to the proposed alternative solution'

- said the proposed alternative method related to spectra for sites just within subsoil Class D near the boundary with Class C and that discussion of buildings falling within Class C was irrelevant, as was the expert's comment about the exclusion of Class E sites
- agreed it was preferable that implementing this method was based on site-specific measurements or taken from 'carefully prepared maps' rather than on rough estimates of site period.

4.2.3 The agent responded to the expert's report and to GNS Science's reply in a letter dated 19 November. The agent also attached an updated version of the engineering consultants' 25 September 2013 report (dated 18 November 2013). The agent submitted that

- the expert's report noted that the changes only applied for buildings with site periods greater than 0.25s to 0.7s
- the GNS Science response pointed out that site period estimates usually had uncertainties of at least +/- 0.05s and referred to site periods of 0.55s and 0.65s in NZS1170
- both documents referred to specific site measurements rather than estimates
- the updated report of the engineering consultants 'clearly defines our specific site measurement as 0.64s'

4.2.4 The agent concluded by asking that interpolation (the proposed method) be allowed 'as our site has specific measurement that is inside the criteria of both expert reports'.

5. Discussion

5.1 In considering whether or not the authority correctly refused to exercise its powers in respect of the proposed building consent, I have considered its process in terms of whether this was carried out in accordance with the requirements of the Act.

5.2 In particular, I have considered the information available to the authority at the time it made its decision. As already noted, this included the applicants' proposal to use the method outlined in the McVerry paper for assessing site subsoil.

5.3 However, I have assumed that the information did not include the results of any actual subsoil tests at the property as

- the authority said in its 21 June 2013 email to the applicant that it …encourage[d] you to invest in providing specific subsoil calculations, by a geotechnical engineer, with your consent application, and
- the first reference to site testing results I have seen is in the engineering consultants report dated 25 September 2013 (described in paragraph 3.8), which is three months after the authority's response.

5.4 I have carefully considered the expert advice provided to me and have accepted that the proposed method appears to have some merit. I also note the challenges facing building owners in carrying out earthquake strengthening on existing buildings given that the seismic actions standard NZS1170.5 is primarily aimed at establishing strength and serviceability standards for new buildings.

However, I conclude that given the wider implications of adopting lower seismic strengthening requirements for some buildings based solely on the method proposed

in the McVerry paper and without a wider review, and the current lack of site-specific data which is clearly acknowledged in this paper, I consider it was reasonable for the authority not to accept this as part of a proposed alternative solution until – at the very least – it can be applied using more accurate data.

5.5 Therefore, it is my view that the authority correctly refused to consider the proposed method as an alternative solution.

6. The decision

6.1 In accordance with section 188 of the Act, I hereby determine that the authority correctly exercised its powers in respect of the proposed building consent. Accordingly, I confirm the authority's decision to refuse to consider the proposed building consent application.

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 17 February 2014.

John Gardiner
Manager Determinations and Assurance

Appendix A: the expert's report

A.1 This Appendix provides more detail from the expert's report supplied to me on 31 October 2013 and discussed in paragraph 4.1.

The proposed method

A.2 The expert's report notes that NZS 1170.5:2004 gives the procedures and criteria for establishing the earthquake actions to be used in the limit state design of most buildings (including the applicants' building) in New Zealand. The elastic site spectra for horizontal loading is specified as a function of location, return period, proximity to major faults, and the site subsoil characteristics (site subsoil class).

A.3 The expert notes that:

- The site subsoil class has a large effect on the site spectrum for horizontal loading, especially for buildings with periods greater than 0.6s for which the increase from Class C (shallow soil) to Class D (deep soil) is 63%.
- This large "step" increase in design loading is seen as problematic, especially in Wellington where the Class C/D boundary (set in NZS 1170.5 as being at a site period, T_{site} = 0.6 s) traverses the central business district.
- There are difficulties in assessing the site period accurately, so design loads near a class boundary may vary by 63% depending on assumptions made about subsoil conditions.

A.3 The expert says the new method proposed in the McVerry paper (as illustrated in a graph of proposed spectral shape factors, modified from NZS 1170.5 by equations also supplied) allows interpolation between the Class C and Class D spectra based on the site period and eliminating the 63% 'step' at the boundary between those two classes.

Discussion

A.4 The expert says that the greatest change in seismic design coefficient would be for sites at or very close to the present Class C/D boundary (T_{site} = 0.61s).

The expert gave the following examples of its application:

- Tsite = 0.25s (presently Class C) nil change
- Tsite = 0.60s (presently Class C) increase of 18%
- Tsite = 0.61s (presently Class D) reduction of 28%
- Tsite = 1.50s (presently Class D) nil change
- Tsite = 2.00s (presently Class D) increase of 16%

A.5 He notes that these changes only apply to buildings with periods greater than 0.25s to 0.7s. For shorter period structures, the coefficients would not change (other than a slight increase for the maximum coefficient for short period structures in Class C from 2.93 to 3.00).

A.6 In other words, sites falling just into Class D are, arguably, being over-designed by up to 28% at present, but those falling just into Class C are similarly being under-designed by 18%, assuming that the analysis in the McVerry paper was correct.

A.7 The expert stated that while this method may smooth out the assignment of seismic design coefficient and remove the 63% 'step' between Classes C and D, its acceptance would effectively increase the seismic design coefficient for Class C sites by up to 18% while simultaneously reducing the coefficient for many Class D sites by up to 28%.

> Such significant changes to seismic design in New Zealand should only be undertaken after a more thorough overhaul of the seismic design procedures in NZS 1170.5-2004. Many other anomalies were identified as a result of the Canterbury earthquake sequence including amplification effects near to the site period (i.e. a "bump" in the spectra near the site period) and amplification effects where the relatively soft soils of the Springston formation overly the stiff Canterbury outwash gravels underneath Christchurch City. Significant topographic amplification was observed to affect sites in the Port Hills.
>
> A panel of international experts was assembled after the Canterbury earthquakes in a process of "expert elicitation" to review the on-going seismic hazard in Canterbury. These international experts identified a number of significant issues with the existing models and procedures used to calculate the spectra in NZS 1170.5-2004 and which form the basis of the analysis of McVerry [2011].
>
> Until these and other issues are resolved, preferably within the framework of a complete review of the hazard spectra in NZS 1170.5-2004, including international peer review, then it would be inappropriate to permit such a significant reduction in the seismic design coefficient for many Class D sites.

A.8 A significant conclusion of the McVerry paper is that site period is the best predictor of site response in New Zealand rather than Vs30, or average shear wave velocity over the upper 30 m, as used in the USA. However, the expert commented that:

- A 'significant weakness' of the analysis is that it is mostly based on estimates rather than measurements of site period.
- The proposed method does not consider Class E (very soft soil) sites. There is a 'jump' of up to 56% at the Class D/Class E boundary for building periods greater than 0.6s, which is nearly as significant as the 'jump' at the Class C/D boundary.
- Interpolating between soil classes is a rational concept and could potentially improve the current procedure by eliminating the large 'steps' at the soil class boundaries. However, any interpolation method should be fully integrated with a thorough revision of the hazard spectra and should take account of other site effects currently being ignored.

Conclusions and recommendations

A.9 The expert recommended that the method proposed in the McVerry paper should not currently be accepted as an alternative to NZS 1170.5, saying that:

> The consequences of accepting this alternative would be a substantial change to the seismic design coefficient of many buildings, both up and down. Such large changes should not be adopted without a more comprehensive review of the seismic hazard spectra and procedures in NZS 1170.5-2004.

Appendix B: The legislation

B.1 The relevant verification method and associated standards are B1/VM1 and the AS/NZS 1170 suite of structural design actions standards. Extracts from these are included below.

Verification Method B1/VM1

1.0 General
1.0.1
The Standards cited in this Verification Method provide a means for the design of structures to meet the performance requirements of New Zealand Building Code Clause B1 Structure. For any particular building or building design, the Verification Method shall consist of AS/NZS 1170 used in conjunction with the relevant cited material standards as modified by this Verification Method .

2.0 Structural Design Actions Standards
2.1
The requirements of the AS/NZS 1170 suite of Standards are to be complied with. These comprise:
AS/NZS 1170.0: 2002 including Amendments 1, 2 and 4,
AS/NZS 1170.1: 2002 including Amendment 1,
AS/NZS 1170.2: 2002 including Amendment 1,
AS/NZS 1170.3: 2003 including Amendment 1,
and NZS 1170.5: 2004.

COMMENT
This suite of Standards, together with their amendments, are referred to collectively in this Verification Method as "AS/NZS 1170".

2.2
The requirements of AS/NZS 1170 are subject to the following modifications…..

NZS 1170.5:2004 Structural design actions - Part 5: Earthquake actions - New Zealand

3.1 3 Site subsoil class: The site subsoil class shall be determined as being one of classes A to E from Clauses 3.1.3.2 to 3.1.3.6.