Department of Building and Housing
Te Tari Kaupapa Whare

Determination 2010/64

Refusal to issue a building consent for an addition to a house with straw bale walls at 35 Loach Road, Wanaka

1. The matter to be determined

1.1 This is a determination under Part 3 Subpart 1 of the Building Act 2004[1] ("the Act") made under due authorisation by me, John Gardiner, Manager Determinations, Department of Building and Housing ("the Department"), for and on behalf of the Chief Executive of that Department. The applicants are the owners, S Henry and A Law ("the applicants"), acting via the design company for the building work ("the designers"), and the other party is the Queenstown Lakes District Council ("the authority"), carrying out its duties as a territorial authority or building consent authority.

1.2 This determination arises from a decision by the authority to refuse to grant a building consent for an addition to a house because it was not satisfied that the straw bale walls proposed for the addition would comply with certain clauses of the Building Code[1] (Schedule 1, Building Regulations 1992). The authority's concerns are in regard to the wall system itself and weathertightness detailing to be used in conjunction with the wall system.

1.3 The matter to be determined[2] is therefore whether the authority's decision to refuse to issue a building consent is correct, in respect of the proposed straw bale walls. In deciding this matter, I must consider:

1.3.1 Matter 1: Weathertightness of the straw bale wall system

Whether the plastered straw bale wall system proposed for the walls of this addition ("the wall system"), will comply with Clause B2 Durability and Clause E2 External Moisture of the Building Code. By "the plastered straw bale wall system" I mean the components of the system (such as the straw bales, the plaster, the timber frames, the windows, the junctions and the flashings) as well as the way the components have been installed and work together. (I address this issue in paragraph 7).

[1] The Building Act 2004 and the Building Code are available from the Department's website at www.dbh.govt.nz.
[2] Under sections 177(a) and 177(b)(i) of the Act

1.3.2 Matter 2: The additional durability considerations

Taking into account the weathertightness of the wall system as assessed within Matter 1, whether the plastered straw bale wall system is able to comply with clause B2 of the Building Code, considering the special risks and durability considerations that apply to the particular type of construction used in this addition. (I address this issue in paragraph 8).

1.4 Based on the information available to me, the authority's concerns are about the straw bale wall system in regard to its compliance with Clauses B2 Durability and E2 External Moisture of the Building Code. I have received no evidence relating to a dispute about other matters related to this proposed building, and this determination is therefore limited to the abovementioned straw bale wall system.

1.5 In making my decision, I have considered:

- the submission by the designers on behalf of the applicants, including the original drawings, specification and maintenance schedule
- the report of an independent specialist experienced in straw bale building construction commissioned by the Department to advise on this dispute ("the specialist")
- the revised drawings (dated 15 March 2010) and information submitted by the designers in response to the specialist's report (see paragraph 4.2)
- the revised drawings (dated 11 May 2010) submitted by the designers in response to the draft determination (see paragraph 4.4.1)
- the other evidence in this matter.

I have evaluated this information using a framework that I describe more fully in paragraph 7.1.

2. The building work

2.1 The proposed building work consists of a single-storey addition to a 16-year-old detached house situated on a flat rural site, which is in a high wind zone for the purposes of NZS 3604[3]. The designers have stated that the wind zone is moderated by the existing house and other outbuildings, established trees to the north and south, and a hill to the south.

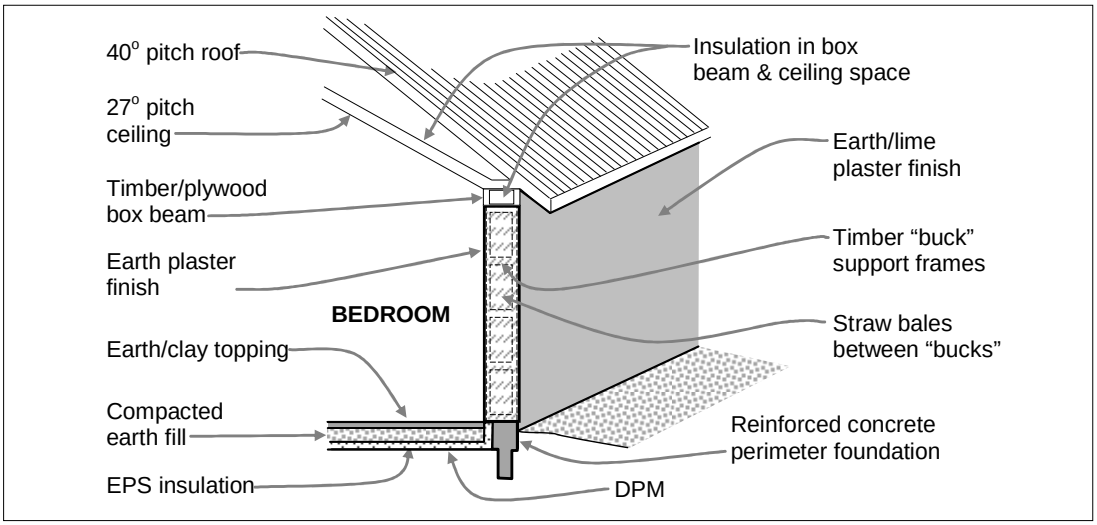
2.2 Based on the engineering details, the existing house has reinforced concrete foundations and floor slab, with what appears to be a specifically engineered reinforced concrete column and bond beam structure. The plastered rammed earth walls appear to form infills to the concrete structure.

2.3 The addition is specifically engineered, with straw bale exterior walls and timber framed interior walls; and links to the south wall of the existing house to provide a master bedroom, walk-through closet, hall and ensuite bathroom. The simple 10.5m x 6m rectangular addition is assessed as having a low weathertightness risk.

[3] New Zealand Standard NZS 3604:1999 Timber Framed Buildings

2.4 General construction

2.4.1 The general construction of the addition is shown in the following sketch:



2.4.2 The perimeter walls and interior load-bearing walls have reinforced concrete foundations, with a tiled concrete slab to the ensuite bathroom and 'earth floors' to the other floors. The hardfill, 100mm polystyrene insulation and damp proof membrane ("DPM") used beneath the concrete slab extends at a depth of 225mm under the earth floor system, which comprises 200mm compacted earth fill and a 30mm clay/earth mix topping layer finished with linseed oil and wax. The compacted earth fill includes embedded water pipes to provide underfloor heating.

2.4.3 Although the addition is one-storey high, the 40° pitch gabled roof results in two gable end walls that are effectively two-storeys high at the ridge. The corrugated steel roof has eaves that vary between about 600mm and 800mm (including gutter widths), with verges of about 650mm. The ceiling over the bedroom slopes at 27°, creating an insulated ceiling space above.

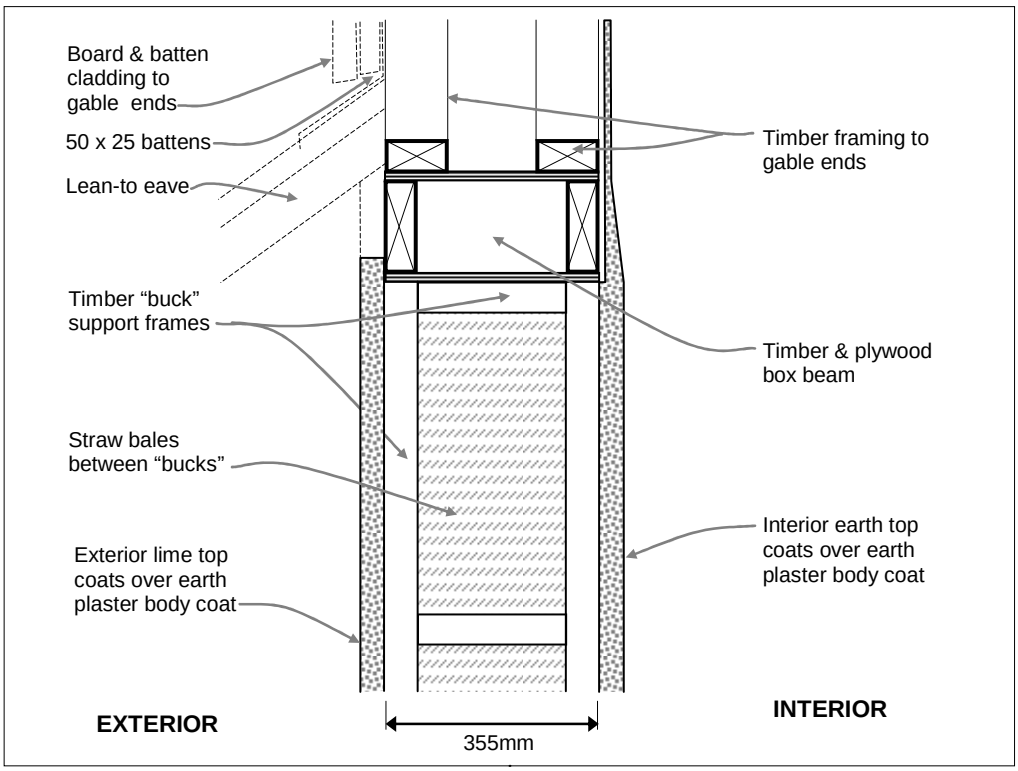
2.5 The exterior walls

2.5.1 The exterior walls are made up of timber frames ("bucks"), with steel cross bracing and a timber box beam to the top. The structure is in-filled with non-loadbearing straw bales to form mass walls more than 400mm thick, which have solid plaster applied to both sides. The specification for the straw bale walls and this determination refer to the set of standards for earth buildings[4] ("the earth standards").

2.5.2 The specification calls for compliance with NZS 3602[5] in regard to timber to the support frames and box beam structure in the exterior wall system and the drawings specify 'H1.2 or larch', which is the minimum required in that standard.

[4] NZS 4297:1998 Engineering design of earth buildings, NZS 4298:1998 Materials and workmanship for earth buildings and NZS 4299:1998 Earth buildings not requiring specific design
[5] NZS 3602:2003 Timber and wood-based products for use in building

2.5.3 The following sketch (not to scale) is based on the revised drawings dated 11 May 2010, and shows the general construction of the gable end walls:



2.5.4 The wall structure is based on 100mm x 50mm timber frames ("bucks") positioned at corners and openings, with a timber and plywood box beam supporting proprietary timber roof trusses. The straw bale infill walls are formed from 900mm x 455mm x 355mm straw bales tightly stacked on edge between the bucks and box beam, with moisture sensors installed within the bales at eight at-risk locations.

2.5.5 The straw bale walls are finished on both sides with a multi-coat plaster system that is about 40mm thick overall, with a 'body coat' of earth (clay), sand and chopped straw and two coats of fibre-reinforced lime plaster applied to all exterior walls and also to the interior bathroom wall surfaces. The remaining interior wall surfaces have earth plaster coats in lieu of the lime plaster. The plaster systems are vapour permeable, with a lime wash finish.

2.5.6 The end walls of the gable roof are timber framed to form double walls in line with the box beam below. Horizontal 50mm x 25mm H1.2 timber battens 'set at slight angle' are fixed through the building wrap to the outer wall frame. Timber boards and battens incorporate aligned weathergrooves and are fixed through the battens to the outer wall framing.

3. Background

3.1 The designers lodged an application for a building consent for the building work on behalf of the applicant (No. 090618).

3.2 In a letter to the designers dated 19 August 2009, the authority stated that a code compliance certificate is issued 'against the approved plans and specifications', so

these 'must clearly reflect compliance with the NZ Building Code'. The authority noted it had assessed the submitted plans and specifications and had suspended the application until it has received 'additional details and/or amendments to ensure compliance is properly demonstrated'. The authority listed 14 items, which included the following:

> 13 The alternative solution for the straw bale construction has no evidence to support the required durability of 50 years. Commonly the eaves are at a ratio of 1: 2 of the height. This is a ratio determined to be appropriate for [some] earth buildings within the scope of NZS 4298. There is little or no eave protection of the straw bale at the gable ends.
>
> 14 Because of the inability to accurately predict the durability of a number of materials and systems in this building design, a way forward may be to amend the building consent to give a limited specified life of 15 years. I refer you to DBH Determination 2006/98 paragraph 6.7. While the determination is binding on the subject building only, the methodology applied... ...appears sound.

3.3 The designers' response to the authority

3.3.1 The designers responded to the above on 10 September 2009, providing additional information and noting various revisions made to the drawings. In regard to Item 1, the applicant attached a revised specification for the straw bales and the plastering.

3.3.2 In regard to Items 13 and 14, the designers attached additional information about straw bale construction and included the following explanations:

> Straw bale structures have been in use for over 100 years internationally. ...All eave protection proposed in this application complies with NZS 4298:1998... (Item 13)
>
> The straw bales (non structural) are protected from moisture under a roof with eaves compliant with NZS 4298:1998 [refer footnote 4], are raised off the ground on a foundation/DPC compliant with E2/AS1 and are fully encapsulated in a plaster system which complies with NZS 4298:1998 and has been in use for as long as buildings have been constructed in New Zealand. This straw bale wall system has been in use for over 100 years internationally.
>
> The reference to Determination 2006/98 is out of context as the issue with the [subject building] is that the plaster system was sealed with a waterproof paint which would dramatically reduce the wall systems ability to dry.

3.3.3 The designers referred to the requirements of Clause E2 to prevent moisture accumulation or transfer, noting:

> The basis of a system, which is durable, is its ability to manage moisture. Thus a wall system must have the ability to release any moisture which will, at some point during the life of a building, find its way in. Clay plaster in direct contact with straw has the greatest ability to dry a wall system of any plaster available.

3.4 The engineer's response to the authority

3.4.1 The design engineer for the building work ("the engineer") also responded in a report to the authority dated 10 September 2009. The engineer focussed on the durability and weathertightness of the straw bale wall system, noting that the addition had a low weathertightness risk.

3.4.2 The engineer described the vapour permeable plaster system and its benefits to the weathertightness of the walls, referring to international standards and tests and noting that the installed moisture sensors allow any problem to be detected and remedied before any long term damage can occur. The engineer also referred to past determinations on straw bale houses, noting that these had not suggested 'that a plastered straw bale system would not meet the requirements of E2 if correctly installed and maintained'.

3.4.3 In regard to durability, the engineer noted that this mainly relied on the exterior plaster system protecting the straw bales, noting that the proposed plaster system complied with the earth standards which provide 'design, specification and testing requirements to ensure material performance is maintained within specified limits'.

3.4.4 The engineer also noted that the earth standards set a durability requirement of 50 years for earth walls providing structural stability, while B2/AS1 only required 15 years for the exterior plaster, which would be exceeded by the proposed system. The engineer also noted that a specified maintenance schedule is included as an appendix to the specification for the addition.

3.5 The authority's response

3.5.1 In a letter to the designers dated 23 October 2009, the authority refused the building consent application and stated:

> The reason for the refusal is that [the authority] is not satisfied that the performance requirements of B2 Durability and E2 External Moisture will be met if the work is carried out as per the building consent documents as they are presented.

3.5.2 The authority did not consider it had sufficient information to establish that the straw bale wall system would meet the 50-year life intended for the building, noting that:

> Because the external cladding [the plaster system] is an integral part of the insulation and structural system of the building, it is required to perform with 'only normal maintenance' for the same durability period as the insulation and structure (50 years).

3.5.3 The authority repeated its earlier proposal that amending the building consent application to a limited specified life of 15 years would allow the application to continue through the approval process, adding:

> This would mean that on or before the end of 15 years, you would be required to apply to alter, demolish or remove building in accordance with Section 113 of the Building Act.

(I note that the authority did not explain that, towards the end of that period, the owner may apply for an 'extension of life' under Section 116. See paragraph 8.5).

3.6 The Department received an application for a determination from the designers on behalf of the applicants on 5 February 2010.

4. The submissions

4.1 The designers forwarded copies of:

- the drawings and specifications
- the engineer's calculations and producer statement - design
- the engineer's report dated 10 September 2009
- a list of straw bale houses with consents issued since 2003
- the correspondence with the authority
- various other statements and information about straw bale systems.

4.2 Follow receipt of the specialist's report and the first draft determination, the designers forwarded copies of:

- revised drawings dated 15 March 2010
- revised earthen floor and plaster specifications
- revised drawings dated 11 May 2010.

4.3 A draft determination was issued to the parties for comment on 9 April 2010.

4.4 The parties' responses to the draft

4.4.1 The designers responded to the draft determination in a letter received on 11 May 2010, attaching two revised drawings dated 11 May 2010. The letter and drawings resolved some of the issues identified in the draft and I have amended the determination as I consider appropriate.

4.4.2 The designers did not accept any reduction to the specified intended life of the additions, repeating some of the information provided in earlier correspondence with the authority and including the following points (in summary):

- If the finding is that the additions do not meet a minimum life of 50 years 'many people will be turned away from this choice of material in the future'. A reason for straw bale construction to be uncommon is that obtaining a consent is 'costly and time consuming', with an unpredictable outcome.
- While the structure of the additions requires a 50-year durability, the straw bales should 'only need a durability period of not less than 15 years'.
- One justification given for a reduction in the life is concern about the reliability of the moisture sensors, which are very simple technology using durable materials that should be assumed to have a 50 year life.
- The other justification relates to maintenance by future owners, which can be catered for by attaching the maintenance requirements to the LIM. The straw bale system is no more complex to maintain than any plastered system.
- In 'almost all situations moisture in straw bales can exceed 15% for prolonged periods of time without mould growth'.

- The Department should engage further experts (several names of international experts were provided), as its decision is based on lack of knowledge with no technical basis for a specified life of 25 years 'beyond a general sense of caution'.

4.4.3 The authority responded to the first draft determination in a letter dated 18 May 2010. The authority generally accepted the decision but considered that it also needed to 'determine whether the strawbale construction system complies with the Building Code', concluding that 'the determination remains incomplete in terms of answering the application under sect 177(a) and would encourage further consideration'.

4.4.4 I am of the opinion that I have addressed and concluded on the general compliance of the system in paragraph 7.6.2 based on the evidence I have seen and collected. However, I consider it remains the authority's responsibility to assess in detail the final revised set of consent application documents.

4.4.5 The authority also included the following points (in summary):

- The authority is 'prepared to accept that we are not the experts in Strawbale Construction and how it performs' and is also not expected to be so. It is 'completely neutral to the concept of whether [straw bale construction is] to be used, encouraged or discouraged', as this is not its role.
- When a system falls outside the limits of acceptable solutions or appropriate appraisals, 'the onus is on the applicant to demonstrate how it will meet the performance requirements of the building code'.
- The authority has no funding base or mandate to investigate and research specific products or building systems'. There are other organisations that are able to independently test, verify and provide appraisals 'on a national basis'.
- The problem is that 'there are varying opinions and results out there for many different types of strawbale construction methods'
- The reason that the authority proposed a 15 year specified life for the additions was to link this to the required durability of the exterior plaster system.
- The durability of the moisture sensors is less critical than whether 'these types of sensor will provide accurate & useful readings – the reality is that this method is untested, and simply no-one knows.'

4.4.6 In a letter to the Department dated 21 May, the designers noted international expert research on monitoring moisture levels in straw bale walls and repeated their request for a report 'by an expert in this field' and for 'a positive determination with no shortened life' for the addition.

5. The code compliance of the wall system

5.1 The available evidence

5.1.1 In order for me to form a view as to code compliance of the straw bale wall system; I need to establish what evidence is available. In this case, the evidence includes:

- the technical information submitted by the applicant, which includes:
  - the detailed drawings and specifications for the addition
  - the engineer's specification, drawings and calculations for the wall system
  - various other tests and information
- the history of approval and/or use of comparable wall systems
- the specialist's report on the proposed wall system (see paragraph 6).

5.2 The history of use

5.2.1 With regard to joinery installation details within the exterior envelope, I consider that the weathertightness detailing shown in the drawings may be assessed on a similar basis to timber joinery installed within solid masonry walls.

5.2.2 However, while it is accepted that this type of straw bale wall system has been used in some other countries for many years, use in New Zealand is relatively recent and examples of older buildings are relatively rare. Compared to more common local systems, the ability to predict the performance of this particular wall system over an expected lifetime of 50 years or more is limited.

6. The specialist's report

6.1 I sought advice from an independent expert who has considerable experience with alternative construction methods including earth and straw bale construction. The specialist is the Chairman of the Standards Technical Committee for earth building and has been the primary author for BRANZ[6] on straw bale guidelines.

6.2 The specialist examined the original consent application documents and discussed various matters with the designers, who he described as 'experienced straw bale designers'. The specialist provided a report dated 3 March 2010, which was forwarded to the parties. The designers replied in a letter dated 15 March 2010, attaching revised drawings and specification sections in response to some of the specialist's comments. I have included the designers' revisions and responses to the specialists report as follows, in order to clarify the updated consent documentation.

6.3 The specialist was asked to consider:

- the straw bale wall details, including the plaster system
- the joinery details
- the level of protection afforded by the roof overhangs

[6] Building Research Association of New Zealand

- the junctions with the gable end cladding and with the existing walls
- the structural design, including the specified timbers.

6.4 The plaster systems

6.4.1 The specialist considered that the proposed lime plaster system would be satisfactory for exterior surfaces, as these systems are durable and have ideal vapour permeability, which suits the application over straw bales.

6.4.2 In response to the specialist noting some confusion about the inclusion of fibre in the plaster, the designers confirmed that the lime plaster system will incorporate fibres.

6.5 The straw bale walls

6.5.1 The specialist noted that the straw bales would be laid on edge rather than on the flat, so making them 'inherently more unstable' and he expressed concerns regarding:

- the ability to achieve a tight enough fit between the timber support bucks
- the lack of ties and connections to the adjacent structural bucks and beam
- taking the above into account, the ability of the proposed construction method to resist lateral loads from wind and earthquake.

6.5.2 In response, the designers revised the specification to clarify that:

- the method of achieving a 'very tight' fit of the bales within the structure will be by compressing the bales and forcing them, with mechanical assistance as necessary, beneath the box beam
- the top two courses of the walls (about 900mm) are to be tied to the bucks and to any bracing members
- netting will be fixed over the junctions of the bucks and box beam with the straw bales, with the netting fixed to the timbers and extending 200mm minimum over the bales onto plaster keyed against the straw.

6.5.3 In response to queries regarding the presence or otherwise of plumbing pipes and wiring in the walls, the designers confirmed that:

- there are no plumbing pipes in the straw bale walls of this addition and, if an exterior hose outlet is ever needed, the pipe would be 'sleeved'
- electrical wiring is to be run through chases in the skirtings, with conduit used up the walls where necessary
- power outlets will be mounted against the timber bucks or, if within the straw bale wall, the boxes will be completely sealed off with plaster.

6.6 The roof overhangs

6.6.1 The specialist considered the roof overhangs shown in the original drawings, noting:

- the eaves and verges shown in the floor plan, the elevations and the eave details appear to be only 400mm wide, excluding gutters and fascias

- deep roof overhangs limit the amount of rain that can reach the walls, so are the best defence against water penetration into the straw bale walls
- for this addition and high wind zone, the earth standards (which cover straw bale buildings) would normally recommend roof overhangs of about 1400mm
- while this particular local climate merits relaxation of the above requirement, the roof overhangs should not be less than the 600mm required for earth walls
- while moisture monitors will provide useful data, what is intended to happen if they indicate elevated moisture levels?

6.6.2 In response, the designers revised the drawings to clarify eaves dimensions, noting:

- the only eave less than 600mm is a short length at 590mm overall (including the gutter and fascia), which continues the eastern eaves of the existing house
- other eaves are 790mm overall, with verges to gable ends at 655mm
- local conditions and specific details must be taken into account when assessing the adequacy of the overhangs; and this site is very dry, with high winds moderated by buildings, trees and a hill to the south
- southerly rainfall is very rare, with the very small amount of rain coming from the northwest where the normally hot and dry prevailing winds rapidly dry out any moisture
- in more adverse climates than this, very few old straw bale structures would have the depth of roof overhangs promoted by the specialist
- within the maintenance schedule, the permanently installed moisture sensors are specified to be checked at least every three months or within one week of a major rain event
- the sensors will monitor long-term performance of the wall system and, should any leaks occur, detect these and allow repairs to be undertaken before damage to the straw bale system results.

6.7 The gable end walls

6.7.1 The specialist noted that:

- the gable end walls are particularly concerning, with regard to the verge projection and the junction of the upper cladding with the straw bale walls
- the verges are at a height of 5.4m at the ridge, so providing almost no protection to the straw bale walls
- the detail of the junction between the board and batten gable end cladding with the straw bale wall is not weatherproof and is likely to result in leaks
- the boards do not include weathergrooves.

6.7.2 In response, the designers revised the inter-cladding junction to show the battens behind the board and batten cladding increased in depth, with a projecting timber 'sill' at the base and a flashing extending over the top of the plaster. The boards are also now shown with weathergrooves aligning with those in the battens. (I note that

the revised details of 11 May 2010 have added a lean-to awning eave to the gable-end walls, making the earlier inter-cladding detail redundant).

6.8 The joinery details

6.8.1 The specialist noted that the joinery and flashing details generally appear adequate, providing sufficient rain deflection is provided. However, he also noted that:

- there is a lack of weathergrooves in some areas where they are required
- the sashes are not shown with double glazing, as required for this climate zone
- it is good practice to nominate a 50mm minimum projection for timber sills.

6.8.2 In response, the designers have revised the joinery details to show weathergrooves, double-glazed sashes and a 50mm sill projection.

6.9 The structural timber elements

6.9.1 The specialist noted that, while he was not qualified to review the work of the engineer, the proposed method of construction for the timber bucks and box beam structure appeared satisfactory in general terms, with appropriate specified timber treatment or species.

6.9.2 However, the specialist repeated his concerns regarding the effect of lateral forces as outlined in paragraph 6.5.1, with the applicant's response as per paragraph 6.5.2.

6.10 Insulation values

6.10.1 The specialist noted that the R-values used for the straw bale walls appeared to be consistent with his experience and information. However, the specialist had some concerns about the proposed earth floor, noting:

- compacting the earth floor over 100mm thick polystyrene could induce localised and unpredictable compaction in the polystyrene, and future cracking when the floor is in use could also result in localised compression
- embedded heating pipes carrying water within the earth floor could similarly be subject to unpredictable stresses, risking damage to the pipes.

6.10.2 In response, the designers revised the drawings and specification, noting:

- the S-grade EPS that was originally specified is used as a road base in New Zealand, and the engineer's calculations support the use of all grades of polystyrene as suitable for use under an earthen floor
- the local EPS manufacturer is not concerned about the concept of compacting the fill over the product
- a floor would have to be constructed poorly to result in the type of cracking described by the specialist
- unless there is severe damage to the floor surface, residential point loads are very unlikely to be transferred through 200mm of compacted fill in a manner that could damage the insulation

- although convinced that S-grade EPS would be adequate, the specification has been revised to H-grade EPS minimum as an additional precaution
- the heating pipes are shown surrounded with a protective layer of sand, which places them at less risk of damage than if they were within a concrete slab and, in the unlikely event of damage, repairs will be easier than for concrete.

6.11 The junctions with existing walls

6.11.1 The specialist could see no particular problem regarding the proposed straw bale walls butting against the existing rammed earth walls, although he noted that no detail of the junction had been provided.

6.11.2 In response, the designers have provided a detail for the junction in the revised drawings. This detail shows timber framing and a timber buck at the junction, with the framing fixed to the existing concrete bond beam and the netting connection taken over the rammed earth wall by a minimum of 200mm.

Matter 1: Weathertightness of the straw bale wall system

7. Weathertightness

7.1 The evaluation of building work for compliance with the Building Code and the risk factors considered in regards to weathertightness have been described in numerous previous determinations (for example, Determination 2004/1).

7.2 Weathertightness risk

7.2.1 This addition has the following environmental and design features which influence its weathertightness risk profile:

Increasing risk

- the addition is in a high wind zone, although moderated by local shelter
- the addition has plastered straw bale exterior walls, with board and batten cladding to gable ends
- although the addition is single-storey, the ridge height is 2-storeys high

Decreasing risk

- the addition is in an area with very low annual rainfall and relative humidity
- eaves and verges are about 800mm to shelter the cladding
- the single-storey addition is simple in plan and form (and I note is about 15% of the finished house floor area)
- the timber buck frames and box beam structure is to be treated to a level that provides some (although not high) resistance to decay if it absorbs and retains moisture.

7.2.2 When evaluated using the E2/AS1 risk matrix, these features show that the elevations of the addition demonstrate a low weathertightness risk rating. The risk assessment is

used at the time of application for consent, before the building work has begun and, consequently, before any assessment of the quality of the building work can be made.

7.2.3 I also note that the straw bale walls incorporate moisture sensors to monitor moisture levels. Although these do not protect against moisture penetration, they can reduce its consequences by alerting an owner to the need for repairs.

7.3 The roof overhangs

7.3.1 I note the specialist's primary concern about the weathertightness of the proposed straw bale walls related to the lack of protection afforded by roof overhangs. The designers have since clarified the proposed eaves, and the eaves in the revised drawings now generally accord with the specialist's recommendations for the minimum acceptable eaves in the particularly dry climatic conditions of this site (see paragraph 6.6.1).

7.3.2 The drawings considered by the specialist and during the preparation of the first draft determination showed little protection to the lower walls due to the height of the gables (see paragraph 6.7.1); and I concluded that additional protection was needed for those areas. In response to the draft determination the designers revised the gable ends to incorporate a lean-to 'canopy eave' at the inter-cladding junction, which provides the same shelter to the straw bale cladding as the other eaves.

7.4 The weathertightness of the walls

7.4.1 Taking into account the specialist's report and the designers' responses, including the revised drawings and specifications, there were several remaining areas where I considered that some details were unclear or not sufficient to ensure weathertightness and these areas were identified in the draft determination.

7.4.2 In response to the draft determination, the designers submitted revised details which appear to satisfactorily resolve those issues.

7.5 The existing house

7.5.1 I have seen little information regarding the general construction details and the current condition of the existing 16-year-old house, apart from several details for junctions between the proposed and existing construction. Although the roof to the proposed addition continues the existing roof design and material, I note that the existing house has a reinforced concrete structure and earth infill walls.

7.5.2 The proposed work includes junctions between new and existing construction; and I therefore also need to be satisfied that the existing house will, under section 112(1)(b) of the Act, 'continue to comply with the other provisions of the building code to at least the same extent as before the alteration'.

7.5.3 Taking into account the specialist's report and the designers' responses, including the revised drawings and specifications, I am satisfied that the proposed addition will have no significant influence on the compliance of the existing house in regard to its current structure, weathertightness and durability performance.

7.6 Weathertightness conclusion

7.6.1 When preparing the first draft determination, there were several remaining areas where I considered that some details were unclear or not sufficient to ensure the weathertightness and these were identified. In response to the draft, the designers submitted revised details which appear to satisfactorily resolve those issues.

7.6.2 Providing the authority is satisfied that the final revised set of drawings resolves the items noted in the first draft determination, I am satisfied that the straw bale wall system will be weathertight and durable when installed in accordance with the revised consent documents (see paragraph 9.1).

7.6.3 In this instance the weathertightness of the straw bale wall system itself will be dependent on the weathertightness risk features of the addition as a whole, the features that protect the walls from the weather, the application of the plaster systems, the weathertightness detailing, and the consequences and likelihood of failure on the building elements themselves. These features can be considered on their merits and independently of the straw bale walls as a structural system.

7.6.4 Taking account of information provided subsequent to the building consent application I consider that there is now sufficient information to provide reasonable grounds for the authority to complete its detailed assessment of code compliance once the revised documents are re-submitted to the authority (see paragraph 9.1).

7.6.5 It is emphasised that each determination is conducted on a case-by-case basis. Accordingly, the fact that a particular wall system has been established as being code compliant in a specific instance, does not of itself mean that the same system will be code compliant in other situations.

7.7 Maintaining weathertightness of the straw bale system

7.7.1 Effective maintenance of the external straw bale wall system, including the plaster system, is important to ensure ongoing compliance with Clauses B2 and E2 of the Building Code and is the responsibility of the building owner.

7.7.2 In the case of this addition, effective maintenance is also important to ensure compliance with Clause B2 insofar as it applies to Clause B1 Structure, because maintaining the plaster system over the straw bales is necessary to ensure that moisture does not reach damaging levels in the structural timbers within the walls.

7.7.3 I note that the specification for this proposed addition includes a maintenance schedule that covers the earth floor system and the straw bale wall system.

7.7.4 I address the particular durability requirements for this proposal in Matter 2 below.

Matter 2: The durability considerations

8. General discussion

8.1 The issues to be considered with regard to the durability of a straw bale house are:

- an appropriate durability period
- the applicable failure factors
- the maintenance required to achieve the durability period, and whether this is 'normal' maintenance for a straw bale house.

8.2 The wall structure of this addition uses timber buck frames and a timber box beam, and any failure in the straw bale infills should be detectable from monitoring the moisture levels of the bales and from signs of cracking in the plaster coatings. The straw bale infills would be moderately difficult to access and replace in this addition, so a durability period of not less than 15 years is considered appropriate.

8.3 The relevant failure factor for the straw bales is that moulds may grow if moisture levels exceed 15%. The designers have pointed to studies indicating that higher levels of moisture can be tolerated in straw without significant decomposition. However, those studies appear to be at an early stage and inconclusive as to a reliable safe limit for moisture levels. I therefore consider it prudent to adopt a conservative approach at this time, as this failure factor is likely to be more critical than the vulnerability to decay of the buck frames specified as H1.2 or larch.

8.4 This straw bale addition relies on the preservation of the exterior lime plaster coating as protection against moisture penetration into the wall of a level that would lead to endangering the underlying straw bales and/or the timber buck frames. It is therefore considered prudent to visually check the exterior plaster at least annually, in addition to checking after earthquakes, very strong winds or storms.

8.5 A specified intended life

8.5.1 This type of straw bale construction is still relatively new in New Zealand, and the performance-based Building Code allows for such alternative, innovative types of construction by providing for buildings to have a specified intended life, with certain conditions attached (refer to the Appendix). The assessment of a particular specified intended life will differ according to the particular type of construction and the design details that may increase or reduce relevant risks.

8.5.2 When considering the original consent documents, the authority proposed that this specified intended life should be limited to 15 years, referring to Section 113 of the Act. However, I note that the authority did not provide the reasons for choosing that period or explain that, towards the end of that period, the owner may apply for an 'extension of life' under Section 116 (see paragraph 3.5.3).

8.5.3 In the case of this addition, the designers have responded to concerns raised in the specialist's report and in the first draft determination; and have clarified and revised the drawings to reduce the weathertightness and durability risks of this type of

construction. I have considered the facts of this case, the environmental conditions and the revised design details. I am now satisfied that, subject to implementation of the specified maintenance plan, the addition will meet the durability requirements of the Building Code without a specified life.

9. What is to be done now?

9.1 I note that the drawings and specification have been revised several times since the original application. In order to avoid potential confusion and inconsistencies, it is important that a final set of revised drawings and specification (without any highlighting of past revisions) be prepared and re-submitted to the authority.

9.2 I therefore suggest that the designers should now modify the building consent application based on the final version of the revised drawings and specifications. Any further items of disagreement can be referred to the Chief Executive for a further binding determination.

10. The decision

10.1 In accordance with section 188 of the Act, I hereby determine that the authority's decision to refuse to issue the building consent was correct at the time of application, based on inadequate information to establish that the proposed weathertightness details would comply with Building Code Clauses B2 and E2.

Signed for and on behalf of the Chief Executive of the Department of Building and Housing on 23 August 2010.

John Gardiner
Manager Determinations

11. Appendix: The legislation

11.1 Specified intended life

11.1.1 The relevant section of the Act in regard to granting a specified intended life is:

113 Buildings with specified intended lives

(1) This section applies if a proposed building, or an existing building proposed to be altered, is intended to have a life of less than 50 years.

(2) A territorial authority may grant a building consent only if the consent is subject to—

(a) the condition that the building must be altered, removed, or demolished on or before the end of the specified intended life; and

(b) any other conditions that the territorial authority considers necessary.

(3) In subsection (2), **specified intended life**, in relation to a building, means the period of time, as stated in an application for a building consent or in the consent itself, for which the building is proposed to be used for its intended use.

11.2 Extending a specified intended life

11.2.1 The relevant section of the Act in regard to extending a specified intended life is:

116 Code compliance requirements: extension of life

(1) The owner of a building with a specified intended life must not extend its life without the written consent of the territorial authority.

(2) This subsection applies to a building with a specified intended life if—

(a) under section 113(2), a building consent for its building or alteration was issued subject to the condition that it must be altered on or before the end of the specified intended life; or...

(3) The territorial authority must not give its consent to the extension of the life of a building to which subsection (2) applies unless satisfied, on reasonable grounds, that the building—

(a) has been altered in accordance with the condition; and

(b) complies with section 112.