MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

Determination 2018/021

The refusal to issue a building consent for a house with membrane roofs at 25 Oceanbeach Road, Mount Maunganui, Tauranga

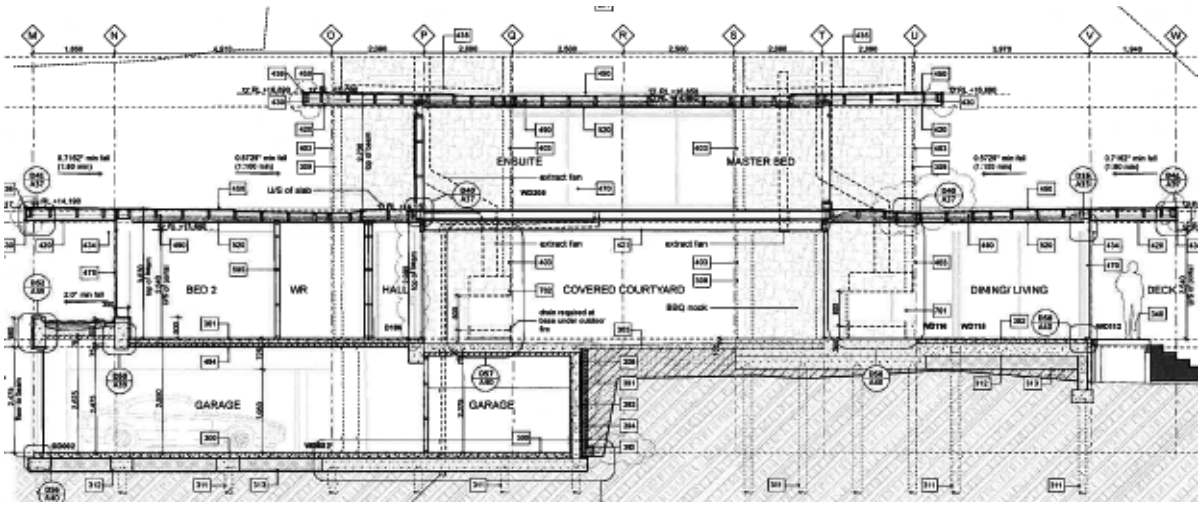


Figure 1: Section through length of house

Summary

This determination considers the compliance of low-pitched membrane roofs to a proposed three storey house. The roofs are inward-sloping and employ slopes less that the provided for in the Acceptable Solution for Clause E2 External moisture. The determination considers the construction of the roofs and the steps that should be taken to ensure that compliance is achieved.

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, Katie Gordon, 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 the determination

1.2.1 The parties to the determination are:

- the owner S Moyle ("the applicant") acting via the architect for the house ("the architect")
- the Tauranga City Council ("the authority"), carrying out its duties as a territorial authority or building consent authority.

[1] The Building Act, Building Code, compliance documents, past determinations and guidance documents issued by the Ministry are all available at www.building.govt.nz or by contacting the Ministry on 0800 242 243.

1.3 The application for this determination arises from the decision of the authority to refuse to issue a building consent. The refusal arose because the authority is not satisfied that building work complies with certain clauses[2] of the Building Code[3] (First Schedule, Building Regulations 1992).

1.4 The authority's concerns relate to the ability of the proposed roofs to shed water due to their low pitch. The matter to be determined[4] is therefore whether the TPO[5] membrane roofs to the house will satisfy Building Code Clause E2 External moisture.

1.5 In deciding this matter, I must consider whether the roof membrane system proposed for the roofs to the ground floor and level 1of the house ("the roof") comply with Clauses B2 Durability and E2 External moisture of the Building Code. By 'the roof membrane system' I mean the components of the system (such as the roof structure, the substrate material and the membrane) as well as the way the components are designed to work together.

1.6 The application for this determination is limited to the roofs of the building, and this determination does not consider other parts of the building or compliance with other clauses of the Building Code.

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

2. The building work

2.1 The proposed building work consists of a 2-storey detached house with a basement as shown in Figure 1. The house is situated on a long and narrow coastal site in a very high wind and sea spray zone for the purposes of NZS 3604[6]. The site is 'near level', with an excavated basement garage at the western end. The drawings take the garage doors as facing west and this determination follows that convention.

2.2 Construction is generally light timber frame, with specifically designed steel portals, concrete slabs, driven pile footings, and reinforced concrete block foundations and retaining walls. The house has vertical cedar shiplap weatherboards fixed over a cavity, aluminium joinery, a two-level membrane roof and two stone-clad reinforced concrete 'chimney' structures that also serve as ducts for downpipes.

2.3 The roofs

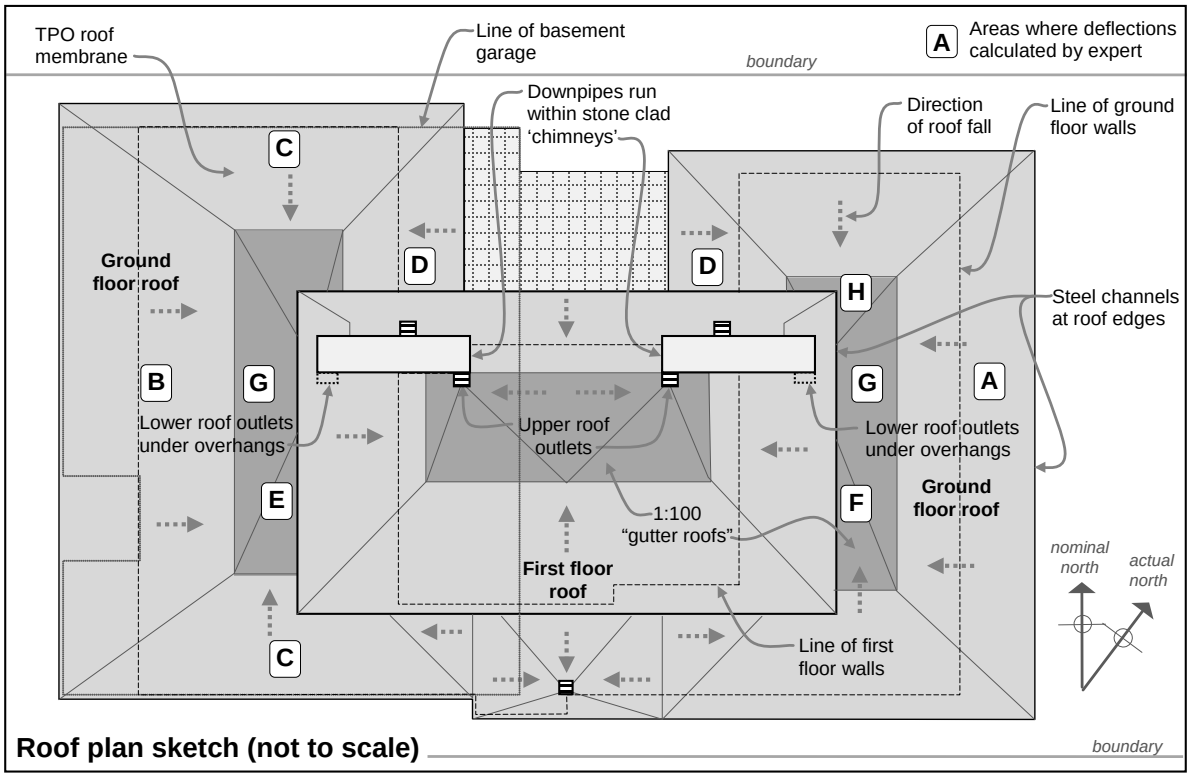
2.3.1 The drawings call for roofs to fall at a minimum slope of 1:80 towards large near-flat central areas ("the gutter roofs") that fall at 1:100 towards drainage outlets, with downpipes taken down the two service ducts as shown in Figure 2. The architect has advised the expert that roof falls will be increased to 1:66 'to allow for settlement and construction tolerances and ensure the finished fall is equal to or greater than 1:80' (see paragraph 5.2.2).

[2] In this determination, references to sections are to sections of the Act and references to clauses are to clauses of the Building Code.
[3] Schedule 1, Building Regulations 1992.
[4] Under section 177(1)(b) and section 177(2)(a) of the Act
[5] Polyester fabric reinforced thermoplastic polyolefin
[6] New Zealand Standard NZS 3604:1999 Timber Framed Buildings

2.3.2 The roof structures incorporate specifically designed proprietary 170 x 45mm LVL[7], H1.2[8] treated rafters at 600mm centres, with 180x75mm steel parallel flange channels (PFC) at the edges of the roof and steel beams within the body of the roof area. The rafters are overlaid with 21mm plywood sheets which form the substrate to the membrane roof cladding. The drawings call for hot air welded seams to be overlapped within recesses in the plywood to provide a flush membrane surface.

2.3.3 The outlets to the roofs are to be domed brass outlets mechanically clamped to the membrane.

Figure 2: Roof plan



2.4 The roof membrane

2.4.1 The roof membrane is a 1.5mm thick adhesive-fixed membrane manufactured in the USA and supplied and marketed by a company in New Zealand. It is a single ply polyester fabric reinforced thermoplastic polyolefin ("TPO") fully bonded waterproofing sheet membrane for roofs and decks. The TPO membrane is to be supplied in rolls 3.0 and 3.6m wide.

2.4.2 The manufacturer has provided the suppliers with a statement dated 3 May 2016 in regard to ponding water, which notes:

> [The manufacturer] has no minimum slope requirements for the purpose of issuing guarantees for our TPO roofing systems.
>
> Standing and/or ponding water has no negative affect regarding the waterproofing integrity of the TPO membranes or the heat-welded seams. With this, [the manufacturer] does not exclude standing (ponding) water areas on our TPO Systems.

[7] Laminated Veneer Lumber
[8] Timber treatment class to New Zealand Standard NZS 3602: Part 1: 2003 Timber and wood-based products for use in building

2.4.3 The membrane supplier's specification calls for a 20-year 'material manufacturer/supplier warranty' and a 5-year installation warranty to be supplied by its certified applicators, based on the manufacturer's installation specifications. The supplier has accepted the proposed roof details and has confirmed that the materials warranty will include the roof fall.

2.4.4 The membrane system has been appraised by BRANZ[9]. The appraisal states that the membrane will comply with Clauses E2 and B2, providing the system is 'designed, used, installed and maintained in accordance with the statements and conditions' of the appraisal. These conditions include the following at section 13.3:

> The minimum fall for roofs is 1 in 30, for decks 1 in 40 and for gutters 1 in 100. All falls must slope to an outlet. Inadequate falls will allow moisture to collect and increase the risk of deterioration of the membrane.

3. Background

3.1 In 2017, the architect applied for a building consent on behalf of the applicant for the proposed house (No. BC170989). I have not seen a copy of the consent application.

3.2 As part of the consent processing, it appears that the authority requested further information and on 8 September 2017 the architect submitted an 'alternative solution assessment' in support for the proposed roof membrane system which included:

1. Relevant clause(s) [of the] Building Code and comments
2. Stability assessment of the flat roof structure
3. Weathertightness and detailing
4. Framing calculations
5. Manufacturers Design Review Statements, Trade literature, Product Technical Statements (PTS).

3.3 The authority's refusals to accept the roof system

3.3.1 The authority refused to accept the proposed roof system and the architect met with the authority on 18 December 2017 to discuss the situation. In an email to the architect dated 19 December 2017, the authority stated that it was:

> ...uncompromising that the falls need to fully comply with the appraisal. The solution we see is to fully comply with the acceptable solution and appraisal or obtain BRANZ Approval for the alternative.

3.3.2 The authority also noted that the large areas of membrane with 1:100 falls were considered as roof areas not gutters; stating that it would:

> ...accept gutter sizes noted in the acceptable solution with the min. depth complying with E2 and E1 requirements. 21mm drop doesn't comply.

3.3.3 The architect requested a further meeting which the authority declined in an email dated 20 December 2017; noting that it would not accept a lower roof pitch and 'another meeting would not change anything', stating:

> Your other option is to apply for to [the Ministry] for a determination. [The authority] will not go against a BRANZ appraisal. We will not make a call on what needs to be provided to satisfy an equivalent, comparative or different element in an appraisal. … The fall requirements are called up in the first paragraph of the appraisal and therefore high in the hierarchy of requirements. It is not a small side issue of the assessment.

[9] BRANZ Appraisal Certificate No. 950 [2017]

3.4 The matter remained unresolved and the applicant applied for a determination on 11 January 2018.

4. The submissions

4.1 The initial submissions

4.1.1 On behalf of the applicants, the architect outlined the 'key issues specifically addressed in the design of the roof', which included (in summary):

- The ground floor roof area is 306m^2 and serviced by gutter roofs able to take up to 317m^2. Gutters are formed in one piece with no laps or cross seams.
- Downpipes exceed demand, with the ground floor roof served by 4 downpipes each with a capacity of 123m^2.
- The roof is carefully designed to prevent ponding and the combination of steel, LVL and plywood provides 'a very stable roof platform' with:
    - the roof steel deflection limited and eaves pre-cambered for wind uplift
    - the LVL rafters designed to minimise deflection and settlement
    - a plywood substrate with almost twice the stiffness of 17mm thick ply.
- Roof details minimise the risk of water ingress via seam welds, substrate joints and penetrations, with:
    - the roofs simple in plan and form to minimise membrane seams
    - lapped seams rebated to provide a flush surface
    - de-bonded sides at plywood substrate joints to allow for movement
    - penetrations and outlets minimised and carefully detailed.
- The roof is designed to allow for the consequences of failure, uncertainties and site conditions in that:
    - overflows allow for outlet failure
    - level of the roof edge is set below the level of upstands at membrane/cladding junctions to allow water to flow over eaves if outlets/overflows fail
    - steel eave members are pre-cambered 10mm to allow for 5mm settlement
    - the lack of parapets and other 'catchpoints' minimise the potential for wind-blown sand to accumulate and block outlets.

4.1.2 The architect forwarded copies of:

- the consent drawings and membrane specification
- some correspondence with the authority
- the BRANZ appraisal of the proposed membrane
- an assessment of anticipated roof deflection
- statements from the membrane supplier and the manufacturer
- membrane manufacturer's and supplier's technical information.

4.1.3 In a statement received on 19 January 2018, the authority noted that the building consent application had been reviewed and the proposed roof system declined due to (in summary):

- a lack of technical information to support a roof pitch reduced below requirements of E2/AS1 and BRANZ appraisal
  (I note the authority had previously advised that it "will not go against a BRANZ appraisal", refer paragraph 3.3.3.)
- the authority's alternative solution policy requirements were not addressed
- argument for lower roof pitch is based purely on manufacturer's statement
- the trend is to increase not decrease membrane pitches
- claiming limited structural deflection is not equivalent to BRANZ testing
- labelling large roof areas as 'gutters' to allow lower pitches is not acceptable.

4.2 The draft determination and submissions received

4.2.1 A draft determination was issued to the parties for comment on 7 March 2018.

4.2.2 The architect responded to the draft determination on 21 March 2018. The architect accepted the draft determination and provided an amended drawing showing increased falls to the roof (refer paragraph 5.8.2).

4.2.3 The authority responded on 22 March 2018 saying the draft was not accepted. The authority's response to the draft is summarised below:

- The expert and the architect are both members of the NZIA[10] and which suggested a conflict of interest; the expert had also been in direct contact with the architect as part of his assessment.
- The calculated roof slopes did not allow for construction tolerances; how was the authority to verify the falls achieved? There was no clear information about what minimum roof pitch was appropriate for a TPO membrane.
- Any failure of the membrane roofs could go undetected leading to the timber substrate being damaged. A low pitch to a concrete substrate provided less risk from undetected failure compared with a timber structure.
- Acceptable Solutions E1/AS1 and E2/AS1 showed that the wide gutter "is actually a roof" and the stance taken in the draft determination suggests that a whole roof could be considered a gutter. "Maximum [gutter] widths are indicated in [Figure 16 of E1/AS1 and Figure 52 of E2/AS1] … bring these together and you have a maximum [gutter] size. "Gutters are designed to min 75mm deep…" as per Figure 52 of E2/AS1.
- The expert's comparison of a 90x45mm rafter from NZS 3604 with the proposed 170x45mm LVL rafters was incorrect as he should have compared this with 190x45mm rafters from NZS 3604.
  (In response I note that the expert compared the dimensional stability of, say, a 90x45mm timber rafter from a cited standard with the LVL rafter proposed.)

[10] New Zealand Institute of Architects

- The effects of wind on the roofs could cause ponding and should be assessed by a "wind expert". Wind has less effect on a narrow deep gutter compared with a wide shallow gutter.
- In relation to the minimum falls noted in the BRANZ appraisal, appraisals provide "reasonable evidence", and most BCAs[11] take appraisals as accurate based on technical and scientific data.
- The authority would rely on the installer's producer statement to confirm the installation of the membrane.
- There is no reference to "how the owners will be able to maintain or inspect the roof over the next 15 years"

4.2.4 The authority also noted some errors of fact and typographical errors. The authority's submission was referred to the expert for comment, refer paragraph 5.9.

4.2.5 The architect responded to the authority's submission on 3 April 2018 noting:

- Many of the matters raised by the authority have been addressed in the alternative solution assessment (refer paragraph 3.2); namely
  - the falls provided exceeded the deflections due to wind load
  - the roofs were as designed to be "very stable"
  - the increased stiffness of the 21mm plywood substrate (compared with 17mm called for in E2/AS1).
- The distinction between a roof and gutter is defined by the allowance for membrane seams in the former but not the latter, "a gutter is not allowed seams". E2/AS1 does not give maximum gutter sizes.
- The BRANZ appraisal has been useful establishing key areas of compliance.

4.2.6 On 30 April 2018 the authority advised the Ministry that a significant portion of the work had been constructed but that the building consent was yet to be issued. I leave this matter to the parties to resolve.

5. The expert's report

5.1 As mentioned in paragraph 1.7, I engaged an independent expert to assist me. The expert is a member of the New Zealand Institute of Architects and reviewed the application documentation and provided a report completed on 19 February 2018, which was forwarded to the parties on 20 February 2018.

5.2 General

5.2.1 The expert noted that the scope of his investigation was to review the consent documentation and other evidence in order to form a view on the compliance of the proposed roof membrane with Clauses E2 and B2.

5.2.2 The expert described the roof membrane, noting that its manufacturer is 'one of the world's largest roofing product manufacturer's' and produces a variety of roofing. The expert also noted that the authority's concerns appeared to be limited to the fall of the roof and the size of the lower pitched areas nominated as 'gutters' despite these being up to 2.9m in width.

[11] Building consent authorities

5.2.3 Following queries about some aspects of the drawings and specification, the architect had provided the expert with additional information in an email dated 31 January 2018 which confirmed that:

- the determination application is limited to the low pitched membrane roof
- the flood test specified as 4 hours is to be increased to 24 hours.
- all roof outlets are to be domed-bronze outlets as shown in drawings and not the plastic outlets referred to in the specification
- the overall roof fall is to be increased by 20mm to about 1:60 'to allow for settlement and construction tolerances and to ensure the finished fall is equal to or greater than 1:80'

5.3 Calculation of expected roof slopes

5.3.1 Roofs slope from a horizontal roof edge (RL[12] 14.217) towards horizontal edges to the gutter roofs (maximum RL 14.165), which results in a minimum difference of 72mm (based on above increase of 20mm in level change). The flatter gutter roofs slope from the horizontal edges (minimum RL 14.144) to the outlet drains (RL 14.217), which results in a minimum difference of 51mm.

5.3.2 Because the asymmetric roof geometry results in varying slopes on different membrane sections, the expert calculated slopes as shown in Table 1 at 4 roof and 4 gutter roof locations (see Figure 2), based on stated levels for the ground floor roof:

Table 1: Calculated roof and gutter slopes

Fig.1 ref.	**Location** (ground floor*)	Noted on drawings	Calculated slope per drawings	Slope based on 20mm increase
The roof areas				
A	East end	**1:80**	1:72	1:52
B	West end		1:92	**1:66**
C	North and South ends		1:65	1:47
D	Central – courtyard ends		1:62	1:44
The gutter roofs				
E	Southwest of west chimney	**1:100**	**1:110**	
F	Southeast of east chimney		1:99	
G	West and east of chimneys		1:55	
H	Northeast E of west chimney (shortest)		1:41	
** first floor roof significantly smaller in area, so within above slope ranges*				

5.3.3 The calculated slopes (based on the increased ground floor roof slope) are:

- Roof slopes – between 1:44 and 1:66
- Gutter slopes – between 1:55 and 1:110.

5.3.4 For the lowest roof slope (Area B at 1:66), the expert modelled likely deflections to assess the likelihood of ponding. For Area B, expected deflection under maximum loads was shown as:

- 2.4mm at mid span of the LVL rafters

[12] Relative Level

- 2.5mm maximum between rafter mid-spans
- nominal 1:66 fall reduced to 1:80 at the nearest edge of the gutter roofs.

5.3.5 The expert noted that maximum loads allowed in his modelling included live loads such as a person on the roof, which is unlikely to be a permanent deflection. Modelling of the worst case scenario still resulted in a positive slope and the expert therefore considered that ponding was unlikely.

5.3.6 Because the BRANZ appraisal provided 'reasonable evidence' that the proposed membrane product will comply with Clauses E2 and B2 when laid on minimum slopes of 1:30 for roofs and 1:100 for gutters (see paragraph 2.4.4), the expert noted that relevant issues for review were therefore whether:

a) there is other evidence that it will also meet the requirements of the code when laid on a roof at slopes of between 1:44 and 1:66 as proposed, and

b) whether the areas designated as gutters up to 3m across can actually be considered as gutters.

5.4 The gutters

5.4.1 In regard to gutter width, the expert noted that:

- E2/AS1 and BRANZ guidance[13] requirements include minimum widths but do not specify maximum widths
- the lack of maximum widths implies that, providing requirements are met, a 3m wide membrane area can be considered to be a gutter
- the proposed roof gutters are to be installed in one piece without seams, which exceeds requirements to have no laps across the slope.

5.4.2 In regard to gutter slope, the expert noted that:

- Area E (see Table 1) has the lowest slope at 1:110
- the specification calls for a minimum slope of 1:100
- relative levels of Area E will need adjusting to achieve the above slope.

5.5 The roof slope

5.5.1 The expert investigated the manufacturer's information regarding the membrane product and roof drainage; including the following comments (in summary):

- Although the supplier has not yet provided documentation on other roofs at the proposed slope, the manufacturer has confirmed that ponding would not affect the water tightness of the membrane (see paragraph 2.4.2).
- Although the above together with the photographs of an internal membrane-lined planter demonstrates the manufacturer's confidence in the product, the planter's recent construction does not provide an extended history of use.
- Multiple test reports and approvals are available for the product from internationally recognised testing and approval agencies in the USA.
- The manufacturer's instructions warn of dangers of ponding for more than 24 hours and include the requirement for 'adequate slope to drain all water to appropriate outlets'. However, no minimum roof slopes are specified.

[13] BRANZ Good Membrane Practice

- There is no clear international consensus on minimum slopes, with one evaluation requiring 1:48 for the proposed membrane[14] while others endorse a similar TPO on roofs with a slope of 1:80 and for roof gardens[15].

5.5.2 The expert also discussed general TPO requirements with a BRANZ membrane specialist. In regard to reasons for requiring different slopes for roofs, decks and gutters, the membrane specialist had noted that (in summary):

- BRANZ follows paragraph 8.5 of E2/AS1 for slopes because:
  - being larger in area than gutters, roofs have a larger number of seams
  - timber framed roofs are prone to deflect and settle, risking lower slopes than specified which can lead to ponding
  - standing water risks deterioration of the membrane and/or seams
- however, some risks can be mitigated because:
  - hot air welding of TPO seams is easily tested and seams can be reheated locally if found faulty (which is unlikely for thicker torch-on membranes)
  - ponded water on roofs without parapets is likely to be blown off by wind
  - some single layer membranes are endorsed for lower slopes but only for concrete substrates, which are less prone to deflection and settlement.

5.5.3 The expert concluded that BRANZ guidance is 'the result of a policy decision rather than evaluation of the properties of the various membranes'. Because the primary concern is ponding on timber framed structures (which can be avoided by a design's specification and the quality of installation), it follows that 'the BRANZ/ E2/AS1 slopes are conservative.'

5.6 Comparison with BRANZ guidance

5.6.1 The expert's assessed roofing problems highlighted within BRANZ guidance[16], and comments on relevant problems for the proposed house are summarised in Table 2:

Table 2: Relevant roofing problems per BRANZ guidance

Relevant problems per BRANZ guidance	Expert's comments on the proposed roof
Flat/low-slope membrane roof areas	• Mitigated by specification and drawings
Poorly flashed roof penetrations	• Chimney upstands terminate above overflow height, with lap under wall membrane
Aerial installation onto roof	• None shown – advisable to show low-risk locations for potential aerials
Poor membrane installation	Mitigated by following: • To be installed by supplier-licensed applicator • Sheet width minimises lapped joints • Automatic lap welding machine for long laps • Simple roof plan – few complex junctions, no parapets or scupper outlets
Unprotected holes through flashings	• Perimeter angle not top fixed through membrane
Buckling of flashings	• Perimeter angle limited to 3m lengths

[14] Texas Department of Insurance Product Evaluation RC-471
[15] BBA Certificate 00/3750 for a different TPO membrane
[16] Source: BRANZ Weathertight website – roof claddings

Relevant problems per BRANZ guidance	Expert's comments on the proposed roof
Internal gutters with no overflows	• Overflows shown on drawings • Roof perimeter lower than upstand top at gutter/ chimney junctions – will flood over roof edge if drainage outlets and overflows blocked
Membrane stress at substrate joints	• De-bond tape called for at plywood sheet joints
Insufficient outlets for catchment	• Calculations show outlets exceed E2/AS1 • Each outlet has overflow
Insufficient membrane upstands	• 150mm upstands specified at gutter/chimney
Loss of adhesion to glued joints	• Joints are hot air welded
Leaking from blocked outlets	• Roof perimeter lower than upstand top at gutter/ chimney junctions – will flood over roof edge if drainage outlets and overflows blocked
Damage from walking over roof	• Damage would be visible at final inspection

5.6.2 The expert considered that the proposed roof lacks most high risk features, noting that he had found the most prevalent causes of single-layer membrane failures to be incompletely fused seams and scupper outlets, both of which are avoided in the proposal.

5.7 Comparison with E2/AS1

5.7.1 The expert also compared features of the proposed membrane system with the requirements of E2/AS1 as shown in Table 3.

Table 3: Comparison with E2/AS1 requirements

E2/AS1 requirement	Proposal	Expert's comments
1.1 NZS 3604 framing (for example, 90x45mm rafters per Table 10.1)	170x45mm LVL rafters Steel channels and portals	LVL more dimensionally stable than Radiata pine and less prone to bowing and twisting
8.5.1 a) Scope – slope min. 1:30	1:66 nominal slope (as revised)	Architect advises slopes to be increased to 1:66 to allow for settlement and construction tolerances
8.5.3 a) Plywood substrate 17mm min	21mm plywood	21mm plywood is more rigid
8.5.4 c) Glued seams within scope	Machine hot air lap welded	Hot air welding avoids on site risks for adhesives – such as dampness.
No requirement for flush seams	Flush laps in ply rebates	Avoids possibility of ponding adjacent to seams on low pitched roofs
No minimum sheet width (butyl rubber is typically 1.4m wide)	3.0m width	Number of seams reduced
8.5.5.1 c) Supports at 400mm min	LVL rafters at 600mm Steel channels and portals	In conjunction with 21mm ply, low deflection and manufacturing tolerances expected
8.5.6 d) ii) Scuppers permitted	No scuppers - outlets domed cast bronze with membrane clamps	Although accepted in E2/AS1, lack of scuppers eliminates a feature that commonly fails

5.8 Summary

5.8.1 Based on his research and discussions, the expert concluded that (in summary):

- minimum slopes in E2/AS1 and the BRANZ appraisal 'result primarily from a combination of policy and concern that deflection and distortion in timber decks will result in loss of slope and ponding'

- in regard to the proposed membrane system, 'the use of 21mm thick plywood, and LVL framing provide a rigid and relatively stable substrate which are unlikely to result in a loss of slope which would lead to ponding'
- the appraisal indicates that the membrane itself will comply with the Building Code, and hence that the seam and material will survive exposure for the required durability period of 15 years
- risks are mitigated by the absence of most of risk features identified by BRANZ, together with some compensating features.

5.8.2 Taking the above into account, the expert concluded that the proposed roof slopes will be sufficient to comply with the Building Code providing:

- drawings are revised to show increase in slope
- Area E (see Figure 2) is adjusted to achieve gutter roof slope of 1:100
- drawings to confirm that structural steel at roof edges will incorporate 10mm pre-camber.

5.9 The expert's response to the authority's submission on the draft determination

5.9.1 The expert noted that he had not met the architect and had "no knowledge of his other work and have had no dealings with him or his company". As members of the NZIA, the expert and the architect shared "a common code of ethics and rules".

5.9.2 The various editions of E1/AS1 and E2/AS1 since 1992 do not provide a definition of a gutter or restriction on maximum width. Figure 16 of E1/AS1 and Figure 52 of E2/AS1 both state minimum not maximum dimensions. Figure 52 of E2/AS1 shows a minimum depth of 75mm for an internal gutter draining from a profiled metal roof: that minimum dimension is not applicable to a membrane roof.

5.9.3 The expert agreed the authority "should verify that the slopes are constructed in agreement with the consent documents". Any areas of ponding would also be evident after the release of water from the specified flood test.

6. Discussion

6.1 The compliance of the proposed roof

6.1.1 The architect has submitted that the particular design and detailing of the proposed roof compensates for the lower proposed slopes by providing sufficient means to shed water from the roof, with design features that protect against ponding and allow for the consequences of failure and uncertainties.

6.1.2 The authority maintains there is insufficient evidence to support the proposed roof slopes as an alternative solution. I acknowledge and accept the authority's concerns with respect to the performance of low-pitched membrane roofs to buildings where deflection of the structure may give rise to ponding.

Clause E2 External moisture

6.1.3 The Building Code has two key performance requirements with regard to external moisture – that external moisture is shed from roofs and walls, and that roofs and external walls prevent the penetration of water that could cause undue dampness,

damage to building elements, or both. The proposed roof design is required to meet the performance requirements of Clause E2 which requires:

> **E2.3.1** Roofs must shed precipitated moisture. In locations subject to snowfalls, roofs must also shed melted snow.
>
> **E2.3.2** Roofs and exterior walls must prevent the penetration of water that could cause undue dampness, damage to building elements, or both.

6.1.4 The proposed roof is an alternative solution by virtue of the membrane material used (TPO) and the reduced slope to the roof (1:60). The Acceptable Solution for Clause E2, E2/AS1 provides deemed-to-comply solutions for membranes of butyl rubber and EPDM[17] installed at a minimum slope of 1:30. The proposed roof also drains via wide internal gutters to an internal surface water drainage system. The intended performance of the roof is reliant on the proposed falls being achieved, the membrane being correctly installed with the appropriate details, and for the roof to receive the appropriate ongoing maintenance for its required 15-year life under Clause B2.3.1(b).

6.1.5 In evaluating the design of a building and its construction, it is useful to make comparisons with the relevant Acceptable Solution and other authoritative sources, which will assist in determining whether features of proposed building work are code compliant. In the case of the roof proposed for this house, the expert has assessed the proposed roof design against E2/AS1 and BRANZ requirements in Table 2 and Table 3 herein, and has concluded that the relatively rigid and stable structure of the roof is 'unlikely to result in a loss of slope which would lead to ponding'. I note that the roof structure is more rigid than conventional timber framing, with LVL rafters supported and stiffened by steel framing.

6.1.6 The proposed falls (taking into account the minor amendments identified in paragraph 5.8.2) will enable the roof to shed precipitated moisture and in this respect I consider the roof will satisfy Clause E2.3.1. However, close construction tolerances are required to achieve the falls and I also consider it reasonable that the authority request that the owner verify that the correct falls have been achieved.

6.1.7 The roof is inward-draining and there is a risk associated with roof outlets being blocked – water ingress may arise from ponded water over-toping membrane upstands at walls, penetrations, and the like. Therefore, any membrane upstands should be finished at a height well above the level of possible ponding and this should be verified by the architect to the authority.

6.1.8 The effects of the roof's deflection on the roof pitch arising from wind loading and the weight of ponded water on the roof have been addressed in the alternative solution assessment (refer paragraph 3.2).

Clause B2 Durability

6.1.9 The BRANZ appraisal establishes that the TPO membrane will be sufficiently durable to satisfy Clause E2.3.2 in order to achieve the minimum 15-year durability period required by Clause B2.3.1(b) and I accept this position in relation to the subject roofs. However, the minimum durability period is subject to the membrane receiving "normal maintenance".

[17] Ethylene Propylene Diene Monomer

6.1.10 Regular inspection and maintenance is required to confirm the condition of the membrane, and to keep the rainwater outlets free of debris to reduce the risk of ponding.

6.2 The authority's submission on the draft determination

6.2.1 I note the following with respect to the submission made by the authority in response to the draft determination regarding matters not covered elsewhere:

6.2.2 I do not consider a conflict of interest arises from the engagement of the expert to assess this matter as raised by the authority. Typically, an expert will contact the parties as necessary to clarify matters, and the expert has recorded the extent of his communication with the architect in his report. The expert has advised that he has previously had "no dealings with [the architect] or his company". The fact that both the expert and the architect are members of the NZIA, the professional body to which registered architects are required to belong, does not of itself constitute a conflict of interest.

6.2.3 The authority contends that gutters have an established maximum size derived from the Acceptable Solutions for Clause E1 and E2. I note that the requirements of E1/AS1 and E2/AS1 are not mandatory and simply represent one way, but not the only way, of establishing compliance with the mandatory provisions of the Building Code.

6.2.4 The minimum sizes of gutters given in E1/AS1 and E2/AS1 are provided to ensure water that drains from a roof is able to be collected without affecting the overall performance of the roof. The 75mm minimum gutter depth referred to by the authority, described in Figure 52 of E2/AS1 (and echoed in Figure 16 of E1/AS1), is to prevent water overflowing the gutter and entering the roof space under the profiled metal roofing. It is noted that a minimum gutter depth of 50mm is given for membrane roofs in Figure 62 of E2/AS1, but this is for gutters with a minimum width of 300mm.

6.2.5 I accept the expert's view that there is no maximum size for a gutter. The features of internal gutters are described in paragraph 8.1.6.1 of E2/AS1: this paragraph says:

- gutters can be installed at slope of 1:100 and formed from a membrane with no cross-joints
- the gutter membrane is to be a "minimum 1.5 mm membrane thickness, or 1.0 mm thickness for gutters less than 1 metre wide", meaning that E2/AS1 allows for gutters wider than 1.0m.

6.2.6 The membrane in this instance is 1.5mm thick and formed without any cross seams and without other high-risk features such as scupper outlets. The clamped and domed brass outlets are also a mitigating feature. It is also noted that a steep roof will have water draining to gutters faster than for a roof with a lower pitch as provided for in Figure 16 of E1/AS1: the subject roofs have a low pitch.

6.2.7 I do not consider there are specific risks associated with the effects of wind on this particular roof as is contended by the authority. Large metal roofs to warehouse buildings, and similar, are typically built to a minimum pitch where junctions are reliant on simple laps. In this instance all laps are thermally sealed, or similar, and provided the membrane upstands are not finished at a level that could lead to water ingress when the roof is ponded I do not consider specific assessment on the effect of wind on the roof is warranted.

6.2.8 I accept that the authority should receive verification that the roof slopes are built in accordance with the consented documents.

6.3 Conclusion

6.3.1 Taking into account the expert's report and the other evidence, I consider that the proposed roof (amended as above) avoids the potential problems identified by BRANZ (see Table 2) in its guidance information. I therefore consider that the roof design proposed for this house is likely to perform at least as well as the materials and systems included within E2/AS1, and thus will comply with the performance requirements of Clause E2 for the minimum 15-year period required by Clause B2.3.1(b).

7. The decision

7.1 In accordance with section 188 of the Building Act 2004, I hereby determine that the roof design to this building, amended in accordance with paragraph 5.8.2 and pending verification of matters set out in paragraphs 6.1.6 and 6.1.7, will comply with Clauses B2 Durability and E2 External moisture of the Building Code.

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 18 May 2018.

Katie Gordon
Manager Determinations