Department of Building and Housing
Te Tari Kaupapa Whare

Determination 2010/105

The fire safety requirements for a large warehouse building at 8 Hautu Drive, Manukau, Auckland

1. The matters 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 the Department.

1.2 The parties are:

- the applicant, the New Zealand Fire Service Commission ("the applicant") represented by a legal advisor
- the owner of the building, Rock Solid Holdings Limited ("the owner") represented by a legal advisor and a firm of consulting engineers who undertook the fire design for the building ("the fire engineers")
- Manukau City Council, carrying out its duties and functions as a territorial authority or a building consent authority ("the authority")[2].

[1] The Building Act, Building Code, Compliance documents, past determinations and guidance documents issued by the Department are all available at www.dbh.govt.nz or by contacting the Department on 0800 242 243.
[2] After the application was made, and before the determination was completed, Manakau City Council was transitioned into the new Auckland Council. The term authority is used for both.

1.3 This determination arises from a dispute about whether the fire safety design for a new warehouse and attached office block ("the building") complies with the C Clauses of the Building Code (Schedule 1, Building Regulations 1992)[3].

1.4 There have been a number of amended fire safety designs for the building, and therefore I have considered compliance with the C Clauses of the original fire safety design ("the original fire safety design") dated 22 July 2008 and the latest fire safety design ("the third amended fire safety design") dated 22 April 2009. I consider the relevant Building Code Clauses are C2 Means of escape, C3 Spread of fire, and C4 Structural stability during fire. I have not considered Clause C1 Outbreak of fire as there were no issues relating to Clause C1 in dispute between the parties.

1.5 Therefore, I take the view that the matters for determination[4] are:

- whether the original fire safety design for the building complies with Building Code Clauses C2, C3, and C4
- whether the third amended fire safety design for the building complies with Building Code Clauses C2, C3, and C4.

1.6 At the request of the applicant, I have also given specific consideration to the Building Code requirements for the protection of firefighters. While the applicant specifically referred to Clause C3.3.9 and firefighter tenability times, given the critical issues in this determination, I have taken a broader approach and considered the Building Code requirements for the protection of firefighters, and the extent of protection afforded to firefighters carrying out firefighting operations. I discuss this in paragraph 7.

1.7 In making my decision, I have considered the submissions of the parties, the reports of the independent expert commissioned by the Department to advise on this dispute ("the expert"), and the other evidence in this matter. I have not considered any other aspects of the Act or the Building Code. The key relevant Building Code and the key text of C/AS1 that is referred to in this determination is included in the Appendix.

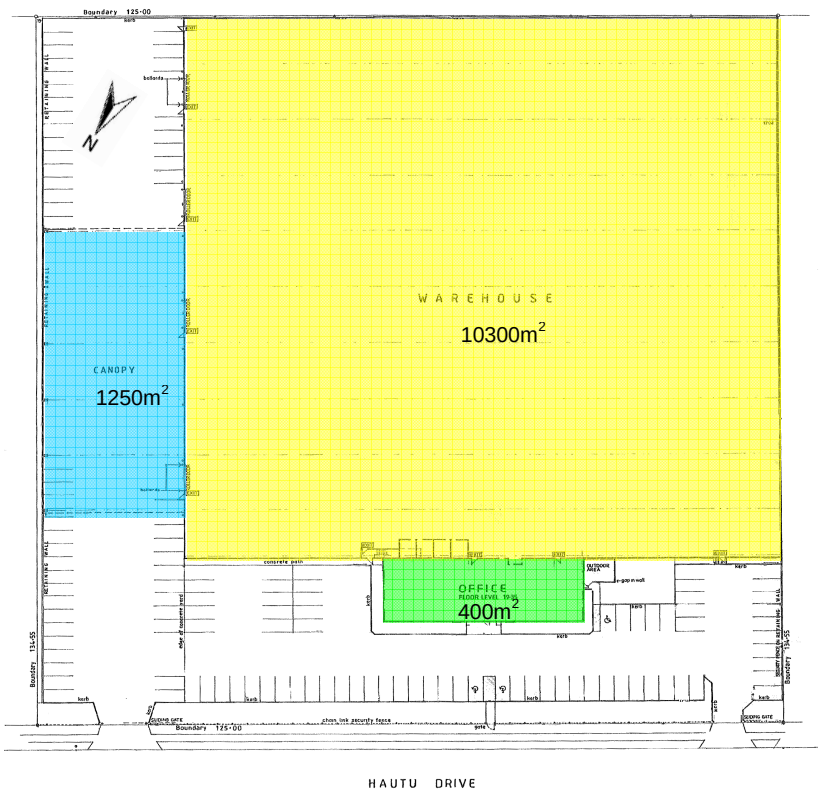
1.8 In this determination, I have considered the submissions by the legal advisors to the applicant and owner to be submissions from the applicant and owner respectively, and although the fire engineers also represent the owner I have distinguished where submissions are from the fire engineers.

2. The building

2.1 The building is an office and warehouse development (refer to Figure 1), that consists of:

- a single storey warehouse with an area of 10,300m^2
- a two storey office building (at the northwest elevation of the building) with an area of 400m^2
- a canopy (at the northeast elevation of the building) with an area of 1250m^2.

[3] In this determination, unless otherwise stated, references to sections are to sections of the Act, and references to Clauses are to Clauses of the Building Code.
[4] In terms of section 177(a) of the Act (prior to 7 July 2010)



2.2 The building is constructed on a concrete floor slab and foundations. The roof of the building is steel framed and lined with pre-coated metal cladding and glass reinforced polyester roof panels ("GRP roof panels"). Two elevations of the warehouse part of the building located on boundary lines have pre-cast concrete external walls, and the other two elevations have steel framing lined with pre-coated metal cladding, fixed over pre-cast concrete sub walls. The office part of the building has external walls formed from toughened glazed aluminium units and specialised aluminium panels.

2.3 The intermediate floor in the office consists of a 140mm thick bonded steel and concrete system. The office part of the building is separated from the main warehouse by a fire rated plasterboard wall. Apart from small areas that are timber framed, the ceilings are lined with a suspended mineral fibre tile system.

3. The background

3.1 The original fire safety design produced by the fire engineers, supporting an application for a building consent (BCN-082089), was submitted to the authority on 30 July 2008.

3.2 On 1 August 2008, the authority requested the applicant provide a memorandum in accordance with section 47. The applicant provided a memorandum to the authority on 14 August 2008, indicating that the fire safety design presented did not demonstrate compliance with the Building Code.

3.3 The Department received an application for determination 2 September 2008, and the determination process commenced on 22 September 2008 on receipt of the appropriate fee.

The original fire safety design

3.4 The original fire safety design (dated 22 July 2008) produced by the fire engineers covered the following aspects of the design for the building:

Fire safety design aspect	Summary of fire safety design
Building classification and occupant numbers	Purpose group WH (warehouse) – fire hazard category 4, 0m escape height Purpose group WL (office) – fire hazard category 2, 3m escape height Total floor area 11074m^2, occupancy design number 162
Fire safety precautions	C/AS1 minimum fire safety precautions – type 3f, type 16, and type 18c
	Portable fire extinguishers/hose reels to comply with NZS 4503 may be required
	F6/AS1 compliant emergency lighting F8/AS1 compliant exit signage
Fire egress	9 final exit doors, including main entry, 900mm door widths, except main entry which is 2,000mm C/AS1 (Table 3.2) egress capacity is 1024 occupants C/AS1 compliant dead end open path travel distances, 21m actual dead end travel distance Alternative solution for open path travel distances, distances exceed C/AS1 compliant distances by 40 metres – increase in travel time of 33 seconds, offset by low occupant numbers, compliant tenability time limits C/AS1/3.17.2 compliant door locking devices
Fire ratings	Single firecell, FRR S180 (based on computer program using Eurocode method).
Internal fire spread	'The building contains an intermediate floor that required smoke control to specific fire engineering design. Based on specific fire engineering design, as required by C/AS1, the smoke control to control smoke mitigation and maintain tenability for occupants on the intermediate floor will be provided by passive smoke separation between the ground floor and intermediate floor, including the stairway. This will allow occupants on the intermediate floor to egress without passing through the ground floor smokecell. The intermediate floor and its supporting primary elements shall have a fire rating no less than 30/30/30 as the area under the intermediate floor is enclosed.'
External fire spread	'Our calculations… show that an external wall 30 [metres] and 10 [metres] high can have 90% unprotected openings with a separation distance of 24.9 [metres] from the relevant boundary. The design fire is based on a compartment with an unrated roof structure that would likely collapse between 10 to 20 minutes creating an open air fire that would reach a maximum temperature of 678℃ after 21 minutes. The calculation is based on an acceptable level of radiation received at a point [one metre] over the boundary equal to 16kW/m^2.' 'The canopy may be of unlimited area provided at least two sides are open to the environment, no part of the roof is closer than [one metre] from the boundary, and the nominal amount of storage under the canopy has a fire hazard category of no greater than 2.'

The third amended fire safety design

3.5 After considerable cross-submission between the parties (refer to paragraph 4.5 to 4.7), the third amended fire safety design dated 15 July 2009 was provided to the Department to address the issues raised in the first draft determination.

3.6 I have discussed in detail the issues in dispute between the parties in respect of the third amended fire safety design in paragraph 9.

4. The submissions

4.1 The complete application for determination was received on 22 September 2008. In a letter to the Department dated 19 September 2008, the applicant provided a submission about the original fire safety design. The applicant questioned whether the building work outlined in the original fire safety design, from a building consent for a proposed building, complied with Clauses C2 and C3 of the Building Code. The applicant also requested the Department provide guidance as to the interpretation of Clause C3.3.9 of the Building Code.

The sequence of events

4.2 The following table summarises the main sequence of events:

Date	Event
22 September 2008	Application for determination
22 September 2008 to 15 January 2009	Submissions called for and provided including counter submissions
24 September 2008	First amended fire safety design provided by the fire engineers ("the first amended fire safety design")
21 January 2009	Expert's first report
21 January 2009 to 16 April 2009	Submissions called for and provided including counter submissions
17 February 2009	Second amended fire safety design provided by the fire engineers ("the second amended fire safety design")
16 April 2009	Expert's second report
16 April to 30 April	Comments called for on Expert's second report
22 April 2009	First draft determination, which found that the design of the building did not comply with Clauses C2 and C3
22 April 2009 to 30 October 2009	Submissions called for and provided on first draft determination including counter submissions
7 May 2009	Hearing requested
20 July 2009	Third amended fire safety design provided by the fire engineers ("the third amended fire safety design")
9 November 2009	Hearing (refer to paragraph 4.3)
9 November 2009 – 11 December 2009	Submissions called for and provided including counter submissions
2 February 2010	Second draft determination
2 February 2010 – 1 March 2010	Submissions called for and provided including counter submissions
15 April 2010 – 4 June 2010	Information circulated about effective fire venting to the industry and members of the fire engineering professional association by persons associated with the parties to the determination
11 June 2010 – 29 July 2010	Submissions called for and provided about effective fire venting to allow the parties to comment on the information circulated to the industry
14 September – 24 September 2010	Information circulated to people involved in the industry about effective fire venting to the industry by persons associated with the parties to the determination

28 September – 8 October 2010	Submissions called for and provided about GRP roof panels to provide effective fire venting to allow the parties to comment on the information circulated to the industry

The hearing

4.3 During the determination process, the fire engineers requested a hearing, which was held in Auckland on 9 November before me. I was accompanied by a Referee engaged by the Chief Executive under section 187 of the Act. In attendance were three representatives of the applicant and the applicant's legal advisor, a representative of the owner of the building and the owner's two legal advisors, two representatives of the fire engineers, an officer of the Department and the expert engaged by the Department to advise on this dispute. All of the parties spoke at the hearing and the evidence presented enabled me to amplify or clarify various matters of fact. I have included the information presented at the hearing as described in paragraph 4.8.

The content of the submissions

4.4 Due to the number of submissions and counter submissions received during the course of this determination, I have recorded the submissions received from each of the parties.

4.5 The following submissions were received from the applicant:

Date	**Submission**
22 September 2008	Application for determination
2 February 2009	Response to expert's first report
16 March 2009	Submission in response to the second amended fire safety design
7 May 2009	Submission accepting the first draft determination
8 June 2009	Submission in response to the submission of the fire engineers of 7 May 2009
31 July 2009	Submission about third amended fire safety design
30 October 2009	Legal and technical submission (hearing) in response to the third amended fire design
26 November 2009	Submission (post hearing) including a research paper about the efficacy of GRP roof panels to provide effective venting
19 February 2010	Submission in response to second draft determination
28 July 2010	Submission in response to outstanding issues about GRP roof panels to provide effective fire venting

4.6 The following submissions were received from the owner and fire engineers, and the owner's legal advisor:

Date	**Submission**
24 September 2008	Submission from fire engineers including the first amended fire safety design
17 February 2009	Submission from fire engineers including the second amended fire safety design
11 March 2009	Submission from owner
16 April 2009	Submission from fire engineers in response to applicant's 16 March 2009 submission
7 May 2009	Submission from fire engineers in response to the first draft determination

20 July 2009	Submission from fire engineers including the third amended fire safety design
14 August 2009	Submission from fire engineers and owner's legal advisor in response to the first draft determination
9 November 2009	Submission (hearing) from owner's legal advisor and fire engineers including a bundle of supporting documents
1 December 2009	Submission from owner
11 December 2009	Submission from owner's legal advisor in response to applicant's 26 November 2009 submission
19 February 2010	Submission from owner's legal advisor in response to second draft determination
12 July 2009	Submission from owner's legal advisor in response to outstanding issues about GRP roof panels to provide effective fire venting

4.7 The following submissions were received from the authority:

Date	**Submission**
27 April 2009	Submission in response to the first draft determination

4.8 I have summarised the content of these submissions, and the application for determination in the paragraphs 4.9 to 4.13 with content grouped to the following topics:

- Fire hydrant requirements (refer to paragraph 4.9)
- Means of escape and fire safety systems (refer paragraph 4.10)
- Fire ratings and fire cell size (refer to paragraph 4.11)
- Effective venting (refer to paragraph 4.12)
- Firefighter tenability times. (refer to paragraph 4.13).

4.9 **Fire hydrant requirements**

Submission	**Summary of submission**
Applicant	A fire hydrant is required to comply with C/AS1. NZS4510:1998 does apply to the building and these requirements should have been addressed at the outset. The NZFS only took the view that no internal fire hydrants were required at the neighbouring property because the overall design of the neighbouring building is too dangerous in terms of firefighting.
Owner	The NZFS clearly stated they would not drive under a canopy or use a hydrant installed in a building. Unless we have permission, we are not allowed to install hydrants into a public system.
Owner's legal advisors	The applicable fire hydrant standard (NZS 4510:1998) does not provide information on installing a hydrant in a single floor building. This is reinforced by the new edition of the hydrant standard NZS 4510:2008 that notes the installation of hydrants in single floor buildings is new and not currently mandatory.

4.10 Means of escape and fire safety systems

Submission	Summary
Applicant	As a fire hazard category 4 purpose group with an escape height of 3 metres the building must have a F30 rating, an automatic fire sprinkler system with manual call points, emergency lighting in exitways and a fire hydrant system if the hose run distance from fire service vehicular access to any point on any floor is greater than 75 metres. Table 4.1/2 of C/AS1 also requires a fire hazard category 4 purpose group building with an escape height of three metres or more to have a F30 rating and an automatic fire sprinkler system with manual call points. There is insufficient detail provided about how the requirements for emergency lighting and exit signage will be met. The proposed smoke control system only considers a fire occurring in the floor space beneath the intermediate floor and neglects the possibility of a fire in the greater warehouse. The egress tenability analysis is deficient in the assumptions made and the application of the model.
Fire engineers	The first amended fire safety design includes a F60 between the office and warehouse to address the issue that was raised by the applicant, providing a single level fire hazard category 4 firecell for the warehouse. In virtually all cases of a significant fire event, in this type of building, the occupants have evacuated before fire service arrival at the scene of the fire. This building in accordance with current requirements has an automatic fire alarm for early warning which would not have been required pre-Building Code. The Building Code does not include provisions for specially saving an owner's property. The warehouse requires a racking fit out building consent, and this will ensure the escape paths remain compliant. Ongoing IQP (Independently Qualified Persons) inspections for building warrants of fitness ensure escape routes are kept in compliance with Clause C. The owner has discussed hydrant requirements with the fire service. C/AS1 Appendix A requires this system to comply with NZS 4510. In turn, NZS 4510 does not require a hydrant in this particular single level building. A type 4f automatic fire alarm has been installed for travel distance in the warehouse firecell and also for warning of fire in the office firecell intermediate floor, which exceeds the requirements of C/AS1 Table 4.1/2.

4.11 Fire ratings and firecell size

Submission	Summary
Applicant	The original fire safety design specified a 30/30/30 fire resistance rating for the intermediate floor, however, also accepts modification to the integrity and insulation rating. The design is based on roof collapse between 10 and 20 minutes of a fire and burnout of the structure. The original fire safety design failed to provide any information to demonstrate that the roof will collapse at this time. The third amended fire safety design proposes an alternative solution to deal with smoke control within the building. Insufficient analysis has been provided to demonstrate that the level of protection provided by the proposed alternative solution is equivalent to that arising under C/AS1. No information is provided as to how material stored under the building's canopy will be maintained at fire hazard category 2 or lower. Insufficient information is provided to demonstrate the stability of the external fire rated walls. Assumptions about the tolerable intensity of radiation across property boundaries may not be correct.

	The time equivalence method was used to calculate the S rating. The original fire safety design does not identify the limitations and does not fall within the validated limits of the empirical data on which the method is based. Insufficient detail is provided to demonstrate the structural stability of the fire rated boundary walls and therefore, their effectiveness in protecting neighbouring property from fire. The building is not a single firecell, single floor building, and the design does not include effective fire venting. Subparagraph 4.2.3 of the compliance document applies to the building, Subparagraph 5.3.2(e) indicates that an S rating applies to the internal wall of the warehouse firecell. Accordingly, the higher of the F and S rating applies to the internal wall and when calculating the S ratings for this FHC4 building, the designer should have taken account of the venting that is purported to be provided by the GRP roof panels. The Eurocode may be used in large compartment type building in the United Kingdom, on the basis that it will be used in accordance with that country's approved documents. The approved documents for the United Kingdom are not the same as those in New Zealand and should not necessarily be compared. The email from the Building Research Establishment (United Kingdom) raises concerns about the possible impact on firefighting operations in a scenario where intervention may involve increasing the available ventilation in an under ventilated fire, causing a sudden and dramatic increase in fire severity. The building is not permitted by Subparagraph 4.2.4. It is not clear that the building is a single floor building as the office firecell contains two floors. Subparagraph 5.6.13 of C/AS1 provides that this building should be sprinkler protected. The building elements supporting the roof are fire rated. The S rated wall appears to support the roof and no documentation has been provided to demonstrate that the roof will collapse with no impact on the surrounding wall structure.
Fire engineers	The smokecell wall between the office and warehouse has been upgraded to an F60 rated wall. There is still smokecell separation between office levels at the main stairway. Passive smokecell construction, which creates smokecell separation between office levels, satisfies the need for smoke control between the two levels and thus meets the criteria of C/AS1 Subparagraph 6.21.3. The method used for the S rating fully complies with the method used for development of Table 5.1 of C/AS1. Use of this calculation method in relation to large firecell compartments with limited initial fire ventilation, is a correct approach and is likely to over specify the S rating. The 20% horizontal roof ventilation design assumption is based on C/AS1 Table 5.1. An S180 rating is calculated on the same basis as C/AS1 Table 5.1 but with a fire hazard category 4 fire load. The method used is the same as that used to develop C/AS1 Table 5.1 and is the usual design method. There is no history of S rated walls designed in accordance with the C/AS1 Table 5.1 method under-performing in practice. The internal office to warehouse firecell wall is not required to be S rated and hence only the F rating is applicable. For large firecells with low ventilation the time equivalent method tends to be conservative. The S rating is to prevent fire spread or structural collapse for the complete burnout of the firecell and is derived from the Firesys spreadsheet program using the Eurocode method as prescribed in C/AS1 Table 5.1. The required fire resistance rating has a value of S180. The ventilation and thermal conductivity characteristics assumed in the calculation of the S rating are all in accordance with C/AS1 Table 5.1. Note 4 of Table 5.1 allows up to A_v of 0.5% of unlined wall area (complied with in calculations) and that A_h/A_f may be taken as 0.2 (complied with in calculations).

Owner	Designed to the industry standard Eurocode criteria and the boundary walls designed to stand up in a fire for 3 hours. The standard fire response time is averaged at 11 minutes, so common sense should prevail to anticipate the fire service should respond prior to the wall collapsing. The rear wall of the office does not require an S rating. If the wall falls over either way, it is still 27m from a road edge and 60m from the neighbouring building.

4.12 Effective fire venting

Applicant	The roof area has not been designed for effective fire venting. GRP roof panels do not provide for effective fire venting, as required by the compliance document. GRP roof panels are a product designed for natural roof lighting. The manufacturer has not endorsed its use for effective fire venting. While there is no definition of 'effective fire venting', fire is defined as 'the state of combustion during which flammable materials burn producing heat, toxic gases, or smoke or flame or any combination of these'. Therefore, fire venting includes smoke venting, and it is irrelevant to split fire and smoke venting.
Owner's legal advisors	There is no definition given for effective fire venting. GRP roof panels have been used for 40 years in the industry and the product is industry recognised. The building is classified as a single storey warehouse building with a separate fire cell for the office, which has two forms of egress with features surpassing the standard required, additional egress to the exterior, and an upgraded alarm. The applicant now brings fresh additional evidence, and this is outside the determination. This refers to ineffective smoke and heat vent when the temperature is at or below 300℃. The Building Code does not discuss smoke and heat venting, or any degrees; therefore, designs cannot be made to clauses that don't exist. The original fire safety design utilised and focused on the unlined and non-fire rated warehouse roof as effective fire venting because under Table 5.1 of C/AS1 it is permitted to assume that 20% of such a roof will provide effective fire venting by means of roof collapse. This means of effective fire venting is allowed by Table 5.1 and exceeds the 15% venting requirement of C/AS1 Subparagraph 4.2.4. The term used in Subparagraph 4.2.4 is effective fire venting, not effective smoke venting. If specific smoke venting was desired, C/AS1 would have reflected this as there are references in C/AS1 on several occasions to smoke control. The purpose of the intended fire venting was to reduce post-flashover (500℃ or more) fire intensity, not to provide pre-flashover (200℃ or less) smoke venting. The building meets the requirements of Clause C3.3.9 because it has complied with C/AS1, including Subparagraph 4.2.4 that requires at least 15% of the roof area be designed for effective fire venting. Although effective fire venting is not defined, the long history of successful use of GRP roof panels, with no fire fatalities linked to venting issues, shows that the practice is appropriate and effective. As previously submitted, the determination process is not the proper forum effectively to ban a commonly used product with good in-service history in favour of new products being promoted in the market place. Any review of the status quo on GRP panels as effective venting should include the opportunity for all industry participants to put forward their views so that all aspects are fairly considered.
Fire engineers	The design provides 15% effective fire venting and hence may have unlimited area in accordance with C/AS1 Subparagraph 4.2.4, and this is provided for effective fire venting area in accordance with The New Zealand Fire Engineering Design Guide recommendations. The roof of the warehouse firecell has been provided with in excess of 15% effective fire venting.
Owner	If every warehouse was required to have sprinklers, it would make New Zealand warehouses uneconomical. Most products, once either smoked out or drenched from sprinklers are ruined anyway.

4.13 Firefighter tenability times

Submission	Summary of submission
Applicant	The provision of adequate means of escape from fire does not preclude the need for rescue operations: there is always a risk that occupants could be impaired or trapped by the fire. There exists a fire brigade intervention model that can be used by designers alongside other fire modelling techniques to go quite some way towards quantifying fire service activity. Alternatively, designers are welcome to enter into a Fire Engineering Brief process to discuss these issues in advance of submitting a building consent application, in order to determine the specific needs of fire service personnel in accordance with Clause C3.3.9 of the Building Code. Firefighting operations are conducive to, and an inherent part of, many of the performance requirements of Clauses C2 to C4. In particular, the role attending fire service personnel play in controlling the spread of a fire may be critical to building evacuation, rescue operations and the protection of other property. This is specifically recognised in Clause C3.3.9 of the Building Code.
Fire engineers	If the fire service considers that there is a quantifiable cost/benefit based case for a change in policy to allow firefighters tenable conditions to enter warehouse buildings, it should develop this case and present it to the profession. The newly perceived need by the applicant for fire service search of this or any other type of similar building remains unsubstantiated. If such a change in policy is deemed by the Department to be necessary then it will add a considerable expense to the construction cost. With regard to this warehouse building, the occupants will have in place procedures to comply with the Fire Safety Evacuation of Building Regulations. If unoccupied, the Act permits the building to burn as long as it does not affect other property. Firefighters are not required to enter the building and they have their own health and safety policies with due regard to when it is appropriate to enter a building for firefighting purposes.
Owner's legal advisors	Nothing in the Act, the Building Code refers to firefighter tenability time or requires an environment within a building that will remain tenable for firefighters to conduct rescue and firefighting operations. The principle of the reasonable expectations of a person who is authorised by law to enter a building to undertake rescue operations or firefighting to be protected from injury or illness when doing so does not elevate what is a desirable installation from the perspective of the fire service carrying out their work, into a mandatory requirement that is over and above the requirements of the Building Code.

5. The expert's reports

5.1 As stated in paragraph 1.7, I commissioned a fire safety engineer ("the expert") to provide me with a report about the aspects of the building's fire safety design. My brief to the expert was broadly set out (refer paragraph 1.4) and included a request to provide a view on the requirements of the Building Code in respect of firefighter tenability times (see paragraph 1.6). The expert provided a report dated 21 January 2009.

5.2 I note the expert considered the original fire safety design and the first amended fire safety design (which was provided by the fire engineers on 24 September 2009).

5.3 In the report, in response to the applicant's comments pertaining to significant departures from C/AS1, the expert also noted that an absolute assessment for the fire safety design may be undertaken, which does not require an equivalent level of safety be demonstrated if a C/AS1 fire safety system is removed.

Assessment of the original fire safety design

5.4 I have summarised the expert's comments in the same general framework as used for the summary of the submissions made by the parties.

Fire safety design aspect	Comments of the expert about the original fire safety design
Fire hydrants	Written support for the coverage of hydrants as required by C/AS1 part 8 should be provided by the [fire engineers] to verify whether the paragraph is complied with and if not the demonstration that the performance requirements have been met.
Means of escape from fire and fire safety systems	The canopy is an opened sided building and designed to C/AS1. The intended limit on content to FHC2 should be specifically tied into the operational control of the building. The escape height is ambiguous as the information presented indicates two different purpose groups with two different escape heights which therefore indicates there are two separate firecells, however, it is also stated that the building comprises of a single firecell. The occupant density imposes a limit that is not necessarily policed unless written into the compliance schedule. The intermediate floor does not appear in the occupancy assessment. The interpretation of Table 4.1 in the original fire safety report is incorrect for the required fire safety precautions. Installation of fire hose reels or extinguishers are a specified system and should be identified as being installed or not. The means of demonstrating the performance requirements for the smoke control system considering the specific details of the separation in question have not been presented and there is insufficient justification given. The external fire spread was assessed using a specific fire assessment methodology; however, the actual method of assessment is not clear.
Fire rating and firecell size	The C/AS1 requirement for a safe place may not have been achieved if occupants need to pass under a canopy which is attached and therefore forms part of the building, and the travel distance in terms of the safe place appears incorrect. The travel distances comply with C/AS1 based on a completely open floor plan. Once racking is provided, the design assumptions may vary. The simulation used for egress is a zone model which is inappropriate for 10000m^2 unless a full contextual justification and sensitivity assessment is provided. The S rating is noted as a calculation but it is not mentioned where the use of the calculation specifically requires application, and the limits should be considered in the assessment to give context to the level of uncertainty in the methodology for this case. The original fire safety report does not mention how compliance with Paragraph 4.2 of C/AS1 is achieved, or if specific fire engineering design has been undertaken in respect of the firecell size.
Firefighter tenability times	There was no data to support the view that it is reasonable to suppose that rescue operations within the building may need to be undertaken by Fire Service personnel. At what point or occupant number would it not be reasonable to expect rescue operations to be undertaken? Demonstrating that 'the environment within the building will remain tenable for sufficient time' is met or is the expected level of performance of a C/AS1 solution could not be achieved in many circumstances.
Effective fire venting	Fire load and associated issues for either effective fire venting or sprinklers is not an easy debate. Guidance on acceptance criteria has only been issued recently, in the past almost all designers considered vents that melted to some extent to achieve the performance requirement of the Building Code.

5.5 I acknowledge that through the revisions to the original fire safety report, a number of the issues raised have been resolved. This has been taken account of in the discussion in paragraph 9.

The further expert's report

5.6 The expert provided me with a further report dated 16 April 2009 commenting on the second amended fire design. For the purposes of this determination, I have included the comments from this report in the schedule containing comments of the expert regarding the original fire safety design (refer paragraph 5.4). As the determination now also considers the third amended fire safety design, in addition to the original fire safety design, I have taken the expert's comments into account, however I have not separately summarised the content of the further report.

6. The alternative solution framework

6.1 The relevant provisions of C/AS1 amount to a means of compliance with the performance requirements of Clauses C of the Building Code. I have considered Clauses C2, C3, and C4 in this determination because the objectives, functional requirements, and performance criteria of each clause are connected to the other clauses.

6.2 One way of evaluating compliance with the Building Code is to compare the design against the Acceptable Solution. In comparing a proposed alternative solution with an Acceptable Solution, it is useful to bear in mind the objectives of the relevant Building Code clauses. The approach in determining whether the design complies with Clauses C2, C3, and C4 of the Building Code is to examine the design features that are intended to provide means of escape from fire, resist the spread of fire, and provide structural stability during fire.

6.3 I note that in Determination 2004/5, the antecedent of the Department, the Building Industry Authority ("the Authority") said:

> As for the proposed alternative solutions, the Authority's task is to determine whether they comply with the performance-based Building Code. In doing so, [the BIA] may use the Acceptable Solution as a guideline or benchmark.[5]
>
> The Authority sees the Acceptable Solution C/AS1 as an example of the level of fire safety required by the Building Code. Any departure from the Acceptable Solution must achieve the same level of safety if it is to be accepted as an alternative solution complying with the Building Code.
>
> As it has in several previous determinations, the Authority makes the following general observations about Acceptable Solutions and alternative solutions:
>
> (a) Some Acceptable Solutions cover the worst case so that in less extreme cases they may be modified and the resulting alternative solution will still comply with the Building Code.
>
> (b) Usually, however, when there is non-compliance with one provision of an Acceptable Solution it will be necessary to add some other provision to compensate for that in order to comply with the Building Code.

[5] Auckland City Council v NZ Fire Service [1996] 1 NZLR 330

> The process by which an Acceptable Solution is changed is set out in section 49 of the Building Act [1991] and involves widespread consultation. Therefore, no matter how strong the arguments a party to a determination advances to justify an alternative solution providing a lower overall level of safety in the particular building concerned, those arguments cannot be accepted for the purposes of the determination. The Authority is mindful of the following passage from the decision in a case[6] concerning the interpretation of the expression "low probability" in Clause B1 of the Building Code:
>
> > 'It is tempting to say that [a risk that does not have a low probability] is a risk that a reasonable and responsible contractor or engineer would not take having regard to the object of protecting property, but that might be to re-write the Building Code. The Code is intended to set the standard for those in the building industry, not the other way round.'

6.4 With respect to this argument, in Determination 2005/109, the Department went on to say:

> In the light of those comments, I accept the Authority's reference to "the worst case" is too broadly worded in an application of this type. A better formulation would be
>
> (a) Some Acceptable Solutions cover the worst case of a building closely similar to the building concerned. If the building concerned presents a less extreme case, then some provisions of the Acceptable Solution may be waived or modified (because they are excessive for the building concerned) and the resulting alternative solution will still comply with the Building Code.
>
> (b) Usually, however, when there is non-compliance with one provision of an Acceptable Solution, it will be necessary to add some other provision or provisions in order to comply with the Building Code.

6.5 In summary, in evaluating the design as submitted I need to compare the levels of fire safety achieved in the design across all the relevant provisions of the Building Code and confirm (or otherwise) whether equivalence has been achieved, giving due regard to the abovementioned guidelines.

7. The Building Code requirements for the protection of firefighters

7.1 The Building Code requires buildings to contain a range of important protections for firefighters. The requirements of Clauses C2, C3 and C4 relating to means of escape, spread of fire and structural stability during fire all require buildings to meet certain levels of performance in respect of those matters so firefighters can undertake firefighting activities.

7.2 The nature of the firefighting activities buildings must allow firefighters to undertake vary with each Clause. For example, Clause C2 only concerns rescue operations by firefighters. Clause C3 concerns rescue operations and protecting property (which includes the building itself). Clause C4 concerns rescue operations and firefighting operations. Firefighting operations is not defined in the Building Code or Act but is broader than the other terms used in the Act and so would include protecting property, controlling the spread of fire, and extinguishing the fire.

[6] Auckland City Council v Selwyn Mews Limited and Ors 18/6/2003 DC Auckland CRN 2004067301-19

7.3 Another important aspect of the interpretation of Clauses C2, C3 and C4 concerns the relationship between the performance criteria and the functional requirements in the Building Code. A building must satisfy the performance criteria when performing its functional requirements. The definition of "performance criteria" in section 7 of the Act states 'the performance criteria are the qualitative or quantitative criteria that the building is required to satisfy in performing its functional requirements'. The functional requirements in the Building Code are just as important as the performance criteria. The functional requirements establish the functions the building must be able to carry out and the performance criteria establish the qualitative or quantitative criteria the building must satisfy. The functional requirements and performance criteria must be read in context and cannot be applied independently of each other.

7.4 The performance criteria in Clause C2 require buildings to have means of escape from fire that allow fire service personnel adequate time to undertake rescue operations (Clause C2.2(b)). The objective is to facilitate fire rescue operations (Clause C2.1(b)). Clause C2 is limited to the role of fire service personnel undertaking rescue operations and does not include firefighters protecting property.

7.5 The performance criteria in Clause C3 require buildings to have safeguards against fire spread so firefighters may undertake rescue operations and protect property (Clause C3.2(b)). The objective is to provide protection to fire service personnel during firefighting operations (Clause C3.1(b)). In particular, the performance criteria in Clause C3.3.9 require fire safety systems to facilitate the specific needs of fire service personnel to carry out rescue operations and control the spread of fire.

7.6 The performance criteria in Clause C4 relating to structural elements require buildings to maintain structural stability during fire to allow fire service personnel adequate time to undertake rescue and firefighting operations (including protecting property, controlling the spread of fire and extinguishing the fire) (Clause C4.2(b)). The objective is to safeguard people (and this includes firefighters) from injury due to loss of structural stability during fire (Clause C4.1(a)).

7.7 There are also some more general provisions in the Act that are relevant to the Building Code requirements for the protection of firefighters. Section 16 of the Act requires all buildings to comply with the functional requirements and performance criteria in the Building Code in their intended use. That term "intended use" is defined in section 7 and includes "activities undertaken in response to fire". Thus, buildings must comply with the functional requirements and performance criteria in relation to activities in response to fire and this includes firefighting operations. Section 4(2)(h) of the Act requires various persons including the Chief Executive to take account of 'the reasonable expectations of a person who is authorised by law to enter a building to undertake rescue operations or firefighting to be protected from injury or illness when doing so'.

7.8 The level of protection afforded to firefighters carrying out firefighting operations was considered in Determination 2001/5 and stated:

> The Authority does not accept that the life of a firefighter is to be safeguarded only while the firefighter is undertaking rescue operations or protecting household units or other property. It is enough that the firefighter is in or around the building for the purpose of activities taken in response to fire or other emergencies as mentioned in the definition of "intended use".
>
> However, in this case the designer has taken the view that their proposed fire ratings are adequate to protect occupants until they escape from the building, and that there is no requirement to protect the building itself and therefore no requirement to protect firefighters when they are protecting the building. For the reasons set out above, the Authority disagrees with that view.
>
> The Authority recognises that there is no such thing as absolute safety. The degree to which a firefighter's (or anyone else's) life is to be safeguarded must conform to section 6(3) of the Act. The Acceptable Solution specifies fire resistance ratings that comply with the building code, but they are not the only means of complying.
>
> The Authority therefore concludes that, in order to comply with the building code, then, unless some other compensating provision is made, the building elements concerned must have fire resistance ratings appropriate for the protection of firefighters, whether they are performing rescue operations or protecting the building. That does not necessarily mean that the ratings must be those specified in the Acceptable Solution.

7.9 Although the determination was made under the Building Act 1991, the relevant sections of the Act and the Building Code have not been substantially changed, and I therefore consider that the findings made in Determination 2001/5 are still directly relevant.

7.10 Therefore, I consider that the Building Code has significant requirements for the protection of firefighters, requiring:

- buildings to have means of escape from fire that allow fire service personnel adequate time to undertake rescue operations (Clause C2.2(b));
- buildings to have safeguards against fire spread so firefighters may undertake rescue operations and protect property (Clause C3.2(b));
- fire safety systems to facilitate the specific needs of fire service personnel to carry out rescue operations and control the spread of fire (Clause C3.3.9);
- the structural elements in buildings to maintain structural stability during fire to allow fire service personnel adequate time to undertake rescue and firefighting operations without injury due to loss of structural stability (Clause C4.2(b)).

8. The original fire safety design

8.1 The determinations process has seen a number of iterations of the fire safety design provided for the building. I note that the fire engineers have stated that 'the fire design itself has not changed significantly, and it is primarily further documentation and explanation of the design that has been provided.'

8.2 I note that a fire design supporting a building consent application should:

- be completely and accurately documented
- satisfactorily demonstrate compliance with Clauses C of the Building Code
- have sufficient documentation and references supporting any engineering assumptions and judgement, and demonstrate best practice design has been followed
- indicate any omissions of Acceptable Solution requirements where C/AS1 is being used as the basis for the design.

8.3 It is clear from the comments of the expert in respect of the original fire safety design as discussed in paragraph 5.4 that there are aspects of the design that do not comply with the Building Code, and aspects for which there is not satisfactory information to demonstrate compliance with the Building Code. These include:

- the occupancy assessment details
- the fire safety precautions listed as being provided, and the lack of fire hydrants
- the assumption for fire egress in respect of travel distances and provision of a safe place
- the substantiation of the calculation of the S rating, which uses a 10-20 minute roof collapse time
- the detail of the smoke control system
- the methodology used to assess external fire spread
- the design of the firecell size.

8.4 Based on my assessment of the original fire safety design and the comments of the expert, I am therefore of the view that there were aspects of the original fire safety design that were not satisfactorily documented to demonstrate compliance with Clauses C2, C3, and C4 of the Building Code and to support the fire engineering design.

8.5 I have concluded therefore that the original fire safety design as submitted by the applicant does not comply with the Building Code.

9. The third amended fire safety design

Outstanding issues

9.1 I have considered the issues that have been identified by the parties as outstanding in the third amended fire safety design which are:

- Fire hydrants – the design of the fire hydrants (refer to paragraphs 9.3 to 9.12)
- Fire ratings and firecell size – the fire ratings applied and the design of the firecell size (refer to paragraphs 9.13 to 9.26)
- Effective fire venting – the design of the effective fire venting using GRP roof panels (refer to paragraphs 9.31 to 9.37).

9.2 These are now discussed in turn. I am satisfied that the remaining aspects of the third amended fire safety design demonstrate compliance with the Building Code.

Fire hydrants

9.3 I have carefully considered the arguments put forward by the parties and the expert.

NZS 4510:1998 Fire hydrant systems for buildings

9.4 With respect to the requirements of the applicable fire hydrant standard NZS 4510:1998, I note the 1998 standard does not provide a great deal of guidance for the design of fire hydrant systems for single floor buildings. However, I also note the standard requires hydrants to be located in protected lobbies or stairwells, which is not possible in single floor buildings, however:

- the foreword states:

> NZS 4510:1998 *Fire hydrant systems for buildings*, supersedes NZS 4510:1978 *Code of practice for riser mains for fire service use*…. The change in title reflects the fact that low rise buildings with very large plan areas as well as multi-storeyed buildings may require internal hydrant systems in order to allow the Fire Service to operate efficiently.

- the standard ‘specifies the requirements for the design, installation, commissioning, and testing of fire hydrant systems within buildings’
- the standard includes references in specific parts to design for single floor buildings, for example, there is a specific value for single floor buildings in Table 4 of clause 3.3 with respect to the design of simultaneous hose streams
- the standard includes references in specific parts to design for multi-storey buildings, for example, clause 5.1.5 states:

> Where the door of the enclosure is on a glazed exterior wall of a multi-storey building, either a verandah or other assembly area shall be provided extending at least 1m in front and 1m either side of the enclosure to provide protection from falling glass.

9.5 This evidence leads me to the view that NZS 4510:1998 specifies requirements for fire hydrant systems for both single floor and multi floor buildings.

NZS 4510:2008 Fire hydrant systems for buildings

9.6 With respect to the requirements of the new standard NZS 4510:2008, I note the foreword to the standard states:

> …the Standard also provides information on the provision of hydrants to protect low-rise buildings (see Appendix C). Given that this is a new addition to the Standard, the committee decided to made this appendix informative (that is, not mandatory) rather than normative (mandatory).

9.7 The new Appendix C (referred to in the foreword of NZS 4510:2008) states:

> This informative Appendix has been introduced to provide guidelines for the provision of hydrants to protect low-rise buildings such as warehouses and shopping malls.

9.8 I do not agree with the statement of the fire engineers that NZS 4510:2008 notes the installation of hydrants in single floor buildings is new and not currently mandatory. The requirement for the installation of hydrants in single floor buildings is not new, however, the explicit framework and guidelines provided for this type of installation (in Appendix C) are new, and these guidelines take account of the fact that there are differences in the way that the Fire Service operates when fighting fires in low-rise buildings compared to high-rise buildings. I therefore do not agree with the statement of the fire engineers that because NZS 4510:2008 now specifically provides guidance for single storey and low rise buildings, these requirements are new.

C/AS1 requirements

9.9 Paragraph 8.2.1 of C/AS1 states 'Where required by Table 4.1, a fire hydrant system shall be installed.' I note there is no dispute that the C/AS1 Table 4.1 minimum fire safety precautions for this building include a 'fire hydrant system' (Type 18c) that is 'Required where Fire Service hose run distance, from the Fire Service vehicular access (see [Subparagraph] 8.1.1) to any point on any floor, is greater than 75m.'

9.10 The fire engineers have stated that 'Technically we agree… that a type 18c system is required by C/AS1 to comply with NZS 4510:1998.' They then go on to state that the standard has a zero hydrant system applicable to the building.

9.11 I do not accept the argument of the fire engineers that NZS 4510:1998 does not provide information on installing a hydrant in a single level building and that a 'zero hydrant system' applies to the building. Therefore, I am of the view that the third amended fire safety design does not comply with C/AS1 in respect of the provision of fire hydrants, and does not comply with the requirement of Clause C3.3.9 that 'The fire safety systems installed shall facilitate the specific needs of fire service personnel to … control the spread of fire.'

9.12 This element of the third amended fire safety design was intended to comply with C/AS1, being the relevant Compliance Document. I note that compliance with C/AS1 is one way, but not the only way, of complying with the requirements of the Building Code. That is to say, the building could be designed to comply with the Building Code by way of an alternative solution.

Fire ratings and firecell size

Firecell size

9.13 I note that C/AS1 is structured to look at fire safety requirements on a firecell by firecell basis, and the standard application of subparagraph 4.2.4 is to a large, single floor firecell. The office area is a separate firecell and contains an intermediate floor, but is not a fully fire separated upper level. Therefore subparagraph 4.2.4 can be applied to the single storey warehouse firecell, however effective venting is required (refer to paragraphs 9.31 to 9.34).

S rating calculations and the Eurocode time equivalence method calculation

9.14 I note that Subparagraph 5.6.11 of C/AS1 states 'Where fire hazard category 4 applies to a given purpose group (see Table 2.1), the S rating associated with the firecell shall be determined by fire engineering design…' I observe that the third amended fire safety design notes that:

> New Zealand Building Code compliance is generally demonstrated using [C/AS1] for New Zealand Building Code Clauses C1, C2, C3, C3, Fire Safety, and the Acceptable Solutions [F6/AS1] and [F8/AS1]. One Alternative Solution is provided to address smoke control for intermediate floors.

9.15 It is clear that the calculations for the S rating associated with the warehouse firecell cannot be considered as complying with C/AS1 as specific fire engineering design is required and therefore this design must be considered as outside the scope of C/AS1 and must be considered as a proposed alternative solution.

9.16 The fire engineers have stated the basis of their justification is that 'the methodology approved and applied in Table 5.1 of C/AS1 can be extrapolated and applied to [FHC4 firecells].'

9.17 I note that Table 5.1 is entitled 'Values of t_e for calculating the S ratings for Fire Hazard Categories 1, 2, and 3'. Note 7 of the table states:

> For firecells which differ from these assumptions, especially with regard to the materials of construction, more accurate answers may be obtained with specific fire engineering design, which is mandatory for fire hazard category 4.

9.18 C/AS1 is clear that fire hazard category 4 firecells clearly require specific fire engineering design. The specific engineering design, whatever methodology is chosen, may use the Eurocode method, and should include a full analysis of the fire effects within the building, describing the method used and all the assumptions made.

9.19 The third amended fire safety design, and supplementary information (provided as a part of the submission from the owner's legal advisors dated 2 February 2010), includes:

- the spreadsheet calculation for the S rated wall, based on the industry standard Eurocode calculation, and a peer review of the calculation
- information on S rating provided by 150mm minimum thickness S rated walls.

9.20 The supplementary information provided was in response to the second draft determination, which found that full engineering calculations that set out the inputs, assumptions, and limitations should be provided as a part of the fire design.

9.21 I accept that the third amended fire safety design and the supplementary information is sufficient to support the calculation of the S rating, and therefore demonstrate compliance with the Building Code.

The application of F rating to the wall between the two firecells

9.22 In accordance with Subparagraph 5.3.1 of C/AS1, 'F ratings apply to primary and secondary elements within a firecell, including walls and floors which are fire separations, together with their supporting elements within the same firecell. In accordance with Subparagraph 5.3.2:

> 'S ratings apply to:
>
> (a) Primary elements which, within a firecell, provide stability to an external wall not permitted to have 100% unprotected area due to:
>
> (i) proximity of the building to a relevant boundary, or
>
> (ii) the configuration of the building or siting of adjacent buildings, where there is a threat of fire spread to sleeping purpose groups.
>
> (b) Secondary elements forming parts of an external wall which are not permitted to be unprotected areas.
>
> (c) All primary elements, in any building with an escape height exceeding 25m (see Paragraph 5.7.7).
>
> (d) Fire separations between firecells containing other property.
>
> (e) Fire separations in firecells which require subdivision due to restrictions on floor areas (see Paragraph 4.2.3).
>
> (f) Buildings containing car parking (see Paragraph 6.10.3).

9.23 The applicant contends that Subparagraph 5.3.2(e) applies. I am of the view that the floor area restrictions in Subparagraph 4.2.3 do not apply to the warehouse firecell and therefore Subparagraph 5.3.2(e) does not apply.

9.24 The third amended fire safety report details the F rating, derived from C/AS1 Table 4.1, as F60 and that it is applicable to the internal firecell separation wall, which will be two way 60/60/60 fire rated and the doors between the two firecells, which will be -/60/30 smoke rated.

9.25 The fire engineers have stated '…an S rating does not apply to the internal office to warehouse firecell wall under the provisions of C/AS1 [Subparagraph] 5.3.2. This internal wall is not providing stability to an external boundary wall. Therefore the F60 rating is correctly applied.'

9.26 Based on the evidence that the F60 wall is not providing stability to the external walls that require an S rating be applied (Subparagraph 5.3.2(a)) and that the floor area restrictions of Subparagraph 4.2.3 do not apply (Subparagraph 5.3.2(e)), I accept that the third amended fire safety report complies with C/AS1 in respect of the fire resistance rating applied to the internal wall, between the two firecells.

Effective fire venting

E*ffective fire venting*

9.27 In Determination 2010/004, I discussed the design features of firecells and their performance in severe fire conditions, and I said:

> Where a firecell has fire rated roof elements, this provides a mechanism for allowing the roof structure to sustain its capacity in severe fire conditions …
>
> The provision of effective venting to 15% of the firecell roof area is an overarching temperature control device, which provides a mechanism for allowing a non rated roof structure to maintain its capacity in severe fire conditions …
>
> Typically, a firecell roof will collapse in severe fire conditions where:
>
> - there is no S rating applied (i.e. in the remote from boundary case and therefore the elements supporting the roof are not fire rated); and
> - there is not 15% effective venting provided to the firecell roof area.
>
> … I am of the view that provision of effective venting is a critical performance characteristic for Subparagraph 4.2.4, unless there is another safety mechanism to control firecell temperature and firecell size.

9.28 I acknowledge there are difficult issues with the interpretation of C/AS1. Determination 2010/004 explained my interpretation of Subparagraphs 4.2.3 and 4.2.4 of C/AS1 in respect to the building work considered in that Determination. I acknowledge there has been ongoing debate about these issues; however I believe the view I took of how C/AS1 should be interpreted was correct.

9.29 I have discussed requirements for the protection of firefighters in paragraph 7, and I note, in particular, the following about the requirements of the Building Code:

- The Building Code has significant requirements for the protection of firefighters requiring time for firefighters to carry out firefighting operations without injury due to loss of structural stability, and fire safety systems to facilitate the specific needs of firefighters to control the spread of fire and protect property.
- Building Code Clauses C4.3.1, C4.3.2, and C4.3.3 must allow firefighters time to undertake firefighting operations without injury due to loss of structural stability. Firefighting operations refers to a wide range of firefighting activities, including controlling the spread of fire, and extinguishing fire, undertaking rescue operations and protecting property. Therefore, the Building Code requires that buildings be designed to allow firefighters time to undertake firefighting operations without injury due to loss of the building's structural stability.

9.30 In addition to the comments I made in Determination 2010/004, I note the following about the application of the Building Code:

- The functional requirement C4.2 requires that 'Buildings shall be constructed to maintain structural stability in fire.'
- Clause C4.3.1 requires that 'Structural elements of buildings shall have fire resistance ratings appropriate to the function of the elements …'.
- The means of maintaining structural stability during fire could include protection (e.g. rating), the size of building elements (e.g. over design) or limiting the assault (e.g. fire venting, sprinklers).
- Effective fire venting is required by Subparagraph 4.2.4 for unsprinklered, single floor buildings, with unlimited floor area and non rated roof elements as a mechanism to limit the assault, as the effective fire venting allows the fire to vent through the roof, thereby reducing the temperature in the building and allowing structural elements to maintain their stability for a longer period of time.

The use of GRP panels to provide effective fire venting

9.31 I have carefully considered the arguments put forward by the parties, the expert, and information provided as discussed in paragraph 4.2, and I note the following points:

- there is no definition for effective fire venting, consequently it is difficult for any manufacturer to market their product as satisfying this criteria
- the use of GRP roof panels as effective fire venting is common practice, and such panels have been in use to provide venting for 15 years
- historically, the industry has been of the view, and made the assumption, that GRP roof panels melted to some extent to provide heat and smoke venting
- there is some evidence starting to emerge that the GRP roof panels commonly used in New Zealand may not perform to the assumed performance level of the product, however, at the current time, this evidence is in the form of small scale, limited testing
- some manufacturers of GRP roof panels have stated that their products cannot be used to provide effective fire venting, and some types of unreinforced plastics are being used instead
- the evidence supporting the use of GRP roof panels to provide effective roof venting is subjective and empirical at best, and does not have a very strong scientific basis.

9.32 I agree with the comments of the owner, fire engineers and expert that at a national level, further research is required by the industry. The rationale, means, and scientific basis for effective fire venting using GRP roof panels must be examined by the industry.

9.33 I also note that C/AS1 is generally considered conservative in terms of the performance of the building in severe fire conditions. Further, I note that there are compensating features with respect to this building of the firecell design, which include, the provision of about 20% of the roof area provided with GRP roof panels to the warehouse firecell, the S rating that is applied to the exterior firecell walls, and the firecells are fire separated and the office area is small.

9.34 However, despite this, I am of the view that the evidence and information provided to me about the rationale and means of effective fire venting through using the GRP roof panels is not sufficient to demonstrate Building Code compliance. Therefore, due to the lack of scientific evidence available at this time, I conclude there is insufficient information to demonstrate that the third amended fire safety design, in respect of the GRP roof panels, meets the performance requirements of Building Code Clause C4.3.1.

Conclusion

9.35 In summary, I have reached the following conclusions about the third amended fire safety design:

- the third amended fire safety design does not meet the Building Code requirements with respect to the provision of fire hydrants (refer to paragraphs 9.3 to 9.12)
    - the third amended fire design does not satisfy C/AS1 (Table 4.1/Type 18c), which was the proposed means of compliance
    - this element of the fire safety design may be addressed by way of an alternative solution
- the third amended fire safety design complies with C/AS1 with respect to the design of the F rating and firecell size, and, along with the supplementary information provided (refer to paragraph 9.19), is sufficient to demonstrate compliance with the Building Code as an alternative solution (refer to paragraphs 9.13 to 9.26)
- there is insufficient information to demonstrate that the third amended fire safety design using GRP roof panels to provide the required effective venting complies with Building Code Clause C4.3.1 (refer to paragraphs 9.31 to 9.34)
    - I have discussed this matter further in paragraphs 9.38 to 9.46, with respect to the building as constructed.

9.36 I note that the Department is currently consulting on proposals to change the Building Code requirements and associated documents for protection from fire. The proposed new Clause C, along with the proposed new verification method, sets out a method for specific designs to comply with the Building Code.

9.37 The proposed new verification method would require the analysis of the effects on a proposed building of a set of up to ten standard fire scenarios, with the parameters specified for pre and post-flashover conditions, thus providing more of a basis for specific engineering fire design to be undertaken.

Modification of the Building Code

9.38 I take the view that under sections 188(1) and 188(3)(a) of the Act I have the power to modify the authority's decision to grant the building consent by adding a waiver or modification of the Building Code subject to the appropriate conditions.

9.39 In the circumstances, I consider it is reasonable and appropriate to incorporate a modification of Building Code Clause C4.3.1 in this determination. I have concluded (refer to paragraph 9.35) that there is insufficient information to demonstrate that the third amended fire safety design, using GRP roof panels to provide the necessary effective fire venting, complies with Clause C4.3.1. Therefore, the modification of Clause C4.3.1 is such, if any, a modification of the extent to which the building must comply with Clause C4.3.1. This modification arises from the use of GRP roof panels as the means effective fire venting without evidence that provides reasonable grounds of the performance of the panels.

9.40 The relevant objective of Clause C4 is to 'Safeguard people from injury due to loss of structural stability during fire' and the relevant functional requirement of Clause C4 is to 'Allow fire service personnel adequate time to undertake rescue and firefighting operations'.

9.41 I note that there are compensating features with respect to this building of the firecell design, with respect to a C/AS1 compliant design (refer to paragraph 9.33), which include:

- the provision of about 20% of the roof area provided with GRP roof panels
- the S rating that is applied to the exterior firecell walls
- the firecells are fire separated and the office area is small.

9.42 I also note that the use of GRP roof panels as effective fire venting is common practice, there is empirical evidence that supports the use of this product and historically the industry has been of the view that GRP roof panels melted to some extent to provide heat and smoke venting.

9.43 While the third amended fire safety design did not demonstrate compliance of the GRP roof panels, I am of the view that the modification of the performance requirement C4.3.1 is minimal in this case in terms of the relevant objective and functional requirement of Clause C4 (refer to paragraph 9.40), because of the compensating features. I also note that the probability of the performance of the venting in making a difference in terms of structural stability in a particular fire is relatively low, although not negligible. It requires a number of low probability and adverse circumstances, each to occur as part of a particular fire event, such as a worst case fire or fire service intervention occurring late in the fire sequence.

9.44 I have also considered section 4 of the Act and considered the principles to be applied in performing functions or duties or exercising powers under the Act and I have taken account of the following principles:

- Section 4(h), which requires consideration of 'the reasonable expectations of a person who is authorised by law to enter a building to undertake rescue operations or firefighting to be protected from injury or illness when doing so'.
- Section 4(f), which requires consideration of 'the importance of standards of building design and construction in achieving compliance with the building code'.
- Section 4(b), which requires 'the need to ensure that any harmful effect on human health resulting from the use of particular building methods or products of a particular building design, or from building work, is prevented or minimised'.

9.45 I am of the view that the modification to the performance requirement C4.3.1 is minimal and does not adversely affect these principles.

9.46 Therefore, I consider it reasonable to incorporate a modification of Clause C4.3.1 in this determination. The modification of Clause C4.3.1 is such, if any, a modification of the extent to which the building must comply with Clause C4.3.1. This modification arises from the use of GRP roof panels as the means effective fire venting without evidence that provides reasonable grounds of the performance of the panels.

10. Decision

10.1 In accordance with section 188 of the Act I hereby determine that:

- the original fire safety design for the building does not comply with the Building Code; and
- the third amended fire safety design for the building:
  - does not comply with the Building Code in respect of the provision of fire hydrants
  - does not comply with the Building Code in respect of the information provided to support the design of the GRP roof panels to provide effective roof venting.

10.2 I also modify the authority's decision to issue the building consent by incorporating into that building consent a modification of Building Code Clause C4.3.1 with respect to the GRP roof panels provided as effective fire venting as specified in paragraph 9.46 of this determination.

Signed for and on behalf of the Chief Executive of the Department of Building and Housing on 5 November 2010.

John Gardiner
Manager Determinations

11. Appendix

11.1 The relevant clauses of the Building Code are:

Clause A2—INTERPRETATION

Fire Safety system The combination of all methods used in a building to warn people of an emergency, provide for safe evacuation, and restrict the spread of fire, and includes both active and passive systems.

Clause C2—MEANS OF ESCAPE

OBJECTIVE

C2.1 The objective of this provision is to:

(a) Safeguard people from injury or illness from a fire while escaping to a safe place, and

(b) Facilitate fire rescue operations.

Clause C3—SPREAD OF FIRE

OBJECTIVE

C3.1 The objective of this provision is to:

(a) Safeguard people from injury or illness when evacuating a building during fire.

(b) Provide protection to fire service personnel during firefighting operations…

FUNCTIONAL REQUIREMENT

C3.2 Buildings shall be provided with safeguards against fire spread so that:

(b) Firefighters may undertake rescue operations and protect property,

PERFORMANCE

C3.3.9 The fire safety systems installed shall facilitate the specific needs of fire service personnel to:

(a) Carry out rescue operations, and.

(b) Control the spread of fire.

Clause C4 - STRUCTURAL STABILITY DURING FIRE

OBJECTIVE

C4.1 The objective of this provision is to:

(a) Safeguard people from injury due to loss of structural stability during fire, and

FUNCTIONAL REQUIREMENT

C4.2 Buildings shall be constructed to maintain structural stability during fire to:

(b) Allow fire service personnel adequate time to undertake rescue and firefighting operations, and…

PERFORMANCE

C4.3.1 Structural elements of buildings shall have fire resistance appropriate to the function of the elements, the fire load, the fire intensity, the fire hazard, the height of the buildings and the fire control facilities external to and within them.

C4.3.2 Structural elements shall have a fire resistance of no less than that of any element to which they provide support within the same firecell.

C4.3.1 Collapse of elements having lesser fire resistance shall not cause the consequential collapse of elements required to have a higher fire resistance.

11.2 Except for Table 4.1, 4.1/2 and 5.1, which are included in paragraph 0 – 11.5, the relevant key parts of the compliance document C/AS1 referred to in the determination are:

C/AS1	**Text**
Subparagraph 4.2.3	Except as permitted by Paragraph 4.2.4, the floor area of an unsprinklered *firecell* to which an S *rating* applies, shall not exceed the maximum *firecell* floor area given in the following table. Fire hazard category (from Table 2.1) — Maximum firecell floor area (m^2) 1 — 5000 2 — 2500 3 — 1500 4 — Specific fire engineering design required
Subparagraph 4.2.4	In an unsprinklered single floor *building* where the *building elements* supporting the roof are not *fire* rated, the *firecell* floor area may be unlimited provided that no less that 15% of the roof area (distributed evenly throughout the *firecell*) is designed for effective *fire* venting.
Subparagraph 5.3.1	*F ratings* apply to *primary* and *secondary elements* within a *firecell,* including walls and floors which are *fire separations,* together with their supporting elements within the same *firecell.*
Subparagraph 5.3.2	*S ratings* apply to: (a) *Primary elements* which, within a *firecell,* provide *stability* to an *external wall* not permitted to have 100 *unprotected area* due to: (i) proximity of the *building* to a *relevant boundary*, or (ii) the configuration of the *building* or siting of *adjacent buildings*, where there is a threat of *fire* spread to sleeping *purpose groups.* (b) *Secondary elements* forming parts of an *external wall* which are not permitted to be *unprotected areas.* (c) All *primary elements,* in any *building* with an *escape height* exceeding 25m (see also Paragraph 5.7.7). (d) *Fire separations* between *firecells* containing *other property.* (e) *Fire separations* in *firecells* which require subdivision due to restrictions on floor areas (see Paragraph 4.2.3). *(f) Buildings* containing car parking (see Paragraph 6.10.3).
Subparagraph 5.6.11	Where *fire hazard category* 4 applies to a given *purpose group* (see Table 2.1), the *S rating* associated with the *firecell* shall be determined by *fire* engineering design, except that where there are multiple *purpose groups* on that floor, only one of which is in *fire hazard category* 4*,* the concession available from Paragraph 5.6.12 may apply.
Subparagraph 5.6.13	(a) In *buildings* with two or more full floors, or the total aggregated area of the intermediate floors in a *firecell* exceeds $35m^2$, all floors shall be sprinkler protected. (b) For a single storey *building* in which an intermediate floor not exceeding $35m^2$ is provided 5.6.13(a) does not apply, but the *building* shall be considered by specific *fire* engineering design under Paragraph 5.6.11.
Subparagraph 6.21.3	Except where permitted by Paragraphs 6.21.4 to 6.22.14, smoke control in *firecells* containing *intermediate floors* shall be by specific *fire* engineering design.
Subparagraph 8.2.1	Where required by Table 4.1, a *fire* hydrant system shall be installed. Refer to Appendix A, Paragraph A2.1.1, Type 18 for *fire* hydrant system requirements.

11.3 Table 4.1 of C/AS1:

Table 4.1: Fire Safety Precautions
Key to table references

Part 3	Paragraphs 3.1.5, 3.13.1 and 3.19.2
Part 4	Paragraphs 4.3, 4.3.1, 4.3.3, 4.4.1, 4.5.2, 4.5.3, 4.5.4, 4.5.7, 4.5.8, 4.5.9, 4.5.10, 4.5.13, 4.5.14, 4.5.15, 4.5.19
Part 5	Paragraphs 5.5.1, 5.6.6, 5.6.8, 5.9.4 (c)
Part 6	Paragraphs 6.2.1, 6.4.1, 6.7.1, 6.8.1, 6.8.5, 6.8.6, 6.10.1, 6.11.1, 6.15.1, 6.19.9, 6.21.2, 6.23.1 (d), 6.23.2, 6.23.3
Part 8	Paragraphs 8.2.1, 8.2.2, 8.2.3
Appendix A	Paragraphs A1.1.1 and A1.1.2

Fire safety precautions

Type	Description
1	Domestic smoke alarm system.
2	Manual fire alarm system.
3	Automatic fire alarm system with heat detectors and manual call points.
4	Automatic fire alarm system with smoke detectors and manual call points.
5	Automatic fire alarm system with modified smoke/heat detection and manual call points.
6	Automatic fire sprinkler system with manual call points.
7	Automatic fire sprinkler system with smoke detectors and manual call points.
8	Voice communication system.
9	Smoke control in air handling system.
10	Natural smoke venting.
11	Mechanical smoke extract.
12	No Type 12 currently specified.
13	Pressurisation of safe paths.
14	Fire hose reels.
15	Fire Service lift control.
16	Visibility in escape routes.
17	Emergency electrical power supply.
18	Fire hydrant system.
19	Refuge areas.
20.	Fire systems centre.

Special applications

a Not required where:
- i) the *escape routes* serve an *occupant load* of no more than 50 in *purpose groups* CS (excluding *early childhood centres*), CM, WL, WM, WH and WF, or
- ii) the *escape routes* are for *purpose group* SA and serve no more than 10 beds, (or 20 beds for trampers huts, see Paragraph 6.20.6), or
- iii) exit doors from *purpose group* SA and SR *firecells* open directly onto a *safe place* or an external *safe path* (see Paragraph 3.14).

b Where only a single *escape route* is available, no less than a Type 4 alarm is required. See Paragraph 3.15.3 for situations where sprinklers are required.

c Required where Fire Service hose run distance, from the Fire Service vehicular access (see Paragraph 8.1.1) to any point on any floor, is greater than 75 m.

e The smoke detection element is Type 5 within *firecells* containing sleeping accommodation. (See Appendix A for description of Type 5.)

f A direct connection to the Fire Service is not required provided a telephone is installed and freely available at all times to enable 111 calls to be made.

Note:
The numbered references are more fully explained in Appendix A. Throughout Table 4.1 dark shading identifies where sprinklers are required.

11.4 Table 4.1/2 of C/AS1 (extract):

Table 4.1/2: Fire safety precautions for active purpose group firecells
Occupant load 101 to 500

		Escape height									
Purpose group	FHC	0 m (or single floor)	<4 m (or two floors)		4 m to <10 m		10 m to <25 m		25 m to <34 m	34 m to <46 m	46 m to <58 m	over 58 m
WL	1	F0	F45		F45		F45		F30	F45	F45	F60
WM	2	F0	F60		F60		F60		F45	F45	F60	F90
WH	3	F0	F60		F60		F90		F45	F60	F60	F90
(Note 5)	4	F0		F30		F30		F45	F45	F60	F60	F90
		3f 16 18c	3f 16 18c	6 16 18c	3b 16 18c	6 16 18c	3b 15 16 18	6 15 16 18	6 15 16 18	6 9 15 16 18	7 9 13 15 16 18	7 9 13 15 16 18 19 20

11.5 Table 5.1 of C/AS1:

Table 5.1: Values of t_e for Calculating the S Ratings for Fire Hazard Categories 1, 2 and 3
Paragraphs 2.2.1, 5.5.2, 5.5.3, 6.10.5, 6.20.15

	Fire Hazard Category 1 (FLED = 400 MJ/m²)					Fire Hazard Category 2 (FLED = 800 MJ/m²)					Fire Hazard Category 3 (FLED = 1200 MJ/m²)				
	A_h/A_f					A_h/A_f					A_h/A_f				
A_v/A_f	0.00	0.05	0.10	0.15	0.20	0.00	0.05	0.10	0.15	0.20	0.00	0.05	0.10	0.15	0.20
0.05 or less	90	60	50	40	40	180	120	100	80	80	240	180	140	140	120
0.06	80	50	50	40	40	160	110	90	80	80	240	160	140	120	110
0.07	70	50	40	40	40	150	100	80	80	70	220	160	140	120	110
0.08	70	50	40	40	30	140	90	80	70	70	220	140	120	110	100
0.09	60	40	40	30	30	140	90	80	70	70	200	140	110	110	100
0.10	60	40	40	30	30	120	80	70	70	70	180	140	110	100	100
0.11	50	40	30	30	30	110	80	70	70	60	160	120	110	100	100
0.12	50	40	30	30	30	100	70	70	60	60	160	110	100	100	90
0.13	50	40	30	30	30	100	70	70	60	60	160	110	100	90	90
0.14	50	30	30	30	30	90	70	60	60	60	140	100	100	90	90
0.15	40	30	30	30	30	80	70	60	60	60	120	100	90	90	90
0.16	40	30	30	30	30	80	60	60	60	60	110	100	90	90	90
0.17	40	30	30	30	30	80	60	60	60	60	110	90	90	90	90
0.18	40	30	30	30	30	70	60	60	60	60	110	90	90	90	80
0.19	30	30	30	30	30	70	60	60	60	60	110	90	90	80	80
0.20	30	30	30	30	30	70	60	60	60	60	100	90	80	80	80
0.25 or greater	30	30	30	30	30	60	60	50	50	50	90	80	80	80	80

Notes:

1. **Determining S rating**
   S = kt_e where k = 1.0 for unsprinklered *firecells* and 0.5 for sprinklered *firecells*. Therefore in this table the t_e values are the same as the *S ratings* for unsprinklered *firecells*.
2. **Interpretation**
   A_f = floor area of *firecell* (m²)
   A_v = area of vertical openings in *external walls* of the *firecell* (m²)
   A_h = area of horizontal openings in roof of *firecell* (m²)
   Linear interpolation is permitted where values of A_v/A_f or A_h/A_f lie between those given in the table.
3. **Location of openings**
   Openings to allow *fire* venting should be located in the most practicable manner to provide effective cross-ventilation. This reduces structural *fire* severity and facilitates *fire* fighting operations.
4. **Effective openings**
   a) Only those areas of *external walls* and roofs which can dependably provide airflow to and from the *fire* shall be used in calculating A_v and A_h. Such areas include windows containing non-*fire* resistant glass and likely to break shortly after exposure to significant heat.
   b) An allowance can be made for air leakage through the *external wall* of the *building* envelope. The allowance for inclusion in A_v shall be no greater than 0.1% of the *external wall* area where the wall is lined internally, and 0.5% if unlined.
   c) Only roof venting which is specifically designed to open or melt rapidly in the event of *fire* shall be included in the area A_h.
   d) For single floor *buildings* or the top floor of multi-floor *buildings*, where the structural system supporting the roof is non-rated and directly exposed to the *fire* (i.e. no ceiling installed), A_h/A_f may be taken as 0.2.
5. **Areas not regarded as openings**
   For the purpose of calculating A_v it shall be assumed that doors in *external walls* are closed. Wall areas clad in sheet metal shall not be included in the area A_v.
6. **Intermediate floors**
   Where a *firecell* contains *intermediate floors*, separate calculations shall be made to determine t_e, first by taking A_f as the total floor area in the *firecell* (as defined in Paragraph 2.3.3), then by taking A_f separately as the floor area of each level. The highest value of t_e shall be used to determine the *S rating*.
7. **Background to table**
   Table 5.1 is derived using Equation E3 from Annex E, Eurocode DD ENV 1991-2-2: 1996, Eurocode 1: Basis of Design and Actions on Structures, Part 2.2 Actions on Structures Exposed to Fire (together with United Kingdom National Application Document); British Standards Institution, London, England. A *firecell* height of 3.0 m has been assumed and a thermal inertia factor corresponding to the most severe conditions (i.e. those which generate the highest t_e values and which correspond to use of k_b = 0.09 in Equation E3) for typical materials of *firecell construction*. For *firecells* which differ from these assumptions, especially with regard to the materials of *construction*, more accurate answers may be obtained with specific *fire* engineering design, which is mandatory for *fire hazard category* 4.