Determination 2005/169

Single means of escape from a high-rise apartment building at 10-14 Upper Queen Street, Auckland City

1 The dispute to be determined

1.1 This is a Determination of a dispute under Part 3 Subpart 1 of the Building Act 2004 ("the Act") made under authorisation by me, John Gardiner, Determinations Manager, Department of Building and Housing, for and on behalf of the Chief Executive of that Department.

1.2 The applicant is Upper Queen St Properties Limited, ("the applicant"). The other parties are the Auckland City Council ("the territorial authority") and the New Zealand Fire Service Commission ("the Fire Service"), which has the right or obligation to give written notice to the territorial authority in respect of these matters.

1.3 I take the view that the matter for Determination is whether a new apartment building with a single means of escape from fire complies with Clauses C2 and C3 of the Building Code (the First Schedule to the Building Regulations 1992) as required by Sections 177 and 188 of the Act.

1.4 In making my decision, I have not considered any other aspects of the Act or the Building Code.

2 Procedure

2.1 The building

2.1.1 The proposal at 10-14 Upper Queen St consists of two apartment towers constructed above four levels of basement carparking. The west tower is four stories above ground level and the east tower is twelve stories above ground level. A typical floor plan is included as Figure 1, with an elevation showing the relationship between the two towers included as Figure 2. The ground floor level of the west tower includes the street level entry and reception, a manager's office, a mail lobby and services such transformer/switch room communications room, fire pump room, and a stair way descending to the car park below plus two apartments.

The east tower has six apartments on the ground floor, either one or two bedroom, which is typical of all floors.

Levels 1, 2 and 3 of the west tower have six apartments, either one or two bedroom.

Access to the east wing where the staircase and lifts are located is by an enclosed bridge which joins the two towers at each level.

Floor plans showing the two towers and their relationship are included as Appendix A.

2.1.2 All of the apartments open onto internal horizontal corridors, which provide access to the stairway and lifts. The proposed building is fully sprinkler protected in accordance with NZS4541, including smoke detectors and manual call points throughout. Charged hydrant riser mains are installed in the stairway and will be pressurised in accordance with AS1668. A voice communication system for use by fire fighters is also installed.

2.1.3 A typical floor plan for Levels 4-15 is reproduced in Figure 1. Figure 2 shows a typical elevation[1].

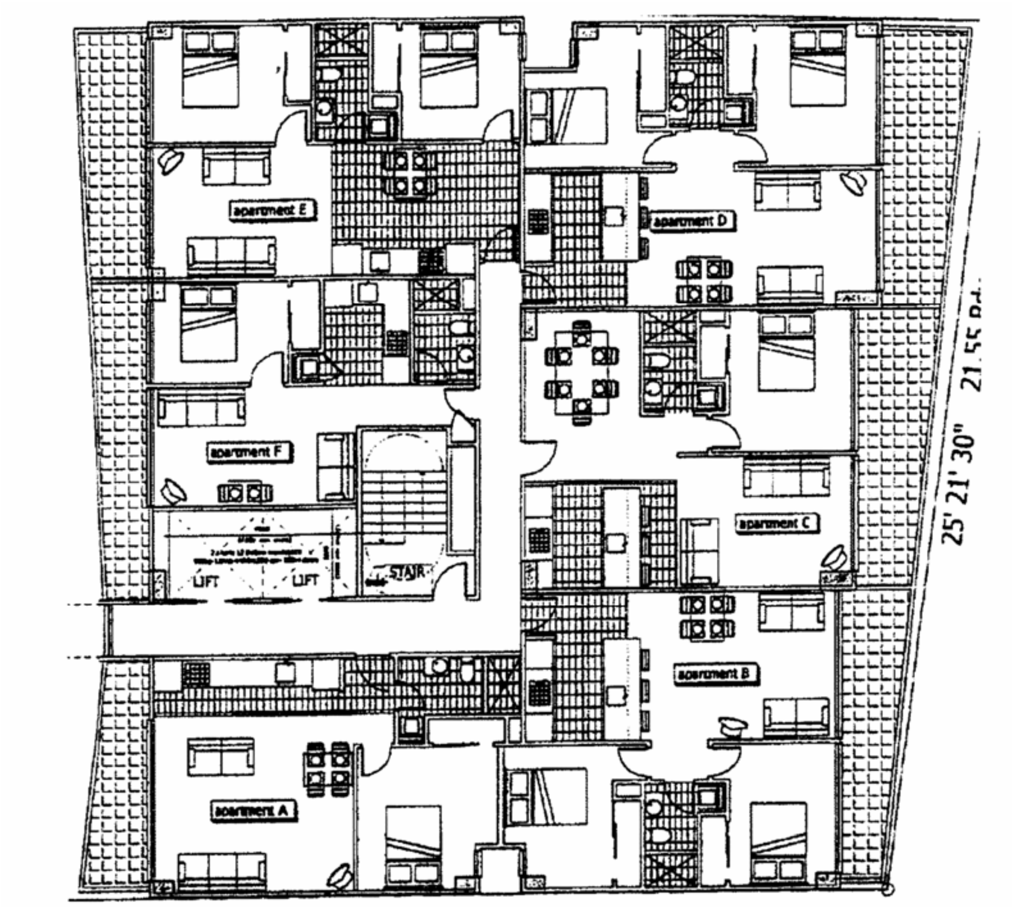

Fig. 1. Typical floor plan, East tower. LO4-L11 reproduced from TP_04 rev B

[1] *From the Architect's drawing No LO5 and L-11- dated 6.08.03*

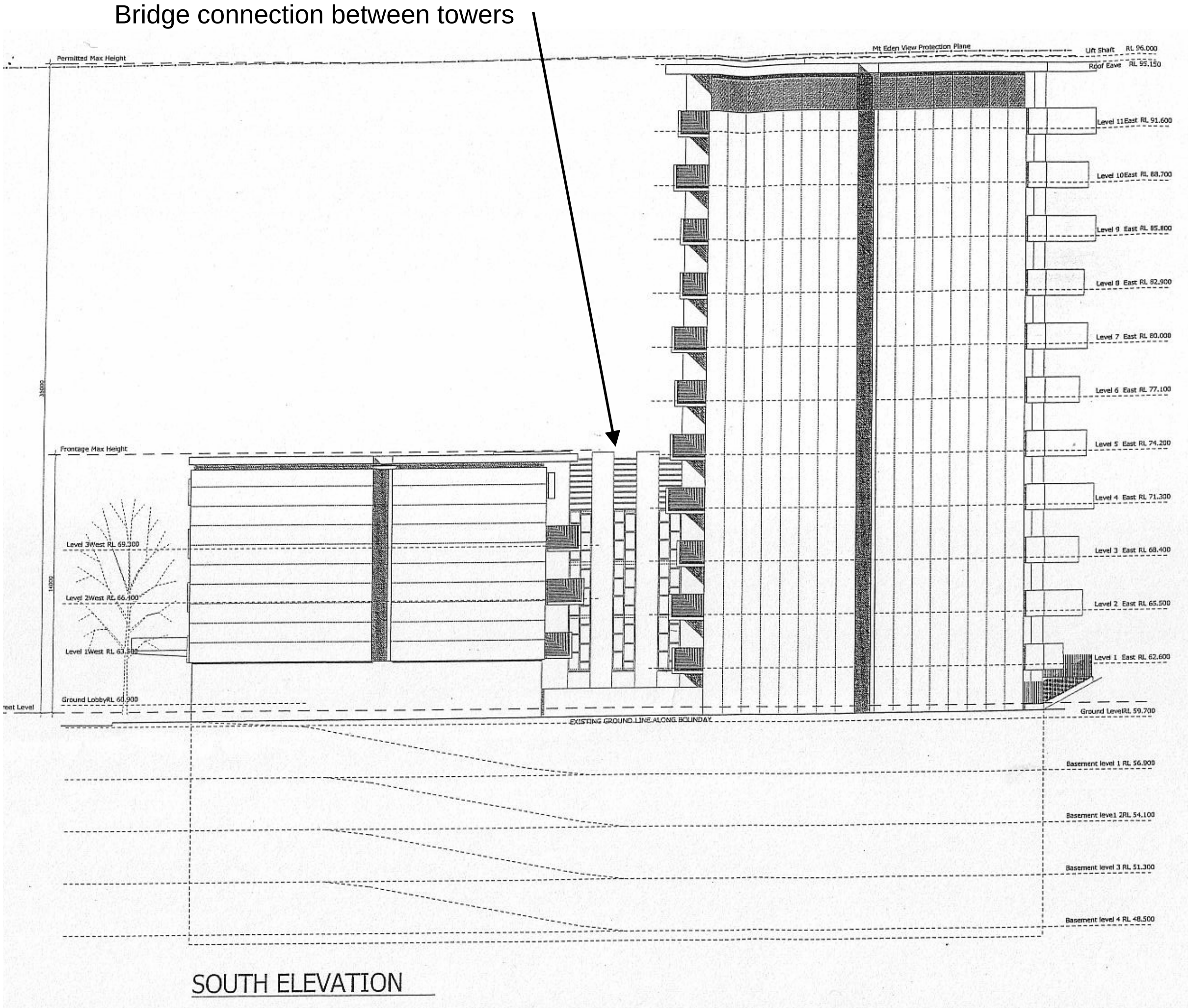

Fig. 2. Elevations, showing East and West blocks, with the bridge between (from architects drawing No TP_10, Rev B).

2.2 Sequence of events

2.2.1 The apartments are to be constructed following the issue of a building consent, which is contingent upon this Determination. Initial application for the building consent was made prior to 16 March 2005. On 16 March 2005 the territorial authority wrote to the applicant advising that, as the proposed works included a single means of fire egress which places the building's fire design outside the scope of NZBC-C/AS1 and "until a level of performance equivalent to that required by NZBC acceptable solutions is demonstrated, Council are not satisfied on reasonable grounds that the provisions of the building code would be met if the building were to properly completed in accordance with the plans and specifications submitted for consent".

2.2.2 The applicant (represented by its architect) applied for a Determination on 13 May 2005. The Department sought clarification of fire related design issues in a letter dated 29 June 2005. This was answered by the architect on 16 August 2005. The Fire Service were provided with copies of the submission and this was acknowledged on 9 September 2005.

The Department commissioned an independent firm of fire engineers ("the experts") to produce a fire report ("the experts' report") that was dated 9 September 2005 and copies of the report were sent to Upper Queen St Properties, the Fire Service and the Auckland City Council on 23 September 2005.

3 The submissions

3.1 On the evidence provided to the Department, the application appears to have been quite straightforward in that the Auckland City Council required either revised drawings and a fire safety report indicating the provision of a second escape route or a Determination from the Department in favour of a single means of escape from the building.

3.2 As part of its submission, the applicant provided copies of:

- architectural drawings titled "Upper Queen St, 10-14 Upper Queen St Auckland City… For Upper Queen St Limited", generally dated 24 June 2004 and varying in revision status
- a fire report prepared by specialist fire safety engineering consultants that was titled, "Fire report for proposed Sexton Apartments, at 10-14 Upper Queen St, Auckland City", dated March 2004 – "the fire report"

3.3 Further information was made available to the experts on request including:

- a description of the sprinkler, fire alarm and hydrant systems
- confirmation that both extinguisher and hose systems would be provided
- confirmation that WIP handsets were to be installed as a part of the Type 8 (voice communication) fire safety precaution.

3.4 Copies of the submissions and other evidence (apart from that listed in 3.3 above) were provided to each of the parties. The owner and the Fire Service made further submissions in response to the experts' report.

4 The relevant provisions of the Building Code

4.1 The dispute to be determined is whether the territorial authority's decision to refuse a building consent for the building because it was not satisfied that the single means of escape from fire complied with Clauses C2 and C3 of the Building Code (First Schedule, Building Regulations 1992) is correct.

4.2 The relevant clauses of the Building Code are:

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 fire fighting operations.

(c) Protect adjacent household units, other residential units, and other property from the effects of fire.

(d) Safeguard the environment from adverse effects of fire.

4.3 The relevant performance statements deriving from these objectives are incorporated in Clauses C2.3 and C3.3 of the Building Code. I note that the applicant is required to satisfy these latter performance requirements in order to comply with the Building Code.

4.2 Fire safety features necessary to comply with the Acceptable Solution

4.2.1 The relevant provisions of the Acceptable Solution C/AS1 amount to a means of compliance with the performance requirements of Clauses C2 and C3 of the Building Code.

4.2.2 In order to comply with the Acceptable Solution C/AS1, a sprinklered multi-unit residential dwelling (Purpose Group SR) having an escape height from fire of 31.9 m (12 storeys) and containing the same apartments and rooms as the proposed building would be required to have the following significant fire safety features:

- an automatic fire sprinkler system with smoke detectors and manual call points (allowing local notification of smoke detector activation in apartments).
- two separate means of escape stairways separated by fire rated construction.
- a fire cell rating of no less than F30.
- fire separations of the safe path to be 30/30/30 (reduced from 60/60/60 due to provision of sprinklers).
- lifts within a protected shaft.
- exit doors from apartments required to open directly onto a horizontal safe path, a pressurised vertical safe path, or a final exit.

- a horizontal protected path at each floor level (other than the top floor) preceding the vertical safe path. The protected path and vertical safe path are to be separated by fire doors.

4.2.3 There are no Acceptable Solution's that have been approved under Section 22 of the Act or Section 49 of the Building Act 1991 that cover single means of escape for buildings of this configuration and size. I am, therefore of the opinion that the system proposed to be installed must now be considered to be an alternative solution.

4.3 Fire safety features proposed as an alternative solution

4.3.1 The proposed building therefore differs from one complying with C/AS1 in that:

(a) It has a single escape route instead of two as required for a sprinklered building with an escape height exceeding 25 m.

(b) The sprinkler system will have a dual ‘Class B’ water supply with a tank, which should be sized according to Clause 604.1 of NZS4541. The primary supply will be the tank supply boosted with a diesel pump and the secondary supply will be the town mains supply boosted by either a diesel or an electric pump set.

(c) The only pressurised safe path is the stairway.

(d) A voice communication system (Type 8 of C/AS1) is provided.

4.4 Alternative solutions and Acceptable Solutions

4.4.1 In comparing an alternative solution with an Acceptable Solution it is useful to bear in mind the objectives of the relevant Building Code clauses.

4.4.2 The applicant contends that the design is an alternative solution complying with the Building Code.

4.4.3 With regard to this contention, I note that the Authority said in Determination 2004/5:

> “5.2.2 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 Authority may use the Acceptable Solution as a guideline or benchmark[2].
>
> 5.2.3 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.
>
> 5.2.4 As in several previous Determinations, the Authority makes the following general observations about Acceptable Solutions and alternative solutions:

“[2] *Auckland CC v NZ Fire Service* [1996] 1 NZLR 330.”

(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."

4.4.4 In the light of comments made separately, I then stated:

"I accept that 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."

5 The experts' report

5.1 The experts' report provides specific information on the single means of escape from fire in the building. The main features of the experts' report can be summarised under the following general headings:

- Introduction
- Description of the building
- Design philosophy
- Methodology
- Risk identification
- Risk analysis
- Risk evaluation
- Results
- Outcome

5.2 Introduction

5.2.1 The experts used documents provided by the Department, including the reports prepared on behalf of the applicant, to evaluate the application. Those documents are listed in paragraph 3.2. They sought and received further information as outlined in paragraph 3.3.

5.3 Description of the building

5.3.1 The experts described the building in relation to its fire safety aspects and noted the features that the designers had introduced to compensate for the deletion of one means of escape (stairway). In particular, this involved the addition of Type 8 (Voice Communication) and Type 13 (Safe Path Pressurisation) systems and a dual water supply, primary tank plus secondary town supply installed to supplement the performance of the sprinkler system.

The experts also noted concerns that at ground level the escape route became an open path and they believed that this did not comply with the Building Code. However, the experts noted that this issue was not part of the determination. This is discussed in more detail in 6.3.7.

5.3.2 For the purposes of analysis, the experts analysed two buildings. One of these being the subject building, referred to hereinafter as Building A. This building is then compared with an "idealised" building, referred to as Building C, in the risk assessment. Building C is of the same height, plan area, and occupant load as Building A, but as it has two stairways, it complies with C/AS1.

5.3.3 Because "protect in place" evacuation strategies are not currently widely accepted, the benefits of the Type 8 (Voice Communication System) system is not quantified in this analysis. This issue is discussed further in paragraph 6.3.

5.3.4 Referring to the manner in which a comparative analysis is carried out, I note that in Determination 2004/65 the Authority has said:

> *"6.1.1 The Authority takes the view that as a matter of law this Determination is binding only on the parties and only in respect of the building concerned.*
>
> *6.1.2 Nevertheless, the Authority recognises that people considering other buildings will frequently use a Determination for guidance. The Authority therefore tends to set out its reasoning in more detail than may be strictly necessary for the particular case, in the hope that the reasoning, as distinct from the conclusions, will be of use as an example of the process of arriving at a decision in a different case involving comparable circumstances.*

5.3.5 I take the same view in this case, but also note that this building and particularly its configuration and floor layout are not common. Any broader interpretation of the conclusions of this Determination must acknowledge that fact.

5.3.6 Figures 1 and 3 (below) show the floor plans for Building A, (the applicant's alternative solution proposal) and Building C, (the corresponding building deemed to comply with C/AS1).

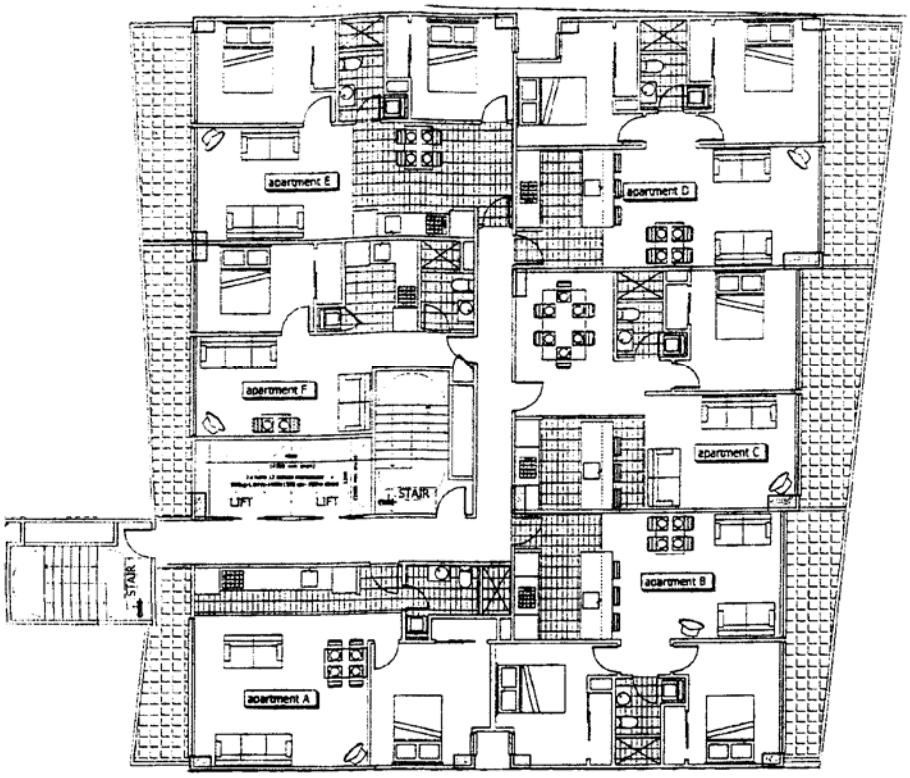

Fig. 3. Compliant building – Building C[3]. (Note additional stairwell lower left)

5.4 Risk design philosophy

5.4.1 It is generally established that it is a fundamental requirement that a quantitative analysis of the alternative solution be undertaken. The key issue is whether the single means of escape, incorporating the compensating features, which are the improvements to the sprinkler system and the stairway pressurisation system in Building A, are sufficient to offset the loss of the second stairway provided in Building C. In the experts' view, the most suitable methods of analysis to establish the impact of these various elements on levels of fire safety are probabilistic-comparative or probabilistic-absolute. Previously, most analysis was based on deterministic methodologies.

5.4.2 The experts then referred to Determination 2005/109, which established that a probabilistic-comparative approach is the more appropriate analysis method for cases such as this, without precluding the probabilistic-absolute approach. Determination 2005/109 had considered the fire safety compliance of an 18-storey multi-unit apartment building, with a smaller floor plate area, in terms of how its features compare with the corresponding (C/AS1) Acceptable Solution building.

5.4.3 Specifically at paragraph 6.2.4 of that Determination, I said:

"…I consider that the type of comparative risk analysis used in the assessment is an appropriate method for deciding whether an alternative solution is effectively

[3] *From the Architect's drawing No LO5-N dated 6.08.03 with the addition of the stairway*

equivalent to the corresponding Acceptable Solution in terms of fire safety. In particular, I accept the following comment from Expert D (a consultant engaged for that matter) as below:"

"In considering changes to the fire safety system in a building of the sort proposed, (deletion of a stairway, improvements to the sprinkler system, stairway pressurization, etc) it needs to be understood that each of these changes affects the level of fire safety in the building in different ways. Consequently the only way of comparing these changes is on a risk basis – how much (and in which direction) each of them changes the level of safety in the building."

5.4.4 I am aware that there are some in the fire engineering community who favour absolute approaches, whether deterministic or probabilistic. A deterministic approach is not appropriate in this case and the current construct of the Building Code is such that there is insufficient performance-based information for an absolute approach. By this, I mean there is no information as to the quantified tolerable or acceptable levels of risk to be used as measuring point of compliance. Until these are developed, a probabilistic-comparative approach with the acceptable solutions as the comparator remains the most appropriate means of analysing these issues.

5.4.5 In the current case the experts noted that "the fire report" was based on a deterministic methodology. As such, according to the experts, this report did not provide sufficient grounds to determine code compliance. The experts acknowledged that the report was, however, produced before Determination 2005/109 was issued. That Determination set a new benchmark for the analysis methodology.

5.5 Methodology

5.5.1 The experts stated that the assessment of the single means of escape for the apartments requires a risk-based approach. This involves the designer undertaking a risk assessment. Risk assessment is defined as the overall process of:

- risk identification
- risk analysis
- risk evaluation.

5.5.2 This process and structure is consistent with that defined in AS/NZS4360 "Risk Management". I describe these more fully in the following paragraphs.

5.6 Risk identification

5.6.1 The experts defined risk identification as "the process of determining what, where, when, why, and how something could happen". The risk identification in the context of their assessment is primarily concerned with the impact on life safety, taking into account the escape stairway contribution within the applicant's Building A, as compared to the corresponding compliant Building C.

5.6.2 The primary scenario that is evaluated by the experts is that arising from a fire in an apartment. The following paragraphs are structured around this scenario. It evaluates the risk to occupants of both the apartment of fire origin and occupants of apartments on the same floor level and above, should the fire spread. An additional risk relating to an arson “attack” was also considered as a unique hazard analysis. Arson scenarios are not generally considered in fire designs as a “credible worst case”. However, given the nature of the alternative solution (single stair) it was deemed to be particularly vulnerable to such a threat, and worthy of standalone analysis.

5.6.3 This building is unusual in that it is constructed with two towers, with an interconnecting bridge on the ground floor and at Levels 1-3, thereby allowing it to act in fire egress tests as a single building. A preliminary review suggests this could lead to some issues on evacuation, for example if the evacuees left the east tower early they may well find themselves in a cul de sac in the western tower with no option but to retrace their steps. Having identified this possibility, it is important that the doors at either end of the air bridge should be able to be opened from either side without the need for a key or other device during fire alarm conditions.

5.6.4 For the purposes of the over height east tower, the experts’ modelled the tower as if it were a standalone building. However, there are obviously some interactions between the two towers in so far as those exiting from the east tower must traverse the air bridges at their respective levels. To address this, my expert made specific adjustments so that, in analysing the occupancy loading on the stairs, the number of people using the stair at a particular time was calculated on the basis of both towers evacuating simultaneously.

5.6.5 Apart from this difference, my expert argues that conceptually the air bridges are no different from internal and horizontal pathways and that the building on the whole is little different from a podium building of the same footprint and height with an apartment tower above. I accept that assessment, although recognise that structurally there is a different between the two concepts which are themselves exposed to different risks.

5.7 Risk analysis

5.7.1 Design philosophy

5.7.1.1 The design philosophy that is being proposed and tested in the risk analysis is that as Building A lacks a second stair in comparison to Building C, it needs to have sufficient compensation to overcome this difference in design features. In this case the compensation is the enhanced sprinkler system and the stairwell pressurisation system, along with fire hose reels, extinguishers, a fire hydrant system and emergency lighting.

5.7.1.2 In apartment buildings, the majority of fire related casualties occur in the apartment of fire origin. The risk of these casualties is therefore relatively insensitive to the number of stairwells. It is sensitive, however, to the overall reliability of the sprinkler system. The greater the probability that a sprinkler will detect and extinguish a fire the lower the fire casualty risk both to the occupants of the apartment of fire origin and other occupants. However this gain may not adequately compensate for the absence of a second stair and a pressurisation system is offered up as a means of further improving the safety outcomes should the enhanced sprinkler system not control the fire and it extends to the stairwell. A pressurisation system is designed to ensure that an escape route remains substantively clear of fire products (e.g. smoke).

6 Event tree analysis

6.1 The experts developed an event tree for both Building A (termed "Event Tree "A" or "ET-A") and for Building C ("ET-C"). A sequence of events, including their probability distributions, resulted in a number of outcome scenarios. The events are summarised in the following Table 1, which is reproduced from the experts' report.

Table 1: Summary of Events

Event	Description of event (yes)
1	Ignition occurs (initiating frequency)
2	Fire origin is in an apartment
3	Fire growth is limited, i.e.; not a flaming fire that would cause detection in an operating detector and untenable conditions are not reached
4	The occupant is awake
5	There is manual suppression or the fire self-extinguishes and untenable conditions are not reached
6	The automatic suppression system (sprinkler system) is effective and untenable conditions are not reached
7	The automatic alarm is effective and warning is given
8	The first fire separation (barrier 1) between the apartment and corridor is effective
9	Given that the first fire separation (barrier 1) has failed, the second fire separation (barrier 2) is effective between the corridor and Stairway I
10	Given that the first fire separation (barrier 1) has failed, the second fire separation (barrier 2) fails or not, the third fire separation (barrier 3) is effective
11	The pressurisation system is effective

6.2 Probabilities

6.2.1 The event trees for each building are simplified, share the same layout, and are based on the same template. The experts noted that the probabilities varied between the event trees, particularly as regards the comparable sprinkler systems and the number of stairways. The "ET-A" and "ET-C" buildings are constructed to test the points of difference between the two buildings. These points of difference (or compensation) are:

- that the Class A water supply system to the sprinkler system in Building A enhances that system when compared with that of Building C.
- the substitution of a stairwell pressurisation system in Building A to compensate for the lack of a second stairway within Building C.

6.2.2 The report gave an in-depth explanation of the probability data used in the analysis for events 4 and 6 to 11 as described in Table 1 "Summary of Events”. For each event the probability was identified in two components; viz reliability and efficacy. Reliability is defined as the probability that the system operates on demand and efficacy is defined as the degree to which a system achieves its objective given that it does operate. The conclusions reached for each of these events are summarised in Table 2. The events described below are sequential and not time dependent.

Table 2 Events Probability

Event	**Description**	**Probability**
4	Occupant awake	The probability assumption is a Normal distribution with a mean of 0.79 and standard deviation of 0.08.
6	Sprinkler system effective	For Building A, the efficacy is .95 with a Uniform reliability function over the range 0.94 to 0.98 For Building C, the efficacy is .95 with a Uniform reliability function over the range 0.93 to 0.97
7	Automatic alarm	The efficacy is taken as 0.90 with the reliability as a normal distribution with a mean of 0.90 and a standard distribution of 0.05
8, 9, 10	Barrier effective	For Buildings A and C (both lightweight partitions), the efficacy is 1.00 with a Uniform reliability distribution over the range .48 to .68.
11	Pressurisation effective	The efficacy is .90 with a uniform reliability distribution from .50 to 1.

6.3 Consequences of Each Scenario

6.3.1 Up to this point, the analysis has considered, via the event trees, sequences that lead to credible scenarios and the **probabilities** that these scenarios will occur. The experts’ report then begins the task of calculating the **consequence** of each scenario by undertaking a time dependent analysis. Given a particular scenario, the probability of a negative escape time margin is calculated as a function of Available Safe Egress Time (ASET) vs. Required Safe Egress Time (RSET).

6.3.2 The following definitions apply:

Available Safe Egress Time

The available safe egress time is the time between the start of a fire and the time to untenable conditions, ie the time to when escape is no longer deemed possible.

The mathematical expression for ASET is:

$$ASET = S \times U_S$$

Where S is the time to untenable conditions, and U_S is an uncertainty factor.

Required Safe Egress Time

The required safe egress time is the time that is actually needed for the occupants to evacuate to a place of safety.

The mathematical expression for RSET is:

$$RSET = t_d + t_i + t_r + t_e$$

Where:

- t_d is the time to detection:
- t_i is the investigation time
- t_r is the occupant response time
- t_e is the occupant movement time

The required result for a safe building is that ASET is greater than RSET so that the available safe egress time is longer than the time for the occupants to escape before untenable conditions are experienced.

6.4 Calculation of risk

6.4.1 The calculation is made for the range of credible scenarios identified in an event tree presented in the report. For each of these scenarios the risk assessment would have calculated a probability that the escape time margin is less than zero. In any risk analysis of this sort the risk is calculated by multiplying the cumulative probability of the specific scenario by its severity. The severity is the probability of a negative escape time margin (G) multiplied by the number of people exposed. The total risk is then the summation of all the partial risks.

6.4.2 The calculation of total risk is complex. For this analysis a computer programme (@RISK) was used. The analysis is probabilistic, using stochastic rates rather than discrete values, using a Monte-Carlo calculation engine to compute the values.

6.5 Risk evaluation

6.5.1 The experts' report notes that the risk evaluation criterion is comparative-probabilistic. The risk profiles of the two buildings are directly compared, and Building A is deemed to succeed where "the risk profile is less than that that of Building C, with the inclusion of a safety margin". The "individual risk of fatality" is the risk measure used in the experts' analysis and in Determination 2005/134.

6.5.2 This assessment assumes that injury is proportional to fatality, that is that if Building A has a lower risk of fatality than Building C, the injury rate is also lower. The assessment also does not include events that might have occurred prior to the fire event in an apartment. The unit of risk is not related to frequency and the measure of risk is not a complete profile. However, the experts noted that this approach is deemed valid in terms of a comparative analysis.

6.6 Results

6.6.1 General

6.6.1.1 Using the risk management framework explained above, the experts conducted six different analyses of the building. They were:

(1) Base case (time dependent)

(2) Base case (non-time dependent)

(3) Design Case with Class B water supply rather than Class A (i.e. as proposed by the applicant, but not as recommended for the base case)

(4) Base case without 1% sprinkler enhancement for Building A

(5) Base case with low efficacy pressurisation system

(6) Base case without 1% sprinkler enhancement and with low-efficacy pressurisation system.

Note that the base case (Building A) reflected by (1) and (2) differs from the applicant's building in that a Class A water supply is installed rather than the lesser Class B, as reflected per (3).

6.6.1.2 The purpose of the various analyses is to look at the "sensitivity" of the margin to various design features.

6.6.1.3 The results from the experts' analysis of the subject Building A in comparison to the C/AS1 compliant building (Building C) are given graphically in Figure 4 (below). This is the base case (time dependent).

6.6.1.4 The graphs are generated from the outputs from the @RISK computer programme. The risk profiles of the two buildings from the @RISK computer analysis are overlaid on each other to show the risk profiles of the buildings in relation to each other. This shows the risk profile for the proposed building (Building A) sitting to the left of the corresponding profile of the control building (Building C), and indicates that Building A has a lower risk in the event of fire. The second graph shows the risk margin, and is the net risk profile of Building C minus the net risk profile of Building A. The result shows that there is a risk margin of 80% in the base case.

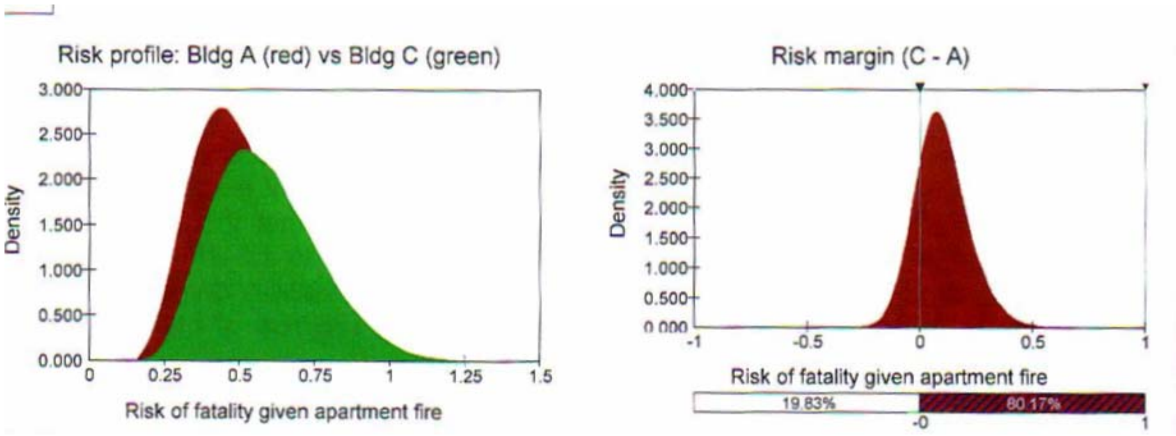

Fig. 4. Risk comparison of Building C and Building A.

Table: Summary of Results

Analysis	Description	Model time dependent	Water Supply	Pressurisation		Margin
			Type	Effective	Percent	P(C-A)>0
1	Base case (time dependent)	Yes	A	Med	68%	80%
2	Base case (non time dependent)	No	A	Med	68%	82%
3	Design case as per case 1 but class B water supply rather than class A	Yes	B	Med	68%	73%
4	As per case 1 without 1% sprinkler enhancement for Bldg A	Yes	C	Med	68%	71%
5	As per case 1 with low-efficacy pressurisation system	Yes	A	Low	34%	39%
6	As per case 1 without 1% sprinkler with low efficacy pressurisation system	Yes	C	Low	34%	<1%

6.6.1.5 The experts noted that the results include safety margins and that two comparable or equivalent buildings will have a margin of 50%. The possibility that things will go randomly wrong in Building A compared with things going right in Building C is covered by the variability in the input parameters. A margin of greater than 50% is sought.

6.6.1.6 The experts point out that in Determination 2005/109, 74% for the base case was not considered high enough. By comparison, the corresponding margin for Building A in the current analysis is 80% (for the base case), which is above the upper limit of Determination 2005/109.

6.6.1.7 Permutation 1 from the table above is the base case with a Class B water supply rather than a Class A supply as recommended in the Determination. The margin decreases from 80% to 73%.

6.6.1.8 Permutation 2 shows the effect on the margin of excluding time dependent variables. The margin increases from 80% to 82%.

6.6.1.9 Permutation 3 is the base case with a low efficacy pressurisation system. In this case the margin has decreased from the base case of 80% to 39%.

6.6.1.10 Permutation 4 is the base case without sprinkler enhancement and with a low efficacy pressurisation system. The margin has decreased from the base case of 80% to <1%.

6.6.1.11 Permutations 3 and 4 illustrate the importance of good pressurisation system design and the impact on safety outcomes of improved water supply. This is why, I impose conditions in this Determination to ensure that these conditions are not met during the life of this building.

6.7 Outcome

6.7.1 The experts' report concluded that, in their view, and subject to some specific qualifications, Building A is equivalent to, or is better than, a comparable Building C that complies with the prescriptive Acceptable Solution. There are therefore reasonable grounds to assume that the proposed alternative solution, as represented by Building A, complies with the Building Code. This conclusion was subject to the following conditions which confirm the features required to be incorporated in the building (which I paraphrase below):

- The sprinkler system water supply is to be a Class A supply, that is a primary tank supply with a secondary town mains supply. Complete and unambiguous plans and specifications are to be supplied to the satisfaction of the territorial authority.
- Doors are not to be locked from the stairwell side in a manner that would prevent occupants from being able to enter any floor level from the stairwell in fire alarm conditions.
- The fire engineer is to monitor construction with sufficient regularity and sufficient detail to be able to provide a "Producer Statement of Construction Review" to the satisfaction of the territorial authority.

(Note: I reiterate the point that the Building A, the base case, is not the building as proposed in the consent, which better corresponds to Permutation 3 of the abovementioned Risk Analysis Table Survey of Results - see 6.6.1.1)

6.8 Comments on experts' report by the parties

6.8.1 Copies of the experts' report were provided to each of the parties. The territorial authority accepted the report without comment.

6.8.2 The Fire Service, by letter dated 15 September 2005, made a number of comments on the experts' methodology, recording in particular its view that:

> "analysis of major departures from the Approved Documents must be assessed by quantitative risk assessment techniques", but that, as noted in paragraph 6.2.5 of Determination 2005/109, "the chief drawback associated with this technique at present is the lack of adequate data".

6.8.3 With regard to the process of establishing the probability that the alternative solution (Building A) is at least as safe as the Acceptable Solution (Building C); it said:

> "given the uncertainty in the assumed data, this amounts to an attempt to establish the confidence or margin associated with an assertion that the alternative design is at least as safe as a compliant design. Determination 2005/109 states that a probability range, [in the margin], of 51% to 74% is not high enough. The question remains as to what is high enough. The independent expert has assumed that a margin of 80% is enough to demonstrate compliance with the Building Code. The Fire Service cannot comment on whether this value is correct, as it would require an extensive study of the uncertainties in the assumptions. Such a general study is clearly required as a matter of urgency if alternative solutions of this type are to be approved.".

6.8.4 With respect to the "arson scenario", it states:

> "Single means of escape buildings are more vulnerable than buildings with two stairways to an arson attack, or other fire, in the staircase… Rather than being a "one-off hazard check", as undertaken by the independent expert, the fire within stairway scenario should have been integrated into the risk analysis, modifying the calculated "margin"."

6.8.5 With regard to "Passive Fire Safety Systems" it recommended that:

> "Given the reliance on fire resisting barriers in the design, conditions should be placed on any building consent relating to inspection during, and on completion of, construction. Final inspection should be conducted by suitably qualified expert and documentation requires as to the integrity and construction methods for all fire barriers."

6.8.6 With regard to "active fire systems", it recommended that:

> "…the compliance schedule for the building includes an appropriate testing and inspection regime complying with relevant standards for all active systems to ensure ongoing compliance…" and noted the approach I had taken in Determination 2005/109."

6.8.7 The applicant's architect by letter dated 6 October 2005 made the following comments in response to the expert's recommendation that:

6.8.7.1 "The fire engineer is to monitor construction and provide a producer statement of construction review to the satisfaction of the BCA.

- The fire engineer will coordinate and supervise a programme for construction monitoring. The programme is to include:
  1. Discussions between the territorial authority, main contractor, architect and fire engineer on what inspection will be provided by the territorial authority.

2. A requirement that wall board installers undertake training as to the manufacturer’s requirements and provide a producer statement on completion. The manufacturer’s representative is to inspect.

3. Passive protection inspection is to be undertaken by a specialist sub-contactor on the fire collars, pipe wrap, intumescent mastic and other penetrations, including full record keeping and certification by way of a site log-book that includes a photographic record and an ultimate producer statement by the installer.

4. A requirement that closures are to be installed and /or certificated by the manufacturer and an appropriate producer statement is to be provided.

5. All active systems are to be inspected and tested by Fire Protection Inspection Services Ltd., including intereactive testing where relevant.

6. The pressurised stair system is to be subject to full commissioning testing as required by its designer, to the satisfaction and in the presence of the pressurisation system peer reviewer. Interaction with the smoke detection system is to be ensured, with on going maintenance and testing protocols for 50-year life to satisfaction of the territorial authority, the pressurisation system reviewer and the fire engineer.

7. The main contractor is to supervise and project manage the above requirements to the relevant New Zealand or Australian standard in each case, with monitoring of programme implementation by the fire engineer as required. The contractor is to have inspection records available at all times for the fire engineer to inspect at random times.”

6.8.7.2 ”The sprinkler system water supply is to be Class A Supply, that is a primary tank supply with a secondary towns mains supply Plans and specifications to be submitted to the satisfaction of the BCA

- The sprinkler system water supply is to be a class A Dual Superior supply, which is defined in NZS4541:2003 as “two approved supplies, both of which shall be carried independently to a combined main within each control valve enclosure, at lest one of which shall be a primary supply, but only one of which may be dependent on a town main.”.

7 Discussion

7.1 General

7.1.1 I have considered the submissions of the parties, the experts’ report and subsequent submissions and the other evidence presented in this matter. The approach in determining whether building work complies with clauses C2 and C3 is to examine the design of the building and the design features that are intended to prevent the loss of life. I have described this process previously in Determination 2005/109, which addressed a similar matter, and I have taken that material into account in the current Determination.

7.1.1 Of the comments of the Fire Service I make the following points. On the question of the margin, I discuss this later. Regarding the arson scenario, I note the comments of the Fire Service on the desirability of the inclusion of the arson scenario (or fires from any other cause outside of an apartment) within the main risk analysis, rather than as a “one-off hazard check” in parallel. I agree with those comments in the long run. However, at this stage, there is limited data to allow these to be included directly in such analysis. At the current stage of knowledge, I believe the "one off hazard check" is the best means of analysing the risk of fires from these causes. I do endorse the need for these scenarios to be considered.

7.2 Is the building code compliant?

7.2.1 I have considered the comparative analysis undertaken by the experts, alongside the other information provided to me about the building, and note the following:

7.2.2 The experts have indicated a comparative margin in the base case of 80% against a target range of 50% to 75%.

7.2.3 There are a number of issues to be evaluated in determining whether the building is code compliant or not in this case. Firstly there is the question of the comparative probabilistic risk assessment and its results. More specifically, what does the margin mean and how does it relate to other compliance measures? Secondly, there is the consideration of the on-going compliance of this building with the Building Code.

7.2.4 Whilst this current result is, on the face of it, moderately superior to that reported earlier for the building described in Determination 2005/109, that of itself is not sufficient to provide me with reasonable grounds on which to decide compliance. It is clear that, taken overall, the safety of occupants within a building of this type hangs on whether the most critical compensation component, namely the pressurisation system, is well designed and robust. This is clearly a first order effect, to be evaluated before efficacy and reliability tests are applied.

7.2.5 With regard to the probabilistic risk assessment, the experts have recommended that I accept 75% as the threshold for the margin. To put it another way, this means that there should be a 25% increase in probability that the alternative building will be better than the compliant building. This extra buffer is required in part because the actual probability distribution may not be a pure random variable as assumed in the experts' analysis. As noted in the Fire Service's comments, more analysis is required before a numerical value can be described to an appropriate margin. Even once one has been developed, this will not take away the need for other factors such as the quality of the overall fire design to be factored into the acceptance criteria.

7.2.6 As discussed in paragraph 5.9.1.1, the design as proposed by the applicant (not the base case) has a margin of 73%. Clearly this is not acceptable as it falls short of the 75% threshold. However the expert has analysed the base case of a compliant building with a Class A water supply in lieu of Class B. This provides a margin of 80% which is acceptable.

7.3 "Protect in place" strategy

7.3.1 This building has been designed to include a "protect in place" strategy. This means that occupants in apartments above a fire will be held in their apartments while the Fire Service fights the fire. The safe egress evaluation conducted by the experts was based on a total (one-out all-out) evacuation and concluded that the design was sufficient before "protect in place" concepts needed to be incorporated.

7.3.2 The experts said in their report:

"The impact of the Type 8 voice communication system is not quantified in this analysis, as "protect in place" evacuation strategies are not currently widely accepted, and certainly not in single escape route buildings."

7.3.3 These comments need to be clarified. I concede that there are two different concepts to consider. The first is that of "protect in place" strategies. The second is the technology to deliver that strategy. In this case, the technology includes a voice communication system (Type 8), which allows the fire fighters to communicate directly with occupants.

7.3.4 What "not quantified" means is that analysis of the safe egress time did not include any time delay arising from occupants being held in their apartments. On one hand this makes the analysis conservative in that it assumes that maximum occupancy in the stairwell thereby raising the overall risk. Conversely, it is less conservative in that non-tenable conditions may be created before the fire fighters call for evacuation.

7.3.5 I am aware that there are arguments for and against the appropriateness of "one-out all-out" and "protect in place" fire egress strategies for apartments. The relative merits of the two strategies also change when considering either single or multiple egress buildings or specialised situations such as hospitals or prisons. There is a view that until such time as research, technology and building practices prove otherwise, the occupants should be evacuated from a single means of escape building in the most expedient and timely manner, i.e. "one-out all-out". This is also consistent with behaviour of people exposed to fires in New Zealand, which historically is for people to want to evacuate as soon as an alarm is sounded. The counter view is that a "protect in place" strategy gives the fire fighters the ability to evacuate people as and if required, thereby minimising the possibility of evacuated or evacuating occupants disrupting fire fighting. It also minimises disruption to those not affected by a fire or even a false alarm. The Type 8 system (the "technology") has merit as it allows for direct communication with apartment occupants.

7.3.6 As discussed above, the "protect in place" concept is not one I believe was contemplated by the Acceptable Solution C/AS1, nor I would suggest, by provisions C2 and C3 of the Building Code itself.

7.3.7 In my view, the objective of the "means of escape" provision within clause C2 of the Building Code is clearly to "safeguard people from injury or illness from a fire whilst escaping to a safe place". Clause C2 of the Building Code defines a "safe place" as a place of safety in the vicinity of a building from which people may safely disperse after escaping from the effects of fire. It may be a place such as a street, open space, public space, or an adjacent building.

7.3.8 Consequently, if a "protect in place" concept was to be relied on in this building as a primary means of ensuring safety of building occupants, then a modification of Clause C2 would be required, solely on the grounds that the safeguards put in place to protect people from the effect of fire were not aimed at achieving exit to a safe place.

7.3.9 In Determination 2005/134, I left the option open to the owner to either elect to stay with the proposed strategy or revert to a "one-out all out" system. Should the evacuation strategy be "protect in place", then I requested that a modification to the building code be sought. In that instance, the building had already been constructed and there were neighbouring buildings in the same complex (with the same management systems) that had been completed and occupied on the basis of "protect in place" strategies.

7.3.10 Those circumstances don't apply in this case. The building is not built and it is not part of a complex. I am of the view that it should have a total evacuation strategy, which is, I believe, the strategy required by the Building Code. However, the benefits that the technology itself brings should not be ignored and the Type 8 system should be retained to allow communication between the fire fighters and the occupants. This would also facilitate the use of a "protect in place" strategy should this receive endorsement in the future.

7.3.11 The experts have also commented that the doors are not be locked from the stairway side in manner that would prevent occupants from being able to enter any floor level from the stairway in fire alarm conditions. This, in effect, enables a "safe refuge" concept to be added as an enhancement feature to the basic fire safety design already evaluated, thereby contributing to the overall robustness of the design and shall be adopted.

7.3.12 The single means of escape fire Determinations have drawn the issue of evacuation strategies into sharper focus and work is now proceeding to develop a view as to the appropriateness of "protect in place" evacuation strategies, particularly in single means of escape buildings.

7.3.13 The experts note in a footnote to their report, that the escape route from the stair's ground floor landing to the final exit is an open path rather than the required safe path. For example:

- Items of upholstered furniture are shown in the safe path
- A stair from the basement lands without a closure (notwithstanding that there is a closure at the stairs basement landing, one is required at each landing)
- Before reaching the final exit the escape route must traverse past glazed areas to the courtyards, a loading dock, an office, the mail lobby and the substation enclosure.

To my mind, it is questionable whether this important fire separation has been adequately designed and detailed. There is a limited amount of description in the fire report but nothing on the architectural drawings. The fire report predates the plans, and when asked, the fire engineer declined to confirm that the plans reflected his design. That is of concern and needs to be reviewed by the territorial authority.

7.3.14 These issues, whilst very important, are matters of detail rather than design philosophy or methodology. The escape route from the stair landing to the final exit is required to be a safe path, particularly so in this building where there is only a single escape route. These are issues that the territorial authority should satisfy themselves on before issuing a consent.

8 Ongoing Compliance

8.1 As noted in paragraph 6.2.3, the pressurisation system is critical to the overall effectiveness of the fire safety systems in the building. Accordingly, it is important that the system be maintained and monitored to a high standard. For this to occur, the compliance schedule needs to include a specific requirement for on-going testing of the system. Determination 2005/109 provides a useful template for an appropriate schedule. I do not expect that the inspections, the maintenance standard, the person responsible and the additional requirements will be to a lower standard than was applied in that case.

8.2 As noted in 6.3.3, the expert also recommended a condition be included ensuring that the doors are not be locked from the stairway side in manner that would prevent occupants entering any floor level from the stairway in fire alarm conditions. This is an important feature that needs to be carried through in the detail design of the building systems and their consequential commissioning. In addition, there should also be an inclusion in the compliance schedule to ensure the systems are tested during the building warrant of fitness checks.

9 Conclusion

9.1 I consider that the building's design as proposed in the consent documents will not comply with the Clauses C2 and C3 of the Building Code.

9.2 However I am satisfied, based on the information provided, that if the work outlined in the decision below is designed and installed to an appropriate standard, and if certain other conditions are met, it is possible that that the building can become code compliant.

9.3 I also consider that the building should not have a "staged evacuation" strategy as these strategies are still not established as being appropriate in single means of escape buildings in New Zealand.

9.4 It is emphasised that each Determination is conducted on a case-by-case basis. Accordingly, the fact that a particular design or system has been established as being code compliant in relation to a particular building does not necessarily mean that the same system will be code compliant in another situation.

9.5 I decline to incorporate any waiver or modification of the Building Code in this case.

10 The decision

10.1 In accordance with section 188 of the Act;

(a) I determine that the building as proposed does not comply with Clauses C2 and C3 of the Building Code.

(b) I also find that a building meeting the following conditions is likely to meet the requirement of the fire clauses of the Building Code provided it is used as a multi-unit residential dwelling corresponding to Purpose Group SR of the current Acceptable Solution C/AS1. These conditions are all subject to the territorial authority being satisfied on reasonable grounds that they have been met. I draw to the territorial authority's notice to the comment made by the experts:

   (i) A sprinkler system water supply with a Class A supply, that is a primary tank with a secondary town mains supply with dual pump sets in accordance with complete and unambiguous plans and specifications.

   (ii) The work outlined in the architect's submission is to be carried out in totality, together with the supply of appropriate producer statements.

   (iii) The evacuation strategy is a "total evacuation" system.

   (iv) Doors are not to be locked from the stairway side in a manner that would prevent occupants from entering any floor level from the stairway in fire alarm conditions. In addition, doors leading to and from the bridges running between the two towers must be able to open from either side during any fire event.

   (v) The compliance schedule for the building shall define escape route compliance, performance, and monitoring standards I will also take note of the Fire Service's recommendation that the compliance schedule includes an appropriate testing and inspection regime complying with the relevant standards for all active systems, to ensure ongoing compliance of the building.

(c) The territorial authority should also verify the adequacy of the exitway from the stairs ground floor landing to the final exit.

(d) I require the territorial authority to provide me with a report within two months of issuing the compliance schedule confirming that these conditions have been met.

Signed for and on behalf of the Chief Executive of the Department of Building and Housing on 22 December 2005.

John Gardiner
Determinations Manager

Appendix A: Floor plans of the two adjoining towers

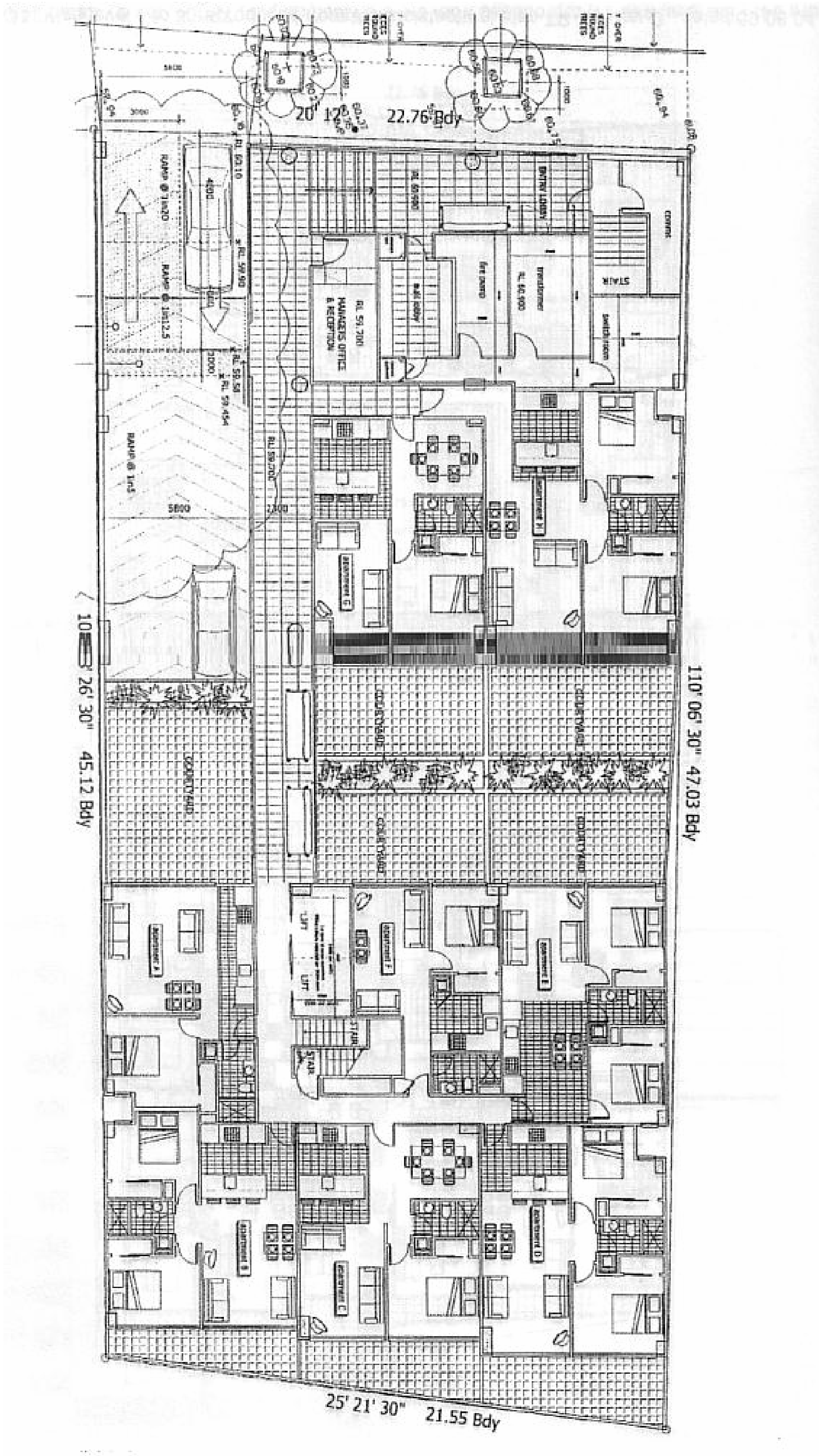

Figure 5 Plan Level Ground, reproduced from the architectural plan TP_02 , rev G, dated 09.08.04

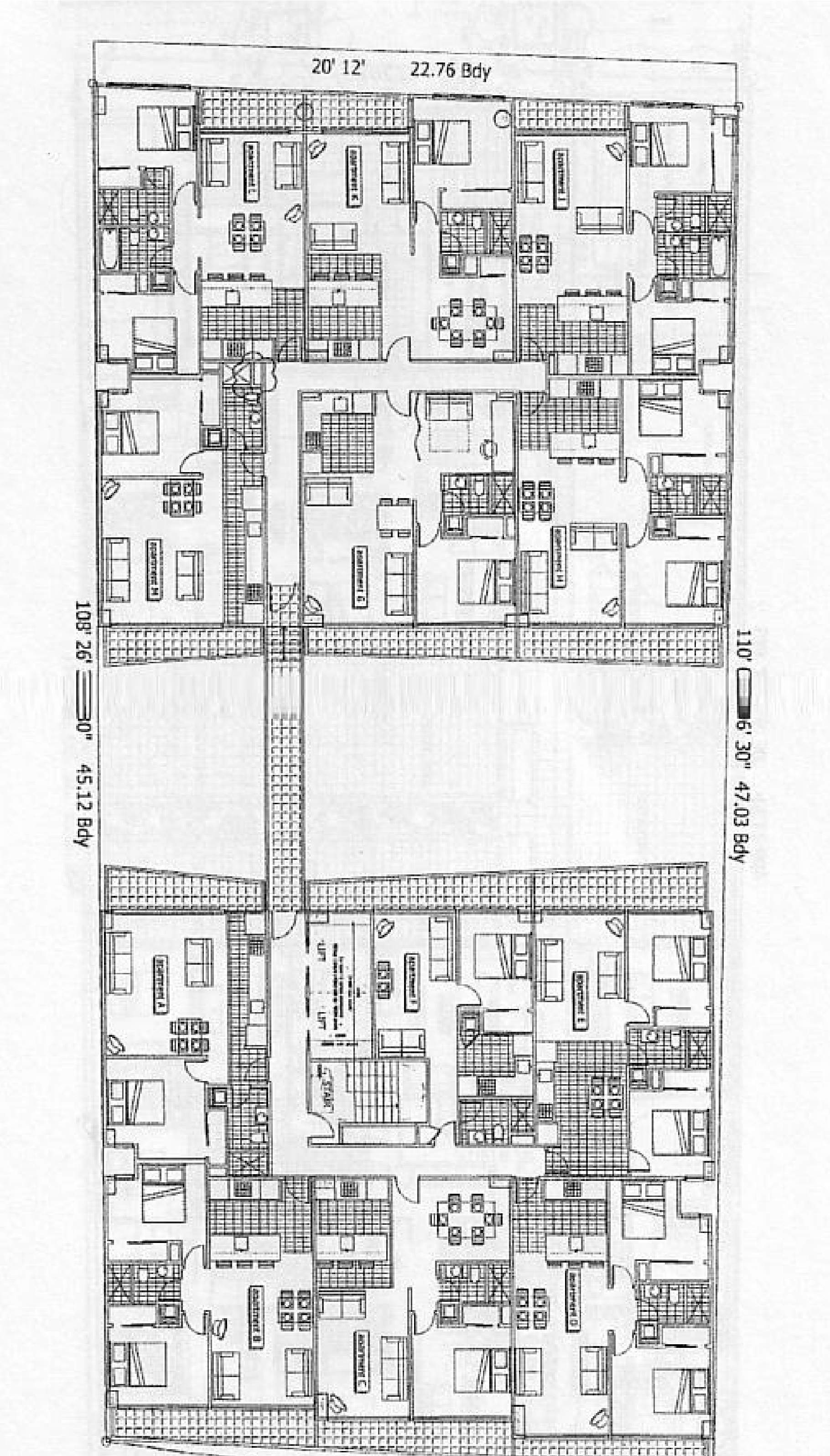

Figure 6 plans, level 1 to 3, reproduced from the architectural plan TP_02 rev G, dated 09.08.04