Determination No. 2003/3

Fire safety provisions in an atrium apartment building

1 THE MATTER TO BE DETERMINED

1.1 The matter before the Authority is whether the fire safety design of a new apartment building complies with the building code (the First Schedule to the Building Regulations 1992) as required by section 7(1) of the Building Act 1991. (That requirement is subject to any waivers or modifications granted by the territorial authority, but the Authority understands that in fact no such waivers or modifications have been sought or granted).

1.2 The Authority takes the view that it is being asked to decide whether the building complies with clause C2.3.2 of the building code in respect of the number of exitways and clauses C3.3.2 and 3 in respect of fire separations within the building. Specifically, the applicant raised the following matters of dispute:

(a) That there are inadequate means of escape;

(b) That there are inadequate means to control spread of fire;

(c) That there is "no fire separation" between the basement and the ground floor; and

(d) That there is "inadequate fire separation" between the ground level parking area and the atrium.

1.3 In making its determination the Authority has not considered any other aspects of the Building Act or of the building code.

1.4 The applicant also queried the current actual use of the building, which the applicant alleged was as a hotel (classified use Community Service in terms of clause A1 of the building code, purpose group SA in terms of the acceptable solution C/AS1) and not a multi-unit dwelling containing individual household units (classified use Multi-unit Dwelling, purpose group SR). All of the submissions assume that the building is in purpose group SR, and the determination proceeds on that basis. If it is not the case, then the territorial authority has the power to take legal action accordingly, perhaps by way of a prosecution under section 80 of the Building Act, and the New Zealand Fire Service has the right, if it considers the territorial authority has failed to take appropriate action, to bring the matter before the Courts under section 81. Those are legal and administrative options over which the Authority has no control.

1.5 This determination identifies the parties in 2 below, describes the building concerned and the relevant provision of the Building Act, the building code, and the Approved Documents in 3, describes the submissions and relevant documents in 4, and discusses the Authority's general approach in 5. In 6 to 13 it then addresses the individual matters of dispute listed in 1.2 above.

1.6 This determination is not a treatise on fire engineering or on the law, and accordingly the account of the submissions and reports, from no fewer than eight fire engineers and two legal counsel, does not purport to do more than indicate the nature of the technical points at issue and cannot do justice to the carefully presented documents themselves. Various matters that were mentioned in the submissions, such as the need for fire hydrants and the protection of doors as distinct from windows, are not discussed below because after full consideration of all the circumstances those matters did not affect the Authority's decision.

2 THE PARTIES

2.1 The applicant is the New Zealand Fire Service. The other parties are the owner of the building, acting through the firm of consulting engineers responsible for the fire design of the building ("the designer"), the territorial authority concerned, and the building certifier concerned.

3 THE BUILDING

3.1 The current situation

3.1.1 The building has apparently been almost completed in accordance with a building consent, and the building certifier has issued an interim code compliance certificate. The building is now occupied. The Fire Service has not approved an evacuation scheme for the building under the Fire Safety and Evacuation of Buildings Regulations. The Authority has been given a copy of the current building warrant of fitness, but has not seen the compliance schedule.

3.1.2 As mentioned in 1.4 above, this determination is based on the assumption that the building's intended use is as a multi-unit dwelling and not as transitory accommodation.

3.2 The building and its fire safety design

3.2.1 The following description of the building, and the description of its fire safety design in 3.5 below, are, as far as possible, confined to the matters of dispute. Those descriptions are based on the information submitted by the parties. The Authority has carefully considered all of the evidence and documents submitted to it in their entirety even though only certain parts of the evidence and documents are described and discussed below.

3.2.2 The building is a multi-unit residential dwelling. It has seven levels, being:

- A basement, at RL 1.10 m, containing car parking, a store room, lockers, and pool plant (a swimming pool and a spa pool protrude into the basement from the floor at ground level);
- The floor at ground level, at RL 4.00 m, containing an office, a gymnasium and sauna, a courtyard around the swimming pool and the spa pool, lockers, refuse storage areas, lobbies, and further car parking; and
- Five upper levels, each 2.78 m higher than the level below, containing a total of 60 apartments, some with one bedroom and some with two bedrooms.

3.2.3 An atrium the entire height of the building above ground floor level is formed by openings in the floors of the upper levels.

3.2.4 The doors to the apartments open off walkways around the atrium. Windows with opening fanlights open on to the walkways from bedrooms and kitchens. Those windows are of two layers of 6 mm thick toughened glass with a 1.5 mm layer of laminating material between them. The walls themselves are of fire rated construction, but the windows and doors have no fire resistance rating. The windows are self-closing on the operation of a fusible link, and the doors are self-closing. Both windows and doors are protected by drenchers within the apartments.

3.2.5 The building has two sets of open stairways connecting the walkways to the ground floor. One of the stairways continues within a fire rated stairwell down to a smoke lobby in the basement. There is a lift that connects each level from the top to the basement.

3.2.6 There is a car ramp to the basement through an automatic roller shutter grille, but the only pedestrian exit is through doors into the stairway.

3.2.7 There is one pedestrian exit from the ground floor parking area and two pedestrian exits from the rest of the ground floor.

3.2.8 The building has no automatic sprinkler system, pressurisation system, or mechanical smoke extraction system.

3.3 The provisions of the Building Act and the building code

3.3.1 The relevant provisions of the Building Act include:

2. Interpretation In this Act, unless the context otherwise requires . . .

"Means of escape from fire", in relation to a building which has a floor area, means continuous unobstructed routes of travel from any part of a floor area of that building to a place of safety; and includes all active and passive protection features required to assist in protecting people from the effects of the fire in the course of their escape:

7. All building work to comply with building code—

(1) All building work shall comply with the building code to the extent required by this Act, whether or not a building consent is required in respect of that building work.

12. Functions of Authority-

(3) Subject to this Act, in the exercise of its functions and powers the Authority shall establish for its use . . . procedures that are appropriate and fair in the circumstances and shall comply with the principles of natural justice.

3.3.2 The relevant provisions of the building code are:

Clause A2 - INTERPRETATION

In this building code unless the context otherwise requires, words shall have the meanings given under this Clause. Meanings given in the Building Act 1991 apply equally to the building code.

Exitway All parts of an escape route protected by fire or smoke separations, or by distance when exposed to open air, and terminating at a final exit.

Final exit The point at which an escape route terminates by giving direct access to a safe place.

Firecell Any space including a group of contiguous spaces on the same or different levels within a *building*, which is enclosed by any combination of *fire separations*, *external walls*, roofs, and floors.

Fire resistance rating (FRR) The term used to classify *fire* resistance of primary and secondary elements as determined in the standard test for fire resistance, or in accordance with a specific calculation method verified by experimental data from standard *fire* resistance tests. It comprises three numbers giving the time in minutes for which each of the criteria *stability*, *integrity* and *insulation* are satisfied, and is presented always in that order.

Fire separation Any *building element* which separates *firecells* or *firecells* and *safe paths*, and provides a specific *fire resistance rating*.

Safe path That part of an *exitway* which is protected from the effects of *fire* by *fire separations*, *external walls*, or by distance when exposed to open air.

Clause C2 - MEANS OF ESCAPE

C2.3.2 The number of *exitways* or *final exits* available to each person shall be appropriate to:

(a) The *open path travel distance*,
(b) The *building height*,
(c) The number of occupants,
(d) The *fire hazard*, and
(e) The *fire safety systems* installed in the *building*.

Clause C3 - SPREAD OF FIRE

C3.3.2 *Fire separations* shall be provided within *buildings* to avoid the spread of *fire* and smoke to:

(a) Other *firecells*,
(b) Spaces intended for sleeping, and
(c) *Household units* within the same *building* or *adjacent buildings* . . .

C3.3.3 *Fire separations* shall:

(a) Where openings occur, be provided with *fire resisting closures* to maintain the *integrity* of the *fire separations* for an *adequate* time, and
(b) Where penetrations occur, maintain the *fire resistance rating* of the *fire separation*.

C3.3.6 Automatic fire suppression systems shall be installed where people would otherwise be:

(a) Unlikely to reach a safe place in *adequate* time because of the number of storeys in the *building*,
(b) Required to remain within the *building* without proceeding directly to a *final exit*, or where the *evacuation time* is excessive,

3.4 The relevant provisions of the acceptable solutions

3.4.1 When the building was designed, the acceptable solutions were C2/AS1 in Approved Document C2 and C3/AS1 in Approved Document C3, read together with the Fire Safety Annex in Approved Document C4. From 1 June 2001 those acceptable solutions were replaced by C/AS1 in the new Approved Document C.

3.4.2 Although C/AS1 is different from the previous acceptable solutions in many significant respects, its substantive requirements for the building concerned are the same as before except as mentioned in 12 below. There are also some differences in terminology as set out in 3.4.3 and 3.4.4 below.

3.4.3 The relevant provisions of C2/AS1 and C3/AS1 are:

Intermediate floor Any upper floor within a *firecell* which because of its configuration provides an opening allowing smoke to spread from a lower to an upper level within the *firecell*.

Comment: An intermediate floor may be open, partly open or closed off (from the opening through which smoke can spread) with non-rated partitions including smoke separations. If closed-off with fire separations the space becomes a firecell, and the floor is no longer an intermediate floor.

Open path That part of an *escape route* (including *dead ends*) not protected by *fire* or *smoke separations*, and which terminates at a *final exit* or *exitway*.

Protected path That portion of an *exitway* within a *firecell* which is protected from the effects of smoke by *smoke separations*.

3.4.4 The relevant provisions of C/AS1, where different, are:

Escape height The height between the floor level in the *firecell* being considered and the floor level of the required *final exit* which is the greatest vertical distance above or below that *firecell*.

COMMENT:
2. Where the *firecell* contains *intermediate floors*, or upper floors within *household units* the *escape height* shall be measured from the floor having the greatest vertical separation from the *final exit*.

Intermediate floor Any upper floor within a *firecell* and which is not *fire* separated from the floor below. Upper floors within *household units* need not meet the specific *fire* safety requirements which apply to *intermediate floors* in all other situations.

COMMENT:
1. An *intermediate floor* may be open to the *firecell* or enclosed with non-*fire* rated *construction*. If enclosed with *fire* rated walls another *firecell* is created.

Open path That part of an *escape route* (including *dead ends*) within a *firecell* where occupants may be exposed to *fire* or smoke while making their escape.

3.4.5 In this case the purpose group is SR and the escape height is 14.52 m, so that in order to comply with C/AS1 the building is required to have the following fire safety precautions as listed in table 4.1/5:

(a) If not sprinklered:

(i) 2 means of escape.

If the walkways are regarded as landings on a vertical safe path for one of the means of escape, then the atrium must be pressurised and the lift must be located entirely within the same firecell as that safe path.

If the walkways are regarded as intermediate floors then the atrium must be protected by a smoke control system.

On a common sense basis, the Authority considers that the walkways are to be regarded as intermediate floors rather than landings, but the real question is whether in fact there are 2 means of escape from each of the apartments. If the two sets of stairs are open paths to comply with paragraph 3.8.3 of C/AS1 the two paths:

" . . . shall be separated from each other, and remain separated until reaching an exitway or final exit . . . . Separation shall be achieved by diverging (from the point where two escape routes are required), at an angle no less than 90° until separated by:

"a) A distance of at least 8.0 m, or

"b) Smoke separations and smoke control doors."

Furthermore, to comply with paragraph 3.19.13(b) of C/AS1 only one of the open paths would be permitted via an intermediate floor.

As the atrium must be a separate fire cell, a fire resistance rating of 45/45/45 is required between apartments and the atrium.

(ii) Type 4 automatic fire alarm system with smoke detectors and manual call points, or Type 5 with heat detection in addition to local smoke alarm systems in each apartment and manual call points.

(iii) Fire hose reels, emergency lighting in exitways, and a fire hydrant system.

(iv) Fire resistance rating of 60/60/60 between the basement car park and the atrium.

(v) Fire resistance rating of 45/45/45 between the ground floor car park and the atrium. However, at the time of design, C3/AS1 required a rating of 30/30/30.

(b) If sprinklered:

(i) 1 means of escape.

In this case the means of escape is within the atrium so that a fire resistance rating of 45/45/45 is required between apartments and the atrium.

(ii) Type 7e automatic fire sprinkler system with smoke detectors and manual call points.

(iii) Fire hose reels, emergency lighting in exitways, and a fire hydrant system.

(iv) Fire resistance rating of 60/60/60 between the basement car park and the atrium.

(v) Fire resistance rating of 45/45/45 between the ground floor car park and the atrium.

3.4.6 Whether the building is sprinklered or not, it is not acceptable for a person to have to enter one exitway in order to get to another exitway, see Determination 92.1101 (the first determination ever issued).

3.5 The design

3.5.1 The design report provides for the building to have the following fire safety precautions:

- 1 means of escape (see 6 below).

  The windows and doors opening from the apartments onto the walkways have no fire resistance ratings but are "smoke rated". The windows and doors are protected by drenchers inside the apartments. The opening fanlights are self-closing with fusible links. The doors are fitted with hold-open devices linked to the fire alarm which will close the doors on activation of the alarm.

  Fire resistance rating of 30/30/30 between the ground floor car park and the atrium except for an unprotected opening. A smoke barrier "will be dropped on smoke alarm down to 2 m above floor level to prevent smoke moving into the atrium and will also allow people to safety [*sic*] move from the car parks into the atrium spaces to exit the structure".

  Fire resistance rating of 30/30/30 between the basement car park and the atrium.

- Type 5 automatic fire alarm system with modified smoke/heat detection and manual call points throughout the building. Also, the bedrooms in each apartment have smoke detection which raises an alarm in that apartment only.

- Fire hose reels, emergency lighting in exitways, Fire Service lift controls, and a fire hydrant system.

3.5.2 As noted in 3.2.8 above, the design successfully submitted for building consent does not incorporate an automatic sprinkler system, a pressurisation system, or a mechanical smoke extraction system.

4 DOCUMENTATION AND THE HEARING

4.1 The application was accompanied by relevant correspondence between the parties and by other relevant documents, all of which were treated as submissions. They included

(a) A fire safety report by the designer ("the design report"), said to be "offered as an alternative design to the NZBC acceptable solution".

Many parts of the design were justified by reference to C2/AS1 and C3/AS1.

The fire safety design was changed somewhat in the course of discussions between the parties before the application for determination. However, except for the addition of the drenchers, the design remained fundamentally as described in the design report.

(b) A peer review by a BRANZ fire engineer ("peer reviewer 1") as the developer of the fire model used for the design.

(c) A peer review of the drenchers by a director of a firm of consulting engineers ("peer reviewer 2").

(d) Submissions by the Fire Service.

4.2 The owner submitted comments from the designer and peer reviewer 2 in response to the Fire Service submissions, to which the Fire Service in turn responded with further submissions.

4.3 The building certifier submitted that it had followed the proper procedures in order to be satisfied on reasonable grounds that the design complied with the building code, but made no technical submissions.

4.4 The territorial authority made no submission.

4.5 The Authority commissioned reports from three independent fire engineers ("engineers 1, 2, and 3"). Those engineers were given copies of the application and of the subsequent submission mentioned above. Their reports were copied to the parties.

4.6 The Fire Service and the designer each made submissions in response to those reports.

4.7 After considering the submissions, the Authority prepared a draft determination, which it sent to the parties with a request that they either accept the draft or request a formal hearing by the Authority.

4.8 The owner requested a formal hearing, which was held before a member of the Authority ("the Tribunal") duly appointed to act for and on behalf of the Authority in respect of this determination. The Fire Service and the owner spoke and called evidence at the hearing, but the building certifier and the territorial authority did not appear.

4.9 At the hearing, the Fire Service and the owner were each represented by legal counsel. Also present were the Fire Service's Director of Fire Engineering and Research and its responsible Regional Fire Engineer on the one hand, and on the other a Director of the owner accompanied by the designer and peer reviewer 2. Two members of the Authority's staff were in attendance.

4.10 The hearing concluded before counsel had the opportunity to make final submissions, and the Tribunal agreed to receive such submissions in writing. Counsel for the owner and counsel for the Fire Service both sent final submissions to the Authority.

4.11 Evidence from those present enabled the Authority to amplify or correct various matters of fact that were not adequately identified in the draft.

4.12 In response to a question from the Tribunal, the fire engineers confirmed that the Authority's determinations about fire matters were studied and applied by the profession.

4.13 At the hearing, counsel for the owner asked: "Who is the decision-maker?" The Tribunal replied that, as he had said when opening the hearing, the Authority had delegated that function to him under section 22 of the Building Act.

4.14 Counsel then submitted that the Tribunal could not ask members of the Authority's staff to draft the final determination unless the Tribunal had first directed them as to every decision that was to be incorporated in the determination. He cited no authority for that proposition, which was opposed by counsel for the Fire Service. Mention was made of judges' clerks, and in his subsequent written submission, counsel for the owner said:

" . . . in some jurisdictions judges' clerks have a role in drafting judgments . . . subject to two relevant restrictions:

"(a) Judges' clerks do not generally draft judgments that include findings of fact, determinations of credibility of witnesses or the weight to be given to the evidence of witnesses; and

"(b) Judges' clerks will not prepare draft judgments without specific direction from the trial judge."

4.15 The Authority considers that the procedures adopted in Courts of Law are not appropriate for, and are not required to be followed by, the Authority. This determination is based on the draft determination that was sent to the parties. Authority staff amended that draft take account of the submissions and evidence presented to the hearing. The amended draft was then further amended as directed by the Tribunal. This determination is the decision of the Tribunal acting for and on behalf of the Authority.

5 THE AUTHORITY'S APPROACH

5.1 General

5.1.1 The draft determination included a discussion of the Authority's general approach to assessing designs that did not comply with the acceptable solutions or verification methods set out in the Approved Documents issued by the Authority under section 49 of the Building Act.

5.1.2 At the hearing, counsel for the Fire Service accepted the general approach described in the draft but submitted that the draft should be altered in several respects as mentioned in 11 and 12 below.

5.1.3 Counsel for the owner did not accept the general approach described in the draft, and identified respects in which he submitted that the approach had resulted in erroneous conclusions. In particular, counsel submitted that in the draft:

(a) The Authority had "not applied the correct principles relating to standards of proof, onus of proof and related principles of natural justice".

(b) The Authority had "applied amended provisions of the Building Code (**Code**) and elements of Acceptable Solution C/AS1 that were not in force when the building consent was granted".

(c) The Authority had given undue weight to the requirements of the Acceptable Solution C/AS1 and insufficient weight to the freedom provided under the Building Act (**Act**) to adopt alternative solutions. In particular, the Authority had not separately considered whether the [building concerned] comply with the Code, but rather has focussed on whether [it complies] with C/AS1."

5.2 Questions of proof and natural justice

5.2.1 Counsel for the owner cited *Auckland City Council v New Zealand Fire Service*[1] partially reported at [1996] 1 NZLR 330 as authority for his submission that an applicant for a determination "is under an obligation to produce at least a minimum level of evidence to support its contentions".

5.2.2 The Authority accepts that submission, and considers that the Fire Service fulfilled that obligation in respect of each of the matters of dispute listed in 1.2 above.

5.2.3 Counsel for the owner submitted that:

> " . . . in determining matters of fact, the [Authority] must apply the civil standard of proof of a 'balance of probabilities'"

and contended that in the draft determination the Authority:

> " . . . has effectively impose upon the [owner], a standard of proof equivalent to the criminal standard of 'beyond all reasonable doubt'."

5.2.4 The Tribunal asked counsel about the test of being "satisfied on reasonable grounds" mentioned frequently in the Building Act and particularly in sections 34, 43, and 56 in respect of territorial authorities and building certifiers deciding whether to issue building consents and certificates. Was that test to be used by the Authority in determining disputes about those decisions? Counsel said that "reasonable grounds" applied to the "evidential burden", the requirement that there must be some evidence. That was different from the "burden of proof" which was "the balance of probabilities".

5.2.5 The Authority does not accept that submission, and points to the following passages from *Auckland City Council v New Zealand Fire Service*[2]:

> " . . . the primary evidence before the Authority is the building or the proposed building itself. The conclusion to which the Authority is obliged to come, depends therefore not on what is urged by particular parties, but rather by the extent to which the proposal meets the purpose of the Act. . . . In those circumstances, it is not particularly helpful to see the Authority's task in terms of burden or onus of proof. . . .
>
> "I therefore answer the fourth question raised by the appeal by saying -
>
>> 'That the Authority must have evidence to support its conclusion but it is not helpful in matters of the kind contemplated by the Authority to consider the provision of evidence in the traditional sense of an onus or burden of proof.'"

[1] *Auckland CC v NZ Fire Service* 19/10/95, Gallen J, HC Wellington AP336/93, partially reported at [1996] 1 NZLR 330.
[2] Ibid.

5.2.6 As to the principles of natural justice, counsel for the owner submitted:

> "The procedure adopted by the [Authority] in determining a dispute must be fair and comply with the principles of natural justice (section 12(3) of the Act). Accordingly, the [Authority] must not:
>
> "(a) Apply a wrong legal test.
>
> "(b) Come to a conclusion without evidence or one to which, on the available evidence, it could not reasonably have come.
>
> "(c) Take into account matters which it should not have taken into account.
>
> "(d) Fail to take into account matters that it should take into account.
>
> "(e) Deprive a party of the opportunity to introduce additional evidence of probative value that might deter the decision-maker from making an adverse finding against that party."

5.2.7 The Authority queries whether those things come within the principles of natural justice, but in any case considers that it did not do any of them, as should be clear from the views taken by the Authority on the individual matters of dispute addressed in 6 to 13 below. The exception is the allegation that the Authority deprived a party of "the opportunity to introduce additional evidence". The Authority takes that to relate to the Authority's refusal to delay the hearing until tests had been made on the disputed sprinkler heads discussed in 11 below. The Authority did so on the grounds that the owner had had adequate opportunity to arrange for tests since the matter was first raised by the Fire Service. In any event, the owner will be able to submit test results to the building certifier or territorial authority in accordance with 15 below.

5.2.8 Counsel also submitted that the Authority "must give reasons for its conclusions, including reasons for rejecting the evidence of the experts it has appointed and the evidence presented to the parties to the determination that is contrary to the findings of the [Authority]". The Authority accepts that proposition as a matter of good practice and common sense (but not as being one of the principles of natural justice). Certain passages in the draft determination have been amended accordingly.

5.3 The building code, the acceptable solution, and the proposed alternative solution

5.3.1 Counsel for the owner submitted that in the draft determination the Authority had given "undue weight" to the acceptable solution and "insufficient weight" to the building code when considering whether the design did in fact comply with the building code.

5.3.2 Counsel quoted paragraph 3.5.1 of the *New Zealand Building Code Handbook*:

"NZBC compliance of an alternative solution may be verified by any of the following methods:

"(a) Calculations – using recognised analytical methods and mathematical models.

"(b) Laboratory tests . . .

"(c) Test in-situ . . ."

5.3.3 The Authority does not accept that paragraph as establishing that the Authority may not lawfully assess compliance by comparison with the acceptable solution.

5.3.4 In his written submissions counsel cited *Andrew Housing v Southland District Council*[3] as authority for the proposition that "it would be possible to fail to comply with an Approved Document but nevertheless not be in breach of the Code". The Authority regards that as confirming the view it has always taken that an Approved Document, being a document prepared or approved by the Authority under section 49(1) as a document for use in establishing compliance with the building code, "shall not be the only means of establishing such compliance" as provided by section 49(2).

5.3.5 However, counsel then orally cited the *Andrew Housing* case as authority for the proposition that the acceptable solution "must be put aside" when considering whether or not there is a breach of the building code. The Authority does not accept that proposition and can find no support for it in the case, which turned on the wording of an information laid by a territorial authority in respect of building work done otherwise than in accordance with the building consent and therefore contrary to the Building Act. The case had nothing to do with the question of how one is to assess whether particular building work complies with the building code.

5.3.6 Counsel also submitted that in any case it was inappropriate to compare the building with the corresponding building that complied with C/AS1, citing the following paragraphs from C/AS1 (emphasis added as in counsel's submission):

"**1.1 Scope**

"**1.1.1** This acceptable solution is one way, <u>but not the only way</u>, of satisfying the New Zealand Building Code (NZBC) provisions for fire safety in buildings.

"1.1.2 The methods given are particularly appropriate for simple, low-rise <u>buildings</u>. However, for individual buildings, alternative solutions developed from specific fire engineering design could produce more economical results."

[3] *Andrew Housing v Southland District Council* [1996] 1 NZLR 589.

5.3.7 The Authority does not read the statement that C/AS1 is "particularly appropriate for simple, low-rise buildings" as meaning or implying that it is not appropriate for buildings such as the one concerned. Such buildings are clearly within the scope of C/AS1, and must be accepted as complying with the building code if they comply with C/AS1. The Authority recognises that it could well be advantageous to adopt "alternative solutions developed from specific fire engineering design", but only if such solutions are shown to achieve the performance criteria specified in the building code as exemplified in the acceptable solution C/AS1.

5.3.8 Counsel for the owner also criticised the Authority's approach of considering whether an alternative proposal provided the same level of safety as did the acceptable solution. The proper approach, he said, was to consider whether the proposal complied with the building code.

5.3.9 The Authority considers that the two approaches are not incompatible. A proposal is required to comply with the building code. That means that it achieves the relevant performance criteria specified in the building code. The question is, therefore, whether the particular building concerned achieves those performance criteria.

5.3.10 That is a comparatively simple matter of measurement or calculation when the relevant criteria are specified in quantitative terms. Examples are the illuminance of 1 lux in certain circumstances specified in clause F6.3.1 of the building code, or the building performance index of 0.13 kWh in certain locations specified in clause H1.3.2(a).

5.3.11 However, that approach is not possible when the relevant criteria are specified in qualitative terms. That is the case with the criteria relevant to this determination, which are specified in clauses C2.3.2, C3.3.2, and C3.3.3 with the use of the words "appropriate" and "adequate". A building complying with the acceptable solution must be accepted as an example (but not the only possible example) of what is appropriate or adequate. Assessing the building concerned by comparison with the corresponding complying building is, in the Authority's view, a valid approach. Of course, that is not to say that it is the only approach.

5.3.12 The designer and peer reviewer 2 gave examples of provisions in the relevant acceptable solution, that, in their expert opinions, were "over-conservative" (such as certain exitway widths) or "inadequate" (such as certain spandrel depths). The Authority points out that the acceptable solutions are open to improvement by the processes specified in section 49 of the Act. However, the Authority takes the view that, as a matter of law, those widths and depths must be accepted as complying with the building code unless and until the acceptable solution concerned has been amended or revised by those processes. In fact, the relevant 1.5 m spandrel depth specified in C3/AS1 was increased to 2.5 m in C/AS1.

5.3.13 Counsel for the owner submitted that:

" . . . the [Authority] has not compared the total fire safety design solution incorporated into [the building concerned] with the minimum requirements of the Acceptable Solution, but rather has cherry picked by supplementing the design with any additional requirements found in the Acceptable Solution. This imposes a higher standard than is allowed for in the Act in contradiction to section 7(2)."

However, in response to a question from the Tribunal, neither the designer nor peer reviewer 2 were able to quantify the extent to which it was claimed that the performance standards of the acceptable solution C/AS1 exceeded the requirements of the building code for the building in question.

5.3.14 By way of example, however, counsel for the owner said that the Authority should have considered the overall safety of the building concerned, and given credit for the fact that its external balconies gave greater protection than the spandrels permitted by the acceptable solution against fire spreading up the face of the building.

5.3.15 The Authority rejects that approach. The fact that the building is safer than is required by the acceptable solution in respect of fire spreading up its face does not necessarily compensate for the fact that it is less safe in other respects. One might as well say that a house may be sited on unstable ground because it has been designed to resist a greater wind load than is required by the acceptable solution.

5.4 The Authority's view

5.4.1 The submissions by counsel for the owner have not persuaded the Authority to make any significant changes to the view that it took in the draft determination.

5.4.2 The Authority's task is to determine whether the building complies with the performance-based building code. In doing so, the Authority may use the acceptable solution as a guideline or benchmark when assessing other solutions[4]. The Authority takes the view that it may use the current version of the acceptable solution, C/AS1 for that purpose, given that its relevant requirements differ only in certain respects from those of the previous C2/AS1 and C3/AS1. That is because a determination in terms of the current acceptable solution will be of most use to practicing fire engineers and others concerned. However, where the relevant requirements do differ, and the building does not comply with C/AS1 but does comply with C2/AS1 and C3/AS1 which were current when the design was finalised, the Authority accepts that as establishing compliance with the building code.

5.4.3 As the Authority said in Determination 2002/10, it is important to remember that most buildings never experience the "worst case" fire or earthquake or other event that the building code requires them to withstand. It is not something that is

[4] Ibid

certain to happen, but it is "something that might well happen"[5]. Thus any failure to achieve the required level of fire safety in a particular building will probably not result in deaths from fire in that building. However, the more often a lower level of safety is accepted in a design solution, the more probable it becomes that deaths will result in one or more of the buildings concerned. Of course, that is not to say that fire deaths will never occur in a building complying with the acceptable solution.

5.4.4 The Authority sees the acceptable solution C/AS1 as an example of the level of fire safety required by the building code. However, that level of fire safety has not been, and perhaps cannot be, precisely quantified. Comparing the level actually achieved by the building to the level represented by the acceptable solution therefore requires the exercise of informed judgment. In exercising that judgment, the Authority takes account of (in no particular order):

(a) The specific details of the building concerned, including the matters listed in section 47 of the Building Act;

(b) The requirements of the acceptable solution for such a building read in the light of the provisions of the building code;

(c) All reasonably foreseeable fire scenarios;

(d) The established principles of fire engineering;

(e) The results of tests, experiments, observations, and other sources of reliable and applicable information relevant to those principles;

(f) The opinions of recognised fire engineers;

(g) The circumstances of New Zealand, particularly in respect of legislation such as the Building Act, the Building Regulations, and the Fire Safety and Evacuation of Buildings Regulations where relevant to the application of information from overseas; and

(h) Any other matter that the Authority considers to be relevant.

The weight, if any, to be given to any one of those factors in any particular case is a matter for the Authority and will depend on the circumstances of the case.

5.4.5 In making its determination in this case the Authority is conscious that the building will be in use as a multi unit residential dwelling for an indefinite period, and that its fire safety provisions could well not be tested by a real fire for 20, 40, or more years. (Of course, at some time in the future the owner might wish to

[5] See the use of that phrase in *Auckland CC v Weldon Properties Ltd* 8/8/96, Judge Boshier, DC Auckland NP2627/95, upheld on appeal in *Weldon Properties Ltd v Auckland CC* 21/8/97, Salmon J, HC Auckland HC26/97.

change the use of the building, but if so then section 46(2) of the Building Act will require any necessary upgrading before the use is changed The Authority offers no comment on the situation if the building is in fact currently being used as transitory accommodation as alleged by the applicant, see 1.4 above).

5.4.6 As an example of how the Authority applies the general approach outlined in 5.4.4 and 5.4.5 above to particular performance criteria, consider the performance specified by clause C2.3.1 of the building code, which requires the number of exitways available to each person to be "appropriate" to various other matters. The acceptable solution C/AS1 gives examples of what is appropriate for various combinations of those factors. As stated in 3.4.5 above, C/AS1 specifies that:

(a) One exitway would be appropriate for this building if it had a sprinkler system and fire separations with a rating of 45/45/45 between the apartments and between each apartment and the atrium. Furthermore, escape from each apartment would be required to be into a horizontal safe path before entering a vertical safe path.

(b) Two exitways would be appropriate for this unsprinklered building if it had 45/45/45 rated separations between the apartments and between each apartment and the atrium, if the atrium were protected by a smoke control system, and if access to one of the exitways were not via the atrium (see 3.4.5 above).

The corresponding discussion below is in terms of "means of escape", the term used in the design report, rather than the more strictly correct "exitways".

5.4.7 Similar comparisons between this building and the corresponding examples given in C/AS1 are made in respect of other performance criteria specified in the building code, including the criteria for fire separations.

5.4.8 As can be seen from 3 above, this building is different from the acceptable solution in respect of the means of escape, the fire separations, and various other matters. Therefore, the Authority must consider whether the building's design may be accepted as different means of complying with the building code, usually referred to as "an alternative solution". In several previous determinations the Authority has made 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.

5.4.9 Of course, acceptable solutions are amended, or revised and replaced, from time to time, which may well result in a higher or lower level of health, safety, amenity, accessibility, or any of the other matters with which the building code is concerned. However, the process by which an acceptable solution is changed is set out in section 49 of the Building Act and involves giving affected individuals and organisations the opportunity to comment before the change is finalised. The process by which the Authority makes a determination is quite different. Using the current acceptable solution as a guideline or benchmark means that an alternative solution must achieve effectively the same level of safety, amenity, accessibility, and so on as the acceptable solution. Therefore, no matter how strong the arguments a party to a determination advances to justify a lower level of safety in the particular building concerned, those arguments cannot be accepted for the purposes of the determination. Of course, that is not to say that the same arguments might not find favour in the process of amending or revising the acceptable solution.

5.4.10 In this case, the building is unusual (although not unique) for New Zealand in having apartments opening off walkways in an atrium. The Authority accepts that there is unlikely to be combustible material on the walkways, so that the building is not the worst case in respect of the fire separation between the apartments and the atrium. As mentioned in 5.4.8(a) above, that may be taken into account when designing an alternative solution

5.4.11 However, there is nothing else about the building itself or its residents that makes the risks associated with the building less extreme than for the usual run of apartment buildings. The general questions in relation to compliance with the building code, therefore, will be the extent of compliance with the relevant provisions of C/AS1 and whether compensating provisions have been made for any non-compliance.

5.4.12 Thus the Authority takes the view that it must consider:

(a) Does the building have one or two means of escape? See 6 below.

(b) Do the non-rated doors and windows between the apartments and the atrium, if not protected by drenchers, provide the same level of safety as would the fire resistance rated closures required by the acceptable solution? See 7, 8, 9, and 10 below.

(c) Do those doors and windows, if protected by automatic drenchers, provide the required level of safety? See 11 below.

6 MEANS OF ESCAPE

6.1 The submissions

6.1.1 The design report said:

"Two means of escape from each occupied level and ground floor level are available but only one means of escape is available from the basement and GL west side car park. . . .

"The means of escape through the Atrium space will be protected by smoke extraction using natural convection at roof level plus the provision of hold open devices for all rated -/-/-Sm apartment doors."

6.1.2 The Fire Service said:

" . . . the only means of escape from the building is through the atr ium. The fire safety design does not provide the number of exitways that is appropriate to the open path travel distance."

6.1.3 The Fire Service also said:

(a) Even if there was adequate separation between the apartments and the atrium, the atrium could not be viewed as a safe path.

"The atrium is in fact open to the car park at ground level. There are smoke curtains to prevent smoke ingress into the atrium from a 1.7 MW fire. But there is experimental evidence that shows that car fires can peak at heat releases greater than this. In our view an analysis should be carried out to show that smoke leakage into the atrium from a larger car park fire does not affect escape."

(b) "The atrium is assumed to be a sterile space, and no design fire within the atrium has been analysed. . . . The two escape stairs both descend through the atrium. The designers need to show that the smoke control within the atrium is such that both of these staircases will not become compromised by the same fire event."

6.1.4 The designer responded that:

(a) "The means of escape from the structure is via one of two stairways within the atrium which have adequate separation. Occupants from each apartment have two options when they leave their apartment generally 180 degrees apart i.e. they can move away from the area of threat."

(b) "The central space is effectively 'sterile'. All rooms opening into it at ground level are fire separated and open connecting spaces are dealt with in the design. The central space contains a concrete walkway around each level, two sets of stairs and a lift. The lift is enclosed in a fire rated shaft."

6.1.5 To which the Fire Service responded that "The two means of escape do not have adequate separation. Smoke from one source can accumulate in the atrium and affect both egress routes." The Authority takes the point to be that the two stairways are separated by distance only, not by fire or smoke separation.

6.1.6 Engineer 1 was of the opinion that the design did not have an appropriate number of means of escape in terms of clause C2.3.2 of the building code.

6.1.7 At the hearing, counsel for the owner pointed to the Building Amendment Regulations 2001 that had amended clause C2.2 of the building code by deleting the phrase "escape routes" and substituting the phrase "means of escape from fire". He submitted that:

" . . the [building] need only comply with the lower of the two standards. . . .

"[The Authority] has erroneously applied the term "means of escape from fire", [and the terms]"exitways", and "safe paths" [used in the definition of "escape route"] and the requirements applicable thereto . . . . The difference between them is material to this determination."

6.1.8 Counsel did not identify why he considered the amendment was relevant to the determination. Clause C2.2 "Functional requirement" was not mentioned in the draft, and the Authority takes the view that it is the performance criteria specified in clause C2.3 that are relevant. Those criteria have not been amended.

6.1.9 In the draft determination the Authority did not accept the assumption that the atrium was "sterile". Counsel for the owner submitted that the draft was wrong on that point for several reasons. Those reasons need not be discussed because the Authority now considers that the point was over-emphasised in the draft and is not necessary to support the reasoning as to why the Authority does not accept that the building has two means of escape, see in particular 6.2.4 below.

6.1.10 In his written submission after the hearing, counsel for the owner submitted that:

(a) " . . . C2/AS1 and C/AS1 do not require an escape route to include a protected path or a safe path. It is sufficient that an escape route consists of an open path leading to a protected path and on to a final exit."

(b) "Once a person enters the atrium space . . . they are in a protected path."

(c) "The actual protected path travel distance is approximately 72 metres. Both C2/AS1 and C/AS1 have a maximum allowance of 60 metres for a protected path. However, [C2/AS1 and C/AS1] allow the open path and protected path distances to be amalgamated. As the open path allowance is 24m . . . the requirements of the Acceptable Solution have been met."

(d) "Clause 7.4.1 of C2/AS1 says that glazing in a protected path need not be fire resisting, but must have a smoke-stopping ability . . ."

(e) " . . . C2/AS1 and C/AS1 do not prescribe any minimum number of 'exitways', 'protected paths' or 'safe paths' [but] applied to [the building concerned] require two escape routes (under C2/AS1) or means of escape (under C/AS1)."

6.1.11 Counsel for the Fire Service, in her written submission after the hearing, emphasised that safe paths must be protected by smoke separation, and the two stairs had no smoke separation between them.

6.2 The Authority's view

6.2.1 As mentioned in 5.4.6 above, the discussion below uses the term "means of escape" rather than the more strictly correct "exitways" because the design report was written in terms of "means of escape" and so were all of the submissions received before the hearing.

6.2.2 One of the reasons for requiring two means of escape is so that one will still be available if the other is not. That is why it is not acceptable for a person to have to enter one exitway in order to get to another exitway, see 3.4.5 above.

6.2.3 The Authority accepts the Fire Service view that the two open stairways do not have adequate separation because smoke in the atrium from any source will affect both stairs.

6.2.4 As the Authority understands it, the design is intended to provide two means of escape (the two stairways) as required by C/AS1, but omits the required separation between those stairways on the grounds that:

(a) The atrium is "sterile", which the Authority takes to mean that there will be no combustible material in the atrium and that therefore the design need not consider a fire in the atrium and consequently the stairs need to be protected only against fire in an apartment and not against fire in the atrium; and.

(b) The construction of the apartments is such that a fire in an apartment will not prevent people from escaping by the stairs.

6.2.5 As to the atrium being "sterile", that is required in any case by paragraph 3.12.2(a) of C/AS1, which provides that no other activity is permitted in a safe path unless an alternative escape route is available. Furthermore, it is a matter that the Authority understands is routinely policed under compliance schedules in accordance with the recommendations in CS 13 of the *New Zealand Building Code Handbook*. The Authority considers that comes as close as is reasonably practicable to ensuring that a safe path (in this case the atrium) is "sterile", but nevertheless C/AS1 still requires fire rated separation between the two means of escape.

6.2.6 Protection from a fire in an apartment is also a requirement of C/AS1, see 7.1 below.

6.2.7 Thus the design complies with the relevant requirements of C/AS1 except that it omits the fire rated separation between means of escape on the grounds that compliance with the other requirements ensures that such separation is unnecessary. That is not an acceptable argument. It may or may not be the case that in future C/AS1 will be amended to omit the requirement for two means of escape separated by fire rated construction in an unsprinklered building. Any such amendment will be made by the proper process under section 49. Unless and until that happens, the level of safety represented by C/AS1 must be achieved. It is not achieved by this design because one fire precaution has been omitted without another precaution being used in compensation.

6.2.8 C/AS1 gives an example of such compensation, namely a Type 7e automatic fire sprinkler system with smoke detectors and manual call points, but of course that is not the only means of compensation that might be adopted.

6.2.9 Furthermore, in order to comply with paragraph 3.8.3 of C/AS1 the two open paths that include the stairs must diverge from each other, from the point where two escape routes are required, at an angle no less than 90°. That is not the case in this building. From the doors of several apartments (four out of 12 on level 1) it is necessary to go in a more-or-less straight line past the top of one set of stairs in order to get to the other set. Again, the design includes noting to compensate for this omission of a precaution required by C/AS1.

6.2.10 Accordingly, although there are two stairways the Authority agrees with the Fire Service and engineer 1 that there is only one means of escape.

7 MEANS TO CONTROL THE SPREAD OF FIRE BETWEEN THE APARTMENTS AND THE ATRIUM

7.1 General

7.1.1 The walls between apartments, and between the apartments and the atrium, are fire rated, but the windows and doors onto the atrium are not fire rated but are protected by drenchers. The original design did not include the drenchers, which were added as a supplementary precaution at a late stage in the design. The drenchers are discussed in 11 below. However, both the designer and peer reviewer 2 have stated that, for the reasons given in the fire report, the drenchers are not necessary. Recognising that this determination will be of some general interest, see 4.12 above, the Authority discusses those reasons below.

7.2 The submissions

7.2.1 In respect of the doors, the design report said:

“The apartment doors shall be smoke rated (ie -/-/-Sm) and fitted with hold open devices linked to the fire alarm which will close the doors on the activation of an alarm.”

7.2.2 The designer subsequently said that the installed solid core doors were 47 mm thick, and:

"Fire testing has shown vertical timber sections subject to fire will char at 40 mm per hour. . . . we believe that a solid core smoke control door will stop fire break-out for in excess of 15 minutes."

7.2.3 The Authority questions that statement, considering that it is true only for a fire corresponding to the standard test used to establish fire resistance ratings. The door will "stop fire breakout" in any other fire for a shorter or longer time depending on the characteristics of the fire concerned. The Authority rejects any assumption that if a particular building element has a fire resistance rating of certain numbers of minutes then in a real fire the tested element will ensure that people necessarily have that number of minutes available in which to escape. A factor of safety must be included in any specific design to cover for this fact.

7.2.4 In respect of the windows, the design report said:

"Normal glazing is used on all exterior glazing. Glazing to the Atrium interior shall be toughened laminated glass with each glass layer 6mm thick. This glass has a considerably higher breaking stress 175mPa against 20mPa for 9.8mm laminated CIP glass.

"A typical apartment was modelled with only normal building leakage paths to obtain a temperature profile in the apartment. This information was then put into BREAK1 to get the time for exterior glazing to break 184 seconds. BRANZFIRE was then used with the normal leakage again and with time for exterior glazing to break and obtain a temperature profile under these conditions. This temperature profile was put into BREAK1 with 175mPa breaking stress glass to get a break time 496 seconds for the Atrium side glazing.

"The fan light windows in the kitchen and bedrooms are to be fitted with fusible links. The structure was modelled with a sprinkler head at the location of the fan light window link. The 'link' was modelled with a RTI [response time index] of 300 and a temperature of 70^{o}C. The time for this link to operate 110 seconds was put into the structure programme with fan lights open for that period before closing.

"The fan lights will need to be tested to ensure the windows will close when the temperature reaches 70^{o}C.

"This was then inserted into BRANZFIRE to show that tenable conditions were provided from the structure with a factor of safety of 300 seconds. . . ."

7.2.5 At the hearing, counsel for the owner argued that because the walkways were intermediate floors there was "no obligation imposed by C2/AS1 or C3/AS1 for the Atrium to be a separate fire cell with fire separations between the Atrium and the Apartments".

7.2.6 In his written submission after the hearing, counsel for the owner cited various provisions of C3/AS1 that, he contended, established that C3/AS1 did not require fire rated separations between the apartments and the atrium.

7.2.7 Counsel for the owner also submitted drawings of the fusible link arrangement intended to ensure that the fanlights closed in the early stages of a fire and said:

" . . . The designer has carried out further modelling to demonstrate that the automatic window closing system will activate, thereby closing the windows before the activation of the drenchers. . . .

" . . . This modelling established that the link RTI is 160 . . .

"Under no circumstances did the modelling demonstrate that the drencher activated prior to the window closing."

Results of that modelling were also submitted.

7.2.8 The Fire Service responded that:

(a) The RTI and operating temperature were based on a single test and queried whether two new parameters can be derived from the results of a single test.

(b) "The modelling does not take account smoke flow out of the atrium window."

(c) In all cases modelled, the calculated time for link activation is never more than 10 s less than the calculated time for drencher operation. "No discussion of likely uncertainty or sensitivity analysis has been presented to justify reliance on the results."

7.3 The Authority's view

7.3.1 The Authority does not agree with the owner's assertion that under C2/AS1 and C3/AS1 there was no requirement for a fire separation between the apartments and the atrium. On the contrary, in C3/AS1 paragraph 2.2.4 of defines an "intermediate floor" as being within a fire cell, and paragraph 2.10 1 requires that "every household unit in purpose group SR shall be a firecell". That requirement is not met if the atrium and the apartments are all in the same firecell.

7.3.2 The modelling of fire development is discussed in 8 below, and of glazing in 9 below. However, the technicalities of computer modelling must not be allowed to obscure the facts that:

(a) At best, all that the modelling could establish is that from the operation of the smoke alarm in the fire apartment, the separation between the apartments and the atrium would prevent smoke and fire from entering the atrium for long enough to allow people in the building to escape from the fire with time to spare. That is said to achieve “a factor of safety of 300 seconds”. That of itself does not establish that the non-rated construction between the apartments and the atrium ensures the same level of safety as the fire rated construction required by the acceptable solution. Furthermore, that “factor of safety” appears to be based on the misconception that there are two means of escape.

The Authority does not dismiss the significance of modelling, but emphasises that the results of modelling must be judged against the performance criteria required by the building code and exemplified by the acceptable solution. It is not acceptable to judge the results of modelling against some other criteria, however soundly based. Those other criteria cannot be used unless and until C/AS1 is amended (or a verification method is issued) under section 49 so as to give those other criteria statutory recognition.

(b) Even if the non-rated construction prevented the passage of fire and smoke for the same length of time as the fire rated construction required by the acceptable solution, that would not compensate for the fact that the building has only one means of escape.

7.3.3 As for the fusible link, the Authority notes that the design report said that the fanlights “will need to be tested to ensure the windows will close when the temperature reached 70^{o}C”. Peer reviewer 1 said “it must be confirmed (by physical testing) that the fanlights when released from the open position will close and latch”. The Authority accordingly did not discuss the fusible link in the draft determination in the belief that its proper performance was to be confirmed by physical testing to be carried out at some future time.

7.3.4 The Authority takes the view that it cannot take account of modelling submitted after the hearing that has not been not considered by the peer reviewers or by the independent fire engineers commissioned by the Authority.

7.3.5 The performance of the fusible link has to be established sufficiently in terms of the building code’s definition of “fire resistance rating” cited in 3.3.2 above.

8 MODELLING: FIRE DEVELOPMENT

8.1 The design report

8.1.2 The design report included calculations intended to establish that escape path lengths were satisfactory. The fire model used was BRANZFIRE 2000.04 to calculate smoke height, plus NIST BREAK 1 to determine, for the case of fire in an apartment, when the glazing would break and allow smoke into the atrium.

8.1.3 For the case of a fire in the atrium itself, the ground level of the atrium was modelled as a room ("room 1") with a linking vertical hole into the floor of another similar-sized room ("room 3") at the level above with a typical apartment ("room 2") adjoining on the side, while the rest of the atrium, passing through the upper three levels of apartments, was modelled as a single room ("room 4") above that (presumably, although that is not specifically stated, with a linking vertical hole to room 3 below).

8.2 The submissions

8.2.1 Peer reviewer 1 had earlier expressed various concerns, which had been addressed by the designer by way of amendments to the design report, and in response to the final report peer reviewer 1 said:

> "We note the inclusion of fusible-link operated fanlights in the fenestration between the apartment and the atrium and the fire modelling reports you have supplied in support of the design. We have reviewed these. Our comment on this proposal it [*sic*] that it must be confirmed (by physical testing) that the fanlights when released from the open position will properly close and latch. This will depend on the weight of the window and the degree of opening. The design of window stay should be such that only those opening positions may be selected for which it is known that the window sash will close and latch."

8.2.2 The Fire Service said:

> "Even if the doors within the apartment are open, as assumed, the fire modelling is still affected if there are walls in the apartments. The fire model uses the entire space instead of the smaller bedroom venting into the larger, which means that the time for flashover is extended, and the temperatures within the room increase more slowly than they would in the smaller confined space. Therefore what was modelled is not actually a worst probable fire."

8.2.3 Engineer 1 queried the fact that the designer's fire modelling used only a single apartment fire scenario, which used a room size appropriate to the entire apartment as if there were no internal walls to limit smoke spread and reduce temperature exposure to glazing and slow the time to flashover. Engineer 1 used CFAST Version 3.1.4 to model two fire scenarios and in each of them the fire posed a more severe threat to the glazing and fire separation than in the scenario used by the designer.

8.2.4 Engineer 1 expressed a concern that:

"The fire computer modelling submitted is only one analysis and therefore no variations have been run to evaluate the sensitivity of factors such as room size, ventilation, design fire etc."

8.2.5 At the hearing, counsel for the owner said:

" . . . the concern expressed by engineer 1 that only one analysis was carried out is incorrect. The designer prepared a number of alternative analyses. These can be made available to the BIA on request."

Additional analyses were sent to the Authority after the hearing. However, although acknowledging their existence, the Authority takes the view that it can take no account of those analyses, which were not made available when engineer 1's report was sent to the parties, nor when the draft determination was sent to the parties.

8.2.6 Counsel also said that engineer 1 "did not address the most important factors, which were the evacuation and tenability times". However, those factors were addressed by the applicant, and the Authority accepts, on the basis of a research paper[6] that was included with the applicant's submissions, that the 60 s between the activation of the alarm and the start of evacuation assumed in the design, a time of 169 s (2 min 49 s) "is probably a good representation of the time used by occupants to prepare to evacuate their apartments".

8.2.7 Engineer 3 used BRANZFIRE to model various fire scenarios, and also used FIRECALC to assess visibility, and said:

"The following in particular should be noted:

"(1) . . . the model normally assumes a uniform smoke layer and that it is purely smoke from that layer that moves upwards into the room above. When a void is sufficiently large then clear air moves through the centre of the void whilst smoke around the perimeter becomes a balcony spill plume. The physical representation of this is that less smoke moves up the void than the model states. In other words, smoke is slower to accumulate at upper levels and may build down further at lower levels.

"(2) The BRANZFIRE model does not have the ability to adjust sampling height on individual firecells and the visibility and fractional effective dose values are given at the same level above floor for all firecells. However, the result database may be interrogated for different values. We

[6] Proulx, G Evacuation Time and Movement in Apartment Buildings *Fire Safety Journal 24* (1995) 229.

find from this that visibility within the upper levels of the atrium may in fact be expected to be significantly reduced and this is assessed approximately in the FIRECALC models. From [7] we note that most people will not enter smoke where visibility distance is less than between 4 and 7 m. From the FIRECALC model this is reached in the upper layer from about 4 minutes after ignition for a central atrium fire. By analogy with BRANZFIRE we find this will be reached at approximately 15 minutes when the fire is in a side apartment. Interrogating [one of the scenarios modelled by engineer 3] database confirms this."

8.2.8 At the hearing, counsel for the owner said:

" . . . the FIRECALC model is less accurate than the BRANZFIRE model. FIRECALC needs the user to 'guess' the optical density of the smoke, whereas BRANZFIRE calculates it from the fuel actually burning."

8.2.9 Engineer 3 also said:

" . . . the fire model takes no account of wind direction or speed which depending on the location of the fire may force more smoke into the atrium. However at the same time this may well be compensated by increased stack effect extraction from the upper vents. A worse case scenario should therefore be assumed."

8.2.10 Engineer 3 summed up:

"What may safely in our opinion be inferred from the model is as follows:-

"(1) A fire in an apartment at Level 1, with internal bedroom windows open and with the assumption that all window glass facing atrium is removed, and that windows facing the outside break after approximately four minutes, will produce untenable conditions within the atrium.

"(2) If all windows and doors facing the atrium in other apartments are closed, occupants may safely await the end of the fire. Note that this assumes no interconnection of apartments by penetration of ducts, and that full 30/30/30 separation has been provided around such items as the clothes dryer extraction ducts (this should be checked on site)."

[7] *Society of Fire Protection Engineers Handbook* page 3-259.

8.2.11 At the hearing, counsel for the owner said:

> " . . . Engineer 3 does not describe what he considers untenable conditions to be. Scenario 8 appears to be the one referred to. Here the smoke temperature after 10 minutes reaches only 31°C. The visibility is still 6.2 m, which is above the suggested Draft British Standard of 5.0 m."

8.2.12 In respect of the fire scenarios that had been modelled, the designer said:

> "The apartments are typically about 50 m^2 . . . the design assumed that the doors will be open for maximum air circulation within the apartment."

8.3 The Authority's view

8.3.1 The Authority is conscious that the fire modelling reflected the position that applied prior to the installation of the drenchers. However, it is discussed for the reasons set out in 7.1.1 above. Indeed, the modelling remains relevant because, for the reasons discussed in 11.3 below, the Authority does not accept that the specified drenchers have been established as being a suitable means of achieving the fire resistance rating for the windows.

8.3.2 The Authority takes it that the scenario used in the design report was considered to be the only one, or at least the most demanding one, likely to occur in practice. The Authority does not agree, considering that many of the inhabitants are likely to close their bedroom doors at night, particularly in two-bedroom apartments. The submission by the Fire Service and the modelling done by engineers 1 and 3 establish that other scenarios have more adverse outcomes. Thus the Authority is not satisfied that the design report takes account of all relevant fire scenarios.

8.3.3 Similarly, the submissions by engineer 3 leave the Authority in some doubt about the fire design's model for the atrium, particularly in respect of smoke entering the walkways.

8.3.4 Are there any factors that compensate for those shortcomings in the modelling? The design report included calculations, discussed in 9 below, intended to establish that the time available to escape from a fire well ahead of the smoke layer was in fact more than four times the time actually needed. For the reasons set out in 9.3 and 10.3 below, the Authority does not accept the calculated escape times and therefore does not accept that they compensate for the shortcomings of the modelling.

8.3.5 In any case, the modelling did not attempt to compare the building with the acceptable solution. Again, this is an example of the design achieving criteria which, however soundly based, have not been related to the criteria specified by the building code and exemplified by C/AS1.

9 MODELLING: GLAZING

9.1 The design report

9.1.1 As mentioned above, the design report used the NIST programme BREAK 1 to calculate, for the case of fire in an apartment, when the toughened laminated glass would break and allow smoke into the atrium.

9.1.2 The glazing was described in the design report as being two layers of 6 mm "toughened laminated glass", see 7.2.4 above. However, no particular account seems to have been taken of the characteristics of the glass, and submissions on the glazing were generally in terms of "laminated glass" not "toughened laminated glass". The Authority takes the view that the point is irrelevant for the purposes of this determination, and it has accordingly been ignored.

9.2 The submissions

9.2.1 Before applying for the determination, the Fire Service Regional Fire Engineer e-mailed one of the US developers of BREAK 1 ("the professor") as follows:

"I am currently looking at an application where BREAK1 was used to determine the time to breakage of a laminated glass window.

"I had previously thought that BREAK1 could not be used with laminated glass because of the difficulty of applying the correlations across the laminate layer and also the unknown properties of the laminating material (whether increasing or decreasing the time to breakage.

"Either I have a situation where the program has been misapplied or I am mistaken in my belief.

"Could you pleas confirm that I am mistaken or whether the program has been used outside it's [*sic*] applicable intended parameters by attempting to model the time to breakage of laminated glass."

9.2.2 The professor replied:

" . . . You are right. BREAK1 is not directly applicable to that case."

9.2.3 The Regional Engineer apparently discussed the matter with the designer, who said:

> "It is agreed that BREAK1 may not be suitable for laminated glass, but we know of no actual experiments to prove or disprove this fact. Until such experiments are done one cannot arbitrarily rule that BREAK1 is not suitable."

9.2.4 The Authority disagrees with that proposition. The Authority takes the view that programmes such as BREAK1 cannot be accepted as suitable until verified by actual experiments. Be that as it may, the Regional Engineer e-mailed the designer's statement to the professor, who responded:

> "I am currently conducting experiments . . . on laminated glass. For sufficiently large fires, ~ 1 MW, in the standard ISO compartment the laminated glass not only cracks and falls out but the laminate material begins to burn adding to the fire fuel. I appreciate the confidence in BREAK1 but I would take care in the choice of fire scenarios.
>
> "PS. I have not yet compared BREAK1 predictions with the laminated glass experiments. . . .

9.2.5 The designer also said in response to the Fire Service's correspondence with the professor:

> "Beason's tests . . . on plate, tempered and laminated glass[8] . . . showed that . . . the laminated glass produced the best protection. One would expect therefore that if BREAK 1 is used as the method for calculation it must produce a conservative answer for laminated glass."

9.2.6 When it applied for the determination, the Fire Service submitted that:

(a) The designer's BREAK 1 calculations were based on a growing fire in an apartment assumed to have no internal divisions, but a growing fire in a furnished room "could proceed to flashover much more rapidly than is assumed".

(b) BREAK 1 could not be used to predict failure in laminated glass.

(c) Framing of the windows had not been considered. Aluminium framing could fail even if the glazing did not.

[8] Beason, D "Fire Endurance of Sprinklered Glass" *Fire Journal* July 1986.

9.2.7 The designer responded that the professor had not said that BREAK 1 could not be used to predict failure in laminated glass but that it was not "directly applicable". The designer cited a paper[9] on thermal breakage of double-pane glass which said:

"While it is not appropriate to assume that a double-pane window will take twice as long as a single pane window to break, sequential use of a single-pane model, e.g. BREAK 1, may suffice in many applications. A major difficulty is that . . . BREAK 1 [predicts] only the initial cracking time, not the time when the pane actually falls out."

9.2.8 The Fire Service in turn responded that:

"We agree that double glazing is better than single glazing. However, in double glazing there are two sheets of glass, separated by an air gap. The laminated glass window is not the same as double glazing, so the comparison made is irrelevant."

9.2.9 Engineer 1 said:

"The use of a computer model to model material for which the computer model has not yet been validated is inappropriate. . . .

" . . . the research by D Beason was designed for use in a fully sprinklered building . . .

"<u>Concerns:</u>

- BREAK 1 is not a validated model for use with laminated glazing. There is insufficient information in the references to allow extrapolation for laminated glazing.
- It is not sound engineering to use BREAK 1 model with this non-validated laminated glazing for a life safety system, when the occupants life safety is dependent on the response of that laminated glass in fire conditions."

9.2.10 At the hearing, counsel for the owner submitted that the e-mails from the professor did not "lay any proper evidentiary foundation to support" for the draft determination's conclusion that the Authority did not have reasonable grounds on which to be satisfied that BREAK1 is applicable, and therefore that the fire report's calculated times from an outbreak of fire until the glazing

[9] Cuzzillo B R and Pagni P J "Thermal Breakage of Double-Pane Glazing by Fire". Only one page of that paper was submitted to the Authority, and the journal in which it was published is not apparent from that page.

breaks and smoke enters the atrium had not been verified. Counsel submitted that the Regional Engineer had not asked the professor the right questions, and produced a series of e-mails (post-dating the draft determination) between himself and the professor, and also with other scientists with whom the professor was working.

9.2.11 Having reviewed the correspondence, the Authority does not agree that the Regional Fire Engineer asked the professor "the wrong question", although if the answer had been that BREAK1 was suitable for modelling laminated glass that might have raised the further question of whether it was suitable for toughened laminated glass.

9.2.12 The Authority does not agree that the professor's statements in response were "unreliable".

9.3 The Authority's view

9.3.1 The parties agree that there is no experimental evidence that BREAK 1 is applicable to laminated glazing (toughened or not). Thus the Authority considers that its use for that purpose can be justified, if at all, only on the basis of expert opinion.

9.3.2 The designer's opinion was obviously that it was applicable. Peer reviewer 2's opinion was that "one cannot arbitrarily rule that BREAK 1 is not suitable".. The professor's opinion was that it was not directly applicable. Engineer 1's concerns about the wisdom of extrapolating results from scenario-based computer modelling (see 9.2.9 above) are shared by the Authority.

9.3.3 The Authority does not agree that it is acceptable to use an untested programme for a particular application unless and until testing shows that the programme is not suitable for that application.

9.3.4 As the professor considers that BREAK1 is not applicable to the glazing concerned, then the Authority is not going to decide that it is applicable. To put it another way, the Authority prefers the expert opinion of the professor as to the applicability of BREAK1 to the expert opinions of the designer and peer reviewer 2.

9.3.5 Thus the Authority concludes that the fire report's calculated times from an outbreak of fire until the glazing breaks and smoke enters the atrium have not been verified.

10 EVACUATION TIMES

10.1 The design report

10.1.1 The design report was based on the following assumptions (all times rounded to the nearest second):

(a)	Detection time (heat activated alarm)	87 s	
(b)	Time to gather thoughts	30 s	
(c)	Time to respond	30 s	
	Total time from start of fire to start of evacuation		147 s

And in comparison:

(d) Fanlight closes after 110 s

(e) Glazing breaks after 496 s

10.1.2 Subsequently, the designer treated the building evacuation time as starting from the activation of a smoke detector in the apartment concerned. The time used was 30 s instead of the original 87 s. Thus the total time from start of fire to start of evacuation became 90 s.

10.1.3 From those assumptions, the times (measured from the start of the chosen fire) at which an inhabitant would reach particular locations in the course of escaping from the building were calculated. For the worst case:

Travel commences after 90 s at speed 1.2 m/s:

Travel distance to reach stairs	24 m	
Travel distance to go 1 m down stairs	2.25 m	
Travel time to reach 1 m below walkway level		22 s
Total time from start of fire to reach 1 m below walkway level		112 s

10.1.4 The height of the smoke layer at those locations and at those times, both in the room of origin and in the atrium, was also calculated as follows (heights and distances rounded to the nearest 0.01 m):

(a) In the case of a fire in an apartment, the smoke levels in the atrium identified in the design report are:

For 496 s there is no smoke in the atrium.

At 503 s "the smoke layer has dropped 0.6 m in room 4 . . . and the smoke layer height is 2.46". (The Authority takes it that the height of the smoke layer in the atrium is measured from the floor of the notional room 4.)

At 506 s "Smoke layer height 2.46 m".

(b) In the case of a fire in the atrium, no smoke heights are identified, but the design is described as "using natural ventilation to control the smoke level sufficient to allow safe egress off level 5 of the apartment and allow people to evacuate through level 3".

10.1.5 Those calculations showed, for both a fire in an apartment and a fire in the atrium, an inhabitant evacuating by the longest route from an apartment on the top level would be below the smoke layer throughout the evacuation to the outside of the building.

10.1.6 The results from BRANZFIRE showed that the smoke level on the ground floor had come down to head height 518 s after the start of the fire. The total travel distance from an apartment on the top floor to outside the building was 85 m, giving a travel time of 71 s. Adding the 147 s total time from start of fire to start of evacuation gave an evacuation time of 218 s, which the design report referred to as resulting in a 518 – 218 = 300 s (5 min) "factor of safety", which the Authority prefers to consider a "time margin of safety". The phrase "factor of safety" was also used by the designer and by peer reviewer 2 to refer to the time from the outbreak of fire until glazing broke and smoke entered the atrium divided by the time from the outbreak until an inhabitant of a floor had travelled to 1 m below the level of that floor, being 496/112 = 4.4.

10.2 The submissions

10.2.1 The Fire Service submitted that "a 60 second delay for occupants to gather their thoughts and respond to an alarm of fire is inadequate" and cited Canadian research into evacuation in apartment buildings[10,11,12] in support of its proposition that "at least 5 minutes (and more) should be used for the pre-movement time for apartment buildings where there are sleeping occupants".

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[10] Proulx, G and Fahy, R F " The Time Delay to Start Evacuation: Review of Case Studies", *Fire Safety Science – Proceedings of the Fifth International Symposium* International Association for Fire Safety Science.

[11] Proulx, G Evacuation Time and Movement in Apartment Buildings *Fire Safety Journal 24* (1995) 229.

[12] Proulx, G and McQueen, C *Evacuation Timing in Apartment Buildings* National Fire Laboratory, Institute for Research in Construction, National Research Council of Canada, Ottawa 1994.

10.2.2 The designer responded:

> "The pre-movement time is assumed as 1 minute. This is an acceptable time in the circumstances where (a) the building has smoke detectors (not heat detectors) in each apartment whose response time will be of the order of 30 seconds, and (b) the building is required to have regular fire drills . . . which residents . . . can use to train themselves to respond in less than 1 minute after alarm."

10.2.3 Engineer 1 was concerned that:

> "The occupant decision-making and investigation times affect total egress times. The times of 30 seconds each are much lower then [*sic*] found in generally accepted references. Therefore the calculated egress time is too slow [*sic*], which means that occupants are likely to be exposed to adverse conditions."

10.2.4 Engineer 1 also pointed out that the activation of a smoke detector alerts only the occupants of the fire apartment, not the occupants of the rest of the building. Those other occupants might not be alerted until the heat detector activates 57 seconds after the smoke detector activated. Engineer 1 was concerned that:

> "Smoke detection activation is inappropriate to use for building wide evacuation times. The use of the smoke detector to initiate evacuation leads to times that are not valid and too fast."

10.2.5 Engineer 3 pointed out that occupants of the fire apartment, alerted by the smoke detector, might leave the door latched open when they leave the apartment, and the latch would not be released until the heat detector activates.

10.2.6 Engineer 3 also said:

> " . . . the escape assumption . . . requiring response of sleeping occupants within one minute is very unlikely to be achieved by all occupants, but note that the additional margin of safety of five minutes is reasonably generous.
>
> "The consequences of whether or not the fusible peg [which operates to close the fanlight] and the wetting down of the windows fail or succeed must also be considered. . . . "
>
> "The best time for occupants to leave all apartments and escape via the atrium is within two or three minutes of ignition, i.e. as soon as they can after heat detector activation (assuming fire in a Level 1 apartment).
>
> "The second most prudent course of action is to close windows facing the atrium and wait for the Fire Service to control the fire. Even if the Fire Service do not arrive and the fire burns out at no time will the hot gases reach a temperature high enough to breach the tempered glazing at the upper levels. . . .

"The very worst time for occupants to leave their apartments and escape through the atrium is between 15 minutes and 30 minutes after ignition or, in the case of a fire brigade controlled fire, at the time they see the Fire Service arrive. Conditions in the atrium will be hazardous from about 8-10 minutes after ignition if fire compartment windows facing the atrium are broken early in the fire."

10.2.7 Engineer 3 said that the key issue was how long it took people to respond to an alarm. If response is "normal" as described in the New Zealand Buchanan *Fire Engineering Design Guide*[13], then escape should successfully be made. That was confirmed by engineer 3's modelling for a worst case with all glazing facing the atrium non-functional and with the apartment door left open. Engineer 3 used BRANZFIRE with an approximate check against gross errors using FIRECALC. Thus engineer 3 was of the opinion that the building complied with clauses C3.3.2 and 3 of the building code.

10.2.8 In summary, engineer 3 was of the opinion that:

" . . . a full burnout fire in any apartment will not cause injury or illness to occupants of other apartments who stay in their apartments with windows facing the atrium closed . . . However, an attempt to escape at the wrong time must be avoided."

10.2.9 At the hearing, counsel for the owner emphasised the importance of the regular fire evacuation drills conducted under the Fire Safety and Evacuation of Buildings Regulations.

10.2.10 Counsel also submitted detailed comments on the modelling that had been done by engineers 1 and 3. On the view the Authority takes of this matter, see 10.3 below, it can see no point in discussing those comments.

10.3 The Authority's view

10.3.1 The most that the designer's calculations could establish would be that those occupants able and willing to escape were likely do so within certain times if the alarms, the glazing, the doors, and the ventilation provisions behaved as intended in an actual fire that was not significantly different from the fire scenarios considered by the designer. The Authority sees this as another example of the design achieving criteria which, however soundly based, have not been related to the criteria specified by the building code and exemplified by C/AS1. Nevertheless, the Authority sets out below its views on the submissions about the calculated evacuation times.

10.3.2 The Authority understands that the designer's assumptions as to escape times and travel speed correspond to the mean values (not the least favourable values) empirically established by researchers. Those assumptions have been criticised by

[13] Buchanan *Fire Engineering Design Guide* 2nd ed.

the Fire Service and by engineers 1 and 3. The Authority considers that those criticisms are valid.

10.3.3 The papers mentioned in 10.2.1 above reported measurements of actual escape and travel times, and noted that:

"The overall evacuation time . . . was not significantly affected by the presence of people with limitations [in the buildings concerned these included people carrying babies, slow walkers, walking with a cane, wheelchair users, visually impaired, having MS] because most occupants with serious limitations stayed in their apartments waiting to be rescued by firefighters."

10.3.4 Thus the Authority considers it unrealistic to assume that all occupants will be able and willing to escape at all, let alone within the calculated time. In Determination 2002/2, the Authority said:

"The Authority considers that in comparing the proposal with the acceptable solution, no account need be taken of the fact that a significant proportion of the current residents are said to be elderly, with some needing assistance to escape. That is a situation that could well occur in any house or apartment building, and the Authority takes the view that section 7(2) of the Building Act means that it must be assumed that the acceptable solution allows for the situation."

See also section 50(1)(d) of the Building Act, which provides in effect that compliance with an acceptable solution must be accepted as establishing compliance with the corresponding provisions of the building code.

10.3.5 In relation to engineer 3's report, the Fire Service submitted that:

"Under section 21A of the Fire Service Act 1975, the occupants must be able to evacuate safely, it is not an option for the designer to assume that they remain in their apartments."

10.3.6 The Authority assumes that the Fire Service was referring to the following words in section 21A:

"(1) [In respect of certain buildings] the National Commander [of the Fire Service] may require the owner of that building to make provision for a scheme which provides for evacuation from the scene of a fire to a place of safety outside the building.

"(2) Notwithstanding the provisions of subsection (1) [in certain cases the evacuation may be] from the scene of a fire to some other place of safety (whether within or outside the building)."

10.3.7 The Authority does not read those provisions as imposing additional statutory requirements for the design of buildings over and above the requirements of the Building Act. Furthermore, the Authority regards it as incontrovertible that in fact some people will remain in their apartments whatever assumptions are made by the designer.

10.3.8 Engineer 3 noted that, "provided fan-light windows are closed", people who stayed in their apartments would be as safe as people who escaped.

10.3.9 If the fanlights are closed, then the Authority asks "For how long will people in the apartments be safe?" The answer must be "For however long it takes for someone, probably the Fire Service, to rescue them", by which time the unsprinklered building could be severely compromised and rescue by way of the single means of escape could be difficult if not impossible.

10.3.10 Of course, the comments above apply only to people who are unable to escape, not to people who choose not to attempt to escape until they consider it safe to do so.

10.3.11 The designer pointed out that, under the Fire Safety and Evacuation of Buildings Regulations, residents would have regular fire drills. It is conceivable that such drills would not only ensure that residents were aware of how to escape but also of what to do if they were unable or unwilling to escape. However, the Authority does not accept that such fire drills will prevent people from attempting unsafe postponed escapes.

10.3.12 Whether, and if so when, the doors and windows separating the apartments from the atrium space fail will depend on how effectively they are protected by the drenchers.

11 DRENCHERS

11.1 The design report

11.1.1 The original design was altered to incorporate certain sprinkler heads ("the specified heads") as vertical sidewall sprinklers inside the apartments to act as drenchers for the glazing and doors on to the atrium. It is not specifically stated, but apparently the drenchers operate at 74 ^{o}C. (The documents apply the words "sprinkler" and "drencher" interchangeably to the system of sprinkler heads used to drench the surfaces of the windows and doors in a fire.)

11.1.2 The designer said:

"When [advised that the Fire Service was] going to seek a determination . . . the developers decided [to avoid delays they would] install drenchers over the windows and doors as an additional level of safety. The drenchers providing the fire rating to the openings.

"The installation of the drenchers was not done because it was felt the design was incorrect, it was a commercial decision to avoid delaying completion of the project."

11.1.3 In a letter to the Fire Service, which was accompanied by data sheets for the specified head and also for another sprinkler head (“the listed head”), the designer said:

(a) The glazing concerned consisted of “6 mm toughened plate, 1.5 mm of laminate and a further sheet of toughened laminate [*sic*, presumably ‘laminate’ should read ‘plate’]”.

(b) “We have used 93 ^{o}C quick response bulbs to ensure the window fusible links (rated at 70 ^{o}C) have closed before the sprinkler is activated.”

(c) The [specified head] “puts a higher density of water onto the window area than does the [listed head], and . . . at a higher pressure (1 bar versus 0.5 bar).”

(d) The [specified heads] were available at a much lower price than the [listed heads].

In the discussion above, reference to the “[listed heads]” is to a proprietary head that has been tested by a recognised agency, see 11.1.6 and 11.2.4 below.

11.1.4 In reply to a query from the Fire Service, the proprietor of the specified heads said:

“The proposed application of the [specified heads] to protect the 1.2x1.2 square meter [*sic*] window may work just fine, however, we just have no way of knowing. Sorry we cannot shed any more ‘light’ on the subject for you, but we simply have not done any testing of our sidewall sprinklers for this kind of an application.”

11.1.5 Peer reviewer 2 made the following points:

(a) A 1997 report on drenchers commissioned by the Authority from a working party of fire engineers had reported that wetted glazing up to 4 m high and of unlimited width subjected to the ASTM E119 time/temperature curve could survive for 2 hours or more. A wetting rate of 12.5 $l/min/m^2$ of glass was recommended.

(b) The proposed sprinklers achieved a rate of discharge well above that recommendation.

(c) The design assumptions, and in particular the assumption that glazing would fall out when it cracked, allowing smoke to flow through the entire window area, were "conservative in a number of respects".

(d) In the reviewer's opinion, a drencher system was not required "but if installed it will definitely increase the level of fire safety".

11.1.6 Correspondence between the Fire Service and the US testing and accreditation organisations Underwriters Laboratories ("UL") and Factory Mutual ("FM") established that there was a UL listing for [the listed head] for protection of specific glazing materials, but that listing "does not relate to a fire resistive rating of wall assemblies". There was neither a UL nor a FM listing for any other sidewall sprinkler.

11.1.7 Peer reviewer 2, in a letter that was accompanied by a copy of a paper[14] on sprinklered glass walls, expressed the opinion that the specified heads "would be expected to produce similar results" to the successfully tested listed head for which a data sheet had been supplied.

11.2 The submissions

11.2.1 The Fire Service submitted that for protection of glazing by sprinklers, the water must flow smoothly over the glass to wet its whole surface, which "requires the use of specially designed and approved sprinkler heads".

11.2.2 Engineer 1 gave reasons for the following concerns:

"When modelled correctly, the window does not shut before activation of the drencher system. Therefore the fusible link element of the window shutter will be cooled by the sprinkler stream and is unlikely to activate. . . .

"The drencher system will not fulfil its original intent with the window open.

[14] Beason, D Fire endurance of sprinklered glass walls, *Fire Journal* June 1986.

"Even if the window does shut, the system is still not considered to be acceptable as there are concerns with wetting, laminated glazing and horizontal mullions."

11.2.3 Engineer 2 said that there had been a multitude of tests that prove that drenchers provide a level of protection equivalent to that provided by standard resistance tests. Potential failure modes, and engineer 2's comments on them, were:

(a) Flashover in the fire cell can overwhelm the drenchers.

" . . . all the drencher heads inside an individual apartment are required to be designed to simultaneously operate. The designer has adequately addressed this failure mode."

(b) Due to extreme changes within the fire cell at flash over, the windows break before or as the drenchers operate.

"[Based on experience, and given] the 12 mm thick laminated glazing . . . it would be reasonable to assume that on the balance of probabilities, the windows breaking before the drencher heads operate to protect them seems unlikely."

(c) Inadequate reliability of the drencher system.

"It is commonly understood that sprinkler systems in Australia and New Zealand will reliably control fire in 99.5% of cases. . . . The critical issues not addressed by the designers of the drencher system include monitoring of isolation valves and the maintenance and inspection regime. However, the designers have specified that isolation valves shall be locked open with a standard fire service lock and clearly labelled. If an inspection regime based on the sprinkler standard is included in the Compliance Schedule for the building, then it could be assumed that the drencher system would have an acceptable level of reliability. The compliance schedule would need to address issues over and above that provided for sprinkler systems, such as curtains and the like impeding drencher coverage."

11.2.4 As to the use of unlisted sprinkler heads, that is heads that have not been specifically tested for the proposed use in accordance with a recognised test method, engineer 2 pointed out that the listed head appeared to be the only one listed as having been tested for that purpose of protecting a window, nevertheless "sprinkler heads have been traditionally used to provide drencher protection for exterior walls of buildings [and] 'probably ante-date automatic sprinklers'[15]."

11.2.5 Engineer 2 was of the opinion that:

[15] Marryat, H W *Fire A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986* AFPA 1988.

"Given this, there is wide-spread acceptance that when using conventional sprinkler technology, such as the drencher heads proposed on this project, that careful engineering judgment can be exercised in use of heads outside their listed criteria. Given the small size of openings [and] the relatively high density of water discharged it is the author's opinion that the heads will meet their desired intent. . . . [However], the most conservative choice would be to use fast response elements in these heads."

11.2.6 However, engineer 2 also noted that:

" . . . insufficient information is available for a Building Consent to be issued. . . . For example, it is not clear that the windows that are fitted with drencher heads are not fitted with horizontal mullions or transoms [that would act as] obstructions to the drencher head discharge . . ."

and that the same applied to fittings such as curtains.

11.2.7 At the hearing, a drawing and photographs of the drencher-protected windows were submitted. They made it clear that the installed blinds would not obstruct or interfere with the discharge from the specified head. There is a horizontal mullion, but from inspection the Authority accepts that it also would not obstruct or interfere with the discharge.

11.2.8 Counsel for the owner submitted that the specified heads had been used in other buildings in New Zealand to protect glazing. A large amount of successful testing had been done on glazing protected by drenchers, but little if any of it with heads that had been specifically designed, or tested and listed, for that purpose. "There is no requirement under the Code that [sprinkler heads] be tested or certified by the manufacturer that they are suitable for the purpose of protecting glazing."

11.3 The Authority's view

11.3.1 For the reasons given in 10.3 above, the Authority does not accept that the doors and windows alone would provide adequate protection against fire and smoke entering the atrium. However, the Authority recognises that it is possible for doors and windows with drenchers to provide a level of protection equivalent to that provided by fire rated construction.

11.3.2 The Authority accepts that drenchers used to protect glazing must provide a smooth flow of water over the entire glass area. However, that will depend whether the drencher heads are suitable. In considering what is suitable the Authority is conscious that there are recognised test methods for establishing the suitability of sprinkler heads for particular purposes, and that the specified head itself has been successfully tested for various purposes although not as a window drencher.

11.3.3 The designer and engineer 2 were of the opinion that the specified heads would adequately protect the glazing. The proprietor of the specified heads refused to offer an opinion, saying that they "may work just fine, however, we just have no way of knowing". If the proprietor does not know whether its heads would adequately protect the glazing, then the Authority is not going to decide that they will, despite the other expert opinions. To put it another way, the Authority prefers the expert opinion of the proprietor that there is no way of knowing whether its heads are suitable to the expert opinions of the designer and of engineer 3 that they are suitable. The Authority concludes that it does not have reasonable grounds on which to be satisfied that the specified heads will adequately protect the glazing.

11.3.4 The Authority therefore concludes that it does not have reasonable grounds on which to be satisfied that the specified drenchers, in the circumstances of this particular building, would protect the non-rated doors and windows so as to provide the same level of safety as the fire resistance rated construction required by the acceptable solution. Even if they did, of course, that would not compensate for the fact that the building has only one means of escape.

12 FIRE SEPARATION BETWEEN THE BASEMENT AND THE GROUND FLOOR

12.1 The submissions

12.1.1 In the design report, the fire resistance rating of 30/30/30 between the basement car park and the atrium was calculated from paragraph 2.12.5 and Table 1 of C3/AS1 (now replaced by paragraph 6.10.5 and Table 5.1 of C/AS1).

12.1.2 The Fire Service pointed out that paragraph 2.2.5 of C3/AS1 required a fire resistance rating of 60/60/60 between the top of a basement and the lowest firecell above ground level.

12.1.3 The designer responded that paragraph 2.2.5 of C3/AS1 must be read in terms of a basement that is not ventilated so that the heat can build up and no cooling is provided to the structure:

"In this project, there is an open grill door on the ramp into the 'lower level' car park space, providing both ventilation and cooling, hence the basement criteria does not strictly apply.

"The design treated the carpark as a space within the structure and calculated a 30-minute fire rating for separation between ground level and lower level. The time of 30 minutes provides sufficient time for safe egress and allows time for the [Fire Service] to conduct a search if necessary."

12.1.4 The designer stated at the hearing, and subsequently confirmed in writing, that in fact the floor over the basement car park had a fire resistance rating of 60/60/60, and the doors to the stairs and the stairwell had a fire resistance rating of -/60/60. The Fire Service accepted that the required fire separation had been provided between the basement and the ground floor, but observed that the information had been available but not provided by the owner in response to the application for a determination.

12.2 The Authority's view

12.2.1 The designer's statement and the Fire Service's acceptance would be an end of the matter except that the Authority feels constrained to comment on how the matter was treated in the design report. After all, that report was accepted by the building certifier as establishing that the building complies with the building code, and was submitted to the Authority as evidence to the effect.

12.2.2 The Authority does not understand the designer's reference to the basement car park as "a space within the structure" as distinct from "a firecell". The design report states that the fire resistance ratings of building elements were derived from C3/AS1, in which paragraph 2.12 3 requires car parking spaces within a building to be "separate firecells". However, the design report uses only paragraph 2.12.5 and Table 1 of C3/AS1, and makes no mention of paragraphs 2.2.5, which requires a rating of 60/60/60, and 2.12.3 which provides that car parking spaces within a building "shall be separate firecells".

12.2.3 Furthermore, the Authority considers that paragraph 2.12.5 was misinterpreted in the design report. Specifically, the design used C=0.5, which applies to "floors and supporting elements within the car park firecell" in a sprinklered building, instead of C=1.0, which applies to "fire separations between firecells" in an unsprinklered building. Use of the correct value of C results in a requirement for a fire resistance rating of 60/60/60, which is the same as is required by paragraph 2.2.5.

12.2.4 As paragraph 2.12.5 and Table 1 take account of ventilation, the Authority rejects the designer's contention that because there is "an open grill . . . providing both ventilation and cooling . . . the basement criteria does not strictly apply".

13 FIRE SEPARATION BETWEEN THE GROUND FLOOR CAR PARKING AND THE ATRIUM

13.1 The submissions

13.1.1 In the design report, the fire resistance rating of 30/30/30 between the basement car park and the atrium was calculated from paragraph 2.12.5 and Table 1 of C3/AS1 (now replaced by paragraph 6.10.5 and Table 5.1 of C/AS1).

13.1.2 The Fire Service submitted that was inadequate and cited paragraph 2.12.3 of C3/AS1.

13.1.3 The designer responded:

"The Ground Level carpark area is provided with a minimum of a 30-minute fire rating but in fact higher due to the heavy masonry construction for the structural supports. Because of their size they offer a rating in excess of 30 minutes which will ensure there is no collapse before the occupants evacuate or [the Fire Service] has carried out a search of the structure.

" . . . A car fire was modelled . . . which showed the smoke layer came no lower than 2.31 m above floor level out to a time of 1800 seconds (30 minutes). To stop the flow of smoke into the atrium space, smoke curtains were installed to drop to at least [*sic*, presumably "not more than" was intended] 2m above the floor, activated from the heat detectors or operation of any fire alert device within the structure."

13.1.4 At the hearing, counsel for the owner submitted that:

(a) The 1.7 MW car fire used for the original modelling had been selected from the publication *International Fire Engineering Design for Steel Structures*.

(b) "In any event, the designer has since modelled a 5MW car fire and [the building] was able to cope with the fire and smoke in accordance with the requirements of the Code. . . . Engineer 3 also included an atrium fire model of 4MW in his report [which] produced a maximum smoke temperature of 60°C. The visibility levels were guessed."

(c) "The car park at ground level is also open to the sky on the East and West sides, therefore can freely vent under all conditions."

13.1.5 Also at the hearing, the Fire Service produced photographs showing that in fact there were large openings in the walls between the ground level car park and the atrium. The fire report states that:

"A smoke barrier is required to seal off the car parking areas at GL from the Atrium down to 2 m above GL."

13.2 The Authority's view

13.2.1 As to the fire resistance rating of the walls, the Authority considers that again paragraph 2.12.5 of C3/AS1 was misinterpreted, with C=0.5 being used instead of C=1.0. However, the calculations (12 minutes for C=0.5, 24 minutes for C=1.0) both result in a 30/30/30 fire resistance rating.

13.2.2 For an unsprinklered building with two means of escape, the required fire rating between fire cells under paragraph 3.5.1 and 3.6.2 of C3/AS1 was 30/30/30, while, as mentioned in 3.4.4(a)(ii) above, under C/AS1 it is 45/45/45.

13.2.3 As mentioned in 5.1.2 above, because the building was designed while C3/AS1 was in force, the Authority accepts that, at the time of the application for building consent, the 30/30/30 fire resistance rating between the ground floor car parking and the atrium would have been deemed to comply with the building code.

13.2.4 As to the openings, the design apparently assumes that the only reason for separating the atrium from the car parking area is to prevent smoke from entering the atrium if there is a car fire in the car park area. On that basis, the design includes large openings in the fire rated wall, with those openings being unprotected except for smoke barriers.

13.2.5 The Authority points out that paragraph 2.12.3 of C3/AS1 provides that car parking spaces within a building "shall be separate firecells". Thus to comply with the acceptable solution it was necessary for any openings between the atrium and the car park area to be protected with 30/30/30 rated closures. The Authority does not accept that a smoke barrier down to 2 m above floor level is an acceptable substitute for the required fire rated closure. Again, this is an example of the design achieving criteria which, however soundly based, have not been related to the criteria specified by the building code and exemplified by, in this instance, C3/AS1.

13.2.6 The Authority accordingly concludes that there is inadequate fire separation between the atrium and the ground floor car parking.

14 CONCLUSIONS

14.1 In comparing the building with the acceptable solution, as discussed in 5 above, the Authority concludes that the answers to the questions posed in 5.4.12 above are:

(a) The building has only one means of escape whereas two or more are necessary for compliance with the building code.

(b) The assumptions and methodology of the fire design are not appropriate, in particular because:

(i) The fire modelling does not take account of all relevant fire scenarios.

(ii) The assumptions as to reaction times and evacuation speeds are unreliable.

(c) The glazing, even though protected by drenchers, cannot be relied upon to behave to predicted in the fire design because:

(i) BREAK 1 has not been shown to be applicable to toughened laminated glazing.

(ii) The specified drencher heads have not been shown to be suitable.

(d) The fire resistance rating between the basement car park and the atrium does comply with the building code.

(e) The fire resistance rating between the ground floor car park and the atrium does not comply with the building code.

14.2 Accordingly, in respect of the matters of dispute raised by the applicant, see 1.2 above, the Authority concludes that:

(a) The building has inadequate means of escape.

(b) The building has inadequate means to control the spread of fire.

(c) There is adequate fire separation between the basement and the ground floor.

(d) There is inadequate fire separation between the ground level parking and the atrium.

15 WHAT IS TO BE DONE?

15.1 It is not for the Authority to decide how the building is to be brought to compliance with the building code (subject to any waivers or modifications granted by the territorial authority). That is a matter for the owner to propose and for the building certifier or the territorial authority to accept or reject, with any of the parties entitled to submit doubts or disputes to the Authority for another determination.

16 THE AUTHORITY'S DECISION

16.1 In accordance with section 20 of the Building Act, the Authority hereby:

(a) Determines that the building does not comply with the building code in the respects outlined above, and

(b) Reverses the building certifier’s decision to issue a code compliance certificate.

Signed for and on behalf of the Building Industry Authority on this 27th day of February 2003.

W A Porteous
Chief Executive