Determination No 2002/4

Safety from falling in an entertainment centre

1 THE MATTER TO BE DETERMINED

1.1 The matter before the Authority was whether a safety barrier in an entertainment centre complied with clause F4 of the building code.

1.2 In making its determination, the Authority has not considered any other provisions of the building code.

2 THE PARTIES

2.1 The applicant was the Occupational Health and Safety service of the Department of Labour ("OSH"). The other parties were the owner acting through a senior barrister and the territorial authority concerned acting through a firm of solicitors.

3 THE BUILDING AND THE COURSE OF EVENTS

3.1 The building is an entertainment centre. The barrier concerned is part of a wall to a balcony or mezzanine floor and protects a drop of approximately 15 m to the main floor. When the building was first erected, the wall concerned was an external wall, and the opening was filled by a window. When the building was altered, the wall became an internal wall, the window was removed, and a safety rail was installed to span the opening so that, together with the wall below, it provided a safety barrier. The construction of that barrier was part of the alterations to the building for which the territorial authority issued a code compliance certificate in December 1999.

3.2 As reported by an OSH Investigation Report ("the OSH report"), a 16 year old student "sat on top of the rail . . . lost his balance and fell backward . . . to his death. There was no evidence of alcohol, drugs, or tomfoolery."

3.3 Immediately after the accident, the barrier was altered by raising the safety rail and infilling the gap between the rail and the wall below it. The Authority received conflicting information as to the dimensions of the barrier at the time of the accident, but this determination is made on the basis of the dimensions shown in Figure A on the next page (see also 5.1.4 below).

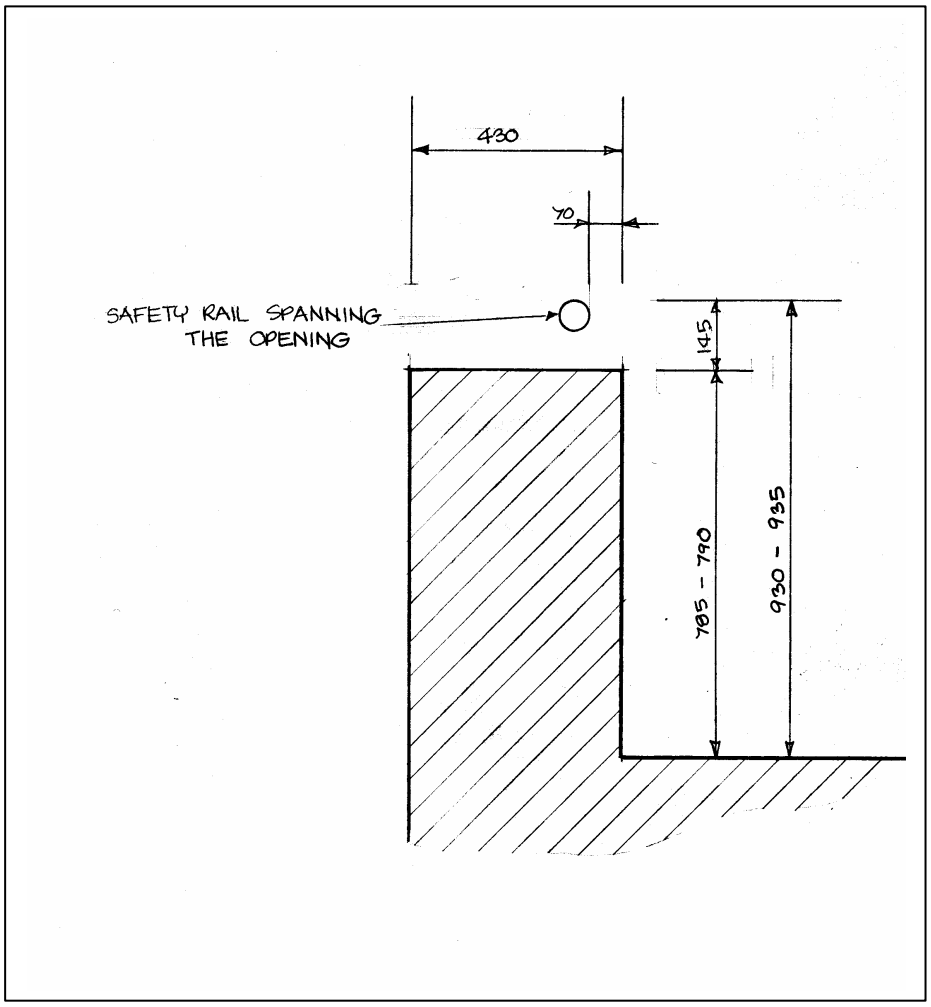

Figure A

4 CLAUSE F4 OF THE BUILDING CODE AND APPROVED DOCUMENT F4

4.1 The relevant provisions of clause F4 of the building code are:

> **F4.3.1** Where people could fall 1 metre or more from an opening in the external envelope or floor of a building, or from a sudden change of level within or associated with a building, a barrier shall be provided.
> **F4.3.4** Barriers shall:
> (b) Be of appropriate height,
> (e) Be constructed to prevent people from falling through them, and
> (f) In the case of a swimming pool, restrict the access of children under 6 years of age to the pool or the immediate pool area.
> (g) Restrict the passage of children under 6 years of age when provided to guard a change of level in areas likely to be frequented by them.

4.2 The relevant provisions of acceptable solution F4/AS1 in Approved Document F4 are:

(a) Barrier heights:

> **1.1.1** Acceptable minimum barrier heights are given in Table 1.

Table 1: Minimum barrier heights

Building type	Location	Barrier height (mm)
All . . . buildings [other than dwellings]	All locations other than stairs or ramps	1000

NOTE:
1 Heights are measured vertically from floor level (ignoring floor coverings) on floors, landings and ramps, and from pitch line or stair nosings on stairways.

(b) Balconies with fixed seating:

1.2.4 Balconies with fixed seating:

Where a balcony or mezzanine floor accommodates fixed seating, a front barrier is shown in Figure 1 may be used as an alternative to Paragraph 1.2.1 and shall have:

(a) A minimum height of 700 mm above floor level,

(b) A horizontal projection extending at least 700 mm forward of the barrier at the top rail level, and

Comment: This solution is expected to be used mainly in places such as assembly halls, theatres and cinemas.

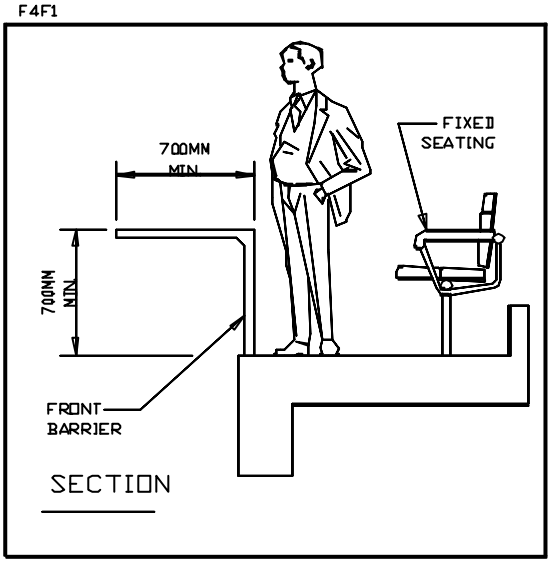

Figure 1: Barriers to balconies
Paragraph 1.2.4

(c) Opening windows:

4.0.1 Where the possible height of fall is 1.0 m or more, measured from the adjacent floor level, windows that open shall have:

(a) The lower edge of the opening no less than 760 mm above floor level, or

(b) A window opening restrictor fitted to limit the maximum dimension of the opening to 460 mm, or

(c) A 760 mm high barrier located in front of the window.

(d) Restricting the passage of children under six

4.0.2 In any part of a building frequented by children under 6 years of age, where the possible height of fall is 1.0 m or more, measured from the adjacent floor level, windows that open shall have:

(a) The lower edge of the opening located no less than 760 mm above floor level and 610 mm above any toeholds, or

(b) A window opening restrictor fitted to limit the maximum opening to a size which prevents the passage of a sphere greater than given by Table 2, or

(c) A 760 mm high barrier located in front of the window, with the barrier having no toeholds above 150 mm from the floor, and with no openings that will allow the passage of a sphere greater than given by Table 2.

5 THE SUBMISSIONS

5.1 The dimensions of the barrier

5.1.1 Because, as mentioned in 3.3 above, the barrier that is the subject of this determination had been altered, the height of the safety rail was derived from measurements of the details of the original still visible after the alteration, and particularly the bolt holes where its flanges had been fixed to the wall at each end. The OSH report included a dimensioned sketch of the barrier made on that basis.

5.1.2 After processing of the determination had been commenced, it was realised that the Authority had previously been sent information about the accident by a Member of Parliament on behalf of a constituent. That information included a sketch of the barrier that showed dimensions different from those shown in the OSH report. Although that information had not been submitted by a party to the determination, it had nevertheless come to the Authority's attention and could not be ignored as evidence.

5.1.3 That information was accordingly copied to the parties.

5.1.4 To resolve the conflicting evidence as to the dimensions of the barrier, the Authority commissioned a consultant to visit the building and measure the barrier. Figure A above is based on the consulting engineer's report. It shows dimensions significantly different from those shown in the sketch forwarded by the Member of Parliament and slightly different from those shown in the OSH report. In particular, Figure A shows the height from floor level to the top of the inside edge of the wall as varying from 785 to 790 mm along the length concerned, whereas the drawing in the OSH report shows the top of the wall as having a height from floor level of 780 mm.

5.1.5 Figure A and some photographs received from the consultant were also copied to the parties.

5.2 Submissions by the applicant

5.2.1 The applicant submitted its Investigation Report ("the OSH report") into the fatal accident. That report was written for the purposes of the Health and Safety in Employment Act and was written largely in terms of that Act. Those parts of the report relevant to this determination are set out in 3 above.

5.3 Advice obtained by the Authority

5.3.1 Initially, the owner and the territorial authority acknowledged receipt of the application but made no specific submissions.

5.3.2 The Authority then commissioned a report ("the report to the Authority") from a consultant specialising in injury prevention, ergonomics, and safety management. That report to the Authority was based on the dimensions shown in the OSH report. The subsequently measured dimensions shown in Figure A on page 2 above differ from the OSH report by a maximum of 10 mm in the height of the wall and the height of the safety rail. The Authority consider that such minor differences are not material to the matter being considered, and accordingly views the report as being compatible with Figure A. The report to the Authority was copied to the parties.

5.3.3 The report to the Authority noted that, on the information available, the barrier did not comply with the acceptable solution F4/AS1 because

(a) "The maximum height of the barrier was about 940 mm. This is 60 mm below the minimum height set out in F4/AS1".

(b) "F4/AS1, Figure 1: Barriers for balconies in front of fixed seating, shows for a barrier height of 700 mm, a horizontal width at the top of the barrier of 700 mm. The . . . ledge was 61% of this width. For a person facing the barrier and able to put out a hand this could have assisted in arresting a fall. For a person with their back to the barrier the ledge would have to arrest the falling trunk."

(The report to the Authority did not discuss the provisions of F4/AS1 for opening windows.)

5.3.4 Considering the barrier as an alternative solution, the report to the Authority took account of NBS IR76-1131, the US *Model Performance Standard for Guardrails* issued by the National Bureau for Standards ("the US Standard"), which requires a barrier height of 1067 mm (42 in) instead of the 1000 mm required by F4/AS1. Commentary clause A3.1.2 of the US Standard states: "The rationale for the height requirement is to inhibit the passage of the human body over the guardrail. The prescribed height of the guardrail is set approximately equal to the height of the centroid (centre of gravity) of the 95 percentile composite adult male population in the United States."

5.3.5 The report to the Authority said that the US Standard also provides [inches converted to millimetres]:

> *A.3.2 Criterion - Height in relation to width.* The height requirement stipulated in Criterion A.3.1 [42 in] may be relaxed under the following conditions.
>
> (a) If the top surface of the guardrail is horizontal and has a width greater than 6 in [152.4 mm], and the floor surface of the interior adjoining region is level, the minimum height H of the guardrail shall not be less than,
>
> H = K-B where B is the minimum width of the top surface of the guardrail and K is 48 in [1219 mm]. However in no case, shall the minimum height be less than 30 in [762 mm].

5.3.6 The report to the Authority said:

> Applying that criterion at 940 mm from the floor, the minimum width of the top would be 279 mm. Applying that criteria at 780 mm from the floor, the minimum width of the top from the near side of the barrier would be 439 mm. That is greater than the total width of the ledge and greater than the width of the ledge beyond the barrier. In any case, the top surface of the top rail was not flat, and the ledge was 160 mm lower. The width of the ledge at the lower level did not meet the requirements of the US Standard.

5.3.7 The report to the Authority concluded that the barrier did not comply with clause F4.

5.3.8 The report to the Authority also discussed anthropometric data and ergonomic factors "determined from tests involved simulation of various postures of people leaning against a guardrail and people moving at normal or brisk walking speeds and squarely impacting against a guardrail".

5.4 Submissions by the territorial authority

5.4.1 After receiving the report to the Authority, the territorial authority submitted a statement ("the architect's statement") from an architect with experience in the design of buildings which accommodate large groups of people for various purposes including entertainment.

5.4.2 The architect's statement included the following passages:

> The building is a complex one – made more so by the fact that portions of existing structures have been retained and incorporated into the floor plates, with major extensions being constructed against them. There are a lot of voids within the complex, so floor areas are defined by barriers where a floor adjoins a void, and by walls.

> The location where the accident occurred appears to be a part, or an extension, of the refurbished wall of the existing building. A window opening has been constructed to match those that existed previously. An additional barrier has then been added within it. The window openings were 2240 wide x 1805 high (measured from the sill height of 780 above the floor tiles), with a depth of 430 (wall thickness).
>
> These openings are similar to the opening windows referred to in acceptable solution F4/AS1.
>
> With a sill height of 780, if considered an opening window, the barrier would have complied with acceptable solution F4/AS1/4.0.1.
>
> . . . the barrier constructed in the opening did not achieve the 1000 dimension described in acceptable solution F4/AS1/1.1.1. The dimension from floor surface to the top of the rail has been defined as varying from 943 to 950. Allowing for a bedding thickness of 12mm and a tile thickness of 6mm (neither of which thicknesses are known), the dimension to be considered would be 39 to 32mm (ave 35.5mm). As a percentage of 1000 this is 3.5% less than that method of achieving compliance.

5.4.3 The architect's statement concluded that if the opening were treated as an opening window then the barrier "would obviously have complied with the Building Code because it would have very substantially exceeded the acceptable solution requirement (4.0.1)". If not treated as an opening window, then "I believe it would be possible . . . to conclude that the barrier complied with the Code (as distinct from the acceptable solutions) even though slightly below 1000mm in height".

5.4.4 The territorial authority submitted that the Authority "would need to consider whether it has jurisdiction given the relevant provisions of the Coroners Act and the Building Act". It also submitted that "the ergonomic opinion [in the report to the Authority] . . . is of no assistance in relation to the key question of whether the barrier was an appropriate height in terms of compliance with the building code".

5.4.5 The territorial authority's submissions continued with a description of the history and scheme of the Building Act and the relationship between the building code and the acceptable solutions issued by the Authority in its series of Approved Documents. Reference was made to the High Court decision in *Auckland City Council v New Zealand Fire Service*[1]. The territorial authority submitted that:

> . . . the approved documents do not constitute an exclusive or absolute solution, but can be used as guidelines in assessing whether there has been compliance with the Building Code. In this case for example the question of compliance does not depend on whether or not the top of the barrier was 1,000mm above the floor – although that would have been one means of achieving compliance and that method was almost satisfied.

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[1] *Auckland CC v NZ Fire Service* 19/10/95, Gallen J, HC Wellington AP336/93, partially reported at [1996] 1 NZLR 330, noted [1995] BRM Gazette 189; NZCLD, 5th Series, 0009

5.4.6 The territorial authority submitted that the whole of F4/AS1 should be taken into account when assessing the barrier for compliance with the building code.Provisions of particular relevance were said to be that:

(a) "900 mm is an acceptable barrier height for stairs or ramps and 1,000 mm is acceptable in other locations".

(b) "heights are measured vertically from floor level (ignoring floor coverings) . . . Thus . . . the height is measured from below the levels of tiles and bedding compound".

(c) "a horizontal projection extending forward of the barrier is a relevant factor to be taken into account in determining the appropriate height – at least on balconies with fixed seating."

(d) paragraph 4.0 "prescribes a minimum height of **760mm** [territorial authority's emphasis] for barriers formed by the lower edge of a window opening or located in front of a window, in cases where the window opens."

5.4.7 On the basis of those provisions the territorial authority submitted in effect that the opening should be treated as an opening window, in which case the barrier "exceeded the 760mm requirement . . . by approximately 27%". In any case, the barrier was "well above the height of 900mm stated for stairs and landings, and on average less than 3.5% less than the method of achieving compliance set out . . . for general barriers". In addition "there was some further protection resulting from the horizontal projection in consequence of the window sill being approximately 430mm thick".

5.5 Submissions by the owner

5.5.1 The submissions by the owner, after receiving the report to the Authority, effectively endorsed the submissions by the territorial authority and covered much the same ground. The owner also pointed out that an independent qualified person, acting on behalf of the owner, had issued a building warrant of fitness for relevant systems and features of the building, including the barrier concerned, as it was at the time of the accident.

5.5.2 In particular, the owner submitted that the opening should be treated as an opening window, in which case the barrier complied with F4/AS1, but if not then "the combination of the height of the barrier, the depth/width of the ledge, and the position of the tubular rail created a barrier of *'appropriate height' "*(territorial authority's emphasis).

5.6 The draft determination

5.6.1 The parties each had the right to ask for a formal hearing at which they could speak and call evidence. The Authority accordingly sent a draft of this determination to the parties. None of the parties objected to the draft, but the owner and the territorial authority pointed out non-controversial errors, which have been corrected in this final determination.

6 DISCUSSION

6.1 The Authority's jurisdiction

6.1.1 The Authority takes the view that the matters it may determine are limited by the relevant words of section 18 of the Building Act:

> An application to the Authority under section 17 of this Act shall be limited to whether or not, or to what extent, particular building work or proposed building work (including any actual or proposed demolition) complies with all of the provisions, or with any particular provision, of the building code

6.1.2 In particular, the Authority has no jurisdiction to determine the causes or circumstances of the unfortunate student's death. It is not for the Authority to speculate as to whether the tragic accident would have occurred if the barrier had been higher. Nor is it for the Authority to determine whether the student was sitting on the rail, as indicated in the OSH report, or on the ledge beyond the rail, with his legs over the rail, as appears to be assumed in the report to the Authority. Those are matters for the Coroner and possibly other authorities. At this point, the Authority can do no more than express its sympathy for the family and friends of the unfortunate victim.

6.1.3 The Authority also has no jurisdiction to determine whether or not, when it issued the code compliance certificate, the territorial authority had reasonable grounds for being satisfied as to compliance with the building code. That is a question of law that can be answered only by the Courts.

6.1.4 It is not relevant to this determination, but the Authority notes that it is currently reviewing clause F4 of the building code and the corresponding Approved Document F4. That review will take account of the forthcoming Coroner's report.

6.2 The Authority's approach to determining whether building work complies with the building code

6.2.1 The Authority has not considered it necessary to set out the submissions by the territorial authority and the owner as to the relationship between the building code and the acceptable solutions, and as to the proper approach for the Authority to take in determining whether building work complies with the building code. Those submissions essentially advocate the approach that the Authority has always taken. Suffice it to say that the Authority recognises that the acceptable solutions are not the only means of establishing compliance with the building code, and that in assessing other proposals the acceptable solution may be used as a benchmark or guideline.

6.2.2 In Determination 2000/5 the Authority made the following general observation about using acceptable solutions to assess alternative proposals:

> "(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."

The Authority continues to hold that view.

6.3 Inspections by independent qualified persons

6.3.1 The owner mentioned that not only had the territorial authority issued a building consent and a code compliance certificate for the construction of the barrier (amongst other work), but an independent qualified person had also issued a building warrant of fitness covering the barrier. However, the Authority notes that the only function of an independent qualified person under the Building Act is to follow inspection, reporting, and maintenance procedures specified in a compliance schedule, see section 45. Those procedures are to be followed whether or not the compliance schedule item concerned, in this case the barrier, complies with the building code.

6.4 Height of fall

6.4.1 The OSH report placed some emphasis on the height of fall. The Authority understands that the 1 m height mentioned in clause F4 of the building code recognises that falls from that height are likely to result in significant injury. The Authority therefore considers that the actual height of fall in excess of 1 m is irrelevant to the question of whether the barrier complied with the building code.

6.5 Types of fall

6.5.1 It is not directly relevant to this determination, but the Authority notes that barriers such as the one concerned are appropriate to safeguard people standing beside or moving towards a barrier from falling over it. They are also appropriate to safeguard people from falling through the barrier, and to restrict children from climbing over it. The only barriers specified in F4/AS1 that will positively prevent children from climbing them are swimming pool barriers covered by paragraph 3.0 (not reproduced in 4 above). Whether barriers should also discourage people from sitting on them is outside the scope of this determination because there is no requirement to that effect in clause F4 of the building code.

6.6 The dimensions of the barrier

6.6.1 The dimensions of the barrier as measured by a consulting engineer engaged by the Authority are shown in Figure A on page 2 above. The ledge varied in height along its length from 785 to 790 mm. This determination is based on the minimum height of 785 mm from finished floor level to the top of the ledge and 930 mm to the top of the safety rail.

6.7 Did the barrier comply with the acceptable solution F4/AS1?

6.7.1 Paragraph 1.1 and Table 1 of F4/AS1

6.7.1.2 The Authority considers that for the purposes of F4/AS1 the height of the barrier is to be measured from the finished floor surface, namely the tiles, not from the underlying structural concrete. In other words, the Authority takes the view that

the phrase "floor coverings" in F4/AS1 refers to removable or temporary coverings such as carpets or rugs, not to the surface finishes of the floor itself.

6.7.1.3 The height from finished floor level to the top of the safety rail varied from 930 to 935 mm. The only relevant height specified in paragraph 1.1 and Table 1 of F4/AS1 is 1000 mm. The owner mentioned a height of 900 mm for landings, but that applies only within dwellings, not to barriers in buildings used by the general public.

6.7.1.4 Thus the Authority concludes that the barrier concerned was not "39 to 32mm (ave 35.5mm)", or 3.5%, lower, as claimed by the territorial authority, but 65 to 70 mm, or approximately 7%, lower than the height required by paragraph 1.1. That is still a comparatively small difference, but it is far more than a reasonable construction tolerance and is enough to prevent the barrier from complying with paragraph 1.1. In that respect, the Authority notes that clause A3.2.1 of the US Standard mentioned in 5.3 above recognises an "evaluation tolerance" of 25 mm (1 in).

6.7.2 Paragraph 1.2.4 and Figure 1 of F4/AS1

6.7.2.1 The barrier was clearly not in the type of situation contemplated by Figure 1 of F4/AS1 reproduced on page 3 above. Furthermore, the barrier differed from Figure 1 not only in that it was higher but narrower but also in that the ledge was not the top of the barrier. The Authority accordingly considers that the barrier did not comply with paragraph 1.2.4 of F4/AS1.

6.7.3 *Paragraph 4.0 of F4/AS1*

6.7.3.1 The architect's statement said that if the barrier was treated as the sill of an opening window then it would comply with the building code. The territorial authority and the owner submitted that the opening should be treated as being an opening window.

6.7.3.2 The Authority considers that the danger of falling out of a window is usually significantly different from the danger of falling off a balcony, at least partly because of the visible presence of the window.

6.7.3.3 In fact, the opening never held a window but had been provided to achieve visual similarity to the original building's window openings. The important point is that at the time of the accident there was no window in the opening.

6.7.3.4 The Authority considers that the opening protected by the barrier cannot be treated as being an imaginary or notional window. The fact that there was once a window there has no effect on the danger when the window is no longer there. The Authority accordingly considers that the barrier did not comply with paragraph 4.0 of F4/AS1.

6.7.4 Children under 6

6.7.4.1 Clause F4 of the building code and its acceptable solution F4/AS1 contain requirements for barriers in locations likely to be frequented by children under 6. The barrier complied with those requirements except in respect of its height.

6.7.5 Conclusion

6.7.5.1 The Authority concludes that the barrier did not comply with the acceptable solution F4/AS1.

6.8 Did the barrier comply with the building code?

6.8.1 The Authority considers that the location of the barrier, in an entertainment centre, involved no special considerations that would justify a lower barrier than that specified by F4/AS1. Accordingly, the barrier was required to safeguard people from falling to at least the same extent as a barrier complying with F4/AS1.

6.8.2 Essentially, the barrier did not comply with F4/AS1 because it was not high enough. What that really means is that the barrier would act as a fulcrum or pivot causing a person leaning against or moving into the barrier to topple over it if that person's centre of gravity was above 930 mm (as compared with 1000 mm for a barrier complying with F4/AS1). In other words, and following the approach set out in 6.2.2 above, unless there was some feature compensating for the lack of height, the barrier would safeguard a significantly smaller proportion of the population than would an F4/AS1 barrier.

6.8.3 The only feature of the barrier that might be seen as compensating for the lack of height was the 430 mm width of the ledge located 145 mm below the top of the safety rail. The question is whether that would enable a person toppling over the barrier to save themselves by putting a hand on the ledge.

6.8.4 That appears to be similar to the question addressed by paragraph 1.2.4 and Figure 1 of F4/AS1 and by criterion A3.2 of the US Standard mentioned in 5.3 above. That US Standard safeguards people whose centres of gravity are at or below 1067 mm as compared with 1000 mm for F4/AS1. In other words, a barrier that complies with the US Standard will safeguard people to a greater extent than one that complies with F4/AS1, and therefore exceeds the requirements of the building code.

6.8.5 Obviously, if a barrier were wide enough it would not be physically possible to fall over it (as distinct from climb over it). At some lesser width, it would be possible for a person who started to fall over it to save themself by putting a hand on the top of the barrier. The Authority accepts the equation given in the US Standard, requiring a minimum barrier width of 1219 mm minus the barrier height in millimetres as reflecting the reality of people's abilities to save themselves.

6.8.6 The barrier without the safety rail would almost have complied with Criterion A.3.2 of the US Standard, which, for a barrier 785 mm high, permits a minimum width of 434 mm – slightly more than the 430 width of the barrier concerned. Thus the barrier without the safety rail did not comply with the US Standard.

6.8.7 However, as discussed in 6.8.4 above, the US Standard is based on a centre of gravity height of 1067 mm as against 1000 mm for F4/AS1, and applying a factor of 1000/1067 to allow for that difference would give a required width of 407 mm. On that basis, the Authority concludes that the 430 mm wide barrier, without the safety rail, would safeguard people to at least the same extent as a barrier complying with F4/AS1.

6.8.8 The Authority cannot see any reason why the addition of the safety rail in the position indicated in Figure A should have made the barrier any less effective. On the contrary, anyone whose centre of gravity was higher than 785 mm could pivot on the edge of the ledge and start to fall over the barrier, but if their centre of gravity was lower than 930 mm they would be saved by the safety rail (ignoring momentum effects). The Authority does not consider that the safety rail would obstruct hand movement so as to prevent people whose centres of gravity were between 930 and 1000 mm from saving themselves by putting their hands on the ledge.

6.8.9 The Authority recognises that factual data based on tests from the New Zealand adult male population would be preferable to comparison with the US Standard. Nevertheless, and given that the US Standard sets a higher level of safety than F4/AS1, the Authority concludes that the barrier was at least as safe as a barrier complying with F4/AS1 and therefore complied with the building code.

7 THE AUTHORITY'S DECISION

7.1 In accordance with section 20(a) of the Building Act, the Authority hereby determines that the barrier complied with clause F4 of the building code and confirms the territorial authority's decision to issue the code compliance certificate.

Signed for and on behalf of the Building Industry Authority on this 16th day of May 2002

W A Porteous
Chief Executive