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Transforming Melbourne's Icon Swimming Pool - Learning from 1981 (world's first?) performance-based fire safety design

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2003 Introduction

When Melbourne's architectural icon swimming pool from its 1956 Olympic Games was converted into a multi-purpose sports centre in 1981, the fire aspects of the renovation were determined from a performance-based design process, rather than from strict adherence to the then current prescriptive regulations.

This performance-based approach contributed hugely to this icon building being afforded a new lease of life, and avoiding an otherwise predictable decline into disuse and eventual demolition.

This design approach may well have been the world's first thoroughgoing use of performance-based fire safety engineering, and Reddaway reported on it in a paper at Australia's National Engineering Conference in 1981. This was after the design was complete, but before construction had commenced.

In 1981, fire safety engineers had few quantitative tools, and the 1981 design process was essentially qualitative.

In this paper the authors review whether the addition of quantification in 1981 would have

- assisted the process or, possibly,

- hindered the quality of the design by distracting effort away from the over-riding concepts and the practical problems of construction.

This highlights the eternal need for engineers, fire brigades and regulatory authorities to balance

- the over-riding need for rigorous qualitative analysis of all relevant issues, including those that cannot be sensibly quantified, against
- the current fashion of concentrating on deriving numerical assessments (albeit only of those factors for which we have the tools to enable us to quantify.)

2003 Performance-Based Design - ideal for icon buildings

Traditional building regulations are 'prescriptive' in that they specify exactly what has to be done in the construction of any new building. Inevitably, such regulations have to assume the worst possible combination of circumstances, and are therefore usually unduly conservative. Moreover, they have usually come from a history of ill-defined regulatory objectives.

In contrast, performance-based regulations specify the objectives that society is striving to achieve, and some more specific requirements. Performance-based regulations allow the designer to devise whatever combination of measures best suits his project, so long as he can then show that the performance requirements are thereby met. Thus performance-based regulations allow the designer and the authority having jurisdiction to recognise, and take advantage of, the unique features of the building in question.

So, one advantage of performance-based regulations is that they provide a more rational process for resolving a suitable package of measures for, say, a particular icon building.

2003 Performance-Based Design - the practice today

Performance-Based regulations are spreading in various formats in an increasing number of countries, including UK, New Zealand, Australia, and USA.

The typical process of performance-based design is for the fire safety engineer to state a provisional belief that some design solution is acceptable, and then utilise argument and analysis to prove his belief to be well founded. Very occasionally, during the process of analysis, the engineer will find his belief challenged to the extent that he backs away from his initial position.

This process of assumption and testing is very similar to that used in other fields of engineering. However, because there are so many factors (such as, crucially, the speed of the fire growth) to input into the testing process, there is considerable scope for the designer to refine his inputs until he gets an output that fits his preconception. In the light of the lack of community-accepted values, this is not necessarily unprofessional or immoral, but it does tend to cast doubt on the quantification process.

One typical fire safety engineering technique is to calculate and compare

- the time that an evacuation is expected to take; and
- the time for untenable conditions to be reached in the fire zone. (Examples of untenable conditions include smoke filling the space in question down to head height, radiation from the smoke layer exceeding a nominated figure, and structural collapse.)

A safe design is one in which the engineer shows that it is reasonable to believe that the building can be evacuated before untenable conditions are reached - with a safety margin added to account for the uncertainty in the process of analysis.

Some of the computerised tools that can assist with these calculations involve 'typical' fires and evacuation scenarios. However,

- the science that underlies some of these models is very complex and the limitations may not always be understood by the end user, and
- the assumptions (perhaps including, say, the use of a particular standard fire scenario) made may not be valid.

2003 Performance-Based Design - keeping the big issues in sight

One danger in any design process is that some key issue will be overlooked, and this may turn out to be an issue of over-riding importance. This danger is particularly real if there is an excessive concentration on the calculations.

In the 1981 case reported below the technology of the day provided no ability to do fire spread calculations, and the designers had no precedents to follow. All they could do was analyse the situation from first principles, as shown in Figure 4. This analysis revealed one issue that seemed to be of critical importance: How easily would fire spread through the auditorium with its stepped, carpeted flooring and padded seats? This issue did, indeed, turn out to be a big issue, and the design of the seats turned out to be critical. This issue is discussed below under the heading "Reviewing The Key 1981 Issue Of Fire Spreading From Seat To Seat".

The lesson here is that, if energy had been diverted quickly into quantification issues, then the importance of this issue would probably not have been recognised at all.

Explaining the 1981 Design

The full text of the 1981 paper is presented below (in boxes), with new material and commentary interspersed between boxes.

SUMMARY Melbourne's large swimming pool, built for the 1956 Olympic Games, is being converted for use as a multi-purpose centre.

The conversion has presented many questions relating to fire safety. All parties accepted an approach to these problems which involved examination from first principles, being guided by Regulations rather than controlled by them. The Engineers developed a fire philosophy co-ordinating all disciplines, and the paper discusses the resulting compromises.

The solutions illustrate some of the inherent limitations of quantitative treatment of fire problems, and of current fire testing. The paper describes how specialist fire engineering can draw on an understanding of fire to interpret the available information in deriving realistic solutions.

The paper also discusses the relevance and limitations of Regulations and Standards in relation to this unique building.

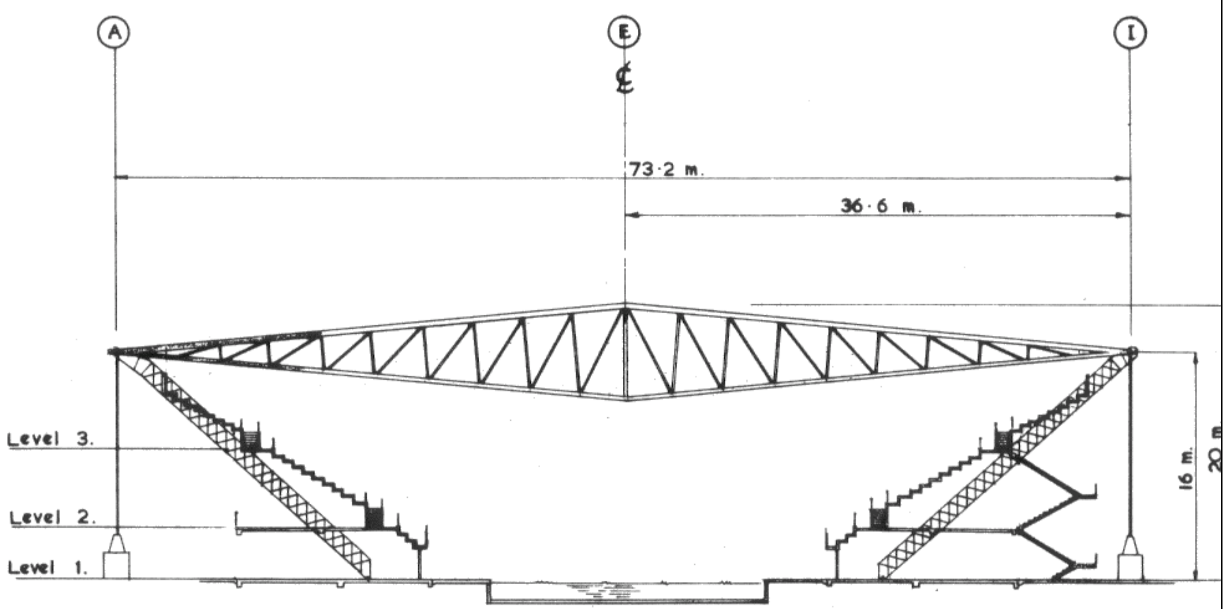

Figure 1 Cross section of original Olympic Pool

1. INTRODUCTION

The Olympic Swimming Pool which was built for the 1956 Olympic Games in Melbourne provided Australia with one of its most notable modern buildings.

Changing requirements led to its proposed conversion into the State Indoor Sports Centre (SISC) capable of housing a variety of indoor sports and entertainment events providing better comfort for spectators and competitors than the relatively spartan conditions acceptable in the 1953-1956 rush of preparing for the Olympics.

Standards of fire safety have risen markedly since 1953, and this, coupled with increased potential fire hazards associated with the change of use, presented a particular challenge to the SISC design team. The unorthodox original structural form meant that many of the numerous codes, standards and regulations in the fire protection world could not be readily applied.

Attempts to define the conflict between current regulations and the proposals for the new SISC proved to be very difficult. For example:

a) The Public Building Regulations embody many implicit assumptions regarding the nature of a theatre which were not applicable in this case: our stage is to be retractable, and we will have no proscenium arch.

b) All the regulations assumed that floors are horizontal and that walls are vertical. How, then, were we to treat the saw-tooth-shaped concrete ‘plats’ which act compositely as both floor and wall?

In view of the extent of these difficulties it was decided to analyse the fire problems from first principles, using regulations only as a guide and where appropriate. Because the SISC is a State building on Crown Land, normal regulations are not mandatory and it was therefore possible to use the results of this analysis as the basis for the design of the fire protection measures, as discussed in this paper. This freedom from regulatory restraint has imposed a heavy burden of responsibility upon the design team.

GOVERNMENT SUBMITTING TO REGULATORY STANDARDS

In 1981, under the state of Victoria’s normal Uniform Building Regulations, one could make application to a panel of Building Referees requesting that particular regulations be modified for a particular project in some particular way. Thus there was the potential to get any design approved. However, up to the mid-1980s the government was adamant in not submitting itself to the normal regulatory processes. (The later abandonment of this stance resulted in a more disciplined approach to design and regulations on government projects, and the government has felt the benefit of following the normal process for modifying regulations.)

REMOVING REGULATORY OVERLAP

Moreover, in 1981 a public building (such as SISC) also had to comply with the separate Public Building Regulations, for which there was no clear-cut process for obtaining dispensations. Later, this duality of controls was removed, and later still the Building Code of Australia became the sole source of technical building standards. No one doubts the benefit of moving to a single source of minimum regulatory standards.

2. THE 1956 OLYMPIC POOL

The 1956 Olympic Pool represents a landmark in Australian architecture and engineering. The pre-stressed high tensile roof trusses, the building articulation and the economy of structure were, and remain, its outstanding engineering features.

The major elements can be seen in Figure 1:

- The concrete seating plats, with horizontal members only 50 mm thick and vertical members only 75 mm thick, span 5.5 m between
- Raking steel girders which span between actual hinges tap and bottom. The top hinge connects to
- The main roof trusses, same 6 m deep at the centre, and pre-tensioned by means of the
- Steel tie down bars which connect to springs in underground pits.

The hinges allow the building to avoid secondary stresses within the members. Thus as temperatures or loadings change, so the raking girders may rotate and the top hinges may move by up to 65 mm. The stairs and the structures under the plats on the North side are independent structures, not susceptible to movement, and so there are small gaps where fixed and moving parts abut each other.

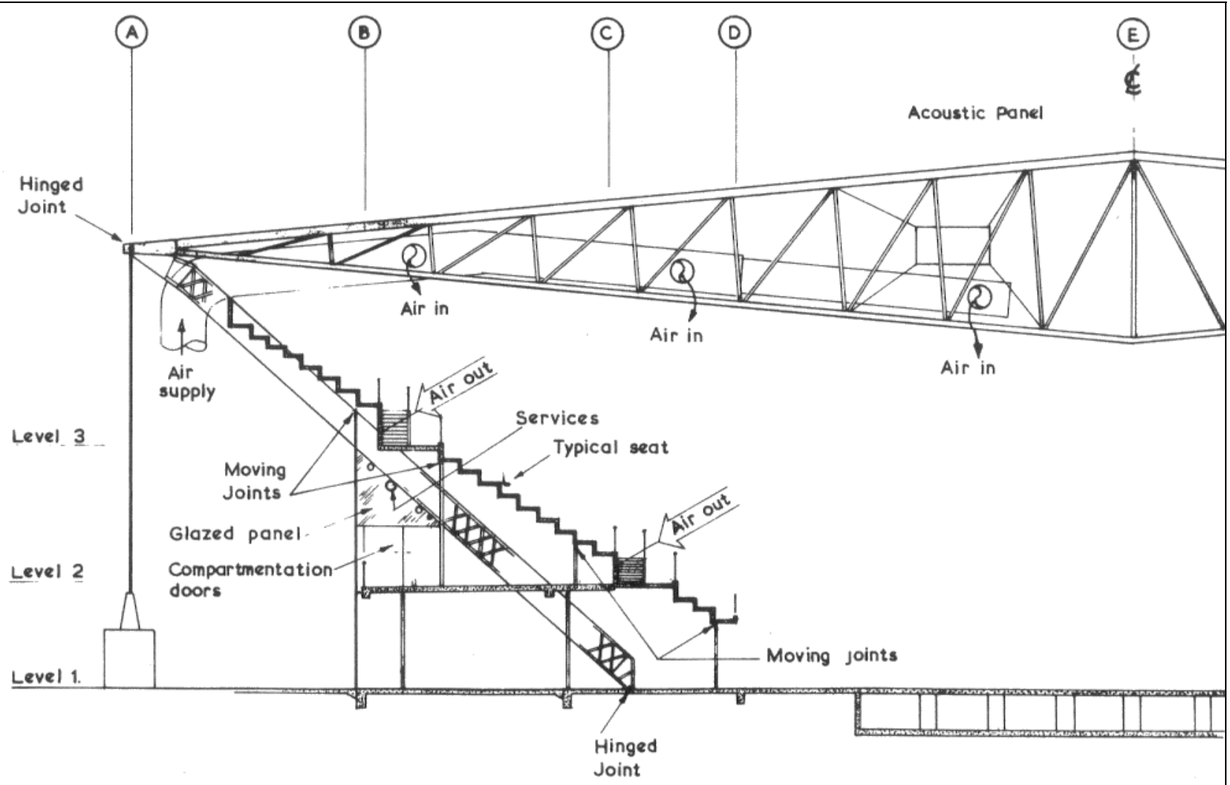

Figure 2 Illustrative section through SISC

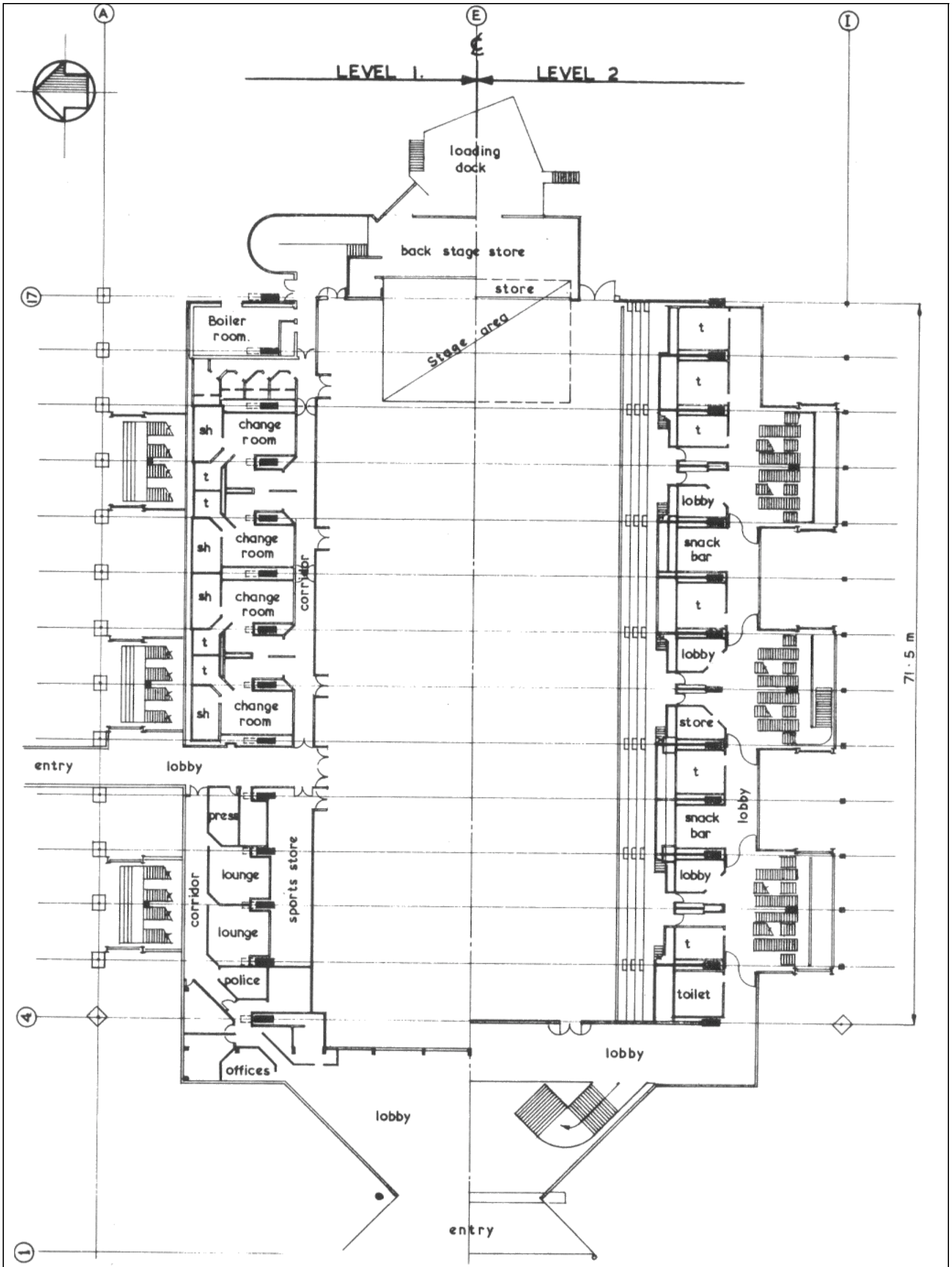

Figure 3 Plans at levels 1 and 2 at SISC

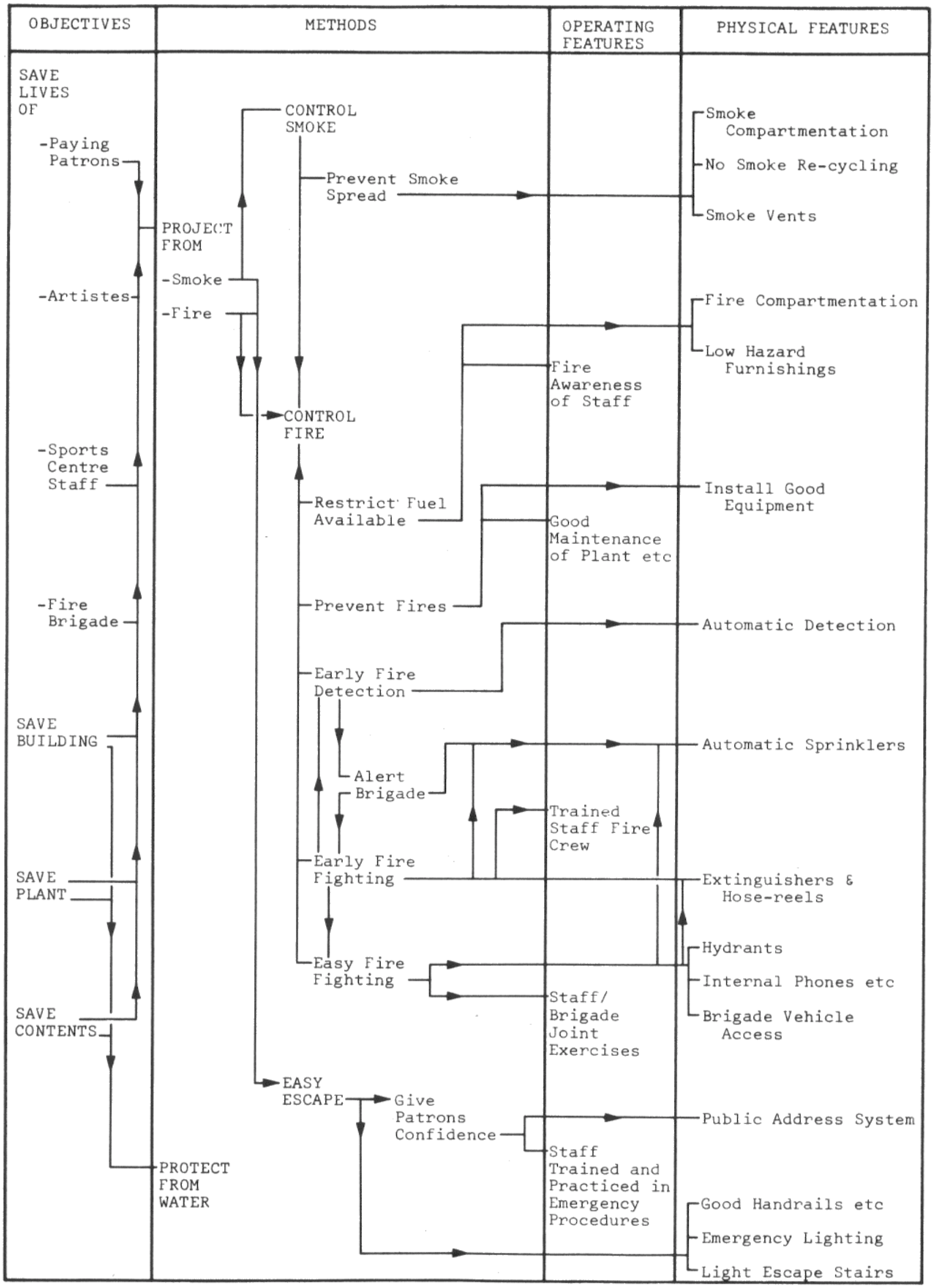

Figure 4 Schematic inter-relationship of issues

3. FROM OLYMPIC POOL TO SISC

The large building with seating for 5,000 provided an opportunity to create a well-used venue for indoor sports and for entertainment.

The scheme of the new centre is shown in Figures 2 & 3 and the main features are as follows:

- The pools will be covered with a permanent floor.
- Two levels of concourse, change rooms, snack bars, offices, etc. will be created an each side, enclosed behind vertical glass walls.
- The stairs will be enclosed behind glass walls.
- 4,750 fixed, individual seats will be installed on the concrete plate. Removable seating for 2,250 will be available for use on the sports floor rising up to Level 2 at the West end.
- There will be a retractable stage at the East end, together with a back stage area.
- New ticket offices, foyers, etc. will feature at the West end.
- Extensive provisions will be made for lighting, sound systems, broadcasts, TV etc.
- All main floors will be carpeted.
- The auditorium will be airconditioned, and concourse areas will be conditioned with spill air from the auditorium. Air will be separately exhausted from the toilets.

4. PHILOSOPHY OF SISC FIRE PROTECTION

4.1 Inter-relationship of Issues

Figure 4 is a simplified version of the chart that was prepared at the start of the project as an aid to understanding how various factors inter-relate. This indicated various options and ideas, but was not thought of as more than an ‘aid to thinking’. However, it did highlight an important on-going role for the SISC staff in maintenance, training and good housekeeping. The Engineers will draw this to the attention of the SISC managers, and offer to assist in staff training.

BRINGING INTANGIBLE ISSUES INTO ACCOUNT

These ‘intangible’ issues, such as maintenance, training and good housekeeping, have now been brought within the potential ambit of the Building Regulations, by means of each building now having specified levels of maintenance set for certain ‘essential services’, that can include training procedures etc.

4.2 Objectives

Our first, and traditional, objective is ‘To prevent injury and loss of life in the event of a fire, explosion or comparable emergency’.

In the absence of nearby buildings, the second objective is to minimise damage to this building. Although the client had indicated that significant money should not be spent to this end, this is still largely necessary to save life: premature collapse of part of the building may prevent people escaping, or may injure firemen.

Another aim was for these objectives to be achieved in collaboration and harmony with the Melbourne Fire Brigade (MFB) and other relevant bodies.

FIRE BRIGADE HAS POWER CURTAILED, BUT ITS INFLUENCE INCREASES

In 1981, the MFB had considerable regulatory power, and their policy was normally to simply insist that all their guidelines and all relevant Australian Standards be followed. The concept of accepting the potential loss of a building was an anathema to them. Thus it was difficult for them to accept, in this case, that the government was not allowing them to exercise their normal power. For example, the MFB would have wished to insist that sprinklers be installed throughout the building, including in the auditorium, because this was the only way that conformity with the Australian Standard could be achieved.

In 1994, the legislation was changed and much of the MFB power was removed from them – with the result that, in order to retain influence, they have had to become more professional in their approach to regulatory matters. This, in turn, has brought them respect and, arguably, more long-term influence.

4.3 Practical Restraints to be Accepted

The design process was an exercise in reality, and so the following principal features of the existing building had to be accepted without significant alteration:

- Only one extra exit staircase (at the West end) could be provided.
- The thin concrete seating plats had to be accepted without thickening.

It is necessary for the normal functioning of the SISC for staircases to open out on to the concourse at Levels 1 & 2 without an intervening door, as may be seen, for example, in Figure 3. Thus the stairs could not be made to even approximate to 'fire-isolated stairs'.

4.4 Guiding Concepts

The following guiding concepts were derived:

a) If a fire starts in the auditorium while there is an audience present, the audience can be relied upon to evacuate itself. To be reasonably sure that no fire death would occur, very rapid spread of fire should not occur.

b) The escape stairs should be effectively smoke-free at all times. To achieve this, each stairway will be separated from the surrounding areas with partitions and doors which are designed to be smoke resisting. The 'compartmentation' doors across the concourses will be normally kept open by magnetic holders which will release when any of the smoke detectors in the concourses is activated. The doors to the auditorium will be 1 hour fire doors. Thus each of the six original stairs will become a three-storey 'escape compartment', but only fully enclosed when the compartmentation doors close. The location of these compartmentation doors was restricted by practical constraints, and hence the escape compartments are larger than strictly desirable. In deriving the requisite compromises, the following rules were observed:

   i) An escape compartment could contain toilets, because they represent only a low risk of fire and smoke.

   ii) A snack bar, representing a relatively high potential risk, was never to be within an escape compartment.

   iii) Open circulation space was allowed within an escape compartment, but any closed room was sealed off from the enclosure by a 1 hour fire-rated door.

An attempt was made to assess a time in which the people could be expected to evacuate the auditorium. The calculations clearly incorporated many assumptions, and a figure of 10 minutes was accepted as conservative and acceptable.

c) The greatest danger of a very large loss of life in a fire seemed to lie in a fire developing in one of the rooms beneath the plats and suddenly bursting through as a fully developed fire into the auditorium. Therefore, with only a few carefully judged exceptions, the auditorium has been separated from the rest of the building by fire-rated barriers.

d) Following on from concept (a), it did not seem likely that fire detection equipment within the auditorium would significantly reduce the risk to life. (Nonetheless, certain measures are incorporated, as discussed in Section 5.1.3.)

e) Following on from concept (c), however, it was clear that sprinkler protection of the areas outside the main auditorium would
- reduce the likelihood of a fire developing undetected in some unattended room; and
- reduce the risk of exits becoming impassable.

Thus sprinklers will be installed in effectively every area except the auditorium.

f) As discussed in section 5.3, there will be no smoke-exhaust mode in the air-conditioning system.

g) The Public Address and internal telephone systems, provided for normal operations, will incorporate features especially for emergency use, as discussed in section 5.6

h) Re-wiring will reduce the risk of fire.

REVIEWING THE 1981 SUITE OF FIRE SAFETY MEASURES

Generally, these precepts in section 4.4 stand up well to scrutiny today.

In principle, in 2003, a computer-assisted evacuation assessment could be undertaken. However, the geometry of steps and the multiplicity of joining queues would be difficult to model (see Appendix), and the results would therefore always be doubted. A full-scale trial evacuation would be preferable, but would be very difficult to arrange in a realistic manner.

5. PROBLEMS AND SOLUTIONS

5.1 Auditorium Protection

5.1.1 Carpet selection

Because the new carpet is to be laid on both vertical and horizontal surfaces of the main plats, it has great potential for spreading fire rapidly, thereby producing excessive volumes of smoke. The carpet first considered had been tested very satisfactorily under the Hot Metal Nut Test (BS 4790-72), which is supposed to simulate a glowing ember falling onto a horizontal carpet. However, this offers no measure of how, if the carpet was ignited, it would contribute to smoke generation and fire spread.

Therefore, it was decided to test this then-proposed carpet in accordance with AS 1530 Part 3 (Test for Early Fire Hazard Properties of Materials), which more closely measures a material’s behaviour in these regards. The resulting indices revealed that this particular carpet would have contributed very much more to smoke generation and fire spread than many other carpets would have done. As a result of this, in conjunction with the Australian

Wool Corporation, a full specification was prepared for the carpet covering all factors including the fire-related indices specified in the N.S.W. Theatres and Public Halls Act for floors in 'Internal Exits' (i.e. Spread of Flame Index 0, Smoke Index 5).

The same carpet specification applies to the carpet in the exit enclosures, including the stairs, where the indices required by the N.S.W. Regulations would effectively prohibit carpeting of any kind. We are content, however, that the standard set in the specification will provide adequate safety in view of all the circumstances, and that it was not warranted to sacrifice other architectural objectives for the sake of adherence to the N.S.W. standards which were, presumably, strictly set to cater for an imaginary 'worst case'.

REVIEWING THE 1981 CARPET SELECTION RATIONALE

As far as could be found out, the standards set in the NSW regulations were totally arbitrary, and virtually impossible to meet with any carpet.

For some unremembered reason, the 1981 paper did not reveal that the AS1530.3 test on the originally-selected carpet created so much smoke that the test laboratory had to be evacuated!

5.1.2 Seat selection

Non-padded, individual seats were specified for the permanent seating, partly as a result of fire consideration. However, it is clearly very important to ensure that the particular combination of stepped flooring, clad in carpet, together with the seating, would not allow fire to spread too rapidly, or produce too much smoke. So the specification calls for a series of fire tests on a mock up of the stepped floor fitted with the carpet and the seating actually proposed. This section of specification was prepared in conjunction with Dr. Caird Ramsey of the C.S.I.R.O. Division of Building Research, and does not include specific acceptance/rejection criteria. Rather, the tests are exploratory with a view to seeing whether any unexpected adverse phenomenon is revealed, whereupon its solution would have to be tackled jointly by all parties.

REVIEWING THE KEY 1981 ISSUE OF FIRE SPREADING FROM SEAT TO SEAT

The seats, installed on a carpeted mock-up of the stepped floor, were tested after the 1981 paper was written, and the series of tests revealed that the likely means of fire spread from one seat to the next was by the armrest igniting, and thence igniting the next seat. This had not been foreseen although, with the wonderful benefit of hindsight, perhaps it could have been. The response was to adopt a less easily ignited armrest and, by so doing, the risk of ever having a blazing row of seats (rather than just one seat) was very greatly reduced.

This is an excellent example of how full scale testing of unusual arrangements should be undertaken on large projects where the cost of testing can be justified.

This issue is an example of how significantly increased fire safety has been achieved from a consideration of issues from first principles, rather than a mere reliance on routine prescriptive standards.

5.1.3 Auditorium fire detection and protection

Despite the belief that fire detection in the auditorium would not materially assist in saving lives of patrons, a system of smoke detectors is incorporated in the roof with the main objective of providing early alarm in the event of a fire developing at night, say from a cigarette left by a spectator (although smoking will be officially forbidden).

The main roof ridge will be provided with simple smoke vents (operated by fusible links) which, although they amount to only about 0.4% of the roof area, are intended to assist in reducing the risk of the main trusses reaching too high a temperature and thereby weakening. These vents will require special treatment for acoustic insulation. Their location at the ridge represents a compromise to economy and aesthetics: they were originally proposed as being more equally spread within the central half of the roof. Considerations of air-conditioning, lighting, weight, cost and detailing ruled out the possibility of smoke curtains.

An attempt was made to compute an appropriate area of roof vent, but the theory did not readily take account of all the features of this building. The final area was a subjective judgement, compatible with what could be realistically provided.

The general absence of sprinklers in the auditorium created a difficulty: the building would be only partially sprinklered, and there would not be a 4-hour fire rated separation between the sprinklered and non-sprinklered areas, which is required by the AS 2118, the Sprinkler Code. Since it is the firm policy of the MFB to provide direct brigade alarms (DBA) only to sprinkler systems which comply with AS 2118, there was a danger of the SISC not being connected to the MFB, which would have markedly reduced the efficacy of the systems to be installed. However, it was recognised that the efficacy of sprinkler protection at the relevant heights is in some doubt. And, moreover, the roof trusses would have required extensive strengthening in order to carry sprinklers.

The fire philosophy was developed in conjunction with the MFB whose officers influenced, sometimes upwards and sometimes downwards, the levels of protection in the various areas. In the end, the MFB formally agreed that a DBA would be permitted, subject to strict reservations concerning possible disconnection in the event of excessive false alarms which they fear may originate from the smoke detectors.

High above the stage area, a new space frame structure will be provided, principally in order to provide hanging points for very heavy speakers and lights associated with ‘pop’ shows. The space frame has been designed to carry the extra weight of sprinklers, which will be provided over the stage and back-stage areas, where the fire hazard can be considered as higher than in the main auditorium.

The problem of the ‘breach’ of AS 2118 does reveal how a Code, inevitably prepared with a view to orthodox new construction, should not be expected to be capable of direct and unyielding application to unusual situations, such as at SISC. In this special case the close liaison between the engineers and the MFB allowed the matter to be resolved. But the author suggests that all such Codes should incorporate a statement to the effect that ‘where particular and unusual circumstances occur, then nothing in this code should be interpreted as imposing solutions contrary to the precepts of sound design. The principles underlying the code, however, are expected to be applicable in all situations, and the code committee will be pleased to comment in situations of extreme difficulty’.

REVIEWING THE 1981 APPROACH TO ROOF VENTS

By the time the roof vents were actually installed, they could have been seen as a mistake: too small to be of much significant use; too difficult to add the sound insulation; too difficult to maintain. Some difficulties inherent in undertaking a modern computer analysis of likely upper layer temperatures, and how effective roof vents could be, are listed in the Appendix.

REVIEWING THE 1981 CONTROVERSY: INCOMPLETE SPRINKLER PROTECTION

The Sprinkler Code had its historic roots in insurance requirements, and hence the 4-hour separation that it would require presumably had is origins in property protection objectives. But the non-transparency of the normal 1981 regulatory process, lacking in any stated objectives, did not reveal the resulting basic discrepancy with the 'life safety is the only objective' regime adopted by the government for this project. Thus the MFB argued strenuously to defend their belief in fully conforming sprinkler systems. Today, in contrast, the MFB would readily recognise the validity of omitting sprinklers from the auditorium.

5.2 Fire Fighting

We discussed with the MFB whether they would like water cannons ('monitors') to be permanently installed high up in the seating, but this was not thought to be necessary. But the building will be equipped with hydrants (without hoses), and with hose-reels, to normal standards or better.

The MFB requirement for hose-reels, intended for first-aid fire attack by building occupants, is in complete conformity with the author's philosophy relating to the need for Staff Training: simple regular training in the use of hose reels and fire extinguishers can be expected to pay dividends in the event of a fire.

The overwhelming desirability of attacking a fire at the earliest possible moment has led to extinguishers (of modest power) being specified at closely spaced intervals. These are specified to be of types related to the nature of the predominant risk in the relevant locality.

Pear of vandalism has led, reluctantly, to most hose-reels and extinguishers being put in boxes. However, their locations will be marked in accordance with the Commonwealth Fire Board's guidelines.

The fire extinguishers have been specified by reference to the performance ratings set out in AS 1850 (Classification, Fire Testing and Rating of Portable Fire Extinguishers). Thus the controversial choice between C02, Halon and Dry Chemical types will be resolved on the basis of price by the competitive process of tendering. All extinguishers are to be operated by the 'pull-pin-squeeze' system, and extinguishers of the water type are to be of the stored-pressure type: The author considers that these two features are desirable and will soon be universal.

5.3 Air-conditioning

It is well known that air-conditioning can greatly exacerbate a fire situation if it is not prudently designed. AS 1668 Part 1 (Fire Precautions in Buildings with Air Handling Systems), provides guidance for prudent design in ordinary multi-storey buildings; and although its underlying precepts were kept in mind, its detailed provisions were not directly applicable and have not therefore necessarily been followed.

In view of the large volume of the auditorium a considerable volume of smoke could be ‘stored’ without threatening life (except, conceivably, at the very top of the seating). Thus smoke extract from the auditorium did not seem necessary. Moreover, because the air extract grilles are located amongst the seating, any smoke extract system would merely serve to draw smoke towards people. Thus the air handling system will simply switch off when smoke is detected either by the detectors in the roof, or by detectors in the return air ducts.

The fans extracting air from areas other than the auditorium will not be controlled by any f ire- related device: if they extract smoke, that is all to the good; if they only extract air, that will hardly aggravate the fire situation.

5.4 Electrical Provision

Complete re-wiring will be in accordance with normal standards and requirements except in that where cables penetrate the fire-resisting wall of the main switch room there will be fire-resisting glands rather than simple holes in the brickwork as requested by the supply authority.

The design incorporates a carefully graded system of fault levels throughout the system. The switchboard bus bars will be coated with Emercoat to provide a level of security above that required by normal standards or regulations.

Emergency lighting will be powered from a central battery system at 11OV D.C., influenced largely by AS 2293 (Emergency Evacuation Lighting in Buildings).

ADVANCES IN EMERGENCY LIGHTING

It is of interest to note how, only two decades ago, self-contained emergency lighting units were not available.

5.5 Emergency Evacuation Communication

The specification calls for a complex overlapping of several communication systems, and we envisage that the resulting overall system will include a microprocessor. Emergency communication facilities will be provided within the overall system largely in accordance with AS 2220 (Emergency Warning and Intercommunication Systems for Buildings), but will have the advantage of being used for non-emergency purposes as well.

REVIEWING THE 1981 COMMUNICATION ISSUE

It is of interest to note how, only two decades ago, computers, pagers and mobile phones were not available!

5.6 Miscellaneous Problems and Details

5.6.1 Movement joints at tops of walls

Gaps will be provided at the tops of many new walls in concourse areas and these will change in size as the building moves, as described in Section 2. These gaps are therefore difficult to seal against either fire or smoke.

Fortunately, the range of movement at the top of the only relevant fire-rated walls is only an estimated ± 5 mm, and in these locations the gap is specified as being 25 ± 10. A folded ceramic blanket, of original nominal thickness 25 mm, will be forced into this gap, and is expected to provide an adequate seal against fire, whatever the size of gap at the time of the fire.

In the case of some walls which are required to resist smoke (around escape compartments at Level 2) the movement may be as large as ± 10 mm. The gaps at the top of these walls are specified as being between 50 mm and 60 mm and into this is to be inserted a slowly-expanding, pre-compressed, neoprene-impregnated, closed-cell polyurethane foam, whose Australian trade-name is Willseal.

Naturally, it would be very desirable if a wall, designed only to be smoke resistant, actually prevented fire passing unduly rapidly. Thus the type of seal at the top of the wall was chosen only after considering many other potential solutions. Because the movement includes a horizontal component, and because some walls have to follow the ‘saw tooth’ profile of the concrete plats as well as lying at 45^0 in plan, a system of ‘stuffing an appropriate stuff in the gap’ had very great merit: it would adapt to the irregularities that would surely occur in practice. A strip of Willseal had been tested previously in a fire test between two precast concrete planks, and a perusal of the result of that test gave grounds for judging that it would not fail badly or quickly if attacked by smoke or by fire.

REVIEWING THE 1981 FLEXIBLE SEALING ISSUE

This very difficult issue of detail was a source of much agonising. But the principle was surely correct to create a detail that, above all, could be executed reasonably easily. And this would have to be reasonably easy even in difficult corners where walls and seating plats met at complex angles creating difficult access. And this practicality principle should be supreme even if the fire-resistiveness of the detail is not as high as would be required by normal regulations.

5.6.2 Sealing pipes passing through glass

At high level in the Level 2 corridors many services will be hung from the concrete plats above and these therefore move with the plats. These ducts, pipes and cables will pass through the glazed screens above the compartmentation doors, which do not move. Therefore the holes in the glass will have to be oversized to allow for the movement, and in some cases longitudinal expansion is also possible. In this location the philosophy would require smoke isolation; but the best realistic detail may let smoke through is some circumstances. However, we judge that the volumes will be acceptably small.

5.6.3 Sound baffles in the auditorium roof

150 sound baffles of polycarbonate sheet, typically 2.5 m x 1.2 m, are to be hung in the roof of the auditorium. The author was concerned that in the event of a fire these might soften at the suspension points, and drop without warning on a fireman below. Therefore a suspension detail was devised by which, it is envisaged, that such a falling baffle would be caught by the bottom restraining wires and hang at a lower level where the temperature would be correspondingly lower.

REVIEWING THE 1981 ROOFSPACE TEMPERATURE ISSUE

In principle, in 2003, computer-modelling of smoke and temperature spread in the auditorium could be undertaken. However, there would be many awkward elements which would be difficult to model (see Appendix), and the results would therefore always be doubted.

5.6.4 Protection of minor structural steel members

In general, structural steelwork in sprinklered areas will not receive an applied protection. However, in some areas of anticipated high fire load, new steel members have been oversized to provide an added reserve of strength; and members with low Exposed Surface Area/Mass (ESA/M) ratio have been favoured.

REVIEWING THE 1981 VIEW OF MINOR STRUCTURAL INTEGRITY

In principle, in 2003, computer-modelling of steelwork temperatures could be undertaken. However, conventional opinion today would be content to rely on the sprinkler protection.

5.6.5 Protection of main structural steel members

In concourse areas the main raking steel girders will be protected by block-wall enclosures and/or by enclosures made of steel studs and fire-resisting plaster board. In some cases these blockwork enclosures actually constitute the return air ducts, and therefore heat from a fire in the auditorium might be sucked into contact with girder within the enclosure. To prevent failure of the girder occurring by this means, a smoke detector in the return air duct will stop the fan. Then, it is envisaged, the rate of heating of the girder will be acceptably low.

There is only a low likelihood of fire heating the roof trusses excessively during the evacuation period, given the volume over which heat may dissipate and the presence of roof vents. We consider that their protection would add only minimally to life safety, and therefore they will remain unprotected.

If, contrary to expectation, a raking girder, a main truss or a tie down bar were to fail, the building might conceivably collapse by ‘unzipping’ up the middle and falling outwards. This possibility cannot be eliminated entirely, and ideally every fireman in Melbourne should understand it. But this level of awareness can scarcely be achieved, and such a mode of collapse will remain as one of those many remote risks which firemen face regularly.

REVIEWING THE 1981 VIEW OF MAJOR STRUCTURAL INTEGRITY

In principle, in 2003, computer-modelling of steelwork temperatures could be undertaken. However, the airflow through ducts of irregular geometry would be difficult to model (see Appendix), and the results would therefore always be doubted.

5.6.6 Fire rating of concrete plats

Fire ratings represent a useful method of comparing the efficiency of different structures in resisting a 'standard' fire. The test is specified in AS 1530 Part 4, and the fire rating period is, simplifying, the time that the test specimen endures without collapsing, and without its 'cold' face temperature rising by more than 139^{o}C. This test period may not correlate closely to actual real fire circumstances where the fire will not be a 'standard' fire, and the criteria for actual failure may not be the same as those in the test.

These matters have been borne in mind when assessing the likely actual endurance of the thin concrete plats: the author would expect the test temperature criterion to be reached in less than 30 minutes in a standard fire whereas their inherently rigid shape might allow them to survive against collapse f or much longer. However, the actual temperature failure criterion may not have much relevance to life safety in the auditorium above: steadily rising temperatures can be expected to encourage people to evacuate themselves long before the fire 'bursts through' upon collapse.

With these considerations in mind, the author has accepted that bolts may pass through the concrete plats in some locations.

6. CONCLUSIONS

The author believes that the first-principles approach to the fire protection problem has resulted in an acceptable solution which has taken into account the realities of

– the unique historical and structural nature of the existing building,
– the client's emphasis on life-safety rather than property conservation,
– costs,
– modern standards and community expectation,
– modern knowledge or fire and fire behaviour.

This has been achieved by ensuring that the <u>design</u> remained paramount, rather than an excessive dependence upon regulations, codes and arbitrary tests.

By viewing the problem as a whole it is believed that no significant major factor has been overlooked, whereas if energy had had to be devoted to proving compliance with codes and regulations, then the important principles might not have been kept so firmly in mind.

Although this approach has been, arguably, both necessary and successful with this relatively unorthodox project, it does not follow that all projects should be approached in this manner. However, it is suggested that a rigorous analysis of the fire problem can benefit <u>any</u> project, even if, unlike this project, regulations have to be complied with in any case: regulations are minimum standards, and an analysis of the fire problem may reveal areas where an owner would be well advised to spend more (such as smoke detectors) or to include fire as one selection criterion (such as when choosing seating).

Fire prevention and fire protection should continue to exercise the mind of the managers of any building for the life of the building. If the manager of the SISC prevents fires from occurring, then we will be well pleased — and content to remain ignorant as to how right or wrong we were in our judgements!

7. ACKNOWLEDGEMENTS

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REFERENCE

Fire Protection Engineering at State Indoor Sports Centre, Melbourne – L.N.Reddaway (Irwin Johnston & Partners Engineers Pty Ltd) – Paper 337 Australia's Engineering Conference 1981

APPENDIX Difficulties for computer modelling

Problems with modelling of evacuation:

- Difficulty in using any computer model for a building with a complex three-dimensional geometry of this type.
- Difficulty in knowing which values of the various parameters to use.
- Very broad range of credible evacuation times to emerge from the analysis.

Problems with modelling of smoke spread (using two layer model such as CFAST):

- Difficulty in characterising this building as a rectangular shape of cross section
- Difficulties in using CFAST
- Lack of verification of CFAST as reliable in a building of this shape and size
- Difficulty in deciding on suitable fire scenarios
- Difficulty in knowing which values of the various parameters to use
- Difficulty in interpreting effectiveness of roof vents
- Very broad range of credible smoke spread times likely to emerge from the CFAST analysis.

Problems with modelling roof steelwork temperatures

- Difficulties in temperature modelling, as just listed
- Difficulty in assessing rate of response of steelwork temperature to changes in temperature of surrounding atmosphere.

Problems with modelling steelwork temperatures in smaller spaces

- Difficulty in modelling the temperature rise in the room in question, due to irregular geometry etc
- Difficulty in assessing when the sprinklers will operate
- Difficulty in assessing the effect of the sprinkler activation
- Difficulty in assessing rate of response of steelwork temperature to changes in temperature of surrounding atmosphere
- Difficulty of deciding how to respond to the (unlikely) case of the sprinkler activating.