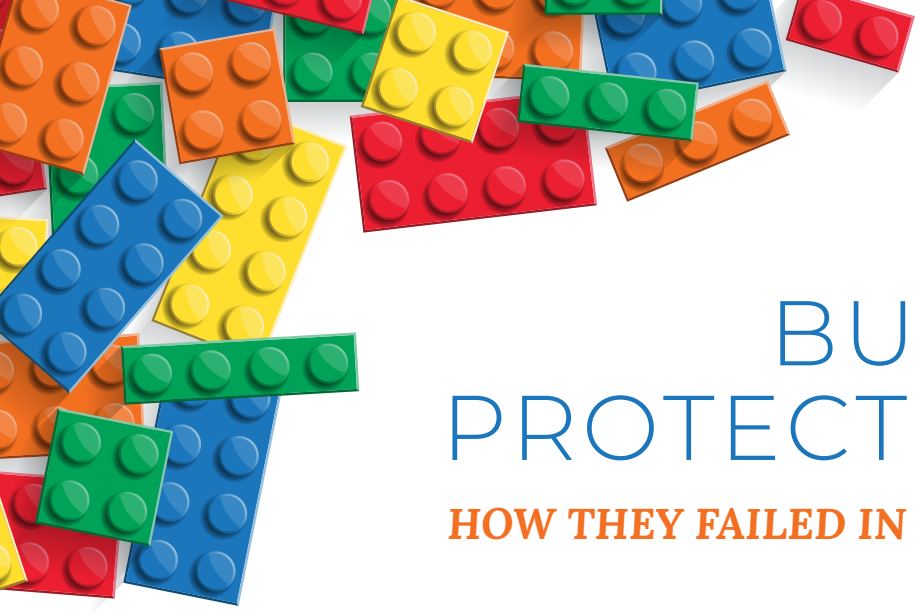


BUILDING FIRE PROTECTION LAYERS:

HOW THEY FAILED IN THE 1973 SUMMERLAND FIRE

BY BENJAMIN KHOO and GUILLERMO REIN, PhD

On the 14th of June 2017 in West London, a devastating fire broke out in Grenfell Tower, killing 72 people. The incident is the deadliest building fire in the UK. However, this was not the first façade fire that resulted in fatalities. The Summerland Leisure Centre fire on the Isle of Man on August 2, 1973, which killed 50 people, shares many similarities with the Grenfell fire.

The Summerland building was a single, large, transparent structure with limited compartmentation. During the 1973 fire, the building lost five of its six fire protection layers: prevention, detection, evacuation, compartmentation, and suppression. These layers were meant to work with each other to keep the building users safe during a fire.

Investigation into the incident found that the failure of these layers was mostly due to human negligence that resulted in: 1) use of flammable materials; 2) unauthorised modifications on the building; and 3) lack of staff training to deal with emergencies. As a consequence, emergency services arrived after the fire was well developed, and the evacuation process was severely delayed, resulting in the high death toll.

HISTORY

The building façade is considered one of the most complex and expensive parts of a building at around 20–25% of the total cost.[1] This is not surprising since the façade must achieve multiple objectives to ensure the building is safe and comfortable for occupancy.[2] To achieve these objectives, façade engineers often need to balance and compromise on some objectives to ensure the overall design is sound (i.e., improves energy efficiency without significantly compromising fire safety).

Over the past decades, façade fire around the globe has been steadily increasing, as shown in Figure 1. This has raised concern about the possible breach of compartmentation in high-rise buildings. Compartmentation, one of the six layers of fire protection, aims to contain the fire to its origin until emergency services are able to arrive and extinguish it.[3]

However, it is important to note that façade fire does not always result in a fatal incident. Previous incidents such as the Lacrosse fire in Australia and The Marina Torch in Dubai that involved quick fire spread across the façade reported zero fatalities.[4, 5] This suggests that, while compartmentation in the Lacrosse building and the Marina Torch failed, fatality due to façade fire may require the collapse of multiple layers of fire protection.

Indeed, one of the deadliest façade fires in the British Isles prior to the Grenfell fire was the Summerland fire in 1973. The incident, which started with a discarded match, resulted in 50 fatalities and 80 injured. A commission was appointed to investigate the incident, and it was found that multiple failures in building design had led to the massive loss of lives.

Unfortunately, some of these defects can still be found in buildings built after the incident.[6]

This article intends to describe the shortcomings in the Summerland's fire protection layers and draw parallels between some of the failures still found in the building industry.

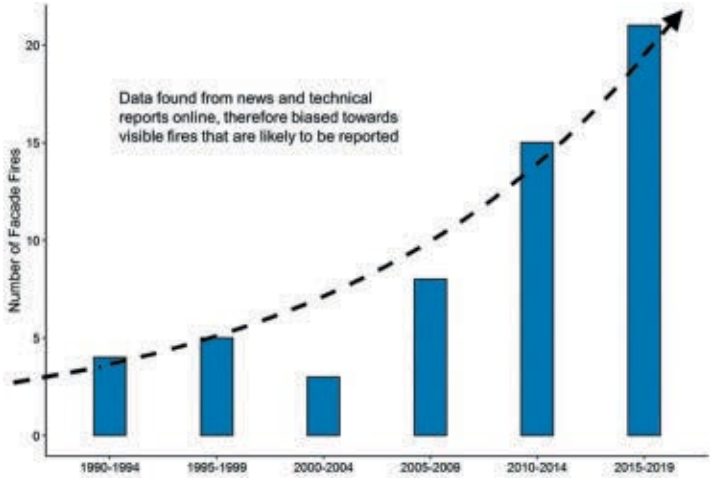


Figure 1. Plot of Façade Fires Reported by Media Every Five Years 1990–2019[7]

TIMELINE

The Summerland Leisure Centre was a new and innovative concept in the 1960s when it was first proposed. The concept can be traced to the travel from the UK to mainland Europe, reducing the number of tourists to the Isle of Man. The Isle of Man, a country that relies heavily on tourism from the UK, was desperate to re-attract tourists.[8] To achieve this, the government of Manx commissioned a leisure centre with a single, large, and transparent structure that mimics the Mediterranean weather by admitting as much light into the building as possible. It was a popular tourist destination for the British at that time. The building was designed to hold 5,000 people, and it was among the first buildings to contain various recreational activities such as a swimming pool, amusement area, bar, disco, etc.[9]

The construction of the Summerland building began in 1968. Throughout the construction process, financial issues contributed to several modifications to the building plan as well as project delays. Finally, on May 25, 1971, the Summerland Leisure Centre was completed and opened its door to its first customer.

On August 2, 1973, at 7:40 PM, three Liverpool schoolboys were smoking near a dismantled kiosk. The boys discarded a lit match and caused a section of the kiosk to catch fire. The kiosk and its contents burned intensely within minutes, and flames began impinging onto the building's façade.[10] Within about 20 minutes, an extensive fire was established on both the façade and within the building. At around 8:06 PM, the first fire appliances arrived to suppress the fire.[11] Unfortunately, by this time, the fire was too well developed, and the fire brigade could only prevent further spread to other parts of the building. The fire was eventually extinguished around 9:00 PM.

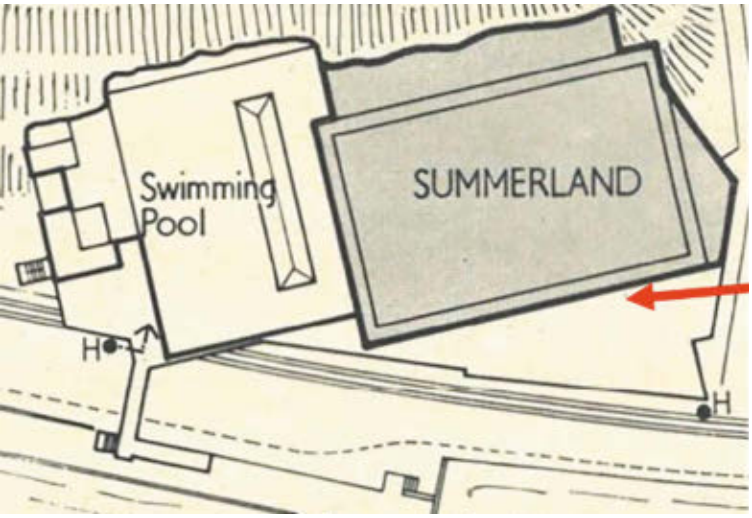
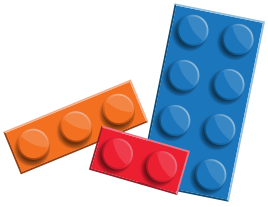


Figure 2a. The red arrow represents the area where the fire was believed to have started. (Source: RIBA Journal)

Figure 2b. The façade showed extensive fire within about 20 minutes.

HOW DID THIS HAPPEN?

After the incident, blame for the rapid fire spread was quickly assigned to the poor choice of construction materials. However, as aforementioned, failure of such magnitude is often caused by the collapse of multiple protection layers. In building fire safety, there are six layers of fire protection:



1. Prevention
2. Detection
3. Evacuation
4. Compartmentation
5. Suppression
6. Structural resistance[12]

Each layer plays a role in preventing or reducing the severity of an incident. Figure 3 shows how these layers could work together to prevent cataphoric failure during a fire.

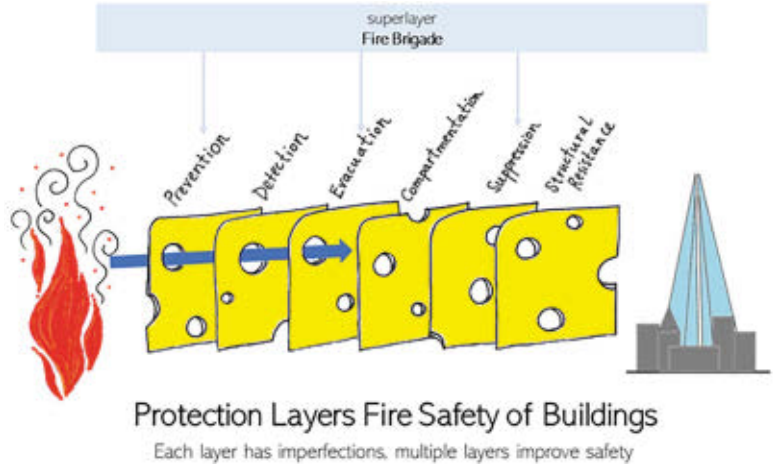


Figure 3. A simplified Swiss-cheese model shows how each fire protection layer works. These layers might not all be present in a building, but multiple layers improve the overall fire safety.

Of these six layers of protection, all but the structural resistance layer failed in the Summerland building. These failed layers will be explored to understand how they are meant to prevent a fire disaster and how they failed in the Summerland disaster.

PREVENTION LAYER

The prevention layer is responsible for ensuring that no self-sustaining fire can take place in the building. This is often achieved by using non-flammable materials at vulnerable areas or by removing ignition sources at these areas. In Summerland, the prevention layer was compromised due to a fuel source near an extremely flammable façade.

Months before the fire, a storm damaged a kiosk outside the golf terrace near the building façade. The standard procedure by management was to disassemble the kiosk and store it safely.[10] However, the kiosk was dismantled but became a fuel source near the façade because it was not stored away.

Nevertheless, fuel alone was not enough to cause a fire of this magnitude. The use of flammable material as façades allowed the flame to spread quickly. The Summerland façades can be broken down into three different materials:

1. Oroglass (PMMA)
2. Galbestos (corrugated steel sheet coated in a mixture of asbestos and bitumen)
3. Decalin (a sound-absorbent fibreboard)

All three materials are extremely flammable and cover the building extensively, as shown in Figure 4.

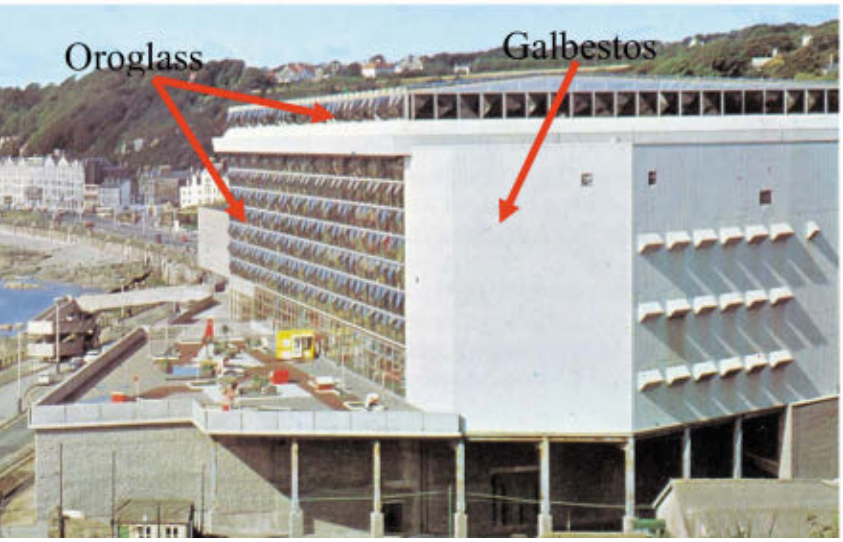


Figure 4. Oroglas and Galbestos were used extensively across Summerland's façade. (Source: Fortes Promotional Booklet)

Oroglas

After the incident, questions were raised about the choice of materials and how they were approved under building regulations. Under the Isle of Man's Local Government (Building Bye-Laws) Act 1950, three Bye-Laws would have restricted the use of these façade materials, as shown in Table 1.[11]

Bye-laws	Requirement	Affected Materials
Bye-law 39	Requires **external walls** of any building to be **non-combustible** and **fire resistant for two hours**	Oroglas, Galbestos
Bye-law 47	**Cavity wall** with combustible material shall be **fire-stopped.**	Galbestos, Decalin
Bye-law 50(1)	**The roof** should have adequate **protection** against the **spread of fire.**	Oroglas

Table 1. Bye-laws of Interest and the Materials Each Would Have Restricted

The use of Oroglas, a relatively new material at that time, was granted after relaxation of the regulations. The relaxation was given on the basis that Oroglas was believed to be noncombustible although not fire resistant after passing the BS 467 Part 5 test (since withdrawn).

To pass this test, the material is held vertically and is subjected to a small flame at the centre for 10 seconds. The material passes the test if the sample ceases to burn within 10 seconds after the flame is removed. However, this test is inappropriate as almost all dense combustible material more than 4 mm (0.04 in) thick would pass.[14] Failure to understand the test result meant that the authority granted the relaxation without knowing the weakness they imposed on the building. Despite later evaluation by the chief fire officer making clear that the Oroglas was combustible, he fell short of objecting to the relaxation as he believed the building had a generous fire evacuation strategy based on its initial building plan.[11]

Galbestos

Galbestos was initially not included in the building plan and was introduced later as a substitute for reinforced concrete due to financial reasons.[11] The designer was aware that Galbestos would not comply with the regulation as it is both combustible and not fire resistant. However, he believed that the material would still be adequate to prevent fast fire spread. The proposal to replace the reinforced concrete with Galbestos was then submitted without making clear that Galbestos required further relaxation of regulations. The authority thought the application was to reconfirm the waiver for Oroglas and approved the submission without seeking further advice. The approved submission made no mention that the waiver was only for Oroglas, leading to a misunderstanding that both materials were approved.

Lastly, the gap formed between the Galbestos and Decalin allowed the fire to develop with great intensity from within, as shown in Figure 5.[11] This gap was technically not considered a cavity under Bye Law 47. However, from a fire engineering standpoint, it behaves similarly to a cavity and would still need to be

fire-stopped as a matter of good practice. The severity of the fire in the cavity was made worse with the use of Decalin. The decision to replace plasterboard with Decalin was made hastily after the designer was introduced to it.[11] Under time pressure to find a sound-insulating board, the designer found Decalin fit the requirements and replaced the less-combustible plasterboard without further investigation of Decalin's fire properties.

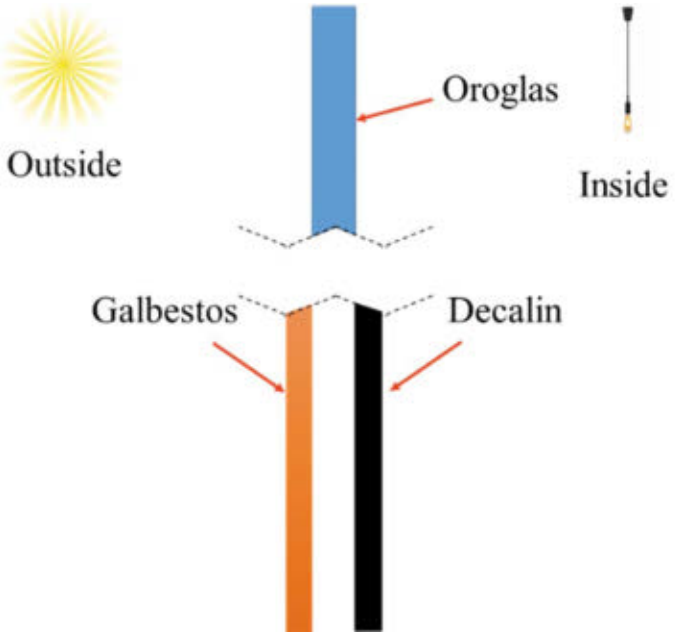


Figure 5a. Two Façade Types on the Summerland Building: Oroglas and Galbestos/Decalin (Decalin Not Always Present)[13]

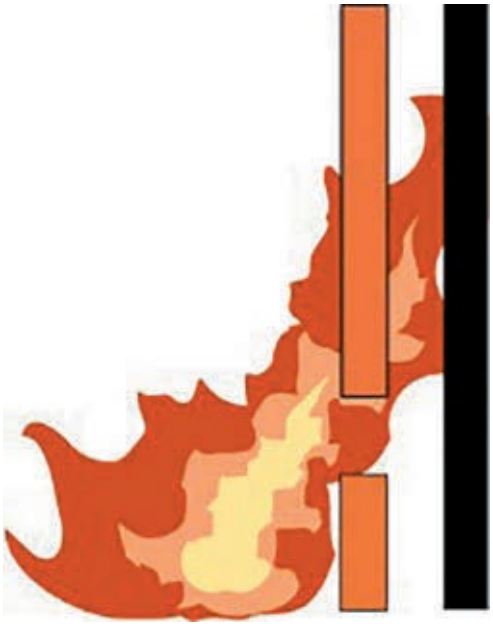


Figure 5b. Note that the cavity formed between Galbestos and Decalin encouraged fire spread.[13]

DETECTION LAYER

Whenever a building's prevention layer fails, the building relies on its detection layer to inform both its occupants and emergency services of a fire. This is typically achieved by installing detection systems such as fire alarms in buildings.

At Summerland, the fire was discovered almost immediately, but the detection layer was breached and the alarm failed to inform the occupants and fire service of the fire until the fire was too well developed. The fire service was informed of the fire by a passerby instead of Summerland staff or its automated system. This resulted in the fire service arriving at the scene about 21 minutes after the fire was discovered.[11]

To understand how the detection layer in Summerland failed, it is essential to first understand the detection systems available in the building. In essence, the detection system in Summerland was split into two systems: one accessible by the public and another accessible only by staff members. When activated, both systems will immediately inform the fire brigade of a fire. The difference between the systems, however, was that sirens would sound immediately if the staff's alarm was triggered, whereas the public alarm would not cause sirens to sound. During the incident, at least two public fire alarms were found to be activated.

Investigation into the matter found that building management tampered with the public alarm mechanism to delay the call to the fire brigade to allow more time for staff to investigate false alarms. The chief fire officer was not informed of this change and told the public inquiry that he would have disapproved of the changes had he been informed of it.[11] Summerland staff members were also not trained to react to an emergency. This resulted in the failure of staff to trigger the alarms and to announce the fire to the public via a public speaker.

EVACUATION LAYER

The purpose of the evacuation layer is to enable the safe abandonment of the building by all users when a fire is detected. The failure of this layer in Summerland can be attributed to two factors: 1) the ill-defined responsibilities within management, and 2) the poorly thought-out building layout.

The evacuation process is a complex procedure that cannot be improvised during an emergency. A well-executed evacuation procedure requires coordination between staff that is worked out well in advance and involves required fire drills to be conducted periodically. Summerland management had a guidance document for all future general managers that showed all evacuation exits and stated staff responsibility during an emergency, evacuation drill routine, and best practices for staff. The inquiry committee believed this document would have helped prepare Summerland employees for the fire.[11]

Unfortunately, as different general managers assumed the job, the lack of handover caused newer general managers to not be made aware of this document. This resulted in management

staff assuming that responsibility to organize fire drills fell on other staff, and no emergency procedures were in place. Consequently, during the emergency, staff were not aware of their responsibility to guide occupants out of the building nor unlock emergency exits, as shown in Figure 6. Some staff also committed a mistake by cutting off the electrical supply, believing it was the correct procedure to ensure public safety. This reduced visibility within the building due to the lights being turned off, which worsened the evacuation process.

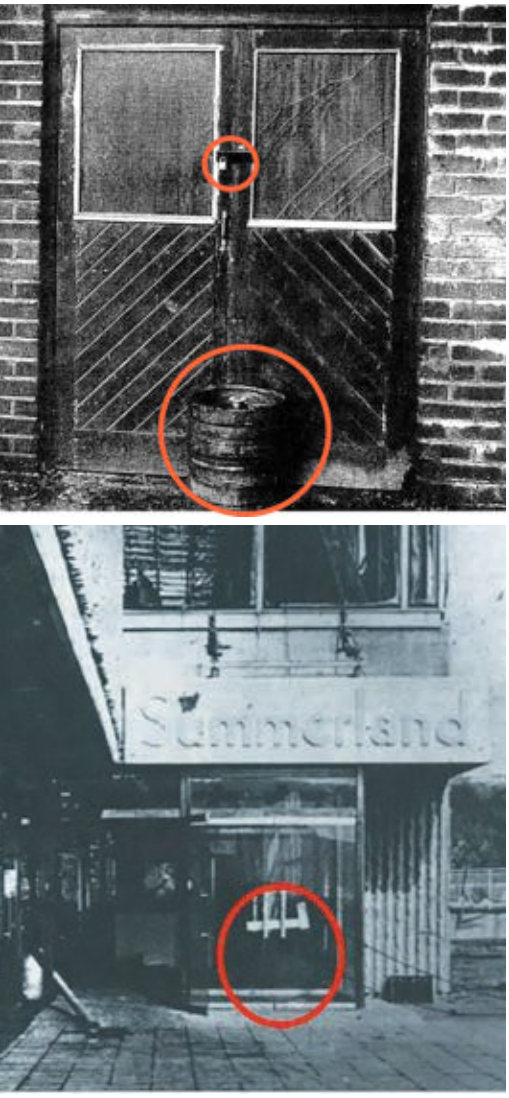


Figure 6a and b. Photos taken after the fire show some exits are still locked and obstructed. (Source: Police Photographs, Isle of Man Public Record Office)

In addition, the building plan was poorly designed to allow an orderly evacuation. Throughout the construction stage, several changes to the design plan were made. These include removing and reducing the width of stairways. No advice was sought from the chief fire officer on these changes. When the building was completed, the chief fire officer's inspected revealed that many of these changes had created bottlenecks that would hinder the evacuation process. He required a few changes to improve this, but some areas were still inadequate to allow for safe evacuation.

Furthermore, the building lacked exit and directional signs that caused sheep syndrome among the occupants. Since people instinctively tend to leave a building by the way they exit, it is essential for buildings to have enough signs to direct occupants out of the building from all possible exits. It was found that, apart from a few marked exits, many exits in Summerland were not marked as emergency exits.

The Summerland building layout was also such that parents tended to be separated from their children.[15] This was due to the layout of the building, which had entertainment for children and adults located at different levels. As a result, some parents went against the evacuation flow during the emergency to look for their children on different floors, slowing down the evacuation process.

COMPARTMENTATION LAYER

The compartmentation layer of a building ensures that fire does not spread quickly throughout the building. This allows more time for emergency service and occupants to react to the fire. The nature of the Summerland building to have a single, large compartment meant that it could not be compartmentalized completely, as seen in Figure 7. Additionally, the lack of fire-stop between each level and the external wall meant that fire could spread upward quickly via the chimney effect.[8] Furthermore, as the fire spread to the roof, Oroglas at the ceiling melted to not only vent the fire below, but also to spread fire across the building via burning droplets.

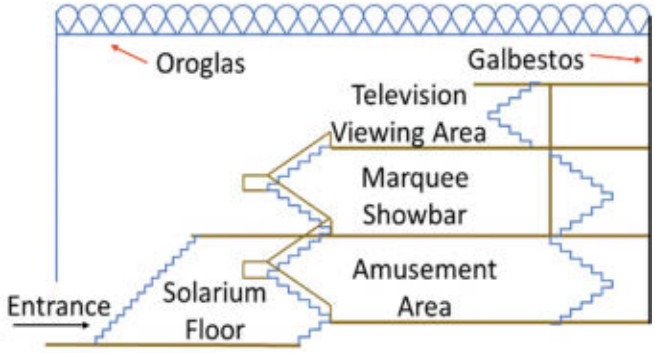


Figure 7a and b. Summerland was designed to have a single, large space with limited compartmentation. (Source: Fortes' Promotional Booklet)

Lastly, to ensure safe evacuation of the building users, stairways are normally compartmentalized. When the Summerland building was first designed, some stairways were compartmentalized to facilitate an emergency evacuation. Unfortunately, when the reinforced concrete was replaced with Galbestos, the northeast service stair, as shown in Figure 8, was surrounded by combustible walls. A further breach of this compartmentalized stairway was made by an unauthorized doorway to allow easier movement of goods into and out of a bar. The unauthorized doorway was responsible for a huge amount of smoke entering the stairway, which may have resulted in 12 people dead just 3 meters from the exit.[11]

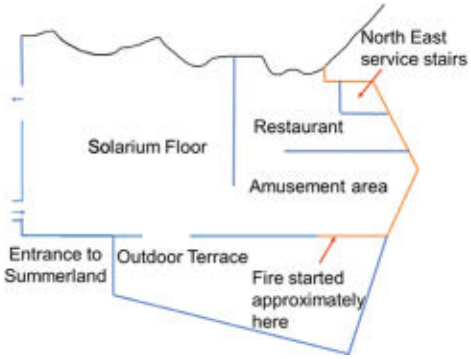


Figure 8a and b. The northeast service stairs, one of the supposedly compartmentalized stairways, was surrounded by Galbestos (orange line), which is flammable (Source: Report of the Summerland Fire Commission)

SUPPRESSION LAYER

The suppression layer acts to suppress or slow down the spread of fire to buy more time for building users to evacuate the building. Suppression of fire can be achieved either automatically by using sprinklers or manually by the use of fire extinguishers by trained staff. After Summerland construction was completed, its insurance company offered a large reduction in premium if sprinklers were installed in the building. While the installation of sprinklers might not have suppressed the fire completely, the sprinklers could have helped offset the limited compartmentation and allow more time for evacuation.[16] Unfortunately, the sprinklers were deemed unnecessary and were not installed. Additionally, the lack of staff training meant that available firefighting equipment was not used correctly. This, together with the lack of sprinklers in the building, caused the suppression layer in Summerland to fail.

HAS THE LESSON BEEN LEARNED?

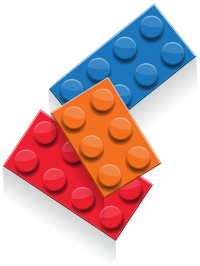
Ten years after the Summerland Incident, Dennis Harper, part of the three-man commission that investigated the incident, noted that many lessons from Summerland were not learned.[6] Indeed, after the 2017 Grenfell incident, an independent review into building regulations and fire safety chaired by Dame Judith Hackett found the building industry was "an industry that has not reflected and learned from itself, nor looked to other sectors."[17]

The reason the Summerland fire spread so quickly was due to the failure of both the prevention and compartmentalization layers. The failure of both layers can be attributed to the lack of understanding of the fire properties of innovative materials, failure to follow good practices when constructing the building, and failure to consider the effect of modifying building components

on the system's overall flammability. Similar failure was seen in the 2017 Grenfell incident where the cavity barrier was found to be poorly fitted, and building refurbishment allowed a kitchen fire to develop into a disastrous fire.[18]

CONCLUSION

The 1973 Summerland disaster was due to the collective failure of five of the six fire protection layers: prevention, detection, evacuation, compartmentation, and suppression. Only the structural protection layer remained intact. The tragedy took 50 lives and seriously injured 80. The combination of using flammable materials as the façade and having a fuel source near the façade resulted in a severe breach of the prevention layer, causing rapid fire spread on the building's façades. The choice and use of these materials was driven by failure to understand the properties of new materials and poor communications between authorities and designers. The prevention layer breach could have potentially been avoided if the procedures to remove any fuel source from flammable sections of the building were followed and the consequence of the regulation waiver on new materials was fully understood.



Failure of such magnitude is often caused by the collapse of multiple protection layers.

However, the high death toll was not solely due to the breach of the prevention layer. The failure of the detection layer in Summerland also played a role. Untrained staff and unauthorised alteration of the alarm system caused the delayed response to the fire. As a result, the fire service was notified 21 minutes after the discovery of the fire, and the occupants were not notified of the fire via public announcement.

The evacuation layer in Summerland also failed due to inadequate staff management and poor building layout. Senior management was not aware of their responsibility, and no training was provided to staff to deal with fire emergencies. Poor building layout and lack of emergency exit signs also delayed the evacuation process due to bottlenecks at key areas of the evacuation path.

In addition, the compartmentation of the building failed due to poor material choices at key areas and unauthorized modifications to the building. The use of a flammable material as the wall in the emergency stairway failed to provide a safe pathway to exit the building.

Furthermore, an unauthorized doorway near the compartmentalized stairway for easier movement of goods allowed smoke to enter the stairway resulting in multiple deaths.

Lastly, the suppression layer, while it may not have stopped the fire completely, could have helped to buy more time for the evacuation process. In the Summerland fire, the suppression layer failed due to sprinklers not being installed and improper handling of fire extinguishers by staff due to lack of training.

This tragic outcome could have been avoided with fire expert input at various stages of construction to identify potential breaches in fire safety and allow time to fix the problem.

Forty-seven years later, the Summerland fire still echoes, with many similar failures to be found in modern building fires. The lessons from the Summerland fire should and must be learned, for if they are not, a similar disaster will repeat itself in the future.

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