FIRE SAFE

This case study was written at the time when OneSteel was part of BHP. In that context, in some instances within this case study, reference may be made to BHP.

Bare Steel for Lynnmall Shopping Centre

a Fire Engineering Approach

Extensive research has been conducted to examine fire safety in shopping centres, with a fire engineering design approach being proposed. This research was conducted as part of a Fire Code Reform Centre Research Programme and the final research report entitled 'Fire Safety in Shopping Centres' is now available from Standards Australia (Phone 1300 654 646 or Fax 1300 654 949). This method allows the use of bare steel for sprinklered shopping centre buildings up to 4 storeys. The fire engineering design for Lynnmall drew upon this research work.

Introduction

Built in the 1970's, Lynnmall Shopping Centre in Auckland, New Zealand is one of the city's older retail shopping malls. It is located in the western suburbs of the city and covers a floor area of 43,500 metres^2, essentially on one level. Four major tenants share space with over 100 smaller specialty shops, a foodcourt, a central court for events and displays and adjacent two level carparking structures. Only one of the major tenants has a sales floor at a second level.

Due to its age and the need for retail shopping malls to meet the changing demands of shoppers, the owners of the centre embarked on a programme of staged refurbishment. The staging of the proposed work was necessary to ensure the mall could be kept operational while the refurbishment took place. Steel was the natural choice as the structural element to be used for the refurbishment, as the existing structure was steel and it offered the least disruption to the centre's operations due to both the off-site nature of fabrication and the ability to erect on-site, by crane.

Design Basis

New Zealand's building regulations require that a building which is to undergo alteration be upgraded, if necessary, to meet the current Building Code requirements for means of escape. This includes an assessment of the necessary fire safety systems in the building and the provision of fire separations, where required, to ensure safe egress.

In addition to these, any new construction must also comply with Building Code requirements for control of fire spread to *other property*.

The mandatory requirements of the New Zealand Building Code are stated in non-quantifiable performance-based terms. Deemed-to-comply design methods are available which contain prescriptive solutions (Acceptable Solutions), but there is no obligation to recognise these or to design for an equivalent level of safety. Alternative solutions may be submitted, with the Territorial Authority issuing a building consent if it is satisfied on reasonable grounds that the alternative solution complies with the (performance-based) requirements of the Building Code. However, because it is often difficult to demonstrate convincingly that an alternative solution does meet Building Code requirements, the Acceptable Solutions are sometimes used as a basis for comparison.

The fire safety design for the Lynnmall Shopping Centre refurbishment is an alternative solution. It was necessary to address all issues relating to means of escape and life safety, but because the building was undergoing an 'alteration' and not a 'change of use' there were no specific requirements to design against fire spread to other property. Also, there were no specific requirements from the building owner to design for levels of fire protection greater than those needed to satisfy the Building Code.

Fire Engineering Design Brief (FEDB)

Due to the staged nature of the project, a Fire Engineering Design Brief was prepared to describe the fire safety design philosophy, design assumptions and to lay out the basis of design for the future building consents for each stage of the works. It was essential to produce this document to ensure there was no risk of having an issue of fundamental importance challenged during the design or construction of the final stages of the project.

The Fire Engineering Design Brief was reviewed by the client, architect, peer reviewer, local authority and other design consultants to ensure that all relevant input and approval was obtained before confirming the FEDB as the fire engineering design basis.

The acceptance criteria that were adopted in the FEDB to satisfy the performance requirements of the Building Code covered means of escape and the interaction of smoke with the building occupants:

- the time for safe egress of building occupants must be suitably less than the time it takes for conditions around the occupants to become untenable
- building occupants must be able to escape to

a safe place within eight minutes, to minimise occupant uncertainty
- smoke layer height must be maintained at least 2.0 metres above occupied floors or higher if smoke temperatures would cause excessive radiation to occupants.

A number of design assumptions were also recorded in the Fire Engineering Design Brief, relating mainly to the computer software that was used for modelling egress, smoke detector activation, sprinkler activation and smoke control.

The Refurbishment

The refurbishment and upgrade of Lynnmall involved the complete alteration of almost all existing parts of the shopping centre and the construction of two new blocks, one at the east and one at the west end of the main mall.

The first stage started in 1996 at the east end with the construction of a new mall entry, major tenant space, glazed dome roof and associated specialty shops. Work moved progressively westward, with the design and construction carried out in stages to suit tenant movements. Because the construction boundaries did not always match logical zone boundaries for the fire safety systems it was necessary to be aware of the overlaps between the various construction stages.

Fire Safety Systems

Prior to refurbishment the Lynnmall Shopping Centre was protected by an automatic sprinkler system and contained a manual fire alarm system, automatic smoke detection and fire hose reels. These systems were retained as part of the refurbishment, although modified and upgraded as required to accommodate the new internal fitout work.

In keeping with the day to day use of the mall areas, the fire design philosophy was based around the concept of ensuring that the mall remained a place of relative fire safety when compared to the smaller specialty shops. This involved the design and installation of active systems to contain and suppress an outbreak of fire (automatic sprinkler system) and to control smoke (smoke extract system) rather than subdividing the mall into firecells with fire separations. This approach provides much greater future flexibility, both in terms of alterations to individual tenancy spaces and for the future expansion of the shopping mall itself.

Fire hose reels or hand-held fire extinguishers were provided in the new and refurbished areas in recognition of the (largely unrecognised) benefits of occupant extinguishment of small fires.

Design for Means of Escape

Instead of following the prescriptive requirements contained in the Acceptable Solutions, the design for means of escape was based on observed human behavioural characteristics in emergencies for this type of occupancy. The design recognised that occupants are much more likely to evacuate using the main mall areas and the public entry points rather than using fire escape corridors leading directly to the outside, even though these may be closer than mall entry points. The time that it takes for the public to respond to an evacuation signal also tends to be very long for this type of occupancy, which makes it more important for the mall to be a safe area, giving people sufficient time to evacuate without suffering injury.

Therefore, the mall was designed to be a safe place, for the purposes of designing the egress from the specialty shops. Egress from each tenancy was therefore evaluated in terms of the travel distance / time to reach the mall or to an open space outside.

Although the mall area does contain some fire load and is an enclosed space directly linked to the specialty shops, the design aim was to ensure that the occupants in parts of the mall remote from the fire could still use the mall as a safe escape route, and that even those closest to the fire in its initial growth stages would be provided with a high degree of safety when in the mall area.

As a check on sufficient egress width through the main entry doors, computer modelling of evacuations was carried out to verify the minimum required door widths. The main entry door widths were designed so that sufficient egress capacity would still be available even with occupants favouring the use of familiar escape routes over the fire egress corridors.

Some dedicated fire egress corridors have been provided in locations adjacent to security grilles that are lowered to close off parts of the mall when only specific areas are open for trading. Without the egress corridors, occupants in most of these locations would have only a single means of escape.

Design of Smoke Extract Systems

The main reason for providing active smoke control with specific smoke extract fans is to maintain tenable conditions in the mall areas for an indefinite period. In doing so, the mall effectively becomes a safe place and egress from the mall to the outside becomes a less critical issue. In assessing the design parameters for the smoke extract system, various fire scenarios and different levels of redundancy were considered.

Fire Scenarios

The reliability of sprinkler systems in New Zealand and Australia is generally accepted as being high. The principal fire scenarios were therefore chosen as sprinkler-controlled fires for both the design of smoke control systems and the associated check on tenable conditions for egress design. Two design fire scenarios were considered: a sprinkler-controlled fire in a specialty shop and a sprinkler-controlled fire in the main mall. The assumed fire growth characteristics for these two scenarios were based on an evaluation of experimental data.

Levels of Redundancy

In keeping with the performance-based design approach and applying a quasi-risk based approach, it was agreed that while a certain level of redundancy needs to be included in the design it is not necessary to design for multiple worst-case situations in one scenario. In other words, various margins of safety and level of redundancy were considered for each scenario in turn, but in assessing adequate performance (using the criteria established previously) several levels of redundancy were not incorporated simultaneously.

Fire Design of the Steel Structure

The roof structure for almost the entire shopping centre consists of longrun steel roofing supported on cold-formed purlins and hot-rolled steel beam sections. For a single storey shopping centre such as Lynnmall the deemed-to-comply Acceptable Solutions do not require any of the roof structure to have a fire resistance rating. However, the floor and supporting structure for mezzanine floor areas are required to have a 30 minute fire resistance rating (according to the Acceptable Solutions).

The performance of the structure for various fire scenarios was considered. In the sprinkler-controlled design fires, the structure was never exposed to temperatures that would have any effect on the strength or stability of the steel members. The extremely unlikely case of a fire reaching flashover and full development was also considered from the point of view of life safety. There were no cases in which the performance of the unprotected steel structure in such a fire, would have an adverse affect on life safety. In the cases where the structure might be subjected to fire conditions causing local loss of strength or stability, untenable conditions would be reached before the structure reached a limit state and so the application of passive fire protection would have no life safety benefit.

Therefore, the steel roof and mezzanine floor structure were not required to have any applied passive fire protection.

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