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 metres², 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 purpose of providing 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.

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 long-run 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
erating. 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.

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
occupied 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.