Fire Engineering Design and Steel Standard Revision

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Introduction

This article gives recommendations for Alternative Design methods for fire engineering of common types of multi-storey steel structures. These are Alternative Designs because they do not follow 100% the Compliance Document for Fire Safety, (DBH, 2005). However, they meet or exceed the provisions of the New Zealand Building Code, (DBH, 1992), which is required under the performance based Building Control System (BCS) that was introduced in 1992.

Alternative Designs require the design procedure to be approved by the Building Consent Authority. In many instances, the building control official responsible for reviewing the design is familiar with historical prescriptive designs and unfamiliar with new fire engineering methods that have been developed under the current BCS. The current Steel Structures Standard NZS3404 (SNZ, 2007) provides only a simplistic and element based approach to the design for fire, as this material was written for application under a prescriptive based system. These two factors are leading to significant delays in the processing of some Alternative Designs. A complete revision of NZS 3404 commenced in 2008 and the design provisions for fire are to be presented in an expanded new stand-alone part which will provide a Complying Solution directly.

Alternative Fire Design Solutions for Steel Structures

A brief overview of alternative fire design solutions for three groups of multi-storey steel structures are now given, along with references to the complete design procedures. All design procedures are based on delivering the following performance of steel framed multi-storey buildings in fully developed fires:

- prevention of collapse
- in unsprinklered buildings, minimising damage especially to columns to facilitate post fire repair
- in sprinklered buildings, allowing permanent damage to beams and floors without compromising the floor's requirement to function as a fire separation (floors are typically required to be fire separations)

Car Parking Buildings

Details are given in session 2 of (Bhatt et al, 2006). These prescribe Fire Resistance Rating requirements (FRRs) for the beams, floors, walls and columns of structural elements of car parking buildings to ensure structural stability from fire exposure within the car park. They are derived from experimental burn testing of cars in representative car parking building enclosures and fire modelling of cars in a wider range of car parking enclosures. The design approach involves determining the Period of Structural Adequacy (PSA) from NZS 3404 Clause 11.3 for each structural element and ensuring that PSA ≥ FRR for each element. The FRRs range from 15 to 30 minutes and for most of the 15 minute cases, the steel can be left unprotected.

Apartment and Hotel Buildings

For ambient temperature design of multi-storey apartment and hotel buildings, all supporting steel beams and columns must be hidden behind fixed wall and ceiling linings to satisfy acoustic insulation requirements. In the event of a fire, these linings will shield the steel members from direct fire exposure and, as noted above, if they remain in place they may keep the steel temperatures well below the limiting temperature. Following research by (Brown, 2007), which established appropriate failure criteria for fixed gypsum plasterboard linings, a design procedure and computer program have been developed by (HERA, 2006) for design of steel members hidden behind these linings in both unsprinklered and sprinklered apartment and hotel buildings. For unsprinklered buildings, the structural system and materials should meet the requirements of (Clifton, 2006) to ensure that they have dependable deformation capacity in the event of local barrier failure. The design involves selecting a

radiation barrier sufficient to keep the individual steel member below the limiting temperature given by NZS 3404 Clause 11.5 and is applied on an element by element basis.

Commercial and Office Buildings
The most generally applicable and widely used of the three alternative methods is the Slab Panel Method (SPM) (Clifton, 2006). It is applicable for the full range of fire severity expected in multi-storey buildings and for most types of concrete floor system which act compositely with supporting steel beams. The procedure has been developed for large regions of flooring incorporating unprotected steel beams, where these members may be subjected to very high temperatures and the floor system subjected to considerable inelastic demand in the event of a fully developed fire. The design procedure determines the extent of this inelastic demand and allows for a dependable proportion of the additional reserve of strength available from the rest of the building when the floor system undergoes this deformation. It is recommended that the SPM is used in conjunction with sprinklers or radiation barriers to prevent structural damage immediately following the onset of full fire development.

The SPM is based on the tension membrane concept developed by Bailey (Bailey, 2000). The SPM design and detailing provisions have been developed from a multi-year research programme, described in section 8 of (Clifton, 2006). The procedure has been independently peer reviewed and is now in use in New Zealand, Australia, and from 2007 in the UK and USA.

The procedure requires estimation of the design fire severity associated with burnout of the firecell. The adequacy of the floor system to support the design vertical load throughout this burnout is determined using the procedure. It also specifies minimum detailing and material requirements to ensure that the expected deformations can be achieved without premature failure.

Proposed NZS 3404 Part 6: Design for Fire
As part of the revision of NZS 3404, it is proposed to produce a standalone Part 5: Design for fire. This will provide a means of compliance with the NZBC Fire Safety Clauses C2: Means of escape, C3; Spread of fire and C4: Structural stability during fire for the design of steel structures to resist fully developed fires.

As of February the draft is at a very early stage of development, with the first scope and content being considered by the Committee.

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