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Structural Steel Fire Guide – Guide to the Use of Fire Protection Materials

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First Edition 2008

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by

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PREFACE TO THE 1st EDITION

This publication is designed to provide builders, architects and engineers with elementary details on fire protective products based on the two general paths that designers may choose to follow:

1. ‘Deemed-to-Satisfy’ solution; or
2. A fire engineered solution.

The fire engineered option may offer a further 2 alternative options:

2a. Fire engineered solution for pricing and final design for construction; or

2b. Use of ‘Deemed-to-Satisfy’ for pricing and then a fire engineered solution for final design for construction.

The guide will examine the steps required for these options and guidance on which products may be most appropriate for certain scenarios.

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David Ryan

July 2008

1. INTRODUCTION AND PURPOSE

The performance-based building regulations in Australia and New Zealand principally relate to the safety of occupants (including fire fighters) and the prevention of fire spread and damage to adjacent properties.

The performance requirements of the regulations may be met by following the 'Deemed-to-Satisfy' (DTS) approach or by designing an 'Alternative Solution', both referred to in the Building Code of Australia (BCA). The former approach is achieved by complying with all of the prescribed requirements in relation to fire resistance of structural elements, sprinklers, hose reels, hydrants, detection, egress requirements, smoke management and the like. These requirements vary depending on the building classification (office, retail, residential, public, car park, etc) and the height and area of the building. The Alternative Solution permits greater flexibility in architectural form and design and can permit buildings that do not fit the type of building details upon which the DTS provisions were developed.

The design of an Alternative Solution must be undertaken by a professional fire safety engineer usually in conjunction with a team which is likely to include at least the architect and/or owner's representative, the fire safety engineer, the building certifier and fire brigade representatives. This development of an Alternative Solution is not a trivial process but can offer significant project savings including reduction of required fire resistance for some elements. The fire engineered Alternative Solution can cover tenant requirements over and above that of the BCA. This may cover consequential losses through loss of use of the building and loss of building contents. It may also result in a more efficient building design in accordance with client preferences.

The BCA requirements with respect to the fire-resistance level required for a particular situation will be dictated by the Deemed-to-Satisfy provisions or the requirements of an Alternative Solution. In either case the building certifier (building approval authority) must advise on the FRL required. It is therefore not necessary for the builder or specifier to have a detailed understanding of the fire requirements of the BCA. Therefore, a detailed description of the BCA requirements will not be covered in this document.

The purpose of this publication is to increase awareness of the fire-protection materials that are now available for structural steel and to provide a list of major suppliers of fire-protection materials. This publication does not specify thicknesses required to achieve particular fire resistance levels. Manufacturers listed in this document can be approached directly for this information.

2. THERMAL RESPONSE OF STEEL

A steel section absorbs heat through its surface and the greater the surface area exposed to fire the more it will heat up. Conversely, the greater the mass of section the more it will act as a heat sink and resist heating up. Thus the ratio surface area/mass (surface area-to-mass ratio) becomes a useful measure of a steel member's ability to resist temperature increase – the lower the number, the better the resistance. In most cases, practical steel members do not have a sufficiently low exposed surface area-to-mass ratio to provide a sufficient resistance to temperature rise and it is necessary to enhance this performance by the addition of materials to the outside of the steel. These fire protection materials both insulate and in some cases absorb energy.

The performance of a given thickness of fire protection when applied to a given steel member is expressed in terms of a duration time of fire resistance. Thus if a particular combination of steel member and protection thickness is stated as giving a fire resistance period of 95 minutes, this means that if this member was tested under standard fire test conditions, it would support the load applied to the member for at least 95 minutes. Standard fire test conditions are those experienced when the member is tested in a standard test furnace in accordance with AS 1530.4 and requires the member to be subjected to a prescribed time temperature curve known as the Standard Time Temperature curve. This curve provides a relatively standardised approach to evaluating fire materials performance.

Systematic testing of protected steel members results in a range of fire-resistance periods which are used by manufacturers to determine material thicknesses to meet required fire-resistance levels (FRLs).

The thickness of fire protection required to achieve a given fire resistance is dependent on the thermal properties of the fire protection material and the ratio of exposed surface area to mass. The higher this ratio, the greater the thickness of protection required to achieve a particular fire resistance.

Given the beam or column size and the exposure condition (three sided or four sided exposure to the fire) a supplier will provide the thickness required to achieve a fire resistance level.

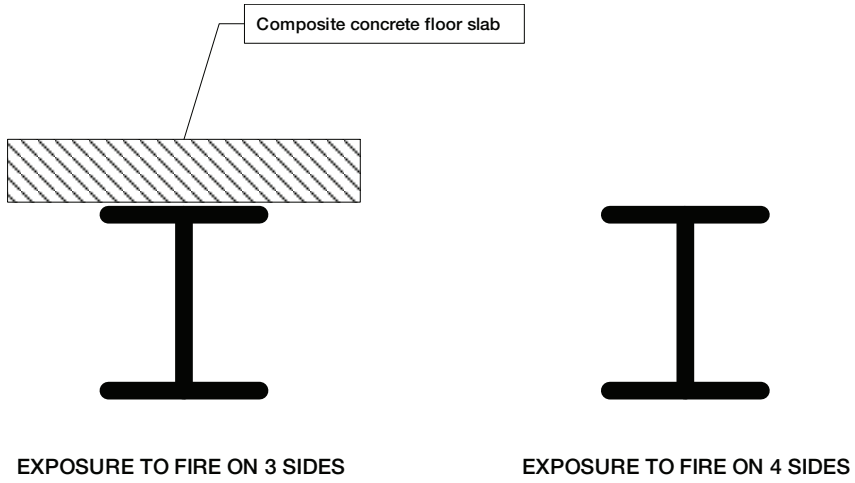


Figure 1: Three sided and four sided exposure

3. DETERMINATION OF FIRE RESISTANCE LEVELS (FRL) – PROCESS INVOLVED

The attached flow chart demonstrates the regulatory process that is involved for a major project in determining the required FRL for structural steel members. The chart covers two situations - the adoption of the DTS requirements or the development of an Alternative Solution.

Paramount to the process of fire-safety engineering is the reliance on appropriately accredited and registered persons. There are many bodies that accredit or register the professionals in the fire engineering process. Each state legislation is different, however, Engineers Australia is one of the main bodies that have a register of accredited / registered professionals in the fire engineering field.

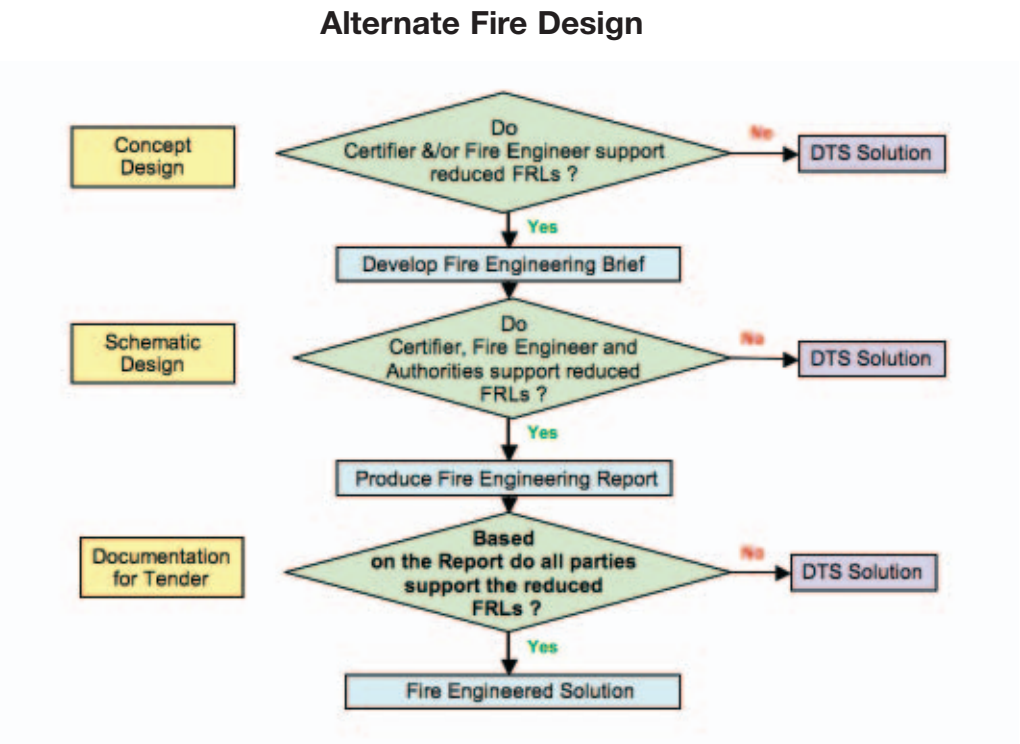


Figure 2: Alternate Fire Design

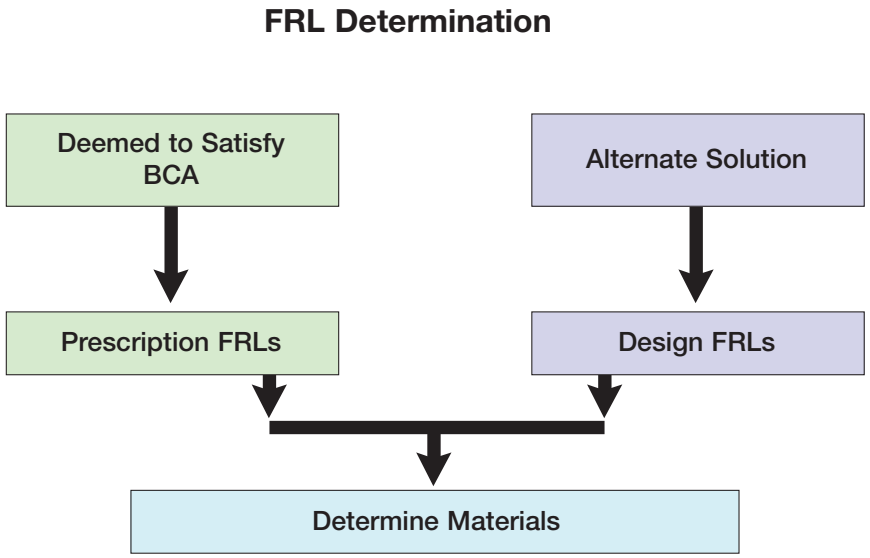


Figure 3: FRL Determination

4. FIRE PROTECTION OF STEELWORK

As noted in Section Two, the fire resistance of steel members is enhanced by the addition of fire protection materials which insulate the surface. The type of fire protection material opted for will depend on a number of factors such as:

- Cost and availability of selected fire protection materials and application.
- Location of the site – availability of type of material in relation to site.
- Aesthetic considerations – is the steel section to be visually expressed?
- Fire resistance to be achieved.

Note: Fire protection materials are not specifically designed for corrosion protection and advice on this should be sought from the design engineer.

For the purpose of this publication, fire protection materials have been allocated into three distinct categories:

- Conventional spray applied materials.
- Fire resistant board materials.
- Thin film intumescent coatings (paints).

These categories and the relevant materials within are now considered in detail.

5. CONVENTIONAL SPRAY APPLIED MATERIALS

5.1 General

These are the oldest and at present the most widely used form of fire protection material in Australia.

They are relatively low density materials (at least when compared to concrete), which are typically supplied in bags, mixed with water and sprayed as a type of slurry to the structural steel profiles requiring protection.

Application of spray applied materials is through specialist contractors using specialist equipment. This process has a perception of being quite a messy process but with adequate masking and other on site measures, control of overspray has proven to be more than possible and hence this process deemed very popular.

Conventional spray applied materials are cost effective for large projects and if applied early in the construction process prior to other trades being on site, further improvement in economies can be made.

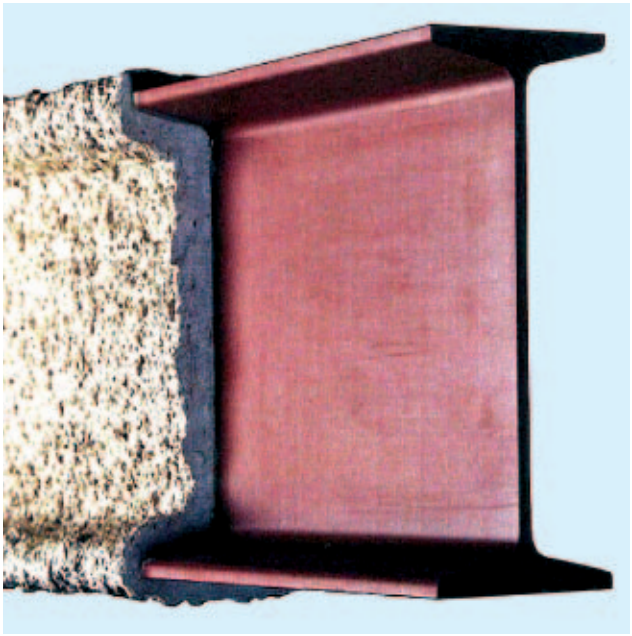


Figure 4: Application of conventional spray applied fire protection material

Figure 5: Conventional spray applied fire protection material

5.2 Available Materials

Supplier	Product TM	Composition
Promat	Cafco 300	Premixed vermiculite plaster with other chemical based materials
LAF Group	Vermitex AF	Gypsum-Vermiculite blend plus trace chemical additives

Note: This table is not intended to be exhaustive and other suppliers and materials may be available.

1. Product is not suitable for external use
2. Surface preparation is to remove loose rust and grease

6. BOARD MATERIALS

6.1 General

Fire resistant board materials, like conventional spray applied materials, have been used for a long time in Australia. Board materials are cut to size and fixed around steel section, in essence ‘boxing’ them to provide the necessary fire-protection.

There are several proprietary board materials on the market and these are typically calcium silicate based, vermiculite based, or gypsum based (plasterboard).

Application of board materials requires trained and approved applicators who are familiar with the unique fixing requirements.

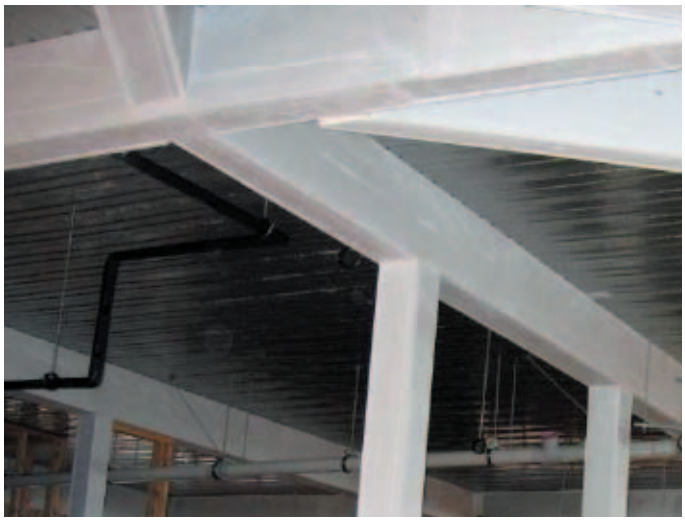


Figure 7 and 8: Steel sections clad in fire proofing board materials

6.2 Available Materials

Supplier	Product TM	Composition
Boral	Firestop	Gypsum based board (plasterboard)
CSR	Fyrchek	Gypsum based board (plasterboard)
Fire Containment	Maxilite	Calcium Silcate
Firepro	Spiralite	Compressed mineral fibre
Lafarge	Fireshield	Gypsum based board (plasterboard)
Promat	Promatect 100	Calcium Silcate
Promat	Vermiculux	Calcium Silcate

Note: This table is not intended to be exhaustive and other suppliers and materials may be available.

1. Plasterboard is suitable for internal use only
2. Other products may be suitable with external protective coatings
3. Firepro is recommended by the manufacturer as suitable for use in humid, wet or cold climates

7. THIN FILM INTUMESCENT COATINGS

Thin film intumescent coatings, sometimes referred to as 'intumescent paints' are the most recent form of fire-protection materials to be used in Australia. This form of technology has been significantly improved and more suppliers have products available to the Australian market.

Figure 9: Intumescent char insulating layer after fire

Intumescent materials are those which expand to many times their original volume when heated creating an insulation barrier and are widely used in other applications. Examples are intumescent fire collars used for protection of plastic pipes or intumescent sealants used around steel pipes.

Intumescents are coatings which can be applied at relatively low thicknesses when compared to conventional spray applied materials (e.g. 0.5 mm to 5mm dry thickness coating) and can be used to allow expression of the steelwork from an architectural perspective. These materials have a much higher viscosity compared with conventional paints and the application is required by specialist and

approved contractors. The intumescent coating system may require preparation of the steel surface by means of abrasion (e.g. a blasted finish) and application of a primer (or tie coat). The intumescent paint material (known as the basecoat) is applied over the primer and in some cases a decorative and/or protective top coat or top sealer coat may be applied for architectural reasons.

Products are proprietary and therefore the application and performance will vary by brand.

Proprietary formulations can behave differently under fire in the following ways:

- different degrees of stickability (some requiring proprietary primers for example)
- different degrees of expansion
- different thermal heat transfer coefficient of the char materials
- different thicknesses for protection of the same steel section
- different FRL capabilities
- different generic make up (solvent based, water based or epoxy based)

Intumescent coatings are engineered through chemistry for their intended use:

- External or internal
- Applied on site or applied off-site
- Low or high FRLs
- Low budget or premium quality product (pay for what you get)

Figure 10: Intumescent paint being applied in the field

7.2 **Available Materials** (See Note 1.)

Supplier	Product TM	Composition	Durability
Phoenix Fire Protection	Phoenix 167 – Hollow Sections	Water borne	Suitable for internal and external use with Phoenix approved top coats
Phoenix Fire Protection	Phoenix 168 – One hour	Water borne	Suitable for internal and external use with Phoenix approved top coats
Phoenix Fire Protection	Phoenix 270 – Two hour	Water borne	Suitable for internal and external use with Phoenix approved top coats
International Protective Coatings	Interchar 963	Solvent based	Suitable for internal and external use with International approved top coats
Firepro	C608 Fireshield	Water borne	Internal use only
PPG Industries	Steelguard	Solvent based	Suitable for internal and external use with approved top coat
Promat	Cafco WB3	Water borne	Suitable for internal and external use with approved top coat
Resene	Firetex M77	Solvent based	Suitable for internal and external use with approved top coat

Note: This table is not intended to be exhaustive and other suppliers and materials may be available.

1. Grit blasting and priming is required as preparation for intumescent coatings

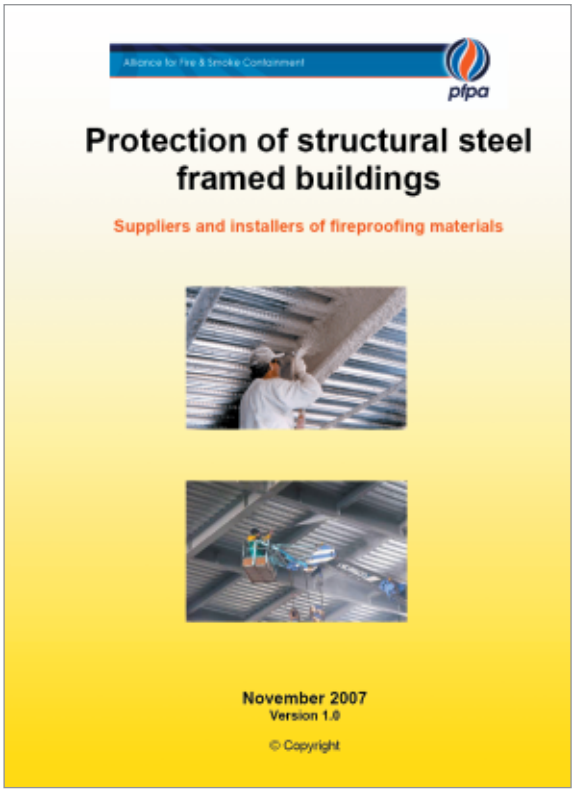
8. SUPPLIERS AND INSTALLERS OF FIRE PROTECTION MATERIALS

Supplier	Phone	Web Site
Boral	02 8280 7133	www.boral.com.au
CSR	1800 621 117	www.gyprock.com.au
Exfoliators (PFP) Aust.	03 9706 6049	www.exfoliatorspfp.com.au
Fire Containment	1300 792 832	www.firecontainment.com.au
Firepro	02 9804 0262	www.firepro.com.au
International Protective Coatings	03 8336 8444	www.international-pc.com
Phoenix Fire Protection	1300 792 832	www.phoenixasia.com.au
PPG Industries	0407 722 744	www.ppgmc.com.au
Promat	1800 30 20 20	www.promat-ap.com
Resene	1800 738 383	www.resene.com.au
Trafalgar Building Products	02 9938 5499	www.trafalgarbp.com.au

The reader is also referred to the PFPA web site for a comprehensive list of local suppliers and installers of fire-protection materials and product guidance.

Please contact the suppliers for performance data on their materials.

Relevant web sites are:
http://www.pfpa.com.au in the structural fire-protection dedicated area and specifically at
http://www.pfpa.com.au/product/steelfire protection.html



9. APPLICATION OF FIRE-PROTECTION MATERIALS

9.1 On site application

Traditionally fire-protection materials have been applied on site to the as constructed steel structure.

This work is usually conducted by manufacturer approved and specialist contractors who have the correct equipment and both training and experience with the fire protection materials typically used.

Figure 11: on site application

9.2 Off site application

With the advent of off site intumescent coatings, some fire-protection of structural steel is applied in the steel fabrication yard, prior to delivery and erection on site. In the UK where FRLs of 60 minutes are common, this has become the preferred means of fire protection but in Australia this practice is limited at present since the Deemed to Satisfy provisions typically require steel members to achieve an FRL of 90 minutes or greater. In most cases in this country an Alternative Solution to reduce the FRLs to this level is required.

Figure 12 and 13: Photos of off site application

10. A GUIDE TO THE DIFFERENT ATTRIBUTES OF FIRE-PROTECTION MATERIALS

The following table compares the attributes of the various generic fire protection materials.

Attribute	Spray	Board	Intumescent Paints		
			Water based	Solvent based	Epoxy based
1 Hr & 2 Hr Protection	✓	✓	✓	✓	✓
$/sqm	Low	High for beams	Low	Low	High
Apply On site	✓	✓	✓	✓	✓
Apply Off site	✗	✗	✓	✓	✓
Aesthetics	Poor	Average	Paint-like	Paint-like	Rippled Paint
Environmental	✓	✓	✓	Solvent issues	✓
Impact resistant	Poor	Poor	Good	Good	Excellent

11. CASE STUDIES

a) Deemed to Satisfy
SCOTS CHURCH Kent St Sydney

Figure 14: Scots Church, Sydney CBD

This Presbyterian Church located in the heart of Sydney was redeveloped as a site for residential development by Westpoint Corporation. The new development extended from the Church at levels 6 to 12b and comprises contemporary two storey lofts. The building was protected by a combination of fire sprayed material and fire rated plasterboard, a solution derived using the Deemed to Satisfy provisions of the BCA.

1. **Basement floor structure over car stacker excavation**

   This structure also supports the ground floor church stratum.
   Structural steel trusses and beams were fire sprayed.

2. **Existing Ground Floor to Level Five**

   The structure comprises steel framed columns and beams with in situ reinforced concrete floor slabs and concrete encased floor beams. Columns were either concrete encased or masonry clad.

Note: in areas where the 'Deemed to Satisfy', provisions were not applicable, fire engineer, De Fire, assessed fire loads and determined the available cover was adequate.

3. **New structure above Level 5**

   Transfer beams (Four in total transferring four columns) at Level Six

   These beams were conventionally fire sprayed because of their structural criticality.

   Building columns (Steel)

   External columns fire sprayed.

   Internal columns achieved their rating by being located within fire isolating party walls.

   Floor beams (Steel)

   Perimeter beams were fire sprayed.

   Primary beams and trusses like the columns are fire isolated between party walls.

   Secondary internal beams being located within the ceiling were fire isolated. A number of special case beams were fire sprayed due to their location.

a) Alternative Solution
LATITUDE EAST at World Square Sydney – Fire Engineered

Figure 15 and 16: Latitude East, Sydney

This ten storey A-grade commercial building in the Sydney CBD was designed to sit atop an existing retail complex. The first new level was built as a transfer deck and from level 13 the structure is composite steel.

Fire engineering was conducted by Norman Disney & Young and supported by OneSteel.

The solution provided required only the primary beams and the main secondary beams joining columns to be fire sprayed and only to an FRL of 60 minutes. The fire engineering solutions also allowed the entire top two levels of the office floors to be completely unprotected steel floor beams.