SC902

Modern Hybrid Intumescent: Revolutionary system pushing for revolutionary change in industry

Today's construction industry is undergoing some of the greatest changes seen in decades. A drive to – often paradoxical requirements of – faster construction, increased emphasis on safety, greater design flexibility and increased profits has seen a change in focus and methodologies employed by engineers, architects and builders alike.

This paper seeks to review the common aspects of the fire rating industry, things often taken for granted and to provide insight on where new thinking and processes are required to maintain commercial competitiveness. Nullifire is tackling the drive to change the passive fire protection sector head on, specifically with the development of the one coat, one application hybrid-intumescent (SC902) for structural steel.

Under section C of the National Construction Code (NCC) – Volume One 2016 [4]: The requirement that constructed buildings must satisfy adequate fire protection for load bearing building elements such as columns, beams and trusses to meet a Fire Resistance Level (FRL).

More often than not, to satisfy the NCC requirements, builders have depended on legacy and outdated Passive Fire Protection (PFP) systems such as sprayed-on Vermiculite and Boarded systems. Repeatedly, builders have assumed that not only are these choices the only options available, but they are also cheap to apply. Anecdotal evidence from builders points to a lower square metre rate for traditional products and guaranteed compliance as selling points– both of which will be investigated in this report.

To estimate materials, builders and construction estimators tend to rely on the m^2 of surface area required to be protected and factoring in a rough cost of materials. However, this basic m^2 rate tends to be easily miscalculated and fails to consider factors such as:

- The susceptibility to damage and the cost of repairs to maintain the required FRL
- The cost of labour application
- The difference in performance of the products
- The structural loads and unique building characteristics that needs to be incorporated into the PFP system.

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The Price of Speed and Efficiency

One benefit of using a more modern and specialized system (SC902) is the added benefits of a more controlled and efficient project environment.

With cost in mind, a faster performing PFP system such as SC902 which can be applied rapidly in one coating, with minimal labour is expected to deliver huge benefits and cost savings over legacy and outdated PFP systems.

With changes in technology and expectations, it is time that those responsible for design and build become more aware of newer technologies which opens new possibilities for construction. These include cleaner, greener and more flexible design solutions in the form of intumescent coatings.

Through this paper we investigate the misinterpretation of the M^2 rate, and take a look at the importance of steel selection in achieving optimal outcomes and design considerations.

Intumescent coatings – char formation

"When advances in skills and technology outpace current practices, it is critical for industry leaders to embrace modernisation, those who are static with new technological challenges are ultimately responsible for the diminishing construction quality over time".

The m^2 Rate Misinterpretation

The constant evolution in technology and methodology within the construction industry is making the use of the m2 rate as a way to estimate become increasingly redundant.

The adoption of the m2 rate historically with regard to the low performance PFP solutions has been popular within the industry. The square metre rate was used to make broad estimates for a required FRL and do not take into account the many design considerations and inherent fire properties of the steel that need to be investigated.

Simply put, the continual existence of the square metre rates indicate that suppliers and industry bodies have failed to educate the broader industry that there are newer ways to adhere to specific design standards and methodical testing. As a result, many tenderers still specify and demand a square metre rate while specifying modern PFP technology such as intumescents.

How Do Intumescent Coatings Work?

An Intumescent coating is a special coating that swells when exposed to fire, thus increasing in volume and decreasing in density.

The charring process forms a thick layer of thermally insulating char that protects the substrate it is applied to.

Intumescent coatings are a modern form of PFP used throughout the world and require approval for use in their installed configurations.

The first Water-borne intumescent coatings were developed by Nullifire in the 1980s with the flagship S707 thin-film intumescent product.

The next step revolution in intumescent technology came in 2013 with the introduction of the world's only hybrid-intumescent: SC902.

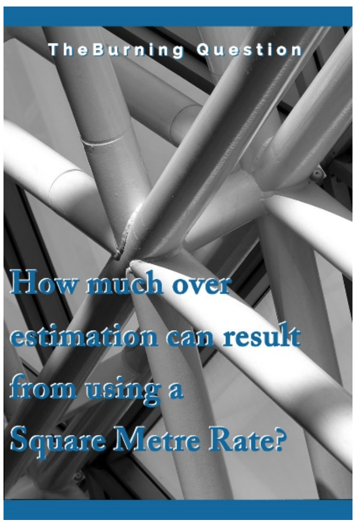
An Optimal, New Solution

To estimate modern passive fire rating product usage, the engagement of the whole design team is necessary to provide an optimal solution.

Modern passive fire rating product usage quantity vary based on the level of fire rating requirement, structural steel member to be protected as well as structural loading and exposure conditions.

As such, a number of information require inclusion for optimal estimation purposes, they are:

- The required FRL (Structural Adequacy / Integrity / Insulation)
- The ratio of the design action on the member under the design load for fire "r_f" used to optimise steel critical temperatures.
- The structural steel size, quantity and lineal metre lengths.



The solution and way forward lies in a closer knit framework for design, by involving fire engineers, structural engineers, certifiers, builders and architects to specify a comprehensive solution which can be shown to save time, cost, prevent delays and ensure that a product is fully certified to perform.

Consider a structural steel PFP project with SC902 Dry Film Thickness (DFTs) ranging from 0.5 to 6 millimetres:

Without an optimised steel schedule, m^2 rate estimates are based on median DFTs and labour cost per m^2 and extrapolated to apply over the entirety of the surface area. In this example, the median DFT is 3.25mm.

What it critically fails to consider is the variable DFTs, if the majority of the steel is sizeable and only requires 0.5mm to 2mm DFTs, the total amount of product used in quantity and labour involved is significantly less. In many real world cases, the amount saved can be as high as 50%.

Additionally, the savings associated will greatly outweigh the estimates based on a m^2 rate. Nullifire Australia has the capability to estimate almost exactly the total amount of product required for any given project, with considerations being made for wastage and onsite repairs.

What is an FRL?

A Fire Rating Level (FRL) is a determination of the fire resistance levels of building elements in minutes during a fire event. FRLs are specified in the Australian Standard, AS3959 for 'Construction of buildings in bushfire-prone areas' and the *Building Code of Australia (BCA)*.

FRLs are used as performance indicators for various building elements and are denoted by three numbers, in order: **Structural Adequacy/Integrity/Insulation**

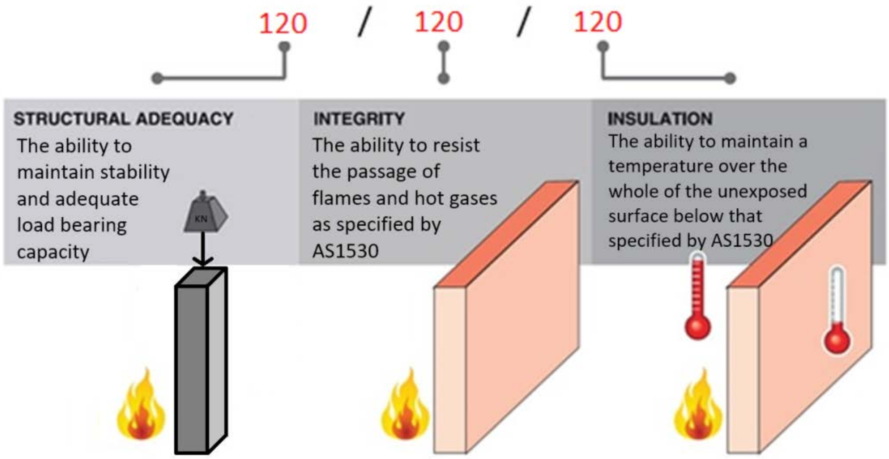
In the example above, the first type number is for **Structural Adequacy**, which is the ability of a load bearing element to support a load when tested in accordance with AS1530.4[2].

The second number is for **Integrity**, the ability of an element of construction to resist the passage of flames and hot gases from one space to another when tested in accordance with AS1530.4.

The final number is for **Insulation**, the ability of an element of construction to maintain a temperature on the surface that is not exposed to the furnace, below the limits specified, when tested in accordance with AS1530.4.

For example, a fire wall that is required to meet an FRL of 120/90/60 means that the wall must maintain structural adequacy for 120 minutes, integrity for 90 minutes and insulation for 60 minutes.

A dash in the FRL (e.g. 120/-/-) means there is no requirement for that criterion.



"Structural steel is only required to meet structural adequacy requirements, the first number. Integrity, the second number, and Insulation, the third number, are not associated with structural elements."

Steel Selection

One key aspect of structural steel fire design that many engineers often overlook or neglect is optimised structural steel selection. Although they may not realise its importance, the size of structural steel and its steel mass contribute hugely to the structural-fire performance of the building and ultimately the product and material costs of the project.

Selecting the correct steel size is essential and should be based on testing evidence which demonstrates the heated perimeter to cross sectional area ratio (HP/A) that can achieve the specified FRL.

The FRL is only achieved once a minimum HP/A level is met, a coating thickness is specified for the type of steel section based on the calculated HP/A. The role of the design engineer is to select steel with the correct HP/A, which governs the heating rate of the steel during a fire event. Generally, a larger, thicker steel member will have a lower HP/A and thus have a lower heating rate than a smaller, thinner steel member. This is important to consider because limitations in available fire testing data will impose a HP/A range limit to vulnerable, thinner steel sizes with high HP/A over 350 which cannot achieve higher FRLs in many circumstances.

As a result, selecting the minimal structural steel size to meet structural loads will not necessarily achieve structural adequacy for fire design. Structural engineers must consult with fire engineers or learn themselves to select steel sizes which do not just meet factored structural compressive loads, but also take into account the load reduction factor during a fire event case, as given in AS1170.1-2012[3].

Unforeseen benefits of selecting the right steel include; ease of application, better coating finishes and less product wastage. Larger steel sections are inherently easier to spray due to their higher flat surface area, thus lowering wastage and resulting in better coating finishes. Smaller steel sections have advantages in steel cost and a lowered carbon footprint, however the smaller sizes create challenges in meeting the required FRL and desired aesthetic finish.

According to the BRANZ FAR 3997 Fire Assessment Report[5], lighter I-section steel with HP/A of 220 or higher will not achieve a two hour FRL. I-sections with relatively high HP/As of 200-219 which are able to achieve the required FRL, do so with a much higher film builds due to their low mass and low surface areas. Using members with HP/As of 200-219 for a two hour FRL is a clear example of a non-optimised solution which will result in higher project costs, and a generally poor aesthetic finish due to the low sectional surface area.

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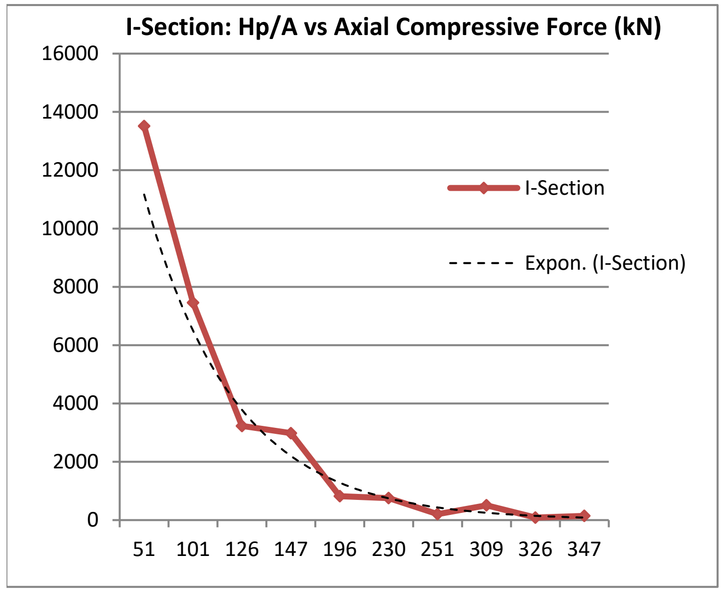
Impending Challenges

Structural steel with properties such as high HP/A should in theory, provide challenges to all types of PFP, where critical steel temperatures and structural load ratios are considered. Behind such an obvious challenge lies a lack of questions and answers in industry due to an outdated 'old faithful' way of thinking. The same critical factors such as optimization, compliance and structural adequacy that applies to modern solutions should also be considered and rethink for traditional passive fire protection solutions.

A new way of thinking will require that older products such as Fire-Sprayed Vermiculite, be subjected to the same rigorous testing as modern products in order to justify a 'square metre rate' methodology. Accountability is one aspect of PFP that has not been examined in detail, and the industry itself with help from legislators and experts to make necessary changes.



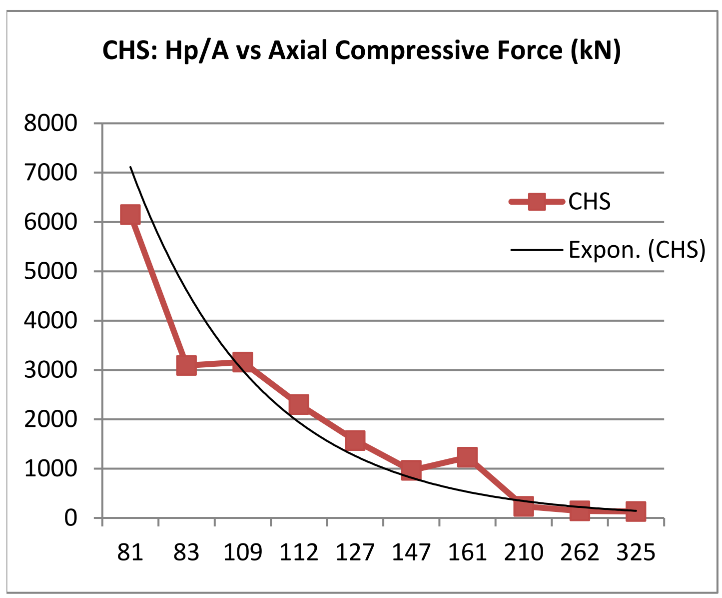
Plot of I-sections with varying Hp/A revealing the loss of load bearing capacity with increasing Hp/A [7]

Professional Engagement

Extensive testing has shown that structural steel with the best adequacy performance in a fire event are non-hollow sections with high steel mass. These include I-sections, PFC Channels and Angles.

Hollow sections tend to perform relatively poorly compared to other sections, especially when selected as beams and bracing members. As columns, hollow sections may require core-filling depending on the specified FRL and member thickness. Builders and designers who request low mass hollow sections in their designs must be wary of 'under designing' as core-filling can be intrusive and costly.

To select the right structural steel, it is important that structural and fire engineers be engaged cooperatively to determine the sectional size, thickness and utilising AS4100-1998 Section [1] for load capacities required to meet the FRL and designed loads. For this reason, Nullifire Australia have utilised our own internal structural engineers and estimators whom engage on a day to day basis with other structural engineers, fire engineers and architects to find the best PFP solution. This cooperative process results in the selection of the most efficient steel sections, and minimise the need to upgrade or core-fill further down the track. Thus minimising unnecessary delays and unexpected costs related to manufacture, labour and transport.



Plot of CHS hollow-sections with varying Hp/A revealing the loss of load bearing capacity with increasing Hp/A [8]

Note: The overall load bearing capacity of CHS and hollow sections in general are much lower than that of I-sections, at all Hp/As.

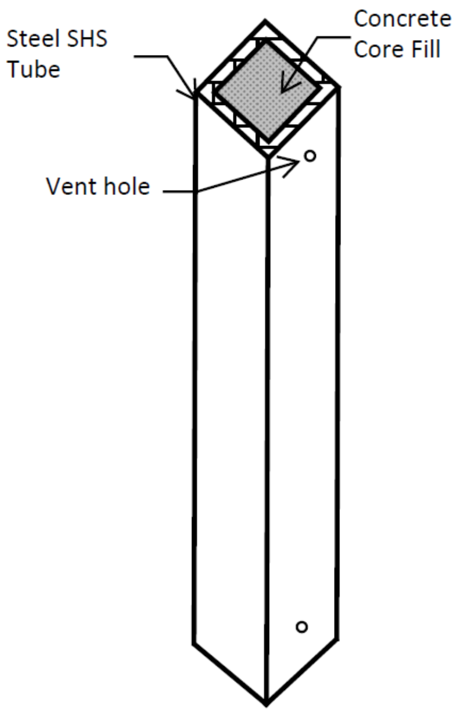
Down to the Core

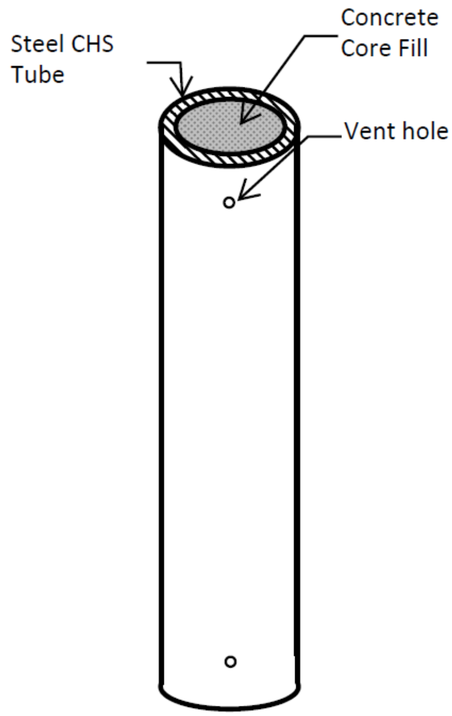
Core-filling is an essential construction practice in the steel PFP process, it is considered as a secondary solution for structural steel members with HP/As too high to achieve the desired FRL. By pouring a concrete or grout mixture with a normal aggregate mix inside the void of structural hollow section columns, the goal is to reduce the effective HP/A of the structural steel section.

The mix serves two purposes; to provide extra load bearing capacity and also act as an effective heat sink. Both of these effects essentially serves to reduce the effective HP/A value of the structural steel element, and thus justifies a significant reduction in required dry film thickness so that certain hollow sections can be used to achieve higher FRLs [6].

Dr Simon Jones, technical director of Nullifire UK recommends that a standard concrete mix, typically less than 40MPa is used as this allows for the easy egress of steam that is formed in the concrete during a fire event. Additionally, steam vents should also be included in the form of small holes at the top of the columns so that steam may escape during a fire event, if blocked this could lead to cracking or explosive results. Similarly, if a very high MPa concrete mix is used, the increased density could trap steam which will expand during a fire event, essentially risking an explosive result. Trivial as this may seem, having a dense mix core-filled column could be detrimental as this could lead to a less effective heat sink.

When in-situ core-filling is required, the mix can be poured by drilling a hole into the top of the column and pouring the mixture through. Alternatively, columns which have not been erected can be accessed and poured from the top, the same process is used in off-site constructions.





Core-Filling maintains structural adequacy and improves fire performance in structural hollow sections

Nullifire Australia's Initiative

Leading intumescent supplier Nullifire Australia has learnt that merely meeting the required HP/A may not give the best outcome in terms of cost, as product usage must also be considered. Designing for a balance between achieving the required loads and exceeding the required HP/A will give the best result of structural adequacy, fire safety and overall project cost.

With the help and expertise of our technical team, Nullifire Australia has the capacity to provide a catered and well-designed solution for all structural steel PFP projects. Nullifire Australia have a developed relationship with third party IANZ accredited assessors BRANZ, Exova Warringtonfire, access to fire laboratories in the United Kingdom, Australia, New Zealand and the technical collaboration with University of Queensland and Victoria University.

We ensure compliance with all of our product certifications, test and assessments to the National Construction Code and relevant Australian Standards including AS4100-1998 and AS1530.4-2005 for structural steel PFP. In all cases, where performance based solutions are required, we undertake project specific and member specific designs together with fire engineers, structural engineers and our corporate partners. Our team has the capacity to optimise project outcomes based on the structural and fire information supplied. Our combined service aims to reduce overall project cost, prevent delays and streamline the application, delivery and erection process for onsite and offsite projects.

Working with a leading product, the Nullifire hybrid SC902 intumescent, our aim is to provide the ultimate solution to the cost of product, optimisation of steel selection and fire performance to guarantee the best possible project delivery.

References

ł - AS4100-1998 – Steel Structures [1]

ł - AS1530.4-2005 – Methods of Fire Tests [2]

ł - AS1170.1-2002 – Structural Design Actions [3]

ł - National Construction Code (NCC) Volume 1 – 2016 [4]

ł - BRANZ FAR 3996 – SC902 I-Section Fire Assessment Report [5]

ł - Exova Warringtonfire – WF Report No: 364408 "Assessment of the ability of an Intumescent Coating known as Nullifire SC901 and SC902 to Protect Concrete Filled Hollow Steel Columns in Accordance with the Method Defined in EN13381-6:2012." [6]

ł - Australian Steel Institute (ASI) – Design Capacity Tables for Structural Steel, Vol.2: Hollow Sections [7]

ł - Australian Steel Institute (ASI) – Design Capacity Tables for Structural Steel, Vol.1: Open Sections [8]

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