

# Delivering structural fire protection to live projects: a supplier's perspective

**Bob Glendenning, global fire engineering manager at Sherwin-Williams and IFE Fire Resistance SIG member, offers some insight into the challenges that the design process can bring**

**H**aving worked in the steel construction industry for a well-known UK steel fabricator, plus a design consulting engineer for a combined 20 years before joining the fire protection industry, I would hope to have good experience and knowledge of the “supply chain” in the construction industry. Having worked on projects where specialist fire consulting engineers are employed, I have also been involved in some key projects where this has not been the case and it often falls upon the expertise of the protection manufacturer to bring more detailed knowledge to the project.

In recent years, and particularly over the past five to ten years, the UK steel construction industry for medium and high rise buildings has evolved rapidly. It is now commonplace to see long span construction, with fewer columns, coupled with down-stand cellular beam construction to incorporate services through floor beams, rather than below as was the norm some years ago. This construction style also brings further advantages: more “lettable” floor area, future proofed spaces, lines of uninterrupted view, faster construction, reduced floor zone depths, allowing lower building height and reduced cost or more available floors being some of the most obvious. This evolution also coincided with a huge upturn in the use of intumescent coatings, in particular also, coatings being applied away from the construction site, often in the steel fabricator’s paint shop. This has brought further advantages, such as single source of supply, removal of on-site health and safety issues, steelwork built ready fire protected (in case of construction fire) and improved quality due to better application conditions.

This rapid change, however, brought a significant challenge – how to design coating thicknesses capable of withstanding complex beam forces that



present in cell beams in the event of fire. These beams have to be carefully considered in fire due to potential web instability at the fire limit state, something that we often find consulting engineers (without fire expertise) can struggle to understand properly. Indeed, we have also experienced challenges with some advanced fire engineering solutions that have failed to fully consider such issues within advanced computational models, such as finite element analysis.

It remains a real industry challenge in my view for the steel design community. As an ex practicing steel designer myself I find it is most often the case that structural engineers have little or no training in the concept and understanding of fire. Most consulting engineers are, to be fair, employed to design only to ambient conditions, often under pressure to deliver the lightest main frame designs. It is often the case from a steel fabricator’s perspective that the lightest structure is not necessarily the most cost effective. However, if you then add the fire design to this equation then the cost can rise exponentially. More experienced steel fabricators will look towards optimising the cost of both elements. This can, however, be very challenging if the consulting engineer cannot or will not engage with them.

The worrying aspect here is that it could be the case that design for the fire limit state requires a more “robust” approach to achieve the desired fire solution. If the fabricator cannot recover the additional costs of such additions (reinforcement and/or heavier steel members often being a possibility) then this could be omitted from the supply. The bigger challenge then might be that the frame is erected without these modifications, particularly where the fire protection design was not included in the fabricator’s package. It is conceivable then that this fire requirement is missed altogether, resulting in a potentially dangerous solution.



Had these omissions been a result of a performance based fire engineering solution it could be more worrying still as the supply chain may well have the conception that all was well having invested in an advanced solution to deliver fire safety.

When considering a fire engineering solution that does contain cellular beams, I am of the opinion that the fire consultant ought to consider some key points. First of all, the web stability ought to be carefully considered in the finite element modelling. Intumescent paint products are specifically tested for this scenario and modern products will have furnace test results that capture the performance of the product in relation to how efficient the product is at keeping the web post temperature as low as possible. These tests are “product specific” and vary even from a single manufacturer, from one product to the next. Therefore, the manufacturer ought to become a part of the design process so as to best advise on the most appropriate products and how their performance can be incorporated robustly in any analyses.

There are many factors to consider and a reputable manufacturer will nowadays have sophisticated analysis software to help advise early in the project design life – the earlier the better. It is only at this early stage in a project’s design life that manufacturers have the opportunity to influence the

design considerations; beyond this it can be too late. As well as cellular beams, very thin walled hollow sections and very lightweight steel profiles can be particularly vulnerable for either high cost or, in the worst case no protection offer being available. Often these are simple fixes but to leave this too late is folly.

I would point out though that the practice of simply assuming design output (for example, assuming a fixed, low value of ambient strength utilisation) is also a risk-filled approach that should be questioned vigorously. To simply assume a value to gain a competitive advantage or solve a challenge is not engineering, it is potentially risking life and property safety which is unacceptable. As a manufacturer we are often faced with trying to make solutions work where such consideration has not been given, often then faced with a fire strategy report that quotes “generic” beam temperatures that have been developed from the FE modelling. These reports are often lacking in information that allows us to fully understand what has been considered. For example, are these beam temperatures based upon the whole “average” section or has an elemental approach been used whereby such a temperature has been derived for the web or bottom flange?

Modern intumescent products are tested up to the point of maximum beam deflection in the test

furnace and the data generated is both elemental as well as of a multi-temperature “thermal map” format. As such, the FE results, based purely on beam temperature, need to be specific in order for the manufacturer to determine the correct coating thickness to adequately protect the beam.

Another common consideration that can often be missed is the design of the beam’s top flange temperature to adequately account for the decking solution in the case of composite construction. The design for the fire condition of a cellular beam must consider, as does the ambient condition, such factors as restraint, applied floor loading, floor slab construction and so on. Often the manufacturer is faced with designing the coating without such knowledge and is then forced to make assumptions, normally on a highly conservative basis. This is even more critical for cellular beam designs where a “prescriptive” limiting beam temperature cannot be applied.

Where the floor construction includes for an open trapezoidal metal deck, the top flange temperature will increase due to the open void. This must be handled properly otherwise the perceived conservatism may in fact not exist. In extreme cases this could lead to the beam protection being un-conservative.

Finally, the fire engineering solution must also carefully consider the connecting areas of fire protected and unprotected steel members. Where a structural fire engineering strategy makes use of tensile membrane action and, therefore, has unprotected intermediate beams, particularly where the primary beams are cellular, the connections between these members cannot and should not simply be ignored. Advice given in early fire engineering design guides (most as a result of the Cardington fire testing) did not at that time consider beams to have web penetrations as they were neither popular nor common. Indeed the Cardington tests did not include any such beams and some FE modelling tools therefore do not fully allow for such factors. Care should be taken and the manufacturer concerned should always be consulted.

It is my opinion that fire engineering solutions offer much value in terms of enhanced safety, putting the fire protection where it is specifically required and that such solutions offer beneficial commercial options. However, in our experience such solutions must be handled properly and structural engineers as well as fire engineers need to proceed with clarity and caution and work closely with the supplier of the fire protection. It would be of further benefit to the supply chain as well as building management if any assumptions made during design is clearly documented and passed on.

I also believe that it is high time we took the opportunity to better educate our forthcoming graduate engineers about fire and fire design. Use and knowledge of ambient design output can greatly enhance the efficiency and practicality of using intumescent paints, lowering not only applied cost but also the cost of repairing damaged coatings.

Fire safe buildings are a societal expectation. They cannot be realised in an environment where the steel frame design is developed without any consideration of the potential impact of fire. Greater frequency of working in the interface between fire and structural engineering is necessary to ensure that we continue to deliver safe, cost effective and sustainable buildings. Indeed, I recommend that the fire design professionals work closely with the manufacturer as early in the project life as is practicable.

I have long held the belief that all the really great advancement that the UK fire design community has gained can be undone when it reaches the final stage of practical application of fire protection. Such has been the concern that a new working group has been developed, aimed at bettering understanding and highlighting the consequences of these advanced solutions falling short of their intended outcome. This group is currently known as the Steel Structures Group and has assembled a team of representatives from across the supply chain. This includes Sherwin Williams, the IFE, structural fire engineers from private practice(s), building control, the Association for Specialist Fire Protection, Greater Manchester Fire and Rescue Service, as well as a property insurer. More disciplines have also been invited including representatives from the architectural and insurance communities.

We aim to produce guidance to help enhance knowledge and educate the supply chain to improve building design as well as fire safety in steel structures. Ultimately, the aim is to ensure a good, robust fire engineered solution is delivered exactly as it was intended.

The Steel Structures Group welcomes interested and enthusiastic organisations who they feel could bring relevance and contribution to the group. The group will meet two or three times a year at Manchester offices, but this could change if the group grows. If anyone wishes to become involved please contact: Bob Glendenning, Global Fire Engineering Manager, Fire Engineering and Estimation Team, Sherwin-Williams Protective & Marine Coatings, Tower Works, Kestor Street, Bolton BL2 2AL UK. Mob +44 (0) 7817 016763; Tel +44 (0) 1204 556423; Fax +44 (0) 1204 381826; Email [bob.glendenning@sherwin.com](mailto:bob.glendenning@sherwin.com); Web <http://www.sherwin-williams.com/protectiveEMEA> 