melting moments

Structural steel needs no introduction as a reasonably cheap, plentiful building element with an excellent strength to weight ratio. Its strength comes down to its chemistry and the ionic bonding of adjacent atoms in and between the steel crystals.

So far, so good - however a few quirks appear when steel is exposed to heat. At first it is not too problematical. The atoms in the steel pick up a little more energy from the heat and begin to 'jiggle' a bit. Just like a dancer on a dance floor, as the tempo increases, the dancers need a bit more room to move in. To accommodate these more energetic atoms, the steel expands in size, which can lead to distortion problems such as buckling of railway tracks in a heat wave.

As the temperature increases further, the increasing separation of the atoms leads to reductions in the ionic bonding and a consequent loss of strength. By the time it reaches 450ºC it has lost 10% of its strength with a further 100ºC rise making it go really weak at the knees, losing 40%. Such a loss significantly affects its ability to fulfill its design purpose and by the time the temperature hits 800ºC, it is completely useless as a load bearer, having lost 90% of its initial strength.

Such was the horrific Twin Towers scenario.

In order to improve the load bearing capacity of steel in a fire (referred to as 'Structural Adequacy' in AS1530 part 4:2005) and hence the time for escape or intervention, the steel needs to be protected from the heat; invariably by insulation.

Three regimes are typically used: total enclosure with poured concrete; application of hydraulically setting, insulating plasters in relatively thick (15-50 mm) layers or thin layers of intumescent paints - it will come as no surprise to the reader that it is the latter on which I will focus!

It is my opinion that intumescent paints are the crowning achievement of the paint chemist's art. The concept is this - combine a series of disparate chemicals into a binder, which can be applied to a substrate, and then lie dormant for years, only to spring to life when called upon by the rising temperatures resulting from a fire.

Firstly, the binder starts to melt; not so much that it starts running off the surface and not so little that it is unable to perform its next task. A very few further degrees increase and the latent chemical factory bound within the film is shaken out of its torpor, triggering a cascade of chemical reactions that eventually results in the production of a large amount of gas - mainly nitrogen and carbon dioxide.

The binder has now melted to the degree that the released gas will create a stable uniform foam within the molten binder, expanding the volume of the original film many times until it's ready for the final trick. The binder 'honeycomb' burns in a controlled manner leaving a stable, thick insulating char, which is the designed, protective goal of the paint.

Such products are extremely sensitive to formulation where even trivial variations in raw materials can have significant downstream effects. Naturally, they have to be made under the aegis of an appropriate product quality system able to produce certification for the compliance of each and every batch to the standard to which it has been approved.

The stringency does not end there - the appropriate specifications of these paints is a discipline unto itself. Steel has some 'heat sink' properties of its own, depending on its total bulk and the ratio of its cross-sectional area to its surface area. Calculation of these parameters, along with the desired time to retain structural adequacy is necessary in order to determine

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the required film thickness and hence spreading rates.

Any primer must be specified with a knowledge of the substrate requirements along with the all important knowledge of whether the molten matrix of the intumescent will continue to wet the primer surface and not 'crawl' or slump.

Finally, the type and amount of any protective topcoat must be chosen so as not to impede the expansion of the developing foam. Clearly, the correct specification of these products is a job for experts.

The next step towards successful protection is to ensure that the application is done in an accurate and conscientious manner. Only applicators with an 'in house' quality system need apply!

The final step is to supply the building owner and/or manager accurate documentation describing the protection system that they have got; what maintenance is required; advice as to how to rectify damage and advice as to the appropriateness of any subsequent cosmetic coats that may be desired for whatever reason.

If all of the above sounds complex, serious and exacting - I guess you are right.

As the final onus falls onto the specifier, every single step of the process, and every piece of documentation must be absolutely trustworthy, for it really is a matter of life and death.

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