MMI Engineering

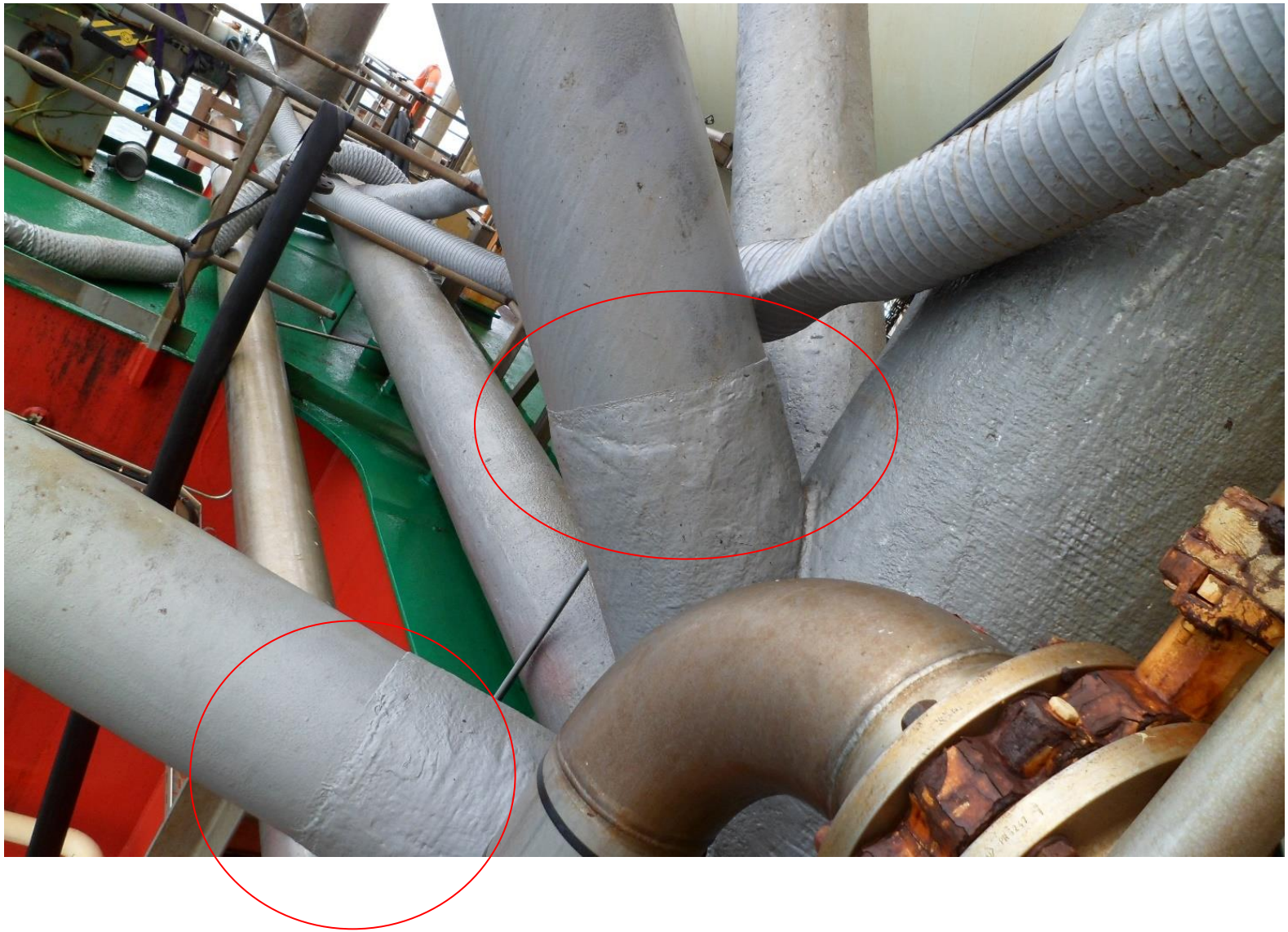
Coatback: Does Size Matter?

Authors: Ruirui Sun / Graham Boaler
Date: 3rd December 2015
www.mmiengineering.com

Agenda

- Background for coat-back requirement
- The mechanism for the coatback
- Purpose of coatback and acceptance criteria
- Factors affecting the coatback length
- Uniform thickness solution
- Other issues
- Conclusion


23/10/2013 14:00



Background for Coatback Requirement

- Coatback ‘rules’ lost in the mists of time
- Historical origins with ships – late 1960’s and based on calculation and verified by testing
- Based on deck and bulkhead not structural steel
- Has been a multitude of coatback lengths over the years
  - 12” (300mm), 15” (380mm), 20” (500mm) and 450mm (18”)
- SOLAS adopted 450mm many years ago – unsure of date
- Offshore adopted 450mm rule – difficult to find supporting data

Background for Coatback Requirement

- Coatback rules most frequently used:
  - Coat-back length along secondary = 450mm
  - PFP on secondary at same thickness as primary
- Minimum size of secondary requiring coatback is variously stated as:
  - 1000mm^2 (Norsok S-001); 3000mm^2 (manufacturer and FABIG TN13)

Typical Coatback detail FABIG TN13

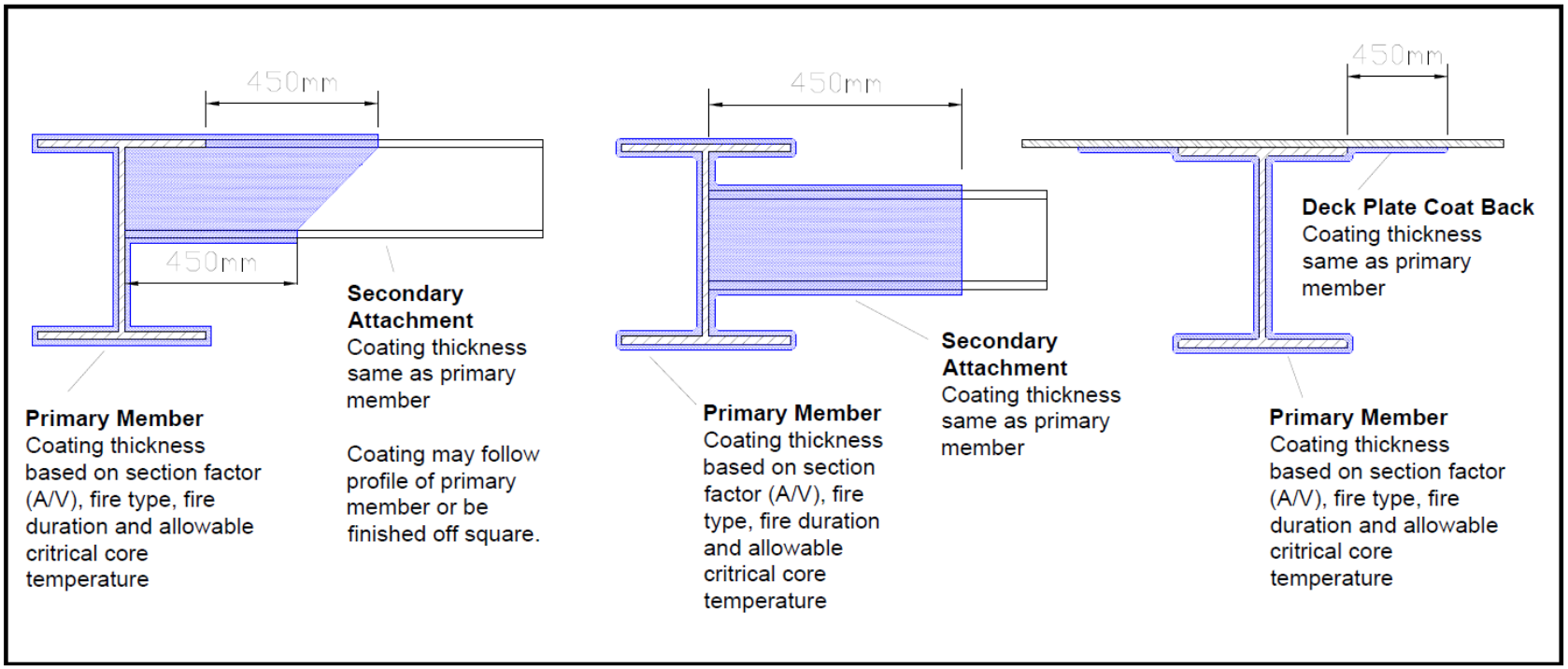
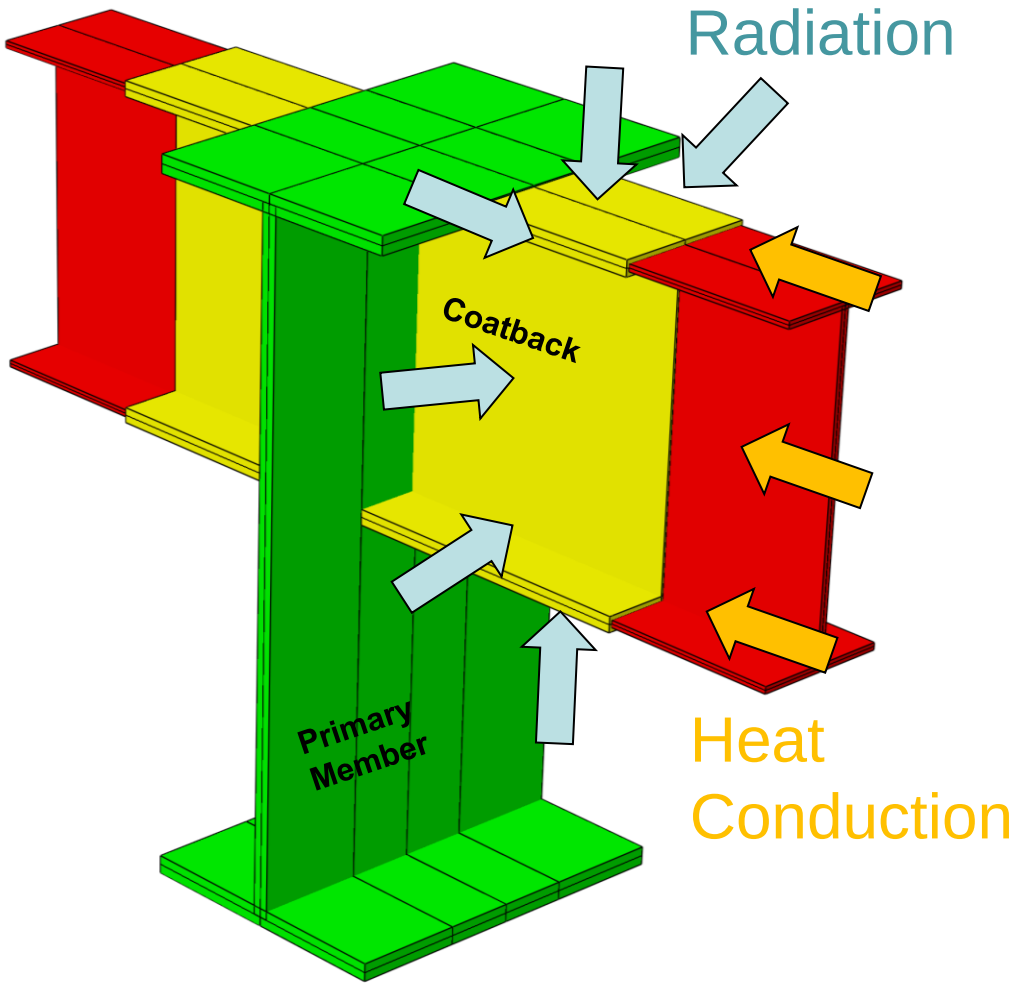


Figure 6.1 Typical coatback details

- A number of studies have been carried out that indicate that 450mm may be conservative.

Mechanism and Purpose of Coatback

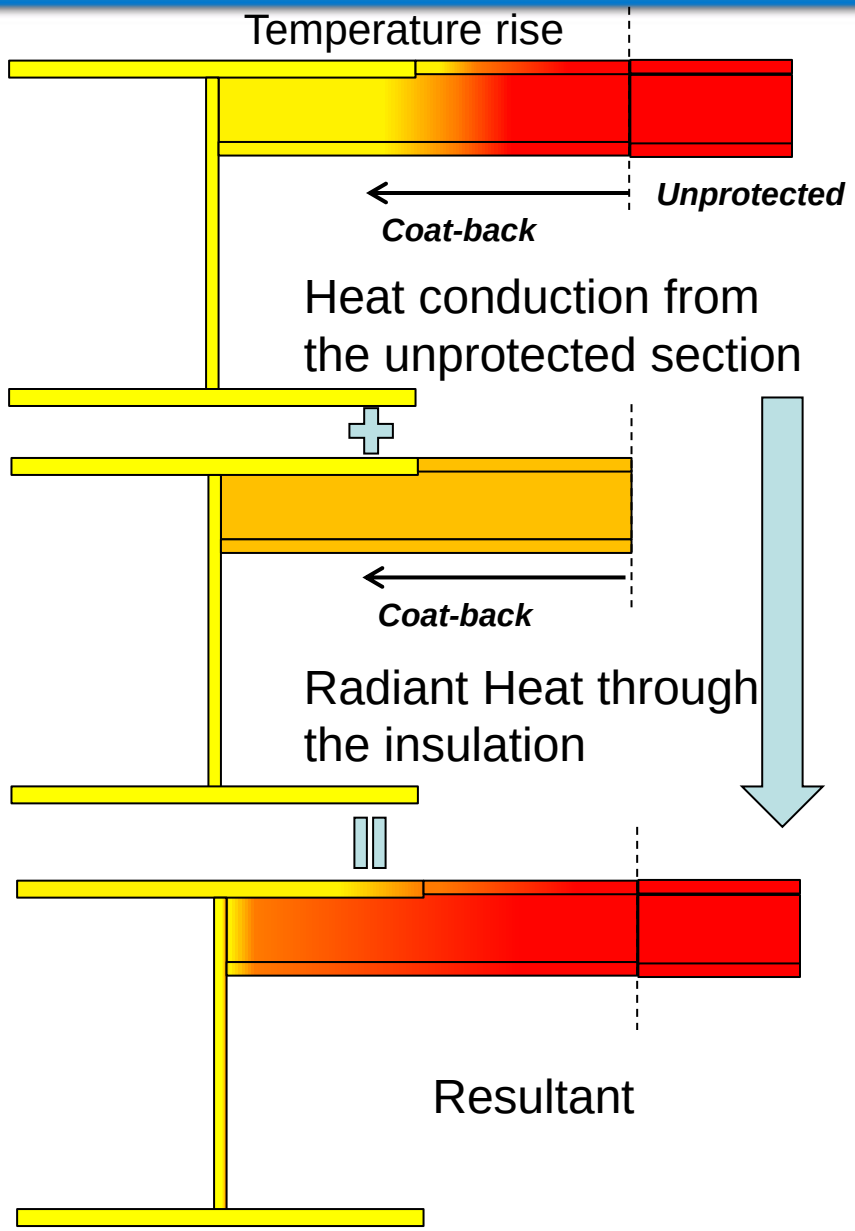


Coatback insulation from PFP to slow down the heat-up of the attachment;

Radiant heat and heat conduction from the unprotected section induce the heat up of the protected attachment;

The temperature difference between the section with coatback and the primary structure drives the heat conduction towards the primary member creating a hot spot.

Mechanism and Purpose of Coatback



Temperature rise
due to heat conduction decreases as coatback length increases;

Temperature rise due to the radiant heat from the fire decreases as the PFP thickness for coatback increases.

Minimise the temperature difference between the attachment and primary member

Mechanism and Purpose of Coatback

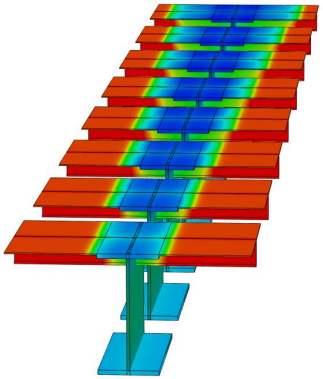
Purpose of the coatback:
Coatback is the extension of the PFP coating from the protected primary members along secondary, tertiary members or plate to **limit local heating of the protected member** at the attachment point and hence **reduce the potential of premature failure**.

The heat conduction between attachment and the primary member is driven by the temperature differences, which is attributed to (1) **radiant heat up through the coatback** and (2**)** **heat conduction from the unprotected section**. The coatback need to compensate both effects.

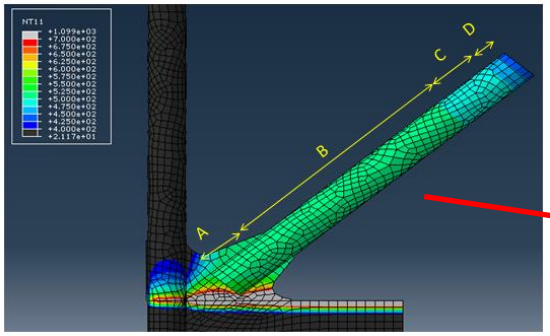
How to optimise

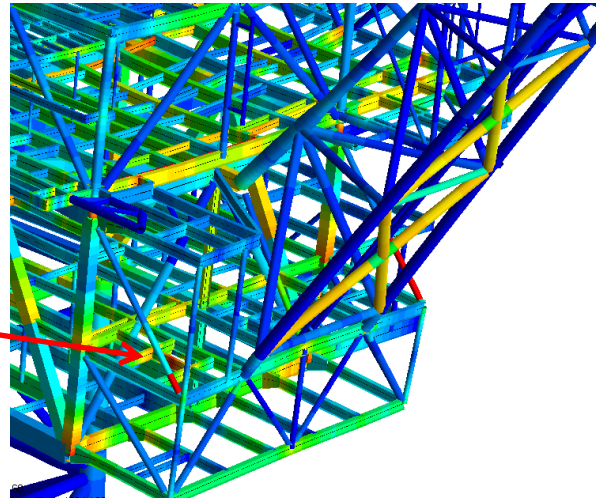
- **Testing** e.g. Tests done by Norwegian University of Science and Technology and SINTEF

- **Thermal analysis**



- **Thermal and Mechanical analysis**





Acceptance criteria for optimisation

Common Practice Critical Core Temperature

-- typically 400°C for structural steel in offshore industry;

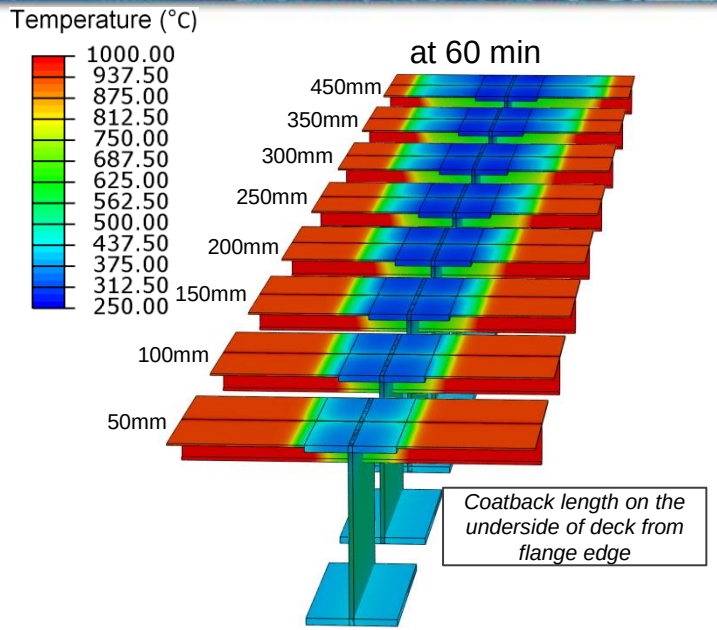
-- Higher CCTs may be considered for lower utilisation.

However, attention should be given to the long-term validity of these higher CCTs as frequent load modification during the service life due to platform and process modifications could lead to larger loading on members than was identified at the time of PFP specification.

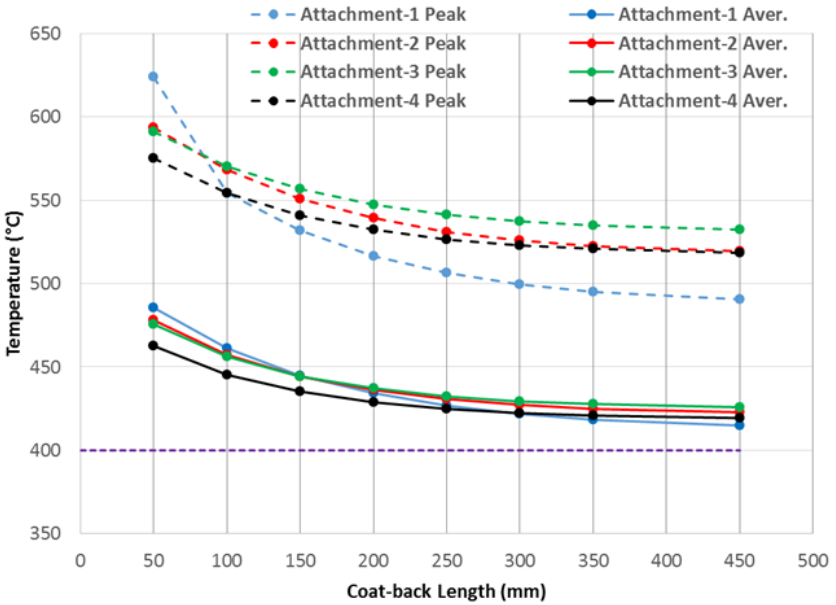
Factors affecting the coatback length

Hp/A Ratio ($\frac{Attachment\ Hp/A}{Primary\ Hp/A}$)

Primary Member	Hp/A	Section Area (mm^2)	Attachment Section	Attach. Hp/A	Attachment Section Area (mm^2)	Hp/A Ratio
IG1000x 400x16x 20	101	313.6	1. UB457x191x89	131	114	1.29
			2. UB406x178x60	175	76.5	1.73
			3. UB406x140x46	211	58.6	2.08
			4. UB254x102x28	228	36.1	2.25



Same Thickness as Primary Member



- Temperature reduces as the coatback length increases;
- No clear trend indicating the effect of Hp/A ratio on the coatback requirement;

This is because of the mix effects of the **radiant heat rate** **of the coatback section** and the **heat conduction** **from the unprotected section**.

Thickness

Length

Section Area

Factors affecting the coatback length

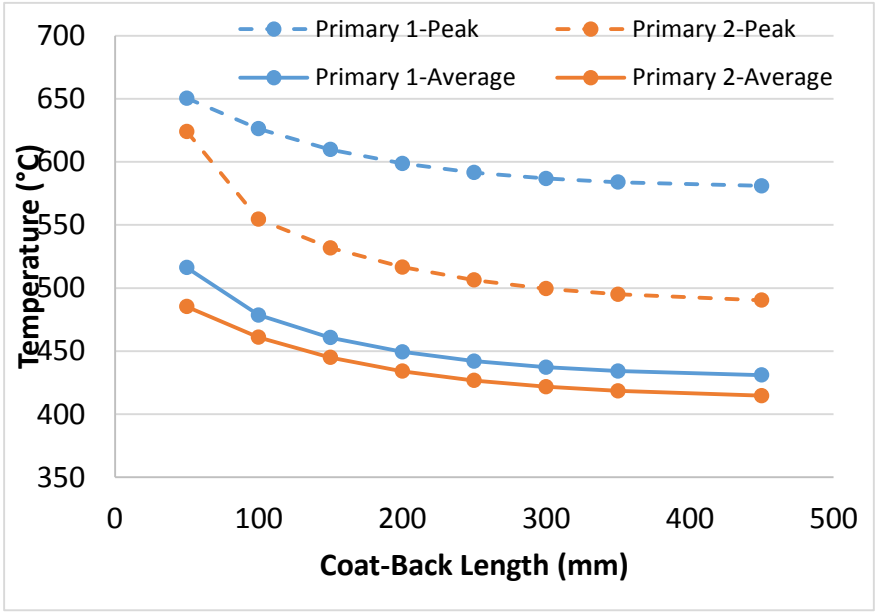
Hp/A Ratio $\left(\frac{Attachment\ Hp/A}{Primary\ Hp/A}\right)$

Primary Member	Hp/A	Section Area (mm^2)	Attachment	Attach. Hp/A	Attachment Section Area (mm^2)	Hp/A Ratio
1.IG600x380 x16x30	73	314.4	UB457x191x89	131	114	1.79
2.IG1000x 400x16x20	101	313.6				1.29

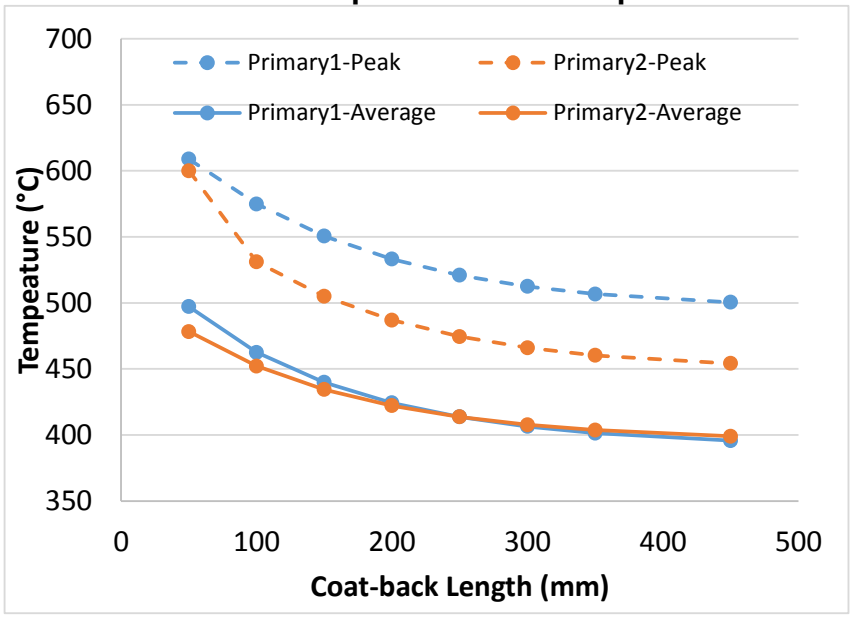
Similar section area

Primary sections have different Hp/A ratio but the same Section Area ratio.

Same Thickness as Primary Member

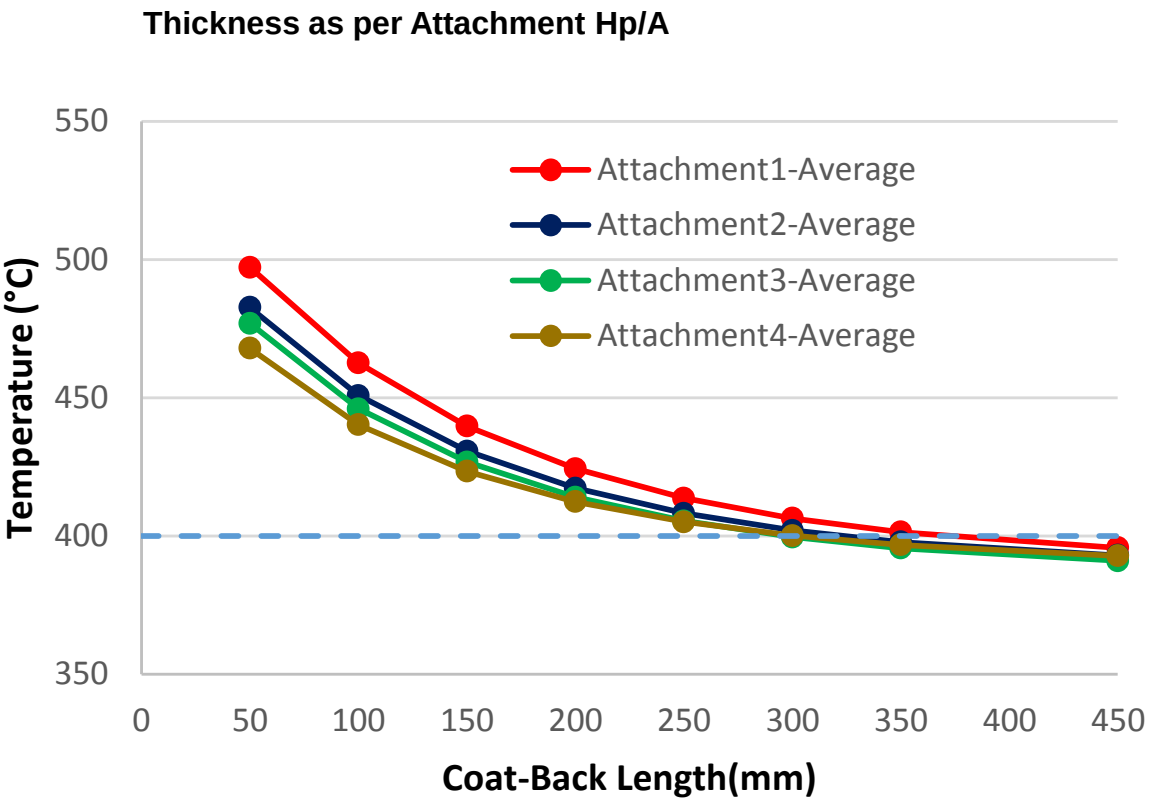


Thickness as per Attachment Hp/A



Factors affecting the coatback length

Section Area Ratio ($\frac{Attachment\ Section\ Area}{Primary\ Section\ Area}$)



Heat conduction equation

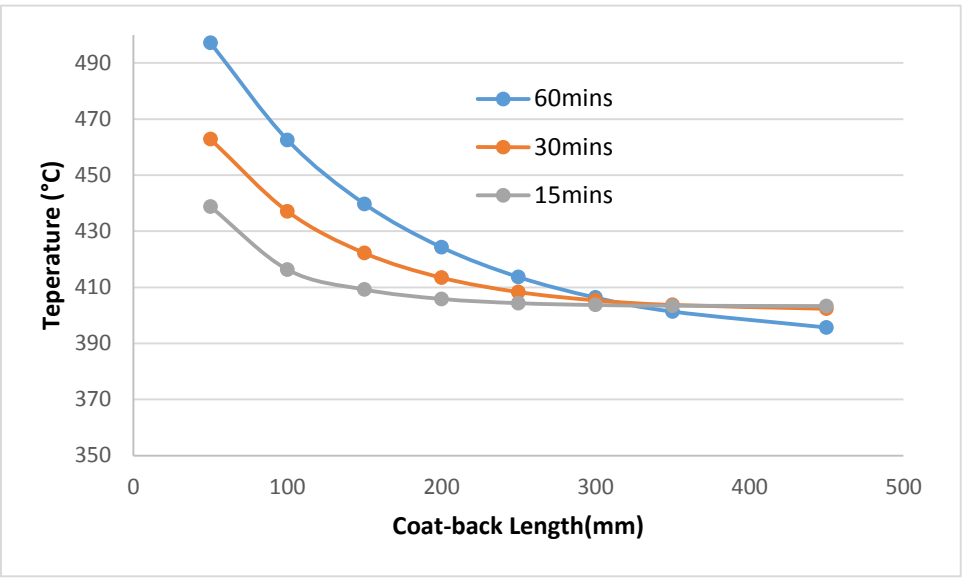
$$\dot{q} = \frac{kA(T_{Hot} - T_{Cold})}{L}$$

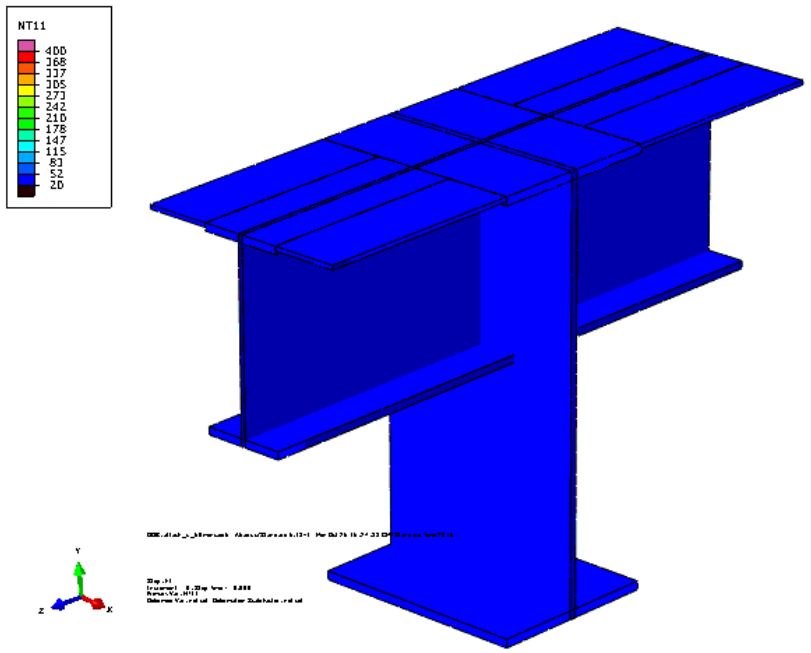
If the thickness as per the attachment Hp/A is used;

- Average temperature in the primary temperature can be controlled below 400°C;
- Higher section area ratio gave higher temperature for certain coatback length;
- The curves converge indicating the effect of section area is weakening as the coatback length is increasing.

Factors affecting the coatback length

Fire duration

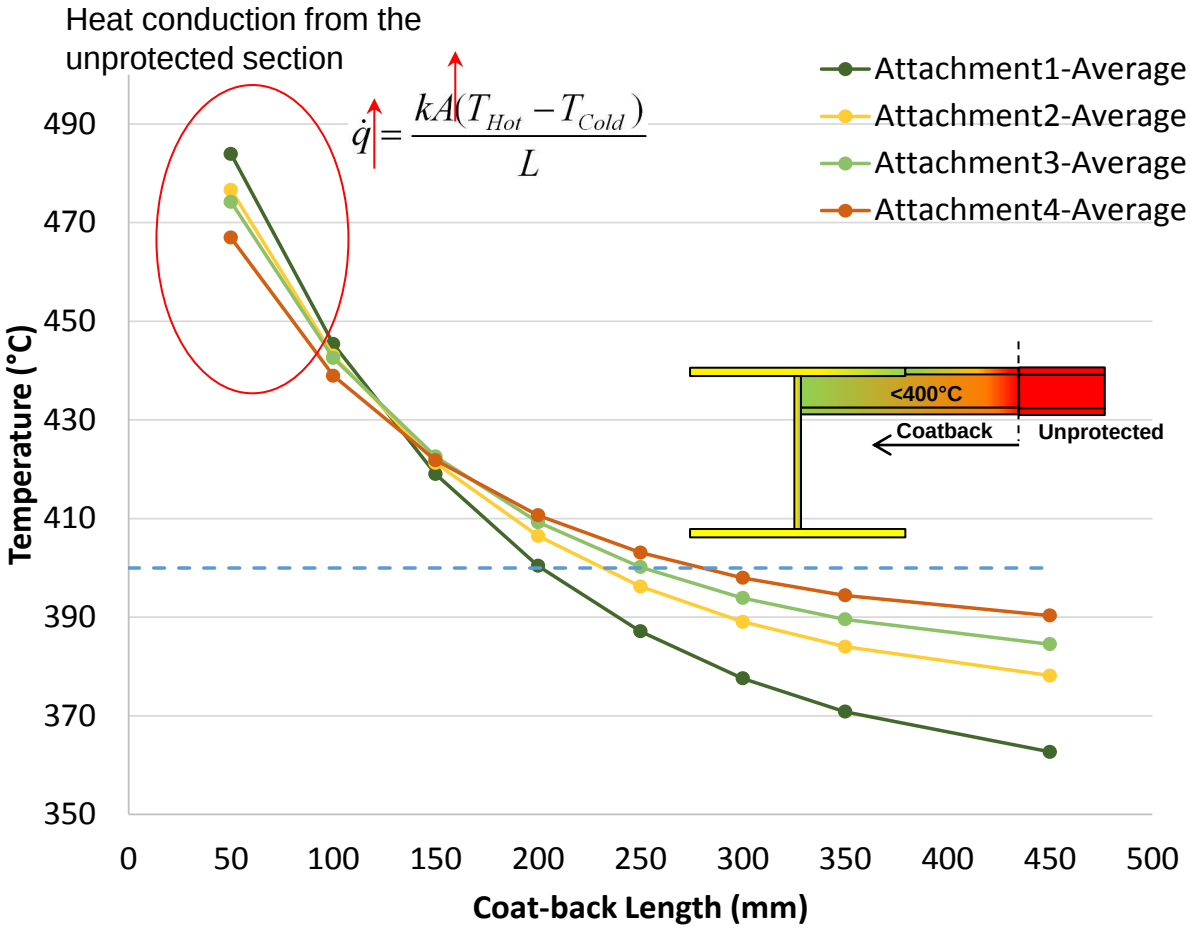




- Longer duration requires more coatback to achieve same CCT in the primary structure;
- With proper thickness applied to coatback, the coat back length is dominated by the heat conduction from the unprotected attachment section to the primary member;

Uniform Thickness Approach

- Applying the different thickness for different attachment might not be practical;
- Uniform thickness approach for all the coatbacks is preferable from the applicator's point of view as it simplifies application and inspection;
- Thickness as per a high Hp/A (e.g. 250) can be applied as uniform coatback thickness;



Cost Saving

Increasing the thickness of the coat-back can significantly reduce the required coatback length and more importantly can guarantee the control of the temperature rise in the primary structure.

Note the industry standard approach may not satisfy this criteria

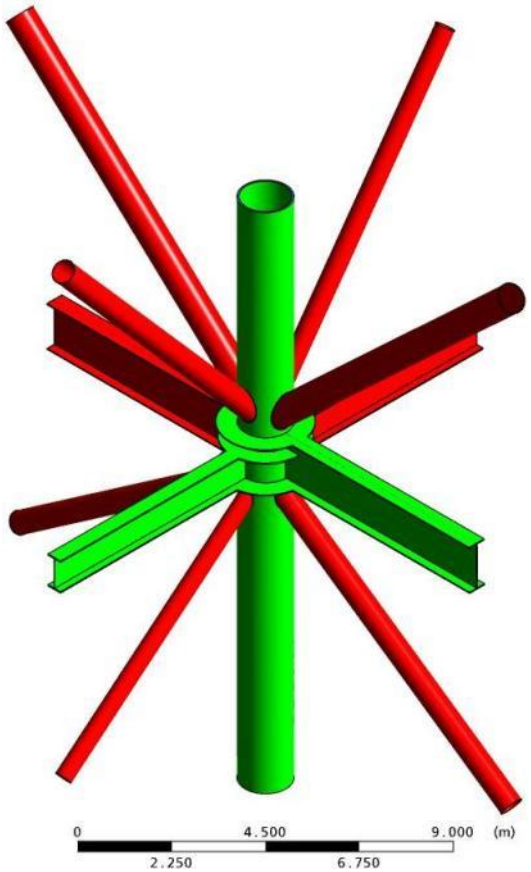
Primary section	Secondary section	Industry Standard			Criteria	Optimised Coat-back (Hp/A of 250)			Weight Saving
		Length (mm)	DFT (mm)	Mass (kg)		Length (mm)	DFT (mm)	Mass (kg)	
IG1000x 400x16x 20	457x191x89	450	6.7	4.46	400 °C	200	8.9	2.63	41%
	406x178x60	450	6.7	4.01	400 °C	250	8.9	2.96	26%
	406x140x46	450	6.7	3.67	400 °C	250	8.9	2.71	26%
	254x102x28	450	6.7	2.45	400 °C	300	8.9	2.17	11%

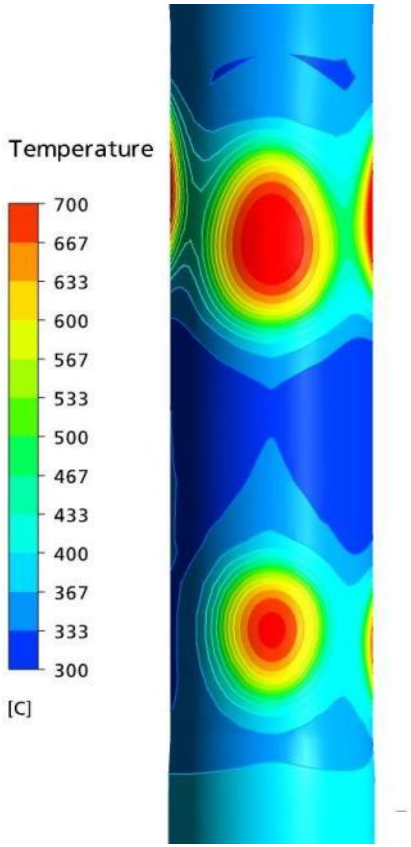
Primary section	Secondary section	Industry Standard			Criteria	Optimised Coat-back (Hp/A of 250)			Weight Saving
		Length (mm)	DFT (mm)	Mass (kg)		Length (mm)	DFT (mm)	Mass (kg)	
IG1000x 400x16x 20	457x191x89	450	6.7	4.46	450 °C	100	8.9	1.32	71%

Other Issues

Geometry

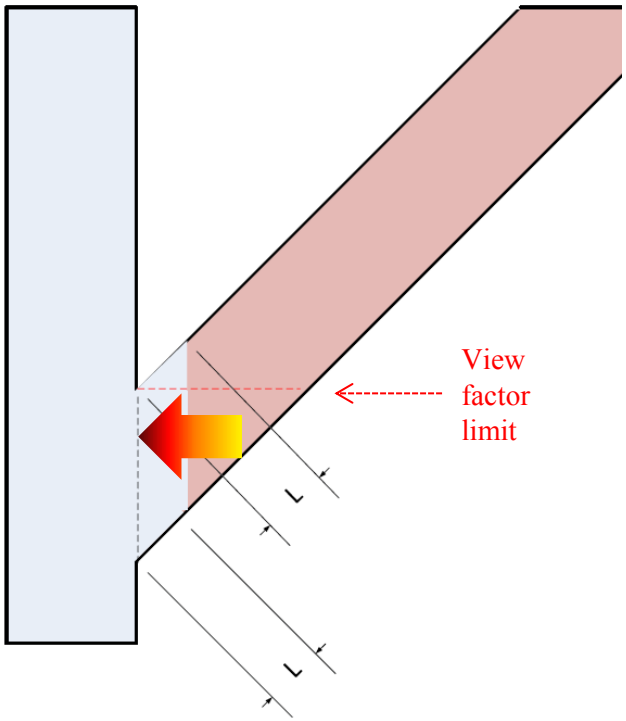
3D model of node with Primary PFP'd members in green and un-coated members being assessed for coatback in red.



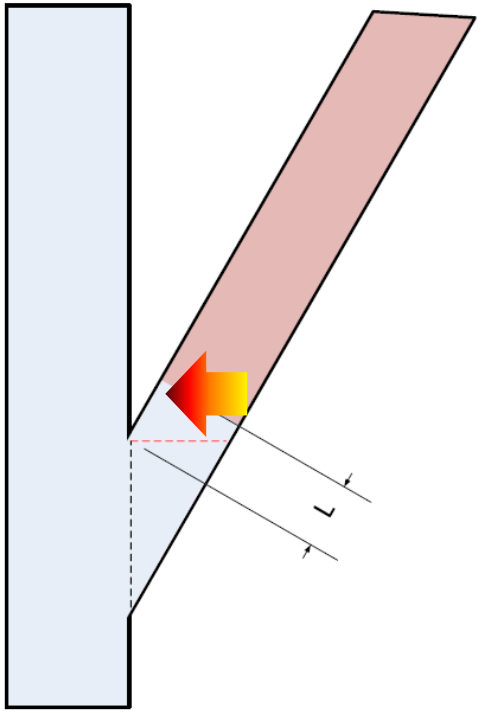


Internal temperatures on Primary column at the end of a 60 minute fire due to internal radiation.

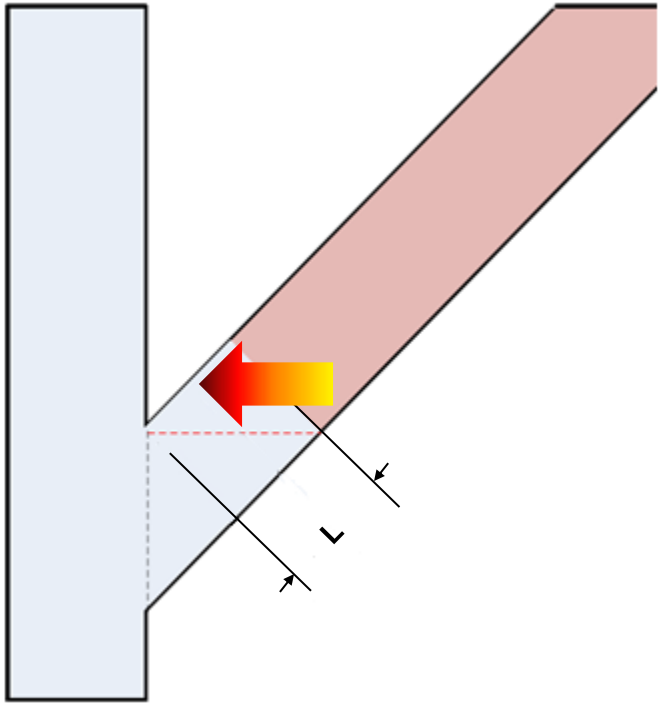
Other Issues



Radiation Impinges Primary



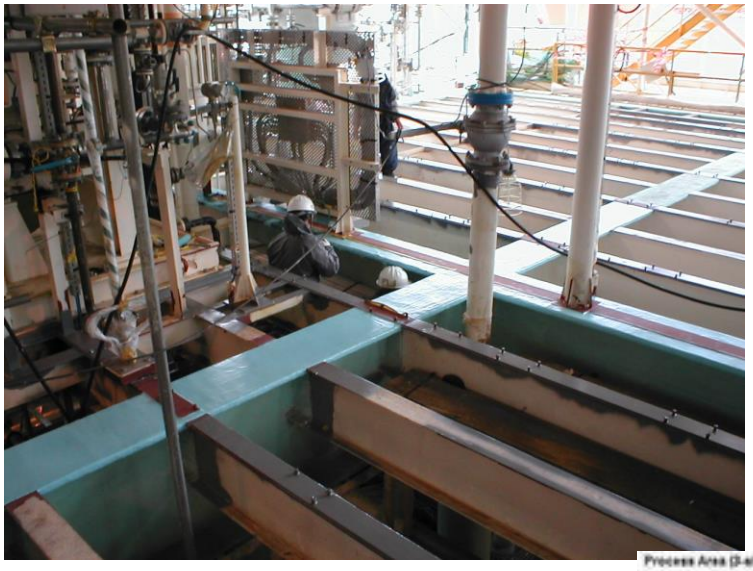
Minimum Coatback
Prevents Radiation

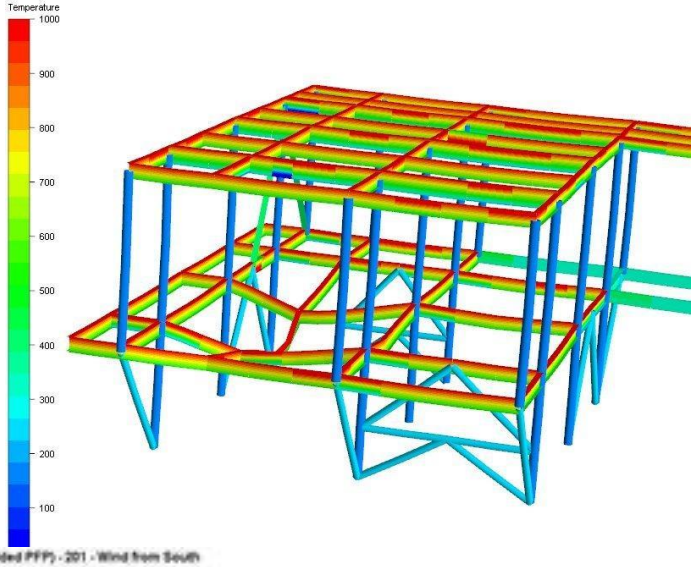


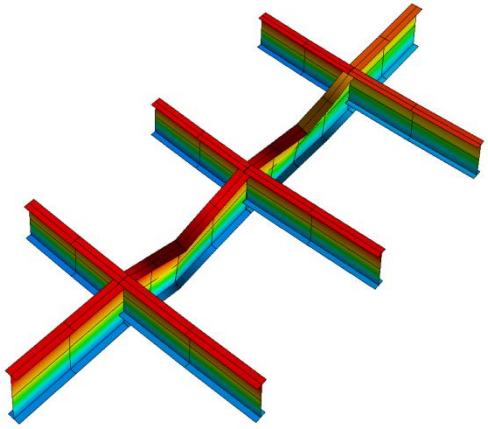
Minimum Coatback
Prevent Radiation

Other Issues

Three side protection in fully engulfed scenario







- The top flanges of both the primary member and attachments are exposed to fire;
- Critical core temperature criteria is difficult to satisfy;
- Normally require advanced thermal-structural analysis to determine the proper coatback scheme (both thickness and length);

Conclusions

- Heat transfer from the attachment to the primary member is driven by the temperature difference;
- Coatback reduces the heat-up rate of the attachment from radiant heat and from heat conducted from the unprotected region of that attachment;
- The ‘450mm rule’ may result in the average temperature in the primary member at the contact area to be greater than the design CCT (e.g. 400°C). This localised hotspot may not lead to structural collapse but analysis should be carried out to inform that decision;
- Increasing coatback thickness to that required for the Hp/A of the secondary member better controls the CCT of the primary member at the contact area and may allow for a reduction in coatback length;

Conclusions

- A reduction in coatback length would not be considered as a benefit if a variety of PFP coatback thicknesses were required dependent on the attachment Hp/A, as this would be difficult to implement on site;
- A single coatback thickness for a given project can be used if this is based on the Hp/A of the lightest attachment. In this way coatback length may be reduced. Whether or not coatback weight is lower than that required for the ‘450mm rule’ will depend on the length and thickness applied to the lightest Hp/A attachment. However, the temperature in the primary member is controlled.

- Coatback requirements depend on the various factors including:
  - Size of the primary and secondary attachments
    - Ratio of section area
    - Ratio of Hp/A
  - Fire duration and Intensity
  - Load ratio
  - Fully protected or 3-side protection

- Coatback is not a ‘one size fits all’ solution and an optimisation study is recommended in order to achieve the most weight and cost efficient solution, that is demonstrated to be ALARP.

Thank you

Acknowledgement:
Enrique Munoz Garcia
Charles Hendry
Stavros Lazarou
Shuyuan Lin
Richard Holliday
Paul Mather

MMI
engineers • scientists • innovators

MMI Engineering
www.mmiengineering.com

Engineering a Safer World