STEEL INDUSTRY GUIDANCE NOTES

Galvanizing Structural Steelwork – Guidance for Engineers on how to reduce the risk of Liquid Metal Assisted Cracking

The galvanizing of structural steelwork is a long established and cost-effective way of providing economic and long-lasting protection against corrosion, with low maintenance requirements and good damage resistance. This SIGN gives the engineer practical guidance on the causes of Liquid Metal Assisted Cracking (LMAC) and factors that should be considered for the design and detailing of steelwork to be hot dip galvanized to avoid it.

Liquid metal assisted cracking (LMAC) is an uncommon form of cracking that may occur when steel components are hot dip galvanized. Although rare this form of cracking, if not detected and repaired could have extremely serious consequences on the performance of the structure.

While evidence from a number of countries has highlighted the occurrence of LMAC, an exact understanding of the circumstances that trigger this type of cracking remains elusive. However, it is generally accepted that there are three main prerequisites for LMAC to occur in steel fabrications. These are:

- A high stress level
- A susceptible steel
- The presence of a liquid metal

Figure 1. An example of LMAC

As already noted the vast majority of steelwork that is galvanised has little susceptibility to LMAC. The following guidance can be used to identify the factors where there is an increased risk of LMAC. To reduce the risk of LMAC, the following issues should be carefully considered:

- Design and detailing
- Type and quality of steel
- Quality of fabrication
- The galvanizing process

Design and Detailing

1. Changes in thickness

Substantial changes in material thickness at any point will induce large thermal stresses, when dipped into the galvanizing bath, as the thinner material will heat up much faster than the thicker material. A rule of thumb is to keep the ratio of the thick-to-thin members less than 2.5 to 1.

2. Welding and Weld Design

Although this might not be strictly the responsibility of the engineer it is sensible to endeavour to minimise welding stresses. This can be done by a variety of means but can range from minimising the heat input to selecting the correct type of weld. For instance, fillet welds are better than butt welds for fitments such as brackets and secondary stiffening.

Where possible balanced weld patterns should be adopted, particularly for asymmetrical components. The welds should be as close as possible to the axis through the centre of gravity of the entire profile. If they are not, they should be as symmetrical as possible, at the same distance from the axis through the centre of gravity.

Asymmetrical sections constitute a greater risk of warping especially if thicker welds are positioned on one side, at a greater distance from the axis through the centre of gravity.

3. Lattice-type structures

In lattice-type and other fabrications as few redundant members as possible should be used as these will increase stresses and distortions throughout the component members when heated.

Components in which any internal static redundancy leads to high secondary stresses in the zinc bath should be avoided.

4. Unbalanced internal stress states

Variation in local restraint can lead to unbalanced internal stress states, which should, if possible, be avoided in steel constructions to be hot dip galvanized and alternatives such as bolted connections or full depth end-plates should be used.

Type and Quality of Steel

5. Grade of steel

The Engineer should specify the minimum grade of steel that will do the job. Higher-grade steels (such as Quench and Tempered grades, cold formed hollow sections or steels with yield strengths in excess of 355MPa) are regularly galvanized but can be considered to be at a higher risk of exhibiting LMAC.

6. Carbon equivalent

There is also evidence that limiting the Carbon Equivalent Value (CEV) to 0.44% or less can reduce the risk of LMAC. It should be noted that the vast majority of steel supplied to EN10025: 2005 meets this requirements.

However, if engineers are using higher grade or more highly alloyed steels then the engineers should consider limiting the CEV to reduce the susceptibility to LMAC.

In all cases steel intended for galvanising should have a known chemical analysis.

Quality of Fabrication

7. Good Practice

Normal good practice as specified in the National Structural Steelwork Specification documents will reduce the risk of LMAC.

8. Special measures

The Engineer should consider whether any 'special' treatment needs to be specified for exposed cut edges and notches (e.g. grinding or reaming) particularly where copes have bean cut in to the 'k' areas of beams. The 'k' area is the meeting point between the web and the flange.

The Galvanising Process

9. Venting and drainage holes

Any venting and drainage holes/cuts to assist during galvanizing should be as large as possible, few in number and should not be placed in the heat affected zone of the welds.

The key points from the above guidance are summarised in the box below.

Key Points

The key points to minimise the possibility of LMAC are:

1. Keep the ratio of thick to thin material to less than 2.5 to 1.
2. Welding should be balanced and heat input should be kept to a minimum
3. Components in which the redundancy may lead to high secondary stresses in the zinc bath should be avoided
4. Avoid variations in local restraints which could lead to unbalanced stress states
5. Use the minimum grade of steel possible
6. For higher grade steels try to limit the CEV to 0.44% or less
7. Consideration should be given to any special treatment needed for exposed cut edges particularly in the web-to-flange areas of beams.
8. Use normal good practice as specified in the National Structural Steelwork Specification documents.
9. Venting and drainage holes for the galvanising process should be few in number and as large as possible. They should not be placed in the heat affect zone of welds.

Further sources of Information

1. **Galvanizing Structural Steelwork – An Approach to the Management of Liquid Assisted Cracking, Published by the British Constructional Steelwork Association and the Galvanizers Association, publication No. 40/05, 2005.**