GAA PFC Distortion Investigation

This report was produced by the GAA to investigate the issues around the distortion/deformation of PFC during the hot dip galvanizing (HDG) process.

Reasons for this Report

Recently the GAA has received a number of enquiries regarding the deformation of PFC's upon collection or during installation. While many fabricators and galvanizers are aware of the issues surrounding the galvanizing of PFC's, the high rate of occurrence and the cost associated with remedial straightening can potentially put customers off specifying HDG as the corrosion protection coating on these types of sections.

This report will present the reasons deformation occurs, how often galvanizers are experiencing it and the mitigative processes put in place to minimise the effects of the deformation.

Two identical fabricated PFC sections galvanized at the same time with vastly different deformation

Reasons for Deformation

The hot dip galvanizing process takes place in a bath of molten zinc held at a constant temperature of 450^{o}C. This results in a form of low temperature heat treatment for steel articles that enter the bath.

Most steels have residual stresses present. These stresses are a result of the material obtaining equilibrium after it has undergone plastic deformation. These are sometimes present due to the manufacturing processes used in the production of the steel but in most cases these stresses are introduced during fabrication (either by welding, bending etc). Heat from welding may cause localized expansion, which is taken up during welding by either the molten metal or the placement of parts being welded. When the finished weldment cools, some areas cool and contract more than others, leaving residual stresses.

Because of the unsymmetrical geometry of PFC sections and the residual stresses that are present, when the articles enter the molten zinc bath the steel heats up and these residual stresses can "relax" and cause the steel article to deform. Due to the high stiffness of one plane of a PFC being offset from the centroid this deformation can be more severe than in other steel articles that have symmetric geometry (U beams, RHS etc.). The galvanizers also generally hang PFC sections by the ends and dip

them with the web in the vertical plane to allow for molten zinc to freely run off the edges and eliminate the likelihood of air pockets collecting resulting in a “missed” section of the channel as the article is lowered into the bath.

Deformation Occurrence

A number of galvanizers were contacted and asked to comment on the likelihood of deformation occurring. Their responses are shown in the table below:

Type of PFC	Occurrence (as a %)
Straight lengths (no fabrication)	5-15
Fabricated	75-85

One of the most frustrating aspects revealed in this investigation was the inability to predict which straight unfabricated lengths will distort. Although the occurrence of this is much lower for these types of PFC sections, the randomness makes it difficult to control/design for.

The main issue with deformation is when a PFC has had cleats or angle welded down one side. These are typically used as fascia’s by builders and architects. The welding of these cleats introduces fabrication stress and also stiffens up one side of the PFC section further exaggerating the already unsymmetrical geometry.

The hole positions for hanging can also have a large impact how the section is able to be dipped. A galvanizer can only hang and dip a PFC section based upon the hanging points that are present.

Length was also mentioned as one of the factors that contribute to distortion. If longer PFC sections require double dipping the temperature differential along the length of the beams can also enhance the likelihood of deformation occurring.

A galvanizer also mentioned the inclusion of hollow sections welded to PFC with inadequate draining and venting holes result in longer emersion times also increasing the likelihood of distortion.

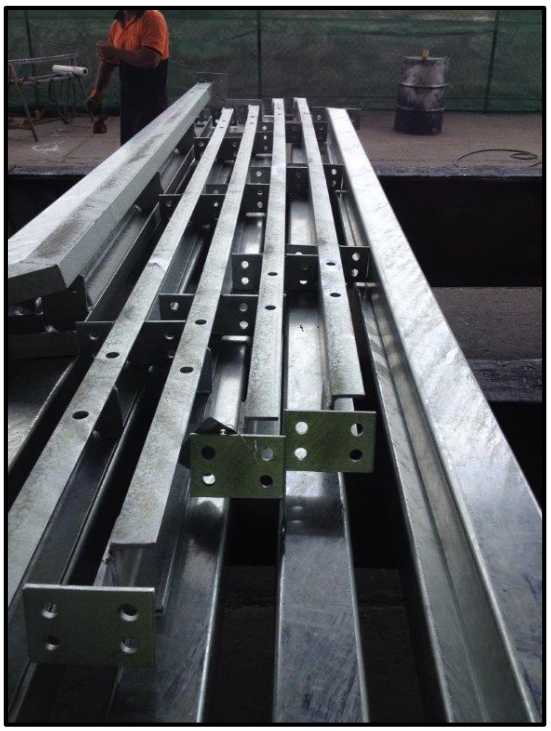
A fabricated PFC that has distorted during the galvanizing process

Mitigation

Most galvanizers and fabricators understand that distortion is likely to occur on fabricated PFC sections. All of the galvanizers spoken to will often air cool sections they think will be a problem. The lower cooling rate allows the steel to relax slower than when plunged into the quenching bath. This is only viable when the whole section can be air cooled.

The speed of dipping, dipping techniques and location of the hanging hole points were also mentioned as variables the galvanizers try to control but again this is not viable on all articles.

If deformation does occur, the sections are sent back to the fabricator to be straightened. Usually the client or the fabricator will wear the costs, and if this is unexpected it can result in a negative attitude towards the HDG process. Most of the time the fabricator will simply clamp the beams in place and jack the beams until the desired level of straightness is achieved. This is a simple process and something industry has come to expect to have to do. Some fabricators also have access to straighteners however these can only be utilized when dealing with straight, unfabricated sections.



Fabricated PFC sections with a shallow curve along the welded face

Conclusions

When discussing this problem with engineers, their main concern is the desire to plan for distortion, however due to the unpredictability of the deformation but it is difficult to quantify this with dimensional variance magnitudes. Education of industry on the distortion of PFC sections along with communication with the galvanizer and fabricator are essential in controlling the likelihood of distortion occurring. Critical points to remember are:

- Letting customers know that there is a likelihood PFC sections will distort and there may be an extra cost to have them straightened
- Good fabrication practices
- Stress relief of welds if possible
- Discuss with galvanizers optimal hanging point locations and potential to air cooled