Hot Dip Galvanizing Data Sheet GA

2.9 Welding Before Hot Dip Galvanizing

1. General

When steel structures are intended to be hot dip galvanized it is best if this is taken into account during design. Otherwise, internal stresses and stress due to expansion caused by the temperature of the galvanizing bath may cause warping or twisting. The most important requirement in welded steel structures which are to be hot dip galvanized is that internal stresses are kept to a minimum. At normal galvanizing temperatures of about 450 °C most steels have about half the resistance to applied stress which they have at normal room temperature. Also, the modulus of elasticity of the steel is significantly reduced from, for example, 215 kN/mm^2 at normal ambient conditions to about 170kN/mm^2 at 140 °C.

2. Defects due to fabrication procedures

Any intention to hot dip galvanize a steel fabrication or structure should be taken into account during design, production and fabrication. Welded seams must be clean and free of pores and notches. Welding slag must not be left on the weld because it is not removed by standard galvanizing pretreatments and may give rise to defects in the galvanized coating (fig. 1). Some types of anti-spatter spray can also result in defective galvanizing because they produce a surface film which is invisible to the galvanizer, which is not removed by normal galvanizing pretreatments but which interferes with the metallurgy of the galvanizing process. (See also Data Sheet 2.1).

Sometimes the chemical composition of the welding material differs considerably from that of the parent metal of the components. In this case the appearance of the galvanized coating on the weld and the galvanized coating on the adjacent parent metal may be very different. In particular, welding rods used in gas welding often have a high silicon content. In this case the silicon content of the weld metal will be high and in the hot dip galvanizing process the weld will be more reactive with the molten zinc than will be the adjacent steel. (See also Data Sheet 2.2). This is especially true for welded joints which have been ground out (fig. 3) where the high silicon content of the weld may cause it to become much more prominent after galvanizing than it was before.

In cases where a welded fabrication has already distorted as a result of stresses induced by the welding operation, the skilled and judicious application of heat (hot straightering) or the use of a hydraulic press (cold straightening) will often restore the original or intended shape. Obviously, straightening involves extra costs and loss of time, and it is advisable to remember that great precision in straightening before galvanizing represents wasted effort because the temperature change during galvanizing will result in further stress relief with consequent change of shape or alignment.

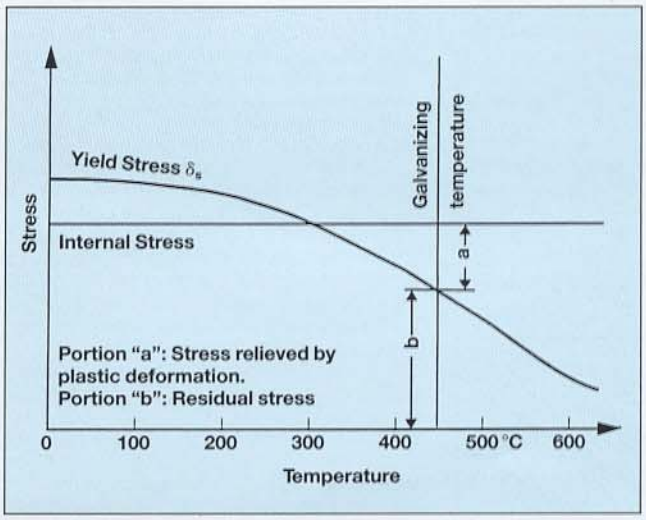

Fig. 1: Variation of yield point of steel with temperature.

Fig. 2: Defects in galvanized coating due to presence of welding slag.

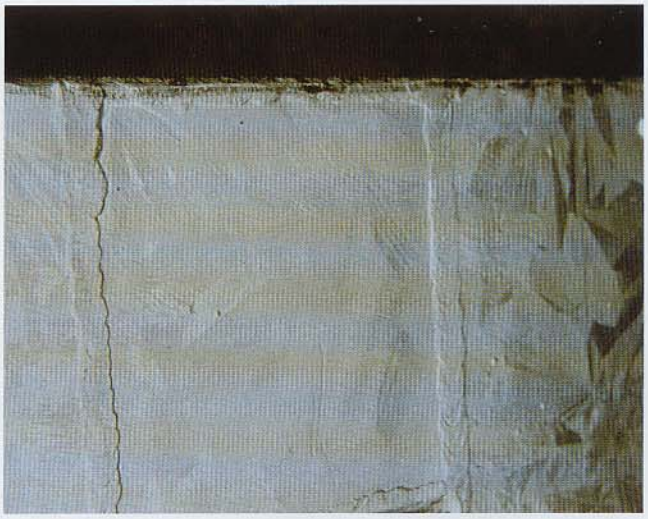

Fig. 3: Thick galvanized coating on weld due to high silicon content.

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Where surfaces overlap, design and fabrication procedures should aim to use the smallest surface area permitted by structural considerations to make the welded connection (fig. 4) as large overlapping areas may not be capable of penetration by the liquid zinc but may form a moisture trap with danger of corrosion in subsequent service. In reality the liquid zinc seals the edges of many overlapping areas which have not been fully penetrated by liquid zinc in the galvanizing process, but this is an unreliable design basis. Small gaps and pores may remain, resulting in unsightly brown discoloration in service.

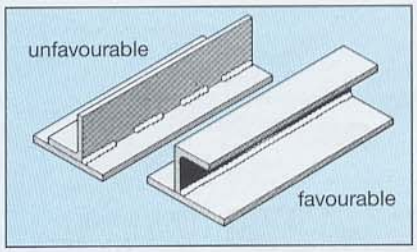

Fig. 4: Extensive overlap should be avoided.

3. Internal stress caused by welding

Stress within a structure caused by welding or other fabrication procedures may be sufficiently high to cause distortion. In effect, the distortion is the result of the structure relieving internal stresses. General guidance is therefore that all welded structures should be designed and built so that internal stress is maintained at low levels unless the design actually calls for (say) a stressed skin as an essential element of structural integrity.

Welding involves the application of heat, with resulting high temperatures, at localized areas within the structure. This may produce a complex series of interactions due to differential expansion and contraction. The greater the extent of the welding the more likely is distortion caused by expansion and contraction stresses.

During the design stage consideration should be given to minimising the extent of welding if it seems that stress relief during the galvanizing process might lead to distortion. The example of the box beam (fig. 5) shows that there are usually several solutions for any design problem. Proposals (a) and (b) are both permissible but apply for different loadings. Proposal (c) would probably result in distortion during galvanizing and might distort during fabrication due to the asymmetric arrangement of the welded seams and contraction as welds cool down. Proposal (d) is stiff but requires very extensive welding.

Design guidance for welded seams, especially in fabrications and structures intended for galvanizing, is that they should as far as possible be located at the centre of gravity of the structure. If this is not possible the seams should in general be symmetrically placed and equidistant from the centre of gravity. Again, the general rule is that welded seams should be no larger than necessary commensurate with the structural integrity of the steelwork.

The essential point to remember is that the risk of distortion is minimised with symmetrically placed welds and is much greater when the design calls for asymmetrical welded seams. A welding method statement should be worked out during the design stage and the fabrication shop should be obliged to respect the method statement. The method statement should be based on the principle of distributing stress evenly over the cross section at all stages of fabrication. This will almost always avoid distortion during the fabrication process and makes it much more likely that the completed structure will be hot dip galvanized without distortion.

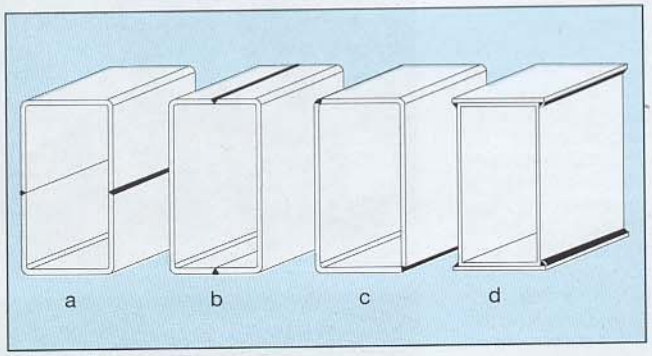

Fig. 5: Design of box beams. Designs (a) and (b) acceptable, designs (c) and (d) unsuitable.

In summary, the most important points for avoiding distortion in hot dip galvanized structures are:

- Implement design procedures which minimise the extent of welding. This minimises the opportunity for distortion caused by expansion and contraction stresses.
- Design weld seams so far as practical to be situated on the centre of gravity of the fabrication or arranged symmetrically around the centre of gravity.
- Arrange for those seams which give most stiffness to the structure to be welded last.
- Arrange for the welding sequence to be "from the outside inwards". This minimises stress arising from contraction after welding.
- Make sure the fabrication shop has a method statement which reflects the design basis. Do not assume the fabricator knows the rules as well as you do.
- Use fabricators with skilled welders and a proven record in fabricating the class of work you are designing.
- Avoid very light structures which rely on many welded fillets and gusset plates for stiffness. It is very likely that a structure of this type will warp at galvanizing temperature. The effect is sufficiently common that galvanizers recognise structures of this type and may decline the work.
- Consult the galvanizer at an early stage if there is any doubt about the suitability of the design for galvanizing.
- Unsuitable designs will often be made suitable by relatively small design changes.
- For most economical galvanizing and ease of handling do not design very large welded structures. Smaller welded structures with on-site bolted connections are easier to handle and galvanize and often just as effective.

Published by:
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B 72 1 SY, U.K.