Preparing for effective corrosion protection No. 8.01

Scope

This Guidance Note covers some of the considerations that are needed in the design, detailing, fabrication and assembly of bridge steelwork to ensure that the protection against corrosion is not compromised by inadequate preparation, damage, or an unnecessarily severe local environment.

The selection of a protective coating system is outside the scope of the Note - see References 1 & 2 for guidance on that aspect.

General information on alternative protective treatments is given in the following Guidance Notes:

- GN 8.03 Hot dip galvanizing
- GN 8.04 Thermally sprayed metal coatings
- GN 8.05 High performance paint coatings

General

The application of a protective coating system is the most common way of controlling corrosion. However, the effectiveness of the system depends not just on the coating materials and specified application procedures, but also on the initial surface condition, the access for application and the environment under which the work is done.

Initial surface condition

For new works, it is wise to specify that the surfaces shall comply with rust grades A or B according to EN ISO 8501-1 (Ref 3). Material that is pitted, i.e. rust grades C or D, should be avoided if at all possible, since it is difficult to prepare such material sufficiently to clean all the corrosion products from the pits in the surface.

Surface preparation

The presence of even small amounts of surface contaminants, oil, grease, oxides etc. can physically impair and reduce coating adhesion and these should be removed before abrasive blast cleaning or mechanical preparation. (It is erroneous to think that subsequent blast cleaning operations will remove such contaminants and it is bad practice to permit them to remain on the surface).

Similarly, millscale on new steelwork is unsuitable for modern high performance coatings and must be removed. This is usually achieved by abrasive blast cleaning to Grade Sa 2½ or Sa 3 as defined in EN ISO 8501-1 (ref 3), depending on the exposure, the coating system and the requirements of the designer.

In addition to the degree of cleanliness, surface preparation also needs to consider the 'roughness' appropriate to the coating to be applied. For example, shot abrasives produce a rounded surface profile and are used for thin film paint coatings (rarely used on bridges), whereas thick or high build paint coatings need a coarse angular surface with a high profile, as provided by grit abrasives, to give a mechanical key.

The surface treatment specification therefore should describe the abrasive to be used and the roughness required, usually as an indication of the average amplitude achieved by the blast cleaning process, and state a method of measurement e.g. comparator panels, special dial gauges or replica tapes. Usually, comparators or replica tapes are used. The comparators are covered by EN ISO 8503-1 (Ref 4). The replica tape method, which is more widely used, is covered by EN ISO 8503-5 (Ref 5).

After abrasive blast cleaning, it is possible to examine for surface imperfections and changes to surface conditions caused during fabrication processes, e.g. by welding.

It may be necessary to remove general surface imperfections on welds and cut edges to produce an acceptable surface condition for coating.

Weldments on fabricated structural steelwork represent a relatively small but important part of the structure and can produce variable surface profile and uneven surfaces or sharp projections that can cause premature failure of the coating. Although welded areas are inspected, the requirements for weld quality do not usually consider the requirements for coating. Welds must generally be continuous and always free from pin holes, sharp projections, excessive undercutting and weld spatter. Any sprayed coatings used in inspection (e.g. those used in MPI) need to be removed as well. The treatment of welds, cut edges and other areas is covered in EN ISO 8501-3 (Ref 6).

After the preparation of the surface to an acceptable standard of cleanliness and profile, it is important that the steelwork has no residual dust or particulate matter on the surface and is not allowed to deteriorate. Re-rusting can occur very quickly in a damp environment and unless the steel is maintained in a dry condition coating of the surface should proceed as soon as possible. Any significant re-rusting of the surface should be considered as a contaminant and be removed by re-blasting.

Corners and cut faces

Sawn and flame-cut ends and edges need treatment to ensure that the coating adheres and is of sufficient thickness.

At outside arrises (i.e. the meeting between two surfaces), there is a potential problem when there is a sharp (i.e. 90°) edge, because the fluid coating will not cover it properly. Consequently, they should be smoothed by grinding or filing. It is generally considered sufficient to smooth the corner to a radius of about 2 mm; this minimum radius is specified in the SHW, clause 1810.2 (Ref 10)

In addition to the requirement for smoothing arrises, the SHW, clause 1914(13) (Ref 1), specifies the application of one or more stripe coats (an extra coat applied only locally) for all external corners (and for welds and fasteners, for a similar reason).

The corners of rolled sections generally do not require grinding, as they are usually smooth as a result of the rolling process.

For the treatment of flame-cut surfaces, which are harder than the rolled surface, refer to GN 5.06.

Site connections and splices

Girder splices and connection details are often not given full protection in the shops, leaving the connection zones to be made good on site. A frequent consequence is that these zones are the least well prepared and protected, and are the first to show signs of breakdown.

Welded connections

At welded connections, the key factors in ensuring the effectiveness of the coating system are the effectiveness of the protection before final coating. The areas locally to welds are usually masked, to prevent them being coated. The masking stays in place until the joint is welded; this is not an ideal protection if there is prolonged exposure before welding.

After welding, it is essential that the joint surfaces, including the weld itself, are prepared to the specified standard of cleanliness and profile. Because of the contamination that occurs from the welding flux, particular attention needs to be paid to cleaning off all residues.

The surfaces of welds themselves should not need any grinding if they comply with the requirements of EN 1011-2: 2001 (Ref 7) for smoothness and blending into the parent metal. Rough profiles, badly formed start-stops, sharp undercut and other defects such as adherent weld spatter should be removed by careful grinding, such that that the weld is not compromised. Particular attention needs to be paid to the blast cleaned profile, because weld metal is harder and site blast cleaning is more difficult than shop blasting.

Bolted connections

Bolted connections, which are almost always preloaded slip-resistant connections, merit particular consideration, both of the surfaces that will remain exposed and of those that will not (i.e. the faying surfaces). Attention should be paid to the removal of any adhesive used on the protective films for the faying surfaces, and to the removal of any lubricants used on the threads of bolts. Care should be taken to avoid contamination of surfaces during bolting up, for example, older air-power wrenches tend to produce a fine oily/misty exhaust that may settle on the surface.

Damage during handling

During handling, turning and assembly, damage to edges and to surfaces by the use of sharp-toothed clamps must be avoided by taking precautionary measures, such as the use of properly designed lifting cleats. If damage does occur, it must by carefully

blended out by grinding (and the full protective treatment restored, with specified overlaps between coats).

Cleanliness at site
Just as surface cleanliness before first coating is fundamental to performance of the system, so is the cleanliness of painted surfaces prior to the application of subsequent coats. On site, thorough cleaning shortly before painting is always necessary to remove contamination accumulated over time and from construction activities including dust, grout leaks from concreting, and the products of blast-cleaning, bolting and welding.

Access for application of coating
Since the effectiveness of a coating depends on the preparation and the proper application of the coating, it is essential that the preparation, application and inspection are straightforward. Narrow gaps, difficult to reach corners, and hidden surfaces should therefore be avoided wherever possible.

Cope holes
A typical detail that is difficult to protect is a cope hole in a web stiffener. Unless the hole is very large, it is virtually impossible to blast clean the surface properly, and to apply a protective treatment to the surface. (A fluid coating can only be applied by 'bouncing off' other surfaces, and it is totally impossible to apply metal spray.)

If cope holes are used, they should be circular and of at least 40 mm radius, preferably more. (If the cope hole were formed by a 45° snipe, the weld would not be returned through the hole and there will be the additional problem of a narrow crevice - such a detail should not be used at all.)

There is an argument for using a cope hole in a web stiffener that is fitted to the bottom flange, to provide a drainage path along the flange. The benefits are, in most cases, marginal, and the action of channelling water past surfaces that have probably been less well protected than they should have been is questionable.

The best detail at the inside corner of a web stiffener is a small snipe, just sufficient to clear the web/flange weld, so that the stiffener fillet weld can be continued round the corner, completely sealing the junction.

Interfaces
There are two common types of interface in steel and composite bridges - the faying surfaces of a slip-resistant bolted joint and between a steel flange and a concrete deck slab.

Faying surfaces are usually either unpainted or metal sprayed without sealer. They need to be protected (usually by masking tape) until the parts are finally bolted together (see GN 7.05).

Surfaces in contact with concrete are usually (with the exception of a marginal strip at the edges of the interface) blast cleaned bare steel. The marginal strip should be treated as for the external surfaces, except that only the shop coats need be applied. It is recommended that the width of the marginal strip should be at least equal to the required cover to the reinforcement, for the same exposure condition. A width of 50 mm is common. Any aluminium metal spray on surfaces in contact with concrete needs to receive at least one coat of paint, to prevent the reaction that may occur between concrete and aluminium. It is recommended that any shear connectors be positioned such that they (and their welds) do not lie within the marginal strip; they should also be protected against overspray of the coating.

In both cases, the perimeter of the interface needs to be considered carefully, since water may penetrate through capillary action. It is usual to specify that a margin inside the interface is also coated; this does not compromise the bonding of the concrete or the friction capacity of the joint. Joints may also be sealed with a suitable high quality alkali resistant mastic.

Narrow gaps
Sometimes narrow gaps are created between two steel elements. These will be very difficult to maintain properly and should be avoided if at all possible. If there are narrow gaps, they should be sealed, either by welding or by proprietary sealants, and covered by the protective coating.

Bolts, nuts and washers
The exposed surfaces of bolted fasteners need to be protected to at least the same level as the rest of the steelwork. Indeed the crevices associated with these fasteners are particularly vulnerable. Short-term protection of the fastener can be obtained by the specification of a sherardized or electroplated coating, but the full coating system should be applied after assembly. Hot dip galvanized fasteners are commonly specified; they should be overcoated after assembly. The SHW requires stripe coats to be applied to all fasteners, including washers. See GN 8.02 for further details on protective treatment of bolts.

Moisture and dirt traps
In detailing the steelwork, avoid any features that would hold or trap water and dirt. For example: avoid arranging channels with toes upward; arrange angles so that the vertical leg is below the horizontal. As a last resort, if features that trap water or dirt cannot be avoided, provide drainage holes, but ensure that they are large enough to be coated properly and kept clean, and that they do not discharge onto other vulnerable areas.

Access for maintenance
Remember that the bridge will have to be maintained and that the coating will need to be renewed during the life of the bridge. This can only be done effectively if there is good access, both for personnel and for the process of cleaning and recoating. Avoid creating details where this would be difficult or impossible in the assembled configuration.

Further advice on design considerations is given in references 8 and 9.

References

1. Manual of Contract Documents for Highway Works: Specification for Highway Works, series 1900; Notes for Guidance on the Specification for Highway Works, series NG1900, TSO, 2014.
2. Steel Construction website:
   www.steelconstruction.info/Corrosion_protection, BCSA, Tata Steel, SCI
3. EN ISO 8501-1:2007 Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.
4. EN ISO 8503-1:2012, Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces.
5. EN ISO 8503-5:2004, (BS 7079-C5:2004) Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Replica tape method for the determination of the surface profile.
6. EN ISO 8501-3:2007 (BS 7079-A3:2006) Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Preparation grades of welds, cut edges and other areas with surface imperfections
7. EN 1011-`2, 2001, Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels.
8. EN ISO 12944 Paints and varnishes. Corrosion protection of steel structures by protective paint systems.
9. Design of steel bridges for durability, The Steel Construction Institute, 1997.
10. Manual of Contract Documents for Highway Works: Specification for Highway Works, series 1800; Notes for Guidance on the Specification for Highway Works, series NG1800, TSO, 2014

